

UPPER COLUMBIA RIVER

Work Plan for the Remedial Investigation and Feasibility Study

Volume I of II

Modified by

U.S. Environmental Protection Agency

Based on Draft Work Plan Provided By:

Teck Cominco American Incorporated

P.O. Box 3087

Spokane, WA 99220-3087

December 2008

CONTENTS

VOLUME I

LIST OF FIGURES.....	IX
LIST OF TABLES	XV
LIST OF MAPS.....	XIX
ACRONYMS AND ABBREVIATIONS	XXI
1 INTRODUCTION.....	1-1
1.1 UPPER COLUMBIA RIVER SITE OVERVIEW	1-2
1.2 PURPOSE AND OBJECTIVES	1-3
1.3 SCOPE OF THE RI/FS	1-3
1.4 CULTURAL AND NATURAL RESOURCES	1-4
1.5 COORDINATION OF PARTICIPATING PARTIES.....	1-4
1.6 WORK PLAN ORGANIZATION.....	1-4
2 OVERVIEW OF UPPER COLUMBIA RIVER RI/FS PROCESS.....	2-1
2.1 GENERAL APPROACH.....	2-1
2.2 TASK DESCRIPTIONS.....	2-3
2.2.1 Scoping (Task 1).....	2-4
2.2.2 Community Relations (Task 2)	2-6
2.2.3 Remedial Investigation	2-7
2.2.4 Feasibility Study Tasks.....	2-10
2.2.5 Project Schedule (Task 8)	2-12
2.2.6 Potential Early Actions (Task 9).....	2-12
3 SITE DESCRIPTION.....	3-1
3.1 SITE CHARACTERISTICS AND USE	3-1
3.1.1 Human Settlement and Cultural Resources.....	3-2
3.1.2 Current Demographics	3-5
3.1.3 Site Uses	3-7
3.2 PHYSICAL SETTING.....	3-11
3.2.1 Geology	3-11
3.2.2 Hydrogeology	3-12
3.2.3 Hydrology.....	3-14
3.2.4 Characteristics of UCR Reaches.....	3-20
3.2.5 Climate/Meteorology	3-27
3.3 ECOLOGICAL RESOURCES.....	3-28

3.3.1	Wildlife and Aquatic Life	3-28
3.3.2	Vegetation.....	3-30
3.3.3	Habitat.....	3-31
4	ASSESSMENT OF CHEMICAL SOURCES.....	4-1
4.1	MINE, MILL, AND SMELTING OPERATIONS	4-1
4.1.1	Trail, British Columbia, Teck Cominco Facility.....	4-2
4.1.2	Le Roi/Northport Smelter	4-9
4.2	ADDITIONAL POTENTIAL CHEMICAL SOURCES	4-10
4.2.1	Pulp Mill Operations	4-10
4.2.2	EPA Toxics Release Inventory Sites	4-11
4.2.3	Water Quality Discharge Permitted Sites.....	4-12
4.2.4	Municipal and Non-point Sources	4-12
5	ENVIRONMENTAL CONDITIONS	5-1
5.1	OVERVIEW AND DATA EVALUATION APPROACH	5-1
5.2	SURFACE WATER QUALITY	5-1
5.2.1	Temperature	5-2
5.2.2	Dissolved Oxygen.....	5-2
5.2.3	Nutrients	5-3
5.2.4	Conventional Parameters	5-4
5.2.5	Metal and Metalloid Concentrations	5-5
5.3	SEDIMENT QUALITY	5-8
5.3.1	Surface Sediments.....	5-9
5.3.2	Subsurface Sediments	5-20
5.3.3	Chemical Distributions in Sediment Porewater	5-24
5.3.4	Sediment Toxicity	5-28
5.4	FISH TISSUE RESIDUES.....	5-33
5.4.1	Historical Investigations of Fish Tissue Residues	5-33
5.4.2	EPA 2005 Investigations of Fish Tissue Residues	5-33
5.5	AIR QUALITY	5-36
5.5.1	WDOH/Ecology Air Quality Study at Northport, Washington.....	5-36
5.5.2	TCM Air Quality Monitoring at Northport, Washington.....	5-39
5.5.3	USGS Study of Occurrence and Distribution of Trace Elements in Air Along Lake Roosevelt (Marcus Flats/Kettle Falls, Inchelium, and Seven Bays).....	5-39
6	CONCEPTUAL SITE MODELS	6-1
6.1	CHEMICALS OF INTEREST.....	6-1
6.1.1	Metals and Metalloids.....	6-2
6.1.2	Semivolatile Organic Compounds (including PAHs)	6-2

6.1.3	Pesticides and PCBs.....	6-2
6.1.4	Polybrominated Diphenyl Ethers.....	6-2
6.1.5	Polychlorinated Dibenzo- <i>p</i> -Dioxins and Polychlorinated Dibenzofurans	6-2
6.2	PHYSICAL/CHEMICAL CONCEPTUAL SITE MODEL.....	6-3
6.2.1	Hydrodynamic/Fluid Transport.....	6-3
6.2.2	Sediment Transport	6-3
6.2.3	Chemical Transport and Fate.....	6-5
6.3	ECOLOGICAL CONCEPTUAL SITE MODEL	6-6
6.3.1	Sources.....	6-7
6.3.2	Transport and Fate Mechanisms	6-8
6.3.3	Exposure Media	6-11
6.3.4	Exposure Pathways	6-11
6.3.5	Ecological Receptors.....	6-11
6.4	HUMAN HEALTH CONCEPTUAL SITE MODEL	6-15
7	DATA GAPS AND STUDY SEQUENCING	7-1
7.1	DATA GAPS.....	7-1
7.1.1	Understanding of Chemical Distributions, Sources, and Effects.....	7-1
7.1.2	Understanding of the Physical System.....	7-6
7.1.3	Resource Abundance and Distribution Studies	7-7
7.2	STUDY SEQUENCING AND MAJOR DECISION POINTS	7-8
7.2.1	Process Overview	7-8
7.2.2	Overview of Studies and Major Decision Points.....	7-9
8	OVERVIEW OF UPPER COLUMBIA RIVER STUDIES FOR 2009 – 2012.....	8-1
8.1	2009/2010 STUDIES	8-1
8.1.1	Surface Water Study	8-2
8.1.2	Fish Tissue Study	8-3
8.1.3	Zooplankton Tissue.....	8-4
8.1.4	Beach Sediment Study.....	8-5
8.1.5	White Sturgeon Study	8-6
8.1.6	Resource Use and Consumption Surveys	8-6
8.1.7	Upstream Sources Study.....	8-7
8.2	2011 STUDIES.....	8-7
8.2.1	Soil Study	8-8
8.2.2	Sediment Studies.....	8-9
8.2.3	Aquatic Resource and Benthic Tissue Study	8-11
8.2.4	White Sturgeon Toxicity Study.....	8-13

8.3	2012 STUDIES.....	8-13
8.3.1	Terrestrial Studies.....	8-14
8.3.2	Aquatic Studies.....	8-17
8.3.3	Transport and Fate Study.....	8-19
9	ECOLOGICAL RISK ASSESSMENT APPROACH.....	9-1
9.1	PROBLEM FORMULATION.....	9-3
9.1.1	Evaluation of Existing Data.....	9-3
9.1.2	Constituents of Interest.....	9-3
9.1.3	Preliminary Chemical Sources and Releases, Chemical Transport and Fate, Exposure Pathways, and Potential Ecological Conceptual Site Models.....	9-3
9.1.4	Exposure Pathways and General Receptor Groups.....	9-4
9.1.5	Assessment Endpoints and Measures.....	9-4
9.1.6	Testable Hypotheses.....	9-5
9.2	EXPOSURE CHARACTERIZATION.....	9-6
9.2.1	Exposure Characterization for Aquatic Receptors.....	9-6
9.2.2	Exposure Characterization for Terrestrial Receptors.....	9-7
9.3	EFFECTS CHARACTERIZATION.....	9-8
9.3.1	Effects Characterization for Aquatic Receptors.....	9-8
9.3.2	Effects Characterization for Terrestrial Receptors.....	9-9
9.4	RISK CHARACTERIZATION.....	9-10
10	FEASIBILITY STUDY APPROACH.....	10-1
10.1	GENERAL APPROACH.....	10-1
10.2	DEVELOPMENT OF REMEDIAL ALTERNATIVES.....	10-1
10.3	SCREENING OF REMEDIAL ALTERNATIVES.....	10-4
10.3.1	Effectiveness Evaluation.....	10-4
10.3.2	Implementability Evaluation.....	10-5
10.3.3	Cost Evaluation.....	10-5
10.4	DETAILED ANALYSIS OF ALTERNATIVES.....	10-5
11	DELIVERABLES.....	11-1
11.1	TASK 1: SCOPING.....	11-1
11.1.1	Technical Memorandum on Risk Management-Based Action Objectives for Ecological Risk Assessment.....	11-1
11.1.2	RI/FS Work Plan and Addenda.....	11-1
11.1.3	SLERA Report.....	11-2
11.1.4	Sampling and Analysis Plans.....	11-2
11.1.5	Site Health and Safety Plan.....	11-2
11.1.6	Cultural Resources Coordination Plan.....	11-3

11.2	TASK 2: COMMUNITY RELATIONS PLAN	11-3
11.3	TASK 3: SITE CHARACTERIZATION	11-4
11.3.1	Technical Memorandum on Modeling of Site Characteristics	11-4
11.3.2	Preliminary Site Characterization Summary and Data Gap Evaluations...	11-4
11.3.3	Remedial Investigation Report	11-5
11.4	TASK 4: ECOLOGICAL RISK ASSESSMENT	11-5
11.5	TASK 5: TREATABILITY STUDIES	11-6
11.5.1	Determination of Candidate Technologies and the Need for Testing	11-6
11.5.2	Treatability Testing Work Plan(s).....	11-7
11.5.3	Treatability Study Sampling and Analysis Plan(s), Health and Safety Plan(s), and Cultural Resources Coordination Plan(s).....	11-7
11.5.4	Treatability Study Evaluation Report(s).....	11-7
11.6	TASK 6: DEVELOPMENT AND SCREENING OF REMEDIAL ALTERNATIVES	11-7
11.6.1	Technical Memorandum on Refined Risk Management-Based Action Objectives	11-8
11.6.2	Technical Memorandum on General Response Actions	11-8
11.6.3	Technical Memorandum on the Development and Preliminary Screening of Remedial Technologies, Assembled Alternatives Screening Results, and Final Screening	11-8
11.6.4	Technical Memorandum on Comparative Analysis.....	11-9
11.6.5	Draft Feasibility Study Report	11-9
12	PROJECT MANAGEMENT PLAN.....	12-1
12.1	PROJECT ROLES AND RESPONSIBILITIES	12-1
12.1.1	Agency Roles and Responsibilities.....	12-1
12.1.2	TCAI Roles and Responsibilities	12-2
12.1.3	TCAI Consultant Team Roles and Responsibilities	12-2
12.2	COMMUNICATIONS AND COORDINATION	12-2
12.2.1	Communications and Meetings – TCAI Technical Team	12-2
12.2.2	Communications and Meetings – EPA and Participating Parties	12-3
12.2.3	Comment tracking	12-4
12.2.4	Community Relations	12-5
12.3	DELIVERABLES.....	12-5
12.4	DECISION-MAKING PROCESS	12-5
12.5	KEY DECISIONS.....	12-6
12.5.1	Data Quality Objectives	12-6
12.5.2	Risk Assessment Parameters.....	12-6

12.5.3 Preliminary Risk Management-Based Action Objectives	12-6
12.5.4 Field Sampling and Analysis Plans.....	12-6
12.5.5 Treatability Testing.....	12-7
12.6 SCHEDULE.....	12-7
13 REFERENCES	13-1
14 GLOSSARY OF TERMS	14-1

VOLUME II

Appendix A. Technical Memorandum No. 1, Preliminary Ecological Risk Management-Based Action Objectives (RMAOs)	
Appendix B. Data Management Plan	
Appendix C. Preliminary Hydrodynamic and Sediment Transport Analyses for the Upper Columbia River	
Appendix D. Trail Facility Operations	
Appendix E. GIS Maps of Various Information from the Upper Columbia River Study Area	
Appendix F. Summary of Analytical Data for EPA 2005 Fish Composite Samples	
Appendix G. Summary of Air Monitoring Data for Northport, Washington, Provided by Teck Cominco Metals, Ltd. on August 21, 2006, and December 14, 2006	
Appendix H. Ecological Community Information	
Appendix I. Upper Columbia River Chemical Stressors	

LIST OF FIGURES

- Figure 1-1. Generalized RI/FS Process and Relationship to UCR RI/FS Tasks
- Figure 2-1. Relationships among Major Tasks in the UCR RI/FS
- Figure 3-1. NPS Recreational Facilities, Upper Columbia River, WA
- Figure 3-2. Definitions of Group A and Group B Water Systems
- Figure 3-3. Geological Regions of Washington State
- Figure 3-4. Principal Surficial Aquifers of Washington State
- Figure 3-5. Groundwater Withdrawals by County in 2000
- Figure 3-6. Major Dams Upstream of the Study Area
- Figure 3-7. Mean Columbia River Daily Discharge Hydrograph at the U.S.-Canadian Border as Recorded at USGS Station No. 12399500
- Figure 3-8. Monthly Mean Flow Across the U.S.-Canadian Border for Two Time Intervals as Recorded at USGS Station No. 12399500
- Figure 3-9. Plot of Water Elevation in Lake Roosevelt as a Function of Time
- Figure 3-10. Actual January through June Runoff Volume from 1995-2005 at the Dalles, OR Compared to the 1961-2005 Average
- Figure 3-11. Daily Pool Elevations over the Period 1995-2005
- Figure 3-12. Daily Average Lake Roosevelt Water Retention Time Over the Period of 1995-2005
- Figure 3-13. Photograph of UCR at Kettle Falls Prior to the Inundation of Lake Roosevelt, circa 1937
- Figure 4-1. Estimate of Areas Potentially Affected by Historical Smelter Emissions
- Figure 5-1. Daily Average Water Temperature at the International Border and Grand Coulee Dam Forebay, 1998-2003
- Figure 5-2. Seasonal Alkalinity of Surface Water Samples Collected at the Birchbank Sampling Station BC08NE0005 as Part of the Canada – British Columbia Water Quality Monitoring Agreement, September 1999
- Figure 5-3. Box Plots of Surface Water Sample pH at Birchbank, Waneta, and Northport Sampling Stations in UCR between 2000 and 2006
- Figure 5-4. Box Plots of Surface Water Sample Alkalinity at Birchbank, Waneta, and Northport Sampling Stations in UCR between 2000 and 2006
- Figure 5-5. Box Plots of Surface Water Sample Hardness at Birchbank, Waneta, and Northport Sampling Stations in UCR between 2000 and 2006

- Figure 5-6. Total Arsenic: Comparison of Surface Water Concentrations at Birchbank, Waneta, International Boundary, and Northport (2001–2005)
- Figure 5-7. Total Cadmium: Comparison of Surface Water Concentrations at Birchbank, Waneta, and International Boundary (2001–2005)
- Figure 5-8. Total Copper: Comparison of Surface Water Concentrations at Birchbank, Waneta, International Boundary, and Northport (2001–2005)
- Figure 5-9. Total Lead: Comparison of Surface Water Concentrations at Birchbank, Waneta, International Boundary, and Northport (2001–2005)
- Figure 5-10. Total Zinc: Comparison of Surface Water Concentrations at Birchbank, Waneta, International Boundary, and Northport (2001–2005)
- Figure 5-11. Northport: Dissolved Arsenic Concentrations in Surface Water
- Figure 5-12. Northport: Dissolved Cadmium Concentrations in Surface Water
- Figure 5-13. Northport: Dissolved Copper Concentrations in Surface Water
- Figure 5-14. Northport: Dissolved Lead Concentrations in Surface Water
- Figure 5-15. Northport: Dissolved Mercury Concentrations in Surface Water
- Figure 5-16. Northport: Dissolved Zinc Concentrations in Surface Water
- Figure 5-17. Combined UCR and Tributary Stations: Total and Total Recoverable Arsenic Concentrations in Surface Water
- Figure 5-18. Combined UCR and Tributary Stations: Total and Total Recoverable Cadmium Concentrations in Surface Water
- Figure 5-19. Combined UCR and Tributary Stations: Total and Total Recoverable Copper Concentrations in Surface Water
- Figure 5-20. Combined UCR and Tributary Stations: Total and Total Recoverable Lead Concentrations in Surface Water
- Figure 5-21. Combined UCR and Tributary Stations: Total and Total Recoverable Mercury Concentrations in Surface Water
- Figure 5-22. Combined UCR and Tributary Stations: Total and Total Recoverable Zinc Concentrations in Surface Water
- Figure 5-23. Longitudinal Distributions of Percent Sand, Silt, and Clay in Surface Sediments (top 2-4 cm) in the UCR in 1986
- Figure 5-24. Longitudinal Distributions of Iron, Zinc, and Copper Concentrations in Surface Sediments (top 2-4 cm) of the UCR in 1986
- Figure 5-25. Longitudinal Distributions of Arsenic and Manganese Concentrations in Surface Sediments (top 2-4 cm) of the UCR in 1986

- Figure 5-26. Longitudinal Distributions of Cadmium, Mercury, and Lead Concentrations in Surface Sediments (top 2-4 cm) of the UCR in 1986
- Figure 5-27. Sampling Period (April 14–May 3) for the 2005 Phase I Sediment Study in Relation to Water Elevations in the UCR
- Figure 5-28. Longitudinal Distribution of Percent Sand in Surface Sediments (top 10-15 cm) of the UCR in 2005
- Figure 5-29. Longitudinal Distribution of Percent Silt in Surface Sediments (top 10-15 cm) of the UCR in 2005
- Figure 5-30. Longitudinal Distribution of Percent Clay in Surface Sediments (top 10-15 cm) of the UCR in 2005
- Figure 5-31. Longitudinal Distribution of Percent Colloids in Surface Sediments (top 10-15 cm) of the UCR in 2005
- Figure 5-32. Longitudinal Distribution of Iron Concentrations in Surface Sediments (top 10-15 cm) of the UCR in 2005
- Figure 5-33. Longitudinal Distribution of Zinc Concentrations in Surface Sediments (top 10-15 cm) of the UCR in 2005
- Figure 5-34. Longitudinal Distribution of Copper Concentrations in Surface Sediments (top 10-15 cm) of the UCR in 2005
- Figure 5-35. Longitudinal Distribution of Arsenic Concentrations in Surface Sediments (top 10-15 cm) of the UCR in 2005
- Figure 5-36. Longitudinal Distribution of Cadmium Concentrations in Surface Sediments (top 10-15 cm) of the UCR in 2005
- Figure 5-37. Longitudinal Distribution of Mercury Concentrations in Surface Sediments (top 10-15 cm) of the UCR in 2005
- Figure 5-38. Longitudinal Distribution of Nickel Concentrations in Surface Sediments (top 10-15 cm) of the UCR in 2005
- Figure 5-39. Longitudinal Distribution of 4,4'-DDT Concentrations (Dry Weight [DW]) in the UCR
- Figure 5-40. Longitudinal Distribution of Aroclor 1260 Concentrations (Dry Weight [DW]) in the UCR
- Figure 5-41. Longitudinal Distribution of Benzo(a)pyrene Concentrations (Dry Weight [DW]) in the UCR
- Figure 5-42. Spatial Variation in Organic Carbon-Normalized Concentrations of Total Simultaneously Extracted Metals and Acid Volatile Sulfides ($(\sum \text{SEM-AVS})/\text{foc}$) Reported by EPA for UCR Sediments in 2005

- Figure 5-43. Spatial Variation in Acid Volatile Sulfide (AVS) Concentrations Reported by EPA for UCR Sediments in 2005
- Figure 5-44. Relationship between Acid Volatile Sulfide (AVS) and Total Organic Carbon (TOC) Concentrations in the UCR between River Miles 603 and 698
- Figure 5-45. Relationship between Acid Volatile Sulfide (AVS) and Total Organic Carbon (TOC) Concentrations in the UCR between River Miles 704 and 744
- Figure 5-46. Spatial Variation in Total Organic Carbon (TOC) Concentrations Reported by EPA for UCR Sediments in 2005
- Figure 5-47. Survival of *Hyaella azteca* and *Ceriodaphnia dubia* in Sediments from the UCR
- Figure 5-48. Reproductive Success (Mean Neonates per Adult) of *Ceriodaphnia dubia* in Sediments from the UCR
- Figure 5-49. Median Reduction in Light Output of *Vibrio fischeri*
- Figure 5-50. Mean Concentrations of Lead in Composite Samples of Largescale Sucker
- Figure 5-51. Mean Concentrations of Arsenic in Composite Samples of Burbot
- Figure 5-52. Mean Mercury Concentrations in Composite Samples of Fishes from the UCR Grouped by Dietary Preference
- Figure 5-53. Comparison of Normal and Lipid Normalized 2,3,7,8-TCDF Concentrations in Whole Body Burbot, Largescale Sucker, and Whitefish by River Mile Collected in the UCR by EPA in 2005
- Figure 5-54. Comparison of Normal and Lipid Normalized 2,3,7,8-TCDF Concentrations in Whole Body Rainbow Trout and Walleye by River Mile Collected in the UCR by EPA in 2005
- Figure 5-55. Comparison of Normal and Lipid Normalized Aroclor 1254/1260 Concentrations in Whole Body Fish Collected in the UCR by EPA in 2005
- Figure 5-56. Comparison of Normal and Lipid Normalized Aroclor 1254/1260 Concentrations in Whole Body Burbot, Largescale Sucker, and Whitefish by River Mile Collected in the UCR by EPA in 2005
- Figure 5-57. Comparison of Normal and Lipid Normalized Aroclor 1254/1260 Concentrations in Fillets of Rainbow Trout and Walleye Collected in the UCR by EPA in 2005
- Figure 5-58. Mean Air Monitoring Concentrations for Northport from 1994-2006

- Figure 5-59. Mean Concentrations for Air Monitoring Results at Three Sampling Locations along UCR in 2002
- Figure 5-60. Mean Concentrations for Air Monitoring Results at Three Sampling Locations along UCR in 2003
- Figure 5-61. Mean Concentrations for Air Monitoring Results at Three Sampling Locations along UCR in 2004
- Figure 6-1. Components of a Generic Conceptual Site Model
- Figure 6-2. Preliminary Transport and Fate Conceptual Site Model
- Figure 6-3. Preliminary Conceptual Site Model
- Figure 6-4. General Exposure Pathways and Receptor Groups
- Figure 9-1. Superfund Eight-Step Ecological Risk Assessment Process
- Figure 9-2. EPA Ecological Risk Assessment Framework
- Figure 10-1. CERCLA Evaluation Criteria for Detailed Analysis of Alternatives during the RI/FS
- Figure 12-1. UCR Site RI/FS – Project Organization Chart
- Figure 12-2. UCR Site RI/FS – Project Lines of Communication
- Figure 12-3. 2008-2010 Field Studies

LIST OF TABLES

Table 2-1.	Preliminary Ecological Risk Management-Based Action Objectives
Table 2-2.	Preliminary Identification of Potential Applicable or Relevant and Appropriate Requirements for the UCR Site RI/FS
Table 2-3.	Preliminary Identification of To Be Considered Requirements for the UCR Site RI/FS
Table 3-1.	Demographics of Larger UCR Communities, Indian Reservations, and Adjacent Counties
Table 3-2.	Active Surface Water Rights within the Study Area with Potential Domestic Uses
Table 3-3.	Public Water Systems Groundwater Wells and Springs within Five Miles of UCR/Lake Roosevelt Shoreline
Table 3-4.	Group A Water Systems with Mapped 10-Year Wellhead Protection Areas
Table 3-5.	Gaging Stations Used to Develop Water Budgets
Table 3-6.	Water Budget for the UCR
Table 3-7.	Statistical Measures of Daily Discharge at the U.S.-Canadian Border
Table 3-8.	Terrestrial Animal Species Present in the UCR RI/FS Study Area
Table 3-9.	Aquatic Species Present in the UCR RI/FS Study Area
Table 4-1.	Reported Spills and Permit Limit Exceedances from the Trail Facility to the Columbia River
Table 4-2.	Summary of Permits Issued to the Trail Facility by the B.C. Government Authorizing Onsite Activities and/or Discharges
Table 4-3.	Summary of TRI Facilities and Associated Chemicals in the Vicinity of the Study Area
Table 4-4.	Current Non-municipal General Permit Facilities That Discharge to WRIAs in UCR Drainage Basin
Table 4-5.	Ecology Municipal General Permit Facilities That Discharge to WRIAs in UCR Drainage Basin
Table 5-1.	Combined Summary Statistics for Conventional Parameters Analyzed at Four Upper Columbia River Stations and Four Columbia River Tributary Stations
Table 5-2.	Summary Statistics for Selected Surface Water Conventional Parameters Sampled Between 2000 to Present at the Birchbank, Waneta, and Northport Stations

Table 5-3.	Summary of Surface Water Metals Data
Table 5-4.	Cross-Sectional Distributions of Grain-Size Parameters, TOC, and Metals in Surface Sediments Collected from the UCR in 2005
Table 5-5.	Mean Metals Concentrations in Surface Sediments of Beaches Sampled along the UCR in 2005
Table 5-6.	Vertical Distributions of Metals in the Sediment Core Collected at RM 693 in the UCR in 1986
Table 5-7.	Vertical Distributions of Metals in Sediment Cores Collected from the UCR in 2005
Table 5-8.	Vertical Distribution of Organic Compounds in Phase I Core Samples of UCR Sediments
Table 5-9.	Metal/Metalloid Concentrations and Hardness Measured in Porewater in Studies Conducted in August 1989 (Johnson 1991b), September 2002 (Cox et al. 2005), and September 2004 (Paulson et al. 2006)
Table 5-10.	Metal/Metalloid Concentrations Measured in Porewater by Paulson et al. (2006)
Table 5-11.	Porewater Concentrations of Metals Measured by EPA in UCR Sediments in April 2005
Table 5-12.	Elements Measured in Porewater by EPA in 2005 in Relation to Detection Limits (DL) and Frequency of Detection
Table 5-13.	Analytical Results for Simultaneously Extracted Metals (SEM), Acid Volatile Sulfides (AVS), and Total Organic Carbon (TOC) Measured in UCR Sediments by EPA in 2005
Table 5-14.	Results of Sediment Toxicity Bioassays of UCR Bulk Sediments
Table 5-15.	Sediment Toxicity Test Results Reported by Bortleson et al. (2001)
Table 5-16.	Toxicity of UCR Sediments to <i>Chironomus dilutus</i> (formerly <i>tentans</i>), <i>Hyalella azteca</i> , and <i>Vibrio fischeri</i>
Table 5-17.	Results of Sediment Toxicity Tests Conducted in the UCR by EPA in 2005
Table 5-18.	Summary of Fish Tissue Residue Studies Conducted in the UCR
Table 5-19.	Summary of Historical Measurements of Inorganic and Organic Compounds in UCR Fish Tissues
Table 5-20.	Description of 2005 EPA Study Design, Including Fish Collection Locations and Number of Composite Samples, Tissue Types, and Individuals Sampled

Table 5-21.	Summary of Detected, Nondetected, and Qualified Values in the Inorganic Analyses Reported in the 2005 EPA Fish Tissue Analysis
Table 5-22.	Summary Statistics for 2,3,7,8-TCDF, Aroclor 1254/1260, and Total PCB Congeners in Fish Tissues Collected by EPA in 2005
Table 5-23.	Frequency of Detection of Analytes in Fish Tissues (all species) Collected by EPA in 2005
Table 5-24.	Northport Air Monitoring Concentrations (Arithmetic Mean, $\mu\text{g}/\text{m}^3$) from 1994 to 2006
Table 5-25.	Mean Concentrations ($\mu\text{g}/\text{m}^3$) for Air Monitoring Results at Three Sampling Locations along UCR in 2002
Table 5-26.	Mean Concentrations ($\mu\text{g}/\text{m}^3$) for Air Monitoring Results at Three Sampling Locations along UCR in 2003
Table 5-27.	Mean Concentrations ($\mu\text{g}/\text{m}^3$) for Air Monitoring Results at Three Sampling Locations along UCR in 2004
Table 6-1.	Initial Chemicals of Interest
Table 7-1.	Studies Planned for 2008-2010
Table 8-1.	Overview of Studies Specified in the SOW, Rationale, Dependencies Assigned, Proposed Field Year if Appropriate, and RI/FS Element
Table 12-1.	Contact Information for Key Personnel Working on the UCR Site RI/FS
Table 12-2.	Project Mailing List for the UCR Site RI/FS
Table 12-3.	Project Schedule

LIST OF MAPS

- Map 1-1. Site Location and River Reach Delineations
- Map 3-1. High Use Beach and Developed Recreational Areas
- Map 3-2. Public Surface Water Systems and Domestic Supply Surface Water Rights
- Map 3-3. Surficial Geology
- Map 3-4. Water Supply Wells and Springs within Five Miles of the Study Area Shoreline
- Map 3-5. Ten-Year Wellhead Protection Areas (WHPAs) Within Five Miles of the Study Area Shoreline
- Map 3-6. Meteorological Stations within the Study Area
- Map 3-7. Priority, Wetland, and Endangered Habitats within the UCR Study Area
- Map 4-1. Mine, Mill, and Smelting Facilities in the Vicinity of the Study Area
- Map 4-2. TRI Reporting Facilities (1996 to 2005) in the Vicinity of the Study Area
- Map 4-3. WPLCS Sites in the Vicinity of the Study Area
- Map 5-1. Approximate Historic Sampling Sites of Nutrients, Periphyton, Phytoplankton, and Zooplankton
- Map 5-2. Study Area Surface Water Sampling Locations
- Map 5-3. Locations Sampled by Johnson (1991c), Bortleson et al. (2001), and Era and Serdar (2001)
- Map 5-4. UCR Locations Sampled by EPA for Porewater SEM/AVS and for Toxicity to Benthic Invertebrates in April 2005
- Map 5-5. EPA 2005 Fish Tissue Sampling Locations

ACRONYMS AND ABBREVIATIONS

A

ASCTF	Area-wide Soil Contamination Task Force
AINW	Archeological Investigations Northwest
amsl	above mean sea level
ARAR	applicable or relevant and appropriate requirement
ASIL	acceptable source impact level
AVS	acid-volatile sulfide

B

B.C. MoE	British Columbia Ministry of Environment
BERA	baseline ecological risk assessment
BiOp	biological opinion
BLM	biotic ligand model
BPA	Bonneville Power Administration

C

°C	degrees Celsius
CCRH	Center for Columbia River History
CCT	Confederated Tribes of the Colville Reservation
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CFR	Code of Federal Regulations
cfs	cubic feet per second
CGM	coarse-grained material
cm	centimeter(s)
COI	chemical of interest
COC	chemical of concern
COPC	chemical of potential concern
CRIEMP	Columbia River Integrated Environmental Monitoring Program
CRITFC	Columbia River Inter-Tribal Fish Commission
CSM	conceptual site model

D

DDD	dichloro-diphenyl-dichloroethane (DDT metabolite)
DDE	dichloro-diphenyl-dichloroethylene (DDT metabolite)
DDT	1,1,1-trichloro-2,2-bis(<i>p</i> -chlorophenyl)ethane
DIN	dissolved inorganic nitrogen
DIP	dissolved inorganic phosphorus
DOC	dissolved organic carbon
DOI	U.S. Department of the Interior
DQO	data quality objective

dsm ³	dry standard cubic meter(s)
dw	dry weight
E	
EC50	median effective concentration
Ecology	State of Washington Department of Ecology
EOH	Eastern Okanogan Highlands
EPA	U.S. Environmental Protection Agency
ERA	ecological risk assessment
F	
°F	degrees Fahrenheit
FSCA	fish sample collection area
FSP	field sampling plan
ft	foot/feet
ft/s	feet per second
G	
g	gram(s)
GIS	geographic information system
GRA	general response action
H	
HASP	health and safety plan
HCl	hydrochloric acid
HHRA	human health risk assessment
HI	hazard index
HQ	hazard quotient
I	
IJC	International Joint Commission
in.	inch(es)
K	
K _d	partition (or distribution) coefficient
kg	kilogram(s)
kg/d	kilogram(s) per day
K _{oc}	organic carbon-normalized partition coefficient
K _{ow}	octanol-water partition coefficient
L	
L	liter(s)
LOAEL	lowest-observed-adverse-effect level

LRF	Lake Roosevelt Forum
LRNRA	Lake Roosevelt National Recreation Area
M	
µg	microgram(s)
µg/kg	micrograms per kilogram
µg/L	micrograms per liter
µg/m ³	microgram(s) per cubic meter
µm	micrometer(s)
m	meter(s)
M	Molar
Ma	million years ago
mg	milligram(s)
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
mi ²	square mile(s)
mi ³	cubic mile(s)
mL	milliliter(s)
mm	millimeter(s)
N	
NCBP	National Contaminant Biomonitoring Program
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
ng/g	nanograms per gram
NIOC	nonionic organic chemical
NGVD	National Geodetic Vertical Datum
NHPA	National Historic Preservation Act
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NOAEL	no-observed-adverse-effect level
NPL	National Priorities List
NPDES	National Pollutant Discharge Elimination System
NPRI	National Pollutant Release Inventory
NPS	National Park Service
NWPPC	Northwest Power Planning Council
O	
OFM	Office of Financial Management (Washington State)
ORNL	Oak Ridge National Laboratory
P	
PAH	polycyclic aromatic hydrocarbon
PBDE	polybrominated diphenyl ether

PbS	galena
PCB	polychlorinated biphenyl
PCDD	polychlorinated dibenzo- <i>p</i> -dioxin
PCDF	polychlorinated dibenzofuran
pg	picograms
pg/g	picograms per gram
PM10	particulate matter smaller than 10 µm in diameter
ppm	parts per million
POM	particulate organic matter
PRG	preliminary remediation goal

Q

QAPP	quality assurance project plan
------	--------------------------------

R

RI/FS	remedial investigation and feasibility study
RM	river mile
RMAO	risk management-based action objective
ROD	record of decision

S

SAIC	Science Applications International Corp.
SAP	sampling and analysis plan
SEM	simultaneously extractable metals
Site	Upper Columbia River site
SLERA	screening-level ecological risk assessment
SO ₂	sulfur dioxide
SOP	standard operating procedure
SOW	statement of work
SQG	sediment quality guideline
STI	Spokane Tribe of Indians
SVOC	semivolatile organic compound

T

TAL	target analyte list
TAP	technical assistance plan
TBC	to be considered (criteria)
TCAI	Teck Cominco American Incorporated
TCDD	2,3,7,8-tetrachlorodibenzo- <i>p</i> -dioxin
TCDF	2,3,7,8-tetrachlorodibenzofuran
TCL	Teck Cominco Limited
TCM	Teck Cominco Metals Limited
TEQ	toxicity equivalent

TOC	total organic carbon
TRI	Toxic Release Inventory
TSP	total suspended particulates
TSS	total suspended solid
U	
UCR	Upper Columbia River
UCRWSRI	Upper Columbia River White Sturgeon Recovery Initiative
USBR	U.S. Bureau of Reclamation
USCGS	U.S. Coast and Geodetic Survey
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
V	
VOC	volatile organic compound
W	
WDFW	Washington State Department of Fish and Wildlife
WDOH	Washington State Department of Health
WOH	Western Okanogan Highlands
WPLCS	Water Quality Permit Life Cycle System
WRIA	water resource inventory area
ww	wet weight
Z	
ZnS	sphaelerite

1 INTRODUCTION

This document presents the work plan for implementation of a remedial investigation and feasibility study (RI/FS) at the Upper Columbia River (UCR) site (Site) in the state of Washington. The RI/FS for the Site is being conducted according to the provisions of a June 2, 2006, settlement agreement (the Agreement) (U.S. Environmental Protection Agency 2006h) entered into by the United States, on behalf of the U.S. Environmental Protection Agency (EPA), and by Teck Cominco American Incorporated (TCAI) and a separately incorporated affiliate, Teck Cominco Limited (TCL),¹ collectively, the “Parties” to the Agreement (EPA 2006h).

The RI/FS was triggered by concerns regarding historical discharges into the Columbia River, including granulated slag, liquid effluent, and other discharges by Teck Cominco Metals Limited (TCM) near Trail, British Columbia. Although the discharges occurred north of the U.S.-Canadian border, the Site addressed by the RI/FS is located wholly within Washington State and includes the portion of the UCR that extends from the Canadian border to Grand Coulee Dam, including Lake Roosevelt (EPA 2006h). The Site includes the areal extent of contamination and all suitable areas in proximity to such contamination necessary for implementation of response actions. Investigations north of the U.S.-Canadian border are being conducted separately, under the oversight of the Canadian government.² When those investigations are complete, EPA may evaluate the information generated from that work and, if appropriate, incorporate that information into the RI/FS.

This RI/FS work plan describes the activities that will be undertaken by or on behalf³ of TCAI to develop and implement the RI/FS for the Site. This work plan builds upon prior investigations of sediment and fish tissue residue conducted by EPA and others in the past, including the Phase I RI/FS sediment and fish tissue sampling program conducted by the EPA in 2005 (EPA 2006d; 2006e). The scope and results for the previous investigations are summarized in Section 5 of this work plan.

This work plan complies with the Agreement and associated statement of work⁴ (SOW), as well as EPA’s Guidance for Conducting Remedial Investigations and Feasibility Studies under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)

¹ TCL is a Party to the Agreement solely for the limited purposes described therein (EPA 2006h).

² The Trail Smelter is classified as a high profile site by the BC Ministry of Environment (MoE) Land Remediation section because historical and current discharges associated with the smelter have resulted in contamination in the lower Columbia River Valley (B.C. MoE 2007).

³ This work plan includes tasks that may be conducted through contractors, subcontractors, laboratories, and consultants retained by TCAI, or through funding of activities performed by others as specified in the Agreement.

⁴ Exhibit A to the Agreement, i.e., identify goals of the study (EPA 2006h).

(EPA 1988). As described in the SOW, the purpose of this RI/FS is to investigate the nature and extent of contamination at the Site and assess risks to human health and the environment to an extent sufficient to develop and evaluate potential remedial alternatives for the Site that will meet applicable or relevant and appropriate requirements (ARARs) and statutory and regulatory requirements. Consistent with this purpose, this work plan presents the RI/FS approach anticipated for the Site.

This work plan does not include all planning and scoping elements related to completion of the baseline human health risk assessment (HHRA), which will be conducted by EPA and documented separately in draft and final HHRA work plans and memoranda prepared by EPA (EPA 2006h). However, the work plan does include descriptions of certain HHRA-related studies where TCAI is responsible for collection of data (e.g., beach sediment study).

1.1 UPPER COLUMBIA RIVER SITE OVERVIEW

The Site is located wholly within Washington State and includes approximately 150 river miles of the Columbia River, extending from the U.S.-Canadian border to the Grand Coulee Dam. Map 1-1 shows the location of the Site. Brought into service in 1942, the Grand Coulee Dam is a multipurpose structure, providing flood control, irrigation, hydropower production, recreation, and fish and wildlife benefits (EPA 2003b). Located immediately behind the dam is Lake Roosevelt, a large reservoir extending approximately 133 river miles north of the dam at full pool⁵ and bordered by over 600 miles of shoreline, approximately 312 miles of which are part of the Lake Roosevelt National Recreation Area (LRNRA) (National Park Service [NPS] 2006c; EPA 2003b; EPA 2007c). The Columbia and Pend Oreille rivers represent the primary source of water to Lake Roosevelt. The Spokane River and, to a lesser extent, the Colville, Kettle, and Sanpoil rivers also contribute (Lake Roosevelt Forum [LRF] 2006a). Operation of the dam may result in seasonal reservoir level fluctuations in excess of 80 feet, ranging from full pool conditions at 1,290 feet above mean sea level (amsl) to low pool conditions as low as 1,208 feet amsl for flood control during years of high precipitation; however, fluctuations during more typical years are generally about 45 feet (EPA 2003b; 2007c). Exposure of bed and bank sediments along the length of the reservoir occurs during spring drawdown periods (EPA 2003b).

A large portion of the reservoir has been designated as the LRNRA and is managed by the U.S. Department of the Interior's (DOI's) National Park Service. Portions of the reservoir that are not included in the LRNRA are managed by the Confederated Tribes of the Colville Reservation (CCT) and the Spokane Tribe of Indians (STI).

The NPS, the CCT, and the STI cooperate as managing partners in designating acceptable recreational uses for Lake Roosevelt. The purpose of the LRNRA is to provide opportunities

⁵ Contributors to EPA Round 2 comments have stated that at full pool (elevation 1,290 feet) the reservoir has backwater effects up to and perhaps north of the border. A description of effects of backwater on the river can be found in the 1941 International Joint Commission (IJC) Order of Approval.

for outdoor recreational experiences for the public; to preserve, conserve, and protect the integrity of natural, cultural, and scenic resources; and to enhance public appreciation and understanding of those resources (Lake Roosevelt General Management Plan, NPS 2006c). Designated recreational uses of the LRNRA include boating, fishing, swimming, wading, camping, canoeing, and hunting.

The UCR provides a subsistence fishery for Native American populations (EPA 2007c). For the CCT and the STI, anadromous and resident fish (primarily salmon, but also steelhead trout, whitefish, bull trout, and others) historically were the principal subsistence fishery (EPA 2003b). Since the construction of the Columbia River Dams, some resident fish have become a significant and necessary alternative as a subsistence resource (EPA 2003b). The draft Fish and Wildlife Resource Management Plan for the Colville Indian Reservation include several provisions for creating/maintaining both ceremonial and subsistence fisheries of resident and anadromous fish in Lake Roosevelt (CCT 2006).

1.2 PURPOSE AND OBJECTIVES

As described in the SOW, the purpose of this RI/FS is to investigate the nature and extent of contamination at the Site, to provide information to support EPA's baseline risk assessment for human health and the environment, and to develop and evaluate potential remedial alternatives for the Site.

Upon completion of the RI/FS, EPA will select the Site remedy, will publish a Proposed Plan for public comment, and will document its final selection of a remedy in a record of decision (ROD).

1.3 SCOPE OF THE RI/FS

The SOW for this RI/FS requires completion of nine tasks:

- Task 1—Scoping
- Task 2—Community Relations
- Task 3—Site Characterization
- Task 4—Risk Assessment
- Task 5—Treatability Studies
- Task 6—Development and Screening of Remedial Alternatives
- Task 7—Detailed Analysis of Remedial Alternatives
- Task 8—Project Schedule
- Task 9—Early Actions

The sequencing and interrelationships of the tasks are illustrated in Figure 1-1. Section 2 of this work plan presents a more detailed overview of the underlying rationale and objectives for each of the tasks.

Completion of the RI/FS will be an interactive process, wherein new information will refine the understanding of Site conditions and add to the knowledge base necessary for scoping future activities. As more information becomes available and as the understanding of the Site is refined, the EPA may require additional tasks that are necessary to complete the RI/FS.

1.4 CULTURAL AND NATURAL RESOURCES

Consultation under Section 106 of the National Historic Preservation Act (NHPA), the Archaeological Resource Protection Act, and Section 7 of the Endangered Species Act is required for onsite actions associated with CERCLA activities. Section 106 of NHPA (36 Code of Federal Regulations [CFR] Part 800) requires that undertakings directed by EPA take into account the effects of such undertakings on historic properties, including archaeological sites, historic sites, and traditional cultural properties. EPA will consult and coordinate with all Section 106 consulting parties including the CCT, the STI, the State of Washington, and the DOI on all RI/FS-related field sample collection activities. TCAI will submit a cultural resources coordination plan with each quality assurance project plan (QAPP)/field sampling plan. EPA will provide copies of the cultural resources coordination plan and associated QAPP/field sampling plan to all consulting parties for the Site for review and comment.

1.5 COORDINATION OF PARTICIPATING PARTIES

As described in the Agreement (EPA 2006h), EPA “will coordinate closely with the state of Washington, the Confederated Tribes of the Colville Reservation (CCT), the Spokane Tribe and the DOI in the development of the details of work plans, sampling and analysis plans and other project documentation. EPA will work closely with the state of Washington, the CCT, the Spokane Tribe and DOI in the review of deliverables.” TCAI will support EPA’s coordination activities.

1.6 WORK PLAN ORGANIZATION

This work plan is organized to provide a sound foundation for the RI/FS activities that will follow. Elements of problem formulation are found throughout the document. The description of the Site (Section 3), discussion of known and potential sources (Section 4), and synthesis of data from previous investigations into a description of environmental conditions (Section 5) provide the information used to develop the conceptual site models (CSMs) for the UCR (Section 6). Section 7 identifies gaps in the existing data that must be filled to complete the CSMs and understand potential risks, and Sections 8 through 12 provide the framework for data collection, evaluation, and reporting.

In addition to this introduction, the work plan is organized as follows:

- Section 2: Overview of Upper Columbia River RI/FS Process. This section presents an overview of the RI/FS approach and the tasks that will be performed to complete the UCR RI/FS.
- Section 3: Site Description. This section provides a general characterization of the study area, including population; land use; ecological, cultural, and natural resources; and physical setting.
- Section 4: Chemical Sources. This section describes the known and potential sources of chemicals in the UCR.
- Section 5: Environmental Conditions. This section describes selected media and biota which help to characterize general environmental conditions at the UCR and provides a review of the previous investigations conducted in the UCR with respect to surface water and sediment quality, fish tissue residue, and air quality.
- Section 6: Conceptual Site Models. This section describes the COIs and presents the physical/chemical, ecological, and human health CSMs for the UCR.
- Section 7: Data Gaps and Study Sequencing. This section summarizes the gaps in existing data that must be filled in order to complete the RI/FS and provides an overview of study sequencing and major decision points.
- Section 8: Overview of Upper Columbia River Studies for 2009 – 2012. This section describes the initial studies and analyses identified in Section 7.
- Section 9: Ecological Risk Assessment Approach. This section describes the ecological risk assessment (ERA) process and general approach that will be used to conduct the ERA for the Site. It includes discussions on the major ERA steps and anticipated data needs for the aquatic life and plant/wildlife ERAs.
- Section 10: Feasibility Study Approach. This section presents the data quality objectives (DQOs) developed for each significant feasibility study work element, including a description of the data needed for those work elements, a description of the feasibility study task work elements, and information on how those data will be used in the feasibility study.
- Section 11: Deliverables. This section summarizes each deliverable to be completed as part of this work plan.
- Section 12: Project Management Plan. This section reviews information on how the project will be managed, including roles and responsibilities, contact information, communications, and schedules.
- Section 13: References. This section contains references for the documents cited in this work plan.
- Section 14: Glossary of Terms. This section defines the terms used in this work plan.

In addition to these sections, the following appendices are also provided with this work plan:

- Appendix A. Technical Memorandum No. 1, Preliminary Ecological Risk Management-Based Action Objectives (RMAOs)
- Appendix B. Data Management Plan
- Appendix C. Preliminary Hydrodynamic and Sediment Transport Analyses for the Upper Columbia River
- Appendix D. Trail Facility Operations
- Appendix E. GIS Maps of Various Information from the Upper Columbia River Study Area
- Appendix F. Summary of Analytical Data for EPA 2005 Fish Composite Samples
- Appendix G. Summary of Air Monitoring Data for Northport, Washington, Provided by Teck Cominco Metals, Ltd. on August 21, 2006, and December 14, 2006
- Appendix H. Ecological Community Information
- Appendix I. Upper Columbia River Chemical Stressors

2 OVERVIEW OF UPPER COLUMBIA RIVER RI/FS PROCESS

The purpose of this RI/FS is to investigate the nature and extent of contamination at the Site, provide information to support the baseline risk assessments for human health (to be completed by EPA) and the environment, and develop and evaluate potential remedial alternatives for the Site. Upon completion of the RI/FS, EPA will select the Site remedy and will document this selection in a ROD. This section provides an overview of the RI/FS approach and describes the different tasks that will be performed to complete the UCR RI/FS and support EPA's remedy selection.

2.1 GENERAL APPROACH

Implementation of the UCR RI/FS will involve gathering data on the nature and extent of contamination, sources of contamination, and potential risks to ecological receptors and humans, as well as data to support the feasibility study. The RI/FS will be conducted according to EPA guidance (including EPA 1988, 1997a, 1997b, and 2002c). Unless specifically noted, the task descriptions provided in Section 2.2 are meant to detail the process described in these documents. The RI/FS for the Site will utilize a risk-based framework to determine risks to human health and the environment from Site-related chemicals and will evaluate remedial options. The steps involved in an RI/FS, per EPA guidance, are illustrated in Figure 1-1 and a conceptual depiction of the RI/FS process tailored to the Site is shown in Figure 2-1.

EPA's ecological risk assessment guidance (EPA 1998c) will guide the ERA component of the RI/FS. While the ERA guidance is discussed in detail in Section 9 of this work plan, of particular importance to the efficiency of the RI/FS is the refinement process that occurs in Step 3.2 of the guidance. The refinement process involves comparing data to conservative numerical guidelines, such as ecological benchmarks or toxicity reference values, and is used to determine whether chemicals of interest (COIs) in a given medium (e.g., surface water) warrant further investigation or evaluation as chemicals of potential concern (COPCs).⁶ Individual data reports prepared by TCAI and identified on the project schedule as milestone deliverables will present the recently obtained data as well as an interpretation of the data via this refinement process.

⁶ As indicated in Section 6, the list of potential COIs and exposure pathways for the UCR Site is lengthy. EPA risk assessment guidance recognizes that carrying a large number of COIs through the risk assessment may be complex and recommends use of a selection process to winnow the list of COIs down to a reasonable and relevant amount. This list of COPCs, which will be carried into the baseline risk assessments, consists of those COIs that are not screened out based on comparison of site data to general qualitative criteria.

The baseline HHRA will be conducted by EPA and documented separately in draft and final HHRA work plans and memoranda prepared by EPA (EPA 2006h). TCAI will coordinate with EPA on the preparation of the HHRA and may provide comment on HHRA-related documents made available by EPA. As outlined in the Agreement, preparation of the HHRA will involve close coordination with Participating Parties. TCAI will, where specified, collect the necessary data to support the HHRA in accordance with the HHRA Work Plan.

As part of the RI, or prior to development of remedial goals and strategies in the feasibility study, an evaluation of potential loading of COPCs will be required by the EPA. COPCs are or may be entering the Site from release points north of the U.S. border (e.g., permitted discharges from the Trail smelter facility and/or spills), from sources along the UCR and its tributaries, and from atmospheric deposition. An understanding of the background conditions at the Site is also needed to help interpret the nature and extent of the contaminants at the Site. Consideration of background conditions for all media of interest will follow EPA guidance (EPA 2002e) as well as other relevant EPA Superfund guidance and regulatory and statutory requirements.

After completing the evaluation of the nature and extent of contamination in the remedial investigation and assessing risks in the baseline ERA (BERA) and EPA's HHRA, site-specific preliminary remediation goals (PRGs) will be developed for those chemicals identified as posing unacceptable risks. The methods, assumptions, and the PRG development process as well as deliverables will be described in the BERA Work Plan.

To examine spatial distributions of risk, it is anticipated that map layers will be created for each ecological endpoint, depicting areas that exceed the PRGs. The ecological risk-based PRGs and map overlays will be combined with the human health-based PRGs (to be developed by EPA) to examine differences and similarities in spatial distributions. Where overlap exists, the lowest PRG will be identified as the target concentration for consideration in the feasibility study.

Potential remedial alternatives will be developed and screened in the feasibility study. Final alternatives will then be evaluated in detail with respect to the nine CERCLA evaluation criteria (EPA 1988) and the preferred remedy recommended to EPA. Per the Agreement (EPA 2006h), site conditions also may dictate the need for interim actions or early actions prior to or following completion of the RI. The decisionmaking process used to determine whether an interim action/early action is warranted, and the necessary steps to develop and implement these actions, will follow CERCLA guidance.

Key components to successful implementation of the RI/FS approach include the following:

- **DQO Process.** A cornerstone of the RI/FS process will be adherence to EPA's DQO process (2000a) to focus data collection efforts on questions related to the nature and extent of contamination, the evaluation of risk, and the development of remedial

alternatives. The DQO process will be used to identify data gaps and focus the numerous field and laboratory investigations that will be conducted. These studies are identified in Section 8. The sampling and analysis plan developed for each investigation will detail the investigation's DQOs and also describe how existing data were used to evaluate Site conditions and to identify data gaps.

- **Communication.** A critically important component of TCAI's approach for the RI/FS involves working closely with EPA throughout the RI/FS. As discussed in more detail in Section 12, frequent technical meetings will be held in person, via conference call, or via online meetings. TCAI will solicit input from EPA on technical issues and study designs prior to submitting formal sampling and analysis plans (SAPs) and technical memoranda addressing sampling programs, data evaluation, or modeling approaches. The intent is to assist TCAI in producing quality draft deliverables and to ensure meaningful dialogue between TCAI, EPA, and the Participating Parties on those deliverables.
- **Coordination with HHRA.** Successful implementation of the RI/FS will be enhanced by the coordination between TCAI and EPA with respect to the HHRA that will be prepared by EPA and the remainder of the work that will be completed by TCAI. Meeting the objectives of the RI/FS will require close coordination between TCAI, EPA and Participating Parties to ensure that the appropriate data are collected to support all project objectives.
- **Flexibility.** As information becomes available and as our understanding of the Site is refined, EPA may require TCAI to perform additional tasks that are necessary to complete the RI/FS. These additional tasks will be completed in accordance with and will follow the same review and coordination process as established in the Settlement Agreement (2006h).

2.2 TASK DESCRIPTIONS

The RI/FS approach presented in this work plan is based on EPA guidance for conducting an RI/FS (EPA 1988). As defined in the guidance, a number of different tasks are conducted during the RI/FS in a well established sequence. EPA's RI/FS approach has been tailored to the UCR as shown in Figure 2-1. This section provides an overview of the work that will be accomplished within the tasks shown. More specific information on work to be performed in individual technical areas is provided in Sections 8, 9, and 10 of this work plan. The information provided in the remainder of this work plan will be further refined as the RI/FS moves forward, as work plans for the HHRA (prepared by EPA) and BERA (prepared by TCAI) are developed, as strategies evolve to address key issues, and as additional work products are prepared for EPA review and approval.

The Agreement (EPA 2006h) defines nine tasks that must be completed. The nine tasks are summarized briefly in the subsections below.

2.2.1 Scoping (Task 1)

The purpose of project scoping is to compile and evaluate existing information and develop plans for carrying out the RI/FS. This work plan is a key component of project scoping. There are three aspects to scoping as discussed below.

2.2.1.1 Site Background Information

A key first step in the RI/FS is to gather and analyze existing site information and prepare a problem formulation which identifies goals and preliminary assessment endpoints. This work plan presents an overview of existing Site information, preliminary identification of ARARs, and general descriptions of the conceptual site models for fate and transport and ecological exposure.

A preliminary problem formulation for the ERA was reviewed with EPA during an April 2007 workshop. It has been further developed since then and was presented in the draft screening level ecological risk assessment (SLERA) submitted to EPA in December 2008 (TCAI 2008). The preliminary problem formulation will be refined, based in part on detailed evaluation of existing data sets, in the BERA Work Plan, which is due to EPA 120 days after the RI/FS work plan is approved. Note that for planned studies that are not dependent on completion of the BERA Work Plan, detailed evaluations of existing data and identification of data gaps will be included in the SAP for the study.

2.2.1.2 Project Planning

The Agreement calls for the completion of a number of steps under the scoping tasks as part of project planning, including development of preliminary ecological risk management-based action objectives, identification of potential ARARs, and preparation of a tiered screening level risk assessment, as described below. The Agreement also lists documenting the need for treatability studies under project planning. This effort is part of the feasibility study process, and is described in Section 2.2.4.

Preliminary Risk Management-Based Action Objectives

The SOW requires identification of a set of preliminary risk management-based action objectives (RMAOs)⁷ to guide the RI/FS. The RMAOs establish remedial action objectives specific to contaminants and media of concern, potential exposure pathways, and remedial goals. In their preliminary form, the RMAOs broadly encompass the primary exposure pathways and receptors of concern at the Site (see the CSMs in Section 6). The preliminary RMAOs will be refined throughout the assessment process, as problem formulation and the

⁷ As stated in the June 2, 2006, Settlement Agreement (EPA 2006k) between TCAI and EPA, risk-management-based action objectives (RMAOs) developed for this site "shall have the same meaning as remedial action objectives in the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) and their development shall be consistent with the NCP."

conceptual exposure model for the ERA are further developed (e.g., chemicals, receptors, and exposure media may be screened out), as ARARs are identified, and as information about the Site is assembled and synthesized.

As specified in the SOW, TCAI prepared "Technical Memorandum No. 1, Preliminary Ecological Risk Management-Based Action Objectives (RMAOs)." The draft Technical Memorandum No. 1 was submitted to EPA on October 27, 2006, was revised based on EPA comments, and was then submitted in final form on March 11, 2007. A copy of the final memorandum is provided in Appendix A. The preliminary ecological RMAOs included in Technical Memorandum No. 1, by medium, are listed in Table 2-1. These ecological RMAOs will provide a guiding framework for the remedial investigation to ensure the protection of the environment. The human health RMAOs for the Site are being developed by the EPA under a separate human health risk assessment program.

Preliminary ARARs

Potential ARARs for the Site have been preliminarily identified based on current information regarding Site conditions and contaminants. Table 2-2 summarizes these preliminary ARARs. The current understanding of the tribal environmental standards potentially applicable or relevant and appropriate to this Site supports their inclusion as ARARs under the statutory standards and EPA guidelines. As the RI/FS process proceeds and additional information becomes available, the potential ARARs identified in Table 2-2 will be reviewed and additions and deletions will be made, as appropriate. Specifically, as RMAOs are refined and remedial action alternatives are developed, ARARs and TBCs will be reevaluated based on a listing of constituents of concern, affected media, and the specific location of any proposed remedial actions. Additional ARARs may be identified after a thorough review of additional information generated as part of the RI/FS process. Federal, state, tribal, and local laws (if appropriate) that govern the constituents of concern, affected media, and location of proposed remedial actions will be reviewed. As necessary, agencies responsible for implementing environmental laws that are ARARs will be contacted to obtain practical information on meeting the substantive requirements of the ARARs.

As detailed remedial alternatives are developed, each alternative will be evaluated as to whether it is in compliance with the substantive requirements of each ARAR. If a waiver from an ARAR is appropriate, a rationale will be provided for the proposed waiver. As part of the remedy selection, a final determination of ARARs will be made by EPA and after consideration of public comments.

EPA has also developed another category of requirements termed "to be considered" (TBC), which includes non-promulgated criteria, guidelines, and proposed standards issued by federal, state, or tribal governments. TBCs are not promulgated or enforceable. Identification of and compliance with TBCs are not mandatory in the same manner as for ARARs. As required in the SOW, preliminary identification of potential TBCs has been initiated. Results of this preliminary identification are summarized in Table 2-3.

Screening-Level Ecological Risk Assessment

The Agreement, pursuant to EPA guidance, calls for preparation of a SLERA during project planning. The draft SLERA, including preliminary problem formulation, was submitted to EPA in December 2008 (TCAI 2008). Problem formulation will undergo further refinement, per Step 3.2 of EPA's ERA guidance (EPA 1997a; 1997b), in the BERA Work Plan and following each data collection effort. As a result of the refinement process, additional studies or data evaluations may be necessary to improve understanding of site-specific conditions.

2.2.1.3 Scoping Deliverables

A number of scoping deliverables are required under the terms of the Agreement. In addition to this work plan, the Agreement calls for preparation of a cultural resources coordination plan, SAP, and a site health and safety plan (HASP) for each field investigation. The content of these plans is described in Section 11. SAPs will be prepared for each field investigation associated with the RI/FS and will be submitted in 2008 and subsequent years. Prior to delivery of each SAP, TCAI will discuss the study design and rationale with EPA. EPA will coordinate with the Participating Parties and solicit input that may be used to modify or refine the scope of each major data collection effort.

Scoping will continue throughout the duration of the RI/FS as individual components of the project (e.g., SLERA, BERA Work Plan [Task 4], EPA's HHRA work plan) are prepared, with the level of detail increasing as individual tasks are further refined and planned.

2.2.1.4 Permits and Consultations

DOI will require permits as identified in the July 2008 Access Agreement between TCAI and DOI. Briefly, a Special Use Permit will be required and permits associated with cultural resources may be required for each RI/FS sampling activity.

2.2.2 Community Relations (Task 2)

Community relations are an important and highly valuable part of the RI/FS process. Providing information to the community helps keep community members informed of the activities being conducted at the Site and helps EPA respond to community concerns.

EPA is the lead for community relations regarding the UCR Site and has the responsibility for preparing a community relations plan. Under the Agreement, EPA will conduct community interviews, develop a community relations plan, and communicate with local, state, and tribal governmental representatives. EPA will also be responsible for conducting public meetings and workshops. TCAI will assist in EPA's community relations activities as EPA deems appropriate.

2.2.3 Remedial Investigation

The focus of the remedial investigation is to determine the nature and extent of COIs; identify sources of COIs, including the potential for ongoing chemical release and the potential mobility and persistence of chemicals; identify risks associated with COCs within the Site; and characterize transport and fate processes related to current and future conditions representing unacceptable risk. The remedial investigation will involve multiple data collection efforts to gather sufficient information necessary to make informed decisions.

2.2.3.1 Site Characterization (Task 3)

The objective of site characterization is to conduct field investigations to define the nature and extent of contamination and develop the baseline risk assessment as described in EPA guidance (EPA 1988). The UCR RI/FS will include a series of field investigations to collect site characterization data (e.g., physical and ecological settings, sources of contamination, nature and extent of contamination, and background conditions) in order to make informed decisions about the level of risk presented by the Site and the appropriate type(s) of remedial action that may be required. The field investigation effort will be iterative, wherein information acquired in previous efforts will be used to direct and focus subsequent DQO development and sampling efforts.

Transport and fate processes and contaminant source identification are included within the context of nature and extent. In addition, data will be collected for the feasibility study during the remedial investigation to maintain project efficiencies. Additional data collection to support the feasibility study may be needed following the remedial investigation. Site characterization involves evaluating existing data, identifying data gaps using EPA's DQO process, collecting new data via field investigations, and evaluating historical and new data to accurately define and determine site conditions (Figure 2-1). This approach allows the project to focus on the gathering of information necessary to support informed risk-based decisions within designated schedules (EPA 1988).

Studies described in this work plan, and future work plan addenda (as needed), will be undertaken as part of site characterization. The SAPs and the HASP will be implemented during site characterization, as will the coordination steps outlined in the cultural resource coordination plan (see Sections 1.4 and 11.1.5).

Field Investigations

A series of field investigations will be conducted to gather data needed to complete the RI/FS. To support the RI/FS, TCAI will:

- Work with EPA during the development of field studies to garner perspectives from EPA technical staff and Participating Parties prior to the submission of the formal SAP.

- Implement and document field support activities, including obtaining site access agreements and permits, setting up a field support office, and contracting for support services.
- Investigate and define Site chemical, physical, and biological characteristics to characterize the nature and extent of contamination, characterize background conditions, define potential transport pathways, support the human health and ecological risk assessments, support fate analyses, and support the development and screening of remedial alternatives.

Identify sources of contamination to the Site, including the potential for historical and future chemical releases, and the mobility, persistence, and toxicity associated with such releases. A number of required and potential studies are identified in the SOW. As the project progresses, additional studies may be required or it may be determined that some studies described in the SOW may not be required. If it is determined that a SOW-required study is not necessary, the rationale for eliminating it along with supporting data or other evidence will be documented in a memorandum submitted by TCAI for EPA approval.

The field and laboratory studies that are currently planned for 2009 and 2010 are detailed in Section 8. Section 8 also contains brief descriptions of additional studies that may be required to complete the RI/FS. TCAI will notify EPA of upcoming field events at least 6 weeks prior to the initiation of sampling, and will keep EPA informed of sampling progress in monthly progress reports (see Section 12).

Data Analyses

Data gathered during the RI/FS will be evaluated to describe the following:

- Nature and extent of contamination
- Contaminant source characteristics
- Site physical, geochemical (non-contaminant), and biological characteristics
- Contaminant transport and fate

The nature and extent of contamination evaluation will focus on analyses that are important to the risk assessments and subsequent development of remedial alternatives. These analyses are expected to include evaluations of the horizontal and vertical extent of COIs in environmental media and spatial and temporal trends in COI concentrations.

The transport and fate analyses will focus on areas with chemical concentrations that pose an unacceptable current or future risk to human health and the environment either in present locations or potential future ones. The transport and fate analysis will focus on exposure pathways between chemicals and receptors, and will be developed from physical data on the depositional (or erosional) conditions in areas of interest, and on bioavailability and bioaccessibility information. Empirical studies and numeric models will be considered in

developing the approach to assessing the transport and fate of chemicals. Prior to the development and use of such models, TCAI will prepare a technical memorandum describing the recommended models, sampling data needs, and input parameters for EPA review and approval.

Data Management Procedures

TCAI will follow rigorous data management procedures throughout the RI/FS according to the project data management plan that is presented in Appendix B. In the development of the database, TCAI has worked with EPA to ensure the compatibility and accessibility of Site data. The following four data management systems will be implemented: project database, geographic information system (GIS), hard copy files, and project web site.⁸

Site Characterization Deliverables

Several reports are specified in the Agreement, as described in more detail in Section 11 of this work plan, including a preliminary site characterization summary and the remedial investigation report. As new data are collected, the CSMs will be refined. This process of refinement and adaptive management will be documented in site characterization reports that summarize major data collection efforts, apply the results to the UCR CSMs, and identify additional information needs (if any). In addition to these required deliverables, TCAI will provide data validation reports following the completion of each sampling event. These site characterization deliverables are shown on the project schedule.

2.2.3.2 Risk Assessment Tasks (Task 4)

Risk assessments for the UCR will be divided between EPA and TCAI, with EPA preparing the HHRA and TCAI preparing the ERA. Because both risk assessment processes will require the collection of similar data to characterize exposures, it will be important for the risk assessments to follow parallel schedules. Timely coordination between EPA and TCAI on identifying and negotiating data needs, as well as coordinating certain data analyses, will help ensure the efficient completion of the RI/FS.

Human Health Risk Assessment

TCAI will participate in the HHRA process by funding or conducting studies on consumption of Site resources, recreational use, and resource use for both present and future use scenarios at the Site. TCAI will also coordinate with EPA on the preparation of the HHRA and may provide comment on HHRA-related documents made available by EPA.

As outlined in the Agreement, preparation of the HHRA will involve close coordination with tribal members. For studies, surveys, and field sampling pertaining to tribal customs and practices, the tribes and EPA will first coordinate with TCAI regarding possible approaches

⁸ <http://www.ucr-rifs.com>

and methods. After these discussions, the tribes, in consultation with EPA, will develop work plans, field sampling plans (FSPs), and QAPPs. EPA and the tribes will provide these plans to TCAI for comment, with information of a culturally sensitive nature redacted as appropriate. The tribes will implement studies involving tribal behavior, customs, and practices (e.g., fish consumption, tribal uses of native plants), and may implement other studies as approved by EPA. Survey results will be maintained by EPA and made available to TCAI.

Baseline Ecological Risk Assessment

The purpose of the BERA is to quantitatively describe potential ecological risks posed by the Site under current and future conditions. Both aquatic and terrestrial components of the ERA will be completed by TCAI according to EPA guidance (EPA 1988; 1997a; 1999a; 2004e). Additional information on the general approach for conducting the BERA is provided in Section 9.

The draft SLERA was submitted to EPA in December 2008 (TCAI 2008). The final SLERA will contain a comparison of available information on COIs in surface water, porewater, and sediment relative to conservative ecological benchmarks. The SLERA will be followed by the BERA Work Plan, which is due to EPA within 120 days of EPA's approval of this RI/FS work plan. The BERA Work Plan will contain a thorough evaluation, including statistical analyses, of surface water, porewater, sediment chemistry, sediment toxicity, habitat presence, benthic communities, fish tissue, zooplankton communities, and soil data (including both upland and floodplain depositional areas). The BERA Work Plan will build on and refine the preliminary problem formulation for the Site provided in the SLERA and will also provide more detail on ERA methods. Additional information concerning the BERA Work Plan content is provided in Sections 9 and 11.

2.2.4 Feasibility Study Tasks

The objective of the feasibility study is to identify a range of remedial alternatives that meet CERCLA requirements, analyze the remedial alternatives, and present the information necessary for decision-makers to select a Site remedy. The feasibility study will be initiated during the remedial investigation and completed following completion of the remedial investigation report. Following EPA guidance (EPA 1988), the feasibility study will involve three primary phases: development of alternatives, screening of alternatives, and detailed analysis of alternatives. Remedial alternatives may comprise several general response actions (GRAs) and associated technologies (e.g., containment/capping, excavation/dredging, disposal/landfilling), and will be developed to address the contaminated media (e.g., sediment) within specific areas of the Site (e.g., river reaches, bank areas, beaches).

Based on the results of the feasibility study, EPA will select a preferred remedial action alternative. A brief overview of the major feasibility study steps is provided below. Additional details are provided in Section 10.

2.2.4.1 Treatability Studies (Task 5)

Pursuant to the Agreement, TCAI will prepare a technical memorandum on the determination of candidate remedial technologies and need for testing in which the literature will be reviewed, candidate remedial technologies will be presented, and the need for treatability testing ascertained. Where it is determined by EPA that treatability testing is required, and unless TCAI can demonstrate to EPA's satisfaction that it is not needed, TCAI shall submit a treatability testing work plan to EPA outlining the steps and data necessary to evaluate and initiate the treatability testing program. Preparation of a treatability testing work plan, and/or project work plan addendum, will follow EPA guidance for treatability testing and will provide details of the tasks and deliverables associated with treatability testing.

2.2.4.2 Development and Screening of Remedial Alternatives (Task 6)

The purpose of the development and screening of remedial alternatives is to develop an appropriate range of waste management options that will be analyzed more fully in the detailed analysis phase of the feasibility study (EPA 1988). The process involves the following:

- Updating the RMAOs based on the results of the baseline risk assessments
- Developing GRAs (e.g., removal, capping)
- Identifying areas and volumes that may be addressed through response actions
- Identifying and screening technologies to eliminate those that, for technical reasons, cannot be implemented at the Site
- Assembling the technologies into alternatives representing a range of options for the Site.
- Refining the remedial alternatives
- Screening the alternatives based on short- and long-term effectiveness, implementability, and cost

TCAI will document the screening process in a technical memorandum, including the methods used, rationale, and results.

2.2.4.3 Detailed Analysis of Remedial Alternatives (Task 7)

The purpose of the detailed analysis of remedial alternatives is to present the relevant information needed to allow EPA to select a remedy for the Site. Each alternative will be compared against nine CERCLA evaluation criteria (EPA 1988):

- Overall protection of human health and the environment
- Compliance with ARARs
- Long-term effectiveness and permanence

- Reduction of toxicity, mobility, or volume
- Short-term effectiveness
- Implementability
- Cost
- State acceptance (considered after the RI/FS has been released for public review)
- Community acceptance (considered after the RI/FS has been released for public review)

In addition, a comparative analysis of the alternatives against these evaluation criteria will be undertaken. EPA will identify and select the preferred alternative. Additional details are provided in Section 10. TCAI will submit a technical memorandum summarizing the results of the comparative analysis of alternatives as well as the feasibility study report.

2.2.5 Project Schedule (Task 8)

The RI/FS is expected to require approximately 7 to 9 years to complete, depending on the nature of the studies conducted, the interdependency and timing of field and laboratory studies, and the complexity of the risk assessment processes and feasibility study. Additional discussion of the project schedule is provided in Section 12.

2.2.6 Potential Early Actions (Task 9)

The purpose of early actions is to protect human health and/or the environment from contaminants. Early actions are generally removal actions (i.e., contaminant exposure routes are removed through material removal or isolation) implemented within a short planning period. Non-time-critical removal actions have a planning period of 6 months or more, whereas time-critical removal actions require onsite action within 6 months. EPA and TCAI will evaluate the need for early actions on an ongoing basis throughout the RI/FS process, using representative, site-specific data and preliminary risk evaluation findings.

3 SITE DESCRIPTION

This section provides a general characterization of the Site, including descriptions of Site history and usage, physical characteristics, and ecological resources.

3.1 SITE CHARACTERISTICS AND USE

The UCR Site is located in north central Washington (Map 1-1). The Site extends along the Columbia River from the border between the United States and Canada downstream to the Grand Coulee Dam (EPA 2006h). The Site includes the areal extent of contamination and all suitable areas in proximity to such contamination necessary for implementation of response actions.

Immediately upstream of the Grand Coulee Dam, the impounded river forms Lake Roosevelt reservoir. The elevation of water maintained within Lake Roosevelt is managed by the U.S. Bureau of Reclamation (USBR) to provide flood control, irrigation, recreation, fisheries, navigation, flow regulation, and power generation (EPA 2005c). The maximum water elevation maintained in Lake Roosevelt (or full pool elevation) is 1,290 feet amsl. During the annual operating cycle, water levels in the reservoir are typically drawn down between January and April to accommodate increased spring flows. The level of drawdown is determined based on estimates for the spring runoff volumes and the projected runoff at The Dalles (USBR 2007a; EPA 2005c). At full pool, Lake Roosevelt extends at least 133 miles upriver to U.S. Geological Survey (USGS) river mile (RM) 730, within 15 miles of the Canadian border, and is bordered by over 600 miles of publicly available shoreline (EPA 2005c; LRF 2006a; NPS 2006c). At the northern end of the Site, the free-flowing reach of the UCR is generally undeveloped, bordered by the Colville National Forest to the west (EPA 2003b). Highway 25 runs adjacent to the eastern shore of this portion of the river, which is characterized by largely undeveloped public and private land.

The upland area surrounding the Site is generally thinly populated and consists of forests and farmland. Communities located along Highway 395 to the west of the UCR include Barstow and Boyds. Communities located to the east of the UCR, along Highway 25, include, from north to south, Northport, Evans, Marcus, Rice, Daisy, Gifford, Cedonia, Hunters, Fruitland, and Enterprise. Further south, the Colville Indian Reservation borders Lake Roosevelt to the north and west for approximately 93 river miles. This area includes several communities, the largest of which are Coulee Dam, Inchelium, and Keller (EPA 2003b). The Spokane Indian Reservation borders approximately 8 miles of the reservoir to the east, just south of the community of Enterprise and north of the Spokane River.

3.1.1 Human Settlement and Cultural Resources

This section provides an overview of the prehistory, native peoples, and Euroamerican historical development of the UCR drainage. It is intended to offer an introductory framework for addressing the diverse cultural resources of this area. Primary sources of information on the prehistory of the area are Ames et al. (1998), Goodal et al. (2004), and Pokotlyo and Mitchell (1998); for Native peoples, the sources are Kennedy and Bouchard (1998), Lahren (1998), Miller (1998), and Ross (1998); and for Euroamerican history, McKay and Renk (2002).

Human prehistory of the UCR area extends back at least 10,000 years. Although settlements were dispersed and occupied for short periods of time, major resource locations such as Kettle Falls were already being intensively utilized. Kettle Falls is one of the most significant cultural sites in the Western Hemisphere; early artifacts of human occupation there date from about 8,800 to 9,600 years ago (Chance 1986). Permanent villages at Kettle Falls and other locations along the UCR, supported by a substantial salmon fishery, have existed for at least 3,000 years (Kennedy and Bouchard 1998; Lahren 1998; Miller 1998; Ross 1998). Approximately 3,000 years ago, the general patterns of land and resource use among native peoples are evident in the archaeological record. These patterns include residence through the winter at established village locations, with seasonal shifts to resource locations during the summer (although some villages may have been occupied year-round). Native groups were much larger and less mobile than during the early millennia of human occupation. Salmon increasingly dominated the diet of native peoples, eventually becoming the single most important element in the diet. There is evidence of considerable cultural continuity from this period through Euroamerican contact in the late 1700s and early 1800s. At the time of initial Euroamerican presence in the region, which began in the early 1800s, Native American tribes and their sub-groups in the UCR area included: Lakes (sngaytskstx), Colville (sxweyi'7lhp), Sanpoil (snpgwa`ylxex), Lower Spokane (skasi`lhni) and Moses (snk`e7`iwsx) (Bouchard and Kennedy 1979). The Lakes people are named for their lands around Lower and Upper Arrow lakes and Slocan Lake but their homeland extended down the Columbia River to the vicinity of modern Northport, Washington. By the later 1800s, there were Lakes villages as far south as Kettle Falls. The Colville occupied the Columbia River valley south of the Lakes people to near the mouth of Wilmont Creek. Below the Colville on the Columbia River were the Spokane on the east bank of the Columbia and in the Spokane River drainage and the Sanpoil on the west bank.

There were no boundaries in a modern sense between these groups, and group homelands were defined primarily by geographic areas of traditional and regular use. Furthermore, the extensive network of kin, marriage, and exchange relationships that radiated across the Columbia Plateau made the homeland "boundaries" highly permeable. In addition, major resource locations such as Kettle Falls attracted hundreds, if not thousands, of visitors from within and outside the region to fish, trade, and socialize.

Contacts between native populations and Euroamericans in the UCR region began in the early 1800s as Canadian and American fur companies established trading posts throughout the Pacific Northwest. Spokane House was founded on the lower Spokane River in 1810 and a nearby competing post, Fort Spokane, was founded in 1812. Both posts were eventually abandoned and a new one established at Kettle Falls, known as Fort Colville. These fur-trading operations dominated Euroamerican use of the UCR region into the early 1850s.

A harbinger of growing American interest in the region was the Tshimakain Mission, founded in 1838 near the modern location of Ford, and St. Paul's Mission built in 1847 near Kettle Falls (NPS 2007b). The discovery of gold in the upper Columbia drainage spurred a mining boom beginning in the late 1850s and continuing through the late 19th century. Conflicts between Indians and miners led to the 1855 Yakama War; in 1880–1882, a military post (Fort Spokane) was established at the mouth of the Spokane River (the fort was closed as a military post in 1899 and operated as an Indian school from 1900 to 1908). Other federal acts during this era further impacted tribal cultures as individual allotments of lands were made to tribal members in efforts to contain tribal movement and provide lands and resources for settlers and development.

Many of the modern towns in the UCR region were founded from the late 1850s through the 1880s as mining communities or as supply centers for the mining districts. Farming, grazing, and timber grew increasingly important to the development of the area through the early 1900s. By the late 19th century, European farmers and loggers had settled widely in central Washington. Chinese immigrant miners and other laborers also arrived during this time. Irrigation-dependent farming rose to prominence in the early 20th century.

With the growing demand of settlers, treaties were signed in 1855 to cede Indian lands to the federal government. Only one of these treaties (the Yakima Treaty) included groups in the present study area. The Yakima Treaty created the modern Yakama Reservation, which is to the southwest of the UCR region. The Colville Reservation was created by executive order in 1872; the Spokane Reservation was created by executive order in 1881. Portions of the UCR Site are located within the Colville and Spokane reservations. The present boundaries of the reservation include approximately 1.4 million acres (2,200 square miles), including northern and western shorelines of approximately 93 miles of the UCR extending upstream from Grand Coulee Dam (Map 1-1; CCT 2008). The reservation is the home of members of The Confederated Tribes of the Colville Reservation, which include the Colville, the Nespelem, the San Poil, the Lakes, the Palus, the Wenatchee, the Chelan, the Entiat, the Methow, the Okanogan, the Moses Columbia, and the Nez Perce (CCT 2008).

The original north boundary of the reservation was the Canadian border; this former "North Half" of the Colville Indian Reservation continues to be an important homeland to the CCT. The CCT exercises certain management and regulatory authority in this area from the northern boundary of the current reservation north to the Canadian border, bounded by the Okanogan and Columbia rivers. CCT-owned land and individual tribal members reside on the

North Half and use the lands, waters, and natural resources for cultural and subsistence uses as they do on the reservation. In *Antoine v. Washington*, the Supreme Court affirmed the Colville Tribes' rights to hunt and fish on the North Half (*Alexander Antoine v. State of Washington* 420 US 194, 1975). The total population of the Colville Reservation in the year 2000 was estimated to have been approximately 7,600 people (Washington State Office of Financial Management [OFM] 2006).

The Spokane Reservation is the home of members of three bands of the Spokane Tribe of Indians (STI): Upper, Middle, and Lower Spokane (STI 2008). The Spokane Reservation originally consisted of 154,602 acres. A joint resolution of Congress was passed in 1902 to allot the reservation. The Secretary of the Interior was authorized to sell unallotted surplus lands in 1908, and it was opened up for homestead entry in 1909. The Upper and Middle Spokane signed an agreement in 1887, ratified in 1892, to be removed to the Coeur d'Alene Reservation. In 1958, 2,752 acres was restored to the Spokane Indian Reservation by an act of Congress. Today, the reservation includes approximately 160,000 acres of land (250 square miles), including an eastern shoreline of approximately 8 miles of the UCR extending upstream from the confluence with the Spokane River (Map 1-1) (STI 2008). The total population of the Spokane Reservation in the year 2000 was estimated to have been approximately 2,000 people (OFM 2006). The UCR Site remains the permanent homeland for the STI people today.

A western power shortage associated with World War II led Franklin D. Roosevelt to authorize the Columbia Basin Project, including the Grand Coulee Dam and Banks Lake, a holding reservoir. The implementation of this project altered the historical, cultural, and natural resources of the UCR, leading to present day conditions. The construction of Grand Coulee Dam in the late 1930s and the creation of Lake Roosevelt also created opportunities for recreation that have gained greater importance in the local economies over the past 30 to 40 years as mining and timber production have declined. Historic-period communities that were located along the Columbia River and were either destroyed or relocated with the creation of Lake Roosevelt included Keller, Peach, Lincoln, Gerome, Gifford, Inchelium, Daisy, Kettle Falls, Marcus, Boyds, and Fort Colville.

Physical traces of past human settlement in the UCR region can be seen in the hundreds of prehistoric archaeological sites recorded along the river, the dozens of historically documented Indian village locations, and the remains of historic-period farms, ranches, and communities. All cultural and historical sites along the river are protected under state and/or federal law.

Development of the Grand Coulee Dam and concerns about inundation of archeological sites along the waterways where aboriginal tribes had camps stimulated much of the documentation of the prehistory of the UCR Valley. The EPA (EPA 2004e) identifies four phases of archeological investigations: pre-inundation investigations during the 1930s and 1940s by the Columbia Basin Archaeological Survey, post-inundation salvage excavations by the University of Idaho and Washington State University in the 1960s and 1970s, numerous

cultural resource surveys of portions of the reservoir from the 1960s through 1996, and since 1996, archeological and cultural investigations instituted by an intensive compliance agreement program managed and implemented by federal agencies (Bonneville Power Administration [BPA], USBR, and NPS) and the tribes. As of 2006, more than 600 archaeological sites have been recorded between the Canadian border and the dam (EPA 2007d). The archaeological record with respect to cultural historical sequence, prehistoric land use, subsistence, settlement/housing, and trade was reviewed by Galm and Luttrell (1994, as cited in EPA 2004e).

The majority of the project area is in federal or tribal jurisdiction, but some areas outside these jurisdictions may be subject to Washington laws that address Indian burials, historic cemeteries, and archaeological and historical resources.

In addition to archeological cultural resources, continuing use of some areas by tribal peoples and other communities may constitute traditional cultural properties that are also legally protected. In addressing cultural and natural resources, it is important to note that many traditional communities do not distinguish between “natural” and “cultural” resources. Most—if not all—plants and animals also have cultural meaning and play important roles in the cultural life of the community, as do many natural landmarks and features. Elements such as clean water or salmon, which Western culture tends to view as distinct from human life, are often viewed as integral to both individual and group identity. Natural and cultural resources are therefore considered so interwoven that they cannot be addressed separately. In a somewhat similar manner, salmon have achieved an iconic status in the Pacific Northwest as part of the distinctive identity of the region.

3.1.2 Current Demographics

The UCR area includes several towns and communities outside of the Colville and Spokane reservations that are adjacent to or near the river. Demographic profiles based upon the 2000 United States census are available for some of the larger communities. This information is summarized below and in Table 3-1.

The total population of Northport in 2000 was 336, with a median age of 42.8 years (Table 3-1). Six percent of the population in 2000 was under age 5 and 17.3 percent was age 65 or older. Of the total population of Northport, 94.9 percent are categorized as white (U.S. Census Bureau 2006).

The total population of Marcus in 2000 was 117, with a median age of 43.5 years. Of the total population in 2000, 6 percent was under 5 years and 14.5 percent was 65 years and over. The racial diversity of Marcus was similar to that of Northport (U.S. Census Bureau 2006).

The total population of Kettle Falls in 2000 was 1,527, with a median age of 34.4 years; 8.3 percent of the population in 2000 was under age 5 and 15.8 percent was age 65 or older. Of

the total population of Kettle Falls, 91.3 percent was categorized as white, 3.9 percent as American Indian/Alaska Native, and 2.8 percent as Hispanic/Latino (U.S. Census Bureau 2007a).

The total population of Coulee Dam in 2000 was 1,044, with a median age of 44.5 years (see Table 3-1). The percentage of the total population under 5 years of age was 5 percent, and 65 years and older was 20.3 percent. Coulee Dam is a racially diverse community with 64.6 percent of the population categorized as white, 29.1 percent as American Indian/Alaska native, 2.8 percent as Hispanic/Latino, and less than 1 percent Black/African-American or Asian (U.S. Census Bureau 2006).

The city of Grand Coulee had a total population of 897 in 2000, with a median age of 45.3; 5.5 percent of the population was under 5 years of age and 23.6 percent of the population was over 65 years of age. In 2000, 81.3 percent of the population was categorized as white, 12.5 percent as American Indian/Alaska Native, and 4.9 percent as Hispanic/Latino (U.S. Census Bureau 2007a).

The total population of Inchelium in 2000 was 389, with a median age of 32.9 years. The percentage of the total population under 5 years of age was 5.4 percent and 65 years and older was 10.5 percent. In 2000, 76.6 percent of the population was categorized as American Indian/Alaska Native, 20.3 percent as white, and 1.5 percent as Hispanic/Latino (U.S. Census Bureau 2006).

The total population of zip code 99137 in 2000, which includes the towns of Hunters and Cedonia, was 306, with a median age of 41.5 years. The percentage of the total population under 5 years of age was 4.2 percent and 65 years and older was 15.4 percent. In 2000, 87.6 percent of the population was categorized as white, 4.6 percent as American Indian/Alaska Native and 1.3 percent as Hispanic/Latino (U.S. Census Bureau 2007b).

In 2000, the total population of the Colville Indian Reservation was 7,587. The terrain of the Colville Indian Reservation is mountainous and mostly forested, with a small amount of farmland. The Colville Indian Reservation is thinly populated with an average of 3.6 persons per square mile (OFM 2006). Logging and mining dominate the economy (EPA 2003b).

In 2000, the total population of the Spokane Indian Reservation was 2,004 (OFM 2006). The area east of the UCR is a mixture of forest and farmland, with a population density of 14.3 persons per square mile. Forest products manufacturing dominates the economy (EPA 2003b).

The area south of the Site is generally flat with low rolling hills and is primarily agricultural. The population density is 4.2 persons per square mile (EPA 2003b).

3.1.3 Site Uses

A summary of primary uses of the UCR Site by residents and visitors is described below.

3.1.3.1 Recreation and Occupational Uses

A large portion of Lake Roosevelt has been designated as the LRNRA, which is managed by the NPS. The LRNRA attracts more than 1.3 million visitors per year (NPS 2006c). According to the Fiscal Year 2003 Annual Performance Plan, the park employs approximately 54 permanent and 49 seasonal employees and receives up to 4,000 hours of volunteer labor annually. Maintenance and administrative offices for the park are located in Coulee Dam, Spring Canyon, Fort Spokane, and Kettle Falls (NPS 2006c).

Portions of Lake Roosevelt that are not included in the LRNRA are managed by CCT and STI. The NPS, CCT, and STI cooperate as managing partners as described in the Lake Roosevelt Cooperative Management Agreement (the 5-party agreement). Designated recreational uses of the LRNRA include boating, fishing, swimming, wading, camping, canoeing, and hunting.

Developed areas overseen by the NPS include 22 boat launches, 27 campgrounds, and three concessionaire-operated marinas (Seven Bays, Keller Ferry, and Kettle Falls Marinas) that provide moorage, boat rental, fuel, supplies, food service, and other services. Figure 3-1 is a reproduction of an NPS map showing water management zones of the lake and recreational facilities along the UCR (LRF 2007b; EPA 2007c). Two Rivers Marina (not part of the National Recreation Area) is owned and operated by the STI.

The remainder of the Lake Roosevelt shoreline managed by the NPS is undeveloped. The NPS allows camping on any undeveloped shoreline. The Colville and Spokane Indian reservations also provide opportunities for recreational visitors to fish and camp at the UCR (NPS 2006c). Recreational users may include occasional visitors, local residents, and tribal members. NPS employees and volunteers also are present at the Site as part of their work responsibilities and may use the Site for recreation on a regular basis.

As part of EPA's Phase I beach investigation, EPA visited 15 beaches that were known to be frequented by the public based on input from the CCT, the STI, the State of Washington, and NPS (EPA 2006g). The beaches visited by EPA were:

- Black Sand Beach
- Northport City Boat Launch
- Dalles Orchard
- North Gorge Campground
- Marcus Island Campground
- Kettle Falls Swim Beach

- Haag Cove
- French Rocks Boat Launch
- Cloverleaf Beach
- AA Campground
- Rogers Bar Campground
- Columbia Campground
- Lincoln Mill Boat Ramp
- Keller Ferry
- Spring Canyon Campground.

The locations for all 15 beaches are shown on Map 3-1. Typical human activities on the beach areas include dry beach play (digging in sand), shallow water play (wading, splashing, or swimming), camping, picnicking, cooking, and boat launching and retrieval (EPA 2006g).

3.1.3.2 Surface Water Use

Surface water in the UCR is a major source of irrigation water for commercial agriculture. According to the USBR, surface water from the UCR is used to fill Banks Lake to the south and to subsequently provide irrigation to over 600,000 acres of agricultural lands located south of Banks Lake, east of the Columbia River, and north of the Snake River (USBR 2006b).

Based on water right information provided by the Washington State Department of Ecology (Ecology), 77 current surface water rights along the UCR and the Kettle, Spokane, and Sanpoil river arms of Lake Roosevelt are potentially used for domestic supply, including multiple-purpose water rights (Table 3-2; O'Brien 2007, pers. comm.). The approximate locations of these surface water rights are shown on Map 3-2.

Public water systems are defined as all systems serving more than one single-family residence or more than five residences on the same farm, and are classified as either Group A or Group B depending on the number of people served and the number of residential connections (Figure 3-2). Surface water from the UCR is currently identified as a source for three Group A public water supply systems (Washington Department of Health [WDOH] 2007). The three Group A systems are listed below; their locations are shown on Map 3-2. In addition, the City of Grand Coulee formerly drew water for its municipal supply from the UCR just upstream of the dam, but this source was discontinued in February 2006 (Wilson 2007, pers. comm.).

System ID	System Name	County	Surface Water Source Use
38400	Kettle Falls Water Department	Stevens	Emergency ^a
28695	Grand Coulee Dam	Grant	Permanent
15400	Coulee Dam Water Department	Okanogan	Permanent

^a Surface water is used by Kettle Falls system only to augment its fire suppression system water supply (EPA 2003b). This source has not been used since 1989 (Gassaway 2007, pers. comm.).

No Group B systems use UCR surface water; however, one Group B system draws from the Sanpoil River within the boundary of Lake Roosevelt (Map 3-2; WDOH 2007).

3.1.3.3 Fisheries and Hatchery Operations

The UCR currently supports numerous species of game and non-game fish. Rainbow trout, kokanee salmon, walleye, and smallmouth bass are the primary fish harvested from the UCR either by boaters or shoreline anglers. Other game fish include largemouth bass, yellow perch, lake whitefish, mountain whitefish, brook trout, burbot, cutthroat trout, black crappie, pumpkinseed, and yellow bullhead (LRF 2006c). Historically, the white sturgeon fishery was important in the upper portion of the reservoir (RM 702 and above); however, this fishery was closed in 1996 to protect a failing population (Upper Columbia White Sturgeon Recovery Initiative [UCWSRI] 2002a).

Historically, the UCR was a subsistence fishery for Native American populations. For the Colville and Spokane tribes, anadromous and resident fish (mainly salmon but also steelhead trout, whitefish, and other species) were the principal subsistence fishery. Since the construction of the Columbia River dams, some resident fish (primarily rainbow trout and kokanee salmon) have become a necessary alternative as a subsistence resource. The waters of Lake Roosevelt within the Colville and Spokane reservations continue to be managed by the tribes as a subsistence fishery (EPA 2007c). The draft Fish and Wildlife Resource Management Plan for the Colville Reservation includes several provisions for creating/maintaining both ceremonial and subsistence fisheries of resident and anadromous fish in Lake Roosevelt (CCT 2006).

Prior to 1930, an estimated annual average of 1.1 million adult salmonids (i.e., steelhead trout and Chinook, coho, and sockeye salmon) migrated past the current site of Grand Coulee Dam (Scholz et al. 1986). In addition, the second-largest Native American fishery in the Columbia Basin was at Kettle Falls, roughly 108 river miles upstream of the dam site. Scholz et al. (1986) indicated approximately 300,000 to 1.5 million adult salmon were harvested annually at Kettle

Falls and in the Spokane River, with the majority taken at Kettle Falls. As partial mitigation for the losses of salmon in the UCR resulting from construction of Grand Coulee Dam, the BPA constructed two fish hatcheries: the Spokane Tribal Hatchery and the Sherman Creek Hatchery. These facilities were intended to supplement salmonid populations in the UCR to mitigate native salmonid losses due to ecosystem alterations caused by the dam. The Spokane Tribal Hatchery (located on the Spokane Reservation) is operated by the STI and began production in 1991 (Northwest Power Planning Council [NWPPC] 2006a). The Sherman Creek Hatchery is located adjacent to Sherman Creek on the west bank of the UCR near Kettle Falls. This hatchery is operated by the Washington State Department of Fish and Wildlife (WDFW) and began production in 1992 (NWPPC 2006b). Together, these hatcheries serve as a combined effort to rear both kokanee and rainbow trout. The hatcheries and associated net pens (described below) have annually produced up to 800,000 yearling rainbow trout and 3.4 million yearling kokanee for release into the UCR from 1991 to 2005. Typical annual releases have been approximately 500,000 rainbow trout and 500,000 kokanee yearlings.

The UCR fisheries have been tracked by the Lake Roosevelt Fisheries Evaluation Program since 1988 in order to 1) monitor progress toward meeting harvest goals and objectives, 2) evaluate the performance of hatchery releases of selected species, and 3) identify potential effects of hydropower operations on the fisheries (Lee et al. 2006).

Based on evaluations completed to date, harvesting does not appear to be a significant factor in reducing the abundance of the targeted fish species in the UCR, nor does it appear to jeopardize the ability of these species to maintain viable populations. For example, the rainbow trout fishery is supported primarily by a successful hatchery-based put and take program. The harvest of hatchery kokanee is minimal, with the majority of it comprising wild fish (Lee et al. 2006). Successful spawning of wild kokanee in the UCR has not been detected, and minimal spawning occurs in tributaries. Hence, kokanee likely enter the UCR from upstream lakes, such as Lake Kootenay, Lake Pend Oreille, and Arrow Lake (BPA 2006b).

The abundance of the walleye population in the UCR appears to be fairly constant and able to sustain current harvest levels (Lee et al. 2006). WDFW determined that UCR walleye are underexploited by anglers, based on data collected during the fall walleye index net surveys during 2002 and 2005. Those surveys found a moderate population density, average growth, low weight to length ratios (i.e., a condition factor), and adequate recruitment (Divens 2006; Lee et al. 2006). As a result, Washington State harvest regulations for bag limits have changed from five to eight fish per day.

Burbot harvest is believed to be low based on daytime creel surveys (Lee et al. 2006). However, because anglers commonly target burbot at night when creel surveys are not conducted, the harvest may be underestimated. Sampling data suggest the burbot population in the UCR is small, and the length-to-weight ratio of the population is below average, indicating food limitation (Lee et al. 2006; Woller 2006). Small populations with limited food supply are likely vulnerable to overharvest as has occurred in the nearby Kootenay River

(Paragamian et al. 2000). However, the effect of harvesting on the burbot population in the UCR is unknown.

3.2 PHYSICAL SETTING

The physical characteristics of the UCR influence the distribution of potential contaminants released to the Site, potential exposure to those contaminants, and the development and evaluation of potential remedial alternatives. This section presents an overview of Site geology, hydrogeology, hydrology, river reach characteristics, and climate.

3.2.1 Geology

The UCR is situated within two geologic provinces: the Okanogan Highlands and the Columbia Basin (Figure 3-3). The UCR is located along the division between the eastern and western Okanogan Highland regions. The Okanogan Highlands, which are typified by rounded mountains and deep, narrow valleys, include both shores of the Columbia River above the confluence with the Spokane River. The Selkirk, Chewelah, and Huckleberry mountains are located east of the Columbia River and the Kettle, Sanpoil, and other mountains are located west of the river (Washington Department of Natural Resources [WDNR] 2004). Below the confluence with the Spokane River, the Columbia Basin borders the southern shore of the Columbia River.

The Okanogan Highlands comprise Proterozoic basement rocks onto which were deposited, or accreted, a westward younging assemblage of sedimentary terrains and metamorphic complexes abundantly intruded by differentiated granitic plutons of Mesozoic Age (Stoffel et al. 1991). The Columbia Basin consists of a series of basalt layers (Columbia River Basalts) that are interbedded with layers of tuffs, sandstones, and conglomerates.

The UCR region was extensively modified by glacial activities during the Pleistocene. The UCR is located within the footprint of the ancestral glacial Lake Columbia, which formed at least three times during the Pleistocene glacial period. The glacial lake and its tributaries deposited coarser materials interbedded with silt and clay, forming deltas. As the last glacier retreated, the Columbia River caused rapid erosion and large-scale landslides of unconsolidated lacustrine deposits (Washington Water Research Center [WWRC] 1996). The repeated breaking of a massive ice dam that contained Lake Missoula, a massive lake formed from glacial melt waters, caused flood waters to pour through the Spokane Valley and into the Columbia Basin. These waters cut extensive and deep channels through the silt and basalt below the confluence with the present-day Spokane River (WDNR 2004). More recently, with the construction of Grand Coulee Dam and the flooding of Lake Roosevelt, the higher river levels have resulted in saturation of these glaciofluvial terraces and their consequent collapse; more than 300 landslides are documented along the UCR (Jones et al. 1961).

As shown in Map 3-3, surface geology along the shore of the UCR north of the Kettle River consists of gravel, sand and clay deposited by glacial streams adjacent to or downstream from temporary ice fronts. The surface geology south of the Kettle River consists of basalt, and, in some places along the south shore of the reservoir, the basalt cliffs rise nearly 1,000 feet above the lake (NPS 2002).

3.2.2 Hydrogeology

Hydrogeology of the Site is described in the following sections with details on groundwater aquifers and groundwater movement and use.

3.2.2.1 Aquifers in the Project Site Vicinity

Principal surficial aquifers of Washington State are shown on Figure 3-4 (USGS 1985). Aquifers present in the project area are the Columbia Plateau Basalts (south of the lower reach of Lake Roosevelt) and alluvial deposits adjacent to and in valleys of tributaries to the reservoir. With the exception of the Columbia Plateau Basalts, much of the project area is underlain by geologic formations that cannot store or yield significant quantities of groundwater for water supply uses (USGS 1985).

Water-bearing units within the Columbia Plateau Basalts are the major aquifer in eastern Washington (Whitehead 1994). Three basalt units have been assessed and mapped in detail (Whitehead 1994), in order of increasing depth: the Saddle Mountains Basalt, Wanapum Basalt, and Grande Ronde Basalt. Large quantities of groundwater are present in fractures and rubble zones that occur between lava flows in each of these basalt units. Wells completed in the Columbia Plateau Basalts are capable of yields on the order of 3,000 gallons per minute (USGS 1985).

Limited local aquifers are present in the Site vicinity in permeable glacial alluvial deposits and in permeable sedimentary rocks (sandstones and limestones) (Whitehead 1994). Yields of wells completed in these aquifers are in the tens to hundreds of gallons per minute, depending upon the aquifer extent and groundwater recharge (Whitehead 1994).

The aquifer that provides the water supply for the City of Northport is an example of a permeable glacial deposit that contains useable quantities of groundwater. The sand and gravel deposits that comprise this aquifer extend from ground surface to depths greater than 200 feet, with static water levels on the order of 75 feet below ground surface (Weston Solutions, Inc. [Weston] 2004a). Maximum pumping rates from these wells range from 20 to 100 gallons per minute (Weston 2004a).

3.2.2.2 Groundwater Occurrence and Movement

Groundwater in the project area occurs in pore spaces between sand and gravel particles of unconsolidated aquifers and in fractures or voids of rock aquifers. These aquifers receive

recharge from percolation of precipitation into the ground and leakage from surface water bodies (Whitehead 1994). Groundwater flows from higher-elevation recharge areas to lower elevations in the project area, where it discharges into streams, lakes, or rivers, or is pumped from the ground for various uses.

Shallow perched groundwater has been observed at elevations up to 160 feet above the full pool level of the reservoir (Riedel et al. 1997). A study by Thompson (1977), using thermal infrared imagery, identified extensive areas of bank seepage, spring discharge, stream inflow, and subsurface discharge into Lake Roosevelt. Observations of bank seepage and groundwater discharge correlated with the presence of unconsolidated glacial sediments, rather than bedrock. Shallow groundwater seepage into the reservoir has been identified as a contributor to soil instability and landslides (Jones et al. 1961).

Movement of water between the reservoir and the adjacent geologic strata depends upon a number of factors, including reservoir stage, bank storage and discharge during various reservoir stages, elevation and gradients of adjacent shallow aquifers, and regional discharge of groundwater into the reservoir from deeper aquifers (Thompson 1977).

Groundwater in the Columbia Plateau Basalts aquifer discharges to Lake Roosevelt at the northern edge of the south-sloping Columbia basalts (Whitehead 1994). Lower reaches of the Columbia River farther to the south (and outside of the UCR study area) subsequently receive discharge from this extensive basalt aquifer. Groundwater in the three Columbia Plateau Basalts units may flow upward or downward among the units, depending upon local water level and pumping conditions (Whitehead 1994).

3.2.2.3 Groundwater Use

Groundwater from wells and springs in the Site vicinity (e.g., Fort Spokane spring, EPA 2007c) is used for public and domestic potable water supply, irrigation, power generation, and industry. Data compiled by Lane (2004) indicate that groundwater withdrawals in the portions of the Site located in Ferry and Stevens counties are much lower than withdrawals from the more prolific basalt aquifers south of Lake Roosevelt in Lincoln County (Figure 3-5). Groundwater used for irrigation accounts for over 90 percent of the withdrawals in Lincoln County. Map 3-4 shows the approximate locations of 3,312 water wells and 12 water supply springs identified within approximately 5 miles of the UCR and Lake Roosevelt shoreline (Ecology 2007d).⁹

Public water systems are defined as all systems serving more than one single family residence or more than five residences on the same farm, and are classified as Group A or Group B, depending on the number of people served and the number of residential connections (Figure 3-2). Information regarding Group A and Group B water systems that use

⁹ Five miles was selected as an arbitrary extent to illustrate groundwater information within the area.

groundwater as a source was obtained from the WDOH (2006b). The WDOH identified 131 water systems within 5 miles of the UCR and Lake Roosevelt shoreline that utilize groundwater (springs or wells) as a source (Table 3-3).

Wellhead protection areas (i.e., a 10-year zone of groundwater travel) are identified by WDOH for 16 of these Group A systems, which are shown in Map 3-5 and listed in Table 3-4 (WDOH 2006a). Delineation of wellhead protection areas is required of Group A water systems in Washington State and is required by the federal Safe Drinking Water Act to support prevention of groundwater contamination.

3.2.3 Hydrology

General hydrology of the UCR is discussed in this section. Detailed discussion of the UCR river reaches from a hydrodynamics perspective is also provided.

3.2.3.1 Overview

The Columbia River watershed is large and complex, with an area of approximately 260,452 square miles (mi²) that encompasses parts of seven states (Washington, Oregon, Nevada, Utah, Idaho, Wyoming, and Montana) and one Canadian province (British Columbia). The watershed encompasses areas drained by several major tributaries, including the Pend Oreille, Kootenay, Okanogan, Wenatchee, Spokane, Yakima, Snake, Deschutes, Willamette, Cowlitz, and Lewis rivers. The head of the Columbia River is at Columbia Lake in Canal Flats, British Columbia. The river flows approximately 1,245 miles (approximately 470 miles in Canada) before reaching the Pacific Ocean along the border between Oregon and Washington. The river enters the United States in northeastern Washington, just south (downstream) of the confluence with the Pend Oreille River. For this work plan, consistent with the Agreement between TCAI and EPA, the study area is the section of the UCR between the U.S.-Canadian border and Grand Coulee Dam, a river reach extending approximately 150 miles downstream of the international border.

Grand Coulee Dam was built to provide power generation, irrigation, and flood control. Construction began in the 1930s and was completed in 1941. In June 1942, the impounded reservoir of Lake Roosevelt reached its full pool water surface elevation of 1,290 feet amsl (USBR 2006a) (1,288.6 feet National Geodetic Vertical Datum [NGVD] 1927). Major tributaries that influence hydraulic conditions at the U.S.-Canadian border are the Columbia and Pend Oreille rivers. Principal tributaries that join the UCR within the study area are the Kettle, Colville, Spokane, and Sanpoil rivers. Numerous smaller tributaries also join the UCR within the study area, including Deep, Onion, Sheep, Sherman, Hall, Ninemile, and Hawk creeks.

A simple water budget for the UCR was calculated as shown in Tables 3-5 and 3-6. Long-term average flows were calculated for the Columbia River upstream of its confluence with the Kootenay River as well as for the Kootenay, Pend Oreille, Kettle, Colville, Spokane, and

Sanpoil rivers. Flow gaging stations for these tributaries were selected based on proximity to the Columbia River as well as the length of the period of record for each gaging station. The gaging stations used to develop the water budget are shown in Table 3-5. Flow data for the entire period of record were used to determine the long-term average for each station. In developing the water budget, it was assumed that changes in daily or seasonal flow due to flow regulation at dams would change only the timing and magnitude of peak events but not impact the long-term flow from any given tributary.

Long-term averages for the individual tributaries were summed moving downstream to determine the cumulative long-term average flow in the Columbia River below the confluence with each tributary. Long-term averages for a number of stations along the Columbia River were also calculated for comparison to the cumulative values and are given in Table 3-6 with gaging station information given in Table 3-5. These measured flow rates compare favorably with the cumulative values calculated from the individual tributaries.

The calculated long-term average flow entering from each tributary was compared to the sum of the flows entering the UCR system and the relative contributions were determined. Approximately 90 percent of the flow at Grand Coulee Dam enters the system at the international border, with 40 percent coming from the Columbia, 26 percent from the Kootenay, and 24 percent from the Pend Oreille. The additional 10 percent enters the system between the border and the Grand Coulee Dam, with 3 percent coming from the Kettle River and 7 percent from the Spokane River. Less than 1 percent of the flow at the Grand Coulee Dam enters the system through the Colville and Sanpoil rivers. These estimates do not account for contribution from bank storage and groundwater influx.

Flow regimes in the UCR have varied over time. Over the past century, three distinct flow regimes have existed, as described below:

1. **Unregulated (before Grand Coulee Dam or upstream flow control).** Before flow regulation began, UCR flows were governed by precipitation and runoff, particularly the amount of snowpack and snowmelt. During the unregulated era, the river was free-flowing and subject to large, periodic high-flow (flood) events.
2. **Downstream Control (after Grand Coulee Dam but before upstream flow control).** During the period of downstream control, UCR flows were determined by unregulated upstream flow and water-level regulation at Grand Coulee Dam. Although periodic high-flow events still occurred, the extent of the Lake Roosevelt impoundment and backwater effects in upstream areas were controlled entirely by operations at Grand Coulee Dam.
3. **Regulated (after Grand Coulee Dam and after upstream flow control).** During the contemporary era of regulation (post-1972), river flows are controlled by the operation of upstream dams in addition to management operations at Grand Coulee Dam (EPA 2007d). As a result of the combined effects of dam operations, the size and frequency of large flood events has been reduced. This is more fully described in Section 3.2.3.3 below.

3.2.3.2 Flow Regulation across the U.S.-Canadian Border

River flow crossing the border from Canada is regulated by a series of upstream dams in Canada and the U.S. located on the Columbia, Duncan, Kootenay, and Pend Oreille rivers. Major dams upstream of the study area (including the Spokane River) are shown in Figure 3-6. Flow regulation by these dams alters the natural hydrology of the UCR by reducing the magnitude and duration of peak flows, increasing low flows, and reducing the overall variability of flows.

The USGS flow gage at the U.S.-Canadian border has operated continuously since March 1, 1938. As measured at this gage, a significant change in the hydrograph occurred starting in late 1972 to early 1973. This coincides with the construction of Mica Dam (on the Columbia River in British Columbia) and Libby Dam (on the Kootenay River in Montana) and marks a major change in the coordination of flood control at the upstream dams. Because of the impacts that upstream regulation has on the UCR, analyses of river flow for the periods before and after 1973 should be considered separately.

Statistical measures of mean daily flow at the USGS border gage are shown in Table 3-7. The results are split into two intervals, using January 1, 1973, as a representative date for the shift in hydrographic characteristics. Mean annual flows for the two intervals are similar, with the post-1973 interval showing a slight (approximately 4 percent) decrease. However, peak flows and flow variability are quite different. The highest mean daily discharge from the pre-1973 interval was 549,000 cubic feet per second (cfs), which occurred in June 1948. In contrast, the highest mean daily discharge from the post-1973 interval was 302,000 cfs, which occurred in June 1997. As seen in the hydrograph (Figure 3-7), annual variation in river flow was much higher before 1973 than after, reflecting the influence of flood-control regulation by upstream dams. The difference between the two intervals is most apparent when comparing mean monthly flows (i.e., mean of the daily averaged flows separately for each specific month in the multi-year intervals) (Figure 3-8). As shown in Figure 3-8, mean monthly flows prior to 1973 were much higher during the peak snowmelt months of May, June, and July and were generally lower the remainder of the year. Thus, the general effect of coordinated water regulation at upstream dams since 1973 has been a substantial reduction in annual peak flow through storage of seasonal snowmelt, and an increase in the annual median flow and corresponding decrease in flow variability, as stored water is released throughout the remainder of the year.

3.2.3.3 Water-Level Regulation for Lake Roosevelt

The Columbia River was free-flowing until 1933 when Rock Island Dam was constructed at USGS RM 483, followed by Bonneville Dam in 1937 at USGS RM 146, and then Grand Coulee Dam between USGS RM 596 and 597 in 1941.

The Grand Coulee Dam project was authorized several years prior to the outbreak of World War II; it was renamed and reauthorized by the Columbia Basin Project Act of 1943 (U.S. Fish and Wildlife Service [USFWS] 2007b). The project began with fund allocations for Grand Coulee Dam pursuant to the National Industrial Recovery Act of June 16, 1933, and was specifically authorized for construction by the Rivers and Harbors Act approved August 30, 1935 (Center for Columbia River History [CCRH] 2007; USBR 2007b). Construction of Grand Coulee Dam commenced in 1933, and by 1939, the dam began impounding water to form Lake Roosevelt (Figure 3-9). The main structure of the dam was completed by December 31, 1941; it took less than a year for the reservoir to reach full pool elevation (EPA 2007c).

In June 1942, the reservoir reached its full pool level, raising the original water surface 280 vertical feet from 1,010 to 1,290 feet amsl at the dam and inundating more than 70,000 acres of riparian and upland habitat (Merker 1993). At full pool (1,290 feet amsl), the reservoir has a surface area of approximately 82,300 acres and extends upstream of Grand Coulee Dam approximately 133 miles to Onion Creek (USGS RM 730), approximately 15 river miles south (downstream) of the U.S.-Canadian border. However, it is worth noting that the channel is constricted (and conveyance reduced) through the Little Dalles (USGS RM 728) and that water levels upstream of this point may rise during high flow events (U.S. Coast and Geodetic Survey [USCGS] 1950).

Just upstream of the U.S.-Canadian border, the Columbia and Pend Oreille rivers above the border supply the majority of the annual inflow (90 percent) to Lake Roosevelt, with the remainder primarily supplied by the Spokane, Sanpoil, Kettle, and Colville rivers (Table 3-5) (Stober et al. 1981).

Construction of Grand Coulee Dam was authorized by the U.S. Congress to provide electric power, flood control, and irrigation water (CCRH 2007). Power production and flood control were initially provided in 1941, although irrigation uses did not expand until after 1952, when pumping stations began transporting Columbia River water to Banks Lake. In total, the dam and reservoir produce more than 20 billion kilowatt-hours of power annually (EPA 2007d), while providing 5.2 million acre-feet of flood control storage, and water to irrigate 671,000 acres of farmland through the Columbia Basin Irrigation Project. Fisheries and recreational needs within Lake Roosevelt were considered secondary to power, flood control, and irrigation at that time. The dam was not outfitted with a fish ladder or other device to allow passage of adult salmon upstream and consequently it blocks anadromous fish from 1,149 miles of spawning and rearing habitat. In 1969 and 1974, the reservoir was drawn down well below its normal operating range to add a third powerhouse for expanded power production (EPA 2007d). The lowest drawdown on record occurred during this period of construction, at an elevation of 1,160 feet, roughly 130 feet below full pool (Figure 3-9).

Lake Roosevelt's surface elevation, inflow, and outflow are systematically controlled in order to meet the authorized flood protection, hydroelectric power production, irrigation, and downstream flow objectives. Grand Coulee Dam has historically been operated to maximize

the storage capability of the reservoir for retention of flood waters during the spring runoff, to meet irrigation demand and downstream flow targets during the dry summer months (LRF 2007c), and to maintain the highest pool levels possible for maximum power generation at all other times of the year. Overall, the reservoir is highest immediately after the spring runoff (in May and June), gradually decreases through August, and holds relatively stable from September to December (EPA 2007c). With resumption of autumn rains, the reservoir gradually begins to fill until late in the year, when flood control constraints begin to dictate operations in anticipation of next year's spring runoff, and the cycle begins again. By the mid 1980s to early 1990s, water management for fish, wildlife, and recreation, was a secondary consideration (NPS 2007a).

In 1984, the Northwest Power Planning Council (NWPPC) (now Northwest Power and Conservation Council) planned for the implementation of fish restoration and enhancement projects. Hydropower operations were being scrutinized by fisheries managers in the Lower Columbia River, and they argued that salmon smolt survival downstream of Lake Roosevelt was low due to insufficient flows down the Columbia River during the spring seaward migration. In response, the NWPPC recommended implementation of a water budget to both increase and extend Columbia River flows during the spring season for juvenile salmon and steelhead migration (NWPPC 1994). The water budget, in theory, reduced average reservoir elevation and water retention time in Lake Roosevelt.

In 1995, the listing of Snake and Columbia river salmon and steelhead under the Endangered Species Act resulted in the water budget being replaced by a set of operational rules that were included in the National Marine Fisheries Service (NMFS; now referred to as National Oceanic and Atmospheric Administration [NOAA] Fisheries) Biological Opinion (BiOp), known as the 1995 BiOp (NMFS 1995). The 1995 BiOp affected Lake Roosevelt hydropower operations by requiring increased outflows during spring and summer.

To achieve this objective, the spring reservoir elevation was required to be at flood control rule curves¹⁰ by April 15 to maximize available water for lower river flow augmentation in May and June. Prior to the 1995 BiOp, Lake Roosevelt pool elevation was frequently below that required for flood control due to power generation.

In addition, the 1995 BiOp required Lake Roosevelt to be drawn down 10 feet from full pool to a reservoir elevation of 1,280 feet in August. The August drawdown had not occurred historically. A final effect of the 1995 BiOp was an overall reduction in water retention time in Lake Roosevelt due to hydropower operation of Grand Coulee Dam and the upstream storage facilities, such as Libby and Hungry Horse dams. The upstream dams were required to send

¹⁰ Flood Control Rule Curves relate precipitation to reservoir levels based on flood control needs. The curves determine the amount of water to discharge out of the reservoir(s) in order to capture spring snowmelt and minimize flooding. The current date per the 2000 and 2004 BiOps to be at flood control rule curves is April 10 (EPA 2007d).

water downstream in spring and summer, thereby increasing Lake Roosevelt inflows and outflows.

In 1998, NOAA Fisheries appended the 1995 BiOp to include steelhead and referred to the new version as the 1998 BiOp (NMFS 1998). Theoretically, the volume of water contributed by Lake Roosevelt for flow augmentation was the same as prior years, but spread over a longer period. Reservoir volume is a function of reservoir elevation; therefore, lower reservoir elevations result in smaller volumes and shorter water retention times. Thus, the 1998 BiOp likely reduced reservoir elevations and volumes, thereby further reducing water retention time.

In 2000, NOAA Fisheries presented a new hydropower system BiOp, referred to as the 2000 BiOp (NMFS 2000). The 2000 BiOp had one additional effect on Lake Roosevelt: during lower than average runoff years (< 92 million acre-feet forecast at The Dalles), the reservoir was to be drawn down to 1,278 feet (1,280 feet in normal to wet years) by August 31 (i.e., 2 feet lower than previous operations) (EPA 2007d). This has further reduced water retention times. Operators bring the pool elevation back up to 1,285 feet amsl (1,283 feet at a minimum) by September 30 to improve access by mature kokanee to tributary spawning areas and the Sherman Creek adult kokanee trap for egg collection (EPA 2007c).

The extent of water level increases is expected to be influenced by interactions between flow magnitude, reservoir pool level, and conveyance limitations through the Little Dalles. At typical low pool levels, with a water surface elevation of approximately 1,245 feet amsl (EPA 2007c), the reservoir extent is reduced and ends near USGS RM 704. Outflow from Lake Roosevelt occurs via discharge through the dam to the Middle Columbia River or through pumped discharge to Banks Lake for irrigation storage.

Although reservoir elevations are systematically managed, the extent of the elevation fluctuations can be somewhat unpredictable due to varying annual runoff flows. Figure 3-10 illustrates the variable runoff volumes at The Dalles, Oregon, which is the location upon which annual flood control capacity management at Lake Roosevelt is based (USBR 2007a).

In general, reservoir elevation will decrease from January to April, increase during May and June, decrease in July and August, and hold fairly stable from September to December. Figure 3-11 illustrates the 1995 to 2005 reservoir elevation minima, maxima, average, and standard deviations. As depicted, reservoir elevation differs annually, based on the runoff volume for that particular year. Flood control has the greatest influence on elevation, and flood control targets are a function of projected runoff. As previously mentioned, The Dalles, is the system flood control point for the Columbia Basin, and therefore flood control operations at all storage facilities are managed based on the projected runoff at The Dalles. During the 1995 through 2005 water years, runoff has varied by 100 million acre-feet, from a low of about 60 million acre-feet in 2001 to a high of almost 160 million acre-feet in 1997 (see Figure 3-10).

The wide variation in runoff strongly influences the extent of reservoir elevation change, resulting in a range of pool elevations as shown in Figure 3-11. The water retention time is affected and also varies widely among years from a spring minimum of 30 days during low runoff years to 12 days during high runoff years (Figure 3-12). Lake Roosevelt's average annual water retention time is approximately 45 days.

3.2.4 Characteristics of UCR Reaches

For this document, the UCR project area has been divided into six reaches that correspond to relatively distinct physiographic units (Map 1-1). Boundaries for the six reaches were selected based on consideration of distinct geomorphic features (e.g., channel width, sinuosity, confluence with major tributaries), general hydraulic or hydrodynamic characteristics (depth, location of the reservoir pool, riverbed characteristics, flow velocity), and expected differences regarding the principal mechanisms for transport or deposition of particle-bound COIs. More information about hydrodynamics and fate and transport of sediment in the UCR is provided in Appendix C. As previously described, UCR hydrology changed significantly with the construction of Grand Coulee Dam and again with the implementation of coordinated flood control operations at upstream dams beginning in 1973. These flow regime differences are expected to have influenced the initial transport of sediment and COIs in the UCR and may continue to influence their redistribution in the future. Therefore, the changing nature of flow in the UCR was also considered as the boundaries for river reaches were selected.

Characteristics of each river reach have changed over time in response to the construction of Grand Coulee Dam and subsequent upstream flow regulation. As shown in Figure 3-9 and Table 3-7, the timing and magnitude of river flows show clear differences over time. Importantly, flow velocities, cross-sectional areas, and other hydraulic characteristics (width, depth, wetted perimeter, etc.) of each reach have also changed. It is reasonable to expect that these hydrologic and hydraulic alterations have impacted the historical and contemporary patterns of sediment and contaminant transport in the river.

3.2.4.1 Reach 1 (USGS RM 745 to RM 730)

Reach 1 extends from the U.S.-Canadian border (USGS RM 745) southward past the city of Northport to USGS RM 730, near Onion Creek (Map 1-1). The northern section of the reach—approximately 3 miles in length—is relatively shallow and narrow, retaining much of its historical hydraulic characteristics, and is expected to run free much of the time. Water depth at the border was recently reported to be approximately 14 feet (EPA 2004e) and is consistent with soundings from the 1947–1949 surveys conducted by the USCGS (1950).

The southern section of the reach—approximately 12 miles in length—is just upstream of the Lake Roosevelt reservoir and is influenced by the pool level. As flow in the UCR varies and pool elevations change in response to dam operations, this section of the river transitions from a free-running riverine reach to a lacustrine (lake-like) reach. Reported water depths at the

downstream end of this reach are 50 feet or more in the main channel (USGS topographic map, Northport, Washington, 1:24,000; 1,289-foot pool elevation). Several notable geomorphic features exist in the southern half of Reach 1. There is a large gravel bar at USGS RM 738 on the northern bank across from Deadmans Eddy. Aerial photographs suggest that some depositional features exist at the downstream point of the bar. There are also well-defined erosional terraces marking various reservoir pool levels. This suggests that the gravel bar may be a relict feature pre-dating upstream flood-control operations and potentially pre-dating the construction of Grand Coulee Dam as well. At USGS RM 737, the channel thalweg makes several sharp turns between Steamboat Rock and Sand Point. Two minor tributaries enter the UCR at this point, Big Sheep Creek on the northern (left downstream) bank and Deep Creek on the southern (right downstream) bank. Although these tributaries are small, aerial photographs suggest that both tributaries exhibit deltaic features at their confluence with the UCR, further suggesting that these creeks may be an important source of native watershed sediments to the UCR downstream of the U.S.-Canadian border. The mouths of both tributaries are well protected by backwaters, and the mouth of Big Sheep Creek is protected further by two islands (Steamboat Rock).

Detailed characterizations of the riverbed in Reach 1 are not available. However, present information indicates that the bed consists of large (non-cohesive) particle types—gravel, cobbles, and boulders (EPA 2005h). In 2005, 15 mid-channel sites were identified for sampling, but sediment cores could not be obtained because of the coarse-grained nature of the riverbed and/or the high current speeds experienced (EPA 2006e).

3.2.4.2 Reach 2 (USGS RM 730 to RM 711)

Reach 2 extends from near Onion Creek (USGS RM 730) to the approximate upstream head of Marcus Flats (USGS RM 711) (Map 1-1). Historically, Reach 2 was a swift riverine reach, running southwest from USGS RM 730, first through a narrow, deep canyon and a series of rapids called the Little Dalles, then broadening slightly over the remainder of the run down to USGS RM 711 (Symonds 1883). The constriction at Little Dalles was widened as part of Grand Coulee Dam construction efforts (1933 to 1942) by removing a rock island down to 1,255 feet along with part of the southern riverbank (McKay and Renk 2002). This section of the UCR is inundated by the Lake Roosevelt pool approximately 70 percent of the time (EPA 2004e). However, currents through the widened canyon are swift at lower pool levels. Although more sinuous than upstream areas, Reach 2 is still a relatively narrow channel with few embayments or shoreline irregularities. At USGS RM 726, the UCR makes a sharp bend, with the thalweg adjacent to the southern (left downstream) bank. This location, China Bend, was historically a broad, low floodplain that is now capped by an artificial island (China Bar). Downstream of China Bend, the UCR becomes more sinuous as it proceeds through a series of three additional broad bends before reaching the end of the reach. Water depths in this reach vary with reservoir pool elevations. For a pool elevation of 1,289 feet, USGS (topographic map, Northport, Washington, 1:24,000) shows that the thalweg deepens rapidly from 50 feet at the upstream end of Reach 2 to more than 100 feet in the vicinity of the Little Dalles a mile further

downstream (USGS RM 729). From there, the thalweg decreases to approximately 60 to 70 feet until about USGS RM 718, where it narrows and deepens again to 100 feet through another drowned gorge. Further downstream, thalweg depths vary between 70 and 90 feet through the remainder of the reach. Despite the deep and narrow thalweg, depths on the inundated historical floodplain are 20 feet or less at a number of locations (China Bend, USGS RM 726; North Gorge, USGS RM 719; north of Bossburg, USGS RM 717; Snag Cove, USGS RM 714; Evans and Powell, USGS RM 712 and 711).

Like Reach 1, detailed characterizations of the riverbed in Reach 2 are not available; sediment-sampling efforts in 2005 were repeatedly thwarted by the presence of cobbles and boulders in the main channel and sampling locations were often moved laterally onto what would have been the historical floodplain (EPA 2006f). This suggests that the riverbed comprises cobbles and boulders in the area of the thalweg with deposits of finer material in protected areas and on the historical floodplain, which is now inundated frequently by the Lake Roosevelt pool.

3.2.4.3 Reach 3 (USGS RM 711 to RM 699)

Reach 3 extends from the approximate upstream head of Marcus Flats (USGS RM 711) to just downstream of Kettle Falls (USGS RM 699; Map 1-1). The characteristics of Reach 3 include distinct geomorphic features that are believed to influence particle transport (and corresponding chemical transport and fate) under historical and contemporary flow regimes. At USGS RM 710 and again between USGS RM 706 and 707, the UCR thalweg makes two sharp (90-degree) bends while passing through a relatively broad floodplain in the area of Marcus Flats. To the north of the second bend, the Kettle River joins the UCR. The Kettle River is the first significant tributary confluence downstream of the U.S.-Canadian border, with a mean annual flow of approximately 3,000 cfs (USGS 2006c) (Table 3-5). Between USGS RM 704 and 703, the UCR thalweg descends through a steep, narrow constriction. Prior to the construction of the Grand Coulee Dam, this was a powerful series of cascades known as Kettle Falls. A photograph of Kettle Falls (Figure 3-13), illustrates conditions prior to completion of Grand Coulee Dam. Kettle Falls is now inundated by the Lake Roosevelt pool. However, during occasions of extreme drawdown (e.g., during construction of the third powerhouse at the Grand Coulee Dam) Kettle Falls re-emerges. Downstream of the Kettle Falls constriction, the UCR runs through a relatively straight, narrow channel until the confluence with the Colville River at USGS RM 699.

Some aspects of the riverbed in Reach 3 have been characterized. Unlike Reaches 1 and 2, extensive areas of the bed in Reach 3 are reported to contain a large fraction of sand-sized sediment and granulated slag. Seven-foot sediment cores taken from the contemporary thalweg (i.e., the historical channel) between the upstream (USGS RM 708) and downstream (USGS RM 704) limits of Marcus Flats indicate that a relatively uniform and continuous deposit of black granulated slag exists (EPA 2004e). There are also cross-channel gradients in bed composition and grain size. Sediment cores collected from locations across the thalweg and adjacent historical (submerged) floodplain indicate that higher concentrations of

granulated slag and coarser particle sizes occur in areas nearest to the thalweg and that granulated slag content and particle size typically decrease with distance from the thalweg (EPA 2004e). Axial gradients also exist. When viewed from upstream to downstream, the UCR sediment data show that downstream of Marcus Flats, there is a distinct decrease in the fraction of sand-sized particles in mid-channel samples (EPA 2004e).

Historically, Reach 3 may have been similar to Reaches 1 and 2 in terms of water depths, flow velocities, and sediment transport potentials. Prior to construction of Grand Coulee Dam, seasonal high flows may have had the potential to transport sand and even fine gravel-sized sediment and granulated slag through the historical channel to downstream reaches. However, the function and extent of historical floodplain areas differentiate Reach 3 from upstream reaches. For example, when the UCR overflowed its historical banks (reflecting the impact of the channel constriction around Kettle Falls), flow velocities and sediment transport potentials in floodplain areas are expected to have been much smaller than conditions through the historical channel. This decrease in transport potential could have contributed to the significant deposition of sediment (particularly granulated slag) throughout the historical Marcus Flats floodplain.

Under contemporary regulation of pool levels, Reach 3 is expected to be inundated much of the year. Full-pool water depths during seasonal high pool levels are expected to be 50 feet or more over the historical floodplain and more than 100 feet along sections of the thalweg. As a result, flow velocities and sediment transport potentials through Marcus Flats, when pool elevations are high, are expected to be smaller than existed for the historical channel and floodplain since the construction of Grand Coulee Dam and the creation of the Lake Roosevelt pool. Following the initiation of upstream flow control (beginning around 1973), seasonal high flows decreased by nearly 50 percent as determined from 7-day annual maxima reported by the USGS for the intervals 1938–1973 and 1973–2006. Further, sediment transport capacity is proportional to velocity raised to a power of 2, 3, or even 5 (e.g., Soulsby 1997; van Rijn 1993). This suggests that contemporary sediment transport potentials may be one-fourth to one-eighth of those for historical conditions. Consequently, contemporary deposition potentials in this reach for sediment, granulated slag, and contaminants are expected to be considerably larger than historical values. These simple transport assessments are substantiated by measured gradients in grain size and bed composition (EPA 2004e) as previously noted. Additional analysis of river flow and shear stresses (a determinant of transport potential) are presented in Appendix C. It should be noted that the hydrologic model presented in Appendix C was developed using historical bathymetric data obtained between 1947 and 1949. Given the transitional nature of Reach 3 and known changes to the system over time, it is likely that there have been some changes in bathymetry which would impact the outcome of the transport assessment.

3.2.4.4 Reach 4 (USGS RM 699 to RM 640)

Reach 4 extends from just downstream of Kettle Falls (USGS RM 699) to just upstream of the confluence with the Spokane River (USGS RM 640). Because of the length and expected differences in sediment and contaminant transport regimes, exposure, and habitat over time, this reach is further divided into two subreaches. Reach 4a extends from USGS RM 699, at the confluence of the Colville River, to USGS RM 676, just upstream of Inchelium. Reach 4b extends from USGS RM 676 to USGS RM 640 near the confluence with the Spokane River. These reaches collectively represent the middle reservoir. Water levels through the middle reservoir vary as a function of water management at Grand Coulee Dam. Through Reaches 4a and 4b, the reservoir is roughly 0.25 to 1.75 miles (0.4 to 2.8 kilometers [km]) wide. Water depths through these reaches range from 100 to 300 feet (30 to 91 meters [m]), but can become quite shallow near the banks, reflecting the topography of the drowned river valley. The Colville River contributes less than 1,000 cfs of flow to the UCR on a mean annual basis. Reach 4a borders the Colville Indian Reservation, and Reach 4b borders both the Colville and Spokane Indian Reservations.

Landslides and erosion along the banks of the flooded valley that forms the reservoir shore have been noted in numerous areas of both reaches (Carpenter 1984; Jones et al. 1961; EPA 2004e) as shown on the maps for the Phase I sediment study included in Attachment E1 of Appendix E. This erosion occurs when fluctuating reservoir levels expose steep water-saturated shorelines that fail under their own weight. Additional erosion may be caused by the hydraulic action of waves on the banks, which can preferentially erode and transport finer material from the shoreline and deposit it in deeper sections of the reservoir. Thus, the sediment remaining from failed or wave-eroded banks may be the source of coarse sediment found in some nearshore areas of the reservoir bed.

Before the construction of Grand Coulee Dam, Reach 4 would likely have been a transitional reach for sand deposition. The historical thalweg was still quite narrow over much of the region (based on 1947–1949 USCGS bathymetry), but there are a number of reaches where the historical channel appears to widen and where bathymetric contours are much less steep, suggesting that the UCR in this region flowed through a series of cascades and broad pools. Given changes in the UCR flow regime over time, some of these historical pools might contain granulated slag that was discharged before the dam was constructed as well as native sands that originated from the Kettle and Colville rivers. Cores taken in the historical thalweg at USGS RM 692 and 676 showed deep (3- to 5-foot and 5- to 7-foot core intervals) elevated concentrations of COIs usually associated with granulated slag, although typical granulated slag particles themselves were not observed (EPA 2006e). The deepest interval of Core 676 included a small amount (< 10 percent) of coarser “gravelly material” that may be indicative of deposition under much higher flow conditions than occurred for the remainder of the core.

Under present-day conditions, maximum flow velocities in these reaches are expected to be low, rarely exceeding 2 to 3 feet per second (ft/s), even under conditions of low pool elevation

and high flow at the U.S.-Canadian border (EPA 2006e; see Figures 3-7 to 3-9). Sediment transport capacities for these conditions will also be low. Under such conditions, only the finest particles will remain suspended in the water column. Evidence for this transport pattern can be seen in terms of the grain size distribution of the sediment bed. Whereas bed sediments in Reach 3 are composed of 80 to 100 percent coarse particles, there is a pronounced shift in bed sediment grain size distributions observed in Reach 4. In general, mid-channel bed sediments in Reach 4a are largely fine-grained with a moderate coarse fraction (10-20 percent sand, 60-70 percent silt, and 10-20 percent clay/colloidal; EPA 2006e). However, there is a trend of progressively decreasing grain size from upstream to downstream. Mid-channel bed sediments in Reach 4b are also fine-grained but have a larger fraction of very fine particles (10-20 percent sand, 50-60 percent silt, and 30-40 percent clay/colloidal; EPA 2006e). One possible explanation for the increasing fineness of bed sediment is that little coarse sediment is delivered from upstream under present flow and water-management regimes. Alternatively, this may also reflect the deposition of fine sediment washed from the banks and from landslide events by waves and rainfall runoff.

As water levels change, submerged river terraces and more recent bed deposits and bars may be periodically exposed at the surface. At high pool levels, the extent of riparian areas is minimized because most nearshore areas are inundated. At low pool levels, the extent of riparian areas can increase considerably. Sediment in exposed areas can desiccate over time and very fine particles may be subject to aeolian (windblown) transport.

3.2.4.5 Reach 5 (USGS RM 640 to RM 617) and Reach 6 (USGS RM 617 to near RM 597)

Reach 5 extends from USGS RM 640 to USGS RM 617. Within Reach 5, the Spokane River (long-term average annual flow of 7,670 cfs as measured at Long Lake; USCGS 1950) joins the Columbia River at USGS RM 639. Reach 6 extends from USGS RM 617 to the Grand Coulee Dam (near USGS RM 597). Within Reach 6, the Sanpoil River joins the UCR between USGS RM 615 and 614. These reaches collectively represent the Lower Reservoir. Reaches 5 and 6 both border the Colville Indian Reservation. Both reaches can be characterized as a lacustrine environment with slow-moving water.

Water levels at Grand Coulee Dam (and throughout the reservoir) vary as a function of water management needs. Near the dam, the reservoir is roughly 1 mile (1.6 km) wide with maximum water depths that can exceed 400 feet (120 m; EPA 2007c), giving the reservoir lake-like characteristics. Water levels in the reservoir are managed for power generation, flood control, irrigation, recreation, and fisheries management. In a typical year, water level drawdown begins in early winter and continues until a minimum pool level is reached in the early spring. The extent of this drawdown is determined from the water content of snowpack in the watershed, with a larger water content resulting in a larger drawdown. Runoff from snowmelt and upstream releases causes the reservoir to fill until a maximum pool level (1,290 feet elevation) is reached in early summer. A mid-summer drawdown of approximately

10 feet can also occur as needed for fisheries management purposes. In response to changing flows and periodic drawdown, hydraulic residence times in the reservoir can be relatively short and highly variable, averaging 45 days, despite the lake-like appearance of the reservoir (Underwood et al. 2004).

In Reaches 5 and 6, sediment transport, contaminant transport and fate, and contaminant exposure are expected to be influenced by relatively short hydraulic residence times as a result of water management at Grand Coulee Dam. In many locations, shear valley walls rise nearly 1,000 feet (300 m) above the original river floodplain. Landslides and erosion along the banks of the flooded valley that forms the shores of Lake Roosevelt have been noted in numerous areas of both reaches (Jones et al. 1961; EPA 2006e; Whetten et al. 1969) as shown in Attachment E1 of Appendix E. Over time, this erosion may occur as a consequence of the added weight of water when soil pore spaces are saturated and reservoir levels fluctuate. Erosion may also be caused by the hydraulic action of flow and waves on the banks. As noted previously, sediment from failed or eroded banks might be the source of coarse sediment found in nearshore areas of the reservoir bed.

As noted for Reach 4, submerged river terraces and more recent bed deposits and bars may be periodically exposed at the surface as water levels change. At high pool, the extent of riparian areas is minimized as most nearshore areas are inundated. At low pool, exposed beach can increase considerably. Sediment in exposed areas can desiccate and very fine particles may be subject to aeolian transport.

Given contemporary water depths, flow velocities in Reaches 5 and 6 are typically low (< 1 ft/s) and sufficient to transport only very fine particle sizes such as silt, clay, and organic detritus. In general, mid-channel bed sediments are almost entirely fine-grained. However, there is a trend of decreasing grain size between reaches. In Reach 5, bed samples from the mid-channel are approximately 50 percent silt and 50 percent clay/colloidal, whereas in Reach 6, bed samples show increased fining and are roughly 40 percent silt and 60 percent clay/colloidal (EPA 2006e). One reason for the fineness of bed sediment is that little coarse sediment is delivered from upstream. Although the bed is in general very fine, one area where more coarse sediment occurs (40–50 percent sand) is near the confluence with the Sanpoil River. Although less pronounced, bed sediment is also somewhat coarser where the Spokane River enters the reservoir (20–30 percent sand).

Historically, water depth would have been much smaller and flow velocities much larger than those for contemporary conditions. Although detailed analyses have not been completed to date, it is reasonable to infer that before the construction of Grand Coulee Dam, Reaches 5 and 6 would have been similar to historical conditions upstream in Reach 4. Based on inferences drawn from 1947–1949 USCGS bathymetry, Reaches 5 and 6 may have been transitional reaches with respect to sand transport and deposition. The historical thalweg is somewhat broader than exists in Reach 4 (again based on 1947–1949 USCGS bathymetry), but

there are also areas where the historical channel appears to widen and where bathymetric contours are much less steep.

3.2.5 Climate/Meteorology

The UCR area lies in the rain shadow of the Cascade Mountains, and therefore average annual rainfall is low in comparison to the western portion of the state. The northern areas of the Site receive about 20 inches of precipitation a year (NPS 2006b). Moving south, the climate becomes far more arid with average annual precipitation at Grand Coulee Dam of approximately 10 inches. This precipitation occurs mostly in the winter and spring, while summer months are generally hot and dry. Trends in the last 50 to 100 years show a general decrease in winter precipitation and increase in summer precipitation (Ferguson 1999).

During the summer months, temperatures at the Site typically range from 75°F to 100°F in daytime, dropping to 50°F to 60°F at night (NPS 2006a; 2006b). Fall and spring provide plenty of sunshine and cooler temperatures. During these transitional times, the temperatures vary between 50°F and 80°F during the daytime and 30°F and 50°F in the night (DOI 2006). Winters can be extremely cold in this area with cold winds sweeping across the flat terrain. Daytime temperatures are generally between 25°F and 40°F, and nighttime temperature ranges may be as low as 15°F to 20°F. Trends in the last 50 to 100 years indicate a slight increase in winter temperatures and slight decrease in summer temperatures (Ferguson 1999).

As a transition-type climate zone, the climate within the Site is characterized by the interactions of three distinct types of air masses (Ferguson 1999):

- Moist marine air from the west that moderates seasonal temperatures
- Continental air from the east and south that is dry and cold in winter and hot with convective precipitation and lightning in summer
- Dry arctic air from the north that brings cold air to the area in winter and helps cool the area in summer

The timing and extent of influence of these competing air masses is controlled largely by synoptic weather patterns and complex local topographic features that vary across the Site. For instance, prolonged periods of drought occur when Pacific storms are deflected around the region, preventing the intrusion of moist marine air. At these times, dry continental conditions prevail.

Similarly, frosts and freezing conditions commonly occur when arctic air invades the area. Crop damage may be associated with such frosts when they occur before winter hardening in autumn or after bud break in spring. Cold damage also may occur in winter if a warm marine intrusion is followed by a sweep of arctic air (Ferguson 1998; 1999).

In addition, the unique interplay between these three air mass types results in dramatic weather changes during transition periods between the different air masses (Ferguson 1996). The most unique of these transitions is rain-on-snow flooding that occurs when warm, wet marine air displaces cold, arctic conditions in winter. This rain-on-snow flooding, coupled with the spring runoff of snowmelt that typically occurs in April and May, is a major source of water in the reservoir and therefore is tied to the management of water levels in Lake Roosevelt (LRF 2006d).

Another characteristic interplay is the strong, gusty wind that occurs during transitions between continental and marine air masses, mainly in spring and summer (Ferguson 1996). It has been reported that in particularly warm and dry years, 8 to 20 gusty wind events can occur within the Site. The cool, moist air masses from Pacific storms, which progress eastward, are dramatically different than the hot, dry continental air masses. As the air masses meet, the associated fronts can be very strong. These weather fronts often are associated with strong, gusty local winds. This effect is most significant when the seasonal upper-level flow pattern includes frequent southerly or northerly flow over the Site.

Analysis of meteorological monitoring data collected along the UCR indicates that the dominant wind directions are from northeast to southwest and from southwest to northeast (DOI 2006). However, wind direction distributions showed strong seasonal variation. Furthermore, topographic conditions affect local meteorology. Many steep-walled valleys and canyons along the UCR can channel and accelerate winds to very high speeds (Ferguson 1998). These significantly strong winds may occur in directions that are different from prevailing directions. The meteorological stations along the UCR (Map 3-6) reflect special characteristics of the microclimates in these areas.

3.3 ECOLOGICAL RESOURCES

The UCR study area is approximately 150 miles in length, translating to more than 600 miles of shoreline (Creveling and Renfrow 1986; LRF 2006e). Aquatic life, wildlife, and vegetation within the UCR project area are discussed in this section, including listing status by state and federal resource agencies. Additional ecological receptors may be identified during the problem formulation process for the BERA. Important habitat areas identified within the UCR study area are also discussed.

3.3.1 Wildlife and Aquatic Life

Tables 3-8 and 3-9 summarize the terrestrial and aquatic species (respectively) that have been reported in the UCR study area.¹¹ These data were compiled by a number of researchers' databases including WDFW (2006), Seattle Audubon Society (2006), BPA (2006a; 2006b; 2006c;

¹¹ Scientific names are included in Tables 3-6 and 3-7 for wildlife and aquatic life.

2006d; 2006e), Lake Roosevelt Forum (2006b), Marcot et al. (2003), Quigley et al. (2001), Hebner et al. (2000), Cassidy et al. (1997), and Creveling and Renfrow (1986).

3.3.1.1 Wildlife

There are 97 species of mammals (upland, aquatic dependent), 250 species of birds (upland, aquatic dependent), 15 species of reptiles, and 10 species of amphibians reported to occur in the area (Table 3-8). Large mammals include black bear and grizzly bear, elk, lynx, mountain lion, bighorn sheep, whitetail deer, mule deer, and moose. Smaller mammals include beavers, otters, moles, muskrats, mink, badgers, raccoons, skunks, bobcats, coyotes, foxes, porcupines, rabbits, squirrels, chipmunks, marmots, pikas, bats, gophers, rats, voles, shrews, and mice.

Birds reported in the watershed include raptors such as ospreys, eagles, falcons, hawks, harriers, and kestrels. Passerine birds (songbirds) include swallows, finches, jays, chickadees, kinglets, ravens, magpies, robins, sparrows, flycatchers, blackbirds, and juncoes. Water birds include mallards, pintails, teal, goldeneyes, canvasbacks, grebes, coots, scaup, mergansers, loons, and geese. Shorebirds include plovers, killdeer, sandpipers, gulls, snipes, grebes, and yellowlegs. Grassland birds include grouse, doves, pigeons, pheasants, and turkeys.

Several reptilian and amphibian species have been reported in the area. Reptilian species include turtles, lizards, skinks, and snakes. Amphibian species include toads, frogs, and salamanders.

Some of the wildlife species reported within the area and the surrounding watershed are listed as threatened or endangered (state, federal), including the northern leopard frog, American white pelican, ferruginous hawk, northern goshawk, sage and sharp-tailed grouse, sandhill crane, upland sandpiper, pygmy rabbit, western gray squirrel, gray wolf, fisher, woodland caribou, grizzly bear, and Canada lynx (Table 3-8).

There are also many wildlife species reported within the area whose possible decline is a matter of concern to federal and state resource agencies. These species are identified in Table 3-8 as any of the following: federal candidate, state candidate, state sensitive, state monitored, proposed sensitive, and proposed threatened. Species of concern include the western toad, Columbia spotted frog, sagebrush lizard, common loon, osprey, northern goshawk, golden eagle, peregrine falcon, burrowing owl, Columbia sharp-tailed grouse, Columbia spotted frog, loggerhead shrike, Pacific water shrew, myotis bats, Townsend's big-eared bat, Washington ground squirrel, Western pocket gopher, and wolverine.

3.3.1.2 Aquatic Life

Native species of fish in the area include peamouth, northern pikeminnow, kokanee salmon, rainbow trout, bull trout, white sturgeon, burbot, chiselmouth, mountain whitefish, sculpin, and sucker species (Table 3-9). Chinook salmon, once native to the UCR, occur in the reservoir as "wash-downs" from Lake Coeur D'Alene where they have been stocked (LRF 2007a).

Introduced (non-native) species include carp, tench, lake whitefish, brook trout, brown trout, walleye, yellow perch, largemouth bass, smallmouth bass, black crappie, pumpkinseed, channel catfish, brown bullhead, and yellow bullhead. A number of aquatic invertebrate species are also reported within the area, including the California floater (*Anodonta californiensis*), a mussel species that is a candidate for listing by both federal and state resource agencies (WDFW 2006).

3.3.1.3 Invasive Aquatic Species

The UCR contains a few nuisance species, nonindigenous species that adversely affect the environment. Eurasian milfoil (*Myriophyllum spicatum*) is the primary nuisance macrophyte species in the UCR. This plant is present in some embayments, especially in the Spokane Arm, but it does not occur in high densities throughout the UCR (Weaver 2006). The UCR also contains nonindigenous nuisance fish species (e.g., carp, smallmouth bass, walleye). Walleye were introduced to the UCR in the 1950s and were prevalent by the 1970s (USBR 1985). This species has likely played a major role in shaping the current fish community of the UCR through predation on other fish species. Baldwin et al. (2003) estimated 15 percent of the hatchery kokanee released in the Kettle Falls area were preyed upon by walleye over a 41-day period in 1999. The extent of predation throughout the years is unknown, but it likely exceeds 15 percent of the release.

3.3.2 Vegetation

As previously mentioned, the climate of portions of the Site and surrounding area is semi-arid and varies a great deal from one end of the Site to the other (LRF 2006b), with the southern (lower) portion near Grand Coulee Dam being generally hotter and drier. Vegetation in this area (Grand Coulee Dam to Keller Ferry) includes steppe (bunch grass grassland) and shrub-steppe. Common species within this section of the reservoir include grasses such as bluebunch wheatgrass (*Pseudoroegneria spicata*), needle-and-thread grass (*Hesperostipa comata*), and Idaho fescue (*Festuca idahoensis*); forbs such as arrowleaf balsamroot (*Balsamorhiza sagittata*), northern buckwheat (*Eriogonum* spp.), brittle prickly pear (*Opuntia* spp.), alumroot (*Heuchera* spp.), and lupine (*Lupinus* spp.); and shrubs such as big sagebrush (*Artemisia tridentata*), rabbitbrush (*Chrysothamnus nauseosus*), and antelope bitterbrush (*Purshia tridentata*) (Hebner et al. 2000; LRF 2006b). Irrigated agricultural lands are also present.

Between Keller Ferry and the upper end of the Spokane River Arm at Little Falls Dam is a transition from shrub-steppe to ponderosa pine forest (Hebner et al. 2000), with common trees including ponderosa pine (*Pinus ponderosa*) and Douglas-fir (*Pseudotsuga menziesii*). Grasses in the steppe/shrub-steppe zone here are also common. Forbs include arrowleaf balsamroot, northern buckwheat, and lupine; shrubs include big sagebrush, rabbitbrush, antelope bitterbrush, snowberry (*Symphoricarpos albus*), greasewood (*Sarcobatus vermiculatus*), and service berry (*Amelanchier arborea*) (Hebner et al. 2000; LRF 2006b). Trees in this portion of the

UCR watershed include black cottonwood (*Populus trichocarpa*), ponderosa pine, and Douglas-fir.

Areas around the middle and upper reservoir, between the Spokane River and Kettle Falls, receive approximately 17 to 20 inches of precipitation a year (LRF 2006b). This area is covered with a dense mix of ponderosa pine and Douglas-fir (Hebner et al. 2000; LRF 2006b). The steppe environment within this area is less distinct. Grasses in this region of the reservoir include those present in the lower reservoir with the addition of pinegrass (*Calamagrostis rubescens*). Common forbs include hairy goldstar (*Crocidium multicaule*), phlox (*Phlox* spp.), and nodding onion (*Allium cernuum*); shrubs include chokecherry (*Prunus virginiana*), serviceberry, wild rose (*Rosa acicularis*), Douglas hawthorn (*Crataegus douglasii*), snowberry, occasionally some smooth sumac (*Rhus glabra*), and blue elderberry (*Sambucus cerulea*) (Hebner et al. 2000). Alder (*Alnus* spp.), willow (*Salix* spp.), hazelnut (*Corylus cornuta*), and black cottonwood are common along riparian areas (Hebner et al. 2000). The Rocky Mountain juniper (*Juniperus virginiana*) can be found next to the shoreline and on rocky river bars.

The upper portion of the UCR (i.e., north of Kettle Falls to Onion Creek near the U.S.-Canadian border) is dominated by ponderosa pine, Douglas-fir, and western larch (*Larix occidentalis*). Some lodgepole pine (*Pinus contorta*), grand fir (*Abies grandis*), Rocky Mountain maple (*Acer glabrum*), western paper birch (*Betula papyrifera*), and aspen (*Populus grandidentata*) can also be found (Hebner et al. 2000). Among the pines and in dry, rocky areas, a variety of shrubs occur, including mallow ninebark (*Physocarpus malvaceus*), creeping Oregon grape (*Berberis repens*), elderberry, chokecherry, snowberry, deer brush (*Ceanothus sanguineus*), and red-stem ceanothus (*Ceanothus velutinus*) (Hebner et al. 2000). Dominant grassland species include bluebunch wheatgrass, Idaho fescue, and pinegrass (Hebner et al. 2000; LRF 2006b).

Threatened plant species reported within the area include the little bluestem (*Schizachyrium scoparium* var. *scoparium*) and the Palouse milk-vetch (*Astragalus arrectus*) (WDNR 2006). An endangered plant species reported in the area is the Columbia crazyweed (*Oxytropis campestris* var. *columbiana*) (WDNR 2006). Other reported plant species include a number whose decline is a matter of concern to the state. These species include fuzzytongue penstemon (*Penstemon eriantherus* var. *whitedii*), the least bladderly milk-vetch (*Astragalus microcystis*), and the Nuttall's pussy-toes (*Antennaria parvifolia*) (WDNR 2006).

3.3.3 Habitat

Map 3-7 shows the areas near or within the Site that have been listed by state or federal resource agencies as priority habitat (WDFW 2006) or wetlands (USFWS 2006), or have been identified as other endangered habitat in close proximity to the UCR banks at full pool.

4 ASSESSMENT OF CHEMICAL SOURCES

This section provides an overview of the known and potential chemical sources in the vicinity of the study area. The information presented here is intended to be a summary; it is not a definitive discussion of all possible sources of chemicals to the study area.

4.1 MINE, MILL, AND SMELTING OPERATIONS

Ore mining and mineral processing has been occurring in the UCR region, in both the U.S. and Canada, since at least the late 1800s. Most of the operations in the U.S. took place in Stevens and Ferry counties (Orlob and Saxton 1950; Wolff et al. 2005). Mining activities in the drainage basin also occurred in the Metaline mining district in Pend Oreille County, Washington. The locations of the mines and mills in the UCR drainage basin, including that north of the border, and along tributaries to the UCR are shown in Map 4-1. As part of the Upper Columbia River Expanded Site Inspection conducted by EPA in 2001 and 2002, EPA collected sediment samples and visited a number of U.S. mine and mill sites in the northern portion of the study area, including mines and mills along tributaries to the UCR, plus several additional mines and mills located along the Pend Oreille River to the east.

The expanded site investigations (see list below) and the Phase 1 remedial investigation (EPA 2006e) documented sediment contamination along the Upper Columbia River Site from the U.S.-Canada border to the Grand Coulee Dam. Based on these results, the EPA concluded that both the smelter in Trail, British Columbia, and the former Le Roi Smelter in Northport, Washington, are sources of contamination to the UCR Site; however, the Trail smelter was identified as the “primary source of contamination” (EPA 2003b). The mines and mills along the tributaries to the UCR were not identified as current sources of contamination to the Site.¹² The mines and mills in the drainage basin may be investigated in the future if anomalous and significant contaminant concentrations (relative to risk) are found at confluences of tributaries with the UCR and a potential upstream source is suspected. With the exception of the Spokane River, Phase 1 sediment sampling by EPA (2005) near the mouth of selected major UCR tributaries did not identify the presence of notably elevated COI concentrations indicative of major watershed sources of contamination from historical mine and mill sites.

¹² Some of these mines and mills had localized contaminant concentrations that met EPA requirements for time-critical and non-time-critical removal actions. The following sites have been addressed under EPA’s removal program: Anderson-Calhoun Mine and Mill, Bonanza Mill, LeRoi Smelter, Colville Post and Pole, and Cleveland Mine and Mill. The Josephine Mill No. 1 and Grandview Mine and Mill are currently being addressed under EPA’s removal program.

Summaries of the findings and recommendations of the EPA expanded site investigation are provided in the following reports:

- EPA 2001c (2001 Sediment Investigation Trip Report, Upper Columbia River/Lake Roosevelt Expanded Site Inspection. December 2001. Prepared by Roy F. Weston Inc. for EPA Region 10, Seattle, WA).
- EPA 2002f (Preliminary Assessments and Site Investigations Report, Lower Pend Oreille River Mines and Mills, Pend Oreille County, Washington. April 2002. Prepared by Ecology and Environment, Inc. for EPA Region 10, Seattle, WA).
- EPA 2002g (Preliminary Assessments and Site Inspections Report, Upper Columbia River Mines and Mills, Stevens County, Washington. October 2002. Prepared by Ecology and Environment, Inc. for EPA Region 10, Seattle, WA).
- EPA 2003b (Upper Columbia River Expanded Site Inspection Report, Northeast Washington. March 2003. Prepared by Ecology and Environment, Inc. for EPA Region 10, Seattle, WA).
- EPA 2004g (Hecla Knob Hill Mine Site Inspection Report, Ferry County, Washington. July 2004. Prepared by Weston Solutions, Inc. for EPA Region 10, Seattle, WA).
- EPA 2004h (South Penn Mine Site Inspection Report, Ferry County, Washington. September 2004. Prepared by Weston Solutions, Inc. for EPA, Region 10, Seattle, WA).
- EPA 2004i (Mountain Lion Mine Site Inspection Report, Ferry County, Washington. September 2004. Prepared by Weston Solutions, Inc. for EPA, Region 10, Seattle, WA).

The following subsections provide summary information for the Teck Cominco Metals Ltd. facility in Trail, British Columbia, and the former Le Roi Smelter in Northport, Washington

4.1.1 Trail, British Columbia, Teck Cominco Facility

The Teck Cominco facility in Trail, British Columbia, is located on the Columbia River approximately 10 miles upstream from the U.S.-Canada border. Smelter operations have been underway in Trail since 1896 (G3 Consulting 2001a). The original facilities were built in 1896 to smelt copper and gold ores from the Rossland Mines (G3 Consulting 2001b). Onsite operations were designed to separate gold and copper thermally from gold ores mined. At that time, roasting technology was crude and limited to the heap method. The ore was piled up with cordwood and limestone intermixed and set aflame. With such crude processes, the smelter was capable of producing a matte of 50 percent pure copper (i.e., industrially worthless until further refined), while the lead, which was prevalent within local ores, could not be extracted. As a result, further refining was required at Heinze's refinery in Butte, Montana (www.crownsnest-highway.ca). The Spokane Falls & Northern Railway company was reluctant to transport the copper matte and offered an alternative to surrounding area mining

companies willing to construct a smelter in Northport, Washington. The owners of the Le Roi Gold Mining Company of Spokane registered in the state of Washington in August 1897, and the Le Roi smelter was operational by February 1898 (www.crowsnest-highway.ca).

The resulting competition (i.e., lack of ore and manpower) temporarily halted smelting operations in Trail. On March 1, 1898, the Canadian Pacific Railway negotiated the purchase of the Trail smelter and associated railway rights and immediately began modernization activities. By July 1898, the facility, under the name Canadian Smelting Works, was tied into the West Kootenay power grid and by December of that year smelting operations were underway (Cominco 2000). As the number of lead mines within the surrounding area (i.e., Canada and the western U.S.) grew, the decision was made in 1901 to broaden the smelter's base and include lead furnaces. The new furnaces were unsophisticated, however, and until 1902 the resulting impure bullion was transported to the American Smelting and Refinery Company's plant in Tacoma, Washington, for further processing. With the development of the Betts electrolytic process in 1902, the facility was able to produce pure lead, fine silver, and gold. Recognizing the value of securing a source of ore and concentrate, Canadian Smelting Works began working toward the consolidation of surrounding area mines with the smelting facility. This consolidation process culminated in 1906, and the Canadian Smelting Works became known as the Consolidated Mining and Smelting Company of Canada (www.crowsnest-highway.ca). Zinc production began in 1916. By 1925, the facility consisted of a complex of structures housing a lead plant, an electrolytic zinc plant, a foundry, a machine shop, and a copper-rod mill (www.crowsnest-highway.ca). Fertilizer plants were built at the Trail smelter in 1930, facilitating the production of both nitrogen- and phosphorus-based fertilizers (MacDonald 1997). The facility constructed and operated a heavy water plant from 1944 to 1955 (www.crowsnest-highway.ca).

The smelter was officially renamed Cominco in 1966 (G3 Consulting 2001b). In addition to lead, zinc, cadmium, silver, gold, bismuth, antimony, indium, germanium, and arsenic, the Cominco facility also produced sulfuric acid and liquid sulfur dioxide. Ammonia, ammonium sulfate, and phosphate fertilizers were produced at the plant until August 1994, at which time production of the phosphate-based fertilizer was terminated (MacDonald 1997).

Major current operations at the facility include primary smelting of zinc and lead concentrates and secondary smelting for production of a variety of metal products (e.g., antimony, bismuth, cadmium, cobalt, copper, germanium, gold, indium, mercury, silver, and thallium), arsenic products, granular and crystallized ammonium sulfate fertilizers, sulfur, sulfuric acid, sulfur dioxide (SO₂), and ferrous granules (i.e., granulated slag) (EPA 2003b).

While information regarding releases at the Teck Cominco Trail facility prior to the 1970s has not been provided, known discharges and emissions from the Trail facility, historic and current, that have relevance to the UCR Site include but are not limited to:

- Discharges of granulated slag to the Columbia River

- Liquid effluent discharges to the Columbia River
- Atmospheric emissions (stack and fugitive)
- Potential discharges to the Columbia River via groundwater migration from under the smelter and from surface water runoff
- Accidental spills and releases to the Columbia River from Trail facility operations

These emissions are described in the following subsections. More information about Trail facility operations and current processes is provided in Appendix D.

4.1.1.1 Slag

Granulated fumed slag is a byproduct of the smelting furnaces at the Trail facility. Slag is the primary solid-phase byproduct that was discharged directly to the Columbia River. Slag consists predominantly of sand-sized glassy ferrous granules which contain various quantities of trace and major metals. Potential environmental effects of slag discharged to the river include both chemical effects (increased metal loads, potential bioaccumulation, toxicity problems in biota) and physical effects (scouring of plants and animals from river substrates, damage to soft tissues of aquatic insects and fish, smothering of habitat) (G3 Consulting 2001b; Nener 1992; WDOH 1994; Columbia River Integrated Environmental Monitoring Program [CRIEMP] 2005; Cominco 1996).

According to a summary report prepared by consultants to Cominco, the routine discharge of slag into the Columbia River was discontinued in mid-1995. Prior to this, up to 145,000 tons of slag had been discharged annually. Appendix C presents a preliminary sediment transport analysis evaluating various size fractions of granular slag, using historical flow and river/reservoir stage information. The preliminary analysis demonstrates that slag materials representing a range of grain sizes (silt to pebbles) may be transported downstream a considerable distance (Marcus Flats and beyond). This slag will settle out in slower-flowing reaches and localized hydrodynamically sheltered areas along the river (G3 Consulting 2001a). EPA has estimated at least 23 million tons of granulated fumed slag was discharged into the Columbia River (EPA 2006e). Currently, Cominco slag is stockpiled onsite while awaiting purchase (G3 Consulting 2001a; MacDonald 1997) or is sold and transported offsite (TCAI 2008) under the product name "ferrous granules." Sales to the cement industry are the primary outlet for barren slag from Trail Operations. However, there are many sources of iron available to the cement industry, and this competitive market limits the ability of Trail Operations to sell all the barren slag it produces. For the past few years, production has exceeded sales of ferrous granules, and this has led to a net accumulation of the material at Trail Operations. In 2001, to alleviate an inventory backlog created when the specification for cement industry customers became more stringent, Teck Cominco applied for and was granted permission to transport up to 225,000 tonnes of barren slag material to the tailings pond at Teck Cominco's Kimberly Operations. This tailings pond, which spans approximately 140 acres (63 hectares), arose from many decades of milling and flotation of ores from

Kimberley's Sullivan mine. In 2003, approximately 58,000 tonnes of off-specification barren slag were moved to Kimberley by truck. At the end of 2003, approximately 180,000 tonnes of ferrous granules were stored in Trail awaiting sale to customers (Teck Cominco Metals Ltd. 2003).

4.1.1.2 Effluent

Historically, wastewater effluent from the Cominco facility has been discharged to the Columbia River through five outfalls: one outfall from the Warfield Fertilizer Operation, three submerged outfalls from the metallurgical plants, and one from the slag launder system. The average discharges for dissolved metals from 1980 to 1996 were as high as 18 kilograms per day (kg/d) of arsenic, 62 kg/d of cadmium, 200 kg/d of lead, and 7,400 kg/d of zinc. Additionally, fertilizer plant operations contributed up to 4 kg/d of total mercury and 350 kg/d of dissolved zinc (Cominco 1997).

4.1.1.3 Stack Emissions

Atmospheric sulfur emissions historically have been a significant component of facility stack emissions, due to the sulfide-bearing ores (e.g., galena [PbS] and sphalerite [ZnS]) that make up the primary input (i.e., feedstock) to the Trail facility. Historically, the Cominco smelter discharged sulfur dioxide into the air through a brick stack 409 feet high. The air pollution traveled south and remained trapped in the northern Stevens County, Washington, Columbia River Valley. In 1925, the Trail Smelter increased the discharge of sulfur dioxide into the air from 4,700 to 10,000 tons a month. The citizens of Northport complained that sulfur pollution was threatening their health and environment. They formed a "Citizens Protective Association" of farmers and property owners who sent letters of protest to politicians in both Ottawa and Washington. The matter, known as the Trail Smelter Case of 1926 to 1934, was the first case of air pollution brought before an international tribunal (Northport Pioneers 1981).

The Canadian government suggested that the fumes problem should be placed on the agenda of the International Joint Commission (IJC). The IJC did not consider the case until 1928. In 1931, the IJC recommended that the Canadian government stop polluting the atmosphere and pay damages assessed against the corporation in the amount of \$350,000. The U.S. government, speaking for all of the claimants, refused to accept the \$350,000 award, and asked that the case be reexamined by an arbitration tribunal. In 1935, President Franklin D. Roosevelt formally announced that the Treaty of Arbitration was in effect (Northport Pioneers 1981). The tribunal was constituted under, and its powers derived from and limited by, the Convention between the United States of America and the Dominion of Canada signed at Ottawa in 1935, also termed "The Convention" (Cloutier 1941). In 1938, the appointed members of the tribunal announced their decision assessing an additional \$78,000 in damages for injuries sustained from 1932 to 1937. They also decided that a regime or measure of control should be applied to the operations of the Trail Smelter and should remain in full force unless and until modified in accordance with the amendment or suspension of the regime. The tribunal also decided that

no damage caused by the Trail Smelter in Washington State occurred with respect to the period from October 1, 1937, to October 1, 1940 (Cloutier 1941).

Reductions in SO₂ emissions were achieved in 1931 due to the construction of the Warfield Fertilizer plant, which absorbed and scrubbed SO₂ from stack emissions for the production of fertilizer, and the termination of copper smelting that year.

The first air emission permits were issued to the facility on September 9, 1975, and covered all onsite operations at that time (i.e., fertilizer, lead, and zinc operations). Current permits require continuous monitoring of SO₂, particulates, lead, zinc, and cadmium in several stacks. In addition, the facility monitors ambient air quality at stations within and around the facility and the surrounding area. Each station is monitored for SO₂, total particulate matter, and trace metals. Active facility permits include several stack emissions monitoring requirements (e.g., continuous monitoring of SO₂, particulates, lead, zinc, and cadmium). Other permits addressing air, waste storage, and landfills have been issued by the B.C. Government to the facility. A summary of existing facility permits/licenses is presented in Table D1-6 with detailed copies in Attachment D1-2.

In 1977, Cominco began a modernization program consisting of numerous projects that continued through the 1980s and 1990s. Some examples of these projects included controlling spills and dust, building a new lead smelter, installing air emissions controls, eliminating discharge of slag, replacing the phosphate plant with an ammonium sulfate fertilizer production operation, and reducing effluent discharges.

WDOH (1994) concluded from air quality simulation modeling performed by Ecology that Trail Smelter pollutants could move down the Columbia River Valley and produce moderately high (24-hour average) pollutant concentrations in the Northport area. In addition, in 2003, the Area-wide Soil Contamination Task Force (ASCTF) estimated the extent of lead and arsenic contamination that might be associated with air emissions from the Trail and Le Roi smelters (ASCTF 2003). This estimate was based on observations of smoke and the maximum extent of injury to trees from sulfur dioxide documented in 1929. The map (Figure 4-1) shows the area of soil potentially impacted by air emissions to include the UCR Site as far south as Kettle Falls. The defined area of potential impact from both smelters is influenced by the local topography. The deep valley of the Columbia River where the smelters are located provides a channel that influences air dispersion, in part by limiting wind direction along the axis of the river, with the prevailing winds carrying smoke from Trail down the Columbia River valley past Northport.

4.1.1.4 Groundwater Discharge

In 2001, Cominco initiated a groundwater investigation of the Trail Smelter Facility as part of their ongoing work to inventory and characterize potential sources of contamination to the environment. The purpose of the investigation was to obtain an estimate of the quantities of

dissolved metals and other substances discharging into the Columbia River, via groundwater, from under the smelter. The investigation consisted of the installation and testing of 18 groundwater monitoring wells at eight locations, including five along the bank of the Columbia River. The investigation found evidence of groundwater contamination (Cominco 1998). Additional work conducted as part of the groundwater investigation at the smelter site included installation of five more monitoring wells in 2002 to allow a more complete assessment of the contaminant loadings to the Columbia River. Additionally, regional groundwater investigations were begun to identify surface water drainages in the Cominco area that may be affected by contaminated groundwater discharge (Teck Cominco Metals Ltd. 2003). It is not known to what degree this contaminated groundwater discharge may impact surface water quality in the Columbia River.

4.1.1.5 Electronic-waste Management

In 2005, a pilot-scale study was conducted at the Trail facility to assess the feasibility of initiating an electronic waste (e-waste) recycling program, wherein the plastics and woods associated with e-waste would serve as reducing agents for the fuming furnace. The plastics and wood are consumed in the furnace as chemical reductants, liberating carbon dioxide and water vapor. In addition, and critical to the overall processing of e-wastes, is the effective treatment of plastic components because these materials may form organic pollutants such as dioxins/furans, polycyclic aromatic hydrocarbons (PAHs), and polybrominated diphenyl ethers (PBDEs) when burned. The pilot-scale study was conducted over a period of 13 days at the No. 2 slag fuming furnace associated with onsite lead operations.

Strict environmental monitoring was conducted at all potential discharge points, including stacks (gases and particulates), effluents (C-III outfall), and ambient air. Monitoring results showed that emissions of regulated persistent organic pollutants were comparable to baseline levels. Specifically, emissions from the No. 2 fuming furnace were lower than Environment Canada's level of quantification for dioxins/furans (i.e., 32 picograms [pg] toxicity equivalent [TEQ] per dry standard cubic meter [dsm³]), while the production-based release of PAHs was significantly lower than the National Pollutant Release Inventory (NPRI) reporting threshold. Given the success of pilot-scale studies, the British Columbia Ministry of Environment (B.C. MoE) issued a one-year temporary permit to conduct an e-waste recycling program. Based on the positive environmental performance of the one-year program, the B.C. MoE will issue a new permit to the Trail facility for e-waste recycling.

Additional details about e-waste processing and recycling are provided in Appendix D2.

4.1.1.6 Accidental Spills and Releases, Permit Exceedances, and Variances

The Trail facility has historically and recently experienced a number of accidental spills into the Columbia River. According to records obtained from Environment Canada's spilltracker database and the B.C. MoE, chemicals released since 1983 include a variety of metals and

metalloids, nutrients, slag, suspended soils, and oils (Table 4-1). Information about spills prior to 1983 is not readily available, but releases of similar (and potentially additional) chemicals are expected to have occurred periodically over the history of Trail operations. Information regarding permit limit exceedances and variances is maintained by regulatory agencies in Canada.

4.1.1.7 Other Potential Teck Cominco Trail Facility Sources

Other potential chemical sources associated with the Trail facility include its materials management operations, PCBs, and other nonpoint sources (e.g., releases via Stoney Creek), which are discussed below.

Materials Management: Of the 14 permits currently held by the Trail facility (Table 4-2), four are related to management and storage of solid materials (e.g., slag and arsenic) that may be related to COIs for the UCR Site.

PCBs: Since the late 1970s, PCB equipment (e.g., electrical transformers) has been phased out and the equipment has been destroyed at approved hazardous waste management facilities such as the Swan Hills Treatment Centre in Alberta. All PCB equipment and/or PCB-containing wastes have been removed from the Trail facility. As a result, it is PCB-free and the existing permit (Permit No. 08443) will no longer be required nor renewed. Further investigation may be required to identify information on PCB releases and disposal at the Trail Facility.

Non-point Sources: Stoney Creek, located just upstream of the Cominco smelter near RM 755, has also contributed chemicals to the Columbia River (Teck Cominco 1998). Cominco's 1997 environmental report identified Stoney Creek as a significant contributor of contaminants to the Columbia River (Cominco 1998). MacDonald (1997) identifies Stoney Creek as the single largest source of dissolved arsenic, cadmium, and zinc to the Columbia River. Stoney Creek concentrations in 1995 exceeded the permitted levels for the Trail facility's metallurgical sewers. The Stoney Creek watershed is affected by Teck Cominco's past waste dumping and storage activities, which contributed metal-laden drainage from seepage and surface runoff. This stream also received runoff from the urban area and a municipal landfill. Water and sediment in Stoney Creek contained elevated arsenic, cadmium, copper, lead, and zinc levels compared to other tributaries prior to 1997. In 1997 and 1998, a seepage collection system along the banks of Stoney Creek was designed and constructed to redirect drainage containing zinc, cadmium, and arsenic to the effluent treatment plant. Stoney Creek metal levels in both water (loads, calculated as concentration multiplied by flow) and sediment were reportedly reduced substantially between 1995 and 1999, with the exception of copper levels, which increased in sediment (G3 Consulting 2001b). In addition, in 2003 and 2005, two significant sources of contaminant seepage into Stoney Creek were addressed. A closed industrial landfill was capped in 2003 with an engineered, low-permeability, composite clay and synthetic membrane; in 2005, a permanent storage system was created for arsenic-contaminated wastes

using a low-permeability double liner at the base of the material and membrane cap. These two source control measures have improved water quality within Stoney Creek. For example, average zinc concentrations in Stoney Creek declined from 26 milligrams per liter (mg/L) in 1995 to 6.2 mg/L in 1999; average arsenic concentrations declined from 2.0 to 0.9 mg/L during the same period, and copper concentrations from 16 to 6.3 micrograms per liter ($\mu\text{g/L}$) (Table I.30 in Golder Associates 2003).

Possible contributions of chemical from other non-point sources on the Trail facility have not been evaluated. However, surface soil, stormwater, and groundwater data from the facility are available for review.

4.1.2 Le Roi/Northport Smelter

The Le Roi/Northport Smelter (Le Roi) is a former smelter located approximately 7 river miles downstream of the U.S.-Canadian border in Northport, Washington. The Le Roi Smelter property encompasses approximately 32 acres and is accessed from the Northport-Waneta Road via Highway 25 (Science Applications International Corp. [SAIC] 1997). The former smelter operations area occupies approximately the eastern two-thirds of the site, and a former lumber mill occupies the remaining portion. The smelter buildings, which are no longer standing, included the furnace building, the roaster building, and the crusher and ore building (Heritage 1981).

In 1892, D.C. Corbin, owner of the Spokane Falls and Northern Railroad, built a rail line to reach the town of Northport, then consisting of a lumber mill and several tents. The railroad tracks were located adjacent to the Le Roi site. In 1896, Mr. Corbin donated the site to the Le Roi Mining and Smelting Company for the construction of the Breen Copper Smelter. In 1896, the Breen Copper Smelter began refining copper and gold ores from mines in northeast Washington, as well as copper ore from B.C., for the Le Roi Mining and Smelting Company. In 1901, the Le Roi Company smelting operations reorganized with the Red Mountain smelting operations to become the Northport Smelting and Refining Company (Northport Pioneers 1981).

The copper and gold ore was processed by heap roasting, which involves open burning of the raw ore prior to placing it in a furnace. A slag brick platform was used for the initial burning, or heap roasting, of the ore. Burned ore was placed in a furnace that produced iron and slag waste. Some of the waste was formed into slag bricks that were then used as construction materials for onsite as well as offsite buildings. The gold and copper concentrate was shipped off the site by rail for further refining. At the peak of operation, the Le Roi Smelter processed 500 tons of ore per day; operations were suspended in 1909. In 1914, the Le Roi Smelter reopened to process lead ore from Leadpoint, Washington, to meet government demand during World War I. Lead smelting operations during this period produced up to 30 tons per day of airborne sulfur emissions (Weston 2004b). Slag was the main byproduct of smelting operation at the site. This material was sorted in piles on the site or discharged directly to the

river via underground launders (EPA, 2004b). Operations ceased permanently in 1921, and the smelter site remained inactive until 1953. The furnace, roaster, and crusher and ore buildings were removed from the site during this period of inactivity. From 1953 to 2001, the western portion of the site was used as a lumber mill; no wood treatment or chemical use was reported for this period of operation (Weston 2004b).

Emissions from the Le Roi facility that have potential relevance to the UCR Site include:

- Discharges of slag to the Columbia River
- Drainage to the Columbia River from seepage and surface runoff of materials stored onsite
- Stack emissions
- Effluent discharge and accidental spills

From 1993 to 2004, the EPA conducted preliminary assessments, site inspections, and a removal site evaluation. Northport residential and commercial properties were identified in 2003 and 2004 for a removal action. Removal assessment activities included sampling of residential and commercial properties in and around the Northport community, sampling of public areas, and collecting drinking water samples from residents. All sampling results were compared to regulatory levels provided by the State of Washington Department of Ecology (Ecology) for response actions conducted at Northport (Weston 2005).

A removal action was conducted on the Le Roi property and in the town of Northport by EPA in 2004 (Weston 2004b; Weston 2005). Contaminated soils were consolidated at the smelter site (11-acre area), covered with a polyethylene sheet and clean soil, and vegetated.

4.2 ADDITIONAL POTENTIAL CHEMICAL SOURCES

As part of the RI, the potential for contaminants of concern reaching the Upper Columbia River Site from the industrial and non-industrial discharges identified below may also be investigated if significant anomalous occurrences or distributions of chemicals are detected during the course of the RI/FS at concentrations that exceed background or risk-based screening levels.

4.2.1 Pulp Mill Operations

The Zellstoff Celgar Ltd. (Zellstoff) bleached kraft pulp mill is located in Castlegar, B.C., approximately 30 river miles upstream of the U.S.-Canada border. Prior to Zellstoff's acquisition of the pulp mill in February of 2005, the pulp mill was operated by the Celgar Pulp Company (Celgar). From 1961 until mid-1993, the mill primarily used chlorine in its bleaching process. The pulp mill discharged effluent containing chlorinated organic compounds, including dioxins and furans, into the Columbia River (USGS 1994). As a result of health implications of dioxin and furan levels in fish downstream of pulp mills, the provincial and

federal governments initiated fish sampling in the Columbia River from 1988 to 1990 as part of a nationwide survey. Levels in a variety of species downstream of Celgar, including rainbow trout, showed low or normal background levels of contamination, with the exception of whitefish, which showed levels above background. In response to these findings, a consumption advisory was issued by the local Medical Health Officer recommending that consumers of whitefish caught in the vicinity of the area of Hugh Keenlyside Dam to the U. S.-Canada border limit their consumption to one meal per week. The 1990 whitefish consumption advisory prompted voluntary changes to the mill's bleach plant to reduce chlorinated furan (i.e., 2,3,7,8-tetrachlorodibenzofurans) effluent discharges into the Columbia River (CRIEMP, 2005).¹³

As a result of pulp process effluent discharges, a fiber mat formed downstream of Celgar's outfalls. Fiber mats often form when effluent containing wood debris and pulp fibers is discharged into an aquatic environment and then settles to the substrate and accumulates. While fiber mats are readily degraded by microorganisms (producing ammonia and hydrogen sulfide byproducts), they often contain persistent chemicals from pulp production and bleaching processes. Persistent chemicals documented in other fiber mats have included PAHs, tetrachlorodibenzo-*p*-dioxins, and heavy metals (USGS 1994).

Plant modernization in 1994 included the installation of a chlorine dioxide bleach plant and a secondary treatment system for process effluent. Following modernization of the mill, discharges of chlorinated organic chemicals were reduced from 2,755 to 330 kg/d, and polychlorinated dibenzo-*p*-dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs) were undetectable in the waste stream (EPA 2004e). A fiber and fly ash recovery system was also implemented that subsequently led to the reduction of the fiber mat located downstream of the process outfalls, and the recovery boiler previously responsible for high reduced-sulfur emissions was decommissioned, resulting in lower sulfur releases and improved air quality (EPA 2004e). The Zellstoff mill has reported annually to the NPRI since at least 1994; reported releases include surface water discharges of ammonia and air releases of chlorine, chlorinated compounds, methanol, and sulfuric acid (Environment Canada 2007).

4.2.2 EPA Toxics Release Inventory Sites

The Toxic Release Inventory (TRI) is a public database dating from 1988 that contains information regarding toxic chemical releases, transfers, and other waste management activities associated with U.S. facilities. Industrial sources and the associated chemicals based on TRI information (from 1996 to 2005) from Stevens, Ferry, and Lincoln counties are listed in Table 4-3; the locations of those in the vicinity of the study area are shown on Map 4-2. As

¹³ Fish advisories have also been issued for the consumption of walleye, whitefish, and sturgeon from Lake Roosevelt due to mercury and dioxin concerns (WDOH 2002). The health advisory for mercury in these fish is a state-wide advisory.

shown in Table 4-3, releases by industries over the reporting period have included air and/or land releases of metals, ammonia, chlorine compounds, and volatile compounds.

4.2.3 Water Quality Discharge Permitted Sites

Additional releases of COIs may have occurred or continue to occur as industrial stormwater or wastewater discharges to the UCR and its tributaries. Discharges to surface waters are regulated by the Clean Water Act. The administration of discharge permits through the National Pollutant Discharge Elimination System (NPDES) program in Washington has been delegated to Ecology.

Ecology's Water Quality Permit Life Cycle System (WPLCS) database contains information on all facilities with regulated discharge permits, which stipulate specific limits and conditions of allowable discharge that may impact surface water quality. Locations of current permitted facilities in the vicinity of the UCR are illustrated in Map 4-3, and are listed in Tables 4-4 and 4-5. The information in Table 4-4 is organized by water resource inventory area (WRIA), and provides an overview of facility types discharging to several of the watersheds that ultimately drain to the UCR. Discharges from some permitted sites are also reported to the TRI, discussed above. Discharge water quality monitoring results for current permits are available from Ecology but are not presented here.

4.2.4 Municipal and Non-point Sources

A variety of municipal and non-point sources are potentially relevant to the UCR Site, including:

- Municipal wastewater treatment plants that discharge into the Colville, Sanpoil, Spokane, and Pend Oreille rivers
- Municipal wastewater treatment plants in Castlegar and Trail that discharge into the Columbia River
- Point and non-point sources along the Spokane River
- Agricultural runoff of nutrients and pesticides to surface water

5 ENVIRONMENTAL CONDITIONS

This section describes selected media and biota which help to characterize environmental conditions at the UCR Site and provides a review of the previous investigations conducted in the UCR vicinity with respect to chemical concentrations in surface water, sediment, fish tissue residue, and air quality. Information regarding chemical concentrations in upland and floodplain soils, groundwater, aquatic vegetation, or within the tissues of other benthic or pelagic organisms (e.g., mussels, zooplankton) are limited; where available, such information will be presented and evaluated in the BERA Work Plan.

5.1 OVERVIEW AND DATA EVALUATION APPROACH

This section provides the initial identification of data gaps. During SAP development, the data presented in this chapter along with data from other studies relevant to the RI/FS, will be more thoroughly evaluated through subsequent technical discussion with experts familiar with the UCR and the studies. The DQO process will be used to determine appropriate use of data in the RI/FS. It is expected that preliminary statements and analyses in this section (especially regarding data quality and preliminary data interpretation) may be modified during and following the SAP development process.

Along with information presented in Sections 4 and 6, this discussion of findings from past studies and monitoring efforts will serve as a primary basis supporting the identification of major data gaps and development of anticipated data collection activities described in Sections 7 and 8 of this Work Plan. Information from selected U.S. and Canadian studies and monitoring programs is presented. Data collection activities occurring north of the U.S.-Canadian border, although technically outside of the defined extent of the UCR Site, are valuable for understanding temporal and spatial variability in chemical concentrations in various UCR media and biota.

5.2 SURFACE WATER QUALITY

This section addresses surface water quality in the UCR with an emphasis on hydrologic conditions since 1973, when the last of the major flow-regulating upstream dams were completed. Past studies have evaluated a variety of water quality parameters including temperature, nutrients, conventional water quality parameters (e.g., alkalinity, hardness, pH), and metals. A brief summary of these parameters is presented first, followed by a discussion of metals. Only limited data are known to exist for organic compounds in UCR surface water. No discussion of organic compounds in UCR surface water is presented here.

5.2.1 Temperature

Temperature conditions of Lake Roosevelt have not substantially changed since the 1970s according to available data. Ecology routinely monitors water quality parameters, including water temperature, immediately upstream from Lake Roosevelt (Station 61A070 at RM 735.1) and immediately downstream from the reservoir (Station 53A070 at RM 596.0). In addition, USBR installed temperature loggers at various depths in the Grand Coulee forebay in August 1998.

Figure 5-1 provides an example of temperature conditions in Lake Roosevelt and the changes that occur from the U.S.-Canadian border to the Grand Coulee Dam forebay. This information shows approximately a 30- to 40-day shift in the comparable water temperatures between the border and the dam forebay.

5.2.2 Dissolved Oxygen

The relatively constant and substantial flow of water through Lake Roosevelt, together with the lake's generally low biological productivity, apparently prevent greatly reduced oxygen levels in the hypolimnion, according to the available data. Seattle Marine Laboratories (1974) measured dissolved oxygen concentrations at multiple depths at three reservoir locations (Kettle Falls - USGS RM 703, Castle Rock - USGS RM 644, and Pine Tree Point - USGS RM 600) from April through October 1973. Dissolved oxygen was almost always greater than 10 mg/L and at or above saturation in April and May, but was lower in June through August at 6 to 9 mg/L.

In 1976, Stober et al. (1977a) found that dissolved oxygen levels in the Lake Roosevelt forebay were generally greater than saturation. Stober et al. (1981) also measured reduced dissolved oxygen levels near the reservoir bottom in the Spokane Arm during the summer of 1980. Dissolved oxygen levels as low as 49 percent of saturation were measured at the bottom in August.

Higher summertime temperatures and the presence of biodegradable organics can result in lower dissolved oxygen levels due to microbiological oxygen uptake. This is not uncommon and, based on available data, appears to occur in some locations within the UCR. In 2000, Lee et al. (BPA 2004a) measured dissolved oxygen levels of 2.6 mg/L near the bottom in the Spokane Arm. They attributed the low levels to decomposition of summer algal biomass. They reported that the vertical distributions of dissolved oxygen levels were otherwise relatively uniform and near saturation. More recently, Fields et al. (BPA 2004b) reported that dissolved oxygen levels in the Spokane Arm in September reached a low of 6.3 mg/L. They also measured low dissolved oxygen near the bottom at the Spokane Arm's Porcupine Bay of 3.9 mg/L in August and 3.3 mg/L in September. In 2003, the STI monitoring program (BPA 2005a) measured dissolved oxygen concentrations of less than 5 mg/L at Porcupine Bay from July to August, with a rebound to 7 mg/L by September.

5.2.3 Nutrients

Nutrients and light are the basic requirements for growth and reproduction of phytoplankton (i.e., floating algae) and periphyton (i.e., attached algae), the base of the aquatic food web in Lake Roosevelt. Phosphorus, in the form of phosphate, and nitrogen, most importantly as nitrate, are the nutrients that most often limit this primary productivity in freshwater environments. The Trail plant began producing ammonium phosphate fertilizers in the 1930s, resulting in the discharge of soluble waste gypsum containing phosphate (Kenyon and Glover 1994). Nutrient reductions in effluent from the plant began in the 1980s, and releases of phosphate ended in the summer of 1994 (Kenyon and Glover 1994; Wilson et al. 1996).

Other sources of nutrient loading include effluents from municipal wastewater treatment systems. The largest of these is the City of Spokane's, which discharges into the Spokane River just downstream from the city. The City of Spokane constructed its first primary sewage treatment plant in the late 1950s, and the plant was later identified as a major source of nutrients causing eutrophication¹⁴ in Long Lake and the Spokane River (City of Spokane 2006). Advanced wastewater treatment began in 1977 with 85 percent removal of phosphorus. Further reductions in nutrient loading were accomplished in the 1980s by eliminating 85 percent of the combined sewer overflows discharging to the Spokane River. A 1990 statewide ban on selling phosphate detergents in Washington likely also reduced loading from many wastewater facilities in the watershed.

Wilson et al. (1996) conducted three intensive surveys in Lake Roosevelt in 1994 and again in 1995 at nine sampling sites between Grand Coulee Dam and Evans Landing (USGS RM 713; see Map 5-1). Lower phosphorus concentrations compared to previous surveys were attributed to effluent reductions at the Trail fertilizer plant. Total phosphorus ranged between 0.002 and 0.025 mg/L, and averaged only 0.009 mg/L, while most orthophosphorus concentrations were at or below the 0.001 mg/L detection limit. Lake Roosevelt nitrate levels followed the same spatial and seasonal patterns and were within the ranges reported from past investigations (Welch et al. 1992; Stober et al. 1981; USBR 1985). Nitrate concentrations in 1994 and 1995 averaged 0.125 mg/L in the spring, with biological uptake reducing surface concentrations to an average of 0.028 mg/L during summer (Wilson et al. 1996). Also, similar to previous studies, nitrate concentrations in the Spokane Arm were 4 to 10 times higher than at the main reservoir sampling sites. Wilson et al. (1996) concluded that the limiting nutrient of the phytoplankton populations shifted from being predominantly nitrogen in 1980 to phosphorus during the 1994 to 1995 sampling.

CCT (1999) examined the historical records of nutrient sampling conducted at Northport (RM 735) and the Grand Coulee Dam tailrace of Lake Roosevelt (USGS RM 596). Mean summer total phosphorus concentrations in the early 1980s at Northport ranging from 0.020 to 0.050 mg/L declined to 0.005 to 0.015 mg/L through 1998, except for high flow years in 1991

¹⁴ Eutrophication is the accelerated aging of a lake characterized by an abundant nutrient supply and high productivity of algae or other aquatic plants.

and 1997 when the mean summer concentration was 0.025 mg/L. Total phosphorus concentrations at Grand Coulee Dam showed the same general trend observed at Northport, but with generally lower concentrations. CCT (1999) speculated that the lower phosphorus concentrations may be expected from loss to biological uptake, nutrient cycling, and sedimentation. The decline in mean summer orthophosphate at Northport was sharper and more consistent than the decline in total phosphorus, as would be expected from the elimination of phosphate releases from the fertilizer plant. Limited data showed mean summer orthophosphate concentrations generally between 0.030 and 0.050 mg/L between 1981 and 1990, followed by concentrations consistently less than 0.010 mg/L between 1992 and 1998. Mean summer orthophosphate concentrations at Grand Coulee Dam were 0.010 mg/L or less most years between 1978 and 1998, indicating utilization for primary productivity in the reservoir in the 1980s. CCT (1999) did not see any obvious trends in summer average nitrate concentrations at Northport or Grand Coulee Dam between 1978 and 1998, remaining in the range of 0.035 to 0.085 mg/L. In evaluating the ratios of summer dissolved inorganic nitrogen (DIN) and orthophosphate concentrations, CCT (1999) concluded that phosphorus may have been the nutrient limiting phytoplankton productivity in the 1970s, followed by a near balance between phosphorus and nitrogen limitation, and returning to probable phosphorus limitation since 1993.

5.2.4 Conventional Parameters

The following conventional parameters/analytes are briefly discussed in this section:

- Alkalinity
- Calcium
- Chloride
- Conductivity
- Dissolved organic carbon
- Hardness
- Magnesium
- pH
- Potassium
- Sodium
- Sulfate
- Sulfide

Sources of data used to characterize conventional water quality parameters in the UCR largely include the USGS and its National Water Information System, the EPA's STORET database, Columbia River Integrated Environmental Monitoring Program,¹⁵ and various monitoring studies conducted by TCM in the Columbia River near the Trail facility. In general, the averages of the surface water parameters, representing the period from as early as 1948 to April 2006, were representative of many Pacific Northwest streams subject to extensive precipitation and having low solids and nutrient concentrations (Table 5-1).

Although the conventional analytes differed statistically when comparing stations or years, the overall trends in conventional water quality were similar across the UCR and its tributaries. For example, the average alkalinity over the eight sites represented in Table 5-1

¹⁵ <http://www.criemp.org/>

was 55 mg/L as calcium carbonate, corresponding to the same average alkalinity observed at the Birchbank site (upstream of the Trail facility) (Figure 5-2).

Current concentrations of conventional chemical parameters are reflected in data collected between 2000 and 2006 (Table 5-2).¹⁶ Data are available only for Birchbank, Waneta, and Northport during this time period. Nonetheless, these three stations present the best opportunity to observe any changes upstream and downstream of the Trail facility in conventional water quality. When compared with the complete data set, the 2000 to 2006 average concentrations for Birchbank, Waneta, and Northport are, in general, very similar, but the ranges of values differ (e.g., higher minimum values and lower maximum values). Overall, mean concentrations of conventional surface water parameters, except for pH and hardness, are similar at the three stations: above (Birchbank), directly below (Waneta), and farther below the Trail facility (Northport) (Figures 5-3 through 5-5).¹⁷

5.2.5 Metal and Metalloid Concentrations

The following section summarizes the existing water quality data for metals in surface water upstream of, and within, the UCR. The discussion does not address short-term increases in COI concentrations caused by Trail facility discharges or spills. While this summary primarily discusses reported concentrations, the RI/FS may also assess the significance of mass loading of metals and metalloids to the Site.

5.2.5.1 Data Sources

Surface water chemical data sources include the USGS and its National Water Information System, EPA's STORET database, Environment Canada's federal/provincial water quality monitoring program, and monitoring studies conducted by TCM in the Columbia River near the Trail facility (Table 5-3). Locations of surface water chemical concentration data for the UCR and its tributaries are illustrated in Map 5-2.

It should be noted that the studies and monitoring programs listed in Table 5-3 were conducted for a variety of purposes unrelated to the UCR RI/FS. Consequently, the surface water data presented here may not meet all of the data quality requirements for quantitative evaluations associated with the RI/FS (e.g., risk assessment). However, the data are assumed, for purposes of this Work Plan review, to be of sufficient quality to provide a general understanding about the distribution of chemicals in surface water in the UCR. As the RI/FS progresses, the quality of the existing data will be evaluated in the context of task-specific data quality objectives to determine whether the data can be used for decisionmaking purposes.

¹⁶ The period of 2000–2006 is most representative of current operating conditions for dam operations, industrial activities, and irrigation withdrawals.

¹⁷ The data evaluated in this section from the data set excluded a set of unrealistically high values, which were censored by hand (an example being pH values listed at 48 standard units). Nondetect values were set at the value of the detection limit in calculating summary statistics.

These data quality determinations will be documented in the baseline ecological risk assessment (BERA) work plan and other individual sampling and analysis plans (SAPs) that will be developed during the course of the RI/FS.

5.2.5.2 Distribution of Trail Facility-Related Indicator Metals

Potential sources of metals to UCR surface water related to Trail facility operations include:

- Residual granulated slag deposits located north and south of the U.S.-Canadian border (including floating slag)
- Porewater
- Permitted smelter facility effluent discharges
- Direct discharges from Stoney Creek
- Contaminant spills
- Deposition of Trail-related airborne particulates

EPA believes that metal load contributions from other sources (e.g., LeRoi Smelter) likely represent a much smaller overall contribution to the UCR system than the various source contributions associated with the Trail facility. Based on the Trail facility effluent loading data and permitted discharges, arsenic, cadmium, copper, lead, mercury, and zinc are considered to be primary indicator metals and metalloids released from the Trail facility and are the focus of the surface water discussions below. The permit for Outfall III also allows up to 30 kg/day of thallium.

In this section, metals are characterized as either total or dissolved because each of these forms is important (EPA 1996b). Total metals are defined as the combination of particulate-bound metals (metal bound to particles) and dissolved (often defined as those which pass through a < 0.45-micrometer [μm] filter) metals in water.

Surface Water Metals Concentrations: Birchbank to Northport

A substantial amount of Columbia River surface water quality data is available from Birchbank, which lies approximately 10 km (6 miles) upstream of the Trail facility, and Waneta, located approximately 2.5 km (1.5 miles) upstream of the U.S.-Canadian border and 17 km (10.5 miles) downstream of Trail. In addition, surface water quality data are available from two locations on the Pend Oreille River, at Waneta and at a site further upstream referred to as “the international boundary” (also located in B.C.). The Pend Oreille River flows into the Columbia River downstream of the Waneta sampling location.

Box plots of surface water data from the four B.C. locations were developed for preliminary comparison of total metals concentrations to those measured at Northport from 2001 through 2005 (Figures 5-6 through 5-10). The box plots are based only on detected metal concentrations

so that differences in detection limits do not influence comparisons of metal concentrations between stations, although detection frequencies at the four B.C. sites were very high for all metals evaluated here (mercury data are not available for the B.C. locations during the period 2001–2005). At Northport, however, cadmium and zinc were infrequently detected, although detection limits at Northport were higher than those achieved at the B.C. sites. The following preliminary summary describes apparent trends by metal:

- **Arsenic:** Total arsenic concentrations in the Columbia River at Birchbank and Waneta were comparable (Figure 5-6). Total arsenic concentrations at the two Pend Oreille River sites are approximately 4 to 5 times greater than in the Columbia River at Birchbank and Waneta (Figure 5-6). At Northport, total arsenic concentrations are greater than those measured in the Columbia upstream of the border and less than those measured in the Pend Oreille River (Figure 5-6).
- **Cadmium:** Total cadmium concentrations in the Columbia River at Waneta are approximately two times higher than those measured at Birchbank and in the Pend Oreille River (Figure 5-7). Total cadmium was detected at Northport in only one of 26 samples from 2001 through 2005. The detection limit (0.1 µg/L) was higher than the concentrations detected at the B.C. sites, thus precluding any concentration comparisons between Northport and the upstream sites.
- **Copper:** Total copper concentrations are generally slightly higher in the Columbia River at Waneta than at Birchbank (Figure 5-8). Total copper concentrations in the Pend Oreille River are higher than those measured in the Columbia at Waneta, while copper concentrations at Northport are similar to those measured in the Pend Oreille River or intermediate between those measured in the Columbia at Waneta and the Pend Oreille River (Figure 5-8).
- **Lead:** Total lead concentrations were not highly variable between the B.C. sites and Northport, although concentrations are slightly higher in the Pend Oreille River at Waneta, which in turn are slightly higher than those measured in the Columbia River at Waneta (Figure 5-9). The range in total lead concentrations at Northport tended to overlap more with the range in concentrations measured in the Pend Oreille River at Waneta (Figure 5-9). However, relative magnitudes of the total lead concentrations were not large (less than a factor of two).
- **Zinc:** Overall, total zinc concentrations were higher in the Columbia River at Waneta than upstream at Birchbank, while total zinc concentrations in the Pend Oreille River were intermediate between those measured in the Columbia at Waneta and Birchbank (Figure 5-10). At Northport, total zinc was infrequently detected at a detection limit of 5 µg/L, which is higher than the majority of detected concentrations at the B.C. sites. Thus, it is not possible to adequately compare total zinc concentrations at Northport versus the upstream sites.

Overall, detected total or total recoverable copper and zinc concentrations between 2001 and 2005 were approximately 1.5 to 2 times greater (on average) at Waneta than at Birchbank. For

arsenic, cadmium, and lead, detected total or total recoverable concentrations at Waneta were similar to or greater than concentrations at Birchbank. Detected arsenic, copper, and lead concentrations at Northport are generally greater than those at either Waneta or Birchbank. Metals concentrations measured in the Pend Oreille River were often higher than those measured in the Columbia River at Waneta.

Chemical Concentration Trends at Northport

Aside from the upstream surface water metals data for Birchbank and Waneta, the only surface water sampling location on the UCR that has been continuously monitored for metals over a substantial time period, from the 1990s to the present, is Northport, which lies just upstream from the location of full pool in the UCR. Dissolved and total recoverable concentrations of representative metals (arsenic, cadmium, copper, lead, mercury, and zinc) in surface water were plotted as a function of time (Figures 5-11 through 5-16). In each figure, closed symbols represent detected concentrations and open symbols represent the detection limit for undetected concentrations. Similar temporal trends are evident for each metal.

First, there have been reductions in detected concentrations as analytical detection limits have declined and sampling techniques and analytical methods have likely improved. Second, detected concentrations have generally declined over time. This may be due to increased upstream source control, but may also in part reflect the improved sampling techniques (EPA 1996a).

Downstream of Northport, there are other major tributaries that contribute to metals loadings to the UCR, including the Kettle, Colville, Spokane, and Sanpoil rivers. Concentrations of total recoverable metals for these rivers were compared to the concentrations found in the UCR at Northport (with the exception of the Colville River, for which no metals data are available). Comparisons were based on total recoverable concentrations because they are more indicative of relative loading potential. As shown in Figures 5-17 through 5-22, the available metals concentration data for the Kettle, Spokane, and Sanpoil rivers are comparable to the UCR at Northport.

5.3 SEDIMENT QUALITY

The current understanding of sediment quality in the UCR is discussed in the following sections. Included is a discussion of historical and recent studies conducted throughout the UCR of surface and subsurface sediments, sediment porewater, and sediment toxicity. Studies by the USGS (Bortleson et al. 2001) showed that suspended particulates in Columbia River water samples contained elevated metal concentrations. The quantity of suspended sediment in the UCR is generally low, however, compared to other major river systems. Suspended sediment, while recognized as an important component of the overall sediment continuum, is not discussed further in this sediment quality overview, but may be addressed further in the BERA Work Plan.

5.3.1 Surface Sediments

The following sections describe the types and distributions of chemicals in UCR surface sediments.

5.3.1.1 Data Sources

Sources of surface sediment data include Bortleson et al. (2001), EPA (2003b), EPA (2006e), Era and Serdar (2001), Golder Associates (2003), Johnson (1991c), Johnson et al. (1989), Johnson et al. (1991b), Majewski et al. (2003), MacDonald (1997), and Paulson et al. (2006). Sources and locations of sediment data for the UCR are summarized below and illustrated in Map 5-3. Detailed maps for each study are included in Appendix E.

As with surface water, it should be noted that the studies listed above were conducted for a variety of purposes unrelated to the UCR RI/FS. Consequently, the chemical data presented here may not meet all of the data quality requirements for quantitative evaluations associated with the RI/FS (e.g., risk assessment). However, the data are assumed, for purposes of this Work Plan, to be of sufficient quality to provide a general understanding about the distribution of chemicals in sediment in the UCR. As the RI/FS progresses, the quality of the existing data will be evaluated in the context of task-specific data quality objectives to determine whether the data can be used for decisionmaking purposes. These data quality determinations will be documented in the BERA Work Plan and other individual SAPs that will be developed during the course of the RI/FS.

In preparing this work plan an error was found in the manner in which river miles were designated for the upper portion of the UCR during the 2005 Phase I study. This discrepancy occurred when transitioning between the USGS topographic maps for the Inchelium and Rice quadrants. In making this transition, USGS designates a 2-mile distance between USGS RM 680 and the next river-mile demarcation. However, during the Phase I study, EPA designated only a 1-mile distance between these two points. Therefore, all river-mile designations above USGS RM 680 in the Phase I study are 1 mile less than the designations used by USGS. For the purposes of this section of the work plan, all river mile designations made for the 2005 Phase I study are those used by EPA, and are acknowledged as such. In this manner, the identification of specific locations within the UCR will be consistent with the sample and station locations used during that study (i.e., they include the river-mile designations). However, the discrepancies with the river miles used by USGS above USGS RM 680 should be remembered, and are noted on all relevant tables and figures in this section.

5.3.1.2 Historical Studies

Six broad-scale studies of metals concentrations in surface sediments were conducted in the UCR between 1986 and 2002 by researchers from various state and federal agencies, including Ecology (Era and Serdar 2001; Johnson et al. 1989), USGS (Bortleson et al. 2001; Majewski et al.

2003), and EPA (EPA 2003b). Concentrations of organic compounds were also measured in two of these studies (Bortleson et al. 2001; EPA 2003b), in addition to a single study by researchers from Ecology that focused only on organic compounds (Johnson 1991a; Johnson 1991c). Locations of sampling stations for all seven studies are presented in Appendix E (Maps E1 through E7).

Metals

As described previously, six historical studies of surface sediments have evaluated broad-scale patterns of metals concentrations in the UCR. Each of those studies is described below.

Johnson et al. (1989)—This study was conducted by researchers from Ecology to provide an initial characterization of the distribution of metals in surface sediments throughout the UCR, and it represents the first large-scale study of metals in surface sediments in this part of the Columbia River.

Methods: Sampling was conducted in September and October of 1986. Surface sediments (top 2 to 4 cm) were sampled at 12 stations in the UCR from USGS RM 743 near the U.S.-Canadian border to USGS RM 605 near the Grand Coulee Dam (Map E1). Surface sediments were also collected in the mouths of the four major tributaries to the UCR (i.e., the Kettle, Colville, Spokane, and Sanpoil rivers), and at an upstream reference area in Lower Arrow Lake, B.C. Surface sediments at most stations were sampled using a van Veen grab sampler, but an Emery pipe dredge was required to sample coarse sediments near the border. The five stations located at USGS RM 724 and above were located in back eddies and embayments because of the coarse nature of sediments in the main channel. Below USGS RM 724, stations were sampled near mid-channel to a maximum water depth of 135 feet. A single core sample was also collected at USGS RM 693 near French Rocks using a 5-cm gravity corer. In addition to metals concentrations, concentrations of cesium-137 were measured in the core samples to assign a time horizon to each sample.¹⁸

Results: A distinct longitudinal gradient of grain-size distribution in the UCR was identified (Figure 5-23), with stations located at and above Marcus Flats being characterized predominantly by coarse-grained sediment (sand) and downstream areas being characterized predominantly by finer-grained sediment (silt and clay). For the six stations sampled above USGS RM 700, sand accounted for more than 96 percent of the sediment at all but one station. For fine-grained sediments in downstream areas, silt exhibited a peak concentration of 80 percent at USGS RM 692 near French Rocks, and then declined steadily to 46 percent at USGS RM 604 near the Grand Coulee Dam. By contrast, clay exhibited gradually increasing concentrations from 15 percent at USGS RM 692 to 34 percent at USGS RM 604.

¹⁸ Cesium-137 levels are used to estimate the location of 1964 (i.e., the peak cesium-137 concentration related to atomic bomb testing) and 1954 (i.e., the first appearance of cesium-137 concentrations) in core samples.

For metals, Johnson et al. (1989) found that the highest concentrations of iron, zinc, copper, arsenic, and manganese were associated with the coarse-grained sediments found at and above Marcus Flats (Figures 5-24 and 5-25). They found significant correlations ($p \leq 0.05$) between percent sand and the concentrations of the above-mentioned five metals. The authors speculated that the high concentrations of metals in sediment at and above Marcus Flats were largely the result of the presence of granulated slag in the coarse-grained fraction of the sediments. They characterized these sediments as primarily consisting of "brownish black sand." By contrast with the pattern described above, Johnson et al. (1989) found that the highest concentrations of lead, cadmium, and mercury occurred farther downstream in association with finer-grained sediments (Figure 5-26). Significant correlations ($p \leq 0.05$) between fine-grained sediment (silt and clay) and concentrations of cadmium and mercury were observed. Lead did not correlate significantly ($p > 0.05$) with any of the grain size variables or other metals.

With respect to the major tributaries evaluated by Johnson et al. (1989), the results suggest that the Spokane River may be a source of zinc, lead, and cadmium to the UCR because concentrations of 1,540, 128, and 5.6 mg/kg, respectively, were found in sediments from the river. Concentrations of these metals in the other three major tributaries were considerably lower than the values found in the UCR and the Spokane River.

Bortleson et al. (2001)—This study was conducted by researchers from the USGS to characterize the distribution of metals in surface sediments throughout the UCR. It represents a more detailed characterization of metals in surface sediments in this part of the Columbia River than that provided by Johnson et al. (1989).

Methods: Sampling was conducted in September and October of 1992. Surface sediments (top 1 to 2 cm) were sampled at 41 stations in the UCR from the U.S.-Canadian border to the Grand Coulee Dam (Map E2). Surface sediments were also collected in the mouths of the four major tributaries to the UCR (the Kettle, Colville, Spokane, and Sanpoil rivers), in the mouths of three minor tributaries (Sherman, Hall, and Hawk creeks at USGS RMs 700, 675, and 634, respectively), at four beaches (Big Sheep Creek, Colville River, Bradbury, and Keller Ferry at USGS RMs 736, 699, 694, and 615, respectively), and in the river bank at three locations (Ninemile Creek, Seven Bays, and Sanpoil River at USGS RMs 648, 636, and 616, respectively). Above the U.S.-Canadian border, Bortleson et al. (2001) sampled surface sediments in the Kootenay and Pend Oreille rivers (which are tributaries to the UCR) and Lower Arrow Lake, B.C. Surface sediments were sampled using a stainless steel van Veen grab sampler. At most locations in the UCR, stations were sampled along a transect perpendicular to the river that included a station in the historical river channel as well as stations on either bank.

Results: In general, the longitudinal patterns of metals concentrations in the UCR were similar to those identified previously by Johnson et al. (1989), with the highest concentrations of some metals (e.g., iron, zinc, and copper) being associated with the coarse-grained sediments found at and above Marcus Flats and the concentrations of other metals (e.g., cadmium and mercury)

being associated primarily with fine-grained sediments in areas farther downstream. The authors suggested that much of the coarse-grained sediments in the upper parts of the UCR consisted of granulated slag. They also speculated that the elevated concentrations of cadmium, mercury, and lead found in downstream areas may be associated with liquid effluent discharged to the river above the U.S.-Canadian boundary.

With respect to the river banks, which can contribute sediment to the UCR through erosion and landslides, Bortleson et al. (2001) stated that these sediments may be a source of arsenic, but noted that the data were limited to only four samples. The authors found that concentrations of lead and zinc were elevated at the beach sampled near the mouth of Big Sheep Creek, and noted that the creek drains a mineralized area. They concluded that the creek may be a source of those two metals to the UCR, but cautioned that the annual discharge from this tributary is relatively small.

Bortleson et al. (2001) noted that the elevated concentrations of these metals in the Pend Oreille River may have originated in the upstream Metaline mining district, but cautioned that the Waneta Dam and other upstream dams impede sediment transport during most flows.

Era and Serdar (2001)—This study was conducted by researchers from Ecology, primarily to evaluate potential sediment toxicity (see discussion in Section 5.2.4.1) in the lower and upper portions of the UCR.

Methods: Sampling was conducted in May of 2001. Surface sediments (top 10 cm) were sampled at seven stations in the UCR, with three stations located in the upper portion of the river (USGS RMs 745 to 738) near the U.S.-Canadian border, and four stations located in the lower part of the river (USGS RMs 645 to 596; Map E3). Surface sediments were also collected in the mouths of the Kettle and Sanpoil rivers, as well as at an upstream reference area in Lower Arrow Lake, B.C. Surface sediments were sampled using a van Veen grab sampler.

Results: In general, the longitudinal patterns of metals concentrations found in the UCR were similar to those identified previously by Johnson et al. (1989) and Bortleson et al. (2001), with the highest concentrations of zinc and copper associated with the coarse-grained sediments found in the upper UCR and the concentrations of mercury being associated primarily with fine-grained sediments in areas farther downstream. They also found a significant correlation ($p \leq 0.05$) between the concentrations of mercury and clay. Era and Serdar (2001) found no strong longitudinal patterns for lead and cadmium. The authors noted that much of the coarse-grained sediments at the three stations located in the upper parts of the UCR consisted of a visibly dark sandy mixture that suggested the presence of granulated slag. Elevated concentrations of metals were not found in the Kettle and Sanpoil rivers.

Majewski et al. (2003)—This study was conducted by researchers from USGS to evaluate metals concentrations in the fine-grained fraction of sediments (i.e., $< 63 \mu\text{m}$) collected from beaches and nearby river sediments throughout the UCR. The primary objective was to

determine metals concentrations in the sediment fraction that could potentially become components of airborne dust and subsequently be inhaled by humans.

Methods: Sampling was conducted in April and May of 2001. Surface sediments (top 2 to 3 cm) were sampled at 24 stations in the UCR from USGS RM 731 near Northport to USGS RM 601 near the Grand Coulee Dam (Map E4). Sediments were also collected at an upstream reference area in Lower Arrow Lake, the same upstream reference area sampled by Johnson et al. (2003), Bortleson et al. (2001), and Era and Serdar (2001). Surface sediments were sampled using plastic spoons.

Results: Majewski et al. (2003) found that most metals exhibited a gradient of decreasing concentrations from the upper to lower portions of the UCR. Although, this pattern is inconsistent with the patterns identified for mercury and cadmium in one or more of the previous studies described above, it may be related to the fact that Majewski et al. (2003) sampled sediment close to the shoreline, whereas the previous studies evaluated sediments at greater water depths in the river.

EPA (2003b)—This study was conducted by EPA to provide information for determining whether the UCR should be included on the National Priorities List (NPL), and to establish priorities for additional action, if warranted.

Methods: Sampling was conducted in May and June of 2001. Surface sediments (top 2 to 20 cm) were sampled at 49 stations in the upper and middle portions of the UCR from the U.S.-Canadian border to USGS RM 675 near Inchelium (Map E5). Surface sediments were sampled using several kinds of stainless steel equipment, including a petite Ponar grab sampler, hand augers, and spoons.

Results: According to EPA (2003b), elevated concentrations of arsenic, cadmium, lead, mercury, and zinc were found at the majority of stations, ranging from 48 percent of stations for mercury to 97 percent of stations for copper. The area of elevated concentrations included the entire study area. EPA (2003b) also found that concentrations of zinc, copper, and lead tended to decrease with increasing distance downstream, and noted that sediments at a number of sites consisted of a glassy sandy mixture visually characterized by field personnel as granulated slag.

Paulson et al. (2006)—This study was conducted by researchers from USGS to present analytical results regarding the elemental composition of sediments collected from the UCR in 2004, and to evaluate the release of elements from sediment following physical abrasion (i.e., tumbling). The results of sediment composition (total digestion) analyses that were conducted as part of this study are discussed here.

Methods: Sampling was conducted in 2004. Sediments were collected at eight stations between approximately USGS RM 601 and RM 736, to represent the areal distribution of trace element concentrations between the border and Grand Coulee Dam, and one station in the Sanpoil

River to represent background conditions (Map E6). Sampling stations were selected to target locations unaffected by reservoir fluctuations (although one station was likely above the range of drawdown elevations) and locations that had been permanently subaqueous for the previous 2 years. Areas of terrestrial landslides where sediment chemistry may be affected by bank material were purposely avoided.

Samples were collected using a 13.5 cm by 13.5 cm by 12-cm-deep box corer, following EPA (2001a) protocols. Water depths at the stations ranged from 12 to 26 m. Subsamples collected at each site included one 4.4-cm-diameter core (up to 10 cm long) for analysis of elemental vertical distribution in sediments. A total of 28 sediment samples (1 to 4 from each site) were analyzed for total concentrations of 10 alkali and alkaline earth elements, 2 non-metals, and 20 metals, not including mercury. The samples consisted of the following:

- Discrete surface (0 to 1 cm) samples and composite near-surface samples (3-10 cm) from four locations that were analyzed to provide vertical profile information
- Replicate 0 to 2 cm interval samples, which had been previously centrifuged for porewater analysis, from four sites to provide data on horizontal concentration variations
- Composite samples from nine sites representing material from 4 to 10 cm below surface
- Samples of 0 to 2 cm below surface from two sites that had previously undergone a tumbling experiment

A sample of unsorted beach sand collected at RM 743 as part of a previous study (Cox et al. 2005) was also included in the data set for this study.

Results: Results of sediment analyses are summarized and interpreted in Paulson and Cox (Paulson and Cox 2007). Spatial trends in the total concentrations of arsenic, copper, cadmium, lead, and zinc were found to be similar to those of other studies (Paulson and Cox 2007). Concentrations of copper, lead, and zinc were highest in the river reach sediments and generally decreased downstream, while cadmium concentrations, relatively lower in the river reach sediments, generally increased downstream. Cadmium concentrations were found to be related to fine-grained sediment content, and inversely related to granulated slag content. Two locations in the lower reach of the study area contained the highest cadmium concentrations, which were attributed to sorption from the aqueous phase to organic-rich particulates and subsequent downstream transport (Paulson and Cox 2007).

Organic Compounds

As described previously, three historical studies of surface sediments have evaluated broad-scale patterns of the concentrations of organic compounds in the UCR. Each of those studies is described below.

Johnson (1991c) and Johnson et al. (1991b)—As part of Ecology’s investigation of organic compounds in UCR sediments, a series of sediment samples was collected in June 1990 from the UCR and vicinity for analysis of PCDDs and PCDFs (Johnson et al. 1991b). Sediment samples were also analyzed for 44 additional organic compounds (Johnson [1991c]; Map E7). Those additional organic compounds, along with the PCDDs and PCDFs, made up the list of target analytes for EPA’s National Bioaccumulation Study (EPA 1991b), a national survey of contaminants considered to bioaccumulate to significant extents in fish. The impetus for this survey was the need to better understand the spatial distribution of organic compounds as a result of their discharge by the Zellstoff Celgar bleached kraft pulp mill in Castlegar, B.C. (approximately 30 river miles above the U.S.-Canadian border).

Methods: Six sites were sampled in the UCR between the U.S.-Canadian border and Grand Coulee Dam (Map E7), and one site each in the Spokane River at Long Lake and Rufus Woods Lake (the Columbia River reservoir below Lake Roosevelt formed by Chief Joseph Dam). One sediment sample was collected at each sample location. Each sediment sample represented a composite of three grabs taken with a stainless-steel van Veen grab sampler. Only the top 2-cm surface layer was sampled. All 2,3,7,8-substituted PCDDs and PCDFs, except octachlorodibenzo-*p*-dioxin and octachlorodibenzofuran, were analyzed at the parts per trillion (picograms per gram [pg/g]) level. The remaining 44 bioaccumulative organic compounds were analyzed at the parts per billion (micrograms per kilogram [µg/kg]) level.

Results: Detection of target PCDDs and PCDFs in the sediments was limited almost exclusively to 2,3,7,8-tetrachlorodibenzofuran (2,3,7,8-TCDF), and in one instance, 2,3,7,8-tetrachlorodibenzo-*p*-dioxin (2,3,7,8-TCDD). The single detected concentration of 2,3,7,8-TCDD (3.6 pg/g dry weight [dw]) was found at French Rocks (USGS RM 692), just below Kettle Falls (USGS RM 700). Concentrations of 2,3,7,8-TCDF in the UCR occurred at much higher concentrations (up to 166 pg/g dw at French Rocks) than at Rufus Woods Lake (30 pg/g dw) or the Spokane River at Long Lake (2.7 pg/g dw), and they decreased downstream from Kettle Falls. It was not detected in sediments upstream of Kettle Falls. The authors suggested that 2,3,7,8-TCDF and 2,3,7,8-TCDD were not detected above Kettle Falls because of coarse grain size and low TOC content of the sediments. Sediments with greater levels of organic matter sorb greater amounts of hydrophobic, nonionic compounds like 2,3,7,8-TCDD and 2,3,7,8-TCDF (Di Toro et al. 1991; Geschwend and Wu 1985; Karickhoff 1981).

For the remaining 44 organic compounds, detection was almost exclusively limited to PCBs and DDE (a metabolite of DDT). A relatively high concentration of polychlorinated biphenyls (PCBs) was found in the Spokane River at Long Lake (20.8 nanograms per gram [ng/g] dw), whereas PCB concentrations from Rufus Woods Lake were among the lowest found in the survey (4.9 ng/g dw). Results for the UCR showed that levels of PCBs generally were intermediate between those in the Spokane River at Long Lake and Rufus Woods Lake. The concentration found near Grand Coulee Dam (25.2 ng/g dw) (USGS RM 601) was comparable to sediments in the Spokane River at Long Lake. DDE was below detection limits in all sediments, except for a trace amount (2.1 ng/g dw) near Grand Coulee Dam.

The authors concluded that their survey demonstrated long-distance transport of 2,3,7,8-TCDD and 2,3,7,8-TCDF through the UCR, with significant deposition occurring near Kettle Falls. There was a substantial downstream attenuation of 2,3,7,8-TCDD and 2,3,7,8-TCDF in the UCR. The highest levels of PCBs were found in the Spokane River and in the UCR downstream of the Spokane River near Grand Coulee Dam. Because of the environmental persistence of PCBs, Johnson (1991c) recommended a more thorough evaluation of these compounds in the Spokane drainage.

Bortleson et al. (2001)—The study design and sampling methods used by Bortleson et al. (2001) are discussed in detail in Section 5.2.4.1 in the subsection on that study.

Methods: In addition to metals, surface sediments of the UCR were analyzed for two groups of organic compounds: those extractable with methylene chloride and those associated with wood pulp (other than dioxins and furans). Methylene-chloride-extractable compounds were analyzed to assess the extent to which sediments of the mid and lower reaches of the UCR and in its major tributaries may be contaminated by compounds that originate mainly from urban and industrial sources. A limited number of sediment samples were collected on a reconnaissance level to assess whether wood-pulp-related organic compounds, which may have originated from the Zellstoff mill at Castlegar, B.C., occur in the upper part of the UCR.

All trace organic compounds analyzed in sediments were from a composite sample that was wet-sieved through a 2-mm stainless-steel screen. Fifty-four methylene-chloride-extractable compounds were analyzed in sediments collected from three sites in the middle portion of the UCR and two sites in the lower portion. Sediments from three major UCR tributaries, the Kootenay and Pend Oreille rivers and Lower Arrow Lake, were also analyzed for the same compounds. Chlorinated phenols and wood-pulp-related compounds of veratroles, anisoles, and vanillins were analyzed in sediment at Marcus Flats (USGS RM 709) and French Rocks (USGS RM 692).

Results: The UCR and its major tributaries generally did not contain detectable concentrations of methylene-chloride-extractable compounds. In fact, 52 of the methylene-chloride-extractable compounds analyzed were not detected or were below the minimum reporting level. However, 15 compounds were detected, but at concentrations below minimum reporting levels. Of these, 11 were PAHs and 2 were phenolic compounds. PAHs were detected less frequently in the lower part of the UCR than in the upper part. The authors suggested that the widespread presence of PAHs may have been due to atmospheric deposition from incomplete combustion of fossil fuels (Sanders et al. 1993).

Although chlorinated phenols and wood-pulp-related compounds of veratroles, anisoles, and vanillins were not detected in sediment at Marcus Flats and French Rocks, a few chlorinated

guaiacols and catechols¹⁹ were found during the study at those locations. In addition, 8 of 15 unchlorinated resin and fatty acids (components of pulp mill effluent) were found at both Marcus Flats and French Rocks. Extractable organic halides, a gross indicator of chlorinated organic compounds, were not found above their minimum reporting levels of 10 mg/kg dw at either sample site.

Bortleson et al. (2001) concluded that sediments collected from the UCR and its tributaries generally were not contaminated with methylene-chloride-extractable compounds or common wood-pulp-related compounds. However, a few of the non-dioxin and non-furan compounds were found at small concentrations as far downstream from the U.S.-Canadian boundary as French Rocks (USGS RM 692). The authors noted that the concentrations of selected PAHs in UCR sediment were several orders of magnitude less than sediment quality values developed by EPA for freshwater ecosystems. They also concluded that even though the extractable organic halides analytical method does not measure individual chlorinated organic compounds, the data suggested that total concentrations of chlorinated compounds in UCR sediments were low.

EPA (2003b)—The study design and sampling methods used by EPA are discussed in detail in Section 5.2.1.2 in the subsection on that study.

Methods: In addition to metals, surface sediment samples were analyzed for chlorinated pesticides (4,4'-DDE, 4,4'-DDT, alpha-chlordane, beta-BHC, endrin, endrin aldehyde, and methoxychlor), PCBs (aroclors 1254 and 1260), volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), and TOC. Although the discussion of analytical results in the report was limited to metals, a table of analytical results for most organic compounds was provided in an appendix.

Results: Only three organic compounds were detected in the 49 sediment samples (i.e., 6 percent) collected between USGS RM 675 and the U.S.-Canadian border: methoxychlor, Aroclor 1254, and Aroclor 1260. Methoxychlor was measured at 52 µg/kg dw at a nearshore site by Marcus Flats, but was below its detection limit at all other UCR sites. None of the other chlorinated pesticides was detected at any UCR sampling station. Aroclor 1254 and Aroclor 1260 were detected at low concentrations (38 and 17 µg/kg dw, respectively) in a single sample collected at USGS RM 688, but were undetected at all other UCR sites.

5.3.1.3 2005 EPA Phase I Sediment Investigation

EPA conducted a comprehensive survey of grain size and concentrations of metals and organic compounds in surface sediments of the UCR in 2005 as Phase I of the RI/FS (EPA, 2006e). The study was conducted in April and May during the period of low pool in the UCR (Figure 5-27), to facilitate sample collection and depth determinations. Four kinds of sediment

¹⁹ Chlorinated guaiacols and catechols are products of pulp bleaching, whereas veratroles, anisoles, and vanillins are biotransformation products of chlorinated guaiacols and catechols.

stations were sampled: river transect stations, tributary mouths, reference²⁰ areas, and beaches. Surface sediments were collected using a van Veen grab sampler or stainless steel hand tools. Locations of all stations are presented in Appendix E (Maps E9 and E10). More detailed station maps presented for smaller river reaches are presented in Attachment E1 (Figures 2-3 through 2-27).

The remainder of the section describes the results of the 2005 Phase I study with respect to concentrations of metals and organic compounds in surface sediments.

The four kinds of sampling stations included the following:

- **Transect stations**—Surface sediments (top 10 to 15 cm) were collected along 74 transects perpendicular to the river bank, which were distributed from EPA RM 744 near the U.S.-Canadian border to USGS RM 600 near the Grand Coulee Dam (Map E9). Some planned transect stations could not be sampled due to the cobbly nature of the river bottom. This occurred primarily for many of the mid-channel stations located above EPA RM 710.
- **Tributary mouths**—Surface sediments were collected at the mouths of six tributaries to the UCR from EPA RM 736 to USGS RM 615 (Map E10). Two stations were targeted for sampling in each tributary, one near the middle of the mouth and at the tributary's confluence and the other along the near bank of the UCR approximately 0.1 to 0.2 mile downstream from the confluence. For Big Sheep Creek, only the channel station could be sampled because the bank station was characterized by a cobble bottom and swift currents.
- **Reference areas**—Surface sediments were sampled in six streams located between EPA RM 732 and RM 685, to serve as reference areas (Map E10). All reference stations were located above the elevation of maximum water levels in UCR. As noted by EPA (2006e), the reference areas were sampled primarily to support the interpretation of the sediment toxicity tests that were conducted as part of the 2005 Phase I study. They were not intended to define background concentrations of metals in sediments for the UCR.
- **Beaches**—Surface sediments were collected from multiple locations on 15 beaches located between EPA RM 742 and USGS RM 600 (Map E10). Composite sediment samples were collected along three elevations at each beach. The target elevations were 1,285, 1,270, and 1,255 feet amsl.

²⁰ As noted by EPA (2006h), the reference areas were sampled primarily to support the interpretation of the sediment toxicity tests that were conducted as part of the 2005 Phase I study. They were not intended to define background concentrations of metals in sediments for the UCR.

Metals

Although concentrations of 24 metals (the 23 TAL metals plus uranium) were measured in each sediment sample collected during the 2005 Phase I study, EPA (2006e) conducted a set of screening evaluations that identified 12 of the metals as COIs. The screening evaluations were conducted using a variety of sediment guidance values for the protection of human health and the environment (MacDonald et al. 2000). The 12 COIs identified by the screening evaluation were antimony, arsenic, cadmium, chromium, copper, iron, lead, manganese, mercury, nickel, uranium, and zinc.

Findings of the 2005 Phase I study with respect to metals concentrations in surface sediments can be summarized as follows:

- The longitudinal distributions of grain size parameters at mid-channel stations suggested that a gradient of grain-size sorting occurs from upstream to downstream, with percent sand, silt, and clay being highest in the upper, middle, and lower portions of the UCR, respectively (Table 5-4 and Figures 5-28 through 5-31).
- The longitudinal distributions of some metals (e.g., iron, copper, zinc, arsenic) exhibited a pattern that was generally consistent with the distribution of percent sand, with the highest concentrations found above Marcus Flats and lower and relatively consistent concentrations found in most downstream areas (see Table 5-4 and Figures 5-32 through 5-35).
- The longitudinal distributions of cadmium, mercury, and nickel at mid-channel stations exhibited a pattern that was generally consistent with the distribution of fine-grained sediments, with the highest concentrations found below Marcus Flats and relatively low concentrations found above that location (see Table 5-4 and Figures 5-36 through 5-38).
- Based on visual observations of sediments that were made during sampling, sand-sized particles indicative of granulated slag were found only at stations located at Marcus Flats and in upstream areas (see Table 5-4 and Figures 5-36 through 5-38).
- In general, metals concentrations found at the 15 beaches sampled during the 2005 Phase I sediment study were highest at the three most upstream beaches (between EPA RM 742 and 749), intermediate in magnitude at the next two downstream beaches (between EPA RM 718 and 708), and relatively low at the remaining 10 beaches (downstream from EPA RM 708) (Table 5-5).

Organic Compounds

Organic compounds evaluated in the Phase I study were SVOCs, pesticides, PCBs, PAHs, and dioxins and furans. All of these compounds were measured at all stations sampled during the Phase I study (i.e., transect stations, tributary mouths, reference areas, and beaches) except for dioxin and furans, which were analyzed only at the beach stations.

EPA (2006e) conducted a set of screening evaluations that identified the following organic COIs:²¹ 2,4'-DDE, 2,4'-DDT, 4,4'-DDD, 4,4'-DDE, 4,4'-DDT, aldrin, Aroclor 1016, Aroclor 1260, dioxins/furans,²² and PAHs (benzo[a]anthracene, benzo[a]pyrene, benzo[b]fluoranthene, benzo[k]fluoranthene, chrysene, dibenz[a,h]anthracene, and indeno[1,2,3-cd]pyrene).

Organic compounds as represented by 4,4-DDT, Aroclor 1260, and benzo(a)pyrene were largely undetected during in the UCR as indicated in Figures 5-39 to 5-41, which show concentrations of each detected COI as solid data points and undetected results (plotted at one-half their method reporting limit) as hollow data points. The plots show no clear patterns in COI concentration by station type or position along the UCR.

5.3.2 Subsurface Sediments

In this section, the distributions and concentrations of metals and organic compounds in subsurface sediments of the UCR are discussed. Results of historical studies conducted prior to 2005 are discussed first, followed by a discussion of the results of the 2005 Phase I study.

5.3.2.1 Historical Studies

Two historical studies conducted by researchers at Ecology (Johnson et al. 1989) and USGS (Cox et al. 2005) have evaluated metals concentrations in subsurface sediments of the UCR. There are no historical studies of concentrations of organic compounds in subsurface sediments of the UCR. Each of two historical studies related to metals concentrations is described below.

Johnson et al. (1989)—This study conducted by researchers from Ecology provides the first characterization of the distribution of metals in subsurface sediments in a portion of the UCR.

Methods: Sampling was conducted in September of 1986. A single core was collected at USGS RM 693 near French Rocks using a 5-cm gravity corer. The core was sectioned at 5-cm intervals. In addition to metals concentrations, concentrations of cesium-137 were measured in the core sample to assign a time horizon to each sample.

Results: According to Johnson et al. (1989), the location of the single core (RM 693) collected during their survey coincided with the location of the maximum concentrations of lead, cadmium, and mercury in surface sediments (Section 5.1.6.2). The peak cesium-137 concentration in the core was in the 10 to 15 cm sediment horizon. The authors found that concentrations of all metals were elevated in the upper 30 cm of the sediment column

²¹ COIs were identified by comparing the analytical results to selected screening levels. Any analyte detected above one or more of the selected screening levels was identified as a COI by EPA.

²² Dioxin/furan COIs include the 2,3,7,8-TCDD toxicity equivalent (TEQ) and 14 congeners. The TEQ is the PCDD/PCDF-associated toxicity expressed as equivalent concentrations of 2,3,7,8-TCDD (Ecology 1997).

(Table 5-6), and concluded that metals contamination in this part of the UCR appeared to have begun prior to 1954. They also concluded that the level of contamination had apparently not changed appreciably since the 1950s.

Cox et al. (2005)—This study was conducted by researchers from USGS to evaluate the vertical distributions of metals in sediments throughout the UCR and to assess sediment accumulation rates.

Methods: Sampling was conducted in September 2002. Sediments were sampled at six stations from USGS RM 705 to 624 and at one station in the Spokane River (Map E8). According to the authors, sites of continuously accumulating sediments were not found upstream from USGS RM 705, so no cores were collected in the uppermost portion of the UCR. The five cores in the downstream section of the UCR were collected near the original river channel where the accumulation of sediment was thought to be thickest and least likely to be disturbed by fluctuations in water level and river flow. The core at USGS RM 705 (the most upstream station) was located away from the historical river channel toward the left bank on a submerged terrace, because fine-grained sediments were not found in the channel. The core in the Spokane River was collected in the channel near the mouth. All cores were located in areas thought to be minimally affected by large landslides along the shoreline, which could potentially confound the vertical patterns of metals concentrations. Each core was collected using a 6.5-cm-diameter gravity corer. Core depths ranged from 38 to 164 cm and sectioning occurred in intervals of 2 to 5 cm, depending on the core. In addition to metals, concentrations of cesium-137 were measured in the core samples to assign a time horizon to each core.

Results: Using the cesium-137 data to estimate the location of 1964 (the peak cesium-137 concentration related to atomic bomb testing) and 1954 (the first appearance of cesium-137 concentrations), Cox et al. (2005) estimated minimum sediment accumulation rates for each station that ranged from 0.8 cm/year at USGS RMs 624, 692, and 705 (i.e., in the upper and lower portions of the UCR) to 2.8 cm/year at USGS RM 668 in the middle portion of the UCR. The minimum sediment accumulation rate at USGS RM 643 in the middle portion of the UCR was 1.5 cm/yr, and the minimum rate in the Spokane Arm was 1.9 cm/yr. Based on this limited data set, sediment accumulation rates in the UCR are potentially greatest in the middle portion of the UCR, above the Spokane River and below the Colville River.

With respect to the vertical distributions of metals concentrations in the sediment cores collected in the UCR (Table 5-7), Cox et al. (2005) concluded that concentrations generally varied greatly within each core profile (often over a range of 5- to 10-fold), and that concentrations typically were highest below the surface sediments in the lower half of each core profile, with generally decreasing concentrations from the 1964 horizon to the core surface. All of the cores from the UCR showed some evidence of disturbance from landslides in their deeper horizons, based on the concentration profiles of both metals and cesium-137. However, three cores (at USGS RMs 705, 692, and 624) showed no evidence of potential disturbance from landslides since the 1964 time horizon.

5.3.2.2 2005 EPA Phase I Sediment Investigation

As part of the Phase I study, subsurface sediments were sampled in sediment cores collected from nine locations between EPA RM 708 and USGS RM 605 (Appendix E, Attachment E1, Figures 2-3 through 2-12). Although three additional core samples were planned to be collected at several stations above EPA RM 708 (i.e., EPA RMs 723, 734, and 742), the sediments were found to be too coarse to allow coring. Cores were sampled from mid-channel and submerged side-bank locations to a maximum water depth of 200 feet. Cores were sampled to a maximum depth of 5 to 7 feet, depending on the stations. Sediment cores were collected using a 10-cm-diameter Vibracore with Lexan plastic core tubes. Each core was sectioned at 0.5-foot intervals in the top foot, and at 2-foot intervals in the deeper horizons. According to EPA (2006e), the core collected at USGS RM 622 may have been affected by landslides. The following sections describe the vertical distributions of grain size, metals and organic compounds in the sediment cores collected during the Phase I study.

Grain Size

With respect to grain-size parameters, cores collected at EPA RMs 708 and 704 consisted almost exclusively of sand-sized particles throughout their lengths, because percent sand exceeded 93 percent in all sediment horizons (Table 5-7). EPA visually characterized the sediments throughout these two cores as relatively uniform black sand, and suggested that the sampled areas represent primary depositional areas for sandy, granulated slag-enriched sediments. No visual observations of black sediments were found in any of the cores sampled downstream from Marcus Flats. Cores in downstream areas include greater percentages of fine-grained sediments. This is particularly true for cores collected in the middle portion of the UCR at EPA RM 692 and at USGS RMs 676 and 661, which contain relatively large proportions of fine-grained material in most sediment horizons. Concentrations of silt were particularly high in this portion of the UCR, exceeding 40 percent in all but one of the sediment horizons sampled in the three cores. Elevated concentrations of fine-grained sediment in the three cores collected from the lower portion of the UCR at USGS RMs 644, 637, and 605 were largely confined to the top 0.5 to 1 foot of the sediment column.

Metals

Vertical distributions of iron, zinc, and copper (see Table 5-7) show the highest concentrations of these metals were found at EPA RMs 708 and 704. Concentrations in the cores from EPA RM 692 and USGS RM 676 were relatively similar to each other and significantly lower than the concentrations at EPA RM 704. Although iron concentrations in the core from USGS RM 661 were relatively uniform over the length of the core, zinc and copper concentrations tended to be higher in the upper 3 feet of the core relative to the concentrations found in underlying sediment horizons. At USGS RMs 644, 637, and 605 in the lower portion of the UCR, concentrations of all three metals were considerably higher in the top 0.5 to 1 foot of the cores, relative to concentrations in the underlying horizons. In general, concentrations of lead exhibited patterns similar to those found for iron, copper, and zinc.

Vertical distributions of cadmium and mercury (see Table 5-7) were relatively uniform throughout each core collected from the upper four stations. However, by contrast with iron, copper, and zinc, the highest concentrations of cadmium and mercury were generally found in the core from USGS RM 676 near Inchelium. Below USGS RM 676, concentrations of cadmium and mercury exhibited the same general patterns described above for iron, copper, and zinc.

Major findings of the 2005 Phase I study with respect to grain size parameters and metals in subsurface sediments can be summarized as follows:

- With respect to grain-size parameters, cores collected at EPA RMs 708 and 704 in the vicinity of Marcus Flats consisted almost exclusively of sand-sized particles throughout their lengths, whereas cores in downstream areas included greater percentages of fine-grained sediments, particularly in the middle portion of the UCR.
- The highest concentrations of iron, copper, and zinc were found at EPA RMs 708 and 704.
- The highest concentrations of cadmium and mercury were found in the core from USGS RM 676 in the middle portion of the UCR.
- In the three cores collected from the lower portion of the UCR (between USGS RMs 644 and 605), concentrations of most metals were considerably higher in the top 0.5 to 1 foot of the cores, relative to concentrations in the underlying horizons.
- Sediments containing black sand-sized particles assumed to be granulated slag were found only in sediments at Marcus Flats and in upstream areas.

Organic Compounds

Vertical distributions of the organic COIs are presented in Table 5-8. For dioxins/furans, both 2,3,7,8-TCDD and 2,3,7,8-TCDF were detected in samples from four cores collected at EPA RM 692 and USGS RMs 661, 637, and 605; 2,3,7,8-TCDF alone was detected only in the core collected at EPA RM 704. The highest dry-weight concentrations of both 2,3,7,8-TCDD and 2,3,7,8-TCDF were detected in cores collected at EPA RM 692 and USGS RM 637.

Dioxins/furans generally showed decreasing dry-weight concentrations with depth, and the highest dry weight concentrations appeared in the upper 1 foot of each core, unless the core contained multiple undetected concentrations (e.g., 2,3,7,8-TCDD for the core collected at EPA RM 704).

None of the pesticide COIs as identified by EPA (2006e) had more than two detected concentrations in any of the cores, and only one detected concentration was greater than 1 µg/kg dw (i.e., 4,4'-DDT was detected at 2.6 µg/kg dw in the 1–3 feet sediment horizon at EPA RM 704). In addition, the highest dry-weight concentrations did not appear in the upper 1 foot of each core. As such, it was not possible to identify trends in the longitudinal or vertical distributions for these organic COIs. Longitudinal or vertical distribution trends in core

samples also could not be identified for Aroclor 1016 and Aroclor 1260 because they were not detected in any sediment horizon from any of the cores.

Multiple detected concentrations of all PAH COIs were found in two or more cores. The highest dry-weight concentrations of PAH COIs were detected in the cores collected at USGS RMs 676 and 644. PAH COIs generally showed decreasing dry-weight concentrations with depth, and the highest dry-weight concentrations appeared in the upper 1 foot of each core unless the core contained multiple undetected concentrations. Most detected concentrations were less than 10 µg/kg dw.

5.3.3 Chemical Distributions in Sediment Porewater

Porewater that exists between the particles in sediment—the interstitial water—is one of the pathways by which the bioavailable fractions of dissolved phases of metals and organic chemicals are assimilated by aquatic life (Di Toro et al. 2001; EPA 2005f). Another is the dietary pathway, in particular via the ingestion of particulate organic matter in the sediment (Meyer et al. 2002). The net rates of uptake from the aqueous and dietary pathways can contribute to bioaccumulation and, depending on their magnitude, toxicity (Luoma and Rainbow 2005; Simpson and King 2005). Two methods are used to assess metal exposures in sediment porewater: direct measurement of the dissolved metal concentrations in the porewater and evaluation of the difference between the concentrations of acid-volatile sulfide (AVS, extracted with a weak acid) and simultaneously extractable metals (SEM) (Allen et al. 1993; Di Toro et al. 2005; EPA 2005f).

Historical porewater data for the UCR are reviewed in Section 5.2.4.1 below, with data from EPA's 2005 sampling program reviewed in the subsequent section.

5.3.3.1 Historical Studies

Limited historical studies of the chemical composition of sediment porewater in the UCR have been undertaken by researchers at Ecology (Johnson 1991c) and USGS (Cox et al. 2005), and by Paulson et al. (2006). These investigations were limited to measuring concentrations of metals, a few other elements, and hardness. No historical data are available for SEM and AVS concentrations in porewater.

Each of the three historical studies on metals concentrations in sediment porewater in the UCR is described below.

Johnson (1991c)—This study evaluated the chemical composition of water overlying the sediment, whole sediments, and porewater from four locations in the UCR, plus single locations in embayments draining the Spokane and Sanpoil rivers (Map 5-4).

Methods: Samples of fine sediments were collected at a depth of 80 feet with a 0.1-m² van Veen grab sampler.²³ Porewater was extracted from the upper 2 cm of sediment by first centrifuging and then filtering the supernatant through 1- μ m glass filters. Total²⁴ zinc, lead, copper, and cadmium were analyzed by graphite furnace atomic absorption spectrometry and total mercury by cold vapor atomic absorption spectrometry. The samples were not protected from oxidation, which potentially creates uncertainty about the accuracy of the reported concentrations because oxidation of sediments during sampling, handling, and processing can release metals into the dissolved phase (Besser and Giesy 1993; Lee et al. 2000; Simpson et al. 2004; Sukola et al. 2005).

Results: Elevated concentrations of metals were measured in the porewater (Table 5-9). Porewater concentrations of copper, lead, and zinc as reported by Johnson (1991c) correlated most strongly ($r = 0.86, 0.86, \text{ and } 0.99$, respectively) with total metal concentrations in whole sediment.²⁵ Cadmium and mercury concentrations were less well correlated ($r = 0.38$ and $r < 0.01$, respectively), and arsenic concentrations were not correlated significantly ($r = -0.05$). Johnson (1991c) reported “little correlation” between the porewater data and the results of sediment toxicity bioassays (i.e., bioassays of the cladoceran *Daphnia magna*, the amphipod *Hyalella azteca*, and the saltwater bacterium *Vibrio fischeri* [also known as the Microtox test]) and the abundance and diversity of macroinvertebrates collected from the UCR.

Cox et al. (2005)—This study was conducted in September 2002 to evaluate metal concentrations in Lake Roosevelt, the occurrence of granulated slag in accumulated bed sediments, and the potential for release of the metals from the sediments.

Methods: Sediment samples generally were collected from near the pre-reservoir river channel or thalweg, where the authors believed sediment thicknesses were greatest and least disturbed by reservoir hydraulics. Dissolved concentrations of metals (organic compounds were not measured) in porewater were collected from three sediment depths (horizons) at three locations (Map 5-4). The cores, which were collected with a box corer, were placed in polyethylene bags and purged with nitrogen, typically within 5 minutes of exposure to air after sample collection. Extraction involved 30 minutes of centrifugation followed by filtration through a 0.45- μ m membrane before acidification with nitric acid. Because it was not feasible to maintain a nitrogen atmosphere throughout sample handling, which is required to prevent changes in the concentration and bioavailability of metals (Bufflap and Allen 1995), the significance of the oxidation effect on sample integrity is unknown. However, the steps taken

²³ A depth of 40 feet was sampled at Little Dalles because fine sediments could not be collected in 80-foot-deep water.

²⁴ These samples are labeled as reflecting total metals because filtration through a 1- μ m filter does not meet the conventionally adopted operational definition of dissolved, which is the result of filtration through a 0.45- μ m filter. Consequently, the porewater metal concentrations measured by Johnson (1991c), which were comparatively high, could have been influenced by any particulate metals <1 μ m.

²⁵ These “total” concentrations represented those measured after strong acid digestion, considered by the authors to be most indicative of total concentrations.

by Cox et al. (2005) to limit the duration of exposure of the samples to air should have limited the extent of any oxidation that might have occurred in comparison to the potential for oxidation that was present in the earlier study by Johnson (1991c).

Results: Porewater concentrations of hardness and of most of the metals that were reported by Cox et al. (2005) were much lower than those reported by Johnson (1991c). Concentrations typically were highest in the upper 2 cm horizon, and tended to decline with increasing depth in the sediment (Table 5-9). For example, at French Rocks, the only location sampled in both studies, dissolved zinc concentrations averaged 7.0 ± 5.2 $\mu\text{g/L}$ in the Cox et al. (2005) study versus 116 $\mu\text{g/L}$ in that of Johnson (1991c), a difference of 16-fold. Copper concentrations were 2.7 ± 1.3 $\mu\text{g/L}$ compared to 16 $\mu\text{g/L}$, respectively, a difference of 6-fold. Cadmium and lead concentrations were 26 and 67 times lower, on average, but arsenic did not differ: 19 ± 6 versus 19 $\mu\text{g/L}$ (Table 5-9).

Paulson et al. (2006)—Porewater analyses performed as part of this study included direct measurement of dissolved constituents in porewater extracted from sediment samples.

Methods: Samples for porewater analysis were collected in September 2004 using a box corer. Water depths at the stations ranged from 12 to 26 m (39 to 85 feet). No effort was made to prevent the exposure of the sediment samples to the atmosphere during sample collection. Porewater samples were centrifuged from sediment plug samples (0 to 2 cm) within 8 hours of collection, and drawn by syringe through an in-line $0.22\text{-}\mu\text{m}$ filter and preserved with nitric acid. Porewater from individual cores was analyzed if sufficient volume was recovered; otherwise, water was composited from multiple cores collected from the sampling station. Porewater samples from this study were analyzed for total concentrations of 10 alkali and alkaline earth elements, 2 non-metals, and 20 metals, not including mercury.

Results: Results of porewater analyses for the representative metals from the Paulson et al. (2006) study are shown in Table 5-10 and are summarized using median values in Paulson and Cox (2007). Most metals and hardness concentrations reported were similar to those reported by Cox et al. (2005) (Tables 5-9 and 5-10).

Median dissolved arsenic concentrations were found to be highest in the reference location in the Sanpoil River Arm; the second-highest median value was at RM 625.1 in the Columbia River. Concentrations of dissolved copper and zinc were generally highest at RM 735. Median concentrations of dissolved cadmium were variable and above the reporting limit for only 4 of the 10 locations, but were highest at RM 664 (Table 5-9). Dissolved lead concentrations were highest at RM 721.8.

5.3.3.2 2005 Phase I Study

In 2005, EPA evaluated two measures of aqueous metal bioavailability in sediments: dissolved metals in porewater and concentrations of SEM and AVS. SEM is a measure of the total metals that can be leached from sediment using a cold, weak acid (e.g., 1 molar hydrochloric acid [M

HCl) digestion. It is a conservative measure of the leachability of certain dissolved divalent metals²⁶ (i.e., cadmium, copper, nickel, lead, and zinc) from sediments into water under extreme conditions (e.g., pH 4) for river sediments (Allen et al. 1993). The concentration of AVS represents a fraction of the sulfide available for complexing with the divalent metals (Allen et al. 1993). Results of EPA's 2005 survey are summarized in the next two sections.

Dissolved Metals in Porewater

Methods: EPA obtained samples of interstitial porewater by centrifuging sediment collected at 56 sites in the UCR (Map 5-4). At all of these sites, sediment was also collected for sediment toxicity testing. The porewater samples were collected to assist in the interpretation of the toxicity results, rather than to be indicative of in situ conditions (EPA 2006e). Fifty of these sites were located in the UCR and six were in reference areas located in UCR tributaries. Sediment samples were collected in deep water with a van Veen grab sampler and in shallow water with a petite Ponar grab sampler (Standard Operating Procedure [SOP] SEDFSP-3 in EPA [2005e]). Multiple grab samples were collected at each site, as necessary, to obtain sufficient volume. The samples were homogenized in an aluminum-lined stainless-steel bowl under oxic conditions, transferred to two 1-L glass jars (SOP SEDFSP-11 Addendum 1 in EPA, 2006f), and held at 4°C until they were loaded into centrifuge bottles. Samples were then centrifuged for 30 minutes at 3,000 rpm at 10°C under oxic conditions. This step was repeated if the sample remained cloudy. The centrifuged supernatant (porewater) was combined until 200 mL was obtained.

Results: EPA measured 24 elements at 56 sites²⁷ in UCR sediment porewater (Table 5-11). Some elements were either undetected or detected at a low frequency (i.e., < 5 percent) (Table 5-12). Porewater hardness concentrations were generally high and variable, averaging 229 ± 114 mg/L as calcium carbonate, and they generally were higher in the upper UCR above EPA RM 721.

SEM and AVS Concentrations

Methods: EPA measured SEM and AVS in the upper 10- to 15-cm sediment horizon at 56 sites in the UCR and its tributaries in April and May 2005 (Map 5-4; EPA 2005f). The purpose was to determine which sediments may be nontoxic to benthic macroinvertebrates based on divalent metals, such as cadmium, copper, lead, nickel, and zinc, the metals for which the use of SEM and AVS has been validated (Di Toro et al. 2005). Consequently, the SEM data that EPA (2005c) reported for antimony and chromium were not used.

Sediment samples slated for AVS and SEM analysis were removed immediately from the van Veen grab sampler after overlying water was decanted (EPA 2005e). The AVS and SEM aliquot was collected directly into a jar from the upper 10 to 15 cm of sediment in the van Veen

²⁶ Inorganic mercury also is an SEM, but Brumbaugh and Arms (1996) recommend not attempting to quantify it because of poor and variable recoveries.

²⁷ Sixty-one porewater analyses were made, including replicate analyses.

sampler using disposable hand tools. The jar was filled completely and capped quickly to minimize exposure to oxygen. The AVS and SEM aliquot was not homogenized prior to placement in the jar and was held at 4°C until analyzed. Separately, TOC was analyzed to support the AVS and SEM analysis. The sample used to measure TOC was obtained after sediment was transferred from the van Veen grab sampler to an aluminum foil-lined bowl and homogenized. The homogenate may have reflected multiple grab samples, if required, to obtain sufficient sediment to accommodate the sediment analyses.

Results: Total (SEM – AVS)/ f_{oc} concentrations were higher in sediments upstream of EPA RM 720, and overall they were more than an order of magnitude higher than those measured at the five reference locations (Figure 5-42, Table 5-13). AVS concentrations were often low or undetected, but were higher upstream of EPA RM 700 (Figure 5-43). AVS concentrations may be related to TOC concentrations because the microbially mediated degradation of organic matter can produce sulfide in the presence of sulfate, but the relationship was much different downstream of EPA RM 700 (Figure 5-44) from upstream (Figure 5-45). TOC concentrations generally were low (median around 1.0 percent, maximum 3.9 percent), were highly variable spatially, and tended to be higher between EPA RM 736 and USGS RM 675 (Figure 5-46). TOC concentrations were significantly higher ($p = 0.001$) in sediments from the reference sites (2.6 ± 0.8 percent) than those from the study sites (0.5 ± 0.6 percent). Reference site samples were collected at tributary mouths above the level influenced by Lake Roosevelt, so they were not influenced by TOC in the reservoir.

5.3.4 Sediment Toxicity

In this section, results of sediment toxicity tests conducted on surface sediment from the UCR are described. The results of historical studies conducted prior to 2005 are discussed first, followed by a discussion of the results of the 2005 Phase I sediment study.

5.3.4.1 Historical Studies

Three historical studies of the toxicity of surface sediments to benthic invertebrates in the UCR have been conducted by researchers at Ecology (Era and Serdar 2001; Johnson 1991c) and USGS (Bortleson et al. 2001). Toxicity tests were also conducted on sediments collected by Godin and Hagen (1992), Norecol Environmental Consultants Ltd. (1993), Paulson et al. (2006), and Besser et al. (2008); however, these data are not evaluated in this report but will be considered in the BERA Work Plan. This section summarizes the objectives, scope, methods, and results for the aforementioned studies.

Johnson et al. (1991b)—This study represented the earliest evaluation of sediment toxicity within the UCR. The objective was to assess the toxicity of sediments to benthic invertebrates based on prior documentation of elevated metals concentrations in Lake Roosevelt sediments (Johnson et al. 1989).

Methods: Six sites were sampled between August 14 and 17, 1989: one near Grand Coulee Dam (Swawilla Basin—USGS RM 605), one just above the Spokane River confluence (Castle Rock—USGS RM 645), one below the Colville River at French Rocks (USGS RM 691), one below Northport at Little Dalles (USGS RM 728), and two 3.9 and 7.8 miles upstream into the Spokane and Sanpoil River Arms, respectively²⁸ (Map 5-4). Bioassays of whole sediment and a sediment elutriate²⁹ were completed with the cladoceran *Daphnia magna* and bulk sediment bioassays were conducted with the amphipod *Hyalella azteca* and saltwater bacterium *Vibrio fischeri*. The bacterium is tested with a proprietary method (Microtox[®]).³⁰ Bioassays were attempted using an insect, the chironomid *Chironomus dilutus* (formerly *tentans*), but were unsuccessful.³¹ Specific test methods were not identified, but all of these are common laboratory test organisms; however, standard test protocols (e.g., through ASTM or EPA) do not exist.

Results: Johnson (1991c) concluded that the bioassay data showed some evidence of toxicity at several sites (Table 5-14), based on comparison to laboratory (negative) controls.³² At four of the six sites, survival of *Hyalella* and *Daphnia* in bulk sediments was high, but at two sites (Castle Rock and Swawilla Basin), survival was reduced. Because sediment elutriates did not significantly affect *Daphnia* survival, the author concluded there were negligible releases of metals and other potentially toxic constituents from the sediments. Johnson (1991c) reported “few” correlations with metals concentrations: all involved the Microtox[®] assay, where light output was inversely correlated with total cadmium concentrations in bulk (whole) sediment ($r = -0.83$) and arsenic concentrations in porewater ($r = -0.83$).

²⁸ The precise location of the samples collected in the arms is unclear, specifically the reference point used for calculating the distances.

²⁹ The methodology for preparing the elutriate was not described, but elutriates usually reflect the clear supernatant or decant resulting from centrifugation or settling of a homogenized mixture of test water and sediment.

³⁰ This test assesses toxicity to a marine luminescent bacterium, specifically a strain of *Vibrio fischeri*: NRRL B-11177. This bacterium used to be called *Photobacterium phosphoreum*. The tests are conducted in a saline extract of the sediment.

³¹ The control organisms did not meet minimum quality control criteria for test acceptability.

³² There were no positive control samples, that is, samples from reference sediments collected and handled in the same way as the study samples.

Bortleson et al. (2001)—This study of sediment toxicity in the UCR included a comprehensive series of toxicity tests, including those using *Hyaella azteca*, *Ceriodaphnia dubia*, and *Vibrio fischeri*.

Methods: This study was conducted in September and October of 1992. Bulk sediments used for testing were collected from 21 to 27 sites³³ along the riverine and reservoir reaches and at the mouths of several tributaries³⁴ (Map 5-4). Sediments representing a composite of three to five samples from each site were collected using a stainless-steel van Veen grab sampler. The uppermost 0.5- to 1-inch layer of sediment was collected from each grab sample, homogenized, and wet-sieved through a 2-mm nylon screen, before shipment to the bioassay laboratories.

Results: Bortleson et al. (2001) reported significant effects on *Hyaella* survival at riverine sites within 7 miles of the U.S.-Canadian border, all upstream of Northport, Washington: Boundary (USGS RM 745), Auxiliary Gage (USGS RM 743), and Goodeve Creek (USGS RM 738) (Figure 5-47, Table 5-15). Results based on *Ceriodaphnia* were less clear: reduced survival was observed at Auxiliary Gage (USGS RM 743), Boundary (USGS RM 745), and Kettle River (USGS RM 707) (see Figure 5-47). Significant effects on *Ceriodaphnia* reproduction, a chronic toxicity endpoint, were reported for the same three sites above Northport that were identified for *Hyaella* (USGS RM 738, 743, 745) and for two stations in the lower reservoir, at Whitestone Creek (USGS RM 621) and Grand Coulee Dam (USGS RM 596) (Figure 5-48). The toxicity of sandy and fine-grained bulk sediments and of porewater (which appeared to be a centrifuged elutriate) to *Vibrio fischeri* also were assessed. In fine-grained sediments, no toxicity or low apparent toxicity³⁵ was observed in the upper UCR (above USGS RM 697), encompassing riverine and upper reservoir reaches, but toxicity varied from moderate to high in the middle and lower reaches (Figure 5-49). Bortleson et al. (2001; p. 93) reported that porewater toxicity to *Vibrio* ranged from none to low (data not shown). Their Microtox[®] test results for sandy sediments were more limited, and suggested toxicity in two tributaries: Fivemile Creek (USGS RM 733) and Onion Creek (USGS RM 730).

Era and Serdar (2001)—This study of sediment toxicity in the UCR was conducted on sediments collected from May 7 to 9, 2001.

Methods: Bulk sediments were sampled at nine sites in the UCR for which sediment toxicity was reported previously by Johnson (1991c) and Bortleson et al. (2001) (see Map 5-4). Samples were collected using either a stainless-steel van Veen grab or spoon (Kettle and Sanpoil River samples only). The overlying water was decanted, and the sample was then homogenized by

³³ Bioassays of the three species were not always conducted at the same locations, notably samples tested using Microtox[®].

³⁴ For bioassays of some of the species, sites upstream of the border, specifically Lower Arrow Lake and the mouths of Kootenay and Pend Oreille rivers, also were sampled but are not illustrated within Map 5-4.

³⁵ Median effective concentration (EC50) values vary inversely with toxicity, so that a low EC50 value denotes high toxicity and conversely, a high EC50 denotes low toxicity.

stirring in a stainless-steel bowl and transferred to containers with minimal disturbance and no headspace to minimize changes in porewater chemistry. Samples were then shipped to the laboratory where they were tested for toxicity to *Hyalella azteca* (10-day survival), *Chironomus dilutus* (20-day survival and growth), and *Vibrio fischeri* (5- and 15-minute light reduction).

Results: Era and Serdar (2001) concluded there was “significant toxicity” to one or more of the test species at the majority of sites (six of nine) they assessed for toxicity³⁶ (Table 5-16). These included sites in the river (USGS RMs 738, 743, and 745) and those in the lower reservoir (USGS RMs 605, 616, 621, and 645). Nevertheless, the results generally failed to identify consistent toxicity of high magnitude (e.g., 40 to 60+ percent effect) or effects encompassing multiple species and endpoints. For example, only the sediment from Goodeve Creek (USGS RM 738) was toxic to all three species and five endpoints tested (including two *Vibrio fischeri* endpoints), and at only one other site, Castle Rock (RM USGS 645), did more than one species exhibit a response (*Chironomus* and *Vibrio*).

5.3.4.2 2005 Phase I Sediment Investigation

The Phase I study represents the most recent evaluation of sediment toxicity in surface sediments of the UCR. Toxicity testing was conducted in conjunction with the sampling of surface sediments described previously in Section 5.2.1. The following sections provide an overview of the methods used in the 2005 study, describe the reference areas selected for the study, present the toxicity results, and summarize the key findings of these evaluations. A more detailed evaluation of the toxicity data will be provided in the work plan for the BERA.

Overview of Sampling and Analysis Methods

Surficial sediment (i.e., the upper 10 to 15 cm of sediment) was collected at 56 sites in the UCR and its tributaries in April and May 2005 to assess toxicity using laboratory tests of benthic macroinvertebrates (see Map 5-4) (EPA 2005e). Six of these sites were selected by EPA as reference sites. All UCR samples were collected from the nearshore side bank area of the river/reservoir, in water depths typically ranging from approximately 2 to 4 feet. Reference area sediment samples were collected from submerged portions of the main flow channel.

Criteria for reference area selection included location, lack of contamination, and elevations greater than the maximum water level in the reservoir. The reference area sample locations were distributed over a fairly broad portion of the study area and provided a representative range of sediment characteristics (e.g., grain size, organic content) found in the area.

Sediment samples were tested for toxicity using the following laboratory toxicity tests:

- 28-day amphipod (*Hyalella azteca*) toxicity test

³⁶ Two additional sites were also toxic to *Vibrio fischeri* (Boundary at USGS RM 745) and Castle Rock (USGS RM 645).

- 10-day midge (*Chironomus tentans*) toxicity test
- 7-day cladoceran (*Ceriodaphnia dubia*) toxicity test

Organism responses to test sediment exposures were compared to the responses observed in the laboratory negative controls and reference area sediments. Determination of the “hit/no hit” designation for each sediment sample was dependent on the statistical comparison with the negative control and each distinct reference area control, and whether test acceptability requirements were also met. The statistical analyses performed by the laboratories followed those outlined by ASTM and EPA.

For *H. azteca* and *C. tentans*, the endpoints measured were survival (total number of organisms [larvae, pupae, and emerged adults] surviving at termination divided by number of organisms added at initiation) and weight (ash-free dry weight [dry weight minus ash weight] of surviving organisms divided by the number of surviving organisms).

For *C. dubia*, the endpoints measured were survival (total number of adults surviving at test termination divided by the number added at initiation) and reproduction (total number of neonates produced through the first three broods from each adult).

Results of the Sediment Toxicity Tests

The results are summarized by test species and for each sample in Table 5-17, including mean survival (all species), growth (*H. azteca* and *C. tentans*), and reproduction (*C. dubia*). Following is a summary of results reported from the EPA Phase I study (EPA 2005e):

- *Hyalella azteca* survival – 14 of 50 samples had a statistically significant reduction from at least one of the reference areas.
- *Hyalella azteca* growth – 42 of 50 samples had a statistically significant reduction from at least one of the reference areas.
- *Chironomus tentans* survival – 11 of 50 samples had a statistically significant reduction from at least one of the reference areas.
- *Chironomus tentans* growth – 25 of 50 samples had a statistically significant reduction from at least one of the reference areas.
- *Ceriodaphnia dubia* survival – 3 of 50 samples had a statistically significant reduction from at least one of the reference areas.
- *Ceriodaphnia dubia* fecundity – 16 of 50 samples had a statistically significant reduction from at least one of the reference areas.

For all three species tested, the measured adverse effect level appears greatest in the upper reach of the river, in particular above RM 737. In addition to the adverse effects observed in the upper river, measurable impacts to *C. dubia* survival and fecundity were notable at several locations between RM 628 and RM 640 (specifically at RMs 628, 634, and 640).

5.4 FISH TISSUE RESIDUES

Chemical concentrations have been evaluated in a variety of fish species and tissues throughout the UCR. This section summarizes concentrations of inorganic and organic constituents from historical tissue investigations (i.e., those completed prior to 2005) and from the Phase I fish tissue study completed by EPA in 2005 (EPA 2005c; 2006d). As discussed previously, the discrepancies with the river miles used by the 2005 Phase I study and the USGS above USGS RM 680 should be remembered, and are noted on all relevant tables and figures in this section.

5.4.1 Historical Investigations of Fish Tissue Residues

Fish tissues have been collected throughout the UCR since the early 1970s. The primary chemical groups investigated include metals, dioxins and furans, PCBs, and, to a limited extent, pesticides. These investigations have incorporated a variety of fish species and tissue types (e.g., whole body or fillet). A summary of the studies (including dates of collection, areas of collection, species collected, tissue types, and chemicals evaluated) conducted within the UCR is presented in Table 5-18. A summary of the range of concentrations of metals, dioxins/furans, and arochlor PCBs identified in historical studies is presented in Table 5-19. Details of these historical studies have been provided in a previous EPA document (EPA 2005c) and will be discussed as part of future fish tissue sampling and analysis plans.

5.4.2 EPA 2005 Investigations of Fish Tissue Residues

In September and October 2005, six species of fish (burbot, largescale sucker, wild and hatchery-reared rainbow trout, lake whitefish, mountain whitefish, and walleye) were collected from six collection areas on the UCR. The collection areas approximately corresponded to areas where sediments were intensively sampled, described as fish sample collection areas (FSCAs), during the Phase I study. The two FSCAs farthest upstream, Areas 1 (including 1A) and 2, were located in the riverine portion of the UCR. Area 3 was located at Marcus Flats near the confluence of the UCR and the Kettle River, where the river widens and slows. Areas 4, 5, and 6 were located within Lake Roosevelt. Map 5-5, modified from EPA (2006d), identifies the six FSCAs on the UCR used for each species for the Phase I study.

A basic description of the study design, including the number of samples of each species analyzed from each collection area, is provided in Table 5-20. The study included chemical analysis of whole body fish from the six fish species, and both whole body and fillet tissue from two species. For fish from which fillets were analyzed, the offal (the remainder of the fish after removing fillets) was also analyzed to facilitate estimation of whole body concentrations on these samples. In general, samples were submitted for analysis as composites of five individuals. In addition to analyses of whole body and fillets, analyses were performed of gut contents of largescale suckers because consumption of sediment may be an important exposure pathway for this species. The purpose of this analysis was to assess the influence that

undigested sediment in the gut of this species may have on estimates of whole body concentration.

The size range of fish collected in this study approximately bracketed a mean size determined from UCR creel census data and/or reports of mean size from scientific collections. A summary of the mean size of the fish in the composite samples is provided in the tables of analytical data reported in Appendix F. Full details including dates and coordinates of all fish collected are available in EPA (2006d).

All fish tissue samples were analyzed for 23 inorganic analytes (metals), total mercury, PCB aroclors, and PCDDs and PCDFs. Approximately one composite sample of each species (about 20 percent of the total samples) from each collection area was analyzed for PCB congeners³⁷ and approximately 10 percent of all samples were analyzed for inorganic arsenic and organic arsenic species.

The analytical data received are provided in Appendix F of this work plan. The data were initially provided as dry-weight calculations, all results in the tables, including detection limits and other qualified data, were converted to wet-weight concentrations using the moisture content reported for each sample.

A summary of detected, non-detected, and qualified results for metals in each fish species is provided in Table 5-21. Species/metal combinations for which data were below the laboratory detection limit are also identified. The gut analysis data for largescale suckers are not included in Table 5-21. For most metals, the results for all samples analyzed were greater than the detection limit. Silver and beryllium were reported as nondetected for all samples of each species (Table 5-21), and antimony and thallium were detected in only a few samples of a single species. Antimony was detected in two of the four composite samples of largescale suckers at the most upstream collection area (Area 1). Thallium was detected only in the fillets of walleye at the collection area nearest Grand Coulee Dam (Reach 6); concentrations reported were lower than the detection limit for this metal in many other tissue/area combinations. Uranium and vanadium results were also largely nondetected in some fishes and/or tissue types, and in samples where these compounds were detected, variation was limited.

Although dioxin/furans, PCB aroclors, and PCB congeners were evaluated in the Phase I fish tissue sampling program (EPA 2005c; 2006d), pesticides were not evaluated. The numbers of samples by fish tissue and organic analytes are presented along with summaries of organic concentrations in Table 5-22.

³⁷ PCB congeners represent a class of 209 individual compounds that differ in the number and position of chlorine atoms. To summarize this large class of compounds, a sum of all PCB congeners was calculated for each sample. PCB congener detected concentrations were summed to estimate the "total PCB congener concentration." For congeners that were nondetected in a sample, the value of that congener was set equal to zero. This analysis was conducted to assess the magnitude of differences in the PCB congener concentrations, and no conclusions with regard to toxicity are inferred.

Similar to historical studies of dioxins/furans, TCDF was the most frequently detected (99 percent in whole body tissues) organic compound in UCR fish tissues (Table 5-23). TCDD was detected in whole body tissues at a frequency of 9 percent. Other dioxins/furans were detected between 0 and 73 percent in UCR fish tissues. Aroclors 1254 and 1260 were summed in the EPA tissue program and were detected in all species and tissues. All other aroclors (except Aroclor 1016, frequency of detection = 2 percent) were never detected in UCR fish tissues. The frequency of detection of PCB congeners was variable between species and fish tissues, and most congeners were detected at a frequency greater than 10 percent (Table 5-23).

Spatial variation of metal concentrations among collection areas in the UCR was common, but the nature and amount of variation differed among the fish species evaluated. For largescale suckers, the species with the most spatial variation in concentrations, most metal concentrations were greater at upstream sites, but there were exceptions, particularly for mercury, selenium, and arsenic. Similarly, examination of spatial differences within species and among sites for organic chemicals did not indicate a consistent trend. Differences in concentrations of organics among FSCAs were variable and did not constitute a significant declining or increasing trend when comparing upstream versus downstream collection areas.

Concentrations of organic chemicals were observed to vary among species. Lead concentrations in whole-body samples of largescale suckers were more than 10 times greater than that of all other species of fish sampled in each collection area (Figure 5-50). Largescale suckers also had the greatest concentrations of cadmium, chromium, cobalt, manganese, and nickel at every site. Burbot had total arsenic concentrations two to three times greater than other species throughout the study area (Figure 5-51). The spatial pattern of mercury accumulation in fish tissue appeared to group fish by dietary preference (Figure 5-52). The mean concentration in the two piscivorous species followed a similar pattern among collection areas, as did the mean concentration of the invertivorous/planktivorous species, rainbow trout and whitefish. Largescale suckers exhibited a pattern distinct from the piscivores and invertivores/planktivores.

Whole-body wet-weight TCDF concentrations are highest in lake whitefish, followed by burbot and largescale suckers. Lipid-normalized TCDF concentrations are highest in burbot compared to other species (Figure 5-53). Fillet concentrations of TCDF (normal) appear to be higher in rainbow trout than walleye, and hatchery and wild rainbow trout concentrations are comparable (Figure 5-54). Walleye fillet tissues had higher TCDF concentrations per lipid content than rainbow trout fillets. Aroclor 1254/1260 wet-weight concentrations in whole body tissues appear highest in largescale suckers (Figure 5-54). Burbot, walleye, and largescale suckers have higher aroclor concentrations per lipid content than other fish species (Figure 5-55). Rainbow trout fillet tissues contain higher normal concentrations of aroclors than walleye (Figure 5-56), and wild rainbow trout concentrations appear higher than hatchery concentrations. Walleye fillets had higher aroclor concentrations per lipid content than rainbow trout (Figure 5-57). Observed species differences may be due to varying feeding preferences or age classes of the various species.

5.5 AIR QUALITY

Several air quality investigations have been conducted previously in the UCR area. These investigations include a monitoring study conducted by WDOH/Ecology at Northport, air quality monitoring conducted by TCM at Northport, and a study of occurrence and distribution of trace elements in air along Lake Roosevelt conducted by the USGS (USGS, 2006d).

5.5.1 WDOH/Ecology Air Quality Study at Northport, Washington

Responding to inquiries by residents living in the vicinity of Northport, Ecology, in cooperation with the WDOH, conducted an air quality study between December 15, 1992, and December 31, 1998. The purpose of the air quality study was to 1) determine the possibility of cross-border transport of pollutants, 2) identify a potential contributing source(s), and 3) measure pollutant concentrations (Ecology 1998a). The study consisted of four phases:

- Phase 1, December 15, 1992, through February 13, 1993 (WDOH 1994)
- Phase 2, August 1993 through October 30, 1993 (WDOH 1994)
- Phase 3, November 3, 1993, through August 6, 1994 (Divens 2006)
- Phase 4, September 5, 1997, through December 31, 1998 (Ecology 1998b).

The studies at Northport were initiated at the request of WDOH to help identify the cause of health problems reported by the residents (WDOH 1994).

Phase I air sampling included five sampling sites, four in the Northport area and one in Kettle Falls. At all sites, samplers monitored concentrations of total suspended particulates (TSP), lead, and arsenic. In addition, at one of the Northport area sites, a sampler measuring particulate matter with a diameter less than 10 μm (PM10) was also used (WDOH 1994). The results of Phase I indicated no violation of the state or federal lead standards, but WDOH reported that concentrations of lead and arsenic measured during the study were some of the highest recorded anywhere in the state during the Phase I study period (WDOH 1994).

Based on the need for additional data following Phase I, Phase II was conducted. This phase included seven monitoring sites. According to WDOH, selection of air monitoring sites focused primarily on areas suspected of high metals concentrations in the Northport and Kettle Falls area, and secondarily to establish a north-south distribution of monitoring data from Trail, B.C., to Kettle Falls (WDOH 1994). Phase II included analysis of 31 metals, including 7 that WDOH (1994) indicated would likely come from a smelting operation, local mining operations, and other potential sources. These were antimony, arsenic, cadmium, copper, lead, manganese, and zinc.

Laboratory quality assurance was performed only on the seven metals of interest (WDOH 1994). At each of the seven sites, PM₁₀ was monitored using an instrument certified by EPA for use in sampling PM₁₀ on a one-in-six-day schedule consistent with national monitoring programs (WDOH 1994). At one of the two Northport sites, Papparich Farms, two additional samplers were installed. One of these measured TSP and the other measured PM₁₀ using a sequential instrument that is not certified by EPA, but does have the capability to sample on two sets of filters, for six days in a row.

Wind speed, wind direction, and temperature data were also collected at the Papparich Farms site for a limited period (August 10, 1993, through September 27, 1993). These data were used in conjunction with metal concentrations measured at the seven monitoring sites on September 28, 1993, to support computer modeling of predicted distributions of lead, arsenic, and cadmium in air throughout the study area. As reported by WDOH (1994), September 28, 1993, was the worst air quality day of the Phase II study period.

Phase II results reported by WDOH indicated no violation of the 150-microgram-per-cubic-meter ($\mu\text{g}/\text{m}^3$) state particulate standard in effect at the time of sampling. In addition, the maximum concentration of lead measured during the 42-day study period at each site was lower than the federal and state standard for lead, $1.5 \mu\text{g}/\text{m}^3$ averaged over a 3-month period (WDOH 1994). In the absence of federal and state standards for the other six metals, maximum measured concentrations at each site were compared to Ecology's acceptable source impact levels (ASILs). ASILs for antimony, copper, manganese, and zinc are based on 24-hour averages and were not exceeded by maximum measured concentrations of these metals during the study period (WDOH 1994). However, maximum concentrations of arsenic and cadmium measured during the 42-day study period did exceed corresponding ASIL values, which were based on annual average concentrations of these metals. WDOH (1994) noted that the difference in averaging times for the ASILs and the study could be misleading given that average concentrations over the entire study period would tend to be much lower than maximum values and still greater than data measured and averaged over an entire year. Specifically, WDOH (1994) states: "There is a strong likelihood that, had Phase II lasted a whole year, the resulting yearly arsenic concentrations would be much lower still, perhaps much closer to the ASIL values."

Based on the results of Phase II, Phase III air monitoring of PM₁₀, lead, arsenic, zinc, and cadmium at the Papparich Farm was conducted from November 3, 1993, through August 6, 1994 (Ecology 1998a). Ecology reported the need for additional analysis to evaluate the risk to populations exposed to these metals.

Ecology's detailed analysis of the monitoring samples collected during Phase III of the study showed that:

- The quarterly average lead concentration at the monitoring site was $0.14 \mu\text{g}/\text{m}^3$, which was an order of magnitude less than the quarterly standard of $1.5 \mu\text{g}/\text{m}^3$.

- The annual average arsenic concentration was $0.03 \mu\text{g}/\text{m}^3$. This value was higher than Ecology's ASIL value of $0.00023 \mu\text{g}/\text{m}^3$.
- The annual average cadmium concentration was $0.01 \mu\text{g}/\text{m}^3$, which was higher than the ASIL of $0.00056 \mu\text{g}/\text{m}^3$.
- The highest observed value of PM₁₀ was $104 \mu\text{g}/\text{m}^3$, approximately two-thirds of the National Ambient Air Quality Standard of $150 \mu\text{g}/\text{m}^3$ for a 24-hour period (Ecology 1998a).

Comparison of arsenic and cadmium concentrations to the ASIL values is problematic because the values are below detection limits and background concentrations typically exceed these values even in rural areas. Reported mean levels of arsenic in ambient air in the United States range from < 0.001 to $0.003 \mu\text{g}/\text{m}^3$ in rural areas and from 0.02 to $0.03 \mu\text{g}/\text{m}^3$ in urban areas (American Society for Testing and Materials [ASTM] 2004). Similarly, Agency for Toxic Substances and Disease Registry (ATSDR) (1999) reports that during the 1980s and 1990s, mean cadmium levels ranged from $< 0.001 \mu\text{g}/\text{m}^3$ in remote areas to 0.003 – $0.05 \mu\text{g}/\text{m}^3$ in urban areas in the United States. Background levels of arsenic, cadmium, and lead in Northport areas are not available.

Based on the Phase III air sampling results for PM₁₀ and metals in particulate phase, Ecology analyzed the patterns and concentration ratios among arsenic, cadmium, and lead. Through the analysis, Ecology found that for the period of August 13, 1993, through August 6, 1994, "arsenic levels in Northport, on average, were about one-tenth those of lead. Cadmium levels were about one-nineteenth those of lead... arsenic and cadmium were almost always deposited with lead in a similar pattern, i.e., where lead concentrations are high, arsenic and cadmium concentrations are also high and vice-versa" (Ecology 1998a). Therefore, Ecology concluded that "lead, arsenic and cadmium were deposited in the Northport area in ratios that stayed consistent between the metals, which indicated a common source, i.e., Cominco Ltd." (Ecology 1998a).

In October 1995, TCAI proposed to upgrade its lead smelting operation located north of the border. Both B.C. MoE and Ecology conducted extensive reviews of the proposed technology upgrade. Ecology concluded that the technology met U.S. federal and state regulatory requirements and recommended approval to B.C. MoE. Subsequently, B.C. MoE approved the proposal and TCM installed the new technology. The new process began operation in the spring of 1997 (Ecology 1998a). After the implementation of the new process, Ecology further required that three long-term monitoring sites for air quality be operated in the Northport area to track the changes of air quality from the upgraded TCM facility and to aid in future air quality modeling. Phase IV monitoring results were to be used to evaluate the need for additional emission reductions at the TCM facility (Ecology 1998a; 1998b).

Phase IV monitoring results show that the observed averages for particulate matter, arsenic, cadmium, and lead were 47, 0.03, 0.01, and $0.07 \mu\text{g}/\text{m}^3$, respectively (Ecology 1998b). When

compared with the monitoring results for Phase III, Ecology found that average concentrations for arsenic and cadmium showed little change, whereas the average concentrations for lead decreased significantly (Ecology 1998b). Ecology did not elaborate on this finding, but indicated that a final report “including analysis and presentation of all the data” for the Phase IV study would be released (Ecology 1998b). Recently, however, Ecology confirmed that no further analysis was done following release of the 1998 Phase IV progress report (Dahlgren 2006, pers. comm.).

5.5.2 TCM Air Quality Monitoring at Northport, Washington

TCM has been operating a parallel monitoring station located approximately 1 mile north of the Ecology monitoring site at Northport, Washington, continuously since 1994. Similar to the Ecology program, TSP, PM₁₀, trace metals, and sulfur dioxide are measured. After Ecology’s monitoring program ended in 1998, the TCM station operation continued.

TCM air monitoring data for PM₁₀, arsenic, lead, cadmium, and zinc are summarized in Appendix G for the period of January 1994 through August 2006. Mean concentrations for each analyte, by year, are summarized in Table 5-24. Figure 5-58 depicts the trends in annual mean concentration over the multi-year sampling period. Evaluation of these data indicates relatively stable mean annual PM₁₀ concentrations over the period 1994 to 2006 (range: 10 to 19 µg/m³).

For comparable time periods, the metal concentrations at the TCM monitoring station were similar to those reported for samples collected at the Ecology station. Beginning in 1997, the mean annual concentrations of arsenic, cadmium, lead, and zinc followed a decreasing trend, which reflects the effect of implementation of the technological upgrade at the Trail facility. The decreasing trend lasted until 2001, gradually leveling off in subsequent years as represented in Figure 5-58.

5.5.3 USGS Study of Occurrence and Distribution of Trace Elements in Air Along Lake Roosevelt (Marcus Flats/Kettle Falls, Inchelium, and Seven Bays)

During the spring and fall, the water level in Lake Roosevelt decreases substantially and extensive reaches of sediments with elevated metals concentrations are exposed (USGS 2006d). Trace metals associated with the fine-grained fraction of the exposed dry bed sediments have a potential for entrainment into the lower atmosphere by high wind gusts. Once airborne, the dust particles can be carried downwind various distances depending on their size and the magnitude and duration of the prevailing winds throughout the Lake Roosevelt airshed. EPA has recommended additional studies of the potential for metals in airborne dust to pose a human health risk (USGS 2006d).

In cooperation with the Lake Roosevelt Water Quality Council and the USBR, USGS has been conducting an air quality study along the UCR since 2002 to:

- Determine the occurrence, concentration, distribution, and seasonal variability of select trace elements on airborne dust particles at several locations along Lake Roosevelt
- Compare the composition and concentration of airborne trace elements in the ambient atmosphere to that of high wind events occurring during winter/spring and fall reservoir drawdown periods
- Determine, to the extent possible, what percent of the measured concentration of airborne trace elements originated from exposed beach, bed, and bank sediments (Kahle and Majewski 2003; USGS 2006d)

The technical approach used by USGS in this study was to compare the occurrence, composition, and concentration of trace elements measured in airborne dust samples collected before, during, and after the drawdown of the reservoir to the results of a previous study that sampled exposed bed sediments along the entire length of Lake Roosevelt (USGS 2006d). Three monitoring stations were set up along the UCR at Marcus Flats/Kettle Falls, Inchelium, and Seven Bays. The monitoring station at Kettle Falls was operated only in 2002, and it was moved to Marcus Flats in 2003. Using the collected PM₁₀ samples, air concentrations for arsenic, lead, cadmium, copper, zinc, and other elements were analyzed by USGS.

Monitoring results for 2002, 2003, and 2004 data pertinent to Seven Bays, Inchelium, Kettle Falls (2002), and Marcus Flats (2003, 2004) obtained from USGS were evaluated. The evaluation focused on monitoring results for PM₁₀, arsenic, lead, cadmium, and zinc, for consistency with prior data evaluations by TCAI and Ecology. Monitoring results for copper were also evaluated.

Statistical evaluation of results for each analyte, by station (Seven Bays, Inchelium, Kettle Falls, and Marcus Flats) and year (2002, 2003, and 2004), are summarized in Tables 5-25 through 5-27. Figures 5-59 through 5-61 show mean annual concentrations for all sampling stations for 2002, 2003, and 2004, respectively.

The mean annual PM₁₀ concentrations did not show any spatial or temporal trend across the three monitoring stations for 2002 to 2004. All the mean concentrations were within the range of 11 to 22.8 µg/m³. The highest mean concentration, 22.8 µg/m³, occurred at the Seven Bays monitoring station in 2004. Mean concentrations of arsenic, cadmium, and lead showed a gradual decreasing trend from north to south (i.e., from Marcus Flats to Inchelium to Seven Bays) along the UCR within the three monitoring years. Kettle Falls analyte concentrations in 2002 were similar to those at Seven Bays and Inchelium, with only cadmium and zinc showing moderate increases compared to the other sites.

Copper and zinc consistently had the highest mean air concentrations for all sites across all sampling periods. Lead consistently had the next highest mean annual concentrations across all sampling periods with a maximum annual concentration of 0.0101 $\mu\text{g}/\text{m}^3$ observed in 2004 at Marcus Flats. The highest mean annual concentration for arsenic was 0.00074 $\mu\text{g}/\text{m}^3$, which was also observed at Marcus Flats in 2004. Based on the monitoring results for 2002–2004 and additional observations in 2005 and 2006, USGS concluded that for PM₁₀, 24-hour average concentrations for all the monitoring stations did not exceed the short-term standard (150 $\mu\text{g}/\text{m}^3$) and the annual average concentrations did not exceed the long-term standard (50 $\mu\text{g}/\text{m}^3$). Air concentrations of slag-related trace elements were low, and the study did not single out any trace element as being of concern (Kahle and Majewski 2003; USGS 2006a).

6 CONCEPTUAL SITE MODELS

A CSM provides a framework within which the complex suite of chemical, physical, and biological processes and interactions that prevail at a site can be viewed in a systematic and organized manner. For the UCR RI/FS, the CSM is intended to be a dynamic model that will be updated as additional information is collected. A CSM typically considers the sources of contaminants, the physical-chemical processes that control chemical fate (i.e., the physical transport and chemical reaction pathways that control concentrations of chemicals of interest (COIs) over time and space), and the exposure pathways that are needed to evaluate the potential for adverse effects (Figure 6-1).

In developing a CSM, the first consideration is the different sources that release COIs to the primary environmental media (i.e., air, soil, surface water, groundwater, and sediment). Once present in the environment, these chemicals are physically transported within and among the various media by processes that result in a range of chemical concentrations to which ecological receptors and/or humans are potentially exposed. In surface water and sediment, the distribution of these concentrations between the dissolved and particulate phases is relevant in characterizing exposures. However, at a more detailed level, chemical reactions may occur that lead to the formation of a variety of chemical species, particularly for metals/metalloids. These occurrences have important implications for assessing the bioavailability of chemicals to ecological receptors and subsequent potential for adverse effects. This information is critical to human health and ecological risk assessments where the potential exposure, effects, and risks to humans and ecological receptors are assessed and quantified.

The initial CSMs presented here broadly characterize two major aspects of the UCR: 1) the physical and chemical processes that influence the transport and fate of COIs at the Site, and 2) the relationship between sources (primary, secondary, and tertiary), exposure pathways, and receptors (both human and ecological). In the latter case, the primary focus is on ecological receptors, and the CSM for human health is being developed by EPA. At this stage of the process, the CSMs are designed to be inclusive (i.e., screening-level CSMs). As additional information is collected and evaluated, these CSMs will be refined and adapted to the varying sets of processes and conditions that affect the different reaches of the UCR.

6.1 CHEMICALS OF INTEREST

A preliminary list of COIs for the UCR has been developed using information about known and potential sources and data obtained during other investigations and monitoring events. The list, included as Table 6-1, is intended to include a broad range of organic and inorganic chemical groups. It should be noted that the list of COIs for the UCR is preliminary and may be updated to include additional chemicals if new information about sources (e.g., historical operations or releases) or detected chemicals come to light during the course of the RI/FS. The

COIs will be further refined through the risk-assessment process to define the chemicals of potential concern (COPCs) and, ultimately, the chemicals of concern (COCs).

The rationale for including the groups of chemicals listed in Table 6-1 is summarized below.

6.1.1 Metals and Metalloids

Metals occur throughout the UCR both as result of releases from mining, milling, and smelting facilities and because they make up the inorganic constituents of soil and rock. COIs classified as metals and metalloids includes all EPA target analyte list (TAL) chemicals and a large number of specialty metals that can occur as trace constituents of mineralized ores and that have been the subject of previous investigations.

6.1.2 Semivolatile Organic Compounds (including PAHs)

SVOCs from EPA's semivolatile target compound list are included as COIs. PAHs, of particular interest, are a broad class of compounds produced naturally and by man. Natural PAHs are produced by burning vegetation. Man-made PAHs are formed in internal-combustion engines and in petroleum products, including oil, grease, and asphalt.

6.1.3 Pesticides and PCBs

Agricultural activities in the UCR and the surrounding area are potential sources of pesticides. DDT and its degradation intermediates DDD and DDE are the principal pesticides detected in the UCR; they are called legacy pesticides, because DDT production and general use was banned in the United States and Canada. PCBs are persistent in the environment and were historically widely used in a variety of industrial applications (e.g., transformers, capacitors). Although no longer produced, their persistence and toxicity remain a concern for both environmental and human receptors.

6.1.4 Polybrominated Diphenyl Ethers

PBDE flame retardants are used in a wide variety of products, including electronics, foam, and textiles, and have been found to be widely distributed in the environment. The three most common commercial PBDE products are penta-BDE, octa-BDE and deca-BDE, which are widespread and associated with point and nonpoint sources.

6.1.5 Polychlorinated Dibenzo-*p*-Dioxins and Polychlorinated Dibenzofurans

PCDDs and PCDFs are formed during combustion of material containing chlorinated organics, as trace contaminants in chemical production (e.g., historically, pentachlorophenol), and as unintended byproducts of industrial process such as chlorine bleaching of wood pulp.

PCDDs and PCDFs are widespread in the environment and are associated with point and nonpoint sources. PCDDs and PCDFs are included as COIs to reflect the presence of smelting, wood pulping, and wood treatment facilities in close proximity to the UCR.

6.2 PHYSICAL/CHEMICAL CONCEPTUAL SITE MODEL

The physical/chemical UCR CSM focuses on physical and chemical transport and fate pathways. Transport and fate of chemical stressors are governed by hydrodynamic mechanisms and chemical reactions. The following sections discuss the physical-chemical transport and reaction pathways as they relate to the CSM, and they are graphically presented in Figure 6-2. The CSM represents the consensus results of collaborative meetings between TCAI and Participating Parties that were held in a workshop format on April 16 to 18, 2007. The consensus CSM includes all processes of potential importance agreed to at the April workshop. The relative importance of different processes described in the consensus CSM may differ among reaches and may also have greater or lesser importance within a reach, depending on the specific characteristics of that reach.

6.2.1 Hydrodynamic/Fluid Transport

Hydrodynamic transport in the UCR is affected by upstream and tributary inflow rates, which are dependent on watershed hydrology, and the operation of numerous upstream dams, as well as Grand Coulee Dam at the downstream end of the UCR. Water may also enter or leave the UCR through groundwater seepage or drainage and may also be transported in the interfacial bed area via hyporheic (interstitial) flow. Once particulate and dissolved COIs enter the UCR, they are redistributed via the hydrodynamic transport processes of advection and turbulent mixing; these processes result in the dilution and dispersion of these materials within the system (Figure 6-2). Hydrodynamic processes also influence the dynamic coupling between sediment and overlying surface water. The frictional interaction between moving fluid and riverbed roughness induces boundary shear stresses and steep vertical gradients of turbulent mixing near the bottom that regulate particle deposition and resuspension (i.e., scour). Near-bottom turbulence also regulates concentration gradients near the riverbed, altering the diffusional exchange of dissolved COIs between sediments and surface waters. Advective processes in the bed, such as interactions with groundwater and hyporheic flow, can also impact the exchange of dissolved COIs between sediments and surface waters.

6.2.2 Sediment Transport

Sediment transport is often an important fate-controlling process for COIs because of the tendency of many dissolved organic chemicals and metals to adsorb to sediment particles and concomitantly be transported downstream (Figure 6-2). Due to the resulting close ties between COIs and particulate matter (i.e., the sorbed and mineralized fractions), sediment transport is an integral aspect of chemical transport and fate analysis for COIs.

A unique feature of the UCR that differs from many other aquatic environments is that fluid velocities in the upstream reaches are sufficient to induce the movement of relatively large particles of granulated slag as bedload material, in addition to transporting COIs associated with smaller particles and detritus as suspended load. Thus, particle size classes and their vertical distribution during transport are important elements for consideration to understand the distribution of COIs within the UCR. In some instances, size-dependent particle deposition can concentrate COIs in localized regions of the riverbed where relatively low boundary shear stresses persist (e.g., within sheltered embayments and downstream from outcroppings), thereby counteracting dispersion and dilution normally associated with hydrodynamic transport. Conversely, these deposits may also be impacted by the accumulation of uncontaminated native solids that originate from upstream and tributary inputs, bank erosion, and landslides.

In the UCR, sediment particles may be transported into or out of the system by wind-driven (aeolian) transport. Particulates may be carried into the system by aerial deposition over the water surface. Materials exposed during periods of drawdown may be transported from the dried bed back into the water column or onto adjacent land areas. Similarly, when sediments in nearshore areas are exposed during periods of drawdown, those sediments may dry out (desiccate) over time and, when dry, may be eroded by winds. COIs associated with particles transported by the wind are also transported.

Solids may also be produced within the system via autochthonous production. Phytoplankton convert inorganic carbon from the water column to particulate organic matter. This particulate organic matter can bind many COIs and carry them to the bed if they settle from the water column.

In the UCR, hydrodynamic and sediment transport processes vary on a number of relevant space and time scales due to river geomorphology, seasonal patterns of precipitation and snowmelt, water-level regulation, etc. These various factors are believed to have influenced the historical distribution of COIs in the UCR system and are expected to continue to influence their redistribution in the future. For example, both lower pool elevations and higher flows will increase current velocities in the UCR. Maximum current velocities will likely occur with the period of high-flow conditions that typically occur in the spring, at the same time that relatively low-stage conditions reduce the cross-sectional area of the stream. Maximum velocities do not necessarily occur at the time of maximum drawdown due to the offset timing in maximum drawdown compared to maximum flow rate. These conditions maximize the potential for transport of coarse-grained materials (CGMs). To the extent possible for this work plan, the expected roles of these factors and their potential influence on COI distribution and redistribution are described in Section 3.2.

6.2.3 Chemical Transport and Fate

The evaluation of chemical fate and resulting COI-exposure levels of aquatic ecological receptors requires that the important fate-controlling reaction and transfer processes be considered. Figure 6-2 provides a representation of a number of the factors that may control chemical reaction and transfer processes. First, COIs will be distributed between the soluble (i.e., dissolved) and particulate fractions in both the water column and sediment porewater, with the distribution between these fractions affecting the rates of transport within the system. Further, the form of the COI in either of these fractions is also important, because it will affect COI bioavailability and the route of exposure to ecological receptors. The dissolved fraction (both organic chemicals and metals) will include both a freely dissolved fraction and a dissolved ligand-bound fraction. In the case of organic contaminants, the dissolved ligand is generally dissolved organic matter typically quantified as dissolved organic carbon (DOC). In the case of metals, these ligands include dissolved organic matter as well as a number of other chemical species. The ligand-complexed fraction of the dissolved chemical generally has relatively low bioavailability compared to the freely dissolved fraction. In addition, only the freely dissolved fraction of the chemical may be subject to volatilization. A conventional, if somewhat simple, approach to evaluating the distribution of an organic COI between these fractions is to assume that the adsorbed concentration is in equilibrium with and proportional to the freely dissolved concentration. The constant of proportionality is the partition coefficient (typically related to the carbon content of the particulate material) and is COI-specific.

The situation is more complicated for metals, especially where the particulate fraction of bedded sediments is largely associated with granular material that originated from granulated slag. To begin with, significant portions of the granulated slag-related COIs exist within the matrix of internal mineral phases. When present in this form, the interaction between the particulate fraction and the dissolved phase is limited, if not entirely precluded. As speculated by Cox et al. (2005), a portion of this mineralized fraction may be released to the porewater and overlying water column over the longer term, as a result of the relatively gradual processes of weathering/dissolution and subsequent mass transfer between the porewater and overlying water column. Metals may also reversibly precipitate into a mineral phase, depending on the water chemistry at a given time and location in the system. This mineral phase may later dissolve if water chemistry changes. In addition to the mineral fraction, there is an adsorbed particulate metal fraction to consider. It is not unreasonable to consider this fraction to be in an approximate equilibrium with the dissolved concentration in the water column. However, for metals generally, understanding the interaction requires a relatively detailed consideration of both the surficial characteristics of the sorbent (i.e., the particles) and of water chemistry. Interactions of COIs and other positively charged ions (e.g., the hardness cation Ca^{2+}) also influence the degree of adsorption to particulates.

Partitioning of COIs between the dissolved and particulate phases has important implications to COI fate and bioavailability, when considered in combination with the hydrodynamic and

sediment transport pathways. First, adsorbed COIs are transferred between the surface water and sediment in association with the settling and resuspension of particulate matter. The propensity of COIs to adsorb to particulate matter also explains why COIs commonly accumulate in bottom sediments of depositional regions. Depending upon the nature of a specific system, bottom sediments often serve as the ultimate COI repository, with the long-term fate of particulate and porewater COIs being sequestered by burial within the sediment. Second, partitioning reactions also affect the diffusive flux of COIs between sediment porewater and surface water. This is because the diffusive flux is proportional to the concentration gradient between these compartments of total dissolved COIs (free + inorganically complexed + DOC-complexed). Finally, partitioning is important because it often is assumed that particle-associated chemicals (internal or adsorbed) and DOC-complexed chemicals have limited bioavailability (Black and McCarthy 1988; Landrum et al. 1985; EPA 1998a). When this is the case, the particulate fraction does not contribute directly to waterborne toxicity or bioaccumulation in ecological receptors. If the dietary route of exposure is important, the ingested particulate COI fraction could become an additional route of direct exposure.

The relatively simple chemical reactions and transfers described above are expected to be representative of the principal processes controlling the fate of COIs in the UCR. Degradation processes, although important for some organic compounds, are generally of limited importance for metals/metalloids. Conversely, while a relatively simple representation of the distribution of organic chemicals between freely dissolved, DOC-complexed, and particulate organic carbon is commonly assumed, a refined evaluation is often appropriate when considering metals (Paquin et al. 2003). Such an evaluation considers a relatively complex set of chemical speciation and complexation reactions, as well as competition with other cations for adsorption to dissolved and particulate organic matter (POM). Evaluation of speciation is important to the assessment of metals bioavailability, as has been demonstrated in a number of studies (Di Toro et al. 2001; Paquin et al. 2002; Santore et al. 2001; Santore et al. 2002; EPA 1999b). Transport and fate reactions for metals that exist as organometallic forms and/or undergo changes in reduction-oxidation (redox) state (e.g., arsenic, chromium, mercury, and selenium) are more complex than those of metals such as aluminum, cadmium, copper, nickel, lead, silver, and zinc that are not commonly present in multiple forms.

6.3 ECOLOGICAL CONCEPTUAL SITE MODEL

The ecological CSM provides a screening-level framework for identifying potential sources of contaminants in the UCR and the subsequent complex suite of chemical, physical, and biological processes that may occur as a consequence of such inputs. The ecological CSM was developed in coordination with EPA and Participating Parties at the April 2007 workshop. The ecological CSM (Figures 6-3 and 6-4) represents the current understanding of potential sources and the UCR system based on the best available information and recognizes that some of the transport and fate mechanisms, ecological receptors, and exposure pathways will be refined as additional site-specific data are collected and further evaluations are conducted. Primary

components of the CSM (i.e., sources, release and transport mechanisms, exposure media, exposure pathways, and ecological receptors) are summarized in the following sections and depicted in Figure 6-3. Some aspects of the CSM have been described in greater detail in previous sections of the work plan (i.e., Section 4 for chemical sources and Section 6.2 for physical conceptual model) and are only briefly discussed in this section.

6.3.1 Sources

Potential and known sources of COIs are described in Section 4. This section provides a summary of the primary, secondary, and tertiary sources of chemicals entering the UCR. Primary refers to the original source (e.g., discharge point) of a chemical constituent, while secondary and tertiary sources are environmental media (abiotic or biotic) that receive chemical inputs from a primary or secondary source through direct discharge or through chemical transport and fate mechanisms. The sources are defined below and depicted in Figure 6-3.

6.3.1.1 Primary Sources

Ambient Atmospheric Constituents: Ambient atmospheric constituents are those chemicals that are transported to and deposited at the Site from global or regional atmospheric sources and are not tied to a specific point source.

Smelter Operations: This includes chemical discharges via stacks, liquid effluent, or slag discharges from the Trail or Le Roi smelter operations.

Industrial Operations: A number of industrial operations are located above the United States-Canadian border near Trail, B.C., (e.g., Zellstoff mill) or along tributaries to the UCR within the United States (e.g., Spokane River) that historically discharged or currently discharge chemicals to the UCR.

Municipal Point and Nonpoint Sources: Municipal point sources include effluent discharges from wastewater treatment plants located adjacent to the UCR or connected through tributaries to the UCR (e.g., plants located in Trail, B.C., and Colville and Chewelah, Washington). Nonpoint sources include storm water runoff or storm sewer effluent from local communities within the UCR drainage basin.

Agricultural Nonpoint Sources: Many of the areas surrounding the UCR have historically and are currently used for agricultural purposes. Chemicals potentially are released to the UCR through runoff or spray drift from historical or current agricultural operations.

6.3.1.2 Secondary and Tertiary Sources

Chemicals released from primary sources can undergo a variety of chemical and physical transport and fate mechanisms (see Section 6.2.3). These mechanisms result in the distribution

of chemicals to environmental media, which then become secondary or tertiary sources. Environmental media (Figure 6-3) considered to be secondary or tertiary sources of chemicals include the following:

- Air
- Surface water
- Sediment
- Groundwater
- Porewater
- Soil
- Biota

6.3.2 Transport and Fate Mechanisms

A variety of physical, chemical, and biological transport and fate mechanisms influence the distribution of chemicals from their sources to locations throughout the UCR (see Section 6.2 for elaboration of these principles in the aquatic environment). Chemicals generally are transported via solution (i.e., dissolved in water), particulate matter (i.e., chemicals sorbed to sediments, soils, or other particulate matter), or in biological matrices (i.e., bioaccumulated in organisms). The chemical forms (species) and phases³⁸ in which they occur influence their transport, fate, and bioavailability. Each chemical's form and phase depends on its properties as well as local environmental conditions (e.g., temperature, pH, total suspended solids [TSS], and DOC). The transfer of chemicals between phases occurs via primary, secondary, and tertiary release mechanisms described below and presented in Figure 6-3.

6.3.2.1 Primary Release Mechanism

The primary release mechanism of chemicals can generally be described as the direct discharge of chemicals from primary sources to environmental media. The three avenues of direct discharge to the UCR include, but are not limited to, 1) emission of chemicals from stacks from historical or current industrial operations (e.g., smelters), 2) discharge of chemicals from process wastewater or effluents from point or nonpoint sources, and 3) discharge of chemicals in wastes from point or nonpoint sources. Once released to the environment, chemicals present in environmental media (i.e., secondary sources) are distributed through secondary and tertiary release mechanisms.

³⁸ Forms (species) refer to the specific compound (e.g., Cu^{2+} , CuCO_3), whereas the phase refers to how it occurs in the environment (e.g., dissolved versus particulate, including colloidal and bound to ligands like humic acids [Stiff 1971]).

6.3.2.2 Secondary and Tertiary Release Mechanisms

Secondary and tertiary release mechanisms generally are associated with the environmental media in which chemicals are contained (Figure 6-3). The following sections describe these transport and fate mechanisms as they relate to environmental media.

Air: Chemicals in the air can be transported via wind dispersion, aerial deposition, or resuspension. Wind dispersion is the process by which chemicals are transported locally, regionally, or globally via wind currents to different locations. Aerial deposition is the settling of chemicals from air to sediment, soil, or surface water via wet or dry deposition. Finally, chemicals may be resuspended into the air from sediments or soils (i.e., as particulate matter or vapor phase) and may be transported to other locations via wind dispersion and aerial deposition. In the UCR, this may occur when littoral sediments are exposed during drawdown periods.

Surface Water: Chemical transport in surface water occurs through physical, chemical, or biological mechanisms. Physical transport processes include in-stream flow (i.e., longitudinal, horizontal, and vertical movement), infiltration (i.e., movement into sediment pore spaces), advection (i.e., bulk movement of chemicals in water), and diffusion (i.e., movement from high chemical concentration to low chemical concentration). Chemical transport mechanisms include precipitation (i.e., dissolved chemicals forming solids due to chemical and environmental characteristics) and adsorption (i.e., attachment of dissolved chemicals to solid materials). Finally, uptake of chemicals in dissolved or solid forms by biota may result in bioaccumulation in the tissues of ecological receptors.

Sediment: Chemicals in sediment (e.g., suspended or bottom) also are subject to physical, chemical, and biological processes. Physical release mechanisms affected by reservoir operations and in-stream flow include entrainment (i.e., longitudinal transport of suspended, bedload, or banks sediments), deposition (i.e., settling and accumulation or burial of sediments onto banks or floodplain soils), erosion (i.e., bank wasting or bank slumping due to reservoir operations), and wind dispersion of fine sediments following seasonal drawdown. Chemical transport processes include dissolution (i.e., dissolving into solution), adsorption/desorption (i.e., attachment or detachment of chemicals to sediment particles), and decrepitation/weathering (i.e., the wasting or breaking up of particles resulting in chemical releases). In addition, biological uptake of chemicals from sediment may lead to the bioaccumulation of chemicals in tissues of ecological receptors.

Partitioning of inorganic (i.e., metals) and nonionic organic chemicals (NIOCs) involves a number of environmental factors (e.g., temperature, pH, oxidation potential, presence of competing ions [e.g., Ca^{2+}] and organic matter). In addition, metals incorporated within a mineral matrix may be released to the aqueous phase over time through physical weathering of the particle surface, followed by chemical dissolution. The partitioning process conventionally is expressed as a partition (or distribution) coefficient (K_d), which is the ratio of

the reversibly sorbed particulate chemical concentration to the freely dissolved chemical concentration in the surrounding water. In the case of NIOCs and some metals, partitioning to particulate matter is partially related to the organic content of the particles and is commonly expressed as an organic carbon-normalized partition coefficient (K_{oc}). Values for K_{oc} also are chemical-specific and commonly are indexed in accordance with chemical properties such as the octanol-water partition coefficient (K_{ow})³⁹ (Di Toro 1985).

Porewater: Physical transfer of chemicals to porewater generally occurs by advection and diffusion from surface water or groundwater (e.g., upwelling) and sediment. Chemicals may also be released to porewater from the solid phase through dissolution, desorption, and decrepitation/weathering. Chemicals in porewater are available for biological uptake, which may lead to bioaccumulation of chemicals in tissues of ecological receptors.

Groundwater: Release of chemicals to groundwater generally occurs through infiltration from surface water or from wet deposition percolating through the soil column. Chemicals also enter groundwater through release from the solid phase through dissolution, desorption, and decrepitation/weathering. Bank seepage occurs via advection and may affect surface water through discharge from the side banks during pool drawdown. Porewater also may be affected or replaced via groundwater advection. Biological uptake from below surface groundwater aquifers typically is associated with plant root systems and soil invertebrates.

Soil: Chemicals in soils undergo physical, chemical, and biological processes. Physical release mechanisms include entrainment (i.e., transport of particles via storm water runoff), deposition (i.e., settling of solid particles from aerial or sediment sources), erosion (i.e., wasting of soil surfaces by wind or surface water flow), and wind dispersion of fine particles. Some chemicals become irreversibly bound in soil particles through the “aging” process and are no longer available for transport or biological uptake. Chemical transport processes include dissolution, adsorption/desorption, and decrepitation. In addition, biological uptake of chemicals from soils may lead to the accumulation of chemicals in terrestrial plants and wildlife.

Biota: The predominant form of chemical transport to biota is through bioaccumulation of chemicals following exposure to a primary, secondary, or tertiary source. Exposure routes generally are ingestion of, direct contact with, or inhalation of environmental media. For some metals or organic compounds, biological conversion increases their uptake potential (e.g., mercury methylation). Chemicals are accumulated in various tissues (e.g., liver, kidney, brain, or muscle depending upon the chemical) and are transferred throughout the food web or released to the environment upon death and decomposition of organisms.

³⁹ The K_{ow} represents the ratio of concentrations in a lipid (fat) substitute, octanol, and water. For example, log K_{ow} of 4 indicates 10,000 times higher concentration in octanol than in water.

6.3.3 Exposure Media

Through transport and fate processes, chemicals are distributed to environmental media present at the Site, some or all of which may provide exposures to aquatic and/or terrestrial organisms. As shown in Figure 6-3, the exposure media in the preliminary CSM are air, surface water, groundwater, porewater, sediment, soil, and biota. Chemicals are present in these abiotic media in the dissolved phase (i.e., in solution or as a gas) or as particulate forms (e.g., suspended sediment or aerial dust). Ecological receptors that encounter these exposure media are potentially exposed to their chemical constituents.

6.3.4 Exposure Pathways

There are four general pathways through which ecological receptors may be exposed to chemicals in environmental media:

- Direct contact with abiotic environmental media (e.g., soil, sediment, or water) and uptake (i.e., through the skin [dermal], gills, or roots)
- Ingestion of abiotic environmental media (e.g., soil, sediment, or water)
- Inhalation (i.e., lungs)
- Dietary consumption of contaminated biota

Each of these pathways as they relate to specific ecological receptors is shown in Figures 6-3 and 6-4. Exposure pathways are considered either “potentially complete,” “incomplete,” or “not applicable” for each environmental medium and ecological receptor (as shown in Figure 6-3). All “potentially complete” exposure pathways will be considered or refined during the baseline ecological risk assessment (BERA).

6.3.5 Ecological Receptors

This section identifies the preliminary ecological receptor groups considered to be important in the UCR (see also Figure 6-4). Consistent with EPA guidance (EPA 1997a; 1998c), the preliminary ecological receptor groups are the following:

- Receptors that inhabit the UCR or could occupy habitats present in the UCR
- Receptors that are important to the structure and function of the UCR ecosystem
- Receptors that are potentially exposed to chemicals in the UCR or are otherwise toxicologically sensitive

For the screening-level ecological CSM, only broad receptor groups have been identified. Specific surrogate species representative of each of these groups for use in the risk assessment process will be determined during the baseline risk assessment in coordination with EPA. A description of each ecological receptor group is provided below. Additional information about

the aquatic communities, including descriptions of historical and recent studies conducted throughout the UCR, is provided in Appendix H.

6.3.5.1 Plankton Communities

Plankton, both phytoplankton and zooplankton, constitute the base of the primary food chain in the UCR, especially in the lacustrine zone (Scholz et al. 1986; Stober et al. 1981). Phytoplankton (e.g., algae) represent an essential component of aquatic food webs because they convert the sun's energy into organic matter, which can then be consumed by zooplankton. Phytoplankton are primarily exposed to chemicals in the water column. Zooplankton (e.g., protozoa, copepods, cladocerans) reside within the water column and feed on phytoplankton or other zooplankton. Zooplankton, especially cladocerans, are an important food source for some of the fish species in the UCR (Lee et al. 2006). Zooplankton are primarily exposed to chemicals within the water column through sediment contact and consumption of food items.

6.3.5.2 Periphyton Communities

Periphyton consist of assemblages of algae, bacteria, molds, and fungi that live on bottom substrates. Some are autotrophs and others are decomposers. Periphyton may represent an important source of food for benthic and epibenthic invertebrates in the UCR, but they are limited during some times of the year by photoperiod, water temperature, and, in some locations, reservoir operations (Black et al. 2003; BPA 2002c). Exposure of periphyton to chemicals primarily occurs through the water column (Trapp et al. 1990).

6.3.5.3 Macrophyte Communities

Macrophytes are vascular and nonvascular aquatic plants that can be either submerged (e.g., Eurasian milfoil) or emergent (e.g., cattails). Although their occurrence may be limited in the UCR because of reservoir operations, they can provide habitat and food to aquatic life and aquatic-dependent wildlife where they are locally abundant. Exposure of macrophytes to chemicals typically occurs via root uptake from surface water, sediment porewater, and groundwater.

6.3.5.4 Benthic Macroinvertebrate Communities

Benthic macroinvertebrates reside in and on the sediments of the UCR (Bortleson et al. 2001). They typically are a key part of aquatic food webs because they consume zooplankton, plants (e.g., phytoplankton, algae, and macrophytes), and detritus. In turn, they constitute prey for other macroinvertebrates, fish, and wildlife. Benthic invertebrates in the UCR are primarily exposed to chemicals via the sediments and associated porewater, the overlying water column, and through consumption of food items and sediments.

6.3.5.5 Fish Communities

Fisheries of the UCR are important economically and culturally (Scholz et al. 1986). In addition, fish communities form an integral component of aquatic food webs as they process energy from aquatic plants, zooplankton, and benthic macroinvertebrate species. Fish communities also include important prey species for humans and piscivorous (i.e., fish-eating) wildlife. Fish communities include varying trophic groups—including piscivores, planktivores, and omnivores—that live in different habitats such as the water column (i.e., pelagic) or near the bottom (i.e., demersal). Examples of pelagic species in the UCR include rainbow trout, kokanee, and walleye, while examples of demersal fish include largescale suckers and white sturgeon. Fish are primarily exposed to chemicals within the water column through gill uptake, consumption of food items (e.g., plankton, macrophytes, benthic invertebrates, and other fish), and incidental ingestion of sediments during feeding.

6.3.5.6 Amphibians

Early life stages of amphibians are aquatic and omnivorous. As they mature, amphibians develop lungs and prey upon both aquatic and terrestrial organisms. Because amphibians require riparian wetlands for at least part of their life cycle, reservoir operations with annual drawdowns may limit available habitat for amphibians within the UCR. Where they occur, amphibians also are a food source for some aquatic life and aquatic-dependent wildlife. In their early life stages, amphibians are primarily exposed to dissolved forms of chemicals via their gills or by aqueous diffusion through egg membranes or skin. Ingestion of contaminated food items or incidental ingestion of sediments is an important route of exposure for adult amphibians. Dermal exposure may continue into adulthood.

6.3.5.7 Reptiles

Reptiles in the UCR occupy certain upland terrestrial habitats (e.g., snakes), although some species will occupy riparian habitats (e.g., turtles). They are omnivores, invertivores, herbivores, and carnivores, consuming plants, invertebrates, amphibians, fish, small birds, and small mammals. Certain species and life stages of reptiles also represent important prey for birds and mammals. Reptiles are exposed to chemicals primarily through the ingestion of food and surface water, as well as incidental ingestion of sediment and soil.

6.3.5.8 Birds

Avian species near the UCR can be divided into aquatic-dependent and terrestrial species. Aquatic-dependent species include bald eagles, ospreys, herons, shorebirds (e.g., sandpipers), and waterfowl. Terrestrial species include raptors, passerines (i.e., perching birds such as swallows, warblers, and sparrows), and galliformes (e.g., grouse and quail). Some terrestrial groups, such as shorebirds and swallows, use both aquatic and terrestrial habitats. Aquatic-dependent species consume macrophytes, invertebrates, fish, and amphibians. Terrestrial

species primarily consume plants, invertebrates, reptiles, and small mammals. Some avian species represent prey for other avian or mammalian carnivores. The primary avian trophic groups include piscivores, omnivores, invertivores, herbivores, aerial insectivores, and carnivores. Avian receptors are exposed to chemicals largely through ingestion of food and surface water, as well as incidental ingestion of sediment and soil.

6.3.5.9 Mammals

Mammals near the UCR include aquatic-dependent species (e.g., otter, muskrat), terrestrial species (e.g., mice, deer, coyote), and species that use both habitats (e.g., raccoon and mink). Those species with a diet consisting mainly of aquatic organisms often are termed aquatic-dependent. Mammals also may consume aquatic or terrestrial plants and invertebrates, amphibians, reptiles, birds, or other mammals. They are preyed upon by reptilian, avian, or other mammalian predator species. The primary mammalian trophic groups include piscivores, omnivores, herbivores, aerial insectivores (i.e., bats), and carnivores (Figure 6-4). Mammals are exposed to chemicals largely through ingestion of food and surface water, as well as incidental ingestion of sediment and soil.

6.3.5.10 Soil Invertebrates

Soil invertebrates reside in and on the soils of riparian and upland areas near the UCR. They include microinvertebrates (e.g., nematodes), macroinvertebrates (e.g., annelid worms, beetles, ants), and other insects. Soil invertebrates represent key elements of terrestrial food webs because they consume plant material and are sources of food for other organisms. Soil invertebrates are exposed to chemicals primarily through aqueous uptake from soil porewater, food consumption, and soil ingestion.

6.3.5.11 Terrestrial Plant Communities

Terrestrial plants are the primary producers in the upland habitats of the UCR. They include mosses, grasses, forbs (i.e., broad-leafed herbs and grasses), shrubs, and trees. Plants represent a primary food resource for a variety of herbivorous and detritivorous receptors, and they provide cover and habitat for terrestrial and aquatic-dependent species. Dominant plant communities near the UCR are assumed to consist of the following:

- Riparian communities—varied vegetation associated with riparian habitats
- Upland communities—varied vegetation associated with upland habitats

An important exposure pathway for plants is root uptake of contaminants dissolved in groundwater or surface water (Jackson 1998), though foliar uptake can also be important for some chemicals.

6.4 HUMAN HEALTH CONCEPTUAL SITE MODEL

As discussed previously, EPA will develop the human health CSM. The human health CSM as described below and depicted in Figure 6-3 represents the current understanding of the human-health exposure pathways at the time this RI/FS work plan was prepared. The primary sources, and transport and fate to potential secondary and tertiary sources, are the same for both the human health and the ecological CSMs. The preliminary human exposure media, exposure pathways, and receptors are summarized below.

Primary media to which humans may be exposed include air, surface water, groundwater, sediment, soil, and biota. Exposure pathways are defined as the physical ways in which chemicals present in exposure media may enter the human body. The potential exposure pathways for human receptors include the following:

- Inhalation of chemicals in air (i.e., gases or particulates)
- Ingestion or dermal contact with chemicals in surface water
- Ingestion, dermal contact, or inhalation of chemicals in groundwater
- Ingestion, dermal contact, or inhalation of chemicals in sediments
- Ingestion, dermal contact, or inhalation of chemicals in riparian or upland soils
- Ingestion of food items

The duration and frequency of exposure to chemicals in the media and via the pathways described above will vary for different groups of receptors. Some receptor groups may have unique activity patterns (e.g., subsistence fish or shellfish consumption) that result in frequent exposure to a specific exposure medium. Preliminary receptor groups that use the UCR and that EPA will expand upon include the following:

- Current or future residents of communities adjacent to the UCR
- Current or future recreational visitors to the UCR
- Current or future Tribal members residing adjacent to or visiting the UCR

Exposure media, exposure pathways, and receptor scenarios described in this work plan are preliminary and will be expanded as EPA develops the human health CSM throughout the RI/FS process. Detailed input from the STI, the CCT, and DOI will also help refine the human health CSM.

7 DATA GAPS AND STUDY SEQUENCING

7.1 DATA GAPS

This section identifies the key data gaps identified for the UCR RI/FS. These data gaps were identified based on reviews of existing information about the physical setting, chemical sources, distributions of chemicals in Site media, and the preliminary CSMs developed for the Site. Additional data gaps (and studies to fill these gaps) will be identified as data evaluations are conducted in support of sampling and analysis plans (SAPs) and the BERA Work Plan, and as the RI/FS proceeds and new information is collected and analyzed.

Three major categories of data gaps have been identified based on the current understanding of the Site:

- **Chemical distributions, sources, and effects:** This information is needed to better define the nature and extent of contaminants in the UCR media (including surface water, sediment, porewater, air, soil, and biota), to assess contributions from known and potential sources of contaminants, and to evaluate potential effects of contaminants on various ecological receptors.
- **Physical system:** Physical system information, including contaminant fate and transport, will be used to evaluate and identify areas and processes that may contribute to unacceptable risk. Key components of the physical system include UCR hydrodynamics, volumetric extent of contaminated sediments, the potential for sediment remobilization, and the potential for subsequent contaminant accumulation, dispersion, dilution, and burial. This information may also be useful in determining the location and timing for sample collection.
- **Resource abundance and distribution studies:** This information is needed to identify key resources for consideration in the BERA and HHRA.

The following sections describe the types of data that need to be collected to fill these gaps. While some data will be used to fill gaps in more than one of the categories, they are listed only for the category for which they primarily apply.

7.1.1 Understanding of Chemical Distributions, Sources, and Effects

The following sections describe data needs related to chemical distributions, sources, and effects.

7.1.1.1 Surface Water

As indicated in Section 5, most of the available data for potential COIs in surface water at the Site have been collected at Northport, Washington. Extensive data sets are also available for monitoring conducted at the Waneta Station, immediately upstream of the U.S.-Canadian

border. Water toxicity data for white sturgeon are also available (USFWS 2008). Additional surface water data for COIs and conventional water quality parameters are needed to determine whether surface water is an important exposure pathway for people, aquatic receptors, and aquatic-dependent wildlife within the Site. These additional data need to be collected from spatially representative reaches of the UCR at time periods that include seasonal, operational, and extreme conditions of flow and water levels. In addition, surface water quality data that represent near-surface and near-bottom sample depths are needed to account for possible stratification of COI concentrations and/or water quality in surface water.

7.1.1.2 Sediment

Elevated concentrations of various metals and organic compounds have been found in surface and/or subsurface sediments within the UCR, including at a number of beaches. Data gaps and information needs related to COIs in sediments are as follows:

- **Bioavailability:** Although a significant amount of data has been collected regarding bulk chemical sediment concentrations and elevated concentrations of metals have been identified in sediment samples containing granulated slag, an assessment of geochemical fractions and potential bioavailability of the metals to fish and benthic macroinvertebrates has not been completed. Therefore, additional sediment sampling that evaluates and discerns geochemical fractions (i.e., exchangeable, reducible, oxidizable, and residual) related to potential bioavailability is required.
- **Spatial Extent:** To date, sediment samples collected throughout the UCR have largely been located within the thalweg or shallow nearshore river (i.e., banks). Samples positioned within intermediate locations between the thalweg and bank in differing hydrodynamic and environmental settings are limited. As a result, there is a spatial data gap impeding the understanding of nature and extent and transport and fate processes, and additional sampling is required.
- **Beaches:** During the 2005 Phase I study, chemical concentrations in beach sediments were determined for 15 beaches distributed along the UCR (EPA 2005c). Based on these data, subsequent risk screening completed by EPA, and concerns about potential risks at unsampled beaches, additional data are needed to better characterize surface and subsurface conditions at UCR beaches for nature and extent characterization and for risk assessment.
- **Tributary Sediments:** Although a limited amount of information on chemical concentrations in sediments of major tributaries to the UCR has been collected, these data are largely limited to surface sediments. More of this type of data is needed to identify whether sources along tributaries may have significantly contributed COIs to the UCR.
- **Reference Conditions:** EPA (2006d) sampled several areas in tributaries to the UCR and used the resulting data as representative of reference conditions to interpret toxicity tests. The validity of these areas as representative of reference concentrations

for the UCR will be reviewed and evaluated, and additional reference areas will be identified and sampled as needed.

- **Porewater:** Porewater is a key pathway by which COIs can be taken up by benthic and benthic-oriented organisms. It also can be a source of contaminants to the overlying water, thereby exposing epibenthic invertebrates and fish. There are very limited data on *in situ* COI concentrations in porewater. Porewater chemistry and the relationship between COIs in sediment and porewater will be characterized. COI concentrations will be explored in porewater among a variety of sediments, including slag, seasonally exposed by Lake Roosevelt drawdown and in areas used by key ecological receptors.
- **Background Conditions:** Limited data exist on background or natural (i.e., geogenic) sediment conditions within the UCR. Therefore, an assessment/evaluation of background or natural conditions will be required to better understand the nature and extent of contamination and transport and fate processes. Additional field data collection is anticipated.
- **Sediment Toxicity:** Sediment toxicity testing and identification of additional reference stations will be needed to supplement the Phase I testing performed by EPA. Toxicity testing will likely focus on areas where existing data described in Section 5 and any other bioassay data evaluated in the BERA Work Plan indicate the greatest uncertainty and greatest potential for unacceptable risks. A number of approaches may be used to evaluate toxicity. Bioassays are one method that will be applied. A comprehensive written assessment of existing sediment bioassay data and EPA approval will be required prior to designing and implementing the required field studies. In addition, evaluations of the potential toxicity of ingested sediment/slag to fish and benthic invertebrates, as well as higher food chain elements, may also be required.
- **Granulated Slag Weathering:** Weathering of slag may result in releases of COIs to UCR porewater and surface water. The degree to which such weathering occurs and the possible impacts to other media and receptors need to be evaluated.

7.1.1.3 Fish Tissue Residue and Other Biota

Biota from the UCR may accumulate contaminants from surface water, sediment, porewater, soil, or prey items at levels that could pose risks to ecological and/or human receptors. COIs in fish tissues were characterized during historical investigations, including the 2005 Phase I fish tissue sampling program (EPA 2005c; 2006d). However, additional data will be needed because data are not available for specific species or size classes. In addition, tissue residue data will be required for a number of other receptor groups that represent food items for higher trophic levels, such as zooplankton and benthic macroinvertebrates, including mussels.

Data gaps and information needs related to tissue residues are as follows:

Additional Tissue Residue Data: Additional tissue residue data will be collected to support the BERA and HHRA. The identification of receptors, and associated tissues, for sampling will be determined following completion of the SLERA and the BERA work plans. Additional information will be needed on COI concentrations in the prey of fish (i.e., plankton, benthic macroinvertebrates, and fish) and in selected fish species, sizes, and tissues. Sampling of different fish species reflects differences in residues due to variety in habitat preference, food habits, and residue bioavailability.

In Vitro Bioaccessibility Study: If tissue residue data suggest that COI concentrations are present at levels that pose unacceptable risk, metal bioavailability may be further evaluated using an in vitro bioaccessibility study (i.e., a study to determine the fractional dissolution of a metal from a biotic or abiotic medium) (Hund-Rinke and Kordel 2003; Peijnenburg and Jager 2003; Peng et al. 2004; Semple et al. 2004). If a bioaccessibility study is undertaken, the results would be used in the BERA and to assess the need for an oral bioavailability study.

Food Web Modeling: Food web modeling may be needed to supplement field-collected data for the purpose of evaluating exposures to higher trophic levels. If known at the time, the approach, components, and application of any food web model will be presented in the BERA Work Plan. Otherwise, the food web modeling efforts will be discussed with and approved by the EPA before the model is developed and applied.

Benthic Bioaccumulation: Diet is one of the two major pathways by which aquatic biota assimilate contaminants. Dietary uptake of metals by benthic macroinvertebrates in sediments and in the water column can lead to body burdens that have the potential to be toxic to their predators (Cockell 1990; Erickson et al. 2003; Hansen et al. 2004; Pedlar et al. 2002; Rainbow et al. 2006; Woodward et al. 1995b; Woodward et al. 1995a). Based on the BERA Work Plan or a subsequent study, there may be a need to determine whether metals bioaccumulated by benthic macroinvertebrates in the UCR pose risks to predator fish. As part of this evaluation, literature reviews would be conducted to identify whether reliable methods exist for predicting metal dietary toxicity to aquatic life using literature-based information (Barron et al. 2002; Luoma and Rainbow 2005). If such information is not available, the potential chronic effects of bioaccumulated residues on appropriate aquatic organisms may be determined through appropriate laboratory testing.

White Sturgeon: Poor recruitment of white sturgeon (*Acipenser transmontanus*) in the UCR has been reported since the 1970s. While both spawning activity of adult sturgeon and occurrence of eggs and early larval stages have been frequently reported during the past years, young-of-the-year numbers have been limited. Juveniles hatched from resident adults and reared in a hatchery have been released into the UCR as part of the Lake Roosevelt White Sturgeon Recovery Plan and appear to be adapting well to the natural habitat. They exhibit good survival, growth rates, and body condition. In addition, an unpublished study conducted by

USFWS appears to indicate that copper is toxic to early life stage sturgeon at levels below the acute water quality criteria (USFWS 2008). This indicates that a survival bottleneck could exist subsequent to the initiation of exogenous feeding (BPA 2006e; UCWSRI 2002b). Subject to EPA's approval, the work proposed to be conducted as part of this RI/FS will focus on the potential effects of contamination on white sturgeon and will be consistent with the Agreement (EPA 2006h). Available information relevant to the understanding of sturgeon recruitment and potential contamination effects on early-life-stage development will be used when possible. Additional information will be collected consistent with the DQO process, to test hypotheses and answer critical questions relative to contaminant effects on early life stages of white sturgeon. Because adult sturgeon tissue is difficult to obtain due to the prohibition on fishing, investigations on older life stages may require the use of surrogate species, and/or potentially tissue plugs obtained from opportunistic sources.

7.1.1.4 Soil

Atmospheric deposition of smelter emissions and windblown dust from nearshore sediments in the UCR have been identified as potential air sources of chemicals for this RI/FS (EPA 2006e). Section 4.1.1.3 describes the area-wide contamination that may be related to Trail and LeRoi stack emissions. In addition, floodplain deposition of UCR sediments was identified at the April 2007 workshop as another potential source of COIs to upland soils of the Site. At the time this work plan was written, the quantity of available information for both air and soils was limited. Data gaps related to soil (both surface [0 to 6 inches] and subsurface [> 6 inches]) at the Site include, but are not limited to, the following:

- Identification of upland areas potentially affected by COIs (including mercury) from current and historic Trail facility emissions, windblown dust from UCR nearshore sediments, or floodplain deposition of UCR sediments
- Determination of whether COIs in soil are present at concentrations that could adversely impact groundwater
- Determination of whether COI soil concentrations present a potential concern regarding plant uptake and/or impacts to soil biota
- The influence of other potential sources (e.g., Le Roi smelter) of COIs to soils
- The concentrations of COIs in soil from background or reference areas

7.1.1.5 Groundwater

Groundwater data for the UCR are very limited and no assessments have been conducted to assess whether groundwater in the UCR has the potential to impact or be impacted by other environmental media. Preliminary data gaps related to groundwater include determining where groundwater might be adversely affected by COI concentrations in soil and assessing the interaction of surface water and groundwater during different seasons and water level

management periods. Additional data gaps will be identified following review of existing and newly gathered data for soil, surface water, and other media.

7.1.1.6 Upstream Sources

As noted in Section 4, there are a number of municipal and industrial discharges to tributaries and the Columbia River above the Canadian border, upstream of the UCR. EPA may require a review of available information about these discharges in order to identify the chemicals and loading associated with these discharges. This information may be needed to determine if additional sources are contributing chemicals to the system at levels that might pose risks or if continued discharges might adversely impact future remedies in the UCR.

7.1.2 Understanding of the Physical System

Sediments containing various COIs are known to exist within the UCR, and these COIs could pose unacceptable risks to ecological and/or human receptors. If unacceptable risks are predicted as the BERA and HHRA are developed, a more thorough understanding of COI transport and fate processes will be performed before conducting the feasibility study. For example, understanding the potential for remobilization of contaminated sediment and the mechanisms of transport (i.e., bedload or suspended load) for various sediment-size classes may be needed to better forecast future contaminant exposure and risk and to assess the feasibility of remedial alternatives (e.g., EPA 2005a). In addition to contaminant remobilization and transport, it may also be necessary to quantify the potential for contaminant accumulation, dispersion, dilution, sequestration, and burial. A better understanding of the aforementioned transport and fate processes will be required to allow better forecasting of future contaminant exposure and risk and could be integrated into a hydrodynamic model as part of the feasibility study.

Data gaps related to potential transport and fate evaluations include, but are not limited to, the following:

- Updated detailed bathymetry (with an accurately defined reference datum) in targeted areas of the river where additional detail will help to support proposed data collection activities and an overall understanding of river hydrodynamics
- Current velocity measurements
- Water surface elevations
- Improved sediment bed characterization for sediments and metals
- Measurements to estimate inflow and loads for solids and metals
- Sediment deposition, erosion, remobilization, and burial rates
- The quantity and distribution of contaminated sediments in the UCR

- Slag quantity and distribution
- Slag transport properties
- The quantity of bedload solids and their associated metal, metalloid, and chemical composition, and TSS concentrations in waters crossing the U.S.-Canadian border and from targeted UCR tributaries
- Locations of major landslide areas and potential buried contaminated sediments
- Supplemental grain-size data to better characterize the distribution of particle-size classes throughout the UCR
- Discharge rates for the Columbia River and major tributaries
- Cross-sectional flow velocity (using acoustic-Doppler current profilers) and surface-water elevation data at key locations within the UCR to better determine scour and depositional areas for various sediment size classes

7.1.3 Resource Abundance and Distribution Studies

The following sections describe potential resource identification and confirmation field study data gaps. Resources are defined broadly in the Agreement and SOW and include wild and cultivated plants, fish/shellfish, wild game, aquatic invertebrate communities, reptiles/amphibian populations, other wildlife foods, habitat use areas, harvest areas, and foraging areas. These investigations are comparable to the “fish, wildlife and benthic species assessments” and “plant consumption” studies recently defined as priorities by EPA (EPA 2006i).

The scope of studies addressing upland resource use will depend on the limits of the upland footprint related to dispersion of COIs from the Trail facility, windblown beach dust, and floodplain deposition.

Biotic and abiotic resources in the UCR may be exposed to COIs at levels that could pose unacceptable risks to ecological and/or human receptors. To characterize risks to ecological and human receptors in the baseline risk assessments, it is important to characterize Site resources and how they are used, the level of use (for human health), and resource harvest locations within the UCR and if these locations coincide with elevated concentrations of COIs.

Data gaps related to resource abundance and distribution in the UCR may include the following:

- Information on resource use by Tribal members and the general public
- Community characteristics and habitat use by benthic macroinvertebrates and fish
- Fish dietary habits
- Wildlife habitat use and distribution

- Distributions of amphibians and reptiles
- Plant community distributions

7.2 STUDY SEQUENCING AND MAJOR DECISION POINTS

The complete list of studies that will be required for the RI/FS will evolve as existing data are evaluated and as new data are collected as the project proceeds. TCAI will conduct robust sampling programs beginning in 2009 and extending through 2011, or longer if necessary. The 2009 and 2010 studies, which precede approval of the BERA Work Plan and therefore require separate data evaluations and DQO development, include surface water, fish tissue, zooplankton, beach sediment, white sturgeon, resource use and consumption, and upstream sources. These studies were selected either because there is little available data (e.g., surface water), because previous studies have already indicated specific data needs (e.g., fish tissue, resource use), or because they have no field component (e.g., upstream sources). The need for and scope of the remaining studies will be determined as part of data evaluation conducted in support of BERA Work Plan development.

Overall, the sampling programs will provide the data needed to understand the nature and extent of contamination and to assess risks to ecological receptors and humans. In many instances, it would be advantageous to take samples from multiple media concurrently (e.g., taking a sediment sample, surface water sample, porewater sample, and bank sample at a single location at the same time). However, there are multiple time and resource constraints that impact sampling, and so it may not be feasible to do so in many cases.

7.2.1 Process Overview

The data gaps described in Section 7.1 prompted development of initial studies that will be planned and implemented between 2009 and 2011. Additional data gaps and information needs identified in the BERA Work Plan will initiate additional studies in 2010, 2011, and beyond. Results of the initial studies will be used to refine the CSM and focus subsequent studies on the media, areas, receptors, exposure pathways, and chemicals of greatest concern. As currently conceived, activities in 2011 and beyond could be focused, as needed, on population-level assessments and field-verification activities. During an RI/FS, newly collected data often trigger the recognition that additional data of a similar or different type are needed to fulfill the project's objectives. EPA's RI/FS guidance (EPA, 1988) uses the term "iterative" to describe the process of evaluating data, identifying data gaps (using EPA's DQO process), filling data gaps, and then again evaluating all data (i.e., historical and recently collected) to assess whether sufficient data have been collected to address the hypotheses presented in the DQOs and to complete the remedial investigation or risk assessments. This overall process of refinement will guide activities throughout the remedial investigation.

Although the BERA Work Plan will contain a thorough evaluation of existing data and refinement of the problem formulation, many data gaps, such as data needed to characterize

spatial and temporal trends in surface water quality, have been recognized during the compilation of data for the RI/FS work plan.

The overall process to design each study includes early involvement of EPA and Participating Parties. The DQO process will be used to formulate hypotheses and identify data gaps, which will be filled via field and laboratory studies. At present, data have been compiled and summarized to support the identification of data gaps.

7.2.2 Overview of Studies and Major Decision Points

The studies associated with the RI/FS are listed in Table 7-1. These studies will provide information needed to inform the understanding of the nature and extent of contamination, to conduct the terrestrial and aquatic components of the ERA, and to perform the HHRA. Planning documents related to human health, particularly the resource use and consumption surveys, will be considered in the design of the studies undertaken throughout the RI/FS process.

The BERA Work Plan will identify additional information needs related to the terrestrial and aquatic environment. As part of the BERA Work Plan, the rationale for terrestrial soil sampling will be developed from an assessment of the transport and fate processes that disperse COIs in the UCR: air dispersion from the Trail and Le Roi smelters (assessed initially using a soil footprint analysis); wind dispersion of exposed sediment, including beaches; and overbank deposits related to flood events. The soil study will provide an initial assessment of the nature and extent of COIs in the terrestrial environment and will serve as the foundation for the terrestrial element of the risk assessment. Information from the soil study will also be used to evaluate whether COIs in soil are at concentrations which could adversely impact other media.

The initial scope of aquatic studies (separate from the surface water sampling effort) will also be developed in parallel with or as part of the BERA Work Plan. There will be two major categories of aquatic studies: sediment studies and habitat/receptor studies, which will be loosely distinguished by their respective focus on chemistry and biology. The sediment chemistry studies will address data gaps in the nature and extent of COIs in sediment. The porewater and bioavailability studies will address transport and fate issues related to sediment-bound COIs and their susceptibility to mobilization and bio-uptake.

Decision points following completion of the studies will focus and further refine the investigation on areas, receptors, exposure pathways, and chemicals with the greatest potential to be associated with unacceptable risk. Representative soil data will be evaluated to determine the scope of subsequent terrestrial studies. Similarly, representative aquatic data will be used to identify and refine studies to address the key elements of the CSM as they relate to unacceptable risk (i.e., areas, pathways, receptors, chemicals) and to determine if transport and fate modeling is needed. For example, if sediments in substantial portions of the

UCR are anticipated to pose an unacceptable risk to aquatic receptors, the potential for erosion and dispersion of those sediments will be of central concern. As illustrated in Figure 2-1, an iterative approach will be applied to the UCR RI/FS process, whereby components will be continually refined as study results are obtained and new information is gained. Studies are described in greater detail in Section 8.

Additional data needs will be identified in the BERA Work Plan and in the data evaluation reports that result from the initial sampling and analysis programs. As noted above, one of the key decisions following the initial field programs will be the extent of terrestrial studies that will be required to support the ERA. This decision will be based on the existence of an upland footprint of COIs. Some studies may be required whereas others may depend on results of earlier studies. These studies are briefly described in Section 8. The sequencing and dependencies for these studies, as well as generalized descriptions, will be provided in detail in the BERA Work Plan. As with other surveys, detailed study descriptions, including DQOs, will be provided in SAPs.

The need for and possible initiation of complex data evaluations and modeling efforts to support the remedial investigation and aquatic BERA will be initiated in 2011. These evaluations may include, and are not necessarily limited to, sediment transport modeling, transport and fate modeling, and food web modeling. The approach TCAI will recommend for any proposed modeling effort will be described for EPA in a technical memorandum prior to the initiation of modeling.

Most of the sampling and laboratory programs needed for the RI/FS will be completed by the end of 2012. However, as new data are evaluated, new data gaps may be identified. In addition, there may be conflicting lines of evidence for the aquatic, aquatic-dependent wildlife, or terrestrial ERA. If conflicting lines of evidence exist, it may be appropriate to use field methods to verify estimates of risk generated through laboratory studies and/or modeling. Field verification of risks to receptor populations may also be performed, if needed.

Field data collection to fill BERA and other RI data gaps will be complete in 2013. Data evaluation will continue to 2014 with development and delivery of the BERA and remedial investigation reports. The feasibility study report is scheduled to be submitted to EPA in 2015. Each of these reports will necessitate frequent interactions with EPA to make sure EPA and TCAI have a common vision for the content of the reports.

8 OVERVIEW OF UPPER COLUMBIA RIVER STUDIES FOR 2009 – 2012

As discussed in Section 7, the complete list of studies that will ultimately be required for the RI/FS will evolve as the project proceeds and new data gaps are identified. TCAI plans to conduct sampling programs beginning in 2009 and extending through 2012. These sampling programs will be important for defining nature and extent of contamination, as well as for assessing potential risks to ecological (i.e., aquatic and terrestrial) and human receptors. The studies will build on the site-specific information collected throughout the UCR that has been discussed in previous sections of this work plan. The studies outlined below are consistent with Exhibit A of the Agreement (i.e., SOW) and EPA's RI/FS Priorities Letter (EPA 2006c). Table 8-1 provides a listing of work tasks identified in the Agreement's SOW. The assessment of existing information and related data gaps is integrated with the work tasks specified in the SOW to define the initial studies list for 2009 through 2012.

Because performance of these studies is dependent on reviews of existing data, approval of sampling plans, and obtaining access and permits from appropriate governments, the implementation dates may change. The studies identified in the following sections are expected to begin in 2009. The sections that address these studies describe the general objectives and study designs that will likely be identified for each study. Detailed descriptions of the DQOs, study design, and sampling and analysis methods for these studies will be presented in the study-specific SAPs. In addition, the various components of each study may be refined following preparation of the BERA Work Plan and following the collection and evaluation of new information on the Site. The project schedule provided in Section 12 will be amended as additional tasks are identified and updated as the study progresses.

Additional studies and supplemental data collection for the studies listed here will be required to meet the data needs for the HHRA. Data needs for the HHRA which have already been identified (e.g., beach sediment and fish tissue contaminant concentrations) are briefly described in this section. Additional details concerning data needs and uses for the HHRA will be presented in the HHRA Work Plan and/or will be provided to TCAI by EPA.

8.1 2009/2010 STUDIES

Subject to EPA approval, the following field and laboratory studies will be planned and implemented in 2009 and 2010:

- Surface Water
- Fish Tissue
- Zooplankton
- Beach Sediment

- White Sturgeon
- Recreational Resource Use and Consumption Survey
- Tribal Resource Use and Consumption Survey
- Upstream Sources

Each of the above studies is described below.

8.1.1 Surface Water Study

There is limited information on COI concentrations in surface water of the UCR. Nearly all recent information has been collected at a single location (i.e., Northport, Washington), and most of those data are limited to only nine metals: arsenic, cadmium, chromium, copper, lead, mercury, nickel, silver, and zinc. In addition, no information is available on concentrations of COIs in plankton, which can pose risks to the fish that consume those organisms.

At the April 2007 workshop, additional surface water information was identified as a key data gap that should be filled to support various components of the RI/FS, including evaluations of sources, nature and extent, transport and fate, and potential risks to ecological and human receptors. In addition, because seasonal variations in pool levels of Lake Roosevelt and flow of the UCR may affect COI concentrations in surface water, temporal variability of COI concentrations will also be evaluated. Therefore, the surface water study will evaluate the characteristics of UCR surface water at multiple locations during multiple time periods. The investigation will also evaluate the potential impacts of surface water from major tributaries to the UCR by sampling the UCR upstream and downstream of the tributaries during multiple time periods. This effort is intended to determine the degree to which major tributaries may contribute COIs to the UCR.

Primary questions that will be addressed by the surface water study include, but are not limited to, the following:

- Do COIs and associated conventional parameters in surface water collected at representative locations along the length of the UCR show significant spatial variability?
- Do COIs and associated conventional parameters in UCR show significant temporal variability with respect to variations in pool level and flow?
- Do COIs in surface water require further investigation based on comparison to conservative criteria and guidelines?
- Do COIs in surface water pose unacceptable risks to human health and the environment?
- Do COIs exhibit spatial or temporal variations that may be related to facility operation discharges and fluctuations in upper river flow volume?

- Are COIs associated with identified source areas?
- Do COIs exhibit measurable variation due to reservoir drawdown and recharge actions?
- Do COI concentrations vary with depth?
- Do extreme flow events create unique water quality concerns that may not otherwise be observed under more routine, ambient conditions?

The COI list will include metals and selected organic compounds and will be measured in whole water samples and the dissolved fraction. Various conventional variables useful for interpreting the observed patterns of COI concentrations will also be measured in conjunction with the COIs. Because there is a general lack of recent data on COI concentrations throughout the UCR (with the exception of Northport, Washington), sampling stations will be distributed from the U.S.-Canadian border to the vicinity of the Grand Coulee Dam. Stations will be located in each of the six physiographic reaches identified for the UCR and those selected stations will be positioned to evaluate major potential source areas, such as the upstream boundary condition at the U.S.-Canadian border; Northport, Washington; major tributaries; and large depositional areas within the UCR. At least one round of surface water sampling will coincide with zooplankton and fish tissue sampling events described below.

Because of the temporal variability in water column conditions within the UCR, surface water sampling will be designed to evaluate key periods related primarily to pool level and water flow, such as spring drawdown and subsequent high-flow conditions. The method reporting limits for COIs will be below available water-quality criteria and guidelines for protection of human health and ecological receptors to ensure that the results can be compared with those criteria and guidelines.

8.1.2 Fish Tissue Study

A relatively large amount of information has been collected on the characteristics of fish communities and their major species in the UCR. In addition, a relatively large amount of information was collected during the Phase I study on COI concentrations in selected fish species in 2005 (EPA 2006c), as well as in earlier studies.

Despite this large amount of historical information, a number of data gaps have been identified that will be addressed in the Phase II fish tissue study. For example, the Phase I study primarily evaluated larger individuals of recreationally important species. Although these data are useful in evaluating potential risks to humans, they are less useful for evaluating potential risks to those ecological receptors that prey primarily on smaller individuals. An additional shortcoming of many historical fish tissue studies in the UCR is the evaluation and consideration of background or reference fish tissue concentrations; that kind of information is important for estimating the expected tissue concentrations of COIs that are affected by large-scale sources, such as atmospheric deposition or regional geological

characteristics. The additional data collected on fish in the Phase II study will be used primarily to support the evaluations of potential risks to ecological and human receptors, and to further evaluate natural background locally. The distribution of important fish habitats in the UCR will be addressed in the 2009 aquatic resource study. As part of the Phase II fish tissue study, diets of important fish species will be evaluated primarily by summarizing existing information for the UCR (e.g., from tribal studies) and other published literature on each species. Additional information on fish food habits may be generated, as needed, during the collection of fish for the tissue residue analyses.

The primary questions to be addressed by the Phase II fish tissue study include, but are not limited to, the following:

- What are the tissue concentrations of COIs in selected species which have important recreational, tribal, or ecosystem value, and which have not been extensively or adequately evaluated in past studies?
- What effects do slag and other contaminated sediment have on selected species of interest?
- What are the tissue concentrations of COIs in fish species and size classes that represent important dietary components for key piscivorous receptors, including fish, birds, and mammals?
- What are the tissue concentrations of COIs in fish species and size classes that represent important dietary components for human health?

It is anticipated that samples for the fish tissue study will be collected in late summer or early fall of 2009, after fish have had the entire summer to feed and grow in the UCR. In addition, collections during the late summer or early fall will be consistent with the Phase I study, in which fish were collected in September and October. Tissue concentrations used for evaluating potential risks to ecological receptors will likely be based on whole-body concentrations, whereas tissue concentrations used for the HHRA will likely be based primarily on concentrations in fillets; however, other body organs may also be sampled. The importance of slag in fish guts will need to be evaluated, both in terms of impacts to the fish and to potential predators. Ancillary data that may help interpret observed tissue concentrations will also be collected for each individual fish, including length, weight, gender, and the presence of any visible abnormalities.

8.1.3 Zooplankton Tissue

Several site-specific studies in the UCR demonstrate that zooplankton constitute a substantial fraction of the diets of several fish species and contribute to the diets of numerous other fish species. Although there is ample evidence that UCR fish consume zooplankton, there are no data to describe chemical concentrations in zooplankton tissue. Data on chemical concentrations in zooplankton tissue will be used primarily to support the evaluations of the

BERA, where risks to wildlife that eat fish, and to fish that consume zooplankton, will be evaluated. Zooplankton tissue chemistry data are needed to estimate risks posed by COIs to zooplanktivorous fish as depicted on the CSMs, and, with chemistry data for water, sediment, and other media, will also be useful to characterize chemical exposure pathways within the aquatic food web, which may be required if screening level risk assessments identify potentially unacceptable risks to fish, wildlife or people.

The primary objective of the zooplankton study is to collect information on COIs in tissue of zooplankton from the UCR for use in the BERA. The primary risk-related question to be addressed by the BERA is as follows:

- Do COIs in zooplankton pose unacceptable risks to the zooplankton or to fish that prey on zooplankton in the UCR?

Zooplankton sampling will be conducted in conjunction with fish tissue and surface water sampling. The zooplankton samples will be analyzed for TAL metals and metalloids and percent moisture. Depending on the evaluation of fish tissue data (see Section 8.1.3), additional metals, organic compounds, and percent lipids may also be analyzed.

8.1.4 Beach Sediment Study

The beach sediment study is primarily being conducted to provide data for the HHRA. It is described here because TCAI is responsible for preparation and implementation of the SAP and because some of the data may be applicable for other RI/FS evaluations.

COI concentrations in sediments were evaluated at 15 beaches sampled throughout the UCR in 2005 by EPA during the Phase I study (EPA 2006c). Based on the 2005 sampling results, the highest metals concentrations were found at the three most upstream beaches located between USGS RM 745 and 729 (i.e., Black Sand Beach, Northport City Boat Launch, and Dalles Orchard), with concentrations generally decreasing as a function of river mile at the remaining beaches. In general, organic chemical concentrations in the 2005 beach sediment samples were infrequently detected, and detected concentrations were considered safely below human health-based risk standards (EPA 2006g).

The key data gaps for beach sediment are human-health-risk related and will be filled by sampling surface and subsurface beach sediments for use in the risk assessment and for risk communication and risk management. These data may also be useful in evaluating the fate and transport and nature and extent of contamination.

Primary questions to be addressed by the Phase II beach sediment study include, but are not limited to, the following:

- What are the spatial distributions of COIs in beaches not yet sampled?

- What are the spatial distributions of COIs in whole sediments and in different size fractions of sediment (i.e., 2 mm to 250 μm , 250 μm to 125 μm , 125 μm to 63 μm , and < 63 μm)?
- What are the physical properties (e.g., grain size) of selected whole sediment samples?
- What is the spatial distribution of granulated slag in whole sediments?
- What is the vertical distribution of COIs in beach-use area sediments?
- Do metals concentrations in whole sediment and associated fractions pose unacceptable risks to human health or the environment?

The COI list will contain EPA's TAL metals and uranium, and COI concentrations will be measured in whole sediments and the fine-grained fraction of the sediments. Conventional parameters (e.g., grain size distribution), physical properties (e.g., bulk density), and granulated slag composition will also be measured in whole sediments to help interpret the spatial patterns found for COI concentrations. To allow potential risks to benthic macroinvertebrates to also be evaluated, the top 0 to 15 cm of sediment will likely be collected for analysis at each sampling station. To be consistent with the Phase I beach study and to correspond with maximum exposure of UCR beaches, sediment sampling will likely occur during spring drawdown. Method reporting limits for metals will be below available soil and sediment quality guidelines (SQGs) for protection of human health and ecological receptors and to ensure that the results can be compared with those guidelines.

8.1.5 White Sturgeon Study

White sturgeon between one and seven years old may be collected as part of a coordinated effort between various state, federal, and transboundary groups. Fish from this effort may be available for analysis for use in the RI. The need for these sturgeons has not yet been determined. If there is a data gap that these fish would fill, and a DQO developed that supports the use of the sturgeon, then fish from the collection effort will be pursued. There is no current plan in the RI for fishing for sturgeon outside of this collection effort.

8.1.6 Resource Use and Consumption Surveys

Recent information on the use and consumption of UCR resources (e.g., surface water, mussels, fish) by members of the CCT as well as by recreational users from the general public is considered a data gap that should be filled in 2009/2010. DOI will therefore conduct a resource use survey for the general public, and EPA will conduct a similar survey for the CCT. Both surveys will be initiated in 2009 to provide adequate data for conducting the HHRA.

The two user groups considered in the resource use and consumption surveys represent the appropriate focus of the surveys. These surveys will be designed to support parameterization of the exposure assessment as part of the overall HHRA and are designated as a priority data

need by EPA (EPA 2006l). In addition, the results of the surveys may be useful for identifying future sampling locations (e.g., sediment, surface water) and potential target species to support the HHRA.

The tribal resource use survey for the CCT will be designed to elicit specific information on the types and quantities of resources (e.g., wild and cultivated plants, wild game, invertebrates, and fish) harvested within the Site. The survey will likely define the proportion of each type of resource harvested from specific locations, the annual frequency of consumption for each resource, the central tendency and reasonable maximum amounts consumed for all age classes, and general cleaning, preparation, and cooking methods. The tribal surveys will also consider exposure from sources other than consumption (e.g., sweat lodges, medicinal uses, basket weaving).

The resource use survey for recreational users of the general public will be conducted to estimate the degree of recreational use within the UCR. The survey will be designed to elicit information on the types of activities conducted within the UCR, specifically which recreational areas typically are visited, the time spent weekly at each of these studied recreational areas over the year, and the activities typically conducted at each area (e.g., picnicking, fishing, swimming, boating) that affect the degree of exposure to fish or other biota, water, sediment, and soil.

The methods used for the resource use and consumption surveys will be consistent with EPA guidance (EPA 1998b), and will build on previous surveys conducted in the UCR (Columbia River Inter-Tribal Fish Commission [CRITFC] 1994; WDOH 1997). Both types of surveys will be conducted over at least a 1-year period to include data relevant to all seasons of harvest and resource use.

8.1.7 Upstream Sources Study

There are a number of municipal and industrial discharges to tributaries and the Columbia River above the Canadian border, upstream of the UCR. EPA may require a review of available information about these discharges in order to identify the chemicals and loading associated with these discharges. The study is expected to rely on published reports, records, and permits. No sampling is expected.

8.2 2011 STUDIES

Subject to EPA approval, the following field and laboratory studies will be planned and implemented in 2009 and 2010:

- Soil (including background determinations)
- Sediment (including background determinations)

- Aquatic Resource and Benthic Tissue
- White Sturgeon Toxicity

8.2.1 Soil Study

Trail and Le Roi smelter emissions and windblown dust from nearshore sediments in the UCR have been identified as potential sources of COIs to upland soils of the Site (EPA 2006e). In addition, floodplain deposition of UCR sediments was identified at the April 2007 workshop as another potential source of COIs to upland soils of the Site. Floodplain deposition may have occurred as a result of flooding events prior to the construction of both the Grand Coulee Dam and the dams above the U.S.-Canadian border. At the time this work plan was prepared, the quantity of available information for both air and soils at the Site was limited.

Additional data on air and floodplain deposition of COIs at the Site, both existing and new (as needed), will be used to support various components of the RI/FS, including evaluations of sources, nature and extent, transport and fate, and potential risks to ecological and human receptors. In addition, the existence of information on COI concentrations in soil from background or reference areas will be evaluated to help place any soil concentrations measured at the Site into a regional perspective.

The primary questions to be addressed by the soil study include, but are not limited to, the following:

- Have upland soils been adversely affected by air deposition of COIs from the Trail facility and/or from remobilization of windblown sediments from UCR beaches?
- Have soils been adversely affected by air deposition of COIs in windblown sediments from UCR beaches?
- Have soils been adversely affected by COIs from floodplain deposition of UCR sediments?
- What are the concentrations of COIs in any soils that have been influenced by air or floodplain deposition?
- Are there significant COI concentrations in soil that are attributable to Le Roi smelter emissions?
- What are the concentrations of COIs in soils from candidate background or reference areas?
- Do COI concentrations in UCR floodplain or upland soil pose unacceptable risks to human health and the environment?

The scope and extent of soil sampling that will specifically address possible adverse effects from Trail facility emissions will be determined through data analyses presented in the BERA Work Plan. The COI list will include TAL metals. Various conventional parameters useful for

interpreting the observed patterns of COI concentrations will also be measured in conjunction with the COIs. Sampling related to windblown UCR sediments may be coordinated with the Phase II beach sediment study. Any floodplain sampling will focus on the riverine portion of the Site where floodplains were not inundated by the formation of Lake Roosevelt (i.e., following construction of the Grand Coulee Dam). Any inundated historical floodplains in the reservoir portion of the Site have been or will be evaluated by sediment sampling. Any floodplain sampling will be conducted during low pool. Upland soil data related to air deposition will be collected to fill data gaps identified following review of existing soil data. Modeling of smelter emissions may be required to determine the possible footprint for aerial deposition.

8.2.2 Sediment Studies

A relatively large amount of information exists for COI concentrations in surface sediments of the UCR, based on the Phase I study conducted in 2005 (EPA 2006e) and on several historical studies conducted by other investigators (Bortleson et al. 2001; Era and Serdar 2001; Johnson et al. 1989; EPA 2003b). In addition, several Canadian studies of the lower Columbia River between Trail and Waneta also provide useful information on sediment COI concentrations immediately upstream of the UCR (Golder 2003; G3 Consulting Ltd. 2001b; CRIEMP 2005). The Phase II sediment studies will be designed to fill several gaps in the existing data sets. These data gaps are related to the distribution and concentration (i.e., nature and extent) of COIs in sediment and sediment pore water, the fate and transport characteristics of COIs in sediment, and the potential risks to ecological and/or human receptors posed by COIs in sediment and sediment pore water.

8.2.2.1 Nature and Extent of COIs in Sediment and Sediment Porewater

The following are uncertainties and questions related to the nature and extent of COIs in sediment and sediment porewater to be assessed by the Phase II sediment study. Other questions and data gaps may be identified during study design. The study design will also consider and incorporate data needed to support the human health risk assessment.

- What are the background concentrations of metals and other COIs in sediments and pore water in water bodies and drainage basins in the vicinity of the UCR?
- Do COI distributions in UCR sediment vary spatially based on historical river morphology (e.g., within the original pre-dam channel, along the sides of the original channel, in former floodplains, or along submerged benches and bluffs) and longitudinal position?
- Do COI distributions in UCR sediment vary significantly in the vicinity of confluences with major tributaries?
- What are the positions and extent of slag-bearing sediment along the original UCR channel?

- What are the concentrations of COIs in portions of the UCR affected by eroding bluffs?
- What are the concentrations of COIs in sediments in the upper reaches of the UCR where sediment-sized material is relatively limited (e.g., sediments located in areas of coarse cobbly material)?
- How are COIs distributed among different sediment grain size fractions in representative portions of the UCR?
- What are the concentrations of COIs in porewater relative to concentrations of COIs in whole sediment and to different grain size fractions in representative portions of the UCR?
- What are the COI concentrations in sediment and porewater among a variety of sediments, including slag seasonally exposed by Lake Roosevelt drawdown and in areas used by key ecological receptors?

The scope and extent of sediment sampling that will specifically address nature and extent data gaps will be determined through data analyses presented in the BERA Work Plan. The target analytes list for UCR sediment is expected to include all COIs, whereas the target analyte list for background locations may be limited to metals and metalloids. Conventional variables (e.g., TOC, pH, AVS, DOC, and grain size distribution) will also be measured in whole sediments to help interpret the spatial patterns found for COI concentrations, as well as to support fate and transport assessments. As feasible, sediment collection and analyses will be closely coordinated with the sediment toxicity study and the benthic tissue study to ensure completeness and comparability of data.

8.2.2.2 Sediment Toxicity and Risk

The following are uncertainties and questions related to potential ecological risks posed by exposure to sediment and/or porewater. Other questions and data gaps may be identified during study design.

- What portion of COIs in porewater, whole sediments, and sediment fractions in representative areas of the UCR are bioavailable?
- Does toxicity observed in sediment bioassays correspond to bioavailable COI fractions in porewater and whole sediment (i.e., does a dose-response relationship exist between bioavailable fractions and observed toxicity)?
- Does sediment toxicity correspond to particular and readily identifiable site conditions (e.g., grain size, slag content, habitat, or structure of benthic environment)?
- How does UCR sediment toxicity compare to toxicity at reference locations?

- Do COI concentrations in whole sediments or porewater pose unacceptable risks to human health and the environment?

The scope and extent of sediment sampling that will specifically address sediment toxicity and risk to ecological receptors will be determined through data analyses presented in the BERA Work Plan. As feasible, sediment collection for toxicity analysis will be closely coordinated with the sediment nature and extent study and the benthic tissue study to ensure completeness and comparability of data.

8.2.3 Aquatic Resource and Benthic Tissue Study

There is relatively little readily available information on the distribution of a number of key habitats and ecological receptors in the UCR. This kind of information is beneficial for identifying aquatic resource use areas in the UCR, where exposure to COIs may pose the greatest potential risks (e.g., EPA 2001b). These resource use areas include both physical habitats and the ecological receptors that use those habitats. This information may not be readily available in the published literature; EPA will assist in efforts to determine whether some of these data are available from the CCT and STI, as well as various state and federal resource agencies that collect information on the UCR, and will assist in obtaining the data. The field portion of the aquatic resource study will be designed to fill those data gaps that emerge after reviewing the available resource information for the UCR and identifying Phase 1 data gaps. The available information and identification of data gaps will be contained within the aquatic resource study SAP.

There is relatively little current information on benthic macroinvertebrate communities in the UCR. Benthic macroinvertebrates play key roles in recycling organic matter in sedimentary environments and in serving as a food source for a number of fish- and aquatic-dependent wildlife species. Because the characteristics of benthic macroinvertebrate communities are influenced by a variety of habitat features (primarily sediment character and water depth), these communities are expected to be sensitive to the physical complexity of the UCR and are likely to exhibit substantial variability in their composition and structure in the different benthic environments found throughout the Site. Current information on the characteristics of benthic communities in the UCR, as well as on the concentrations of COIs in the tissue of key macroinvertebrates species, is needed to evaluate potential risks to these organisms and to the organisms that prey on them. Freshwater mussels are large benthic macroinvertebrates that are found in portions of the UCR and may be consumed by humans, as well as by ecological receptors. However, relatively little information is available on the current spatial distributions of freshwater mussels throughout the Site. Current information on the spatial distribution of mussels, as well as the concentrations of COIs in their tissue, is needed to evaluate potential risks to mussels and to the ecological receptors and humans that consume them. Toxicity of sediments may be evaluated with early life stages of mussels.

The primary questions that will be addressed by the 2009 aquatic resource and benthic tissue study include, but are not limited to, the following:

- What are the spatial distributions of macrophyte beds that can provide spawning and nursery habitat for juvenile fish, as well as important foraging areas for fish and wildlife species?
- What are the spatial distributions of vegetated riparian areas that can provide habitat for both aquatic-dependent and terrestrial receptors?
- What are the spatial distributions of wetlands that interact with the UCR and that can provide habitat for receptors such as juvenile fish and amphibians?
- Where does fish spawning and rearing occur, and are these areas impacted by COIs?
- What river/reservoir areas appear to be most important for supporting sturgeon populations?
- What is the spatial distribution of soft-bottom and gravel/cobble habitats in the upper portions of the UCR that can provide habitat for various kinds of benthic macroinvertebrates?
- What are the characteristics of benthic macroinvertebrate communities (including mussels) that reside in various habitats of the UCR?
- How do macroinvertebrate (including mussel) diversity and abundance vary in response to changes in COI concentrations in sediment?
- What are the concentrations of COIs in benthic macroinvertebrate (including mussels) in representative portions of the UCR?
- What environments and sediment compositions exhibit toxicity to macroinvertebrates (including mussels)?
- What fish species and life stages are most vulnerable to contaminated sediments?
- Do COI concentrations in benthic macroinvertebrates (including mussels) pose unacceptable risks to human health and the environment?

Some level of field groundtruthing will be required for identified resource-use areas and more detailed surveys may be required for those habitats and receptors for which little existing information is found. Evaluations of sedimentary habitats will include evaluations of existing information on sediment character collected during the Phase I study and other historical studies, as well as information currently being collected by the STI as part of a side-scan sonar survey of portions of the UCR. Evaluations of soft-bottom sedimentary environments and their associated benthic macroinvertebrate communities as well as sampling for toxicity studies will be conducted by using sediment profile imaging and concurrent groundtruthing with conventional grab samples. With respect to timing, any field surveys and sampling will be conducted between spring drawdown, when many nearshore areas can be readily assessed, and late summer or early fall, when certain environments are submerged, some receptors (e.g.,

macrophytes) may reach peak densities, and receptors such as benthic macroinvertebrates have had the full summer to feed and grow, thereby representing potential maximum tissue concentrations. However, the merits of conducting evaluations and sampling during other times of the year will also be evaluated in the SAP.

8.2.4 White Sturgeon Study

Poor recruitment of white sturgeon (*Acipenser transmontanus*) in the UCR has been reported since the 1970s. While both spawning activity of adult sturgeon and occurrence of eggs and early larval stages have been frequently reported during the past years, young-of-the-year numbers have been limited. Juveniles hatched from resident adults and reared in a hatchery have been released into the UCR as part of the Lake Roosevelt White Sturgeon Recovery Plan and appear to be adapting well to the natural habitat. They exhibit good survival, growth rates, and body condition⁴⁰. This indicates that a survival bottleneck could exist subsequent to the initiation of exogenous feeding (BPA 2006e; UCWSRI 2002b). Subject to EPA's approval, the work proposed to be conducted as part of this RI/FS will focus on the potential effects of contamination on white sturgeon and will be consistent with the Agreement (EPA 2006h). Available information relevant to the understanding of sturgeon recruitment and potential contamination effects on early-life-stage development will be used when possible. Additional information will be collected consistent with the DQO process, to test hypotheses and answer critical questions relative to contaminant effects on early life stages of white sturgeon. Because adult sturgeon tissue is difficult to obtain due to the prohibition on fishing, investigations on older life stages may require the use of surrogate species, and/or potentially tissue plugs obtained from opportunistic sources.

8.3 2012 STUDIES

The studies recommended for 2012 will further address essential data needs, building iteratively on the findings from 2009 to 2011 data collection efforts, and critical data gaps identified by the BERA process. As noted previously, one of the key decisions following the 2009 through 2011 field programs will be whether to initiate further field studies to support the terrestrial component of the ERA. This decision will be based on the existence of an upland footprint of COIs at concentrations significantly above background. If the terrestrial component of the ERA requires further support, a number of terrestrial studies will be conducted. The sequencing and dependencies for these studies, as well as generalized descriptions, will be provided in detail in the BERA Work Plan. Detailed study descriptions, including DQOs, will be provided in SAPs.

The need for and possible initiation of complex data evaluations to support the remedial investigation and aquatic portion of the BERA will be initiated in 2010. These may include

⁴⁰ An unpublished study conducted by USFWS appears to indicate that copper is toxic to early life stage sturgeon at levels below the acute water quality criteria (USFWS 2008).

sediment transport modeling, transport and fate modeling, and food web modeling. The approach TCAI will recommend for any proposed modeling efforts will be described in a technical memorandum to EPA prior to the initiation of modeling.

The potential 2012 terrestrial and aquatic studies are described below.

8.3.1 Terrestrial Studies

The terrestrial studies that may be conducted in 2012 are largely dependent on whether the soil study identifies upland areas of the Site that are affected by atmospheric deposition of Trail or Le Roi smelter emissions, windblown dust from nearshore UCR sediments, or floodplain deposition of UCR sediments to levels significantly above background. A list of the potential 2010 terrestrial studies and their components is as follows:

- Soil Study
- Terrestrial Resource Study
 - Upland plant survey
 - Wildlife prey survey
 - Amphibian and reptile survey
 - Wildlife survey
- Terrestrial Tissue Studies
 - Vegetation residues
 - Invertebrate residues
 - Wildlife prey tissue residues
- Specialty Terrestrial Studies
 - Bioaccessibility study
 - Oral bioavailability study
- Terrestrial Toxicity Studies
 - Plant germination study
 - Earthworm toxicity study
 - Amphibian toxicity study

Each of these terrestrial studies is described below.

8.3.1.1 Soil Study

This study will include an evaluation of COI concentrations in soil samples collected from areas of the Site predicted to be affected by COIs. As appropriate, soil samples will be co-located with plant and animal samples collected or evaluated during the terrestrial resource survey and the terrestrial tissue study. Soil samples will be collected and analyzed for COIs (including mercury) as well as conventional variables that may help interpret any observed patterns for COI concentrations. Soil samples will be collected from areas where natural vegetation is present, as well as other potential areas.

8.3.1.2 Terrestrial Resource Study

Major components of the 2010 terrestrial resource study will include surveys of upland plants, the prey of key wildlife species, and amphibians and reptiles. Each of those components is described below.

Upland Plant Survey

This survey will include an evaluation of the kinds of vegetation and relative degree of vegetative cover in affected areas. The evaluation may be based on information collected from existing databases or from new information collected in the field as part of this RI/FS. This survey will be integrated as appropriate with the HHRA.

Wildlife Prey Survey

This survey will focus on identifying the relative abundance of terrestrial invertebrates and small mammals that represent prey to key terrestrial wildlife species. Key wildlife species and their food habits would be identified before the survey is conducted. The evaluation may be based on information collected from existing databases or from new information collected in the field as part of this RI/FS. Various sampling approaches will be considered, including a probabilistic approach.

Amphibian and Reptile Survey

This survey will focus on identifying the relative abundance of amphibians and reptiles. The evaluation may be based on information collected from existing databases or from new information collected in the field as part of this RI/FS. Various sampling approaches will be considered, including a probabilistic approach and a stratified population proportionate design.

Wildlife Survey

This survey will focus on evaluating key wildlife species (both plants and animals) that are identified as important with respect to Tribal and recreational use. The evaluation may be

based on information collected from existing databases or from new information collected in the field as part of this RI/FS. The evaluation would be conducted, as appropriate, in conjunction with surveys conducted for soil, vegetation, and wildlife prey.

8.3.1.3 Terrestrial Tissue Study

Major components of the 2010 terrestrial tissue study will include evaluations of COI concentrations in tissue of key ecological receptors, including upland plants and the prey of key wildlife species. Each of those component studies is described below.

Vegetation Study

This survey will focus on measuring COI concentrations in tissues of upland plants that represent food sources for key wildlife receptors and humans. Key wildlife species and their food habits would be identified before the survey is conducted. The evaluation may include measurements of COI concentrations in both roots and shoots of plants to account for wildlife receptors with different foraging habits. Plant samples would be collected from areas of the Site predicted to be affected by COIs and would be co-located, as appropriate, with soil samples collected for analysis of COI concentrations.

Wildlife Prey Tissue Study

This survey will focus on measuring COI concentrations in tissues of the prey of key wildlife receptors, including both plants and animals. The key wildlife species and their food habits would be identified before the survey is conducted. Prey organisms would be collected from areas of the Site predicted to be affected by COIs and would be co-located, as appropriate, with soil samples collected for analysis of COI concentrations.

8.2.1.4 Specialty Terrestrial Study

The kinds of specialty terrestrial studies that may be conducted in 2010 include bioaccessibility and oral bioavailability studies. Each kind of study is described below.

Bioaccessibility Study

This study will include an evaluation of the potential bioaccessible fraction (e.g., an *in vitro* measure of bioavailability via ingestion by humans or wildlife) of lead and potentially other metals. This study would integrate information on metals concentrations from various Site media, including surface water, sediment, soil, mussels, fish, and terrestrial prey organisms. Depending on the results of this study, it may be appropriate to conduct a follow-on oral study.

Oral Bioavailability Study

Depending on the results of the bioaccessibility study described above, an oral bioavailability study may be conducted. The focus of this study would be to establish estimates of the relative bioavailability of metals in Site media.

8.3.1.4 Terrestrial Toxicity Study

The kinds of soil toxicity tests that may be conducted as part of the RI/FS include plant germination tests, earthworm toxicity tests, and amphibian toxicity tests. Each kind of test is described below.

Plant Germination Tests

These laboratory tests will include evaluations of plant germination in soil samples (and potentially sediment samples) collected in areas of the Site predicted to be affected by COIs. These tests could also be used to evaluate bioaccumulation in plants, as appropriate.

Earthworm Toxicity Tests

These laboratory tests will include evaluations of earthworm survival in soil samples collected in areas of the Site predicted to be affected by COIs. These tests could also be used to evaluate bioaccumulation in earthworms, as appropriate.

Amphibian Toxicity Tests

These laboratory tests will include evaluations of an early life stage (e.g., embryo) of amphibians in soil samples (and potentially sediment samples) collected in areas of the Site predicted to be affected by COIs. The frog embryo teratogenesis assay-Xenopus test will be considered as a candidate test.

8.3.2 Aquatic Studies

Aquatic studies that may be conducted in 2012 are largely dependent on whether the studies conducted in 2009 to 2011 identify key data gaps that should be addressed to complete the RI. A list of the potential 2012 aquatic studies and their components is as follows:

- Surface Water Study
 - Surface water evaluations
 - Groundwater evaluations
- Sediment Study (including porewater)
- Specialty Sediment Studies
 - Toxicity identification evaluations
 - Laboratory dietary toxicity

- Contaminant avoidance tests
- Mercury Study
- Transport and Fate Study

Each of these aquatic studies and components is described below.

8.3.2.1 Surface Water Study

Components of this study would be based largely on the results of the 2009 surface water study and may include both a surface water and groundwater component.

Surface Water Evaluations

If one or more COIs in 2009/2010 surface water data are found to pose potentially unacceptable risks to ecological or human receptors or exceed applicable criteria or standards, additional measurements of surface water chemistry may be warranted in areas found to have elevated COI concentrations. These measurements would be used to better define spatial, temporal, and/or vertical patterns and to identify potential sources of the COIs. In addition, toxicity testing may be used to evaluate predictions based initially on COI concentrations. The toxicity tests would be based on sensitive species (e.g., *Ceriodaphnia dubia*), and may include both acute and chronic tests.

Groundwater Evaluations

If upland soil evaluations indicate the potential for groundwater to be contaminated with metals, or if data analyses indicate possible influx of contaminated surface water from Lake Roosevelt to groundwater during rising or lowering of the lake level, then a groundwater evaluation may be conducted to evaluate potential groundwater discharge of COIs to the UCR. The evaluation will include a literature search to identify existing information, if any, on impacts to groundwater from contaminated soils at the Site, an evaluation of groundwater flow conditions in UCR areas shown by earlier studies to be affected by soil contamination, and a survey of potential groundwater users in the vicinity of the Site.

8.3.2.2 Sediment Study

The components of this study would be based largely on the results of the 2009 surface sediment study, as well as evaluations of historical sediment data for the UCR, including the Phase I data collected in 2005. The study may include additional measurements of COIs in surface sediments, subsurface sediments, and porewater to better define spatial patterns and to further identify sources of the COIs. In addition, toxicity testing may be used to further evaluate predictions based initially on COI concentrations. The toxicity tests would be based on sensitive species and may include both acute and chronic tests, as well as tests that address both whole sediments and porewater.

8.3.2.3 Specialty Aquatic Studies

The kinds of specialty aquatic studies that may be conducted include toxicity identification evaluations, dietary toxicity tests, and contaminant avoidance tests. Each kind of study is described below.

Toxicity Identification Evaluations

These laboratory evaluations will be designed to evaluate the degree to which COIs (rather than other factors) in surface water or porewater account for any observed or predicted toxicity. These kinds of evaluations are based largely on chemical testing and/or manipulations and are potentially followed by toxicity testing.

Laboratory Dietary Toxicity Tests

These laboratory tests will include evaluations of potential dietary toxicity to test fish (e.g., rainbow trout) that are fed benthic macroinvertebrates (e.g., oligochaetes) that have been exposed to field-collected UCR sediments under laboratory conditions and which may therefore be susceptible to bioaccumulative COIs from those sediments. These tests would be designed to evaluate whether diet may be an important source of exposure of fish to COIs in sediments.

Contaminant Avoidance Tests

These laboratory tests will include controlled evaluations of whether fish and/or benthic macroinvertebrates avoid field-collected UCR sediments or water. These tests would be designed to evaluate whether fish may be avoiding potential spawning or foraging areas in the field and/or whether benthic macroinvertebrates may be avoiding areas of potential colonization.

8.3.2.4 Mercury Study

Assessments of data collected during the surface water, sediment, fish, soil, and porewater studies will be used to determine if a more detailed mercury study is required. If mercury in UCR media is found to pose unacceptable risks to ecological or human receptors, additional evaluations may be conducted to evaluate the methylation, bioaccumulation, and fate of this metal in the UCR system. The primary purpose of these evaluations would be to identify the sources and processes that govern the distribution of mercury (including methylmercury) in the system. These evaluations may include targeted sampling of sediment, surface water, and aquatic biota (including benthos and fish). Fish species targeted for sampling will include those with limited home ranges (e.g., sculpins).

8.3.3 Transport and Fate Study

If the results of the BERA or HHRA studies establish that COIs in one or more UCR media pose unacceptable risks to ecological or human receptors, a number of studies related to the

transport and fate of those COIs in the UCR system may be conducted prior to completion of the RI. It is anticipated that most of these fate and transport studies would focus on sediments (both bedded and suspended) and associated porewater. The studies may include targeted evaluations of bathymetry (or, if needed, bathymetry for the entire UCR), surface bottom features (e.g., using side-scan sonar), deposition or erosion rates, subbottom profiling, acoustic Doppler current profiling, and water flow.

9 ECOLOGICAL RISK ASSESSMENT APPROACH

The BERA for the Site will be completed in close coordination with EPA and with EPA oversight, in accordance with the Agreement (EPA 2006h). Consistent with CERCLA guidance, the BERA will focus on chemical stressors. Potential influences and physical and biological stressors on observed or predicted responses of aquatic and terrestrial ecological receptors will be discussed as appropriate in the BERA and elsewhere in the RI/FS process. Appendix I provides more information about chemical stressors and Appendix H provides a summary of studies that have evaluated a portion of the aquatic and terrestrial communities. The BERA will determine whether risk to aquatic and terrestrial ecological receptors occurs at the Site under current and future conditions, and it will identify which COIs, exposure pathways, exposure media, and ecological receptors are associated with risks. The BERA will follow EPA's eight-step ERA process for Superfund (EPA 1997a) (Figure 9-1). The BERA will also be consistent with EPA's general framework for ERA (EPA 1998c) (Figure 9-2) and with other key EPA risk assessment and related documents (EPA 1997b; 1999a; 1999b; 2001b; 2003a; 2004c; 2005b; 2006b). Results of the BERA will provide key input to the remedial investigation, in terms of understanding potential ecological risks posed by the Site, and to the feasibility study, with respect to the identification and selection of remedial alternatives.

In accordance with Steps 1 and 2 of the process, a SLERA will be prepared, in which existing data on COI concentrations in environmental media of the UCR will be compared with conservative ecological benchmarks. The SLERA will be submitted for review by EPA after final submission of this RI/FS work plan and will include a screening-level problem formulation and CSM that are consistent with that presented in Section 6 of this work plan.

The SLERA will address surface water, fish tissue, porewater, sediments (surface and subsurface), and soils (riparian and upland). For each COI, the maximum observed Site concentration in each environmental medium will be compared with the minimum screening benchmark for that COI and medium. All COIs that exceed screening benchmarks and all COIs for which benchmarks are not available will be carried forward in the risk assessment. Although surface water will be considered in the SLERA, all COIs in this medium will be carried forward in the risk assessment, because existing surface water data for the UCR are spatially limited. Results of the SLERA will identify the COIs for each environmental medium evaluated that will be carried forward in the risk assessment process. After the SLERA is finalized, Steps 3 and 4 of EPA's 8-step ERA process will be conducted, in which the screening-level problem formulation and CSM will be refined and the work plan for the BERA prepared.

The draft BERA Work Plan will be submitted to EPA within 120 days from the approval date of the RI/FS Work Plan. The BERA Work Plan will include data quality objectives for the ERA, evaluations of existing data in the context of those DQOs, refined versions of the list of COIs and assessment endpoints, as well as a list of risk questions and measurement endpoints. The

BERA Work Plan will also describe the overall study design and schedule for the BERA and identify the various studies that will or may be used to support the BERA, including the decision criteria for selecting the studies. SAPs for the various studies will be prepared as separate documents.

The EPA risk assessment framework for metals (which are a key group of UCR COIs) recommends that the following principles be addressed to reflect the unique properties of metals:

- Background concentrations
- Essentiality
- Environmental chemistry
- Bioavailability
- Bioaccumulation and bioconcentration
- Acclimation, adaptation, and tolerance
- Toxicity testing
- Metal mixtures

These principles and principles applicable to non-metal COIs will guide the planning, data collection, and interpretation for the UCR BERA and will be key elements of studies that will be proposed to support the conduct of the BERA.

The remainder of this section discusses the general approach to be used for conducting the UCR BERA. Where it is considered important for highlighting information specific to different parts of the BERA, some of the subsections discuss potential approaches for conducting the aquatic and terrestrial elements of the risk assessments.

The subsections presented in the remainder of this section are organized as follows:

- Section 9.1 discusses general methods for preparing the problem formulation, including COIs, CSMs, assessment endpoints, measures, exposure pathways, general receptor groups, and general testable hypotheses.
- Section 9.2 discusses the general approach and considerations for preparing the exposure characterization for aquatic and terrestrial receptors, including discussions of general receptor groups, exposure pathways, exposure measures, receptor measures, ecosystem measures, and general methods.
- Section 9.3 discusses the general approach and considerations for preparing the ecological effects characterization for aquatic and terrestrial receptors, including how effect measures (formerly identified as measurement endpoints [EPA 1997a] and endpoints of concern) will be established, how literature-based toxicity values will be

identified and used, and how empirical effect measures such as toxicity tests will be used.

- Section 9.4 discusses the general approach for ecological risk characterization, including general methods, lines of evidence, and uncertainties.

9.1 PROBLEM FORMULATION

As shown in Figures 9-1 and 9-2, problem formulation is a critical step in the BERA that describes its general technical foundation. Problem formulation establishes the goals and focus of the BERA, including the COIs, exposure pathways, exposure media, receptors of concern, assessment endpoints, measures, and risk questions. Information in the following subsections will be addressed in greater detail in the preliminary problem formulation.

9.1.1 Evaluation of Existing Data

As required in the SOW, TCAI will conduct evaluations of existing data (including data generated by EPA on this project) and studies. The results of these data evaluations may be submitted prior to or as an appendix to the BERA Work Plan. The evaluation of existing data must include a description of each data set and the conclusions of the authors who generated the data set prior to any interpretation by TCAI. In addition, for evaluations that use combined data sets, TCAI will describe data selection and/or rejection processes, evaluate the comparability of the selected data, and fully describe the evaluation process including any data manipulation (e.g., correcting for carbon content) and statistical analyses that are used to characterize Site conditions or identify data needs.

9.1.2 Constituents of Interest

The preliminary list of COIs for the UCR includes a variety of metals and metalloids, as well as several organic chemicals, including SVOCs, PCBs, dioxins/furans, PBDEs, and DDT and degradation intermediates. As discussed previously, this preliminary list of COIs will be further developed and evaluated in the SLERA.

9.1.3 Preliminary Chemical Sources and Releases, Chemical Transport and Fate, Exposure Pathways, and Potential Ecological Conceptual Site Models

CSMs provide a visual depiction of what is known or believed to be occurring at a site regarding ecological receptors. CSMs are used to identify, organize, and communicate what information will be collected to assess risk. The screening-level preliminary CSM for the UCR was discussed earlier in Section 6 of this work plan. The BERA Work Plan will contain updated CSMs based on comments received during work plan reviews. Additionally, the CSM will be refined as warranted through additional data collection and analysis and will guide preparation of the BERA.

9.1.4 Exposure Pathways and General Receptor Groups

The BERA will address key routes through which ecological receptors contact chemical stressors in the UCR (Figures 6-3 and 6-4). These exposure pathways include both direct contact with abiotic media and ingestion (e.g., direct uptake from site media, incidental ingestion, and diet). Site-specific receptors will be identified in the BERA Work Plan for the following general receptor groups: general aquatic receptors and general terrestrial receptors (listed below).

General Aquatic Receptor Groups

- Benthic macroinvertebrates (including mussels)
- Plankton
- Macrophytes
- Piscivorous fish
- Omnivorous fish
- Planktivorous fish

General Terrestrial Receptor Groups

- Riparian/wetland/upland plants
- Soil invertebrates
- Amphibians
- Reptiles (omnivorous, carnivorous)
- Birds (piscivorous, carnivorous, insectivorous, invertivorous, omnivorous)
- Mammals (piscivorous, herbivorous, carnivorous, invertivorous, omnivorous)

The reptiles, birds, and mammals considered in the BERA will include both aquatic-dependent species (e.g., benthivores, piscivores) and species that primarily utilize terrestrial habitats. Examples of receptors in each of these groups that occur in the UCR study area are discussed in Section 6.3.

9.1.5 Assessment Endpoints and Measures

Assessment endpoints are generally defined as "... an explicit expression of the environmental value to be protected, and operationally defined as the definition of an ecological entity and its attributes" (EPA 1997a; 2003a).

Site-specific assessment endpoints will be developed, in coordination with EPA, to guide field study design and data collection activities in the UCR that support the BERA. Site-specific assessment endpoints will define both entities at the Site (e.g., a species, ecological resource, or

habitat type) and a characteristic of that entity to be protected, such as reproductive success (EPA 1997a). The criteria that will be used for developing specific assessment endpoints for the UCR will include ecological relevance, characteristics of the COIs measured at the Site (e.g., fate and mobility), endpoint sensitivity (susceptibility)⁴¹, and ability to actually measure the endpoint (Suter II 1993; EPA 1997a; EPA 2003a). Assessment endpoints proposed may represent different levels of biological organization, including individuals (e.g., certain threatened and endangered species), species populations, and communities of species.

Measures represent the types of information and data used to evaluate specific assessment endpoints in the risk assessment. Measures fall into three groups: exposure, effect, and ecosystem/receptor characteristics (EPA 1998c). Site-specific measures will be used wherever possible to promote maximum relevance. Measures anticipated to support the BERA are broadly discussed for the aquatic and terrestrial risk assessments in Sections 9.3 and 9.4.

9.1.6 Testable Hypotheses

Testable hypotheses represent specific questions that the BERA will evaluate to address each of the assessment endpoints. More specifically, testable hypotheses represent study questions that are identified in Step 2 of the 7-step DQO process (i.e., EPA 2000a). The DQO process will be used to evaluate existing data and plan all studies conducted as part of the UCR RI/FS.

In general, the overall goal in conducting the BERA is to identify risks to ecological receptors that may occur in or near the UCR now or in the future. The broad hypothesis to be evaluated in the BERA is:

COIs in the UCR do not pose current or future risks to the growth, survival, and reproductive success of ecological receptors of concern above reference or background⁴² levels within the UCR.

Specific hypotheses are typically identified during Step 2 of the DQO process used in preparing study-specific SAPs. These and any alternate hypotheses are included in each field study SAP to make sure studies collect data that will specifically address questions/hypotheses.

⁴¹ Susceptibility pertains to the sensitivity of a particular endpoint to the stressor, relative to its potential exposure.

⁴² Identification of reference and background conditions will be conducted in consultation with EPA and will consider guidance provided by EPA (2002d).

9.2 EXPOSURE CHARACTERIZATION

The analysis phase of the BERA (see Figure 9-2) consists of both an exposure characterization (this section) and an effects characterization (see Section 9.4 and EPA 1997a). The purpose of the exposure characterization is to develop an understanding of both the nature and magnitude of receptor exposure to facilitate comparisons with toxicity benchmarks. The remainder of this section discusses general principles that will likely be considered in assessing exposures for aquatic (Section 9.2.1) and terrestrial receptors (Section 9.2.2).

9.2.1 Exposure Characterization for Aquatic Receptors

The purpose of the exposure characterization for aquatic receptors is to estimate the extent to which aquatic life is exposed to bioavailable concentrations of COIs in surface water, sediments, and food. This would also likely include understanding the degree of exposure of aquatic life to similar contaminants at reference locations. Exposures may be characterized through empirical (field) sampling of COIs in water sediment, porewater, and prey, including measurement of parameters (e.g., DOC, pH) that facilitate estimates of bioavailability. Bioassays and assessments of species populations and communities may be other lines of evidence used to evaluate potential exposure and risk.

Aquatic biota are exposed to COIs from surface water, sediments, and prey via aqueous and dietary pathways. The methodologies for assessing these exposures depend on the stressor, exposure medium (e.g., sediment, water, food), receptor, and pathway (aqueous vs. dietary uptake) considered. Each of these is discussed separately below.

9.2.1.1 Surface Water Exposure

In surface water, water column-dwelling, benthic, and epibenthic biota are exposed to (i.e., bioconcentrate and bioaccumulate⁴³) COIs via two pathways: direct uptake from the water and dietary uptake from food (Kamunde et al. 2002; Luoma and Rainbow 2005; Redeker et al. 2005). Exposure to COIs in surface waters will be estimated by sampling for both total and dissolved concentrations. Mercury and selenium may also be measured, based on total concentrations in receptors or their prey or the receptor of concern. Aquatic receptors assimilate the latter two chemicals via their diet (Adams et al. 1998; DeForest et al. 1999; Mason et al. 1995). Other physicochemical parameters may be analyzed to describe conditions at each location sampled and to facilitate estimation of bioavailable COIs.

9.2.1.2 Sediment Exposure

Aquatic biota are exposed to COIs in sediments in a variety of manners, and these will be taken into consideration in defining exposure. The sediments will likely be sampled for

⁴³ Bioconcentrate means uptake directly from the water. Bioaccumulation means uptake from the water and diet.

properties needed to estimate COI exposure and bioavailability following EPA guidelines (EPA 2005g). As required, porewater will be sampled for COIs and parameters needed to estimate bioavailability. Exposure of aquatic life to nonionic organic contaminants in the sediments will likely be based on equilibrium partitioning (Di Toro et al. 1991; EPA 1994) because the organic chemicals detected in the UCR are extremely hydrophobic and meet the assumptions of equilibrium partitioning. Chemicals selected for study will be based on the results of the SLERA, and the species selected for sampling will be based upon review of existing data on each species' biology and distribution during development of the BERA Work Plan.

9.2.2 Exposure Characterization for Terrestrial Receptors

Empirical and literature-based exposure measures may include environmental media concentrations, bioavailability measures, and receptor and ecosystem measures that affect exposure. The exposure assessment for terrestrial receptors will be based on site-specific data whenever possible.

Terrestrial plant and invertebrate tissue data may be collected to assess dietary exposures of receptors that consume them. Concentrations in soil co-located with plants and invertebrates may be compared with existing soil screening benchmarks to assess potential adverse exposures. If adverse exposures to invertebrates and plants are predicted to occur at levels greater than reference-area exposures or screening benchmarks, additional empirical data may be collected to support exposure and toxicity evaluations for these receptor groups. If the potential for adverse exposure is indicated for amphibians and reptiles, empirical data may be collected to support exposure and toxicity evaluations in the BERA through use of standard toxicity bioassays (see Section 9.3.2).

For all other terrestrial receptors (e.g., bird, mammal), exposures will likely be evaluated primarily through estimated ingestion doses, which represent the organism's total COI intake from direct contact exposure pathways—such as incidental ingestion (soil, sediment) and water consumption (where applicable to a given receptor)—and dietary (i.e., food consumption) pathways. Media and/or dietary consumption rates used will be as specific to Site receptors as possible. If needed, rates will be based on surrogate species, available natural history data, and general allometric models (i.e., relationships between growth and size of an organism) developed for broad receptor classes (EPA 2003a). Wildlife receptor doses (chronic exposure) will be estimated using receptor body weights, food and water consumption rate information (EPA 2003a), and empirical UCR media COI concentrations (biotic and abiotic). As previously mentioned, exposure measures that are key to the terrestrial exposure pathway evaluations in the BERA include COI concentrations in UCR environmental media. These media may include sediment, surface water, prey tissues (e.g., benthic macroinvertebrates, forage fish, amphibians, soil invertebrates, and small mammals), soil (riparian/wetland/upland), and associated forage plants. Fish collected as prey items for higher trophic receptors (i.e., birds, mammals) should represent appropriate size classes.

These data will be used to evaluate both direct and dietary receptor exposures. Data and information that describe receptor and ecosystem characteristics in the UCR study area may also be important to assessing exposure of terrestrial receptors. Data on receptor and ecosystem characteristics for the UCR will be sought from resource agencies and other existing data sources before any potential studies to collect these data are designed.

Actual methods of quantifying exposure using the measures identified above will be based on standard oral intake models that address soil, sediment, water, and food as established in EPA (2003a), Fairbrother (2003), and EPA's Metals Framework (2007b).

9.3 EFFECTS CHARACTERIZATION

Effects characterization is the second key step in the analysis phase of the BERA. Effects data represent measures (concentrations or doses) of a chemical associated with adverse effects to a receptor (or surrogate) species. Two general types of effects data may be used in characterizing effects in the BERA: literature-based values and site-specific empirical measures of toxicity based on bioassays and biological assessments. The use of literature-based toxicity values and empirical effects measures in the BERA is discussed below.

9.3.1 Effects Characterization for Aquatic Receptors

The purpose of the effects characterization for aquatic receptors is to define what concentrations of COIs elicit effects on key aquatic receptors (e.g., plankton, fish, benthic macroinvertebrates) in the UCR. Threshold COIs effects may be defined using toxicological data from the scientific literature, bioassays, field biological assessments, or a combination thereof.

The aquatic assessments will use population-level assessment and measurement endpoints. For certain listed species, if selected as an assessment endpoint following EPA guidance, evaluations will be done using organism-level measurement endpoints. The species potentially or actually present include:

- Bull trout (*Salvelinus confluentus*), which is uncommon but is listed on the federal Threatened and state Candidate species lists
- The California floater (*Anodonta californiensis*), listed as a state Priority species
- White sturgeon, selected due to this species' known population and recruitment failure within the UCR, its significant tribal importance, its endangered listing under the Canada's Species at Risk Act, and its listing on the Washington State Priority species list

In some instances (e.g., manganese), EPA criteria are unavailable, and surrogate values (Stubblefield and Hockett 2000) may be derived following EPA guidance (EPA 1985). Effects of whole sediment exposures to certain divalent metals will likely be evaluated by comparing

$(\sum SEM - AVS)/f_{oc}$ measurements to no-observed-effects-concentrations for metal-sensitive species (i.e., daphnids [Di Toro et al. 2005]).

For some organic chemicals, it may be feasible to assess dietary toxicity by comparing tissue residues in prey organisms with effect thresholds for predators (Jarvinen et al. 1977; McCarty 1986; Meador 2006; Van Loon et al. 1997). Measurements of lipid-normalized residues in UCR prey species—fish as well as invertebrates—will likely be needed. These can be compared to toxicological data from the literature concerning effects of these residues on aquatic life. The BERA also may rely on empirical and modeling data to evaluate effects of COIs on aquatic life.

The quality of the toxicological data used will be established using DQOs (EPA 2006h) and will include evaluating scientific data from the published literature using data quality criteria to be specified in an SOP. The SOP will include specific quality control criteria and quality assurance reviews.

9.3.2 Effects Characterization for Terrestrial Receptors

The purpose of the effects characterization for terrestrial receptors is to define what concentrations of COIs elicit effects on key receptors in the UCR. Threshold COIs effects may be defined using toxicological data from the scientific literature, bioassays, field biological assessments, or a combination thereof.

The terrestrial assessments will use population-level assessment and measurement endpoints. For certain listed species, if selected as an assessment endpoint following EPA guidance, evaluations will be done using organism-level measurement endpoints. The species potentially or actually present include:

- Bald eagle (*Haliaeetus leucocephalus*)-protected under Bald and Golden Eagle Protection Act
- Canada lynx (*Lynx canadensis*)-federally threatened
- Grizzly bear (*Ursus arctos horribilis*)-federally threatened
- Gray wolf (*Canis lupus*)-federally threatened
- Ute ladies'-tresses (*Spiranthes diluvialis*)-federally threatened
- Spalding's silene (*Silene spaldingii*)-federally threatened

Effects measures for terrestrial receptors will likely be based on literature-based values in the BERA unless empirical measures are determined to be necessary. If significant risk potential to plants is predicted, for example, other toxicity measures such as bioassays may be used as other lines of evidence in the BERA. Thakali et al. (2006a; 2006b) is an example of a study where toxicity data for nickel and cadmium were used to establish empirical measures of toxicity to plants and soil invertebrates. Benchmarks for plants, invertebrates, birds, and mammals may be represented by EPA soil screening values (EPA 2005g), Oak Ridge National

Laboratory (ORNL) benchmarks (ORNL 1996; 1997a; 1997b), and others. Where toxicological effect thresholds are unavailable for certain COIs or receptor groups, the general scientific literature will be searched for effects studies. Both no-observed-adverse-effect levels (NOAELs) and lowest-observed-adverse-effect levels (LOAELs) will be identified from the literature for each chemical and receptor. Studies identified from the literature for NOAELs and LOAELs will be carefully reviewed and screened based on the appropriateness and sensitivity of the endpoints (i.e., growth, survival, and reproduction) and study quality.

If significant risks are identified for plants, soil invertebrates, or amphibians, it may be necessary to evaluate site-specific empirical measures of effects on these receptor groups. If warranted, appropriate, EPA-approved test protocols for characterizing site-specific ecological effects from UCR soils (i.e., wetland, riparian, upland), sediments, or water will be used.

9.4 RISK CHARACTERIZATION

Risk characterization combines information concerning exposure to COIs with information regarding effects of COIs to allow estimation of risks. For the BERA, risks will be characterized quantitatively and qualitatively using multiple lines of evidence.

Standard approaches to risk characterization include deterministic and probabilistic methods. A conventional deterministic method involves calculation of a hazard quotient (HQ) for each COI, receptor, and exposure pathway to estimate risk. An HQ is estimated for each COI and exposure pathway and is defined operationally as follows:

$$HQ = \frac{\text{Environmental Concentration or Dose}}{\text{Toxicity Value}} \quad \text{Equation 9-1}$$

Where an HQ is greater than or equal to a value of 1.0 (i.e., the environmental exposure/dose for a COI and pathway is greater than the toxicity value), that COI may be identified as posing a potential risk to the receptor. Where an HQ is below a value of 1.0 (i.e., the environmental dose for a COI and pathway is less than the toxicity value), the COI and exposure pathway pose negligible acceptable risk to the receptor. If the chemicals act through the same toxic mechanism, the HQs may be combined, if appropriate, into a hazard index (HI). Where an HI is below a value of 1.0 (i.e., the environmental dose for a COI and pathway is less than the toxicity value), the COI and exposure pathway pose acceptable risk to the receptor. The HQ and HI approach will be one of multiple lines of evidence that will be used to characterize risk to ecological receptors in the BERA. Probabilistic methods that analyze probability distributions of exposure (and, in some cases, effects) may be used as well to describe the probability of risk and its uncertainties.

Risk will be characterized in the BERA for both aquatic and terrestrial receptors using multiple lines of evidence that will be combined to provide an integrated estimate of risk. The use of a lines-of-evidence approach in characterizing ecological risk is the current state of the practice

in ERA (Fairbrother 2003; Menzie et al. 1996; Sample and Suter 1999; Suter II 1996; EPA 1997a; EPA 2004c). For each line of evidence, the relationship of the measurement endpoint to the assessment endpoint and associated uncertainties will be evaluated, as will the quality of the data (e.g., strength of any exposure-response data).

Lines of evidence that may be used in the BERA include but are not limited to risks predicted based on modeled COI receptors, media and pathway-specific associations, site-specific bioassays, special laboratory studies, and biological assessments. In addition to characterizing risks using the lines-of-evidence approach, the BERA risk characterization will provide a discussion of key uncertainties. Characterization of uncertainties provides additional context for the risk manager regarding the nature and magnitude of risk posed to ecological receptors at the Site.

10 FEASIBILITY STUDY APPROACH

10.1 GENERAL APPROACH

The objective of the feasibility study is to identify a range of remedial alternatives that meet CERCLA requirements, analyze the remedial alternatives, and present the information necessary for decision-makers to select a Site remedy. Following EPA guidance (EPA 1988), the feasibility study will involve three primary phases: development of alternatives, screening of alternatives, and detailed analysis of alternatives. The remedial action alternatives may comprise several GRAs and associated technologies (e.g., containment/capping, excavation/dredging, disposal/landfilling). The alternatives may be developed to address the contaminated media (e.g., soil, sediment, surface water), specific areas of the Site (e.g., river reaches, banks, floodplain soils), or the entire Site.

In the feasibility study, remedial strategies will be developed on the basis of the nature and extent of contamination, impacted media, contaminant migration pathways, and potential risks to human and ecological receptors, as identified in the remedial investigation BERA and HHRA. The feasibility study approach will specifically consider the technical and policy guidance of EPA's *Contaminated Sediment Remediation Guidance for Hazardous Waste Sites* (EPA 2005a) and other related EPA and USACE guidance.

Recognizing the iterative nature of the RI/FS (EPA 1988), the initial phase of the feasibility study (i.e., development of alternatives) will be based on existing Site data, coupled with results of the remedial investigation tasks described herein. However, the feasibility study will also include an assessment of data gaps critical to demonstrating the feasibility of the most promising remedial technologies and/or alternatives. Any such data gaps will be addressed, as needed, in conjunction with supplemental remedial investigation activities. Findings from such investigations will be incorporated into the remedy development process, as appropriate.

10.2 DEVELOPMENT OF REMEDIAL ALTERNATIVES

The first phase of the feasibility study, development of remedial alternatives, will involve the following tasks:

- Define or update, as appropriate, the RMAOs for protection of human health and the environment, considering the results of the HHRA and ERA.
- Develop GRAs for each medium, including containment, treatment, excavation, or other actions that may be implemented to satisfy the RMAOs.
- Identify and quantify areas or volumes of impacted media to which the GRAs may be applied, taking into consideration the requirement for protectiveness and the chemical and physical characteristics of the Site.

- Identify and screen pertinent remedial technology types applicable to each GRA to eliminate those that are not technically feasible, based on Site characteristics.
- Evaluate process options for the retained remedial technology types.
- Assemble GRAs and associated technologies and process options into remedial action alternatives.
- Identify and implement treatability studies for potentially applicable remedial technologies, if appropriate.

The RMAOs will specify the contaminants and media of interest, exposure pathways, and initial PRGs representing acceptable contaminant level(s) for each exposure pathway. PRGs will be developed in consideration of the following:

- The risk-based threshold concentrations developed in the risk assessments
- ARARs
- Natural or area background concentrations

The RMAOs and PRGs will form the basis for the development and evaluation of effectiveness of the remedial alternatives.

The following preliminary list of GRAs will be considered in the development of remedial alternatives. These and other potential GRAs will be identified and evaluated by TCAI and presented in a technical memorandum to EPA.

- No action
- Institutional controls
- Monitored natural recovery and enhanced natural recovery
- *In situ* containment (e.g., capping)
- *In situ* treatment
- Removal and disposal (e.g., aquatic, nearshore, upland confined disposal, or upland landfill)
- Removal and *ex situ* treatment

An important early step in the feasibility study is defining areas and volumes of contaminated media that require remediation. At the conclusion of the remedial investigation and risk assessment process, the nature and extent of contamination and risks will be understood in sufficient detail to define specific areas/volumes of impacted media that can be discretely considered “management areas” for development of remedial alternatives. Identification and delineation of management areas will involve, but may not be limited to, the following evaluations:

- Delineation of areas posing unacceptable risks for ecological and human health receptors
- Delineation of areas exceeding chemical-specific ARARs, including Tribal ARARs
- Categorization of risks
- Delineation of volumes that pose unacceptable risks
- Identification and delineation of physical environments
- Identification of habitat types and areas of special habitat significance
- Identification of river and shoreline land uses
- Identification of areas that may be impacted by ongoing sources

Throughout the feasibility study process, the volumes and/or areas of contaminated media will be refined, as appropriate, at locations that represent potential ongoing sources to other media or site locations. If interactions among media appear to be important, the effect of source control actions on the remediation levels or time frames for other media will be evaluated. To minimize the potential for recontamination following the remedial action, ongoing contaminant sources will need to be identified and controlled, to the extent practicable. During the remedial investigation, sediment and water data will be collected to better understand potential sources to the UCR. These data will be evaluated in the context of source control in the following manner:

- The CSM will be refined to show types and locations of ongoing sources associated with areas of unacceptable risk.
- Upland sites that appear to be active sources of COCs to the UCR will be identified and referred to Ecology for source control actions.
- In-river sediment sources that may be adversely affecting downstream areas will be identified.

Process options will be identified and evaluated for the retained remedial technology types based on effectiveness, implementability, and costs. To the extent practicable, at least one representative process will be selected for each selected technology type to simplify the subsequent development and evaluation of alternatives without limiting flexibility during remedial design. The GRAs and associated technologies and process options will then be assembled into remedial action alternatives that address the Site contaminants and associated management areas.

Treatability studies may be conducted early in the feasibility study, concurrent with remedial investigation activities. The purpose of such studies, if needed, will be to provide sufficient information to determine the suitability of treatment technologies for impacted media and to determine the viability of treatment technologies for the Site as a whole. A literature survey will be conducted to gather information about performance, relative costs, applicability,

removal efficiencies, operation and maintenance requirements, and implementability of candidate technologies. If existing information is sufficient to determine suitable technologies, treatability studies may not be necessary. If existing information is insufficient, treatability studies for specific technologies may be necessary and may be implemented as appropriate.

Prior to screening, remedial alternatives will be refined, as necessary, to address the site-specific nature and extent of the Site contaminants, and proposed technologies and process options will be selected and sized accordingly. In addition, key action-specific ARARs will be identified for the assembled remedial alternatives.

10.3 SCREENING OF REMEDIAL ALTERNATIVES

In this phase of the feasibility study the assembled remedial action alternatives will be evaluated and screened for effectiveness, implementability, and cost. The purpose of the screening process is to reduce the number of alternatives that will undergo more extensive evaluations during the detailed analysis of alternatives. Though this is a preliminary screening step, the evaluations will be sufficiently detailed to distinguish among the alternatives and to make sure that the alternatives are compared on an equivalent basis. Generally, comparisons during the screening process will be made between similar alternatives (the most promising of which will be carried forward for further analysis), whereas comparisons during the detailed analysis will differentiate across the range of alternatives. The screening process follows EPA guidance (EPA 1988) and will involve an evaluation of the short- and long-term aspects of three broad criteria— effectiveness, implementability, and cost—as outlined below in Sections 10.3.1, 10.3.2, and 10.3.3.

Alternatives with the most favorable composite evaluation of these factors will be retained for further consideration during the detailed analysis. To the extent practicable, the alternatives retained in the screening process will be selected to represent the range of GRAs.

TCAI will summarize the results of the alternatives screening process in a technical memorandum, and it is anticipated that TCAI will meet with EPA at that time to discuss the alternatives under consideration. The alternatives retained for further analysis will be agreed upon, as well as any additional investigations that may be required to facilitate the detailed analysis of alternatives. In addition, action-specific ARARs will be reviewed at this time, as appropriate. Community outreach activities may also be carried out upon completion of the alternative screening process, as deemed appropriate and necessary by EPA and TCAI. These activities may include development of a fact sheet describing the alternatives under consideration, community meetings, or workshops.

10.3.1 Effectiveness Evaluation

Each alternative will be evaluated as to its short- and long-term effectiveness providing protection and reduction of contaminant toxicity, mobility, or volume. Short-term

effectiveness refers to the construction and implementation phase of the remedy; long-term effectiveness refers to the period after the remedial action is complete.

10.3.2 Implementability Evaluation

The implementability evaluation will involve an assessment of both the technical and administrative feasibility of the remedial action alternative. Technical feasibility refers to the ability to construct, operate, and satisfy technology-specific regulations, as well as operation, maintenance, and monitoring of the completed remedy. Administrative feasibility refers to the ability to obtain regulatory approvals and stakeholder support; the availability of treatment, disposal, and other services; and availability of necessary equipment and technical expertise.

10.3.3 Cost Evaluation

At the screening phase, relative costs of the alternatives will be developed on the basis of readily available cost data from various sources, such as cost guides, vendor information, and engineering judgment based on similar project experience. Both capital and operation and maintenance costs will be considered, where appropriate, using present-worth costing procedures. The focus of this effort will be to maintain a reasonable level of relative accuracy, so that cost decisions among alternatives will be sustained as the alternatives are developed beyond the screening process.

10.4 DETAILED ANALYSIS OF ALTERNATIVES

The detailed analysis of alternatives phase will build on previous evaluations conducted during the development and screening of alternatives. This phase may also incorporate findings from any treatability studies and additional site characterization information gathered during the remedial investigation. Generally, the detailed analysis of alternatives will involve the following:

- Further definition and refinement of each alternative with respect to volumes or areas of impacted media, technologies to be used, and associated performance requirements
- An assessment of each alternative relative to the nine CERCLA evaluation criteria (EPA 1988)
- A comparative analysis of the alternatives

This phase of the feasibility study is aimed at providing decision-makers with sufficient information to select a Site remedy. Results of this evaluation will be compiled into a matrix format to facilitate comparison of each alternative's relative merits, limitations, and tradeoffs. This approach is intended to demonstrate compliance with applicable remedy selection requirements. Specifically, CERCLA (EPA 1988) specifies that remedial actions must accomplish the following:

- Be protective of human health and the environment
- Attain ARARs (or provide grounds for invoking a waiver)
- Be cost-effective
- Use permanent solutions and alternative treatment technologies or resource recovery technologies to the maximum extent practicable
- Satisfy the preference for treatment that reduces toxicity, mobility, or volume as a principal element or provide an explanation as to why it does not

In addition, CERCLA places an emphasis on evaluating long-term effectiveness and related considerations for each of the alternatives.

EPA has developed nine evaluation criteria to address the CERCLA requirements for remedial action listed above (EPA 1988). These criteria, listed below, fall into three categories—threshold, primary, and other—and serve as the framework for conducting the detailed analyses during the feasibility study and for final selection of an appropriate remedial action.

Threshold Criteria (must be achieved for each alternative)

- Overall protection of human health and the environment
- Compliance with ARARs

Primary Criteria (upon which analysis is based)

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

Other Criteria (evaluated in the ROD following comment on the RI/FS)

- State acceptance
- Community acceptance

Evaluation of the alternatives relative to these nine criteria will be accomplished by consideration of specific factors set forth in the CERCLA guidance (EPA 1988), as outlined in Figure 10-1.

The analysis of individual alternatives will be presented in narrative form in the feasibility study report, accompanied by a summary matrix to facilitate a comparative analysis. The narrative will describe the technology components, quantities of hazardous materials to be

handled, timeframe and requirements for implementation, significant ARARs, key assumptions, and other information.

The feasibility study report will also include a comparative analysis to evaluate the relative performance of each alternative in relation to each specific evaluation criteria. The purpose of the comparative analysis is to identify relative advantages, disadvantages, and key tradeoffs for each alternative. The presentation of differences among alternatives may be measured either qualitatively or quantitatively and will identify substantive differences (e.g., greater long-term effectiveness, lower costs).

11 DELIVERABLES

This section of the work plan describes primary work products and deliverables associated with RI/FS work components for the Site as specified in Section V of the Agreement (EPA 2006h).

TCAI recognizes that additional deliverables may also be necessary and required by the EPA to facilitate dialogue within working technical groups. Similarly, because the RI/FS will be conducted over several years, multiple levels of refinement of scoping/planning and implementation documents for some activities (e.g., SAP and HASP preparation, site characterization updates) will be submitted prior to the completion of the RI/FS.

Other deliverables may also be identified by EPA once the RI/FS is more fully under way. The content and delivery schedule of these deliverables will be determined by EPA on an ongoing basis.

11.1 TASK 1: SCOPING

The following scoping deliverables are specified in the Agreement (EPA 2006h).

11.1.1 Technical Memorandum on Risk Management-Based Action Objectives for Ecological Risk Assessment

A technical memorandum summarizing preliminary ecological RMAOs for the Site RI/FS and development of associated potential GRAs was submitted to EPA on October 27, 2006, and revised on March 11, 2007 (a copy of this memorandum is provided in Appendix A). The preliminary ecological RMAOs presented in the technical memorandum are intended to provide a framework for site-specific management decisions regarding ecological resources. In their preliminary form, these ecological RMAOs broadly encompass the primary exposure pathways and receptors of concern at the Site. These preliminary ecological RMAOs will be refined throughout the assessment process, as problem formulation and the conceptual exposure model for the ERA are further developed (e.g., chemicals, receptors, and exposure media may be screened out), as ARARs are identified, and as information about the Site is assembled and synthesized.

11.1.2 RI/FS Work Plan and Addenda

This document (the RI/FS work plan) represents the key scoping document identified in the Agreement and SOW. Because the RI/FS is being conducted in a sequential fashion, it is likely that, as additional RI/FS and risk assessment data needs are identified, addenda to this work plan may be required. Work plan addenda will be incorporated into the SAPs. These addenda will include identification of additional data gaps not previously identified and will be submitted to EPA for review and comment as they are developed, according to the RI/FS

process. In addition, while Sections 4 and 5 briefly summarize contaminant sources and conditions, a number of data assimilation and interpretation activities are incomplete. EPA will require that existing data and records be appropriately integrated into the RI as distinct deliverables, either within the BERA Work Plan or in sampling and analysis plans that precede the BERA Work Plan.

11.1.3 SLERA Report

The draft SLERA, including preliminary problem formulation, was submitted to EPA in December 2008 (TCAI 2008). The primary purpose of the SLERA is to determine if there are adequate data to make a determination on the potential risks of environmental chemicals to ecological receptors. If adequate data are available for a certain environmental medium (e.g., sediment) and COI, and risks are determined to be negligible, then no further assessment is warranted. If inadequate data are available or there is a potential for risk, then the COI requires further evaluation. Any potential risks to ecological receptors identified in the SLERA are not considered definitive and will be evaluated further in later stages of EPA's eight-step ecological risk assessment process. The completion of the SLERA initiates the baseline ecological risk assessment (BERA) process that will provide a more detailed and focused assessment of the key components of potential ecological risks in the UCR.

11.1.4 Sampling and Analysis Plans

SAPs will be prepared for each field-sampling event proposed during the RI/FS. The SAP will provide a mechanism for planning field activities and consist of an FSP and a QAPP. The FSP will define the sampling and data-gathering methods that will be used during the project. Elements of a SAP include sampling objectives, sample locations, sampling frequency, sampling equipment, standard operating procedures (SOPs), and sample handling and analysis. The SAPs will also address site access requirements where special access permission is needed to support sampling activities. The QAPP will detail the QA/QC protocols that will be used to achieve DQOs. The QAPP will include descriptions of sampling procedures, sample custody, analytical procedures, and data reduction, validation, and reporting. Analytical methods will be used to identify contamination consistent with the levels developed for RMAOs, HHRA, and ARAR analysis. Numerous SAPs/QAPPs will be prepared during the course of the RI/FS and submitted to EPA for review and approval prior to the conduct of any field activities. Section 7 of this work plan identifies and discusses data needs that are anticipated to be the subject of SAP/QAPP development.

11.1.5 Site Health and Safety Plan

One overarching HASP was prepared and submitted to EPA on February 23, 2007. The Site HASP is not subject to EPA approval. If addenda are required to address specific sampling programs, they will be submitted concurrently with the SAPs and QAPPs. The HASP was developed in accordance with the health and safety program of TCAI and its contractors, in

compliance with Occupational Safety and Health Administration regulations and protocols and Washington State law. The HASP includes a description of the 11 elements described in the RI/FS guidance (EPA 1988):

- Description of personnel and responsibilities
- Safety risk analysis of site conditions
- Training assignments
- Description of personal protective equipment
- Description of medical surveillance requirements
- Description of monitoring
- Site-control measures
- Decontamination procedures
- SOPs for the site
- Contingency plan
- Entry procedures for confined spaces (if applicable)

11.1.6 Cultural Resources Coordination Plan

The Site contains archaeological, historic, and/or culturally significant properties that could be encountered during field sampling activities. As stated in the Agreement, "The Cultural Resources Coordination Plan shall provide detailed consultation procedures, a detailed description of the sampling program and the methods to be employed to secure sediment/soil samples, information on the nature of the physical impacts that could be anticipated by sediment/soil sampling operations, resource protection measures, and pertinent background information. The Plan shall also identify the state, tribal, and federal parties involved in cultural resources coordination and consultation" (EPA 2006h). A draft cultural resources coordination plan will be submitted with each QAPP and FSP. EPA will coordinate review of and comment on pertinent documents with the Tribal Historic Preservation Officers for the Colville Confederated Tribes and the Spokane Tribe, the State Historic Preservation Officer, and DOI's archaeology programs.

11.2 TASK 2: COMMUNITY RELATIONS PLAN

EPA will prepare a community relations plan to make sure that there are meaningful opportunities for public involvement in the work to be conducted at the Site. TCAI will provide information as requested by EPA for distribution to the public and for public meetings. If requested by EPA, TCAI will prepare a technical assistance plan (TAP) that identifies the process by which qualified community groups can receive funding to participate in the RI/FS process, consistent with the requirements of 40 CFR Part 35, Subpart M.

Participation includes, but is not limited to, hiring independent technical advisors to review documents or providing other assistance related to work conducted as part of the RI/FS.

11.3 TASK 3: SITE CHARACTERIZATION

The goal of site characterization is to describe areas of the Site that may pose a threat to human health or the environment and to understand the transport and fate of contaminants. Information generated from site characterization activities will be used to determine Site physiography and hydrology. In addition, sources of contamination and the nature and extent of contamination will be determined, including the physical and chemical constituents and their concentrations. Investigation of the physical and chemical characteristics of contaminated media, and the extent of migration among Site media, will be conducted to gain a comprehensive understanding of the nature and extent of contamination at the Site.

Site characterization activities include collecting the data needed to understand the physical, chemical, and fate/transport characteristics at the Site. This will include field studies, laboratory studies, and/or modeling efforts. Appendix A of the Agreement (EPA 2006h) includes examples of potential studies. Many of these studies are identified as initial data gaps in Section 7 of this work plan.

Following approval of the RI/FS work plan and SAPs, TCAI will initiate site characterization tasks. TCAI will provide EPA with validated analytical data within 90 days of receipt of all laboratory data packages for each survey in an electronic format showing the location, medium, and validated results, consistent with the data management section of the QAPP. The deliverables described below will be produced during site characterization.

11.3.1 Technical Memorandum on Modeling of Site Characteristics

Site characterization activities may require the use of modeling to determine the nature, extent, and transport of contamination. For example, modeling of the transport of sediment may be required to support an understanding of contaminant transport and fate. A technical memorandum delineating the approach to be used in assessing transport and fate of sediment-bound COCs would be provided to EPA detailing the following: the model(s) proposed, source and data to be used for model parameterization, intended model applications for the Site, and model limitations and associated uncertainties.

11.3.2 Preliminary Site Characterization Summary and Data Gap Evaluations

A concise preliminary site characterization summary report will be submitted following completion of the field sampling and analyses specified in the work plan. Given the sequential nature of the RI/FS, it is anticipated that individual data reports will be prepared and submitted to EPA upon completion of sampling activities specified in addenda to the work

plan. These data reports will document field investigations and describe new Site data, including characterization of contaminants by media and location, and, when relevant, by depth. The primary goals of the preliminary site characterization summary are 1) to further characterize the nature and extent of contamination, 2) to identify additional data gaps (if any) in the current understanding of the Site not already identified herein, and 3) to evaluate remedial alternatives and refine ARARs. Where data gaps are identified, work plan and SAP amendments will be produced to provide methods to meet those additional data needs.

11.3.3 Remedial Investigation Report

A remedial investigation report will be prepared by TCAI after completion and approval by EPA of field investigations and the final site characterization summary. The remedial investigation report will summarize the activities conducted to characterize the Site, the sources of contamination, the nature and extent of contamination, and the transport and fate of contaminants, as necessary.

11.4 TASK 4: ECOLOGICAL RISK ASSESSMENT

TCAI will prepare a BERA in accordance with the Agreement using the best available science and EPA risk assessment guidance (EPA 1997a; 1998c; 1999a; 2004c). The approach for the BERA will be outlined in the BERA Work Plan that will be submitted to EPA for approval. The BERA Work Plan will refine the problem formulation and will describe EPA methods to be used for ecological receptors present at the Site. Components of the problem formulation will include site description, CSMs, exposure pathways, transport mechanisms, contaminants of concern, aquatic and plant/wildlife species of interest, habitat or locations of interest, assessment measurements, assessment endpoints, management goals, and exposure and risk characterization methodologies. The BERA Work Plan will identify all quantitative and qualitative methods to be used in assessing baseline receptor risk, including methods and data sources (i.e., site-specific, scientific literature) for establishing effects thresholds and characterizing exposure and risk. The BERA Work Plan will, at a minimum, identify and/or refine the following:

Problem formulation

- Site physical description and setting
- Chemicals of concern
- Data types and uses in BERA
- Ecological receptors
- General assessment endpoints and measures
- CSM(s)
- Management goals
- Analysis plan

ERA methods

- Exposure assessment (parameter values for species receptors)
- Effects characterization (toxicity reference values)
- Risk characterization (uncertainty, site-specific and other lines of evidence to be used to support/refute risk).

A BERA will be completed by TCAI during the RI/FS process. The BERA will incorporate Site measures of the physical system and chemistry, receptor exposure (e.g., receptor and habitat surveys, bioavailability studies), site-specific toxicity information, and results of field validation studies conducted at the Site. The BERA will incorporate all lines of evidence generated during the remedial investigation into an overall weight-of-evidence analysis regarding receptor risk at the Site, consistent with EPA ERA guidance (EPA 1997a), guidelines (EPA 2001b; 2007b), and practice (Burton and Nelson 2002; Fairbrother 2003; Menzie et al. 1996). TCAI will coordinate closely with EPA and other Participating Parties throughout the preparation of the BERA.

Section VI of the Agreement specifies that EPA will prepare the baseline HHRA for the Site (EPA 2006h). EPA will coordinate with TCAI and Participating Parties during the development and implementation of all components of the baseline HHRA, including the planning, design, and conduct of exposure surveys. The latter will include the preparation by EPA, TCAI, or others of survey work plans and data reports to support the baseline HHRA.

11.5 TASK 5: TREATABILITY STUDIES

As the RI/FS progresses, and/or following approval of the remedial investigation report, TCAI will conduct an analysis of remedial technologies. It is anticipated that the selection of remedial alternatives will be conducted in an iterative fashion and will include the preparation of multiple technical memoranda that address issues related to remedial alternative selection. The need for treatability studies will be assessed as potential alternatives are discussed and developed. The scheduling and scope of treatability studies will be determined as the remedial investigation progresses. If required, treatability tests will be performed and results will be used to design the selected remedial technologies. Activities and deliverables to be completed under this task will include those discussed in the sections below.

11.5.1 Determination of Candidate Technologies and the Need for Testing

A technical memorandum will be prepared to document candidate technologies for treatability studies (if required) during project planning or when appropriate depending on the iterative nature of the RI/FS. The listing of candidate technologies will cover the range of technologies required for alternatives development and screening (Section 11.6). The specific data requirements for the testing program may be determined after the completion of the risk

evaluation phases. This memorandum will include (as appropriate) information on the performance, relative costs, applicability, removal efficiencies, operation and maintenance requirements, and implementability of technologies. If uncertainty in the applicable technologies remains, additional studies may be implemented by TCAI. Once a decision has been made to perform treatability studies, TCAI will prepare and submit a treatability testing work plan for EPA review and approval.

11.5.2 Treatability Testing Work Plan(s)

If a field treatability program is required, a treatability testing work plan will be prepared by TCAI describing the remedial technologies to be tested, the study objectives, experimental and analytical procedures, treatability conditions to be tested, measurements of performance, data management procedures, health and safety provisions, and residual waste management. Treatability studies will be developed by TCAI and approved by EPA.

11.5.3 Treatability Study Sampling and Analysis Plan(s), Health and Safety Plan(s), and Cultural Resources Coordination Plan(s)

Following approval of the treatability testing work plan (if required), TCAI will prepare a field study SAP, HASP, and cultural resources coordination plan that defines the field activities, health and safety requirements, and cultural resource coordination procedures required to conduct the study.

11.5.4 Treatability Study Evaluation Report(s)

If necessary and following approval of all planning documents by EPA, TCAI will conduct one or more treatability studies to support remedial alternative selection in the feasibility study. A treatability study evaluation report (if required) will be prepared that provides a description of the field activities, study results, technology effectiveness, implementability, and cost. The report will also evaluate the full-scale application of the technology for site-wide remediation.

11.6 TASK 6: DEVELOPMENT AND SCREENING OF REMEDIAL ALTERNATIVES

Primary objectives of this task (i.e., development and screening of remedial alternatives) are to document the following:

- GRAs identified for the Site
- Areas or volumes of media to which the GRAs may apply
- Initial screening of GRAs based on feasibility to implement at the Site

- Identification of remedial technologies and process options under the GRAs applicable to the Site
- Screening of identified remedial technologies and process options based on effectiveness, implementability, and cost
- Assembly of remedial actions and process options into remedial action alternatives applicable site-wide or to specific operable units, if applicable
- Refinement of remedial action alternatives and updating action-specific ARARs
- Screening of remedial action alternatives based on effectiveness, implementability, and cost

The Agreement (EPA 2006h) specifies that the aforementioned objectives will be detailed in several technical memoranda (as described below). If appropriate, the screening of remedial alternatives may be combined into a single document, rather than separate and successive technical memoranda to facilitate the selection of remedial alternatives.

The following sections describe the documents that will be delivered as part of this task.

11.6.1 Technical Memorandum on Refined Risk Management-Based Action Objectives

As required by the Agreement (EPA 2006h), during the feasibility study, TCAI will provide EPA with a technical memorandum on refined ecological RMAOs. The refined RMAOs will build upon the preliminary ecological RMAO technical memorandum (Appendix A). Refined ecological RMAOs will provide more specific objectives for reducing to acceptable levels the risks to ecological receptors based on the results of the BERA and the remedial investigation and will include more detailed identification and evaluation of potential remedial action alternatives and associated technologies.

11.6.2 Technical Memorandum on General Response Actions

TCAI will prepare a memorandum defining the general remedial response actions for each medium of interest, contaminant of interest, and treatment technology (e.g., excavation) needed to satisfy the RMAOs. The memorandum may also include the identification of locations and/or volumes of media to which the response actions apply.

11.6.3 Technical Memorandum on the Development and Preliminary Screening of Remedial Technologies, Assembled Alternatives Screening Results, and Final Screening

TCAI will prepare a technical memorandum summarizing the work performed and the results of each task described above, including an alternatives array summary. Evaluation of applicable technologies will be conducted to determine which processes can be implemented

by TCAI at the Site and are in accordance with the remedial action objectives and GRAs. Details on the methods, rationale, and alternatives screening process for selection of the candidate alternative(s) will be specified.

11.6.4 Technical Memorandum on Comparative Analysis

TCAI will prepare a detailed analysis of remedial alternatives by comparing each alternative to the following nine evaluation criteria, as outlined by EPA (1988):

- Protection of human health and the environment
- Compliance with ARARs
- Long-term effectiveness and permanence
- Reduction of toxicity, mobility, or volume
- Short-term effectiveness
- Implementability
- Costs
- State or agency acceptance
- Community acceptance

For each alternative, a description of the waste management strategy involved, key ARARs considered, and assessment of the nine evaluation criteria will be provided by TCAI. Finally, TCAI will conduct a comparative analysis between the candidate remedial alternatives to determine the preferred remedial alternative.

11.6.5 Draft Feasibility Study Report

TCAI will prepare a feasibility study report that incorporates the analyses and results of the remedial alternative assessment technical memoranda discussed above. The feasibility study will detail the candidate remedial alternatives, describe the screening of candidate alternatives, and detail the evaluation process used to select the preferred alternative(s). The feasibility study report will provide the basis for remedy selection for the Site. TCAI will then prepare a final feasibility study report that satisfactorily addresses EPA's comments.

12 PROJECT MANAGEMENT PLAN

This section of the work plan describes the roles and qualifications of key personnel conducting the RI/FS for the Site. This section also describes how TCAI will communicate and coordinate with EPA, other government agencies, and Participating Parties (i.e., the state and the tribes); the decision-making process and key decision points; project reporting requirements; and schedule. A separate data management plan is provided in Appendix B.

12.1 PROJECT ROLES AND RESPONSIBILITIES

Figure 12-1 illustrates the overall project organization and major task responsibilities. As discussed within the Agreement (EPA 2006k), the RI/FS is being conducted by TCAI through the use of contractors and subcontractors, and under the oversight of EPA. All activities performed by TCAI and its contractors will be consistent with applicable EPA guidance and the NCP.

12.1.1 Agency Roles and Responsibilities

As described in the Agreement, EPA will oversee all RI/FS activities conducted by TCAI and will be the lead entity for the preparation of the community relations plan and baseline HHRA. The community relations plan will make sure that the public has meaningful opportunities for involvement in the work that will be conducted at the Site. EPA will complete a draft and final HHRA work plan that follows applicable EPA guidance and the NCP. EPA will also complete the baseline HHRA in cooperation with and with participation by TCAI. EPA will coordinate closely with DOI, the State, the CCT, and the STI in the development and implementation of this baseline risk assessment.

EPA will coordinate all DOI, State, and Tribal input with respect to the review of technical and decision documents prepared and submitted by TCAI. EPA's coordination will result in one set of comments provided to TCAI for each submittal. At the completion of the RI/FS, EPA will prepare and release to the public the proposed plan and ROD. EPA will coordinate with the Natural Resource Trustees on the RI/FS as described under CERCLA (42CFR § 9604 (b)(2)) and OSWER Directive 9200.4-22A (7/31/1997).

EPA will oversee a public involvement process with input from TCAI throughout the duration of the project. This includes convening public meetings to disseminate information, preparing fact sheets, and responding to questions from the public. The Project Coordinator for EPA is Mr. Kevin Rochlin. Members of EPA's UCR technical team include Ms. Monica Tonel, Dr. Bruce Duncan, Dr. David Charters, Mr. David Cooper, Mr. Steve Ells, Mr. Marc Stifelman, Dr. Marc Greenberg, and Mr. Burt Shephard. Contact information for the above-listed individuals is presented in Table 12-1.

As outlined in the Agreement, TCAI also provides financial support to Participating Parties (i.e., DOI, the State of Washington, the CCT, and the Spokane Tribe) to review plans and documents submitted throughout the RI/FS process and provide comments to EPA. Participating parties will also provide input on technical issues associated with the project. Trustee, State, and Tribal contact information for key personnel is presented in Table 12-1.

12.1.2 TCAI Roles and Responsibilities

With the support of contractors and technical experts, and under the oversight of EPA, TCAI will conduct an RI/FS at the Site and report the results in documents according to the Agreement and referenced EPA guidance.

Mr. Marko Adzic will serve as TCAI's Project Coordinator and will have the primary responsibility for making sure that TCAI meets all the requirements and associated deliverables specified within the Agreement and the approved work plans. Mr. Adzic will also be responsible for overseeing all technical aspects of the project, coordinating with the EPA, and managing the overall project schedule. Contact information for Mr. Adzic is provided in Table 12-1.

12.1.3 TCAI Consultant Team Roles and Responsibilities

The TCAI consultant team is responsible for implementation of the RI/FS tasks at the direction and oversight of TCAI. The consultant team includes the following contractors and subcontractors: Integral Consulting Inc. (Integral), Parametrix Inc. (Parametrix), HydroQual Inc. (HydroQual), ENTRIX Inc. (ENTRIX), Archeological Investigations Northwest (AINW), and HDR/FishPro of HDR Engineering Inc. (HDR). Team members for each contractor are responsible for major RI/FS tasks reflecting their areas of expertise. In turn, each contractor will support team members where appropriate and as required.

12.2 COMMUNICATIONS AND COORDINATION

The complexity of this project requires a high level of organization and options for communications not only between TCAI and its contractors but also among EPA and the Participating Parties (i.e., DOI, the State of Washington, the CCT, and the Spokane Tribe). In recognition of this complexity, several communication and coordination tools have been developed. Figure 12-2 illustrates anticipated project lines of communication.

12.2.1 Communications and Meetings – TCAI Technical Team

Mr. Adzic has the primary responsibility for directing the technical scope of the work, coordinating contractors, and managing the overall project schedule and budget for TCAI. He also has the primary responsibility for coordinating with EPA and making sure that all deliverables are submitted to EPA on or before the deadlines specified within the Agreement

and the approved work plans. Assisting Mr. Adzic in contractor coordination activities is Ms. Janet Deisley, Environmental Health and Safety Manager of TCAI. To facilitate project coordination and make sure that deliverables are completed and submitted to EPA in a timely manner, weekly web-based conference calls/meetings are conducted among team members. Attendees include key technical staff as required to adequately address specific project issues that may arise and make sure that internal deadlines are being satisfied.

12.2.2 Communications and Meetings – EPA and Participating Parties

Communication between TCAI, EPA, and the Participating Parties is a critically important aspect of the UCR RI/FS. Timely and constructive communications will enable both policy and technical issues to be fully discussed so that documents reflect input from both TCAI and EPA. Frequent communications among all parties will help make sure that the RI/FS is completed within a reasonable timeframe. A number of tools will be used to facilitate communications among all parties.

A project web site has been established that allows controlled access to project information, documents, and data for the duration of the project. This web site provides an efficient means of distributing project information and deliverables to EPA and Participating Parties. The web site has been designed with two domains, one secure and one public. The secure domain is restricted to TCAI personnel and consultants, EPA, and designated representatives from the Participating Parties. It is anticipated that a database containing validated analytical data will be maintained within this domain. In addition, draft documents (e.g., reports and technical memoranda) specified within the Agreement will also be made available for review and comment via this web site. Access to the password-protected secure domain requires a current web browser and an Internet connection. As new documents or validated data are uploaded to the secure domain, registered users will automatically be notified via e-mail.

Upon approval from EPA, finalized documents will be posted on the public domain of the project web site. In addition to EPA-approved project reports, plans, and memoranda, background information including project status updates, upcoming events, and related news will be posted on the public domain. Access requirements to the public domain will include a current web browser and an Internet connection.

Weekly conference calls are conducted between TCAI and EPA project coordinators to enhance project coordination and cooperation and to facilitate the timely completion of work. Additional technical subgroup meetings involving TCAI staff and consultants, agency experts and managers, and Participating Parties will be used to exchange technical information, foster additional discussion, and develop details of RI/FS tasks and deliverables. Technical subgroup meetings for subsequent RI/FS tasks and deliverables (e.g., HHRA and BERA) are anticipated throughout the project.

Monthly progress reports represent an additional forum for communication. They are submitted by TCAI to EPA by the 10th day of each month, as specified in the Agreement. Progress reports include the following information:

- Actions that have been completed and/or undertaken to satisfy the terms and conditions of the Agreement during the preceding month
- Results of sampling, tests, and/or other data collected or received during the preceding month
- Work planned for the next 2 months, including schedules relating such work to the overall project schedule
- Any and all encountered and/or anticipated problems, any actual or anticipated delays, and solutions developed and implemented to address such issues

Monthly progress reports shall be limited to factual statements and shall not include TCAI's opinions or characterizations of events.

12.2.3 Comment tracking

Comments provided by the EPA on draft technical documents and reports (e.g., sampling and analysis plans) will be tracked using a relational database management system (i.e., Microsoft Office Access). In addition to tracking EPA comments, the database will track the associated responses. In general, the database will be set up and managed to track the following:

- Comment identification number
- Comment document (including date)
- Comment (specific text provided by EPA)
- Technical topics, issues, and/or category addressed by the comment (e.g., surface water sampling)
- Comment response (may include reference to future document where comment will be addressed, if applicable)

As noted above, if comments are more appropriately addressed in future documents, such as but not necessarily limited to respective quality assurance project plans, the database will be queried and applicable comments identified, tracked, and considered. Documents in which comments have been addressed will be summarized in tabular format and included in an appendix of the draft document. The summary table within the respective appendix will include the five categories listed above and, as appropriate, reference sections within the document where the comment was addressed.

12.2.4 Community Relations

Consistent with the Agreement, EPA guidance, and the NCP, EPA will prepare a community relations plan to make sure there are meaningful opportunities for public involvement. TCAI will assist in such efforts as requested and required by EPA.

12.3 DELIVERABLES

Project deliverables described in Section 11 will be submitted to EPA for review and comment according to the scope and schedule set forth within the Agreement and the approved Work Plan. EPA and TCAI will be responsible for distributing documents and information to Participating Parties for review and comment and to the Canadian Government. This activity may include EPA directing TCAI to distribute the documents to various reviewers. Any and all coordination/oversight activities with Participating Parties will be EPA's responsibility. For instance, review comments provided by Participating Parties on project deliverables will be compiled and evaluated by EPA and incorporated into EPA's comments, as appropriate.

As required by the Agreement, deliverables will be sent to EPA project personnel, at the addresses specified within Table 12-2. Deliverables will also be made available on the secure domain of the project web site.

12.4 DECISION-MAKING PROCESS

EPA is the final decision-maker on all aspects of the RI/FS. EPA decision-making will be supported by information provided by key technical and management staff from TCAI and EPA. Through frequent technical and project management meetings, technical issues will be discussed and evaluated.

It is anticipated that EPA and the Participating Parties will hold regular project management meetings to discuss the agencies' technical and policy issues. These informal meetings will provide an opportunity for Participating Parties to raise issues pertaining to any aspect of the RI/FS and to strategize how best to address the issues. EPA will then communicate outcomes from such meetings as appropriate to TCAI.

TCAI, EPA, and Participating Parties will also have periodic formal technical meetings to discuss specific technical issues. Objectives of these meetings will vary; some meetings will be informational with TCAI and their technical team providing data or recommended project approaches. In other meetings, EPA and the Participating Parties will have the opportunity to provide TCAI with comments on technical approaches and documents.

In addition, TCAI, EPA, and the Participating Parties will periodically hold informal ad hoc meetings and technical subgroup meetings during which technical experts will have wide-ranging discussions of certain topics. The goal of these sessions is for technical experts to voice their opinions on technical issues. Representatives from TCAI, EPA, and the Participating

Parties will attend ad hoc and technical subgroup meetings, although final resolution of technical issues generally will not be a goal of these meetings.

12.5 KEY DECISIONS

There are numerous key decisions that will need to be made during the RI/FS, as well as any number of smaller decisions, focusing the overall project. Some of the key decisions are discussed below.

12.5.1 Data Quality Objectives

The EPA DQO process (EPA 2000b) will be relied upon throughout the RI/FS to formulate the technical questions that will be addressed through field and/or literature studies. EPA's seven-step DQO process will be applied prior to and following each data-gathering effort, including the compilation of historical data and field sampling programs, to identify outstanding data gaps and make recommendations on additional data-gathering activities that may be needed to complete the risk assessments and feasibility study.

12.5.2 Risk Assessment Parameters

Numerous decisions must be made prior to submittal of the HHRA and ERA deliverables.

For the ERA, decisions regarding assessment endpoints, receptors, exposure models, toxicological data, and other issues will be made based on updates to the CSMs. These decisions will be made with direction from EPA and through a combination of informal ad hoc, subgroup, and formal technical meetings.

12.5.3 Preliminary Risk Management-Based Action Objectives

The development of preliminary RMAOs is discussed elsewhere in this work plan (Section 2). The preliminary RMAOs are relatively broad statements of programmatic objectives that will be refined as additional information is gathered during the RI/FS, with final RMAOs being developed by the end of the feasibility study process. The final RMAOs will continue to be broadly defined statements of goals for the overall selected remedial alternative or combination of alternatives.

12.5.4 Field Sampling and Analysis Plans

Key decisions on the scope and content of FSPs will be made following application of the DQO process and identification of additional data needs to support the risk assessments and feasibility study. TCAI and its contractors will develop SAPs that address the proposed approach, including the types, numbers, and locations of samples, types of analyses, analytical requirements, and data reporting, for consideration by EPA and Participating Parties.

Following receipt and review of comments from EPA, draft SAPs (which will include QAPPs) will be revised as necessary, based on comments received.

12.5.5 Treatability Testing

Treatability testing of identified candidate treatment technologies is complex and can involve a significant amount of time. The decision on whether treatability testing is needed should be made early in the overall RI/FS to allow time for such testing.

12.6 SCHEDULE

The duration of the RI/FS will be determined by the nature of the studies undertaken (including constraints such as the need for sampling during certain seasons or water elevations), the complexity of the analyses required, and the decisions that are made based on the results of completed studies. Studies to be initiated in 2009 through 2011 are largely independent of one another; studies to be conducted in 2012 and later are dependent on the results of the earlier studies and evaluations.

Schedule control will be an important focus throughout the RI/FS, and both planning and control will be based on adherence to the milestones presented in Table 12-3. The EPA and TCAI will periodically review and update the schedule as the RI/FS progresses.

The schedule for planning and implementation of the RI/FS is shown in Figure 12-3. The schedule provides estimates of the time required for review and approval of deliverables. TCAI is required to meet the deadlines set forth in the SOW unless EPA determines it is necessary to extend SOW timeframes to accommodate appropriately-timed collection of data (e.g., beach sampling during drawdown). This schedule will be updated periodically and additional tasks will be shown as the tasks and sequence are refined.

Milestones related to the HHRA will also be added to the project schedule once the work plan is provided.

13 REFERENCES

- Adams, W.J., K.V. Brix, K.V. Cothorn, L.M. Tear, R. Cardwell, A. Fairbrother, et al. 1998. Assessment of selenium food chain transfer and critical exposure factors for avian wildlife species: Need for site-specific data. In: *Environmental Toxicology and Risk Assessment: Seventh Volume, ASTM STP 1333*. pp. 312–342. American Society for Testing and Materials. Philadelphia, PA.
- Allen, H.F., F. Gongmin, and B. Deng. 1993. Analysis of acid volatile sulfide (AVS) and simultaneously extracted metals (SEM) for estimation of potential toxicity in aquatic sediments. *Environ. Toxicol. Chem.* 12:1441–1453.
- Ames, K.M., D.E. Dumond, J.R. Galm, and R. Minor. 1998. Prehistory of the Southern Plateau. In *Handbook of North American Indians*, vol. 12. W. C. Sturtevant, general editor. Smithsonian Institution. Washington, DC.
- Antcliffe, B.L., D. Kieser, G. Lawrence, W.L. Lockhart, D.A. Metner, and J.A.J. Thompson. 1997a. Monitoring of Mountain Whitefish, *Prosopium williamsoni*, from the Columbia River System near Castlegar, British Columbia: Final Assessment of Fish Health and Contaminants, July 1996. Report no. 2184. Canadian Technical Report of Fisheries and Aquatic Sciences. xiii+79 pp.
- Antcliffe, B.L., D. Kieser, W.L. Lockhart, D.A. Metner, J.A.J. Thompson, and J.R. Roome. 1997b. Monitoring of Mountain Whitefish, *Prosopium Williamsoni*, from the Columbia River System near Castlegar, British Columbia: Fish Health Assessment and Contaminants in 1994. Report no. 2142. Canadian Technical Report of Fisheries and Aquatic Sciences. xii+100 pp.
- Aquamatrix Research Ltd. 1994. *Columbia River Integrated Environmental Monitoring Program (CRIEMP)*. 1991-1993 Interpretative Report. Prepared for CRIEMP Coordinating Committee. B.C. Ministry of Environment, Lands, and Parks, Environment Canada, Department of Fisheries and Oceans. Cities of Castlegar and Trail, BC Hydro, Celgar Pulp Company, and Cominco Limited.
- ASCTF. 2003. *Area-wide Soil Contamination Task Force Report*. June 30, 2003. Submitted to Washington State Department of Agriculture, Washington State Department of Ecology, Washington State Department of Health, and Washington State Department of Community, Trade and Economic Development.
- ASTM. 2004. *Standard Guide for Conducting the Frog Embryo Teratogenesis Assay-Xenopus (FETAX)*. ASTM E1439-98. American Society for Testing and Materials. West Conshohocken, PA.

ATSDR. 1999. Toxicological Profile for Cadmium. <http://www.atsdr.cdc.gov/>. U.S. Department of Health and Human Services, Public Health Service, Agency for Toxic Substances and Disease Registry. Atlanta, GA.

B.C. MoE. 1977. *Kootenay Air and Water Quality Study Phase I, Water Quality in Region 8 the Lower Columbia River Basin*. File No. 0322512-1. British Columbia Ministry of Environment, Water Investigations Branch.

B.C. MoE. 1979. *Kootenay Air and Water Quality Study Phase II, Water Quality in Region 8 the Lower Columbia River Basin*. File No. 0322512-1. British Columbia Ministry of Environment, Water Investigations Branch.

B.C. MoE. 2000. Dioxins and furans in rainbow trout, mountain whitefish, and walleye collected from the Columbia River in September 2000. Unpublished data provided by B.C. Environment.

B.C. MoE. 2001. September 2001 Columbia River fish quality objectives monitoring. Unpublished dioxin and furan data for mountain whitefish. Unpublished data provided by B.C. Environment.

B.C. MoE. 2007. Land Remediation Section, 2006 – 2007 Annual Report.

Baldwin, C.M., J.G. McLellan, M.C. Polacek, and K.D. Underwood. 2003. Walleye predation on hatchery releases of kokanee and rainbow trout in Lake Roosevelt, Washington. *North American Journal of Fisheries Management* 23:660–676.

Barley, D.M., G.A.E. Gall, and B. Bentley. 1985. Preliminary description of the genetic structure of white sturgeon, *Acipenser transmontanus*, in the Pacific Northwest. Pages 105-109. F.P. Binkowski and S.I. Doroshov [eds.]. *North American Sturgeons*. Dr. W. Junk Publishers. Dordrecht, Netherlands.

Barron, M.G., J.A. Hansen, and J. Lipton. 2002. Association between contaminant tissue residues and effects in aquatic organisms. *Rev. Environ. Contam. Toxicol.* 173:1–37.

Besser, J.M., and J.P. Giesy. 1993. Effects of Aerobic and Anaerobic Incubation on the Bioavailability of Copper from Lake Sediments. 14th Annual Meeting, Society for Environmental Toxicology and Chemistry.

Besser, J.M., W.G. Brumbaugh, C.D. Ivey, C.G. Ingersoll, and P.W. Moran. 2008. Biological and chemical characterization of metal bioavailability in sediments from Lake Roosevelt, Columbia River, Washington, USA. *Arch. Environ. Contam. Toxicol.* 54:557-570.

Black, A.R., G.W. Barlow, and A.T. Scholz. 2003. Carbon and nitrogen stable isotope assessment of the Lake Roosevelt aquatic food web. *Northwest Science* 77(1):1–11.

Black, M.C., and J.F. McCarthy. 1988. Dissolved organic macromolecules reduce the uptake of hydrophobic organic contaminants by the gills of rainbow trout (*Salmo gairdneri*). *Environ. Toxicol. Chem.* 7:593–600.

Borgmann, U. 2003. Derivation of cause-effect based sediment quality guidelines. *Can. J. Fish. Aquat. Sci.* 30:352–360.

Bortleson, G.C., S.E. Cox, M.D. Munn, R.J. Schumaker, and E.K. Block. 2001. *Sediment-Quality Assessment of Franklin D. Roosevelt Lake and the Upstream Reach of the Columbia River, Washington, 1992*. Water-Supply Paper 2496. U.S. Geological Survey. Reston, VA. 130 pp.

Bouchard and Kennedy. 1979. Ethnogeography of the Franklin D. Roosevelt. British Columbia Indian Language Project, Lake Victoria, B.C.

Box, S.E., Bookstrom A.A., M. Ikramuddin, and J. Lindsay. 2001. *Geochemical Analyses of Soils and Sediments, Coeur d'Alene Drainage Basin, Idaho: Sampling, Analytical Methods, and Results*. U.S. Geological Survey. Spokane, WA. 206 pp.

BPA. 2002c. *Lake Roosevelt Fisheries Evaluation Program; Limnology, Primary Production, and Zooplankton in Lake Roosevelt, Washington*. Annual Report 1998, Part B. Prepared by the Spokane Tribe of Indians. Project Number 199404300. U.S. Department of Energy, Bonneville Power Administration. Portland, OR. 94 pp.

BPA. 2003a. *Assessment of Three Alternative Methods of Nutrient Enhancement (Salmon Carcass Analogs, Nutrient Pellets, and Carcasses) on Biological Communities in Columbia River Tributaries, 2001 – 2003 Technical Report*. Prepared by NOAA Fisheries, Seattle, WA. Project No. 200105500. DOE/BP-00007621-2. U.S. Department of Energy, Bonneville Power Administration. Portland, OR.

BPA. 2004a. *Lake Roosevelt Fisheries Evaluation Program; Limnological and Fisheries Monitoring Annual Report, January 2000 – December 2000*. Prepared by the Spokane Tribe of Indians. DOE/BP-00000118-1. U.S. Department of Energy, Bonneville Power Administration. Portland, OR.

BPA. 2004b. *Lake Roosevelt Fisheries Evaluation program; Limnological and Fisheries Monitoring Annual Report, January 2002 – December 2002*. Prepared by the Spokane Tribe of Indians. Project No. 199404300. DOE/BP-00005756-5. U.S. Department of Energy, Bonneville Power Administration. Portland, OR.

BPA. 2005a. *Lake Roosevelt Fisheries Evaluation Program; Limnological and Fisheries Monitoring Annual Report, January 2003 – December 2003*. Prepared by the Spokane Tribe of Indians. Project No. 199404300. DOE/BP-00005756-6. U.S. Department of Energy, Bonneville Power Administration. Portland, OR.

BPA. 2006a. *Artificial Imprinting of Juvenile Kokanee Salmon (Oncorhynchus nerka): Implications for Operating Lake Roosevelt Kokanee Salmon Hatcheries, 1996 Annual Report*. Prepared by the Eastern Washington University Fisheries Center. U.S. Department of Energy, Bonneville Power Administration, Portland, OR.

BPA. 2006b. *Lake Roosevelt Fisheries Evaluation Program; Limnetic Fish Surveys and Examination of Some Limiting Factors for Kokanee and Rainbow Trout in Lake Roosevelt, 2001 – 2002 Annual Report*. DOE/BP-00005756-2. U.S. Department of Energy, Bonneville Power Administration, Portland, OR. 51 pp.

BPA. 2006c. *Lake Roosevelt Fisheries Evaluation Program; Limnetic Fish Surveys and Examination of Some Limiting Factors for Kokanee and Rainbow Trout in Lake Roosevelt, 2003-2004 Annual Report*. Project No. 199404300. BPA Report DOE/BP-00014804-3. U.S. Department of Energy, Bonneville Power Administration, Portland, OR.

BPA. 2006d. *Lake Roosevelt Fisheries Evaluation Program; Limnetic Fish Surveys and Examination of Some Limiting Factors for Kokanee and Rainbow Trout in Lake Roosevelt, 2004-2005 Annual Report*. Project No. 199404300. BPA Report DOE/BP-00014804-4. U.S. Department of Energy, Bonneville Power Administration, Portland, OR.

BPA. 2006e. *Lake Roosevelt White Sturgeon Recovery Project Annual Progress Report*. Project No. 1995-027-00. U.S. Department of Energy, Bonneville Power Administration, Portland, OR.

British Columbia Water Quality Monitoring Agreement. 1999. State of Water Quality of Columbia River at Birchbank, 1983-1997.
<http://www.env.gov.bc.ca/wat/wq/quality/birchbank/index.htm>.

Brumbaugh, W.G., and J.W. Arms. 1996. Quality control considerations for the determination of acid-volatile sulfide and simultaneously extracted metals in sediments. *Environ. Toxicol. Chem.* 15(3):282–285.

Bucy, L.K., and W.H. Funk. 1996. *Lake Roosevelt Management Plan*. Prepared for the Lake Roosevelt Water Quality Council by the State of Washington Water Research Center, Washington State University, Pullman, WA. 99164-3002. August 1996.

Bufflap, S.E., and H.E. Allen. 1995. Sediment pore water collection methods for trace metal analysis: A review. *Water. Res.* 29(1):165–177.

Burton, G.A., and W. Nelson. 2002. *Issues in Assessing and Managing Ecological Risk at Contaminated Sites Meeting*. Sponsored by the U.S. Environmental Protection Agency and American Chemistry Council. Chicago, IL. June 4-5, 2002.

Carpenter, J.H. 1984. *Landslide Risk along Lake Roosevelt*. Thesis. Massachusetts Institute of Technology. Cambridge, MA. 125 pp.

Cassidy, K.M., C.E. Grue, M.R. Smith, and K.M. Dvornich. 1997. *Washington State Gap Analysis – Final Report*. Washington Cooperative Fish and Wildlife Research Unit, University of Washington, Seattle, WA.

CCRH. 2007. 1935 River and Harbors Act.

<http://www.ccrh.org/comm/moses/primary/riveract.html>. Accessed on July 4, 2007. Center for Columbia River History.

CCT. 1999. *Lake Roosevelt Studies: Preliminary Analysis of Declining Nutrient Loads and Possible Effects on Aquatic Productivity*. Prepared for Confederated Tribes of the Colville Reservation, Fish and Wildlife Department, Nespelem, WA. May 22, 1999.

CCT. 2006. *Fish and Wildlife Resource Management Plan and Five Year Implementation Schedule, 2007-2011*. Fish and Wildlife Department, Confederated Tribes of the Colville Reservation, Nespelem, WA.

CCT 2008. Facts and Information. <http://www.colvilletribes.com/facts.htm>

CDFO. 1992. *Survival and Water Quality Results of Bioassays on Five Species of Aquatic Organisms Exposed to Slag from Cominco's Trail Operations*. Canadian Department of Fisheries and Oceans, Vancouver, B.C., Canada. 68 pp.

CEC. 1997. North American Regional Action Plan on DDT. North American Working Group for the Sound Management of Chemicals Task Force on DDT and Chlordane. June 1997. http://www.cec.org/programs_projects/pollutants_health/smoc/ddt.cfm?varlan=english#canada. Accessed on June 23, 2007. Commission for Environmental Cooperation.

CEPA. 1999. Canadian Environmental Protection Act of 1999, Chlorobiphenyls Regulations (SOR/91-152, section 3.III). http://laws.justice.gc.ca/en/showdoc/cr/SOR-91-152/bo-ga:s_3/en#anchorbo-ga:s_3. Accessed on June 19, 2007.

Chance, D.H., 1986. People of the Falls. Kettle Falls Historical Society, Colville.

Chapman, P.M., F. Wang, C. Janssen, G. Persoone, and H.E. Allen. 1998. Ecotoxicology of metals in aquatic sediments: Binding and release, bioavailability, risk assessment, and remediation. *Can. J. Fish. Aquat. Sci.* 55(10):2221–2243.

Cirone, P.A., D.W. Karna, J.R. Yearsley, C.M. Falter, and T.V. Royer. 2001. Ecological risk assessment for the Middle Snake River, Volume 1. EPA/600/R-01017.

City of Spokane. 2006. Combined sewer overflow reduction. Available at <http://www.spokanewastewater.org/csoinfo.asp>. City of Spokane Wastewater Management, Spokane, WA.

Cloutier, E. 1941. Ottawa, Printer to the King's Most Excellent Majesty, Trail Smelter Question: Decision Reported on March 11, 1941, to the Government of the United States of America and to the Government of the Dominion of Canada by the Trail Smelter Arbitral Tribunal, under the Convention Signed April 15, 1935.

Clark, G.M. 2003. Occurrence and transport of cadmium, lead, and zinc in the Spokane River basin, Idaho and Washington, water years 1999-2001. Survey 45. U.S. Geological Survey, Boise, ID.

Cockell, K.A. 1990. Chronic toxicity of dietary arsenic to rainbow trout *Oncorhynchus mykiss*. University of Guelph (Canada), *Nutritional Sciences*, 187.

Cominco. 1997. Cominco Limited, Trail Operations, 1996 Annual Environmental Report.

Cominco. 1998. Cominco Limited, Trail Operations, 1997 Environmental Report.

Cominco. 2000. 2000 Cominco Annual Environmental Permit Report for the B.C. Ministry of Environment. Teck Cominco, Trail, B.C., Canada.

Cominco Metals. 1991. Cominco Metals, Trail Operations. 1991 (December). Environmental Management Program - Slag Disposal Options Environmental and Engineering Studies.

Cox, S.E., P.R. Bell, J.S. Lowther, and P.C. Van Metre. 2005. *Vertical Distribution of Trace-Element Concentrations and Occurrence of Metallurgical Slag Particles in Accumulated Bed Sediments of Lake Roosevelt, Washington, September 2002*. Scientific Investigations Report 2004-5090. U.S. Geological Survey, Reston, Virginia. 70 pp.

Creveling, J., and B. Renfrow. 1986. *Wildlife Protection, Mitigation And Enhancement Planning for Grand Coulee Dam*. Final Report. Contract No. DE-AI79-86BP60445. Washington Department of Game, Habitat Management Division, Olympia, WA.

CRIEMP. 2005. *2005 Environmental Status Report: Public Update on the Environmental Health of the Columbia River From Hugh Keenleyside Dam to the Border*.

CRITFC. 1994. A Fish Consumption Survey of the Umatilla, Nez Perce, Yakima, and Warm Springs Tribes of the Columbia River Basin. Technical Report 94-3. Columbia River Inter-Tribal Fish Commission, Portland, OR.

Crozier, R. 1991. Preliminary reports on dioxin and furan levels in Columbia River fish. B.C. Ministry of Environment, Nelson, B.C.

Dahlgren, T. 2006. Personal communication (e-mail correspondence with E. Spalt, Integral Consulting Inc., Mercer Island, WA, on November 15-16, 2006, regarding request for final air quality study). Washington State Department of Ecology, Air Quality Program, Lacey, WA.

Dames & Moore. 1992. Investigation of Geotechnical and Environmental Issues Proposed Land Disposal for Fuming Furnace Tail Slag, Duncan Flats, British Columbia. Prepared for Cominco Ltd. December. Dames & Moore, Los Angeles, CA.

Davidson, F.A. 1964. *The Temperature Regime of the Columbia River from Priest Rapids, Washington to the Arrow Lakes in British Columbia*. Unpublished report. Prepared for Public Utility District No. 2 of Grant County, Ephrata, WA. 31 pp.

De Schamphelaere, K.A.C., and C.R. Janssen. 2004. Development and field validation of a biotic ligand model predicting chronic copper toxicity to *Daphnia magna*. *Environ. Toxicol. Chem.* 23(6):1365–1375.

DeForest, D., K.V. Brix, and W.J. Adams. 1999. Critical review of proposed residue-based selenium toxicity thresholds for freshwater fish. *Hum. Ecol. Risk Assess.* 5(6):1187–1228.

Derewetzky, R.F., W.H. Funk, and S.T. Juul. 1993. Lake Franklin D. Roosevelt water quality retrospective analysis. Report No. 90. Water Research Center, Washington State University, Pullman, WA. 152 pp.

Di Toro, D.M. 1985. A particle interaction model of reversible organic chemical sorption. *Chemosphere* 14(1503):1538.

Di Toro, D.M., H.E. Allen, H.L. Bergman, J.S. Meyer, P.R. Paquin, and R.C. Santore. 2001. Biotic ligand model of the acute toxicity of metals. I. Technical basis. *Environ. Toxicol. Chem.* 20:2383–2396.

Di Toro, D.M., J.A. McGrath, D.J. Hansen, W.J. Berry, P.R. Paquin, R. Mathew, et al. 2005. Predicting sediment metal toxicity using a sediment biotic ligand model: methodology and initial application. *Environ. Toxicol. Chem.* 24(10):2410–2427.

Di Toro, D.M., C.S. Zarba, D.J. Hansen, W.J. Berry, R.C. Swartz, C.E. Cowan, et al. 1991. Technical basis for establishing sediment quality criteria for nonionic organic chemicals using equilibrium partitioning. *Environ. Toxicol. Chem.* 10:1541–1583.

Divens, M. 2006. In: The Lake Roosevelt Annual Conference, Spokane, WA.

DOI. 2006. Historical weather data from AgriMet--The Pacific Northwest Cooperative. Agricultural Weather Network. U.S. Department of the Interior.

Duncan, W.F. 2004. Personal communication (telephone conversation with Rick Cardwell, Parametrix, Albany, Oregon). Teck Cominco Metals, Ltd., Trail, B.C.

Duncan, B., and B. Antcliffe. 1996. *Toxicity Assessment of Effluent from the Cominco Metallurgical & Fertilizer Operations at Trail, B.C.* November 1996.

E&E. 2002. *Preliminary Assessments and Site Inspections Report, Upper Columbia River Mines and Mills, Stevens County, Washington*. Prepared for the U.S. Environmental Protection Agency, Region 10, Seattle, WA, by Ecology and Environment, Inc., Seattle, WA.

Ecology. 1972. *Spokane River Cooperative Water Quality Study*. Report No. 72 -001. Washington State Department of Ecology. Olympia, WA. 72 pp.

Ecology. 1995. *Department of Ecology 1993-94 Investigation of PCBs in the Spokane River*. Publication #95-310. Washington State Department of Ecology, Olympia, WA.

Ecology. 1997. *Polychlorinated Dibenzo-p-dioxins in Upper Columbia River Suspended Particulate Matter, 1990-1994*. Publication No. 97-342. Washington State Department of Ecology, Olympia, WA.

Ecology. 1998a. *Northport, Washington Air Quality Study: Phase III*. Publication No. 98-210. Washington State Department of Ecology, Olympia, WA. 31 pp. October 1998.

Ecology. 1998b. *Northport, Washington Air Quality Study: Phase IV*. Publication No. 98-211. Washington State Department of Ecology, Olympia, WA. December 1998.

Ecology. 2001. *Reassessment of Toxicity of Lake Roosevelt Sediments*. Publication No. 01-03-043. Environmental Assessment Program, Washington State Department of Ecology, Olympia, WA. 54 pp.

Ecology. 2003. Environmental Information Management System (EIM). Water quality data for WRIA 42, 53, 58, and 61. Available at <http://www.ecy.wa.gov/eim/>. Washington State Department of Ecology, Olympia, WA.

Ecology. 2005. Fact Sheet, Sand and Gravel General Permit. <http://cfpub.epa.gov/npdes/>. Accessed on July 26, 2007. National Pollutant Discharge Elimination System (NPDES) permit program. Olympia, WA.

Ecology. 2006a. Ecology Environmental Information Management Database (EIM). Available at <http://apps.ecy.wa.gov/eimreporting>. Washington State Department of Ecology, Olympia, WA.

Ecology. 2006b. *PBDE Flame Retardants in Washington Rivers and Lakes: Concentrations in Fish and Water, 2005-06*. Publication No. 06-03-027. Washington State Department of Ecology, Olympia, WA.

Ecology. 2006c. *PCBs, PBDEs, and Selected Metals in Spokane River Fish, 2005*. Publication No. 06-03-025. Washington State Department of Ecology, Olympia, WA.

- Ecology. 2007a. Confirmed and Suspected Contaminated Sites List. Updated July 3, 2007. <http://www.ecy.wa.gov/programs/tcp/cscs/CSCSpaage.HTM>. Accessed on July 6, 2007. Department of Ecology, Olympia, WA.
- Ecology. 2007b. Facility/Site Database Search. <https://fortress.wa.gov/ecy/facilitysitesearch/FSDetailReport.aspx?id=7288890>. Accessed on July 7, 2007. Department of Ecology, Olympia, WA.
- Ecology. 2007c. No further action report. Updated July 3, 2007. <http://www.ecy.wa.gov/programs/tcp/NFA/NFApage.htm#filesNFA>. Accessed on July 6, 2007. Department of Ecology, Olympia, WA.
- Ecology. 2007d. Well logs. <http://apps.ecy.wa.gov/wellog/index.asp>. Accessed on June 27, 2007. Washington State Department of Ecology, Olympia, WA.
- Ecology. 2008. Maps of Area Wide Soil Contamination. Tier 1 Smelter Map. Available at www.ecy.wa.gov/PROGRAMS/tcp/area_wide/AW/toolbox_chap2.html.
- Environment Canada. 2006. Environment Canada Water Quality Database. Available at <http://waterquality.ec.gc.ca/waterqualityweb/searchtext.aspx>.
- Environment Canada. 2007. Waste Management, Polychlorinated Biphenyls. Available at <http://www.ec.gc.ca/wmd-dgd/default.asp?lang=En&n=75C647A7-1>. Accessed on July 2, 2007.
- EPA. 1971. *Columbia River Thermal Effects Study: Volume II, Temperature Predictions Studies*. U.S. Environmental Protection Agency, Seattle, WA.
- EPA. 1985. *Guidelines for Deriving Numerical National Water Quality Criteria for the Protection of Aquatic Organisms and Their Uses*. NTIS No. PB85-227049. U.S. Environmental Protection Agency, Washington, DC.
- EPA. 1988. *Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA Interim Final*. Interim Final. EPA/540/G-89/004. OSWER Directive 9355.3-01. U.S. Environmental Protection Agency, Washington, DC.
- EPA. 1991b. *National Study of Chemical Residues in Fish (formerly the National Bioaccumulation Study)*. EPA/823R92008. U.S. Environmental Protection Agency, Washington, DC.
- EPA. 1994. *Technical Basis for Deriving Sediment Quality Criteria for Nonionic Organic Contaminants for the Protection of Benthic Organisms by Using Equilibrium Partitioning*. EPA-822-R-93-011. U.S. Environmental Protection Agency, Office of Science and Technology, Washington, DC.

EPA. 1996a. *Method 1669: Sampling Ambient Water for Trace Metals at EPA Water Quality Criteria Levels*. EPA-821/R-96-011. U.S. Environmental Protection Agency, Office of Water, Washington, DC.

EPA. 1996b. *The Metals Translator: Guidance For Calculating A Total Recoverable Permit Limit From A Dissolved Criterion*. EPA 823-B-96-007. June 1996. U.S. Environmental Protection Agency, Office Of Water. Washington, DC.

EPA. 1997a. *Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments*. EPA 540-R-97-006. U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, Washington, DC.

EPA. 1997b. *EPA Region 10 Supplemental Ecological Risk Assessment Guidance for Superfund*. EPA/910/R-97/005. U.S. Environmental Protection Agency, Region 10, Office of Environmental Assessment, Risk Assessment Unit, Seattle, WA.

EPA. 1997c. *Exposure Factors Handbook: Volume 1, General Factors*. EPA/600/P-95/002Fa. U.S. Environmental Protection Agency, National Center for Environmental Assessment, Office of Research and Development, Washington, DC, and Versar Inc., Exposure Assessment Division, Springfield, VA.

EPA. 1998a. *Ambient Water Quality Criteria Derivation Methodology Human Health: Technical Support Document*. Final draft. EPA-822-B-98-005. U.S. Environmental Protection Agency, Region 9, Water Division, Washington, DC.

EPA. 1998b. *Guidance for Conducting Fish and Wildlife Consumption Surveys*. EPA/823/B-98/007. Environmental Protection Agency, Office of Science and Technology, Standards and Applied Science Division, Office of Water, Washington, DC.

EPA. 1998c. *Guidelines for Ecological Risk Assessment*. EPA/630/R095/002F. Environmental Protection Agency, Risk Assessment Forum, Washington, DC.

EPA. 1999a. *Ecological Risk Assessment and Risk Management Principles for Superfund Sites*. OSWER Directive 9285.7-28P. U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, Washington, DC.

EPA. 1999b. *Integrated Approach to Assessing the Bioavailability and Toxicity of Metals in Surface Waters and Sediments*. EPA-822-E-99-001. A report to the EPA Science Advisory Board, Office of Water, Office of Research and Development, Washington, DC.

EPA. 2000a. *Data Quality Objectives Process for Hazardous Waste Site Investigations*. EPA QA/G4-4HW. U.S. Environmental Protection Agency, Washington, DC.

EPA. 2000b. *Guidance for Data Quality Assessment, Practical Methods for Data Analysis*, EPA QA/G9. EPA/600/R-96/084. U.S. Environmental Protection Agency, Office of Environmental Information, Washington, DC.

EPA. 2000c. Section 11, Test method 100.1, *Hyallela azteca* 10-day survival and growth tests for sediments. Pp. 47-54. In: *Methods for Measuring the Toxicity and Bioaccumulation of Sediment-Associated Contaminates with Freshwater Invertebrates*. 2nd Edition. EPA/600/R-99/604. United States Environmental Protection Agency, Washington, DC.

EPA. 2001a. *Methods for Collection, Storage and Manipulation of Sediments for Chemical and Toxicological Analyses*. EPA-823-B-01-002. U.S. Environmental Protection Agency, Office of Water, Washington, DC. October 2001.

EPA. 2001b. *The Role of Screening-Level Risk Assessments and Refining Contaminants of Concern in Baseline Ecological Risk Assessments*. ECO Update Intermittent Bulletin. EPA 540/F-01/014. U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, Washington, DC.

EPA. 2001c. 2001 *Sediment Investigation Trip Report, Upper Columbia River/Lake Roosevelt Expanded Site Inspection*. Prepared by Roy F. Weston Inc. for EPA, Region 10, Seattle, WA. December 2001.

EPA. 2002b. Columbia/Snake rivers temperature TMDL. Preliminary Draft. Available at [http://yosemite.epa.gov/R10/WATER.NSF/840a5de5d0a8d1418825650f00715a27/9d61ce85bbbd93ba88256c3300601055/\\$FILE/ATTV0GJ5/Temperature%20TMDL%209-13-02.PDF](http://yosemite.epa.gov/R10/WATER.NSF/840a5de5d0a8d1418825650f00715a27/9d61ce85bbbd93ba88256c3300601055/$FILE/ATTV0GJ5/Temperature%20TMDL%209-13-02.PDF). U.S. Environmental Protection Agency, Region 10, Seattle, WA.

EPA. 2002c. Principles for managing contaminated sediment risks at hazardous waste sites. Memorandum from Marianne Lamont Horinko, EPA Assistant Administrator, to EPA Policy Managers. OSWER Directive 9285.6-08. U.S. Environmental Protection Agency, Washington, DC. February 12, 2002.

EPA. 2002d. *Short-Term Methods for Estimating the Chronic Toxicity of Effluent and Receiving Waters to Freshwater Organisms, EPA Method 1002.0 "Ceriodaphnia Survival and Reproduction Test."* EPA-821-R-02-013 (2002). U.S. Environmental Protection Agency, Washington, DC.

EPA. 2002e. *Transmittal of Policy Statement: "Role of Background in the CERCLA Cleanup Program."* OSWER 9285.6-07P. U.S. Environmental Protection Agency, Office of Emergency and Remedial Response, Washington, DC.

EPA. 2002f. *Preliminary Assessments and Site Investigations Report, Lower Pend Oreille River Mines and Mills, Pend Oreille County, Washington*. Prepared by Ecology and Environment, Inc. for EPA, Region 10, Seattle, WA. April 2002.

EPA. 2002g. *Preliminary Assessments and Site Inspections Report, Upper Columbia River Mines and Mills, Stevens County, Washington*. Prepared by Ecology and Environment, Inc. for EPA, Region 10, Seattle, WA. October 2002.

EPA. 2003a. *Generic Ecological Assessment Endpoints (GAEs) for Ecological Risk Assessment*. EPA/630/P-02/004F. U.S. Environmental Protection Agency, Risk Assessment Forum, Washington, DC.

EPA. 2003b. *Upper Columbia River expanded Site Inspection Report; Northeast Washington*. TDD:01-02-0028. Contract: 68-S0-01-01. U.S. Environmental Protection Agency, Region 10, Seattle, WA. 84 pp.

EPA. 2004a. *Document and Data Gathering Task Summary, Upper Columbia River Site RI/FS*. December 2004. Prepared by CH2M HILL. U.S. Environmental Protection Agency, Seattle, WA.

EPA. 2004b. *Draft Upper Columbia River Site RI/FS Scoping Plan*. Prepared by CH2M HILL and Ecology and Environment, Inc. (Contract No. 68-S7-04-01). EPA/630/P-04/068B. U.S. Environmental Protection Agency, Region 10, Seattle, WA. 40 pp. August 2004.

EPA. 2004c. *Framework for Inorganic Metals Risk Assessment*. External Review Draft. EPA/630/P-04/068B. U.S. Environmental Protection Agency Risk Assessment Forum, Washington, DC.

EPA. 2004e. *Phase I Sediment Sampling Data Evaluation Approach and Rationale - Upper Columbia River Site CERCLA RI/FS*. Draft Final. December 2004. Prepared by CH2M HILL and Ecology and Environment, Inc. U.S. Environmental Protection Agency, Region 10, Seattle, WA.

EPA. 2004f. *Polychlorinated Biphenyl Inspection Manual*. EPA-305-X-04-002. Office of Compliance, Office of Enforcement and Compliance Assurance, U.S. Environmental Protection Agency, Washington, DC.

EPA. 2004g. *Hecla Knob Hill Mine Site Inspection Report, Ferry County, Washington*. Prepared by Weston Solutions, Inc. for EPA Region 10, Seattle, WA. July 2004.

EPA. 2004h. *South Penn Mine Site Inspection Report, Ferry County, Washington*. Prepared by Weston Solutions, Inc. for EPA, Region 10, Seattle, WA. September 2004.

EPA. 2004i. *Mountain Lion Mine Site Inspection Report, Ferry County, Washington*. Prepared by Weston Solutions, Inc. for EPA, Region 10, Seattle, WA. September 2004.

EPA. 2005a. *Contaminated Sediment Remediation Guidance for Hazardous Waste Sites*. OSWER Directive 9355.0-85. EPA-540-R-05-012. U.S. Environmental Protection Agency, Washington, DC.

EPA. 2005b. *Cultural Resources Coordination Plan Upper Columbia River Site CERCLA RI/FS*. Prepared by CH2MHILL and Ecology and Environment. U.S. Environmental Protection Agency Region 10, Seattle, WA.

EPA. 2005c. *Draft Phase I Fish Tissue Sampling Approach and Rationale - Upper Columbia River Site CERCLA RI/FS*. Prepared by CH2M HILL. U.S. Environmental Protection Agency, Region 10, Seattle, WA.

EPA. 2005d. *Phase I Sediment Sampling Field Sampling Plan- Upper Columbia River Site CERCLA RI/FS*. Prepared by CH2M HILL. March 2005. U.S. Environmental Protection Agency, Region 10, Seattle, WA.

EPA. 2005e. *Phase I Sediment Sampling Quality Assurance Project Plan - Upper Columbia River Site CERCLA RI/FS*. Draft Final. March 2005. Prepared by CH2M HILL and Ecology and Environment, Inc. U.S. Environmental Protection Agency, Region 10, Seattle, WA.

EPA. 2005f. *Procedures for the Derivation of Equilibrium Partitioning Sediment Benchmarks (ESBs) for the Protection of Benthic Organisms: Metal Mixtures (Cadmium, Copper, Lead, Nickel, Silver, and Zinc)*. EPA-600-R-02-011. U.S. Environmental Protection Agency, Office of Research and Development, Washington, DC.

EPA. 2005g. Soil Screening Values, including April 2005 update. Available at <http://www.epa.gov/oswer/riskassessment/ecorisk/ecossl.htm>. U.S. Environmental Protection Agency, Washington, DC.

EPA. 2005h. *Upper Columbia Mercury Field Survey and Removal Assessment Trip Report*. TDD: 04-12-0023. U.S. Environmental Protection Agency, Washington, DC. July 2005.

EPA. 2006a. Guidance for data usability in risk assessment (Part A). Available at <http://www.epa.gov/oswer/riskassessment/datause/parta.htm>.

EPA. 2006b. *Guidance on Systematic Planning Using the Data Quality Objectives Process*. EPA/240/B-06/001. U.S. Environmental Protection Agency, Office of Environmental Information, Washington, DC.

EPA. 2006c. Letter to Marko Adzic from Kevin Rochlin dated October 13, 2006 regarding Upper Columbia River Site - RI/FS Priorities. Kevin Rochlin, U.S. Environmental Protection Agency, Region 10, Seattle, WA.

EPA. 2006d. *Phase I Fish Tissue Sampling Field Summary Report - Upper Columbia River Site CERCLA RI/FS*. Prepared by CH2M HILL. U.S. Environmental Protection Agency, Region 10, Seattle, WA. July 21, 2006.

EPA. 2006e. *Phase I Sediment Sampling Data Evaluation - Upper Columbia River Site CERCLA RI/FS*. Draft Final. U.S. Environmental Protection Agency, Washington, DC. August 2006.

EPA. 2006f. *Phase I Sediment Sampling Field Summary Report - Upper Columbia River Site CERCLA RI/FS*. Prepared by CH2M HILL. U.S. Environmental Protection Agency, Region 10, Seattle, WA. July 13, 2006.

EPA. 2006g. *Screening-level Risk Assessment for Recreational Use of Beaches, Upper Columbia River, Remedial Investigation and Feasibility Study*. Prepared by CH2M HILL and Ecology and Environment, Inc. Draft. U.S. Environmental Protection Agency, Region 10, Seattle, WA.

EPA. 2006h. *Settlement Agreement for Implementation of Remedial Investigation and Feasibility Study at the Upper Columbia River Site*. U.S. Environmental Protection Agency, Region 10, Seattle, WA. June 2, 2006.

EPA. 2006i. *Upper Columbia River Site - RI/FS Priorities*. Letter to Marko Adzic, Teck Cominco American, Inc. from Kevin Rochlin, EPA Region 10 Project Manager, dated October 12, 2006. Environmental Protection Agency, Region 10, Seattle, WA.

EPA. 2007a. *Cleveland Mine and Mill Site, Hunters, WA, EPA Region X*.
http://www.epaosc.net/site_profile.asp?site_id=2807. Accessed on July 6, 2007. U.S. Environmental Protection Agency.

EPA. 2007b. *Framework for Metals Risk Assessment*. EPA 120/R-07/001. U.S. Environmental Protection Agency, Office of the Science Advisor Risk Assessment Forum, Washington, DC. March 2007.

EPA. 2007c. *Round 2 comments on Teck Cominco draft RI/FS work plan dated December 27, 2006, Upper Columbia River RI/FS*. Comments dated April 11, 2007. U.S. Environmental Protection Agency, Washington, DC.

EPA. 2007d. *Round 3 comments on Teck Cominco draft RI/FS work plan dated December 27, 2006, Upper Columbia River RI/FS*. Comments dated June 14, 2007. U.S. Environmental Protection Agency, Washington, DC.

EPA. 2007e. *Toxics Release Inventory, Envirofacts Report, L-Bar Products, Inc*.
http://oaspub.epa.gov/enviro/tris_control.tris_print?tris_id=99109LBRPRHWY39. Accessed on August 14, 2007. U.S. Environmental Protection Agency.

Era, B., and D. Serdar. 2001. *Reassessment of Toxicity of Lake Roosevelt Sediments*. Publication No. 01-03-043. Environmental Assessment Program, Washington State Department of Ecology, Olympia, WA. 54 pp.

Erickson, R.J., T.L. Highland, J.R. Hockett, E.N. Leonard, V.R. Mattson, and D.R. Mount. 2003. *Effects of Dietary Copper, Zinc, Lead, Cadmium, and Arsenic on Growth and Survival of Juvenile Fish using Live Food Organisms*. In: *The Society of Environmental Toxicology and Chemistry 24th Annual Meeting in North America*. November 11, 2003.

Esso. 2007. Product data sheet, Voltesso premium quality electrical insulating oils. Available at http://www.imperialoil.com/Canada-English/Files/Products_Lubes/IOCAENWPOESVoltesso.pdf. Esso Imperial Oil.

EVS. 1998. *Assessment of dioxins, furans, and PCBs in fish tissue from Lake Roosevelt, Washington, 1994. Final Report*. EVS Environmental Consultants, Inc., Seattle, WA. December 1998.

Fairbrother, A. 2003. Lines of evidence in wildlife risk assessments. *Human Ecol. Risk Assess.* 9:1475–1491.

Ferguson, S.A. 1996. *Disturbance Climate Events in the Columbia River Basin*. General Technical Report. U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station, Seattle, WA.

Ferguson, S.A. 1998. *Air Quality Climate in the Columbia River Basin*. Gen. Tech. Rep. PNW-GTR-434. Portland, OR. U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 23 pp. T. M. Quigley, (ed). The Interior Columbia Basin Ecosystem Management Project: Scientific Assessment.

Ferguson, S.A. 1999. *Climatology of the Interior Columbia River Basin*. Gen. Tech. Rep. PNW-GTR-445. Portland, OR. U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 31 pp. Quigley, Thomas M., ed.; Interior Columbia Basin Ecosystem Management Project: Scientific Assessment.

G3 Consulting Ltd. 2001a. *Environmental Performance Review of the New KIVCET Lead Smelter and Elimination of Slag Discharge: Assessment of Columbia River Receiving Waters, Summary*. Prepared for Cominco Ltd., Trail Operations. G3 Consulting Ltd., Surrey, B.C., Canada. June 2001.

G3 Consulting Ltd. 2001b. *Assessment of Columbia River Receiving Waters, Final Report*. Prepared for Teck-Cominco Ltd., Trail, B.C. G3 Consulting Ltd. Surrey, B.C., Canada. December 2001.

Gassaway, J. 2007. Personal communication (telephone conversation with S.FitzGerald, Integral Consulting Inc., Mercer Island, WA, on June 28, 2007, regarding DOH sample from City of Kettle Falls surface water source). City Superintendent. Kettle Falls, WA.

Geschwend, P.M., and S. Wu. 1985. On the constancy of sediment-water partition coefficients of hydrophobic organic pollutants. *Environ. Sci. Technol.* 19:90–90.

Godin, B., and M. Hagen. 1992. *Cominco Sediment Bioassays, Sediment, and Water Chemistry (October and November 1991)*. Regional Data Report DR 92-13. Environmental Protection Service, Environment Canada. North Vancouver, B.C.

Golder Associates. 2003. *Aquatic Problem Formulation Report*. Golder Associates Ltd., Calgary, Alberta, Canada. March 2003.

Golder Associates. 2004. *Large River Fish Indexing Program - Lower Columbia River 2003 Phase 3 Investigations*. Prepared for BC Hydro, Burnaby, B.C. Report No. 03-1480-0021F. Golder Associates Ltd., Calgary, Alberta, Canada. 54 pp.

Golding, S. 1996. *Spokane River PCB Source Monitoring Follow-Up Study, November and December 1995*. Washington State Department of Ecology, Environmental Investigations and Laboratory Services Program, Olympia, WA.

Goodal, N.B., W.C. Prentiss, and I. Krujit. 2004. Cultural complexity: a new chronology of the upper columbia drainage. In: *Complex Hunter-Gatherers: Evolution and Organization of Prehistoric Communities on the Plateau of Northwestern North America*, edited by William C. Prentiss and Ian Krujit. Pp. 36-48. University of Utah Press, Salt Lake City, UT.

Gorsuch, J.W., C.R. Janssen, and M.C. Reiley. 2002. The Biotic Ligand Model for Metals - Current Research, future directions, and regulatory implications. Special Issue. *Comp. Biochem. Physiol.* 133:1-343.

Gundlach, E.R., and R.E. McMahon. 1991. Computerized (GIS) sensitivity mapping in Alaska. 1991 Oil Spill Conference (Prevention, Behavior, Control, Cleanup). API Publication No. 4529. American Petroleum Institute, Washington, DC.

Hansen, J.A., J. Lipton, P.G. Welsh, D. Cacula, and B. Macconnell. 2004. Reduced growth of rainbow trout (*Oncorhynchus mykiss*) fed a live invertebrate diet pre-exposed to metal-contaminated sediments. *Environ. Toxicol. Chem.* 23(8):1902-1911.

Hebner, S., M. Arsenault, R. Depuydt, and R. Plantrich. 2000. Fire management plan environmental assessment - Lake Roosevelt National Recreation Area. Appendix 1.5: Wildlife of the Study Area. Available online at <http://www.efw.bpa.gov/publications/w60445-1.pdf>. Washington Department of Game, Habitat Management Division, Olympia, WA.

Heritage, B. 1981. Bill Heritage Story. *Northport Pioneers*. pp. 185-194.

Hinck, J.E., C.J. Schmitt, T.M. Bartish, N.D. Denslow, V.S. Blazer, P.J. Anderson, et al. 2004. *Biomonitoring of Environmental Status and Trends (BEST) Program: Environmental Contaminants and their Effects on Fish in the Columbia River Basin*. Scientific Investigations Report 2004 - 5154. U.S. Geological Survey, Washington, C.

Hollander, H.I., A.L. Plumley, D.A. Hoecke, and R.S. DeCesare. 1999. International Ash Utilization Symposium, Center for Applied Energy Research, University of Kentucky, Paper #112.

Hopkins, B.S., D.K. Clark, M. Schlender, and M. Stinson. 1985. *Basic Water Monitoring Program, Fish Tissue and Sediment Sampling for 1984*. Pub. No. 85-7. Washington State Department of Ecology.

Horne, A.J., and C.R. Goldman. 1994. *Limnology*. 2nd Edition. McGraw-Hill, Inc., New York, NY.

Hund-Rinke, K., and W. Kordel. 2003. Underlying issues in bioaccessibility and bioavailability: Experimental methods. *Ecotoxicol. Environ Saf.* 56(1):52–62.

Jack, R., and M. Roose. 2002. *Analysis of Fish Tissue from Long Lake (Spokane River) for PCBs and Selected Metals*. Pub. No. 02-03-049. Washington State Department of Ecology, Olympia, WA.

Jackson. 1998. Paradigms of metal accumulation in rooted aquatic vascular plants. *Sci. Total Environ.* 219 (2-3):223-231.

Jarvinen, A.W., M.J. Hoffman, and T.W. Thorslund. 1977. Long-term toxic effects of DDT food and water exposure on fathead minnows (*Pimephales promelas*). *J. Fish. Res. Board Can.* 34(2089):2103.

Jaske, R.T., and G.R. Snyder. 1967. Density flow regime of Franklin Roosevelt Lake. *J. Sanit. Engineer. Div.* 93(SA3):15–28. American Society of Civil Engineers.

Johnson, A. 1991a. Letter to Carl Nuechterlein: Results of screen for EPA xenobiotics in sediment and bottom fish from Lake Roosevelt, Columbia River. Washington State Department of Ecology, Olympia, WA.

Johnson, A. 1991b. *Results of Screen for EPA Xenobiotics in Sediment and Bottom Fish from Lake Roosevelt (Columbia River)*. Pub. No. 91-e24. Washington State Department of Ecology, Olympia, WA.

Johnson, A. 1991c. *Review of Metals, Bioassay, and Macroinvertebrate Data from Lake Roosevelt Benthic Samples Collected in 1989*. Publication No. 91-e23. Washington State Department of Ecology, Olympia, WA.

Johnson, A. 2000. Results from Analyzing PCBs in 1999 Spokane River Fish and Crayfish Samples. Memorandum to John Roland. Pub. No. 00-03-040. Washington State Department of Ecology, Olympia, WA

Johnson, A., and D. Serdar. 1991. Metals Concentrations in Lake Roosevelt (Columbia River) Largescale Suckers. Memo to Carl Nuechterlein June, 21, 1991. Publication 91-e26. Washington State Department of Ecology, Olympia, WA.

Johnson, A., D. Serdar, and D. Davis. 1994. *Results of 1993 Screening Survey on PCBs and Metals in the Spokane River*. Pub. No. 94-e24. Washington State Department of Ecology, Olympia, WA.

Johnson, A., D. Serdar, and S. Magoon. 1991a. *Polychlorinated Dioxins and Furans in Lake Roosevelt (Columbia River) Sport Fish, 1990*. Pub. No. 91-4. Washington State Department of Ecology, Olympia, WA.

Johnson, A., D. Serdar, and D. Norton. 1991b. *Spatial trends in TCDD/TCDF Concentrations in Sediment and Bottom Fish Collected in Lake Roosevelt (Columbia River)*. Publication No. 91-29. Washington State Department of Ecology, Olympia, WA.

Johnson, A., B. Yake, and D. Norton. 1988. *An Assessment of Metals Contamination in Lake Roosevelt*. Publication No. 89-e26. Washington State Department of Ecology, Olympia, WA.

Johnson, A., B. Yake, and D. Norton. 1989. *An Assessment of Metals Contamination in Lake Roosevelt*. Segment No. 26-00-04. 84 pp. Washington State Department of Ecology, Olympia, WA.

Johnson, A., and W. Yake. 1989. *Survey of Mercury and Dioxin in Lake Roosevelt Sportfish in 1989: Preliminary Results for Mercury*. Pub. No. 89-e29. Washington State Department of Ecology, Olympia, WA.

Jones, F.O., D.R. Embody, W.L. Peterson, and R.M. Hazelwood. 1961. *Landslides along the Columbia River Valley, Northeastern Washington, with a Section on Seismic Surveys*. Professional Paper 367. 98 pp. U.S. Geological Survey, Washington, DC.

Kadlec, M. 2000. *Ecological Risk Analysis of Elevated Metals Concentrations in the Spokane River, Washington*. 72 pp. Washington State Department of Ecology, Spokane, WA.

Kahle, S., and M. Majewski. 2003. Trace elements in Lake Roosevelt air. Presentation by the U.S. Geological Survey at the Lake Water Quality Council Meeting, Spokane, WA.

Kamunde, C., C. Clayton, and C.M. Wood. 2002. Waterborne vs. dietary copper uptake in rainbow trout and the effects of previous waterborne copper exposure. *Am J Physiol Regulatory Integrative Comp Physiol* 283:R69–R78.

Karickhoff, S. 1981. Semi-empirical estimations of sorption of hydrophobic pollutants on natural sediments and soils. *Chemosphere* 10(8):833–846.

Karickhoff, S.W. 1984. Organic pollutant sorption in aquatic systems. *J. Hydraulic Engineering* 110 (6):707–735.

Kennedy, D.I.D., and R.T. Bouchard. 1998. 1998 Northern Okanagan, Lakes, and Colville. In: *Handbook of North American Indians*, Vol. 12, W. C. Sturtevant, general editor. Smithsonian Institution, Washington, DC.

- Kenyon, G.F., and D.M. Glover. 1994. Effluent reductions at Cominco's Trail operations. In: *Proceedings from the Technical Session, Canada/United States Technical Workshop on the Upper Columbia River Basin, An International Dialogue*. Report 89. State of Washington Water Research Station, Pullman, WA.
- Koren, D.W., P.L. Bédard, and P.J.A. Prud'homme. 1996. *Investigations of Leach Test Protocols for Slags, Final Report*. Report MMSL 96-10 (CR). April. Mining and Mineral Sciences Laboratories, Ontario, Canada.
- Koster, M., A. de Groot, M. Vijver, and W. Peijnenburg. 2006. Copper in the terrestrial environment: verification of a laboratory-derived terrestrial biotic ligand model to predict earthworm mortality with toxicity observed field soils. *Soil Biology and Biochemistry* 38(7):1788–1796.
- Lahren, S.L., Jr. 1998. 1998 Reservations and Reserves. In: *Handbook of North American Indians*, vol. 12, W. C. Sturtevant, general editor. Smithsonian Institution, Washington, DC.
- Lake Roosevelt Water Quality Council. 2000. *Inventory of Mines, Mills, and Smelters of the Upper Columbia River and Contributing Watersheds of U.S.A. and Canada*. Prepared by D.J. Hurst, State of Washington Water Research Center, Pullman, WA.
- Landrum, P.F., M.D. Reinhold, S.R. Nihart, and B.J. Eadie. 1985. Predicting the bioavailability of organic xenobiotics to *Pontoporeia hoyi* in the presence of humic and fulvic materials and natural dissolved organic matter. *Environ. Toxicol. Chem* 4:459–467.
- Lane, R.C. 2004. *Estimated Domestic, Irrigation, and Industrial Water Use in Washington, 2000*. U.S. Geological Survey Science Investigations Report 2004-5015. U.S. Government Printing Office, Washington, DC.
- Lee, B.G., J.S. Lee, S.N. Luoma, H.J. Choi, and C.H. Koh. 2000. Influence of acid volatile sulfide and metal concentrations on metal bioavailability to marine invertebrates in contaminated sediments. *Environ. Sci. Technol.* 34(21):4517–4523.
- Lee, C., D. Pavlik-Kunkel, K. Fields, and B. Scofield. 2006. *Lake Roosevelt Fisheries Evaluation Program; Limnological and Fisheries Monitoring, Annual Report January 2004 - December 2004*. Prepared by the Spokane Tribe of Indians. Project No. 199494300. Report DOE/BP-00014804-1. U.S. Department of Energy, Bonneville Power Administration, Portland, OR.
- Lemly, A.D. 2002. Symptoms and implications of selenium toxicity in fish: the Belews Lake case example. *Aquat. Toxicol.* 57(1-2):39–49.
- Lofts, S., and E. Tipping. 1998. An assemblage model for cation binding by natural particulate matter. *Geochimica et Cosmochimica Acta* 62:2609–2625.
- LRF. 2006a. Lake Roosevelt Forum website. <http://www.lrf.org>. Accessed on October 1, 2006.

LRF. 2006b. Lake Roosevelt Forum website. Fast Facts: wildlife, vegetation.

<http://www.lrf.org/Ed/Ed-FastFacts.html>. Accessed October 1, 2006.

LRF. 2006c. Lake Roosevelt Forum website: Environmental page. www.lrf.org/Env/Env-History.html. Accessed on September 20 and 28, 2006.

LRF. 2006d. Lake Roosevelt Forum website: Flood control at Lake Roosevelt. Available at <http://www.lrf.org/AboutLR/ALR-Operations.html>.

LRF. 2006e. Lake Roosevelt Forum website: Geography. <http://www.lrf.org/AboutLR/ALR-Geography.html>.

LRF. 2007a. Lake Roosevelt Forum website: Lake Roosevelt Fisheries: History, Management, Angling. www.lrf.org/env/env-history.html. Accessed on September 4, 2007.

LRF. 2007b. Lake Roosevelt Map. <http://www.lrf.org/Rec/Rec-LakeMap.html>. Accessed on July 10, 2007. Lake Roosevelt Forum.

LRF. 2007c. Operations. <http://www.lrf.org/AboutLR/ALR-Operations.html>. Accessed on July 4, 2007. Lake Roosevelt Forum.

Luoma, S.N., and P.S. Rainbow. 2005. Why is metal bioaccumulation so variable? Biodynamics as a unifying concept. *Environ. Sci. Technol.* 39(7):1921–1931.

MacDonald, D.D. 1997. *Lower Columbia River from Birchbank to the International Border: Water Quality Assessment and Recommended Objectives*. Technical Report. MacDonald Environmental Sciences Ltd., Ladysmith, B.C.

Majewski, M.S., S.C. Kahle, J.C. Ebbert, and E.G. Josberger. 2003. *Concentrations and Distributions of Slag-Related Trace Elements and Mercury in Fine-Grained Beach and Bed Sediments of Lake Roosevelt, Washington, April-May 2001*. Water-Resources Investigations Report 03-4170. U.S. Geological Survey, Reston, VA.

Marcot, B.G., B.C. Wales, and R. Demmer. 2003. Range maps of terrestrial species in the Interior Columbia River Basin and northern portions of the Klamath and Great Basins. October. USDA Forest Service, Pacific Northwest Research Station, and U.S. Department of the Interior, Bureau of Land Management.

Mason, R.P., J.R. Reinfelder, and F.M.M. Morel. 1995. Bioaccumulation of mercury and methylmercury. *Water. Air. Soil Pollut.* 80(915):921

McCarty, L.S. 1986. The relationship between aquatic toxicity QSARS and bioconcentration for some organic chemicals. *Environ. Toxicol. Chem.* 5(1071):1080

McKay, K.L., and N.F. Renk. 2002. Currents and Undercurrents: An Administrative History of Lake Roosevelt National Recreation Area. Available at <http://www.nps.gov/archive/laro/adhi/adhi2b.htm>.

McLellan, J. 2006. Personal communication (Washington Department of Fish and Wildlife, Spokane Washington).

Meador, J. 2006. Rationale and procedures for using the tissue-residue approach for toxicity assessment and determination of tissue, water, and sediment quality guidelines for aquatic organisms. *Hum. Ecol. Risk Assess.* 12(1018):1073

Menzie, C., M.H. Henning, J. Cura, K. Finkelstein, J. Gentile, J. Maughan, et al. 1996. Special report of the Massachusetts weight-of-evidence workgroup: a weight of evidence approach for evaluating ecological risks. *Hum. Ecol. Risk Assess.* 2:277–304.

Merker, C. 1993. *Wildlife Mitigation and Restoration for Grand Coulee Dam: Blue Creek Project Phase 1*. Contract No. DE-B179-91BP20291. Report to U.S. Department of Energy. Bonneville Power Administration Division of Fish and Wildlife, Portland, OR.

Meyer, J.S., W.J. Adams, K.V. Brix, S.N. Luoma, D.R. Mount, W.A. Stubblefield, et al. 2002. In: *Proceedings from the Pellston Workshop on Toxicity of Dietborne Metals to Aquatic Organisms*. Society of Environmental Toxicology and Chemistry. Fairmont Hot Springs, B.C.

Miller, J. 1998. 1998 Middle Columbia River Salishans. In: *Handbook of North American Indians*, Vol. 12, W. C. Sturtevant, general editor. Smithsonian Institution, Washington, DC.

Moosmüller, H., J.A. Gillies, C.F. Rogers, D.W. DuBois, J.C. Chow, J.G. Watson, et al. 1998. 1998 Particulate emission rates for unpaved shoulders along a paved road. *J. Air Waste Manag. Assoc.* 48:398–407.

Munn, M.D. 2000. *Contaminant Trends in Sport Fish from Lake Roosevelt and the Upper Columbia River, Washington, 1994-1998*. Report 00-4024. U.S. Geological Survey, Water Resources Division, Tacoma, WA.

Munn, M.D., S.E. Cox, and C.J. Dean. 1995. *Concentrations of Mercury and Other Trace Elements in Walleye, Smallmouth Bass, and Rainbow Trout in Franklin D. Roosevelt Lake and the Upper Columbia River, Washington, 1994*. U.S. Geological Survey, Water Resources Division, Tacoma, WA.

Norecol Environmental Consultants Ltd. 1993. *A 1992 Biological Reconnaissance and Sediment Sampling in the Columbia River between the Hugh Keenleyside Dam and the International Boundary*. Prepared for Columbia River Integrated Environmental Monitoring Program (CRIEMP), Castlegar, B.C. Richmond, B.C.

Nener, J. 1992. Survival and water-quality results of bioassays on five species of aquatic organisms exposed to slag from Cominco's Trail operation: Fisheries and Oceans Canada, Vancouver, British Columbia, Canada, 20 p.

Niyogi, S., and C.M. Wood. 2003. *Effects of Chronic Waterborne and Dietary Metal Exposures on Gill Metal-Binding: Implications for the Biotic Ligand Model Human and Ecological Risk Assessment*. Volume 9, Number 4. 813-846 pp. Department of Biology, McMaster University, Ontario, Canada.

NMFS. 1995. *Federal Columbia River Power System Biological Opinion - Reinitiation of Consultation 1994-1998 Operation of the Federal Columbia River Power System and Juvenile Transportation Program in 1995 and Future Years*. National Marine Fisheries Service, Northwest Regional Office, Seattle, WA.

NMFS. 1998. Steelhead Supplemental Biological Opinion - Operations of the Federal Columbia River Power System including the Smolt Monitoring Program and Juvenile Fish Transportation Program: A Supplement to the Biological Opinion. Signed on March 2, 1995, and May 14, 1998. National Marine Fisheries Service, Northwest Regional Office, Seattle, WA.

NMFS. 2000. *Reinitiation of Consultation on Operations of the Federal Columbia River Power System (FCRPS), including the Juvenile Fish Transportation Program and 19 Bureau of Reclamation Projects in the Columbia Basin*. National Marine Fisheries Service, Northwest Regional Office, Seattle, WA.

Northport Pioneers. 1981. *Northport Pioneers ... Echoes of the past from the Upper Columbia Country*. Compiled by Northport Over Forty Club. Northport, Washington.

NPS. 1997. *Water Resources Scoping Report, Lake Roosevelt National Recreation Area, Washington*. Technical Report NPS/NRWDR/NRTR-97/107. U.S. National Park Services, Water Resources Division, Fort Collins, CO.

NPS. 2006a. Climate at Lake Roosevelt National Recreation Area. National Park Services Webpage. <http://www.nps.gov/laro>,
http://www.wildernet.com/pages/area.cfm?areaID=WANPSLKRV&CU_ID=1.

NPS. 2006b. Introduction of Lake Roosevelt Administration History. National Park Services Webpage. <http://www.nps.gov/laro>,
http://www.wildernet.com/pages/area.cfm?areaID=WANPSLKRV&CU_ID=1.

NPS. 2006c. Lake Roosevelt National Recreation Area web site. www.nps.gov/laro. Accessed on September 20, 2006. National Park Service, U.S. Department of the Interior, Washington, DC.

NPS. 2007a. Lake Roosevelt NRA: Administrative History (Chapter 5).
http://www.nps.gov/history/history/online_books/laro/adhi/adhi5d.htm. Accessed on August 15, 2007. National Park Service.

NPS. 2007b. St. Paul's Mission.
<http://www.nps.gov/laro/historyculture/upload/2007%20StPauls.pdf>. Accessed on June 24, 2007. Lake Roosevelt National Recreation Area, National Park Service, U.S. Department of Interior.

NWPPC. 1994. *Columbia River Basin Fish and Wildlife Program*. Northwest Power Planning Council, Portland, OR.

NWPPC. 2006a. Project proposal request for fiscal year 2007 – 2009. Funding proposal 199104600: Spokane Tribal (Galbr. Sprgs) Hatchery. Prepared by the Spokane Tribe of Indians for the Northwest Power Conservation Council. Available at
<http://www.cbfwa.org/solicitation/components/forms/Proposal.cfm?PropID=466>. Northwest Power Planning Council, Portland, OR.

NWPPC. 2006b. Project proposal request for fiscal year 2007-2009. Funding Proposal 199104700: Sherman Creek Hatchery- operations and maintenance. Prepared by the Washington Department of Fish and Wildlife. Available at
<http://www.cbfwa.org/solicitation/components/forms/Proposal.cfm?PropID=151>. Northwest Power Planning Council, Portland, OR.

O'Brien, M. 2007. Personal communication (emails of June 27, 2007 and July 18, 2007, from M. O'Brien, Ecology, to S. FitzGerald, Integral, re: surface water rights with domestic usage within the UCR Study Area). Water Resources, Columbia River Unit, Washington State Department of Ecology, Olympia, WA.

OFM. 2006. Office of Financial Management, State of Washington website.
www.ofm.wa.gov/databook/population/pt06.asp. Accessed on October 10, 2006. Office of Financial Management, Washington.

Orlob, G.T., and W.W. Saxton. 1950. *A Preliminary Survey of the Sources of Mining and Mill Waste Pollution in the Upper Columbia River Basin and Lake Roosevelt*. The Water Pollution Control Commission, Olympia, WA.

ORNL. 1996. *Toxicological Benchmarks for Wildlife: 1996 Revision*. ES/ER/TM-86/R3. Oak Ridge National Laboratory, Oak Ridge, TN.

ORNL. 1997a. *Toxicological Benchmarks for Contaminants of Potential Concern for Effects on Soil and Litter Invertebrates and Herterotrophic Processes: 1997 Revision*. ES/ER/TM-126/R2. Oak Ridge National Laboratory, Oak Ridge, TN.

ORNL. 1997b. *Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Terrestrial Plants: 1997 Revision*. ES/ER/TM-85/R3. Oak Ridge National Laboratory, Oak Ridge, TN.

Paquin, P.R., J.W. Gorsuch, S. Apte, G.E. Batley, K.C. Bowles, P.G.C. Campbell, et al. 2002. The biotic ligand model: A historical overview. In: Special Issue: The Biotic Ligand Model for Metals – Current Research, Future Directions, Regulatory Implications. *Comp. Biochem. Physiol.* Part C 133(1-2):3–35.

Paquin, P.R., R.C. Santore, K.J. Farley, C.D. Kavvadas, K.B. Wu, K. Mooney, et al. 2003. *A Review: Exposure, Bioaccumulation, and Toxicity Models for Metals in Aquatic Systems*. 160 p. SETAC Press, Pensacola, FL.

Paragamian, V., V. Whitman, and J. Hammond. 2000. Collapse of burbot fisheries in the Kootenai River, Idaho, U.S., and Kootenay Lake, British Columbia, Canada. In: *Burbot Biology, Ecology and Management*. American Fisheries Society, Bethesda, MD.

Paulson, A.J., and S.E. Cox. 2007. Release of elements to natural water from sediments of Lake Roosevelt, Washington, USA. *Environmental Toxicology and Chemistry* 26:12 (December 2007). 2550–2559 pp.

Paulson, A.J., R.J. Wagner, R.F. Sanzolone, and S.E. Cox. 2006. *Concentrations of Elements in Sediments and Selective Fractions of Sediments, and in Natural Waters in Contact with Sediments from Lake Roosevelt, Washington, September 2004*. Open-file report 2006-1350. U.S. Department of the Interior, U.S. Geological Survey, Reston, VA.

Pedlar, R., M. Ptashynski, K.G. Wautier, R.E. Evans, C.L. Baron, and J.F. Klaverkamp. 2002. The accumulation, distribution, and toxicological effects of dietary arsenic exposure in lake whitefish (*Coregonus clupeaformis*) and lake trout (*Salvelinus namaycush*). *Comp. Biochem. Physiol.* 131(1):73–91.

Peijnenburg, W.J., and T. Jager. 2003. Monitoring approaches to assess bioaccessibility and bioavailability of metals: matrix issues. *Ecotoxicol. Environ Saf.* 56(1):63–77.

Peng, S.H., W.X. Wang, X. Li, and Y.F. Yen. 2004. Metal partitioning in river sediments measured by sequential extraction and biomimetic approaches. *Chemosphere* 57(8):839–851.

Pokotylo, D.L., and D. Mitchell. 1998. 1998 Prehistory of the Northern Plateau. In: *Handbook of North American Indians*, vol. 12, W. C. Sturtevant, general editor. Smithsonian Institution, Washington, DC.

Quigley, T., R.A. Gravenmier, and R.T. Graham. 2001. The Interior Columbia Basin Ecosystem Management Project: Project Data. 5 CD-ROM Set. USDA Forest Service, Pacific Northwest Research Station, and U.S. Department of the Interior, Bureau of Land Management.

R.L.& L. Environmental. 2000. *Brilliant Expansion Project: Prediction and Assessment of Project-Related Flow Variations on the Aquatic Environment*. Prepared for Columbia Power Corporation, Castlegar, B.C. R.L.& L. Environmental, Ltd.

Rainbow, P.S., L. Poirier, B.D. Smith, K.V. Brix, and S.N. Luoma. 2006. Trophic transfer of trace metals from the polychaete worm *Nereis diversicolor* to the polychaete *N. virens* and the decapod crustacean *Palaeomonetes varians*. *Mar. Ecol. Prog. Ser.* 321:167–206.

Redeker, E.S., L. Bervoets, and R. Blust. 2005. Dynamic model for the accumulation of cadmium and zinc from water and sediment by the aquatic oligochaete, *Tubifex tubifex*. *Environ. Sci. Technol.* 38(23):6193–6200.

Ridgway, M.S., and B.J. Shuter. 1996. Effects of displacement on the seasonal movements and home range characteristics of smallmouth bass in Lake Opeonogo. *N. A. J. Fish. Manage.* 16:371–377.

Riedel, J.L., C. Gamble, J. Lawrence, and S. Hebner. 1997. *Lake Roosevelt National Recreation Area, Washington, Water Resources Scoping Document*. Technical Report NPS/NRWRD/NRTR-97/107. United States Department of the Interior, National Park Service.

Ross, J.A. 1998. 1998 Spokane. In: *Handbook of North American Indians*, Vol. 12, W. C. Sturtevant, general editor. Smithsonian Institution, Washington, DC.

SAIC. 1997. *X-Ray Fluorescence Investigation of Soils for Le Roi Smelter Site*. Prepared for the Washington State Department of Ecology. June 1997. Ecology Contract No. C9300048, SAI018.

Sample, B.E., and G.W. Suter. 1999. Ecological risk assessment in a large river-reservoir: 4. Piscivorous wildlife. *Environ. Toxicol. Chem.* (4):610–620.

Sanders, G., K.C. Jones, J. Hamilton-Taylor, and H. Dorr. 1993. Concentrations and deposition fluxes of polynuclear aromatic hydrocarbons and heavy metals in the dated sediments of a rural English lake. *Environ. Contam. Toxicol.* 12:1567–1581.

Santore, R.C., D.M. Di Toro, P.R. Paquin, H.E. Allen, and J.S. Meyer. 2001. Biotic Ligand Model Of The Acute Toxicity Of Metals. 2. Application To Acute Copper Toxicity In Freshwater Fish And Daphnia. *Environ. Toxicol. Chem.* 20:2397–2402.

Santore, R.C., R. Mathew, P.R. Paquin, and D.M. Di Toro. 2002. Development of a Biotic Ligand Model of acute toxicity for zinc. In: Special Issue: The Biotic Ligand Model for Metals—Current Research, Future Directions, Regulatory Implications. *Comp. Biochem. Physiol.* Part C 122 (1-2):271–285.

Scholz, A.T., J.K. Uehara, Hisata J., and J. Marco. 1986. *Feasibility Report on Restoration and Enhancement of Lake Roosevelt Fisheries*. Northwest Power Planning Council, Portland, OR.

Scott, P.K., B.L. Finley, H. Sung, R.H. Schulze, and D.B. Turner. 1997. Identification of an accurate soil suspension/dispersion modeling method for use in estimating health-based soil cleanup levels of hexavalent chromium in chromite ore processing residues. *J. Air & Waste Manage. Assoc.* 47:753–765.

Seattle Audubon Society. 2006. Bird Web home page.
<http://www.birdweb.org/birdweb/index.aspx>. Seattle Audubon Society. Seattle, WA.

Seattle Marine Laboratories. 1972. *Dissolved Gas Monitoring at Grand Coulee Dam and Lake Roosevelt*. Unpublished report to United States Department of the Interior, Bureau of Reclamation, Boise, ID.

Seattle Marine Laboratories. 1974. *Dissolved Gas Supersaturation, Grand Coulee Dam Project, 1973*. Unpublished report (D.E. Weitkamp) to United States Department of the Interior, Bureau of Reclamation, Boise, ID.

Sehmel, G.A. 1980. Particulate resuspension: A review. *Environ. Intern.* 4:107–127.

Semple, K.T., K.J. Doick, K. Jones, P. Burauel, A. Craven, and H. Harms. 2004. Defining bioavailability and bioaccessibility of contaminated soil and sediment is complicated. *Environ. Sci. Technol.* 38(12):228A–232A.

Serdar, D., B. Yake, and J. Cabbage. 1994. *Contaminant Trends in Lake Roosevelt*. Pub. No. 94-185. Washington State Department of Ecology, Olympia, WA.

Sigma Engineering. 1992. *Lower Columbia River, Distribution of Slag and the Impact on Fish Habitat*. Prepared for the Department of Fisheries and Oceans by Sigma Engineering Ltd., and Peter Ward and Associates. October 1992.

Simpson, J.C., and R.L. Wallace. 1982. *Fishes of Idaho*. Univ. of Idaho Press. Moscow, ID.

Simpson, S.L., B.M. Angel, and D.F. Jolley. 2004. Metal equilibration in laboratory-contaminated (spiked) sediments used for the development of whole-sediment toxicity tests. *Chemosphere* 54(5):597–609.

Simpson, S.L., and C.K. King. 2005. Exposure-pathway models explain causality in whole-sediment toxicity tests. *Environ. Sci. Technol.* 39:837–843.

Smith, M.E., J.M. Lazorchak, L. Herrin, S. Brewer-Swartz, and W.T. Thoeny. 1997. A reformulated, reconstituted water for testing the freshwater amphipod, *Hyalella azteca*. *Environ. Toxicol. Chem.* 16(6):1229–1233.

Snyder, G.R. 1967. Unpublished data of fish sampling in Lake Roosevelt. National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Seattle, WA.

Soulsby 1997 *Dynamics of Marine Sands*. Thomas Telford Publications, London, UK. 249 pp.

Steenbergen, N.T.T.M., F. Iaccino, M. Winkel, L. de Reijnders, and W.J.G.M. Peijnenburg. 2005. Development of Biotic Ligand Model and a Regression Model predicting acute copper toxicity to the earthworm *Aporrectodea caliginosa*. *Environ. Sci. Technol.* 39:5694–5702.

STI 2008. <http://www.spokanetribe.com>

Still, I., S. Rabke, and J. Candler. 2000. Development of a standardized reference sediment to improve the usefulness of marine benthic toxicity testing as a regulatory tool. *Environ. Toxicol. Chem.* 15(5):406–416.

Stober, Q.J., M.E. Kopache, and T.H. Jagielo. 1981. *The Limnology of Lake Roosevelt*. Contract No. 14-16-0009-80-00004. Final report to the U.S. Fish and Wildlife Service. FRI-UW-8106. National Fisheries Research Center, Seattle, WA. Fisheries Research Institute, University of Washington, Seattle, WA.

Stober, Q.J., R.W. Tyler, J.A. Knutzen, D. Gaudet, G.E. Petrosky, and R.E. Nakatani. 1977a. *Operational Effects of Irrigation and Pumped/Storage on the Ecology of Banks Lake, Washington*. Final Report FRI-UW-7732. Fisheries Research Institute, Seattle, WA.

Stoffel, Joseph, Waggoner, Gulick, Korossec, and Bunning. 1991. Geologic Map of Washington – Northeast Quadrant. Geologic Map GM-39. Washington Division of Geology and Earth Resources.

StreamNet. 2006. Fish species distribution data maintained by StreamNet. http://www.streamnet.org/online_data.html. StreamNet, Portland, OR.

Stubblefield, W.A., and J.R. Hockett. 2000. *Derivation of a Colorado State Manganese Table Value Standard for the Protection of Aquatic Life*. ENSR Corporation, Fort Collins, CO.

Suedel, B.C., and J.H. Rodgers. 1994. Development of formulated reference sediments for freshwater and estuarine sediment testing. *Environ. Toxicol. Chem.* 13(7):1163–1165.

Suedel, B.C., and J.H. Rodgers, Jr. 1996. Experimental factors that may affect toxicity of aqueous and sediment-bound copper to freshwater organisms. *Arch. Environ. Contam. Toxicol.* 30(1):40–46.

Sukola, K., F. Wang, and A. Tessier. 2005. Metal-sulfide species in oxic waters. *Anal. Chim. Acta.* 528(2):183–195.

Suter, G.W., II. 1993. *Ecological Risk Assessment*. Lewis Publishers, Boca Raton, FL.

Suter, G.W., II. 1996. *Risk Characterization for Ecological Risk Assessment at Contaminated Sites*. Report ES/ER/TM-200. Oak Ridge National Library, Oak Ridge, TN.

Sylvester, R.O. 1958. *Water Quality Studies in the Columbia River Basin*. Special Scientific Report No. 329. U.S. Fish and Wildlife Service, Washington, DC.

Symonds. 1883. Report of an examination of the Upper Columbia River and the territory in its vicinity, in September and October, 1881, to determine its navigability and adaptability to steamboat transportation. *American Naturalist* 17(5):517–519.

TCAI. 2008. *Screening Level Ecological Risk Assessment*.

Teck Cominco Ltd. 1998. *Trail Operations 1997 Environmental Report*. Teck Cominco Metals Ltd., Vancouver, B.C. August 1998.

Teck Cominco Metals Ltd. 2003. 2001/2002 Trail Smelter Site Groundwater Investigations Final Report.

Teck Cominco Metals Ltd. 2003. Teck Cominco Metals Ltd. Annual Environmental Permit Report for the B.C. Ministry of Water, Land and Air Protection.

Thakali, S., H.E. Allen, D.M. Di Toro, A.A. Ponizovsky, C.P. Rooney, F.J. Zhao, et al. 2006a. A terrestrial biotic ligand model. 1: Development and application to Cu and Ni toxicities to barley root elongation in soils. *Environ. Sci. Technol.* 40(22):7085–7093.

Thakali, S., H.E. Allen, D.M. Di Toro, A.A. Ponizovsky, C.P. Rooney, F.J. Zhao, et al. 2006b. Terrestrial biotic ligand model. 2. Application to Ni and Cu toxicities to plants, invertebrates, and microbes in soil. *Environ. Sci. Technol.* 40(22):7094–7100.

Thompson, T.H. 1977. Use of infrared imagery in bank-storage studies. *U. S. Geological Survey Journal of Research* 5(1):1–10.

Todd, B.L., and C.F. Rabeni. 1989. Movement and habitat use by stream-dwelling smallmouth bass. *Trans. Am. Fish. Soc.* 118:229–242.

Trapp, S., M. Matthies, I. Scheunert, and E.M. Topp. 1990. Modeling the bioconcentration of organic chemicals in plants. *Environmental Sci. Technol.* 24:1246–1252.

UCWSRI. 2002a. *Upper Columbia White Sturgeon Recovery Initiative*. A multi-organization document published jointly by British Columbia Ministry of Water, Land and Air Protection Nelson, British Columbia, and U.S. Department of Energy, Bonneville Power Administration. Upper Columbia White Sturgeon Recovery Team, Portland, OR.

UCWSRI. 2002b. *Upper Columbia White Sturgeon Recovery Plan*. November 28, 2002. Available at: <http://uppercolumbiasturgeon.org/RecoveryEfforts/Recovery.html>. Upper Columbia White Sturgeon Recovery Initiative.

Underwood, K., D. Weitkamp, and R. Cardwell. 2004. *Factors Influencing Successful Fisheries in Lake Roosevelt, Washington*. 68 pp. Prepared for Teck Cominco Inc. by SP Cramer and Associates and Parametrix.

USBR. 1985. *Assessment of the Fisheries and Limnology in Lake R.D. Roosevelt 1980-83*. 200 pp. Prepared by U.S. Fish and Wildlife Service. Contract No. WPRS-0-07-10X0216, PWS-14-06-009-904. May 1985. U.S. Bureau of Reclamation, Seattle, WA.

USBR. 2006a. Columbia Basin Project. Washington. www.usbr.gov/dataweb/html/columbia.html. U.S. Bureau of Reclamation, Upper Columbia Area Office, Yakima, WA.

USBR. 2006b. United States Bureau of Reclamation Columbia Basin Project website. www.usbr.gov/pn/project/columbia_index.html. Accessed on September 22, 2006. U.S. Bureau of Reclamation, Pacific Northwest Region, Boise, ID.

USBR. 2007a. Columbia Basin Project, Washington. <http://www.usbr.gov/dataweb/html/columbia.html>. Accessed on August 15, 2007. U.S. Bureau of Reclamation, Yakima, WA.

USBR. 2007b. Grand Coulee Powerplant. <http://www.usbr.gov/power/data/sites/grandcou/grandcou.html>. Accessed on July 4, 2007. U.S. Bureau of Reclamation, Upper Columbia Area Office, Yakima, WA

U.S. Census Bureau. 2006. U.S. Census Bureau, American Factfinder website. <http://factfinder.census.gov>. Accessed on September 28, 2006.

U.S. Census Bureau. 2007a. U.S. Census Bureau, American Factfinder Sheet, Kettle Falls city (sic), Washington. <http://factfinder.census.gov>. Accessed on July 9, 2007.

U.S. Census Bureau. 2007b. U.S. Census Bureau, American Factfinder Sheet, Zip Code Tabulation Area 99137. <http://factfinder.census.gov>. Accessed on July 9, 2007.

USCGS. 1950. Legacy document to be provided by Hydroqual. U.S. Coast and Geodetic Survey.

USFWS. 1949. *Preliminary Surveys of Roosevelt Lake in Relation to Game Fishes*. Special Scientific Report: Fisheries No. 5. 32 pp. U.S. Fish and Wildlife Service, Washington, DC.

USFWS. 1969. *Summer and Fall Thermal Regime of Franklin D. Roosevelt Lake, Washington, 1964-67*. Data Report No. 38. U.S. Fish and Wildlife Service, Washington, DC.

USFWS. 2006. National Wetlands Inventory. Banks Lake, Colville, Coulee Dam, Nespelem, Omak, Republic, and Spokane 1:100,000 scale quadrangles downloaded on September 20, 2006. <http://www.fws.gov/nwi>. United States Fish and Wildlife Service.

USFWS. 2007a. Bald Eagle Delisting. <http://www.fws.gov/pacific/ecoservices/BaldEagleDelisting.htm>. Accessed on August 15, 2007. United States Fish and Wildlife Service.

USFWS. 2007b. Digest of Federal Resource Laws of Interest to the U.S. Fish and Wildlife Service, Columbia Basin Project Act.

http://www.fws.gov/laws/laws_digest/COLUMBIA.HTML. Accessed July 10, 2007. U.S. Fish and Wildlife Service, Washington, DC.

USFWS. 2008. Information Sheet. Summary of Kootenai River White Sturgeon Studies. U.S. Fish and Wildlife Service, Upper Columbia Fish and Wildlife Office, Spokane, WA. 2007/2008.

USGS. 1985. *National Water Summary 1984*. U.S. Geological Survey Water Supply Paper 2275. U.S. Government Printing Office, Washington, DC.

USGS. 1992. *Sediment-quality Assessment of Franklin D. Roosevelt Lake and the Upstream Reach of the Columbia River, Washington, 1992*. Water Supply Paper 2496. U.S. Geological Survey, Reston, VA.

USGS 1994. *Sediment Quality Assessment of Franklin Roosevelt Lake and The Upstream Reach of the Columbia River*. October 1994.

USGS. 2003a. *Concentrations and Distributions of Slag-Related Trace Elements and Mercury in Fine-Grained Beach and Bed Sediments of Lake Roosevelt, Washington, April-May 2001*. Water-Resources Investigations Report 03-4170. U.S. Geological Survey, Reston, VA.

USGS. 2003b. National Water Information System. Water Quality Data for Northport, WA. http://nwis.waterdata.usgs.gov/wa/nwis/qwdata/?site_no=12400520.

USGS. 2003c. *Occurrence and Transport of Cadmium, Lead, and Zinc in the Spokane River Basin, Idaho and Washington, Water Years 1999-2001*. Survey 45. U.S. Geological Survey, Boise, ID.

USGS. 2006a. Air Sampling for Trace Metals in Lake Roosevelt Air-Program Update. Presented at Lake Roosevelt Water Quality Council Meeting. U.S. Geological Survey. August 2006.

USGS. 2006b. National Contaminant Biomonitoring Program (NCBP) Database. Available at http://wet_weightw.cerc.usgs.gov/data/ncbp/ncbp.html. U.S. Geological Survey, Columbia Environmental Research Center.

USGS. 2006c. National Water Information System (NWIS) home page for USGS gage 12404500, Kettle River near Laurier, WA. <http://waterdata.usgs.gov/nwis/>. Accessed on October 6, 2006.

USGS. 2006d. Occurrence and Distribution of Trace Elements in Air along Lake Roosevelt: A Pilot Study. <http://wa.water.usgs.gov/projects/roosevelt/summary.htm>. U.S. Geological Survey, Boise, ID.

Van Loon, W.M.G.M., M.E. Verwoerd, F.G. Wijnker, C.J. van Leeuwen, P. van Duyn, C. van DeGuchte, et al. 1997. Estimating total body residues and baseline toxicity of complex organic mixtures in effluents and surface waters. *Environ. Toxicol. Chem.* 16(7):1358–1365.

Van Rijn, L.C. 1996. Principles of Sediment Transport in Rivers, Estuaries and Coastal Seas. Aqua Publications, Amsterdam, NL

VanderKooi, S.P., R.G. Morris, J.W. Beeman, and A.G. Maule. 2003. Chapter II: The progression and lethality of gas bubble disease in resident fish in Rufus Woods Lake. Pages 48-86. In: *Gas Bubble Disease in Resident Fish below Grand Coulee Dam Final Report of Research*. Report by J.W. Beeman, D. A. Venditti, R. G. Morris, D. M. Gadomski, B. J. Adams, S. P. VanderKooi, T.C. Robinson, and A. G. Maule. U.S. Geological Survey, Western Fisheries Research Laboratory, Cook, WA.

Vellidis, G., M. Smith, and R. Lowrance. 2003. Riparian forest buffer systems slow the flow of sediment and nutrients from cultivated lands. *Stormwater*. May/June.

http://www.forester.net/sw_0305_impact.html. Accessed on July 24, 2007.

Von der Ohe, P.C., and M. Liess. 2004. Relative sensitivity distribution of aquatic invertebrates to organic and metal compounds. *Environ. Toxicol. Chem.* 23(1):150–156.

Water Supply and Water Pollution Control Subcommittee. 1966. Columbia River water temperature conditions and research requirements. Pages IV-4 to IV-6. In: *Water Supply and Water Pollution Control Subcommittee, Columbia Basin Interagency Committee*.

WDFW. 2006. Priority Habitats and Species Digital Data. <http://wdfw.wa.gov/hab/release.htm>. Washington Department of Fish and Wildlife, Spokane, WA.

WDGER. 2002. Geologic map of Washington by J. E. Schuster and Brief geologic history of Washington by L. Moses and R. Lasmanis. Washington Division of Geology and Earth Resources, Olympia, WA.

WDNR. 2006. Washington Natural Heritage Program, Graphic Information System Data Layers. CD-ROM. Washington Department of Natural Resources.

WDOH. 1991. *Health implications of TCDD and TCDF Concentrations Reported from Lake Roosevelt Sport Fish*. Washington State Department of Health, Olympia, WA.

WDOH. 1993. Cominco Slag in Lake Roosevelt, Review of Current Data. December 1993.

WDOH. 1994. Air Monitoring Data and Evaluation of Health Concerns in Areas of Northeast Tri-County; Summary of Activities.

WDOH. 1997. *Consumption Patterns of Anglers Who Frequently Fish Lake Roosevelt*. Washington State Department of Health, Olympia, WA. 24 pp.

WDOH 2002. Fish Consumption Advisory Updates. News Release.

WDOH. 2006a. Washington State drinking Water protection areas [computer file]. Washington State Department of Health, Tumwater, WA.

WDOH. 2006b. Washington State drinking water sources [computer file]. Washington State Department of Health, Tumwater, WA.

WDOH. 2007. Water System Data Available For Download (last updated March 28, 2007). http://www.doh.wa.gov/ehp/dw/our_main_pages/data_download.htm. Downloaded June 14, 2007. Washington Department of Health, Division of Environmental Health, Office of Drinking Water.

Weaver, J. 2006. In: The Lake Roosevelt Forum Annual Conference 2006.

Welch, E.B., R.J. Totorica, and R.R. Horner. 1992. *Approach to Developing Nutrient Loading Criteria for Franklin D. Roosevelt Lake*. Report to Washington Department of Ecology, Contract #C0091223. Water Resources Series Technical Report No. 133. University of Washington Department of Civil Engineering, Seattle, WA. January 1992.

Weston. 2004a. Technical Memorandum: Assessment of Effects on Water Quality Due to Mine Waste Contaminated Soil Placements near City of Northport Municipal Water Wells. Prepared for U.S. Environmental Protection Agency. Weston Solutions, Inc., Seattle, WA.

Weston. 2004b. *Le Roi Smelter Removal Action Site Management Plan*. TDD: 04-02-0010, EPA Contract: 68-S0-01-02, prepared for the United States Environmental Protection Agency Region 10. May 2004.

Weston. 2005. *Le Roi Smelter Removal Action Report, Northport, Stevens County, Washington*. Prepared for U.S. Environmental Protection Agency. Weston Solutions, Inc. Seattle, WA.
Wetzel, R.G. 2001. *Limnology: Lake and River Ecosystems*. 3rd edition. Academic Press, San Diego, CA.

Whetten, J.T., J.C. Kelley, and L.G. Hanson. 1969. Characteristics of Columbia River sediment and sediment transport. *J. Sedimentary Petrology* 39(3):1149–1166.

Whitehead, R.L. 1994. *Groundwater Atlas of the United States, Segment 7, Idaho. Oregon, Washington*. USGS Hydrologic Atlas 730-H. U.S. Government Printing Office, Washington, DC.

Wile, K., and G. Trasolini. 1977. *Cominco - Trail Toxicity Survey*. File No. 4780-37/C-685-4. Environment Canada.

Wilson, G.A., W.H. Funk, and S.T.J. Juul. 1996. *Limnological Evaluation of the Upper Columbia River Basin*. 103 pp. Prepared for the Lake Roosevelt Water Quality Council, U.S. Environmental Protection Agency, and U.S. Bureau of Reclamation. State of Washington Water Research Center, Washington State University, Pullman, WA.

Wilson, M. 2007. Personal communication (telephone conversation with S. FitzGerald, Integral Consulting Inc., Mercer Island, WA, on June 14, 2007, regarding DOH records of water supplies utilizing UCR surface water). Washington State Department of Health, Eastern Regional Office, Spokane, WA.

Wolff, F.E., D.T. McKay, and D.K. Norman. 2005. *Inactive and Abandoned Mine Lands - Van Stone Mine, Northport Mining District, Stevens County, Washington*. Prepared for the Washington Department of Natural Resources. Washington Division of Geology and Earth Resources, Washington Department of Natural Resources, Olympia, WA.

Woller, H. 2006. In: *The Lake Roosevelt Annual Conference*. Spokane, WA.

Woodward, D.F., A.M. Farag, H.L. Bergman, A.J. DeLonay, E.E. Little, C.E. Smith, et al. 1995a. Metals-contaminated benthic invertebrates in the Clark Fork River, Montana: effects on age-0 brown trout and rainbow trout. *Can. J. Fish. Aquat. Sci.* 52:1994–2004.

Woodward, D.F., J.A. Hansen, H.L. Bergman, E.E. Little, and A.J. DeLonay. 1995b. Brown trout avoidance of metals in water characteristic of the Clark Fork River, Montana. *Can. J. Fish. Aquat. Sci.* 52(2031-2037).

WSDOT. 2007. Fish and Wildlife Information.

http://www.wsdot.wa.gov/Environment/Biology/bio_esa.htm. Accessed on August 15, 2007. Washington State Department of Transportation.

Wu, K.B., R. Mathew, G. Bielmyer, R. Brix, R. Naddy, M. Grosell, et al. 2006. Development of an acute biotic ligand model for silver: Application to fish and invertebrates. In preparation.

14 GLOSSARY OF TERMS

(Σ SEM – AVS)/foc—The sum of two parameters—the concentration of simultaneously extractable metals minus the concentration of acid volatile sulfides—normalized for the concentration of total organic carbon in the sediment.

Acid volatile sulfide (AVS)—A fraction of the sulfides in sediment that form a complex with heavy metals such as copper, lead, and zinc.

Analyte—The substance in an analysis that is being identified or determined.

Aroclor—The trade name for many commercial polychlorinated biphenyl mixtures used in the United States prior to 1977 when their production stopped in the United States due to environmental and health concerns.

Benthic—The living organisms that are found at the bottom of a sea or lake.

Biotic ligand model (BLM)—An analysis tool used to evaluate differences in the availability and toxicity of metals that occur as a result of changes in water chemistry from site to site, and at a given site over time.

Ceriodaphnia—A genus of sensitive plankton within the family Daphnidae. A close relative of the plankton consumed by a number of fish in Lake Roosevelt.

Conceptual site model (CSM)—A written description and visual representation of the known, expected, and/or predicted relationships between the site chemicals of potential concern and the ecological receptors.

Congener—In chemistry, variations or configurations of a common chemical structure.

Daphnia—A genus of sensitive plankton within the family Daphnidae. One of the planktonic species consumed by a number of fish in Lake Roosevelt.

Daphnids—A group (family) of crustaceans that are filter-feeding plankton. Daphnids belong to the family Daphnidae.

Dioxin—A group of chlorinated organic compounds with similar chemical structures. Some dioxins have harmful properties, depending on the number and position of chlorine atoms. Dioxins are formed unintentionally and released as byproducts of human activities such as waste incineration, fuels combustion, chlorine bleaching of pulp and paper, or pesticide manufacturing. They are also formed by natural processes such as forest fires and volcanoes.

Dissolved organic carbon—The concentration of organic (not inorganic) carbon dissolved in water or porewater.

Diversity—A measure of the number of individuals and their relative abundance in an area.

Drawdown—The distance that the water surface of a reservoir is lowered from a given elevation as water is released from the reservoir. Also refers to the act of lowering reservoir levels.

Effluent—The polluted discharge, from a man-made structure that flows into a body of water.

Elutriate—A mixture of water and sediment that is homogenized and then either allowed to settle or centrifuged, or both.

Endangered species—A plant or animal species that is in danger of extinction throughout all or a significant portion of its range. The U.S. Fish and Wildlife Service or the National Marine Fisheries Service designates endangered species.

Entrainment—The process of fish being transported out of the reservoir with the outflow and deposited downstream of the dam. Entrainment is directly correlated to outflow: the greater the outflow, the greater the percent entrainment.

Eutrophication—The buildup of nutrients in a water body that promotes excessive algal growth.

Furan—An organic compound produced when wood, especially pine wood, is distilled. Furan is a clear, colorless, very volatile, and highly flammable liquid with a boiling point close to room temperature.

Genetic introgression—Process by which the decreasing genetic fitness of a hatchery fish stock, by spawning with the wild stock, passes its diminished fitness on to the wild population.

Haplotype—A combination of very closely linked alleles or markers that tend to be transmitted as a unit to the next generation.

Kokanee salmon—The adfluvial life history form of sockeye salmon. That is, unlike sockeye salmon, kokanee spend their entire life in fresh water, never visiting the ocean.

Lacustrine—Pertaining to or living in lakes or ponds.

Littoral zone—The shore area along a body of water, usually a lake, down to the depth of 10 meters.

Macroinvertebrates—A broad term used to refer to invertebrates large enough to be seen with the naked eye.

Mean—The sum of all the observations divided by the number of observations.

Metal bioavailability—The degree of ability of a metal to be absorbed and ready to interact in an organism's metabolism.

Polychlorinated biphenyls (PCBs)—Mixtures of up to 209 individual chlorinated compounds (known as congeners) that were manufactured and used mostly in electrical equipment prior to 1977 when their production was stopped in the United States due to environmental and health concerns.

Porewater—Water that fills the interstitial space between sediment grains in sedimentary deposits. Porewater may be displaced due to the activities of benthic fauna (animals) or by physical processes such as compaction.

Physiographic—Of or pertaining to the study of physical features of the Earth's surface.

Richness—The number of species identified in a sample or area.

Simultaneously extractable metals (SEM)—The dissolved concentrations of certain divalent metals extracted from sediment using a weak acid. SEM analyses are completed in conjunction with analyses of acid volatile sulfide.

Standard deviation—A statistical measure used to denote spread or variability in the data.

Stratification—The layering effect that occurs during the warm summer months when the shallower waters are heated and differences in density cause the deeper and colder waters to resist mixing with the overlying warmer waters.

Susceptibility—The sensitivity of a specific assessment endpoint to the stressor, relative to its potential exposure.

Threatened species—Legal status afforded to a plant or animal species likely to become endangered within the foreseeable future throughout all or a significant portion of its range, as determined by the U.S. Fish and Wildlife Service or the National Marine Fisheries Service.

Total organic carbon—The concentration of organic (not inorganic) carbon measured in sediment or a particle.

Total suspended solids (TSS)—The portion of the sediment load suspended in the water column. The grain size of suspended sediment is usually less than 1 millimeter in diameter (clays and silts). High TSS concentrations can adversely affect primary food production and

fish feeding efficiency. Extremely high TSS concentrations can impair other biological functions such as respiration and reproduction.

Transport and fate—Determination of the speed, location, and interactions of released chemicals in their release environments (water, soil, or air) over time.

Van Veen sampler—A metal device used to grab a sample of sediment.

FIGURES

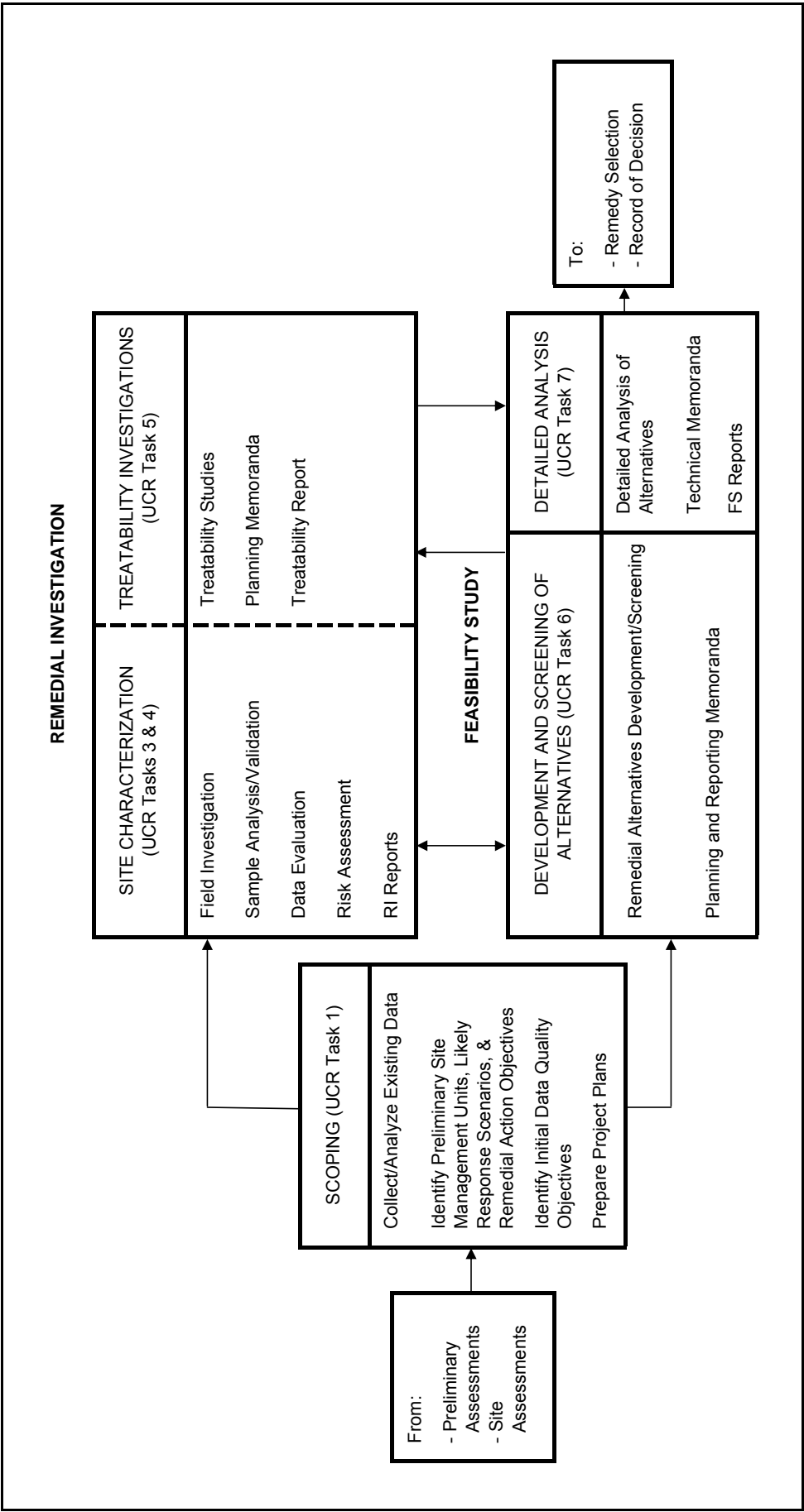


Figure 1-1. Generalized RI/FS Process and Relationship to UCR RI/FS Tasks.
 Source: Adapted from Figure 1-1 and 2-3 of EPA RI/FS guidance (USEPA 1988).
 Notes: UCR = Upper Columbia River.
 UCR Task 2 (Community Relations Plan) can occur in any phase of the RI/FS process. The Community Relations Plan will be prepared by EPA.
 UCR Task 4 (Risk Assessment) includes both a Baseline Human Health Risk Assessment and an Ecological Risk Assessment. The Baseline Human Health Risk Assessment will be completed by EPA.

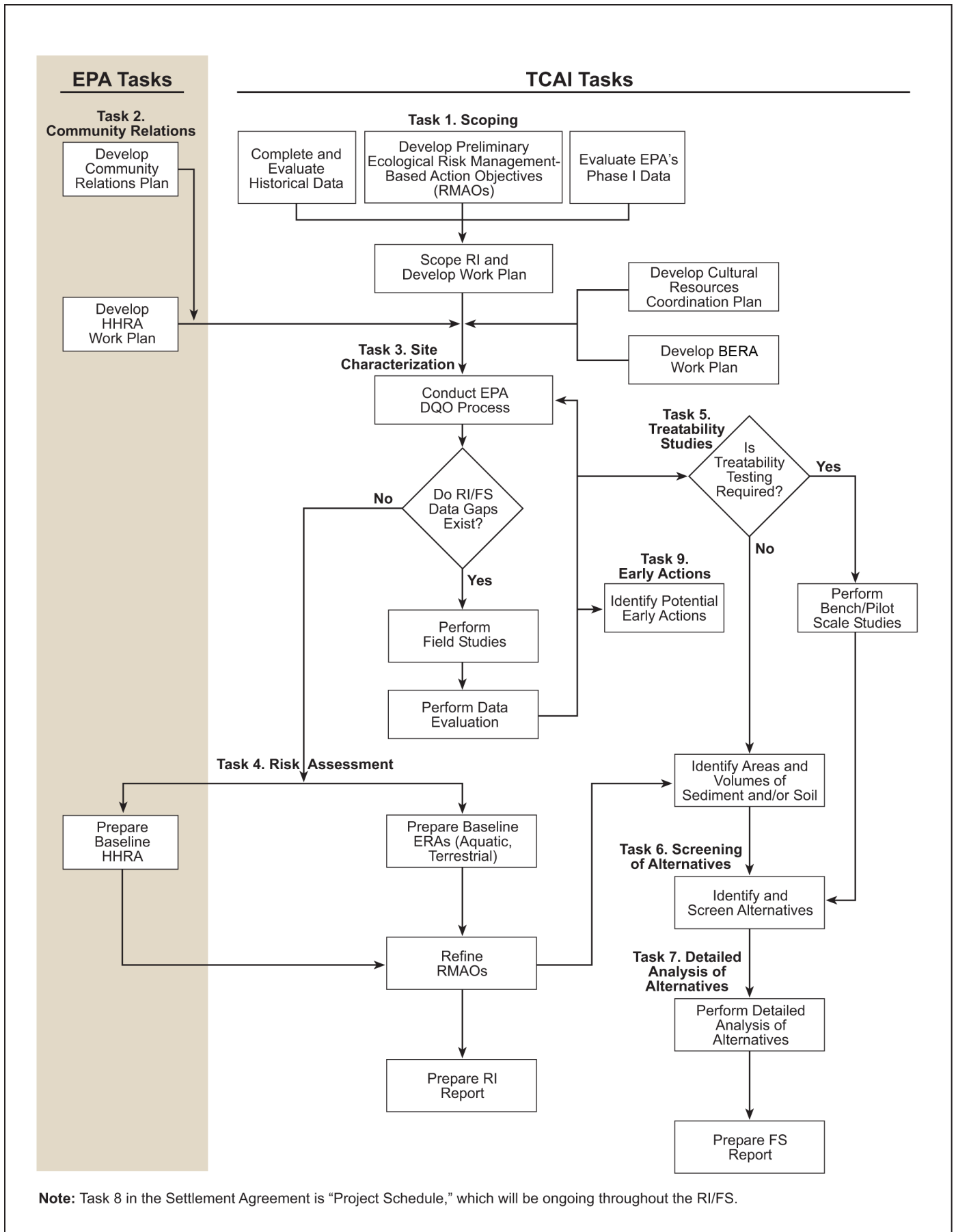


Figure G-1. Relationships Among Major Tasks in the UCR RI/FS.

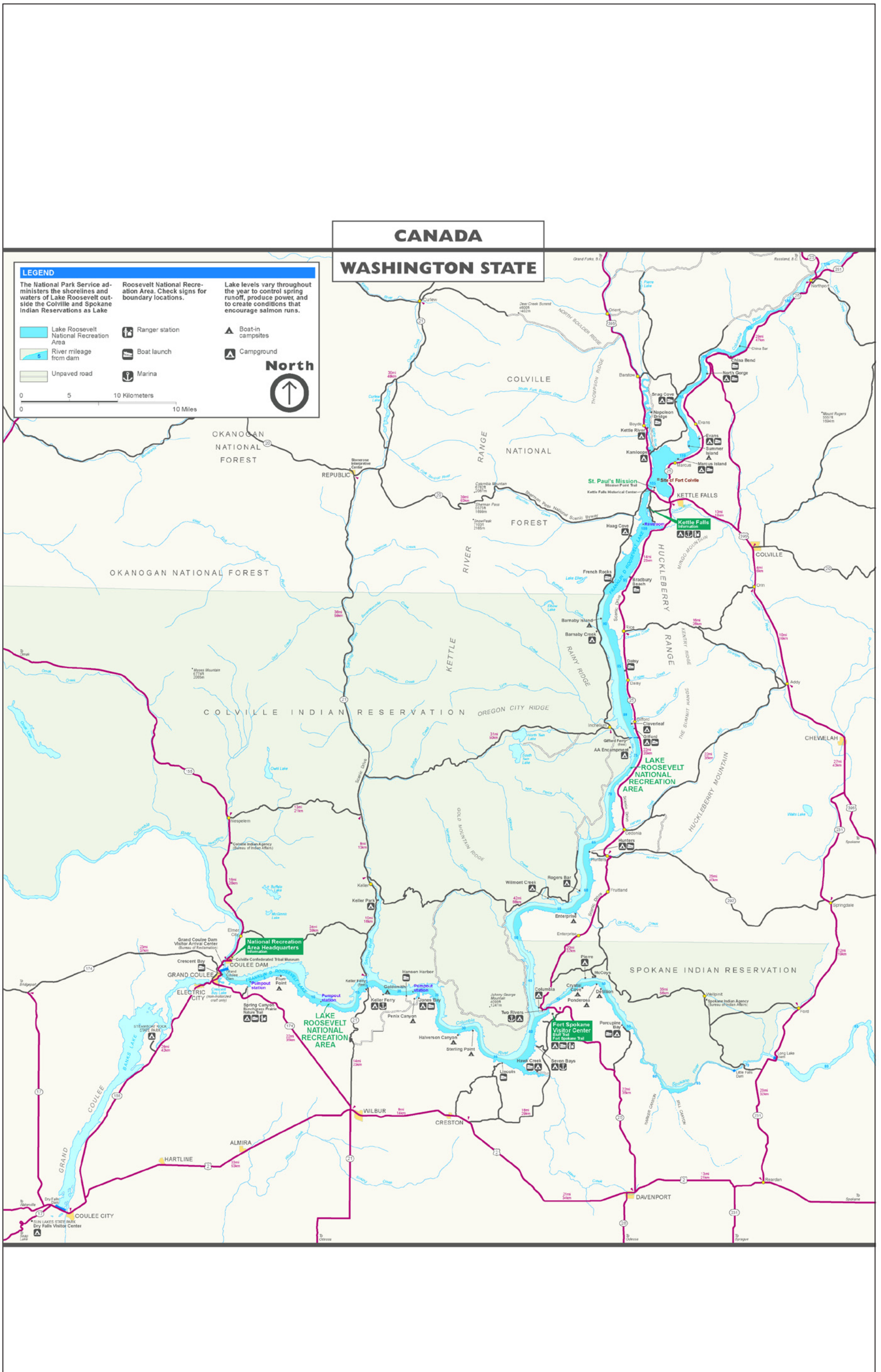


Figure 3-1. NPS Recreational Facilities, Upper Columbia River, WA.
Map Source: LRF (2007a).
Note: Not to a set scale.

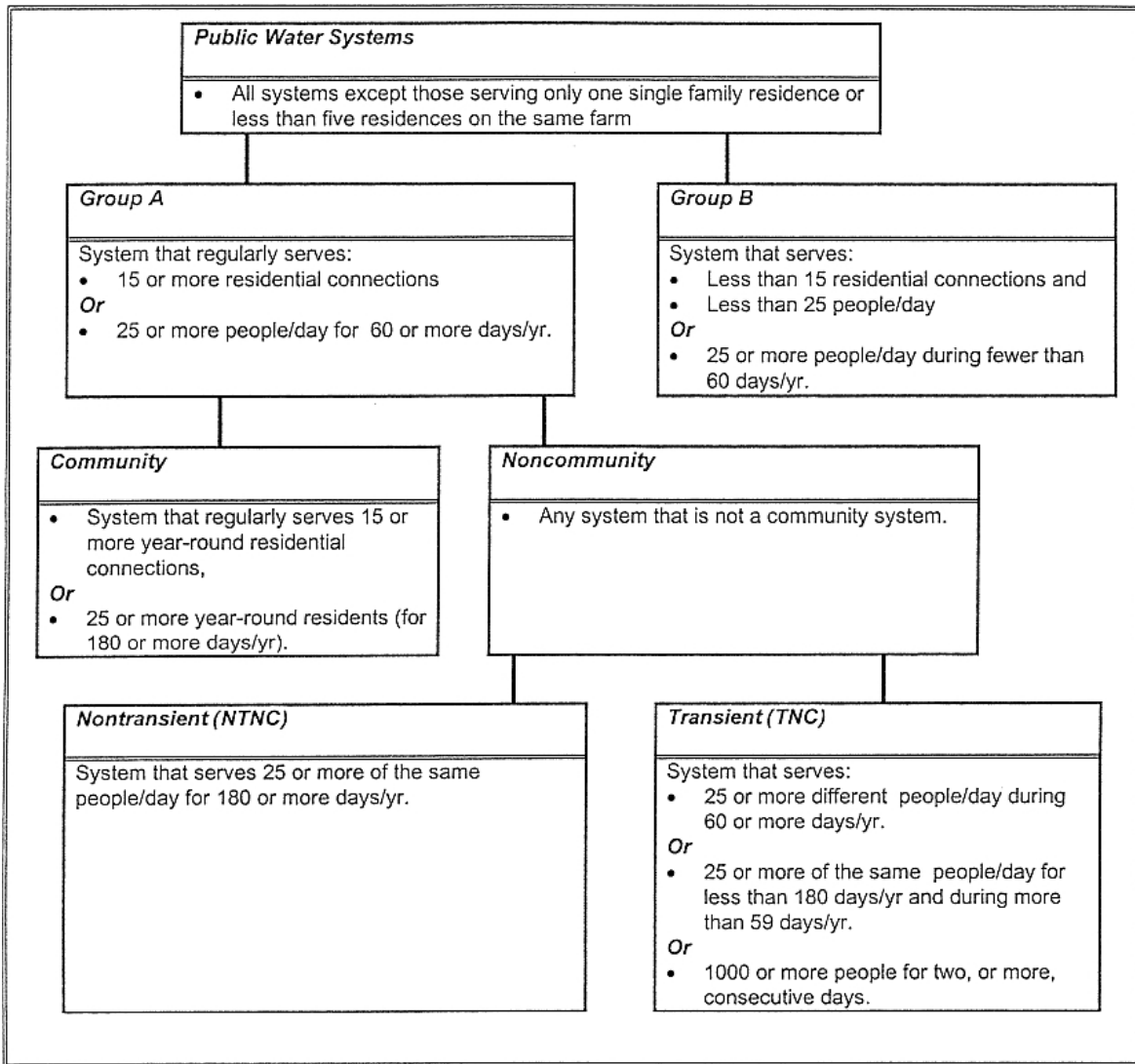
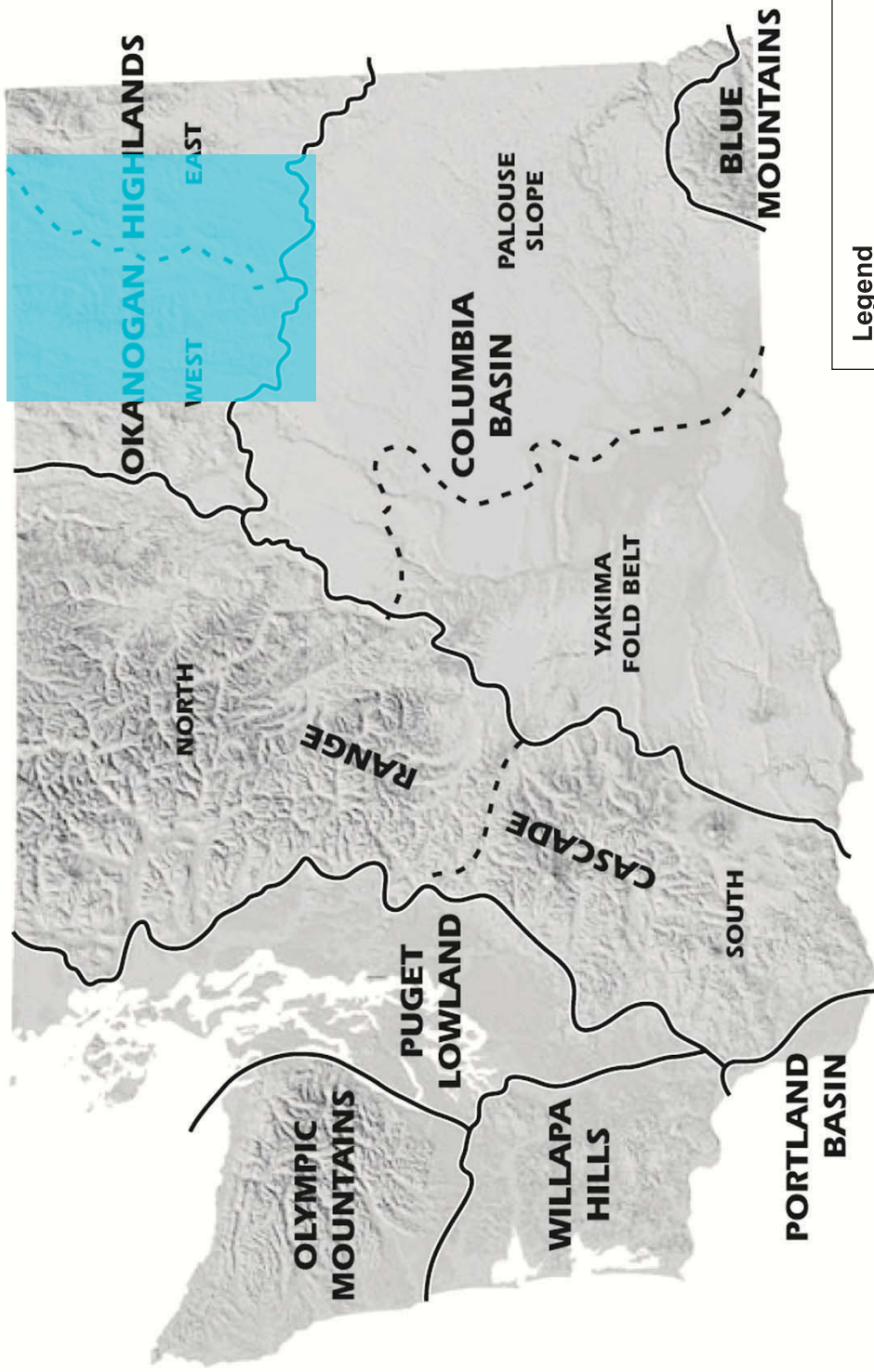


Figure 3-2. Definitions of Group A and Group B Water Systems.
Source: WAC 246-290-020



Legend

- Geological Region Boundaries
- - - Geological Region Subdivisions
- Upper Columbia River

Not to Scale

Figure 3-3. Geological Regions of Washington State.
 Source: WDGER (2002).

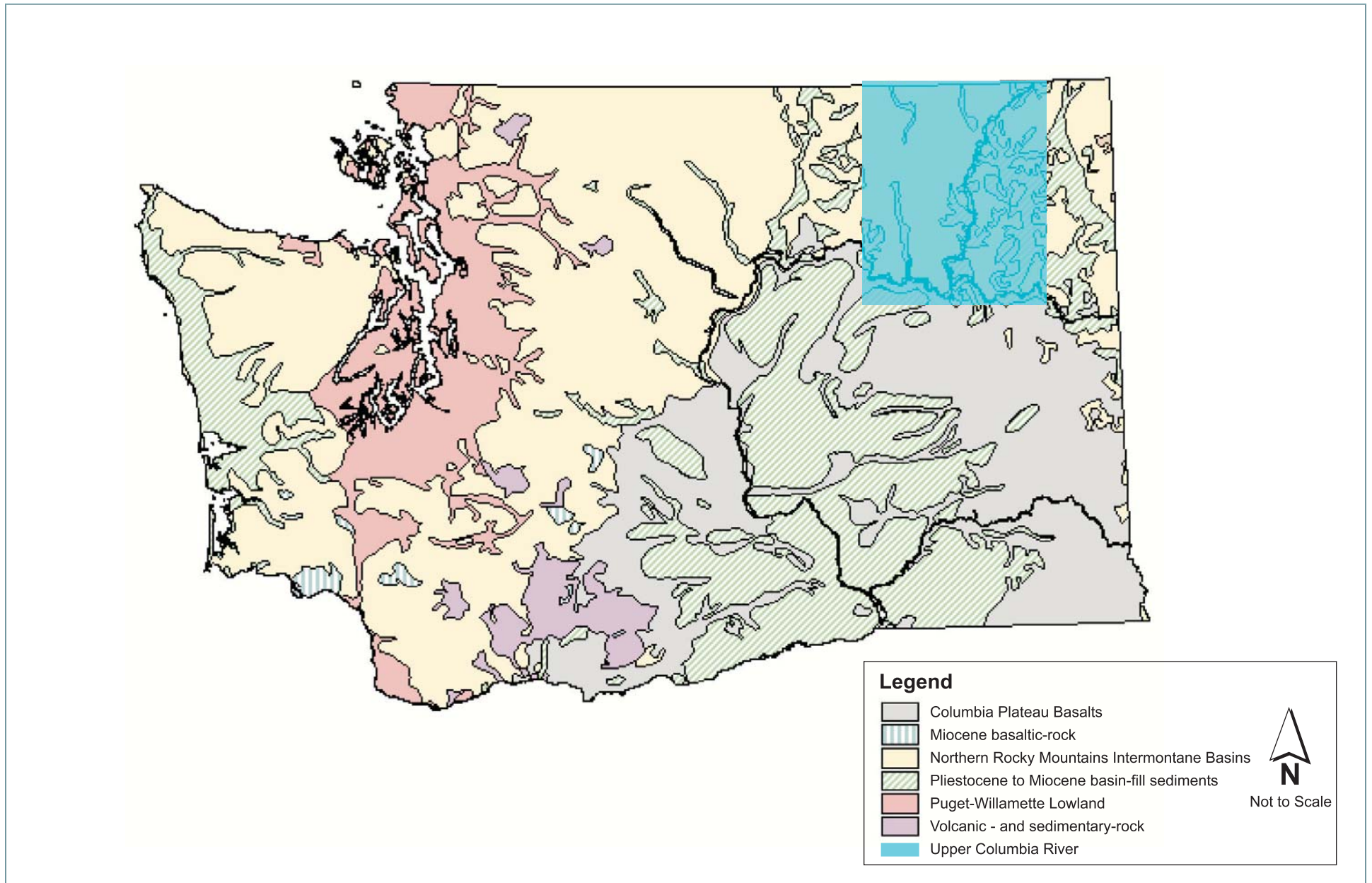


Figure 3-4. Principal Surficial Aquifers of Washington State.
Source: USGS (1985)

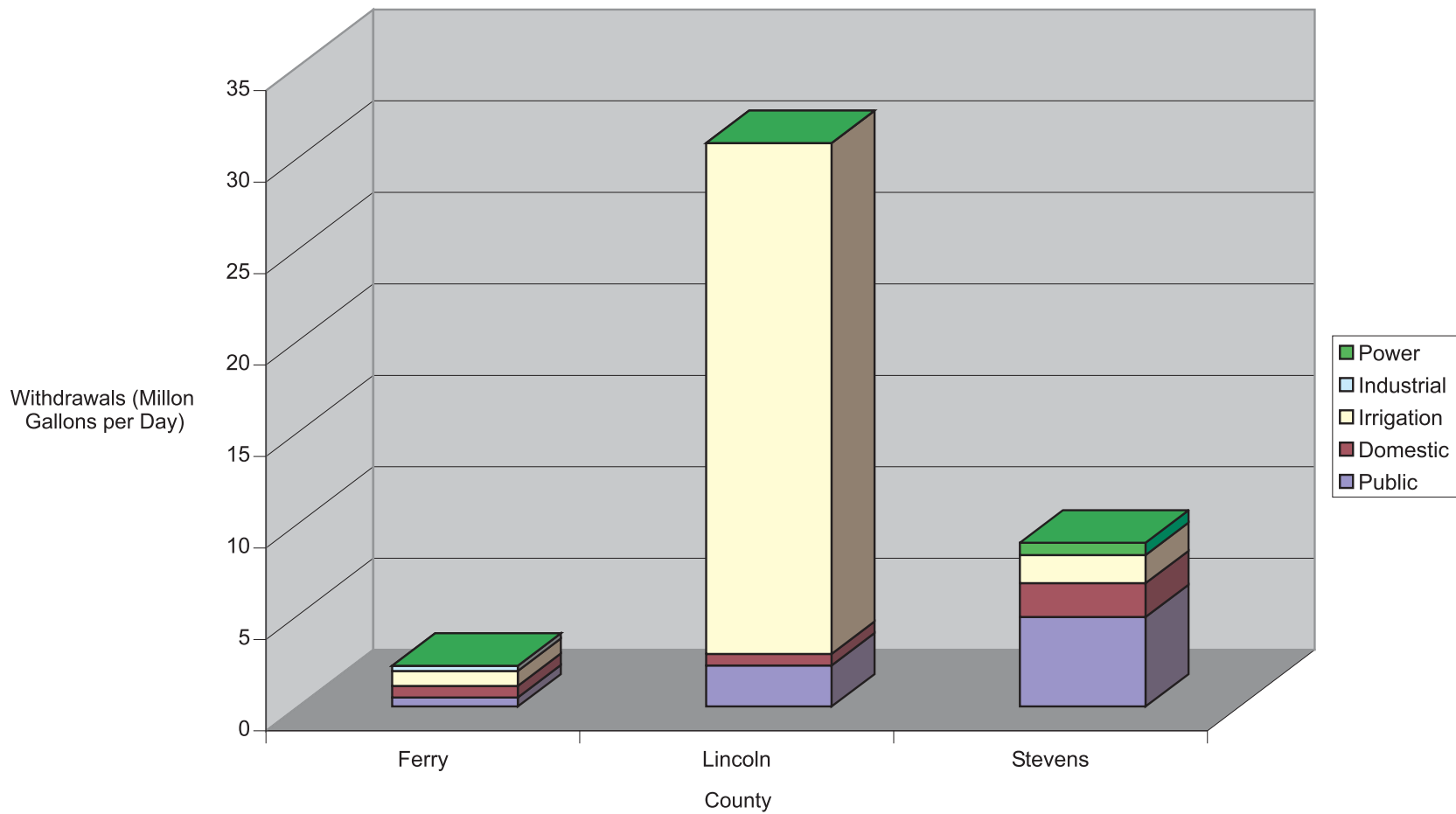
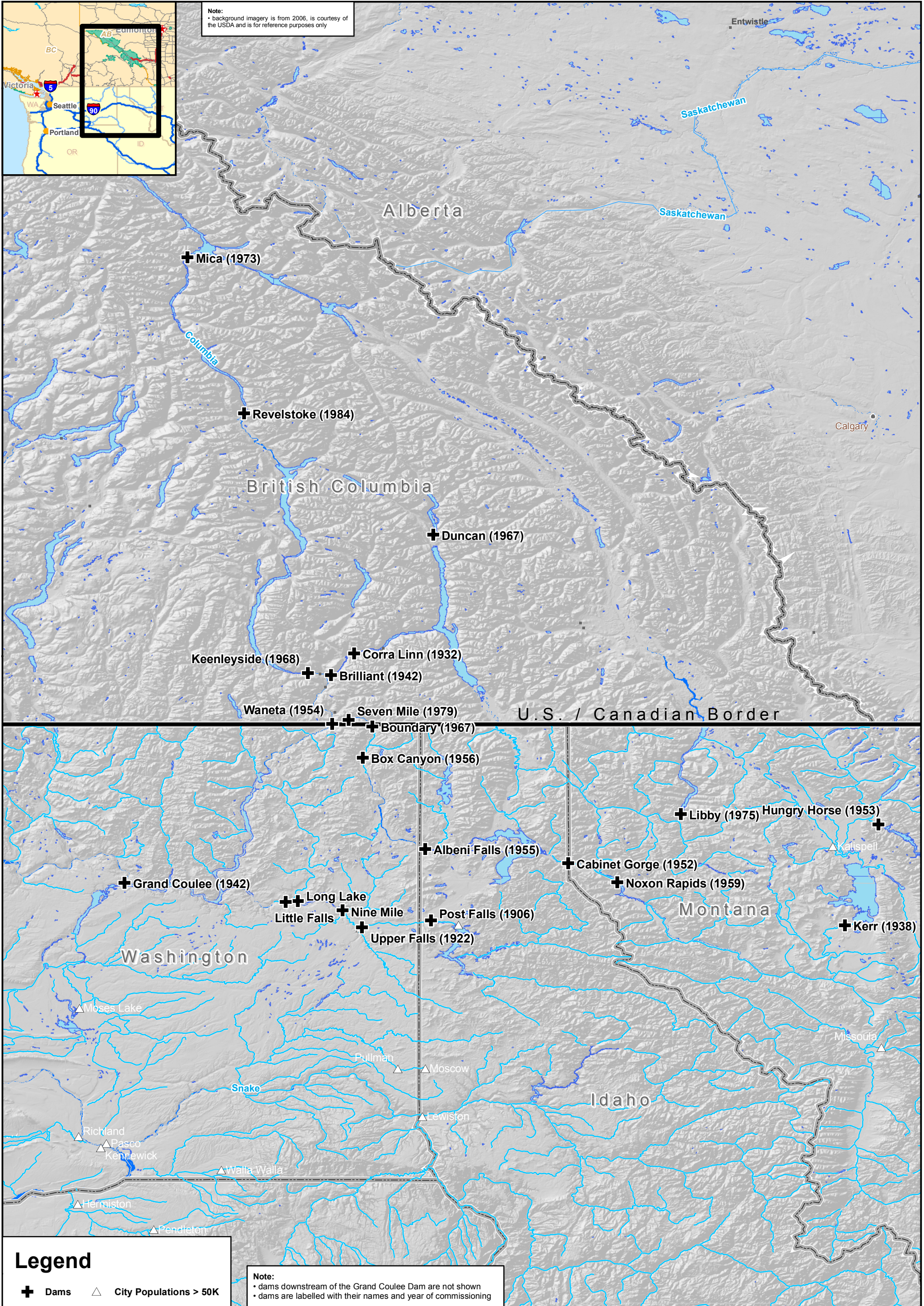


Figure 3-5. Groundwater Withdrawals by County in 2000.
Source: Lane (2004)
Note: Data from 2000 are the most currently available data set.



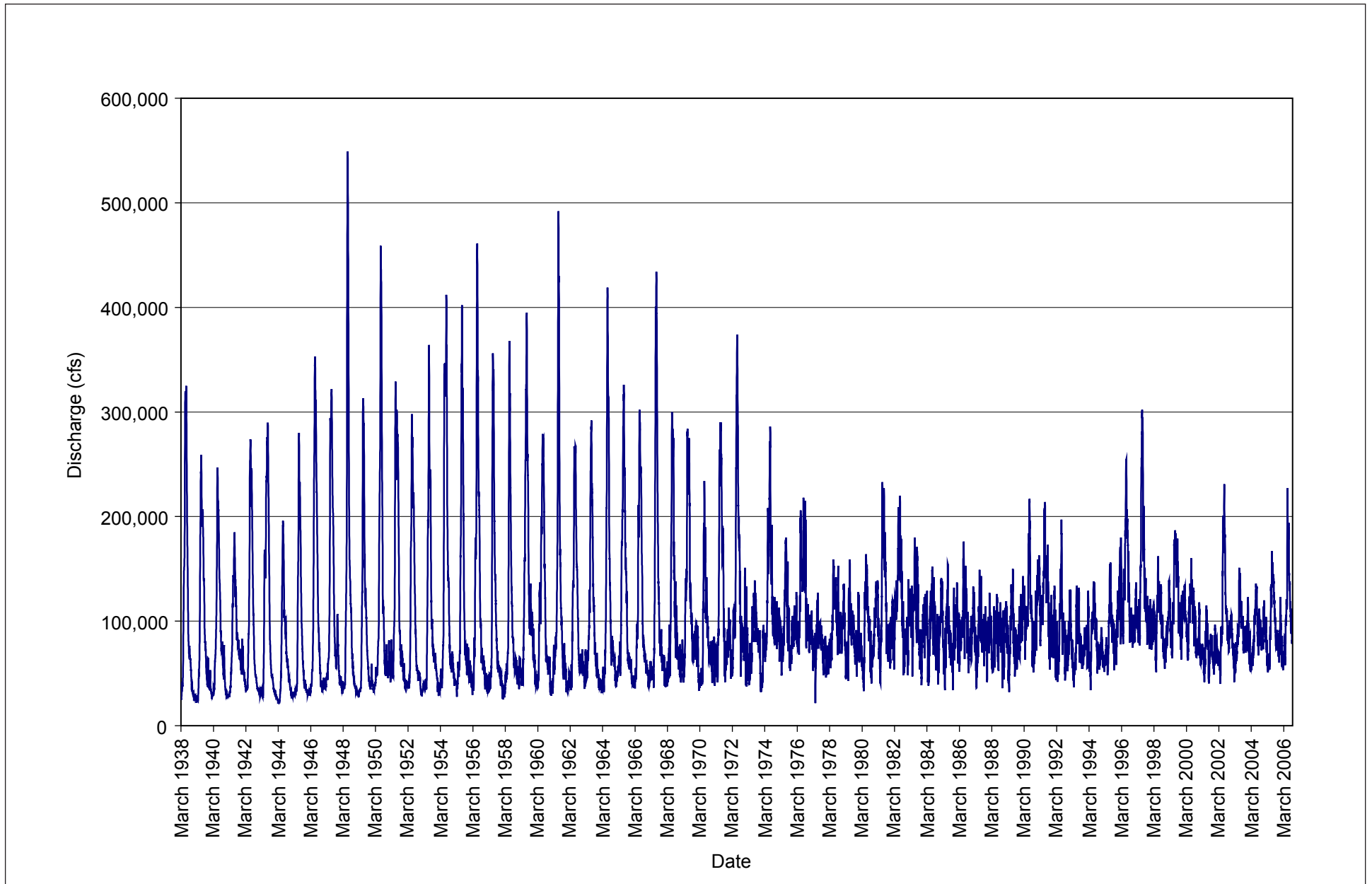


Figure 3-7. Mean Columbia River Daily Discharge Hydrograph at the U.S.-Canadian Border as Recorded at USGS Station No. 12399500.

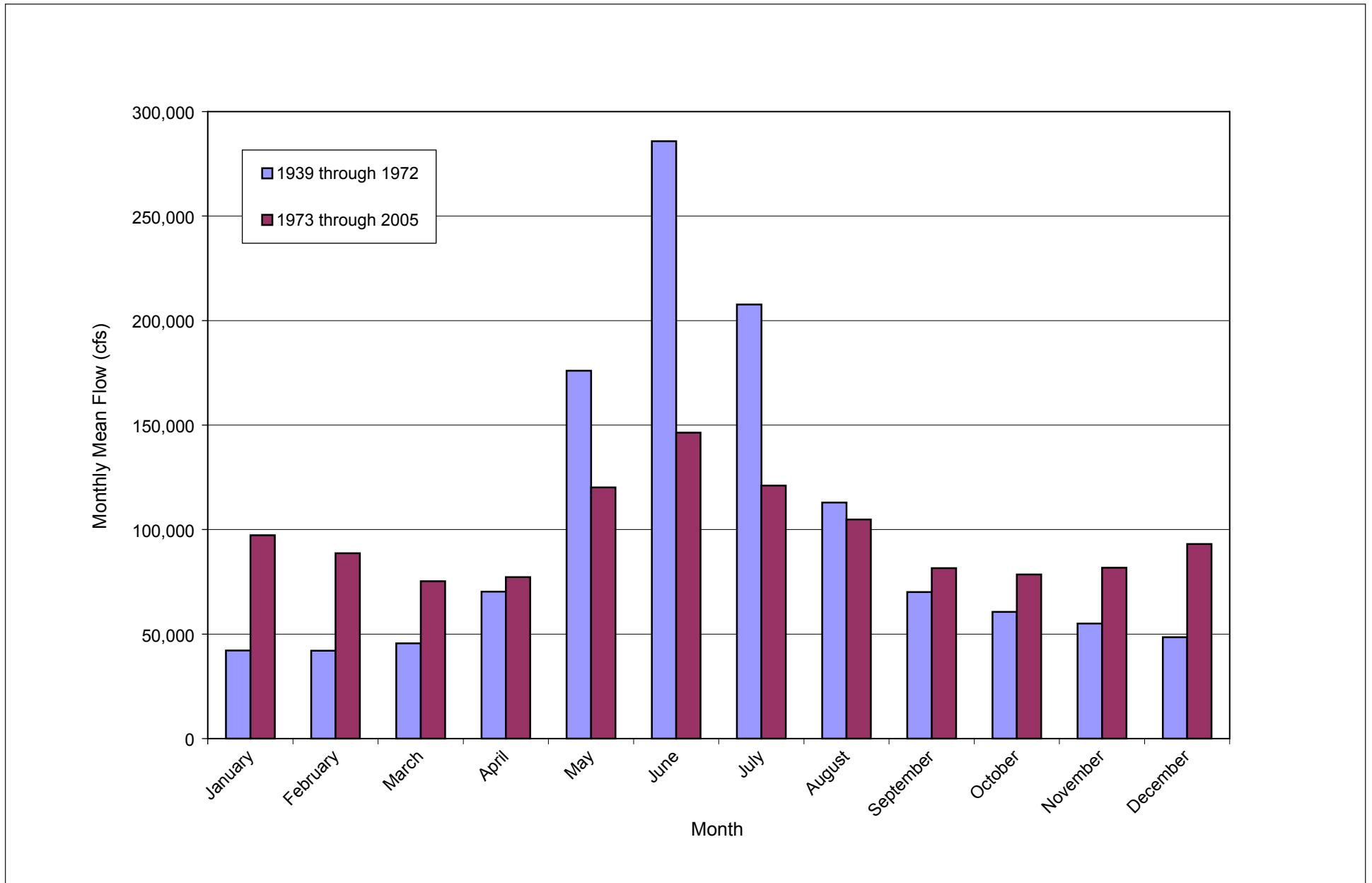


Figure 3-8. Monthly Mean Flow Across the U.S.-Canadian Border for Two Time Intervals as Recorded at USGS Station No. 12399500.

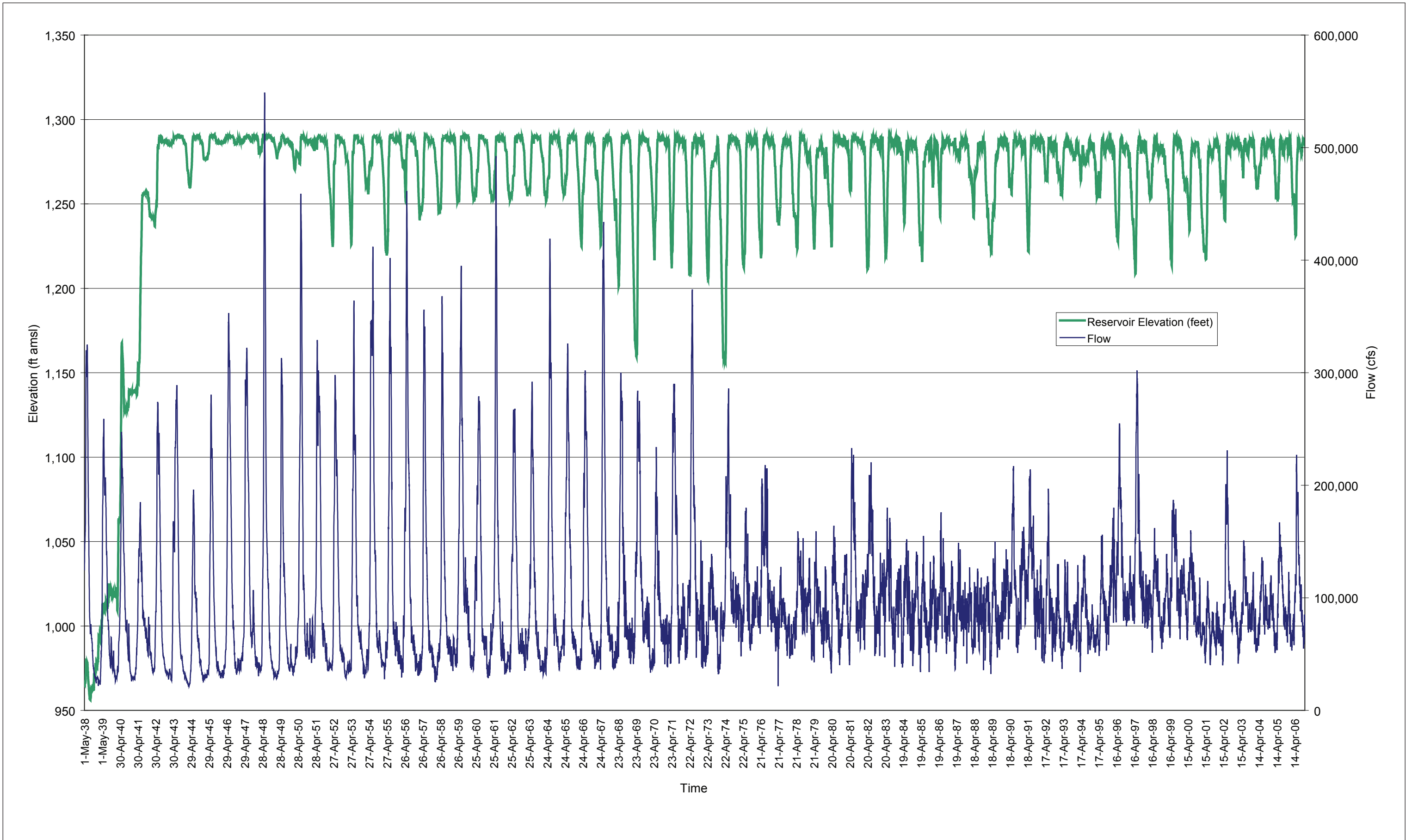


Figure 3-9. Plot of Water Elevation in Lake Roosevelt as a Function of Time.
Notes: Flow recorded at USGS station No. 12399500.
 Water elevation recorded at Grand Coulee.

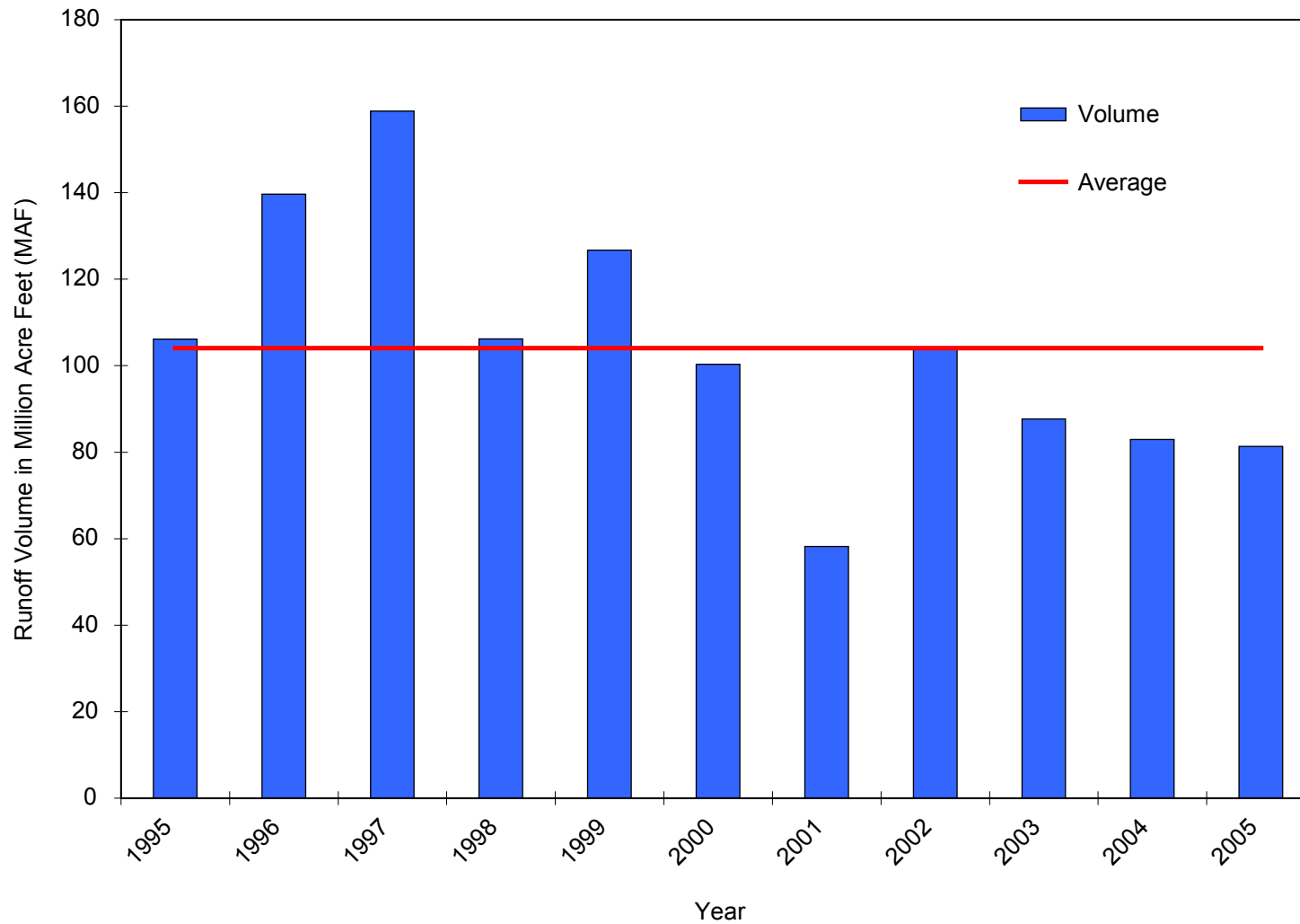


Figure 3-10. Actual January through June Runoff Volume from 1995-2005 at the Dalles, OR Compared to the 1961-2005 Average.

Source: <http://www.cbr.washington.edu/dart/dart.html> (September 2006).

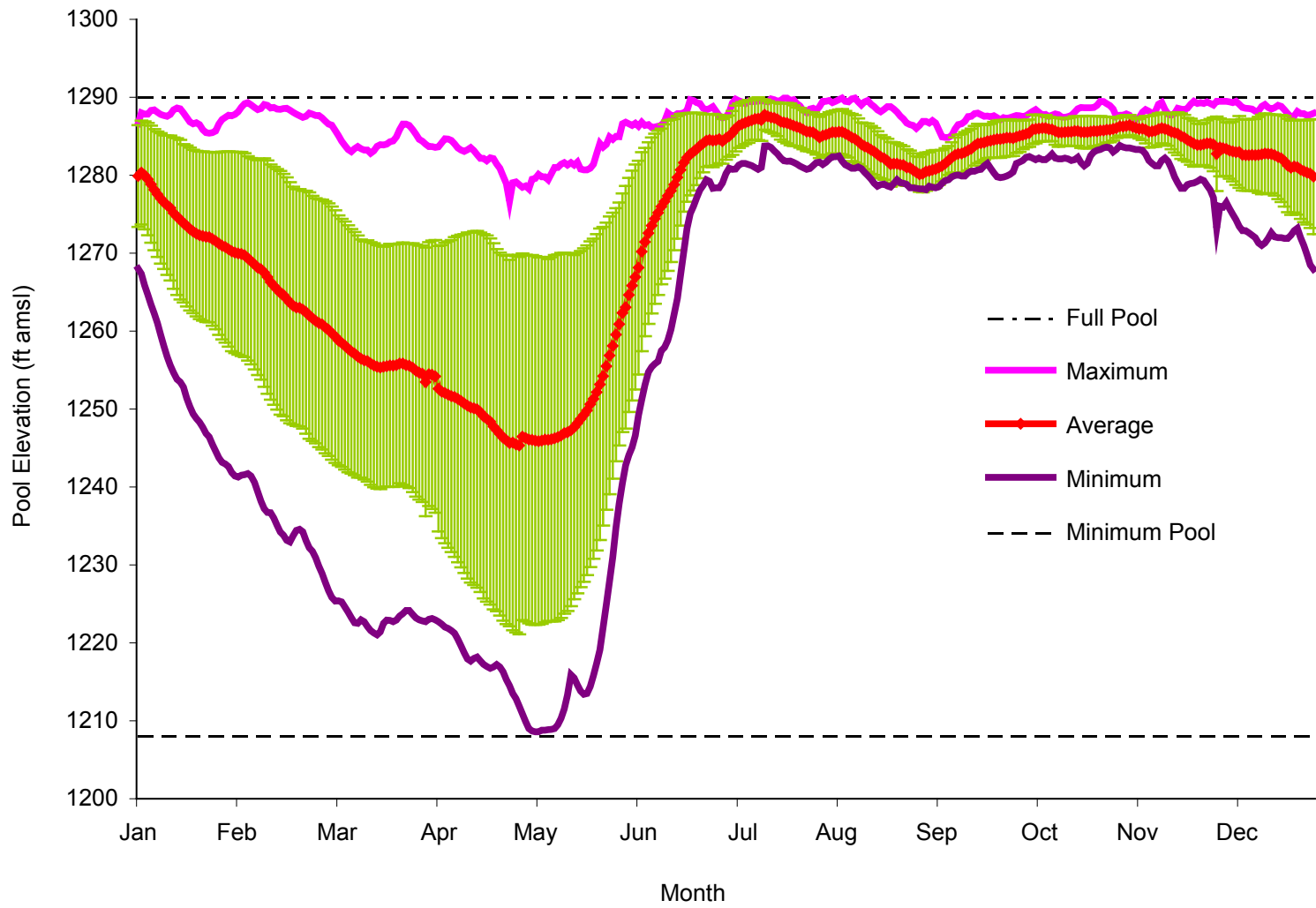


Figure 3-11. Daily Pool Elevations over the Period 1995-2005.
Source: <http://www.cbr.washington.edu/dart/dart.html> (September 2006).
Note: The shaded area around the average represents one standard deviation.

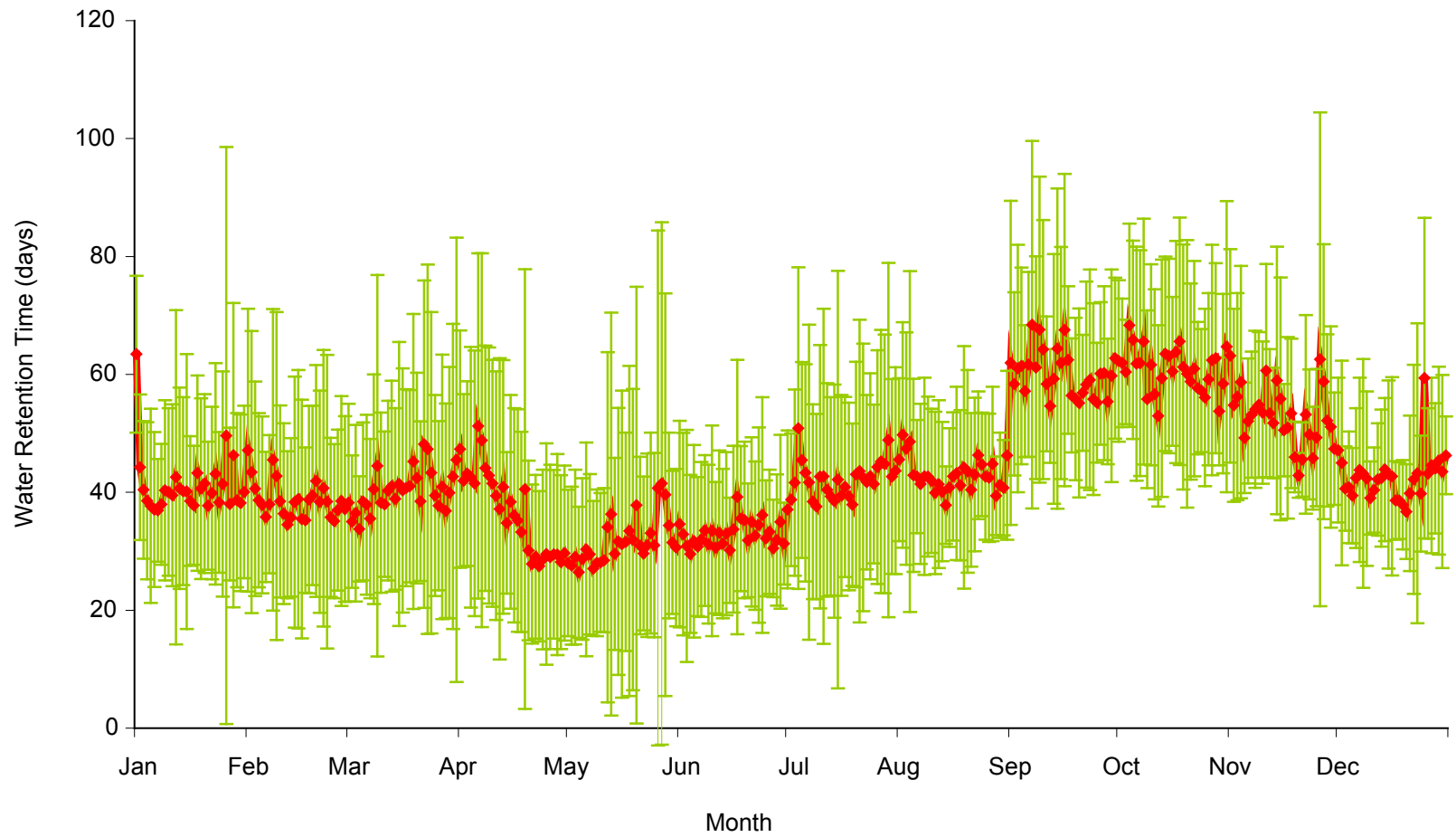
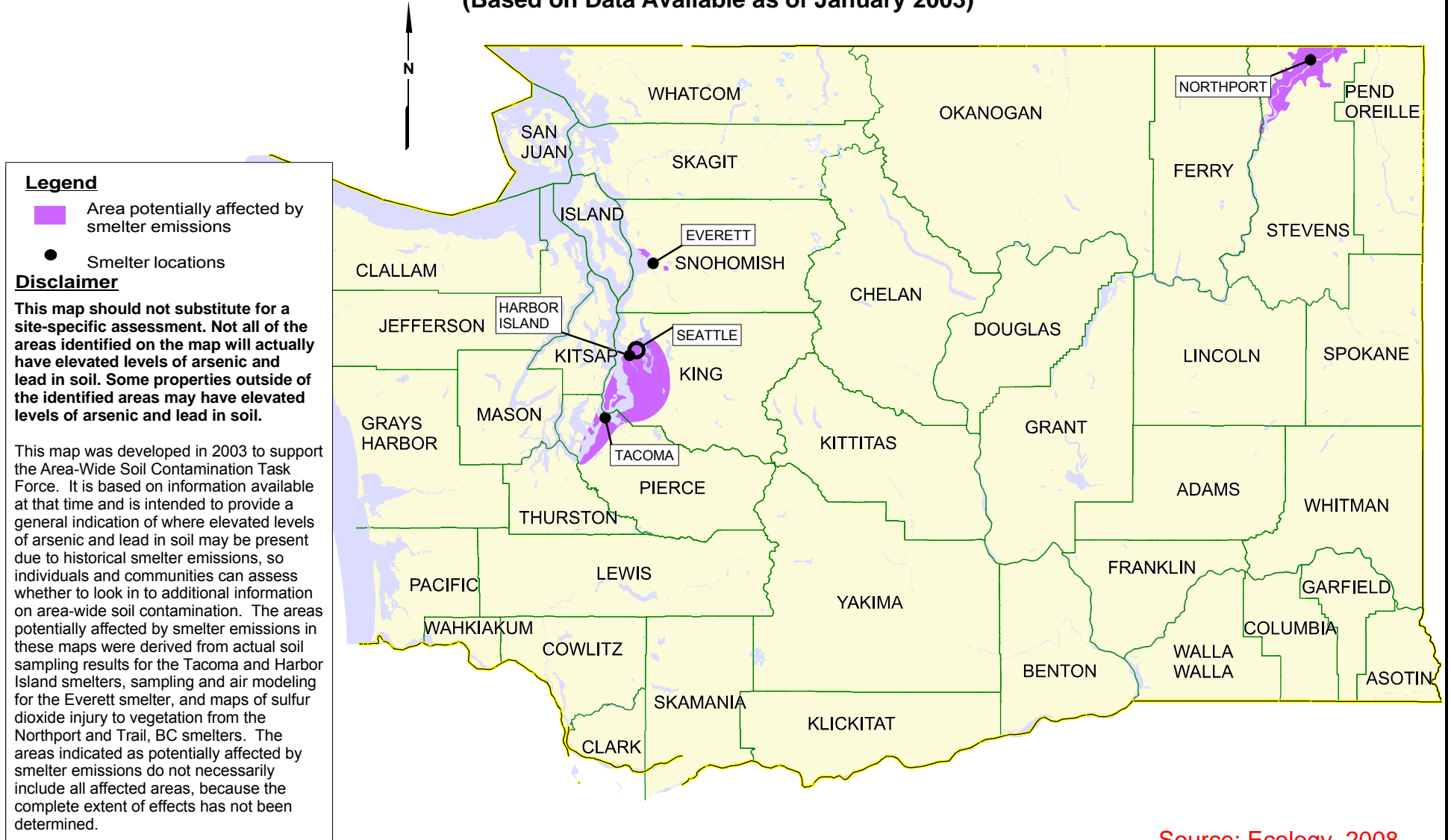


Figure 3-12. Daily Average Lake Roosevelt Water Retention Time Over the Period of 1995-2005.
Source: <http://www.cbr.washington.edu/dart/dart.html> (September 2006).
Note: The shaded area around the average represents one standard deviation.

**Figure 4 - 1 : Estimate of Areas Potentially Affected by Historical Smelter Emissions
(Based on Data Available as of January 2003)**



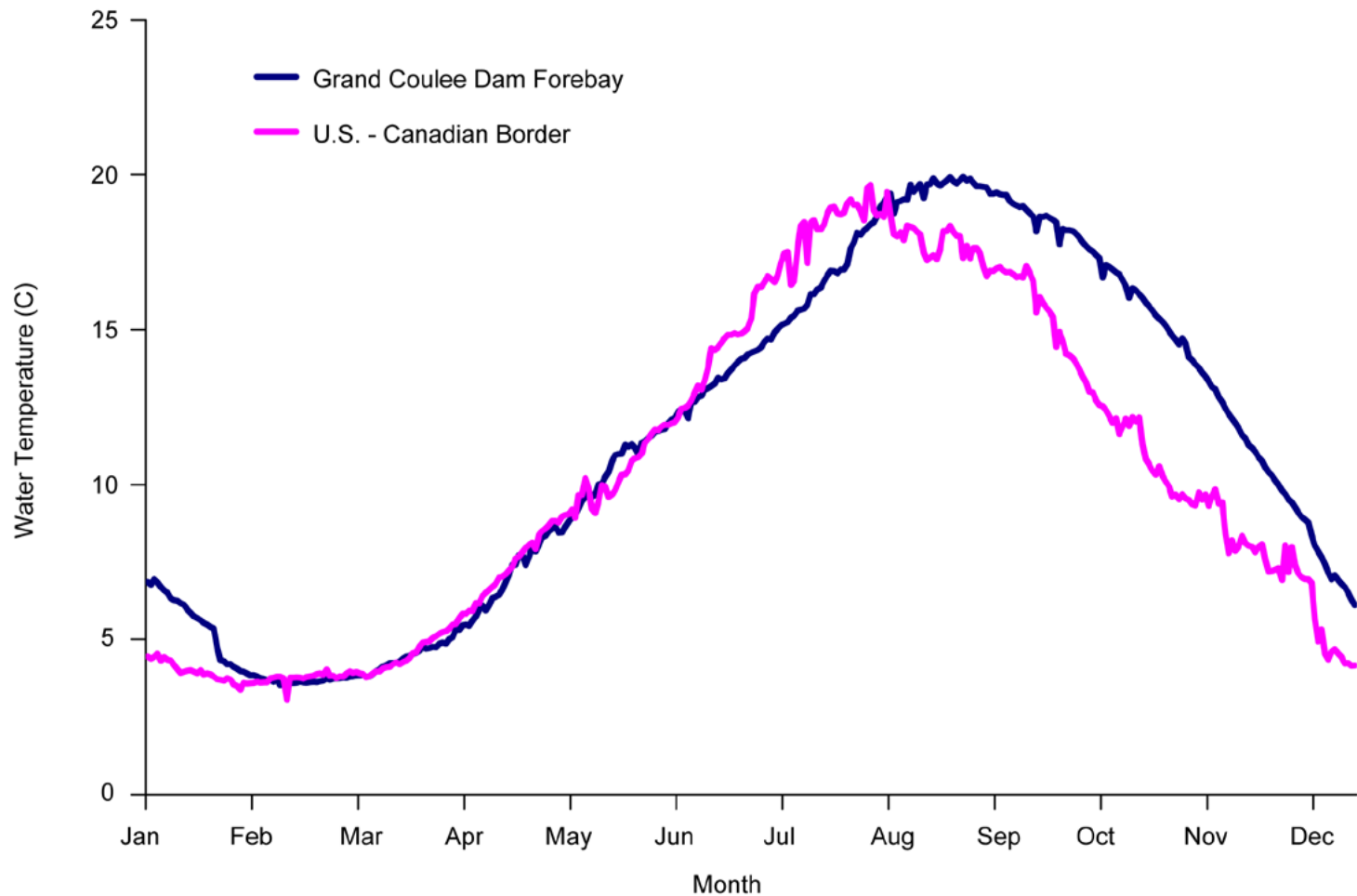


Figure 5-1. Daily Average Water Temperature at the International Border and Grand Coulee Dam Forebay, 1998-2003.

Data Sources: U.S. Army Corps DART (Data Access in Real Time)

<http://www.cqs.washington.edu/dart/dart.html> (September 2006).

Grand Coulee Dam Forebay: Collected by U.S. Army Corps of Engineers, Water Management Division Year-Round Automated Station, RM 596.6 Lat 47°57'24"; Long 118°58'35"; Sensor Depth 15 ft.

U.S.-Canadian Border Boundary: U.S. Army Corps of Engineers, Water Management Division CIBW: Year-Round Automated Station, RM 746 Lat 48°58'16.9"; Long 117°38'44.9"; Sensor Depth 15 ft.

Note: Temperature measurements collected in the forebay are taken at a specific elevation and do not represent the entire water column.

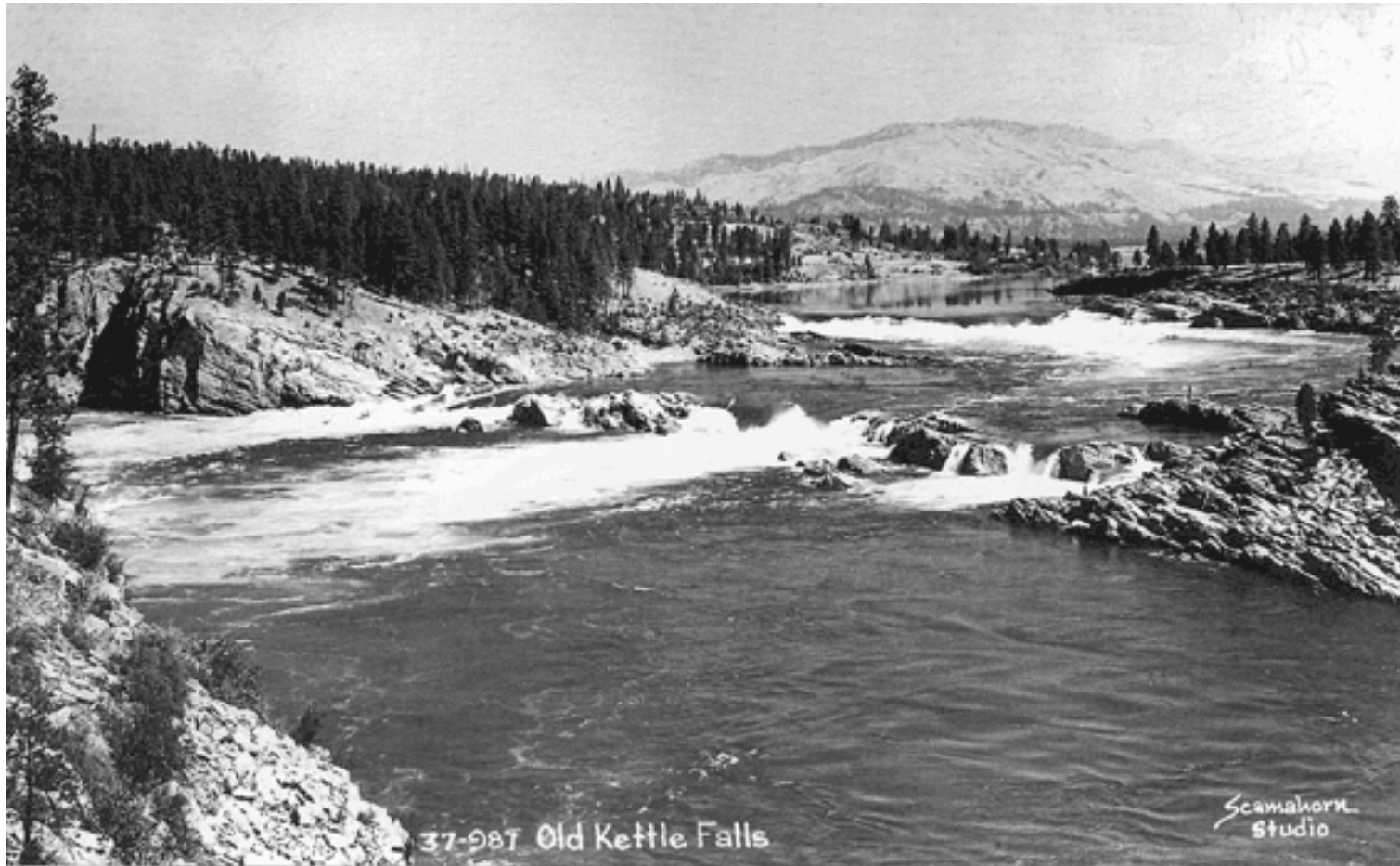


Figure 3-13. Photograph of UCR at Kettle Falls Prior to the Inundation of Lake Roosevelt, circa 1937.
Source: Old Kettle Falls, photo postcard, Scamahorn Studio.

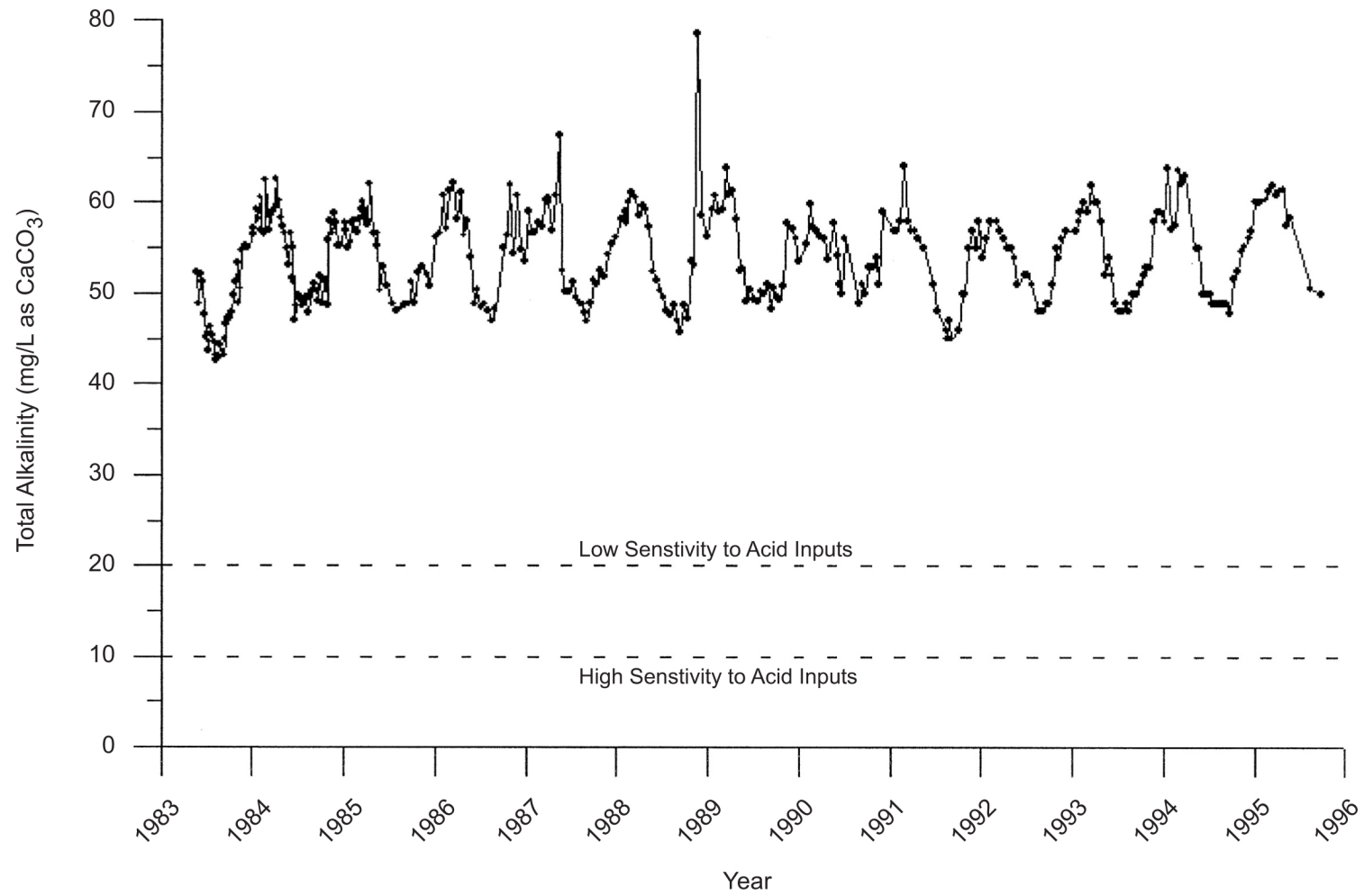


Figure 5-2. Seasonal Alkalinity of Surface Water Samples Collected at the Birchbank Sampling Station BC08NE0005 as Part of the Canada – British Columbia Water Quality Monitoring Agreement, September 1999. **Source:** <http://www.env.gov.bc.ca/wat/wq/quality/birchbank/index.htm>, accessed September 27, 2006.

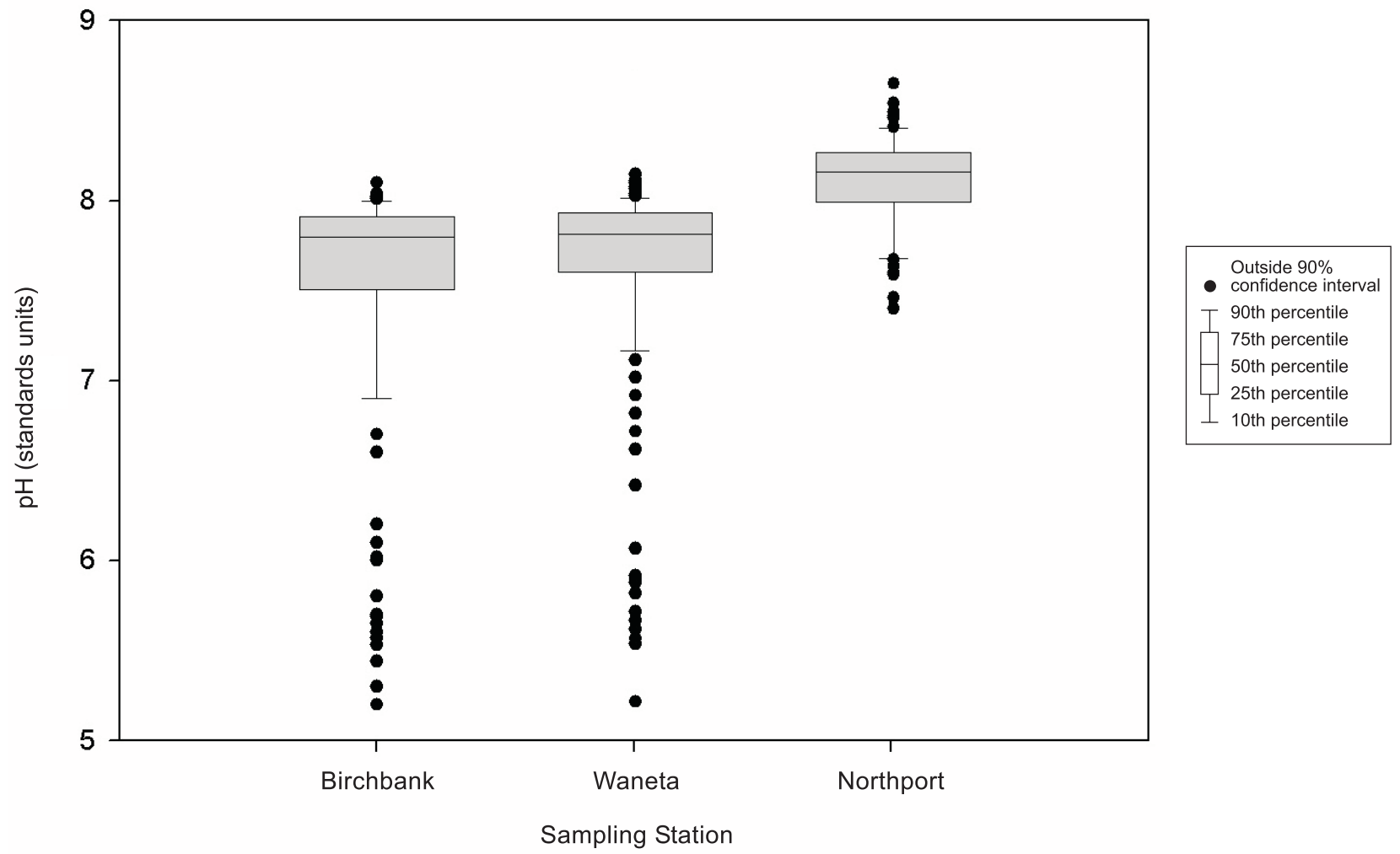


Figure 5-3. Box Plots of Surface Water Sample pH at Birchbank, Waneta, and Northport Sampling Stations in UCR Between 2000 and 2006.
Source: Environment Canada (<http://waterquality.ec.gc.ca>) and USGS (<http://waterdata.usgs.gov/nwis>).

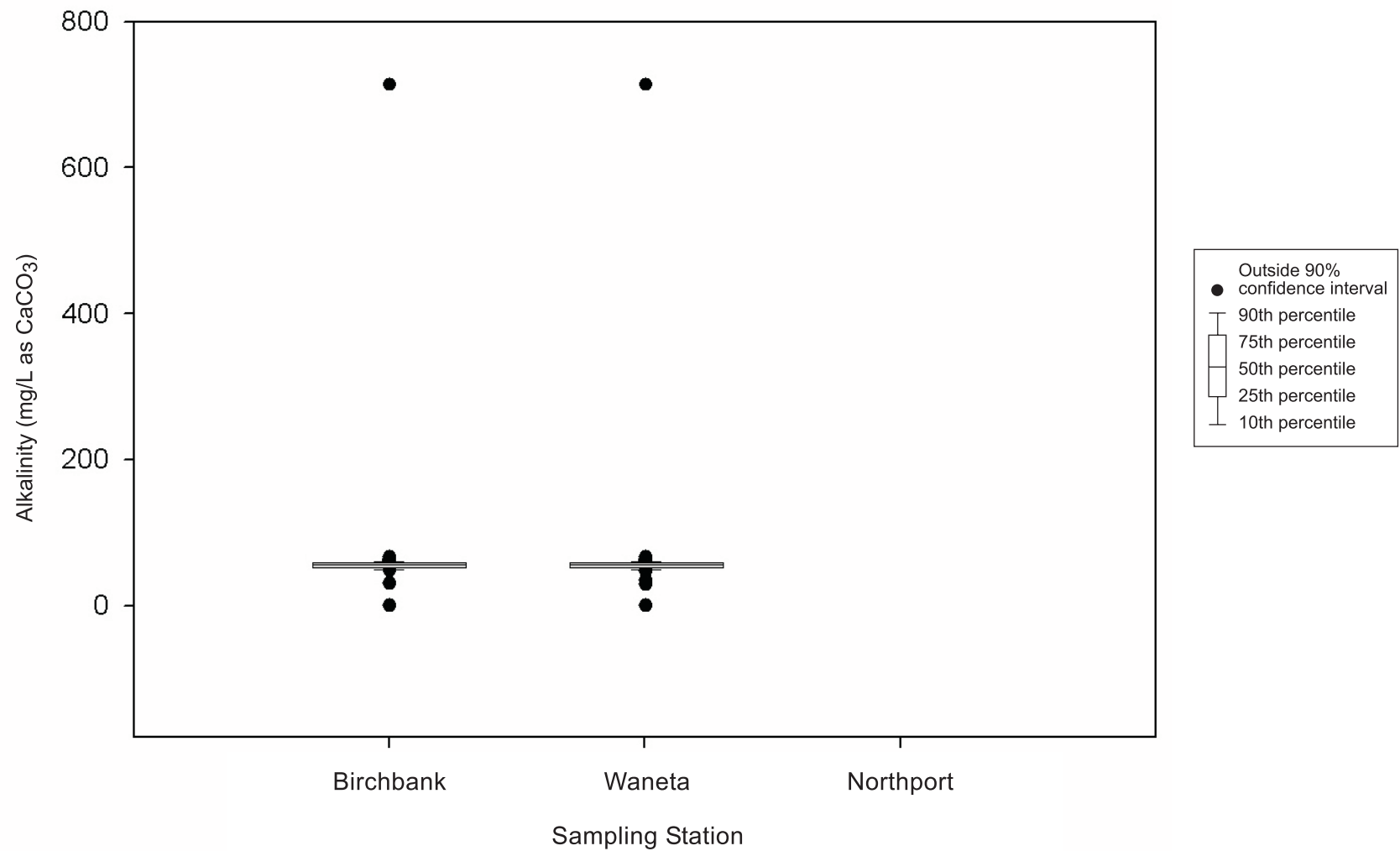


Figure 5-4. Box Plots of Surface Water Sample Alkalinity at Birchbank, Waneta, and Northport Sampling Stations in UCR Between 2000 and 2006.

Source: Environment Canada (<http://waterquality.ec.gc.ca>).

Note: No data were available for the Northport sampling location between 2000 and present.

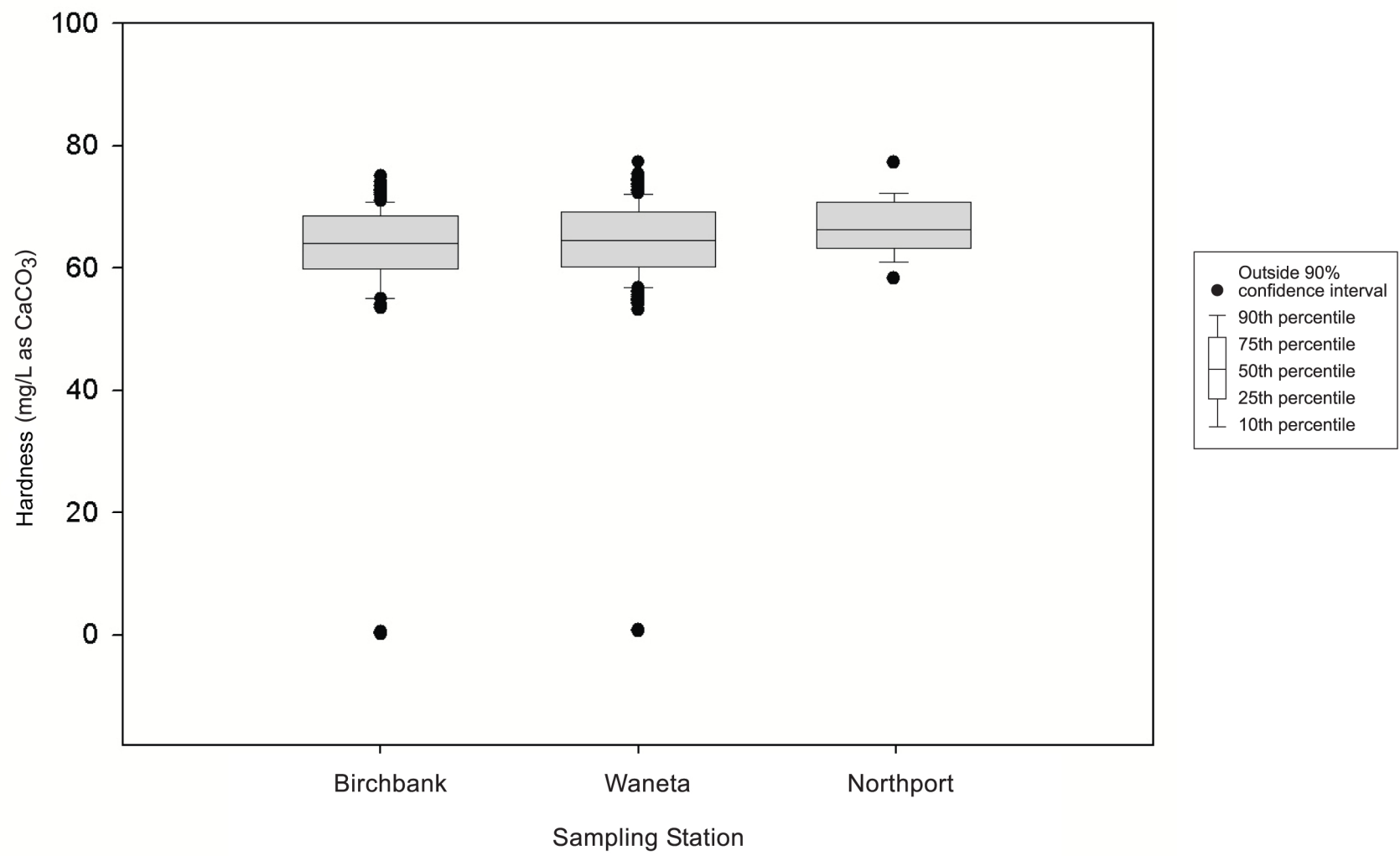


Figure 5-5. Box Plots of Surface Water Sample Hardness at Birchbank, Waneta, and Northport Sampling Stations in UCR Between 2000 and 2006.
Source: Environment Canada (<http://waterquality.ec.gc.ca>) and USGS (<http://waterdata.usgs.gov/nwis>).

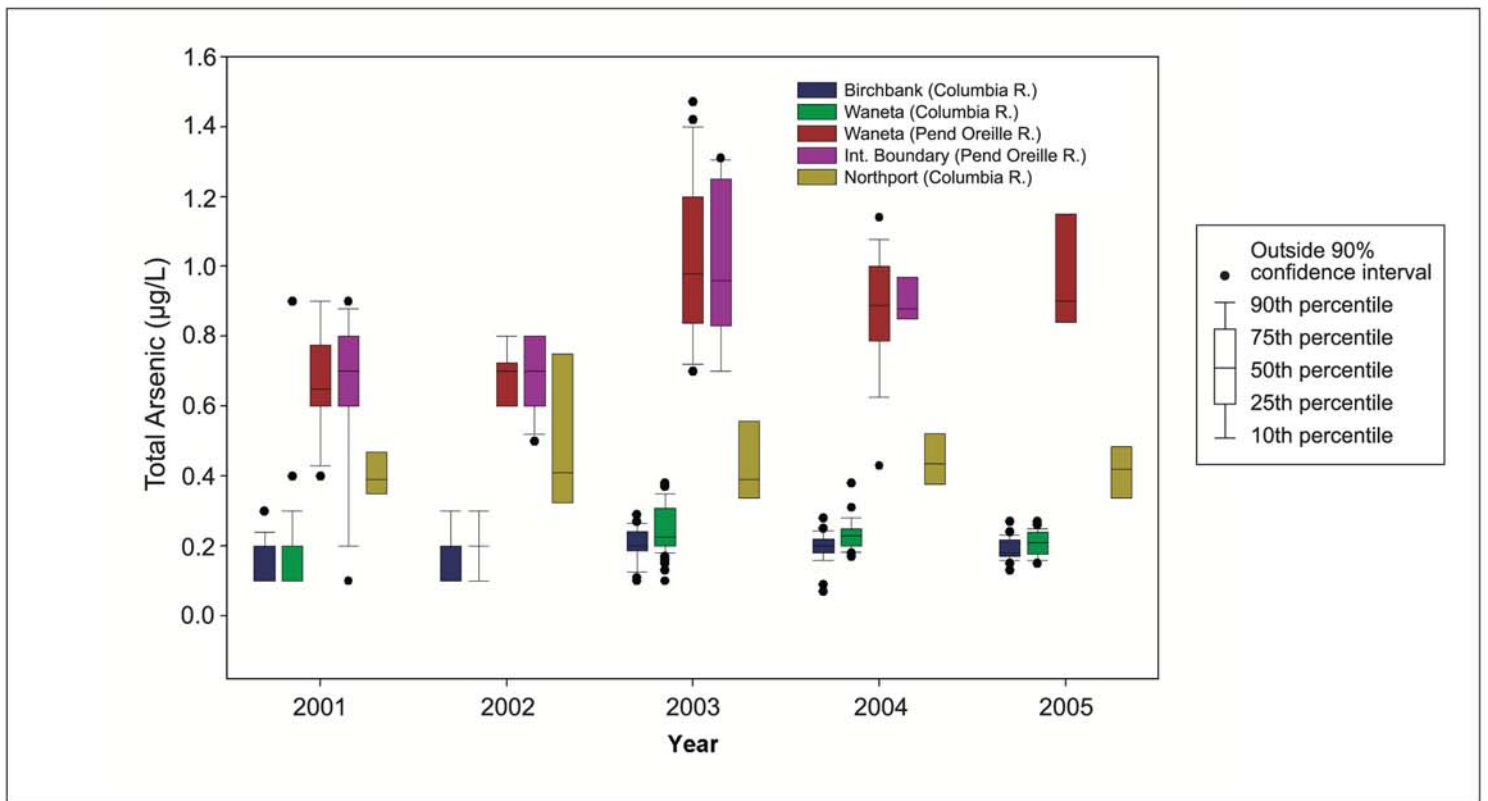


Figure 5-6. Total Arsenic: Comparison of Surface Water Concentrations at Birchbank, Waneta, International Boundary, and Northport (2001-2005).

Source: Environmental Canada (<http://waterquality.ec.gc.ca>), USGS (<http://waterdata.usgs.gov>), and Johnson et al. (1988).

Note: Box plots based only on detected concentrations.

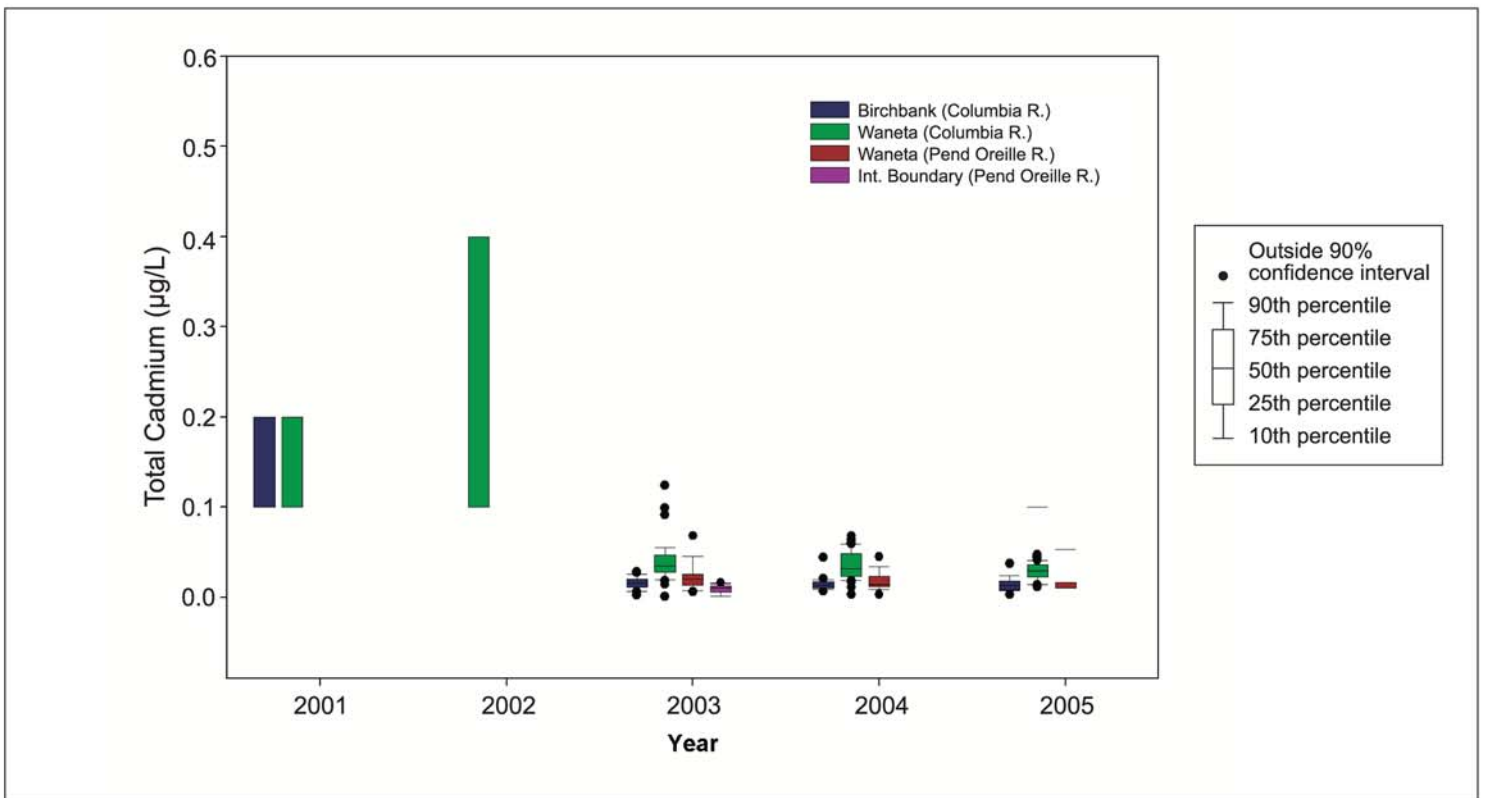


Figure 5-7. Total Cadmium: Comparison of Surface Water Concentrations at Birchbank, Waneta, and International Boundary (2001-2005).

Source: Environmental Canada (<http://waterquality.ec.gc.ca>), USGS (<http://waterdata.usgs.gov>), and Johnson et al. (1988).

Notes: Box plots based only on detected concentrations.

Cadmium was detected in only 1 of 26 samples at Northport from 2001-2005 (detection limit of 0.1 µg/L). Data not available for Pend Oreille in 2001 and 2002.

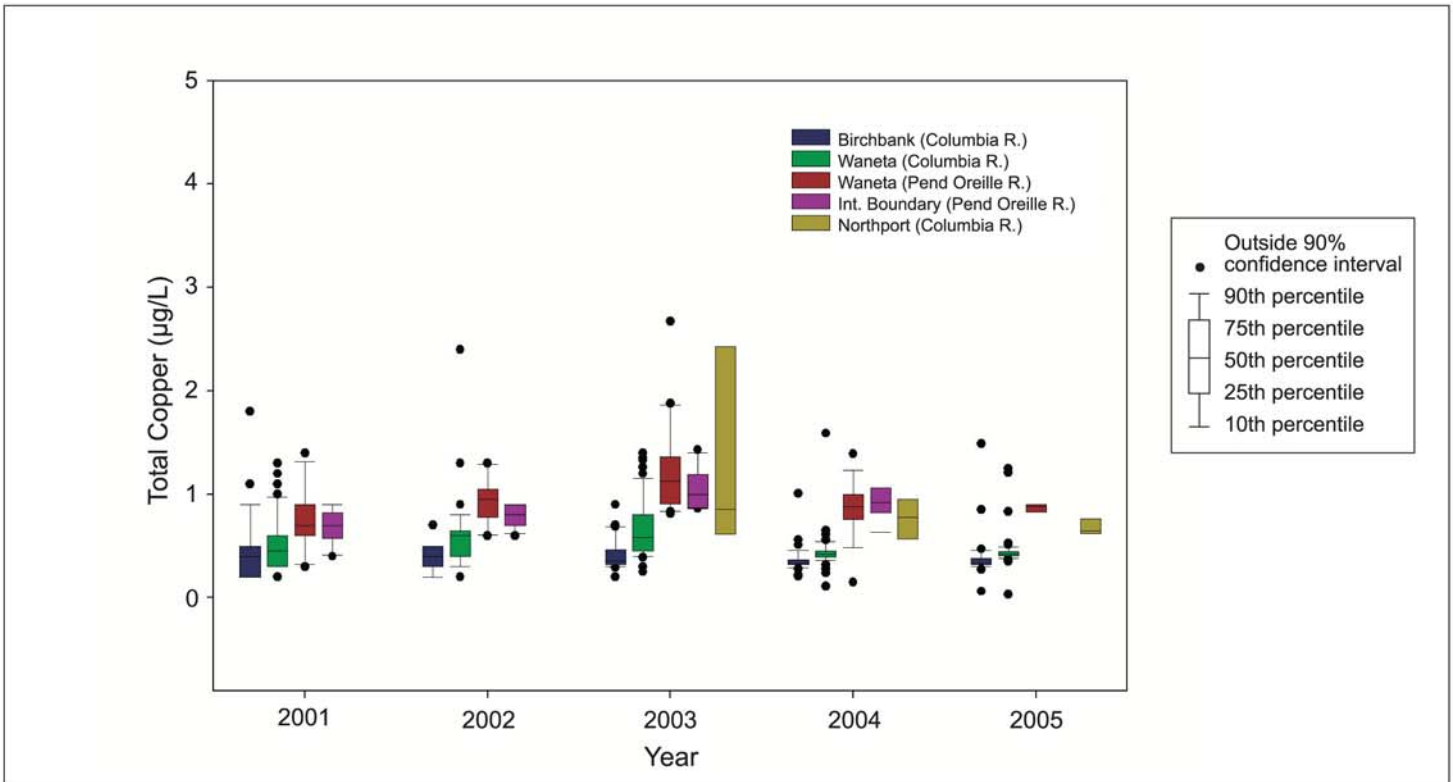


Figure 5-8. Total Copper: Comparison of Surface Water Concentrations at Birchbank, Waneta, International Boundary, and Northport (2001-2005).

Source: Environment Canada (<http://waterquality.ec.gc.ca>), USGS (<http://waterdata.usgs.gov>), and Johnson et al. (1988).

Notes: Box plots based only on detected concentrations.

Copper was not detected at Northport in 2001 and only twice in 2002 (0.49 and 0.78 µg/L).

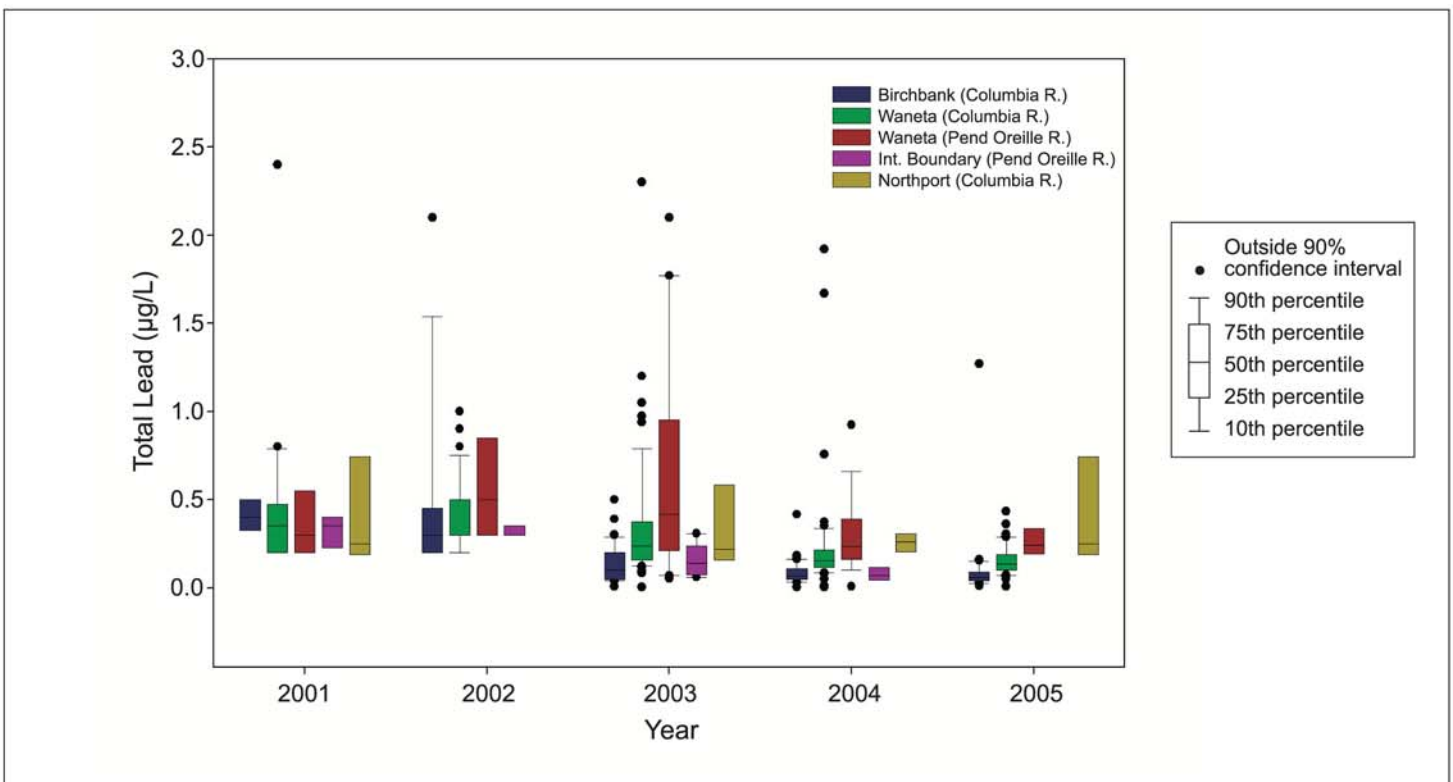


Figure 5-9. Total Lead: Comparison of Surface Water Concentrations at Birchbank, Waneta, International Boundary, and Northport (2001-2005).

Source: Environment Canada (<http://waterquality.ec.gc.ca>), USGS (<http://waterdata.usgs.gov>), and Johnson et al. (1988).

Note: Box plots based only on detected concentrations.

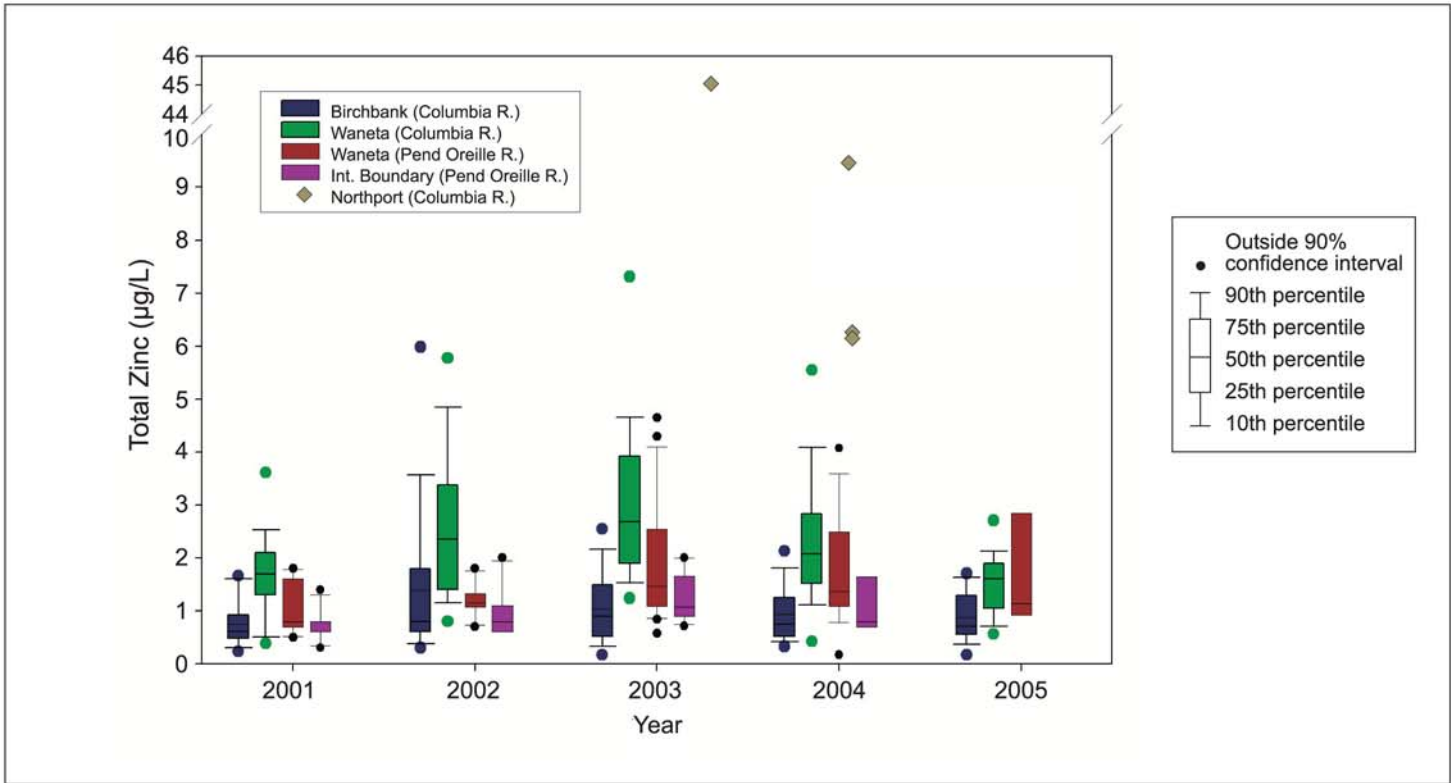


Figure 5-10. Total Zinc: Comparison of Surface Water Concentrations at Birchbank, Waneta, International Boundary, and Northport (2001-2005).

Source: Environment Canada (<http://waterquality.ec.gc.ca>), USGS (<http://waterdata.usgs.gov>), and Johnson et al. (1988).

Notes: Zinc was infrequently detected at Northport at a detection limit of 5 µg/L. Detected concentrations are shown as individual points. Box plots based only on detected concentrations.

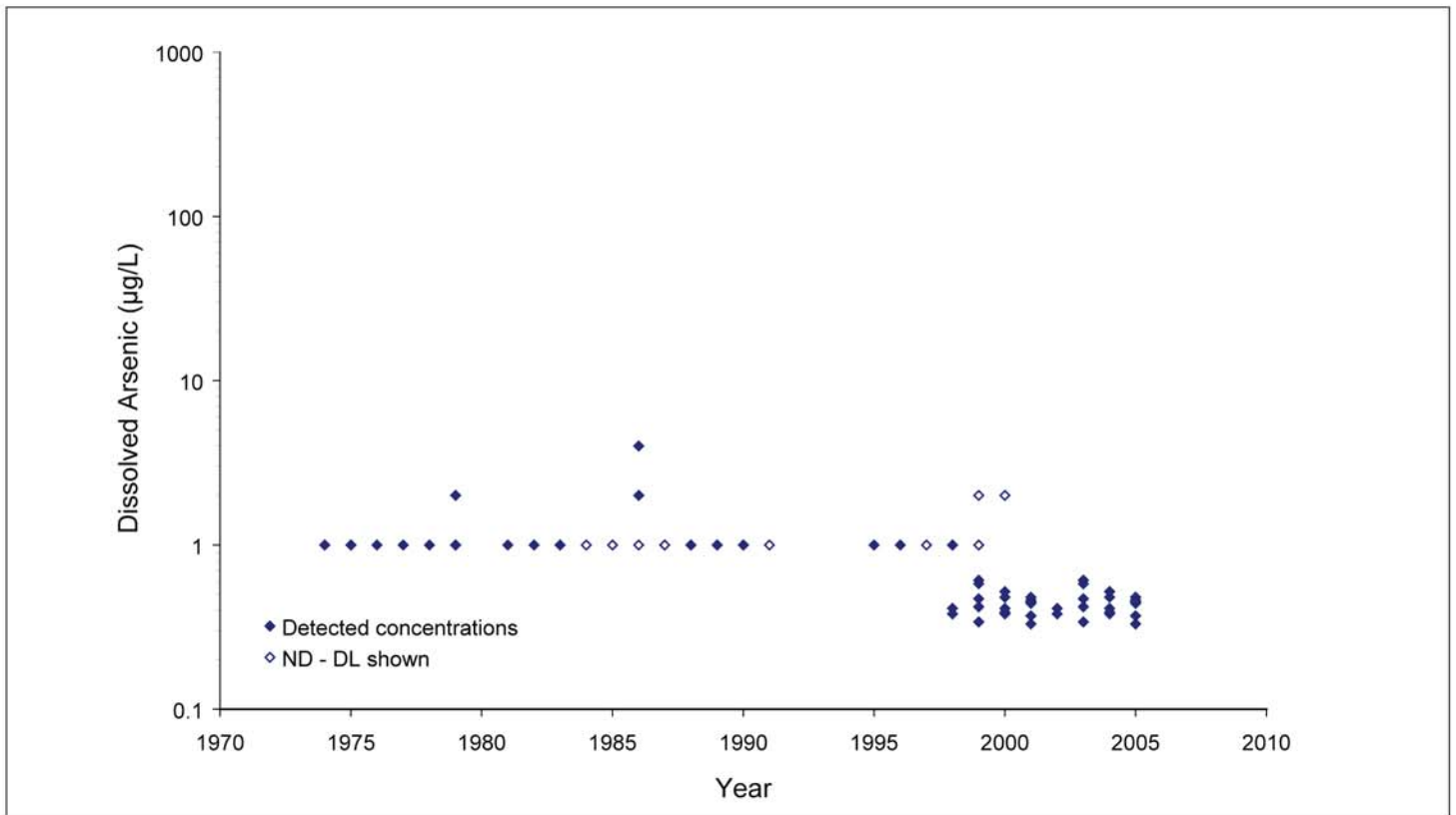


Figure 5-11. Northport: Dissolved Arsenic Concentrations in Surface Water.
Source: USGS (<http://waterdata.usgs.gov>) and Johnson et al. (1988).
Note: Detection limits shown typically reflect several samples collected in the same year.

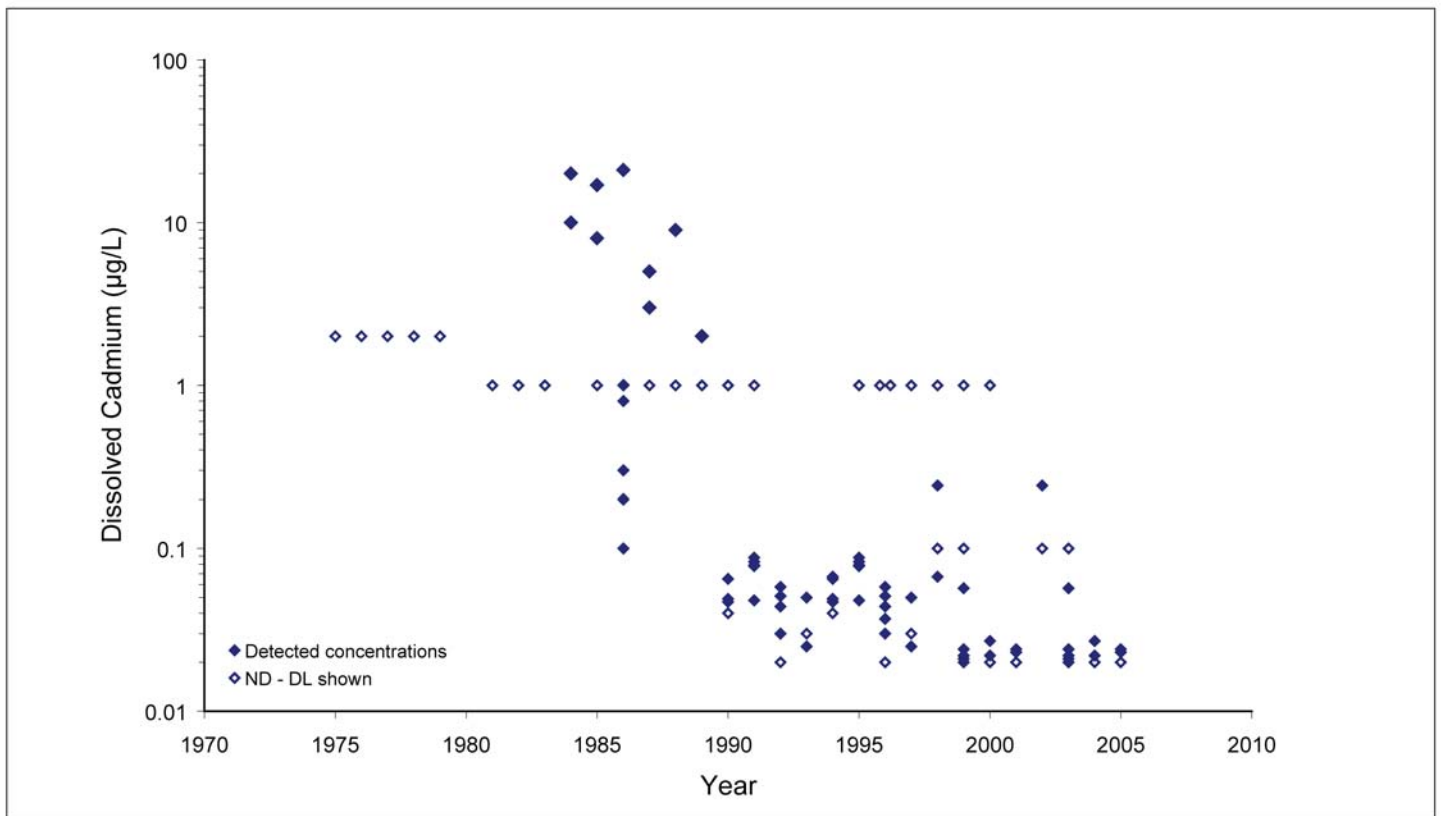


Figure 5-12. Northport: Dissolved Cadmium Concentrations in Surface Water.
Source: USGS (<http://waterdata.usgs.gov>) and Johnson et al. (1988).
Note: Detection limits shown typically reflect several samples collected in the same year.

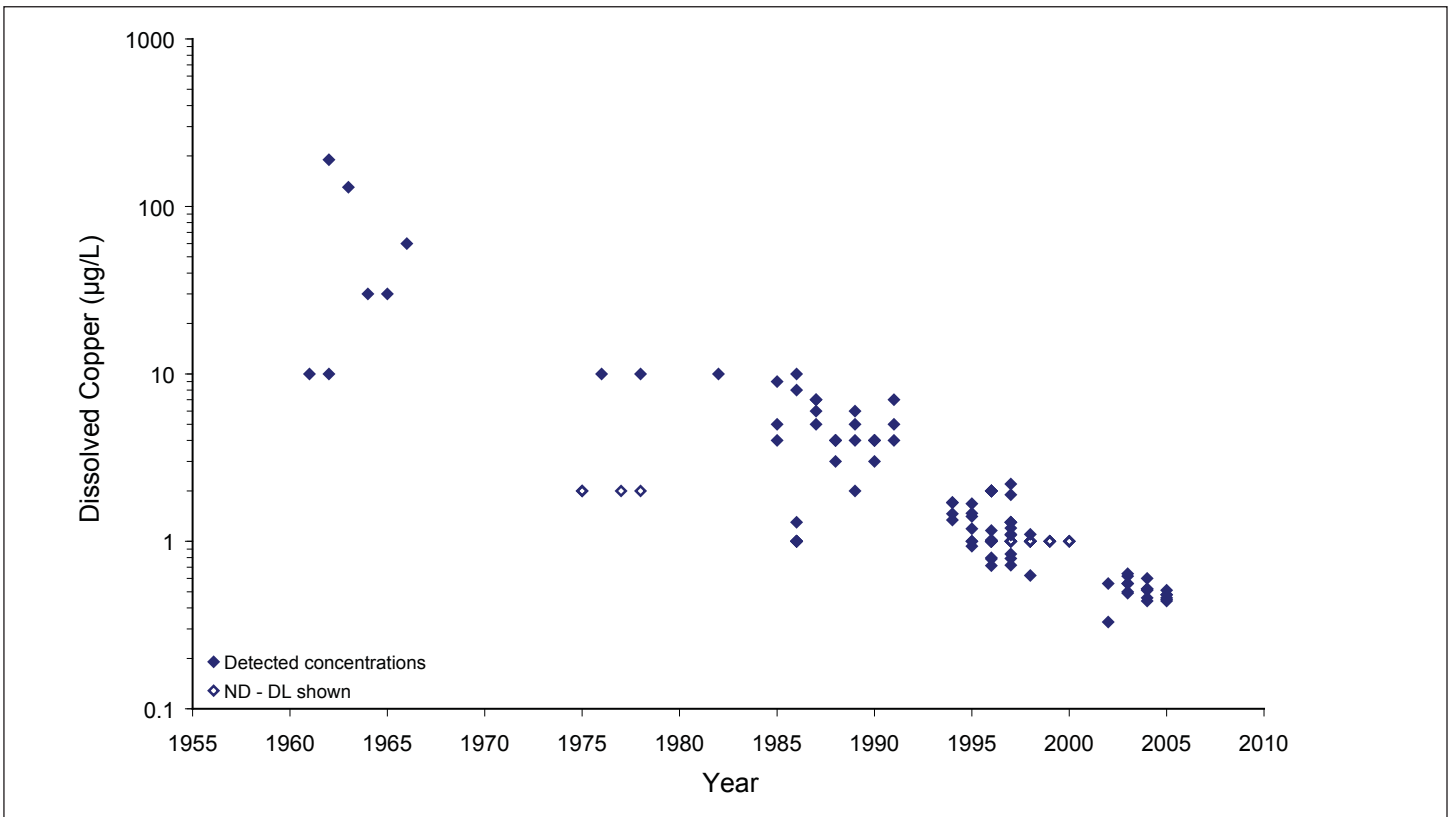


Figure 5-13. Northport: Dissolved Copper Concentrations in Surface Water.
Source: USGS (<http://waterdata.usgs.gov>) and Johnson (1988).
Note: Detection limits shown typically reflect several samples collected in the same year.

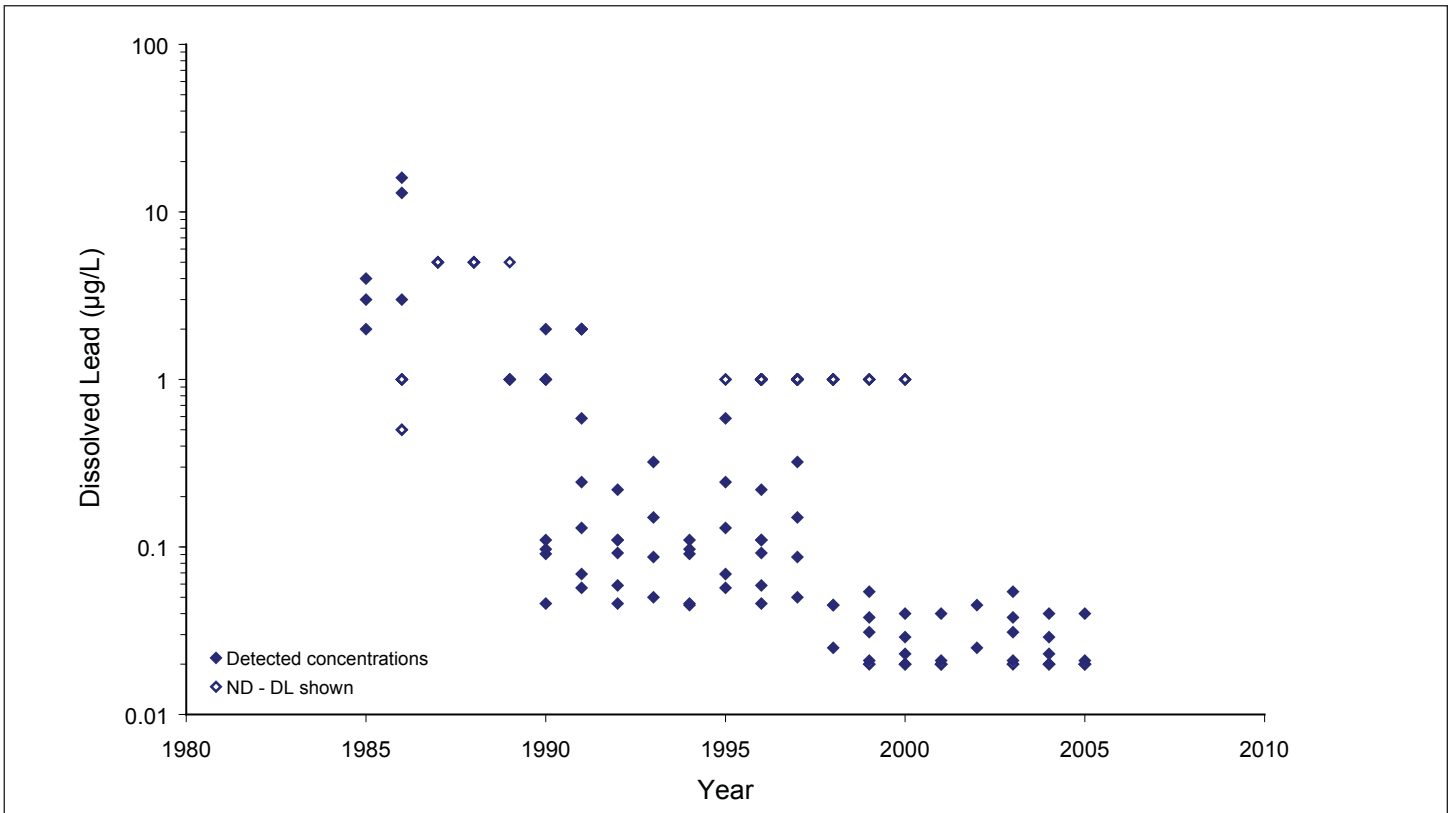


Figure 5-14. Northport: Dissolved Lead Concentrations in Surface Water.
Source: USGS (<http://waterdata.usgs.gov>) and Johnson (1988).
Note: Detection limits shown typically reflect several samples collected in the same year.

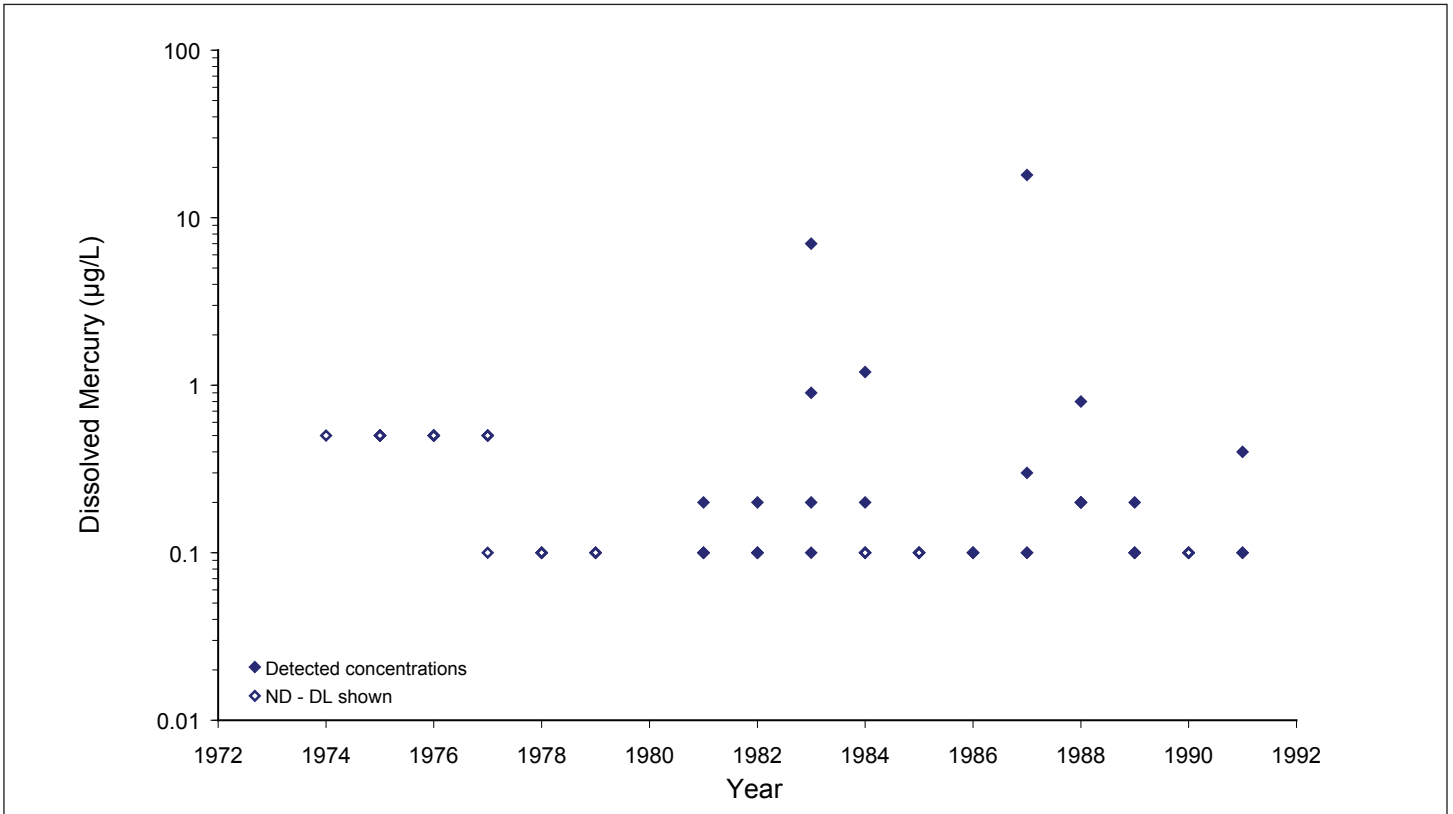


Figure 5-15. Northport: Dissolved Mercury Concentrations in Surface Water.

Source: USGS (<http://waterdata.usgs.gov>) and Johnson (1988).

Note: Detection limits shown typically reflect several samples collected in the same year.

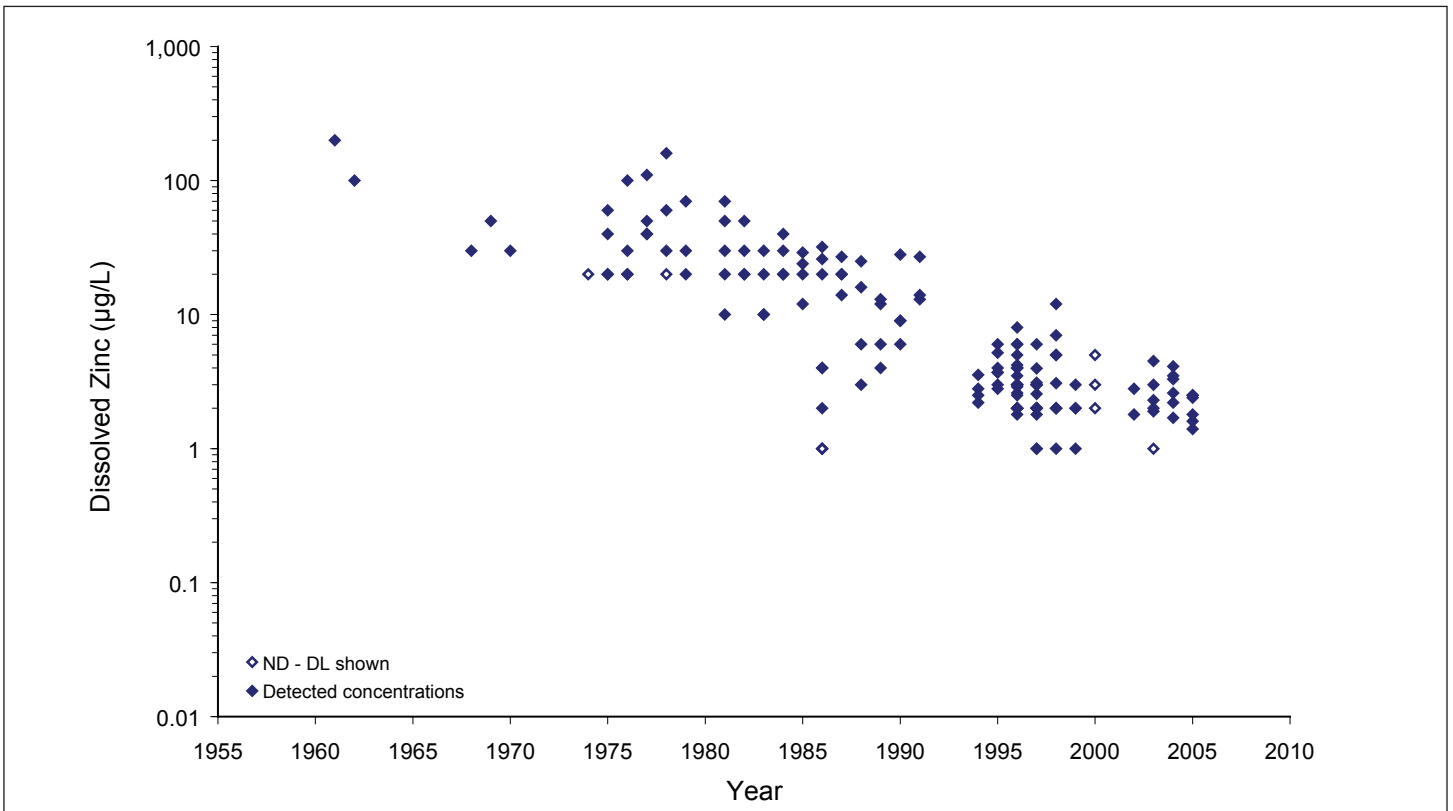


Figure 5-16. Northport: Dissolved Zinc Concentrations in Surface Water.

Source: USGS (<http://waterdata.usgs.gov>) and Johnson (1988).

Note: Detection limits shown typically reflect several samples collected in the same year.

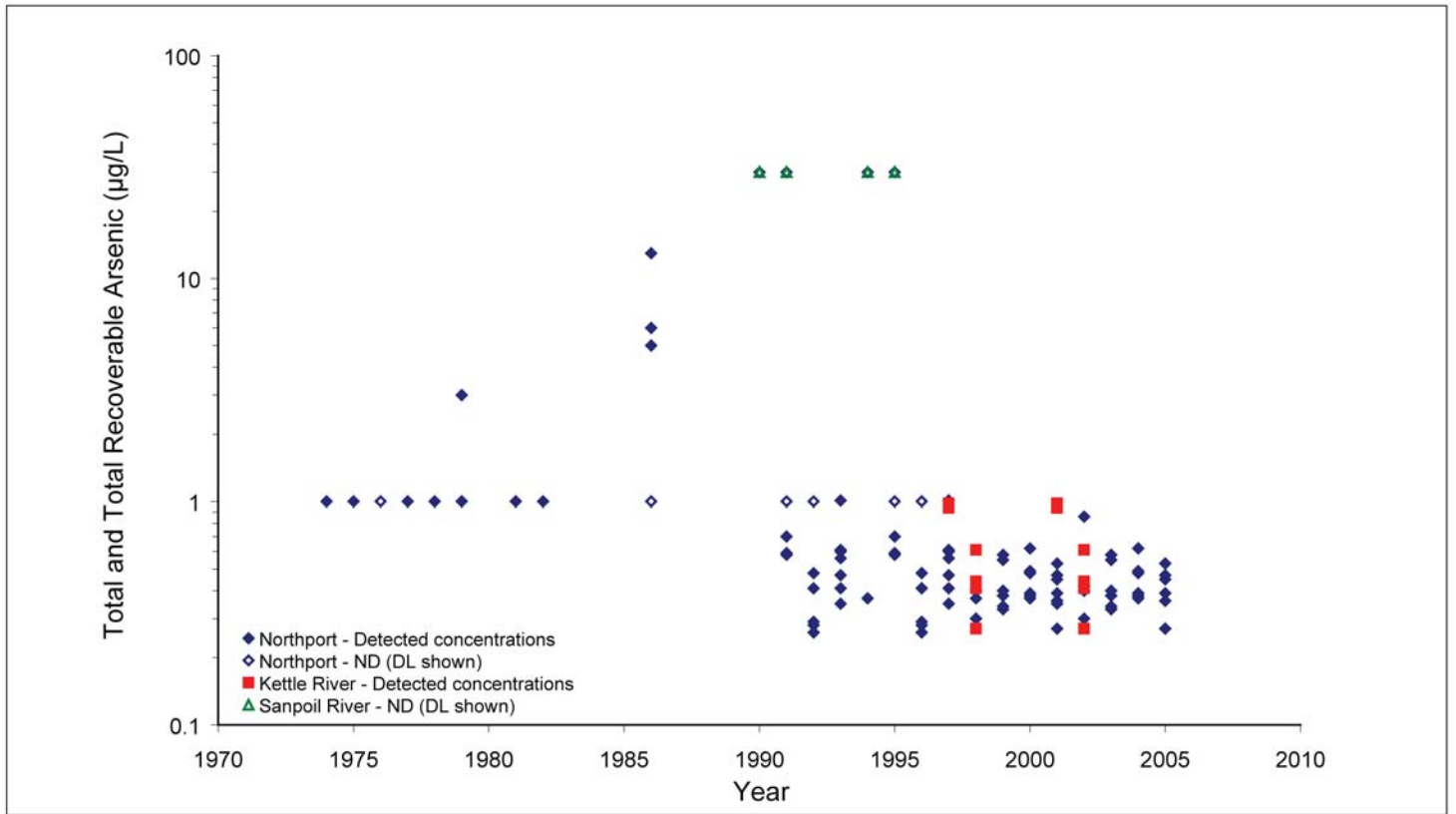


Figure 5-17. Combined UCR and Tributary Stations: Total and Total Recoverable Arsenic Concentrations in Surface Water.

Source: USGS (<http://waterdata.usgs.gov>), Johnson et al. (1988), and Ecology (<http://apps.ecy.wa.gov/eimreporting>).

Note: Detection limits shown typically reflect several samples collected in the same year.

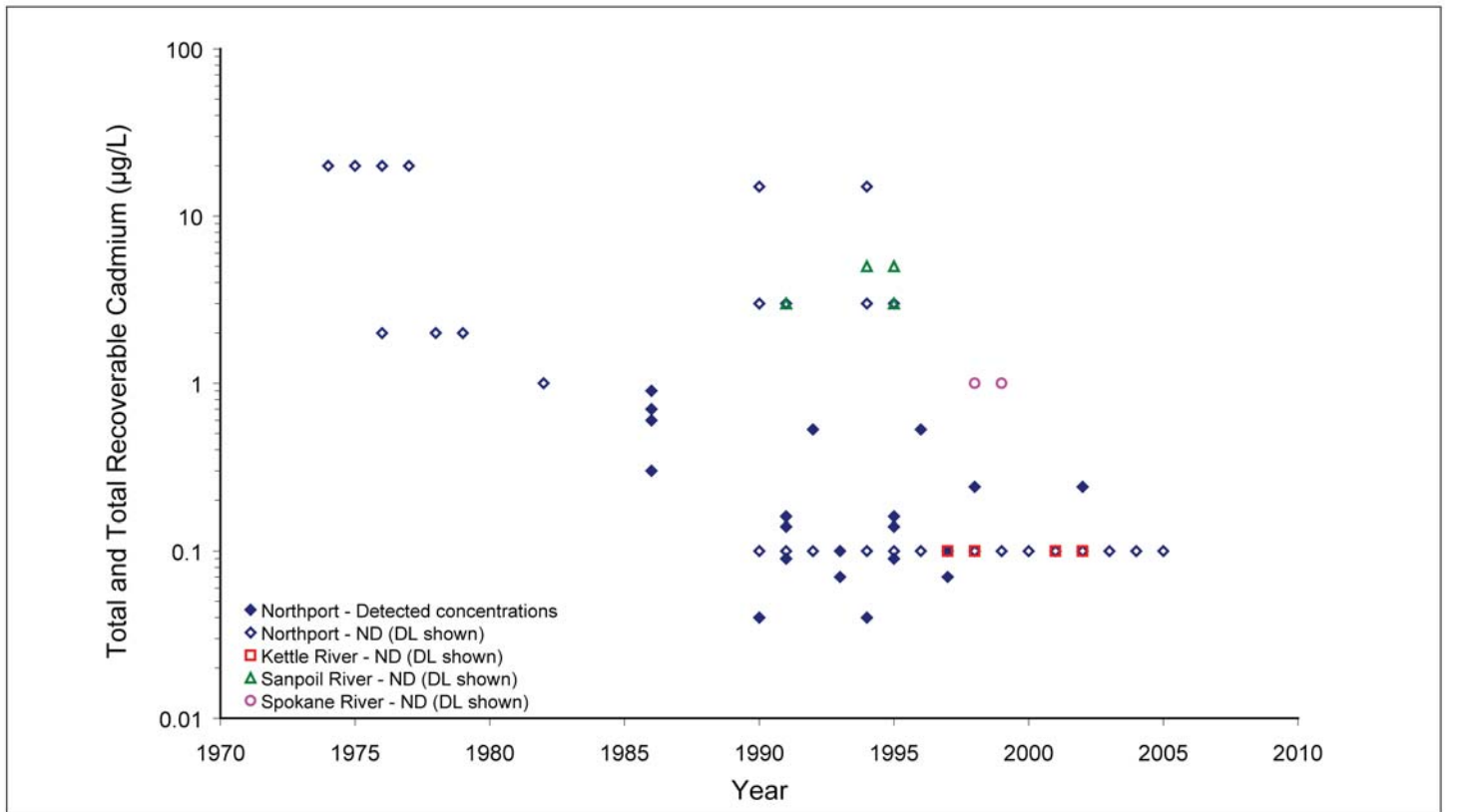


Figure 5-18. Combined UCR and Tributary Stations: Total and Total Recoverable Cadmium Concentrations in Surface Water.

Source: USGS (<http://waterdata.usgs.gov>), Johnson et al. (1988), Ecology (<http://apps.ecy.wa.gov/eimreporting>), and USEPA (<http://www.epa.gov/storpubl/legacy/gateway>).

Note: Detection limits shown typically reflect several samples collected in the same year.

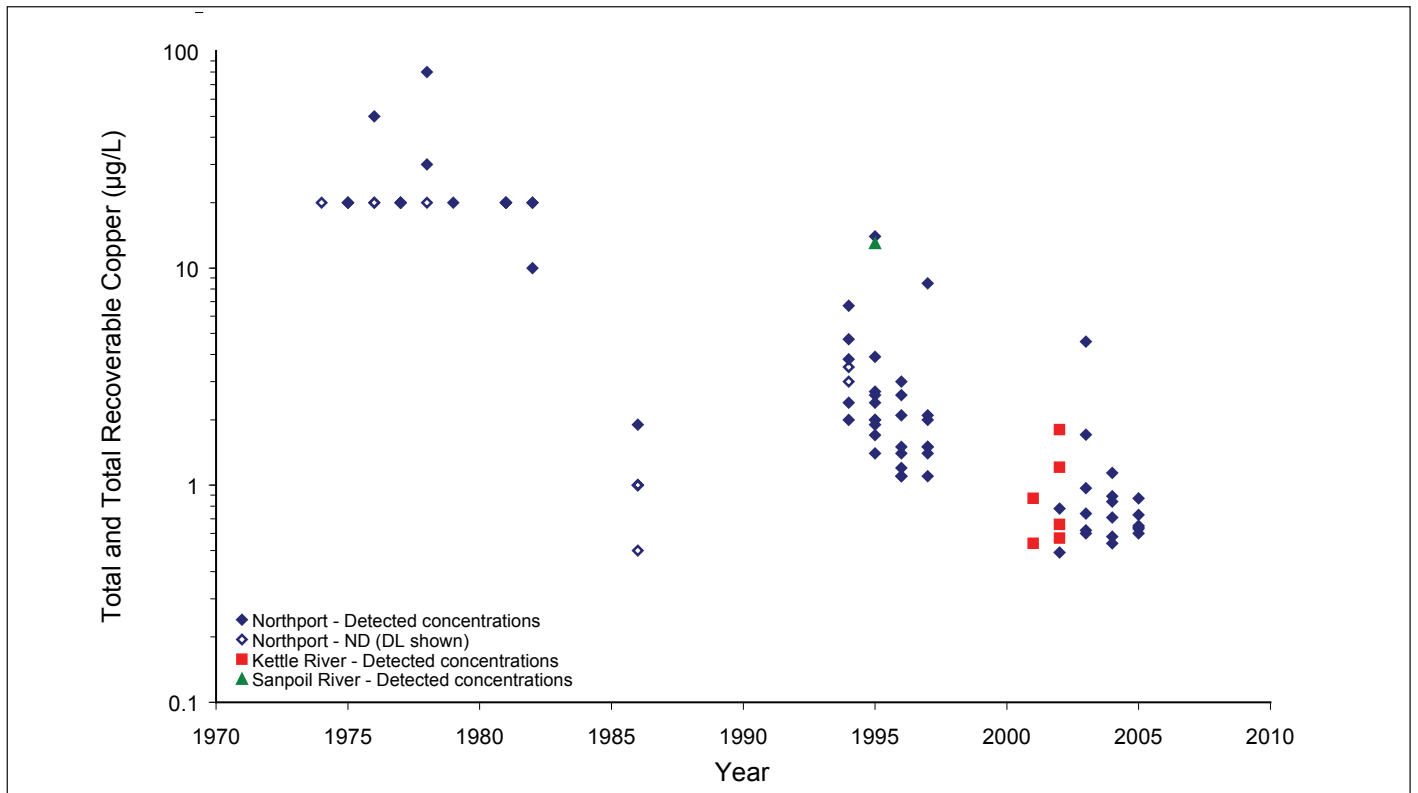


Figure 5-19. Combined UCR and Tributary Stations: Total and Total Recoverable Copper Concentrations in Surface Water.

Source: USGS (<http://waterdata.usgs.gov>), Johnson (1988), and Ecology (<http://apps.ecy.wa.gov/eimreporting>).

Note: Detection limits shown typically reflect several samples collected in the same year.

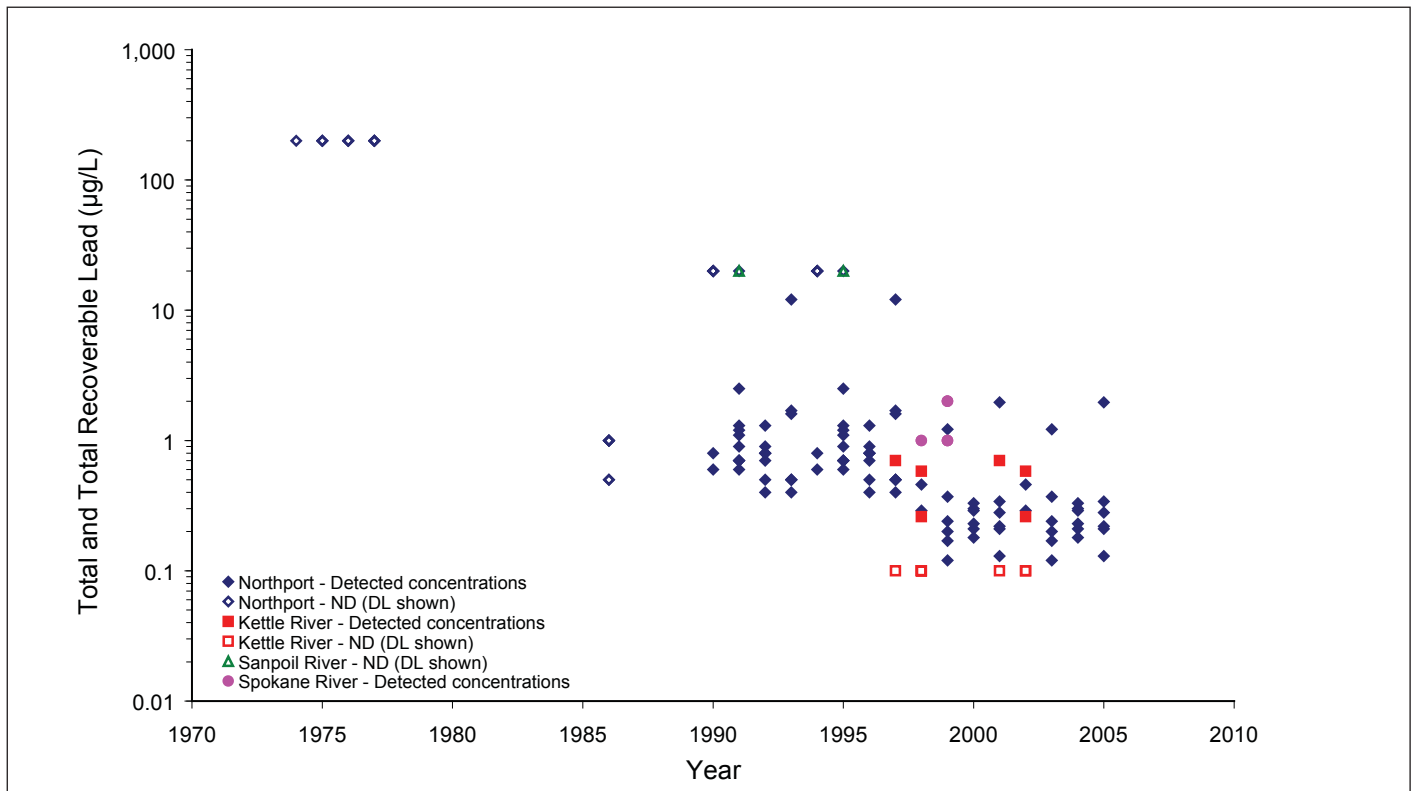


Figure 5-20. Combined UCR and Tributary Stations: Total and Total Recoverable Lead Concentrations in Surface Water.

Source: USGS (<http://waterdata.usgs.gov>), Johnson (1988), Ecology (<http://apps.ecy.wa.gov/eimreporting>) URS (2003), and USEPA (<http://www.epa.gov/storpubl/legacy/gateway>).

Note: Detection limits shown typically reflect several samples collected in the same year.

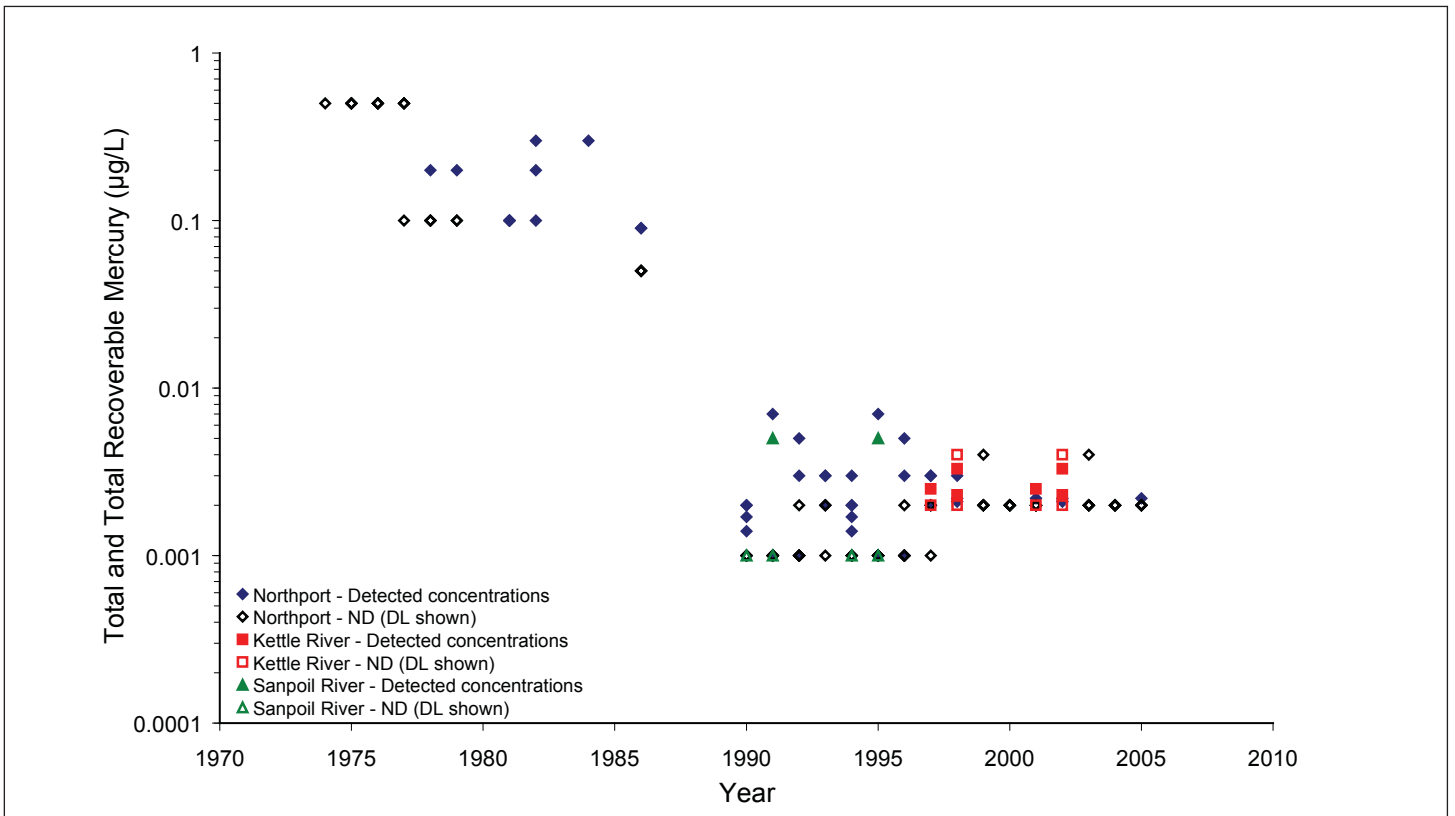


Figure 5-21. Combined UCR and Tributary Stations: Total and Total Recoverable Mercury Concentrations in Surface Water.

Source: USGS (<http://waterdata.usgs.gov>), Johnson (1988), and Ecology (<http://apps.ecy.wa.gov/eimreporting>).

Note: Detection limits shown typically reflect several samples collected in the same year.

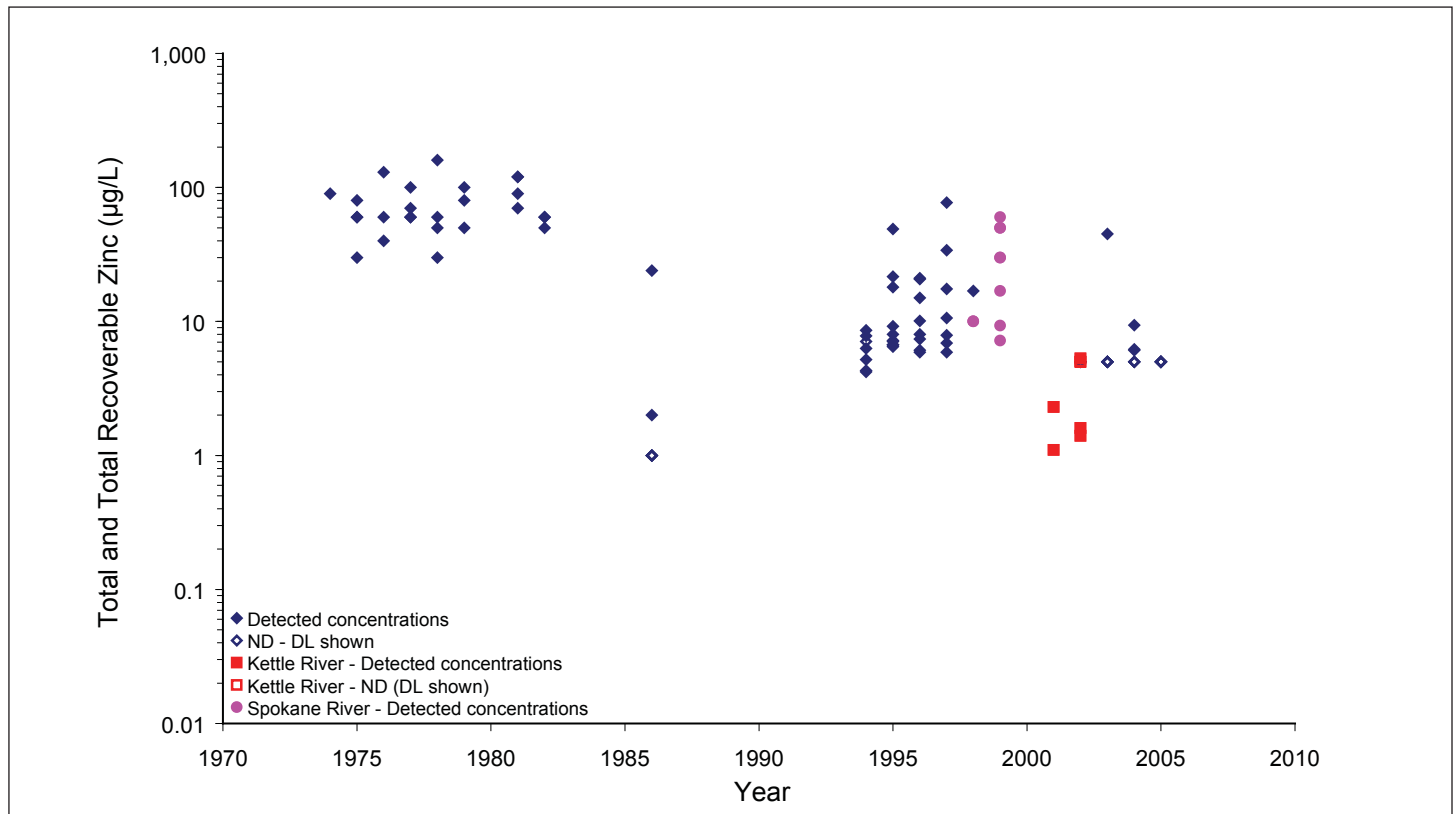
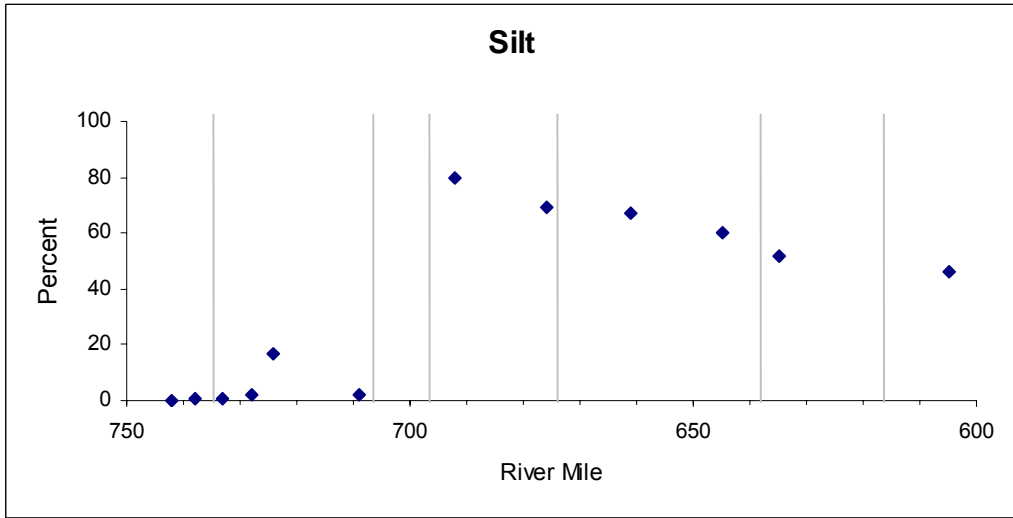
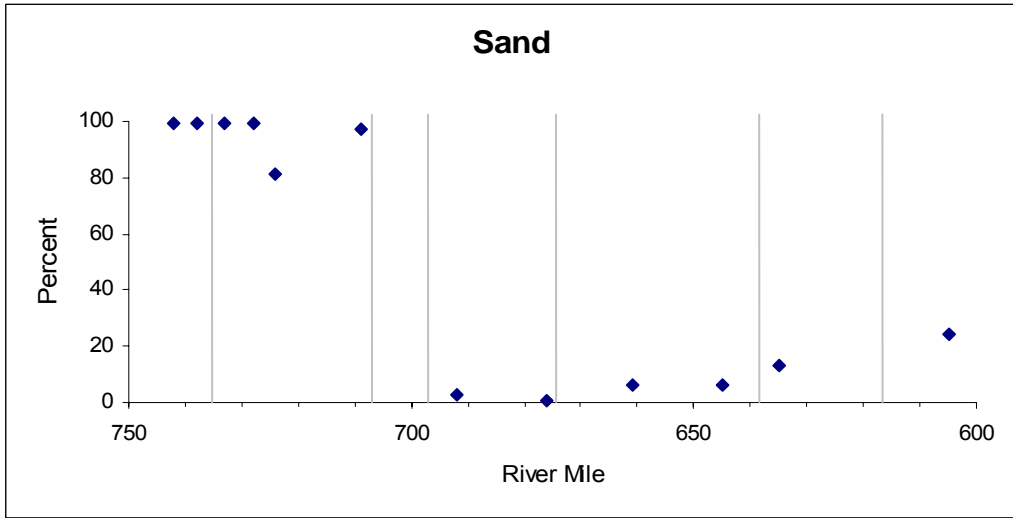


Figure 5-22. Combined UCR and Tributary Stations: Total and Total Recoverable Zinc Concentrations in Surface Water.

Source: USGS (<http://waterdata.usgs.gov>), Johnson (1988), Ecology (<http://apps.ecy.wa.gov/eimreporting>) URS (2003), and USEPA (<http://www.epa.gov/storpubl/legacy/gateway>).

Note: Detection limits shown typically reflect several samples collected in the same year.



Station Approx.	River Mile
Northport 734	
Mouth of Kettle River	706
Mouth of Colville River	698
Mouth of Stranger Creek	675
Mouth of Spokane River	639
Mouth of Sanpoil River	616

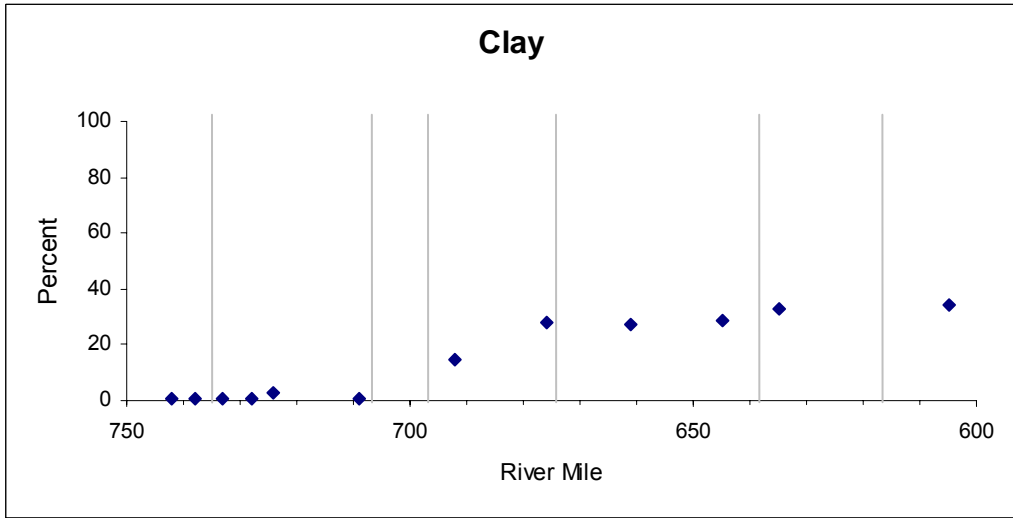
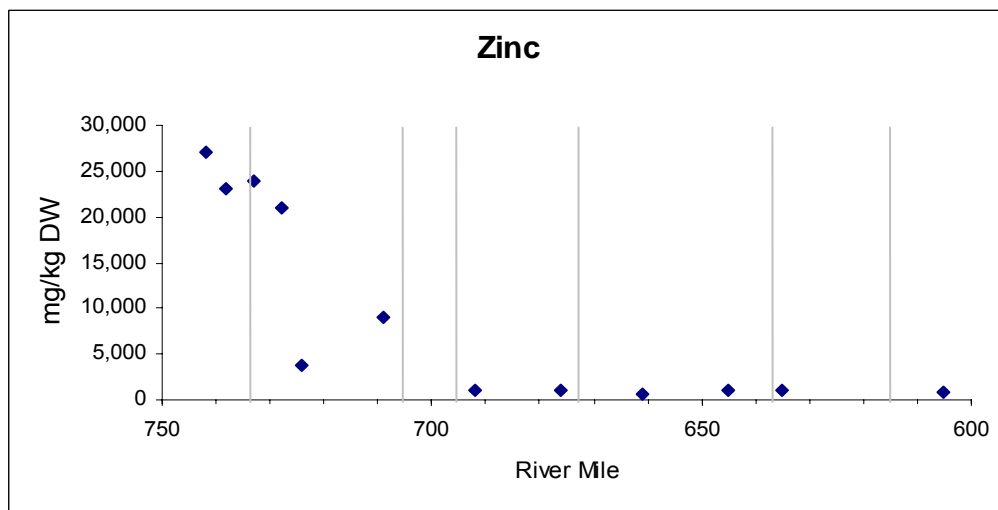
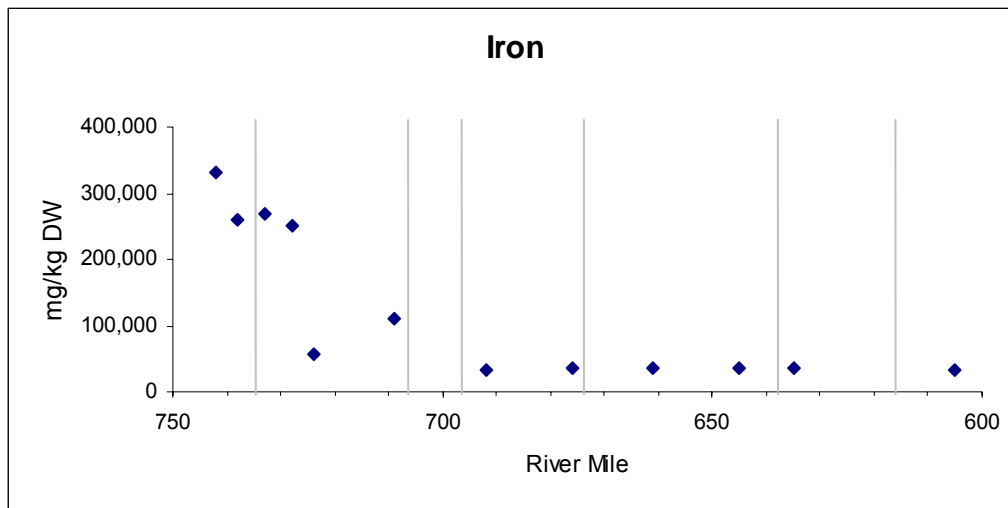


Figure 5-23. Longitudinal Distributions of Percent Sand, Silt, and Clay in Surface Sediments (top 2-4 cm) of the UCR in 1986.

Source: Johnson et al. (1989).

Note: Grey Vertical Lines Represent Approximate River Mile of Stations Listed in the Side Table.



Station Approx.	River Mile
Northport 734	
Mouth of Kettle River	706
Mouth of Colville River	698
Mouth of Stranger Creek	675
Mouth of Spokane River	639
Mouth of Sanpoil River	616

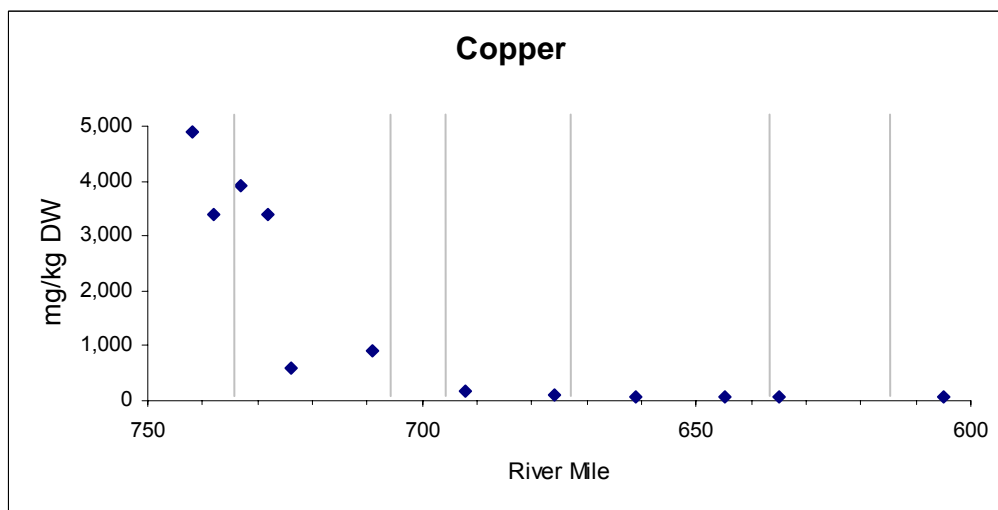
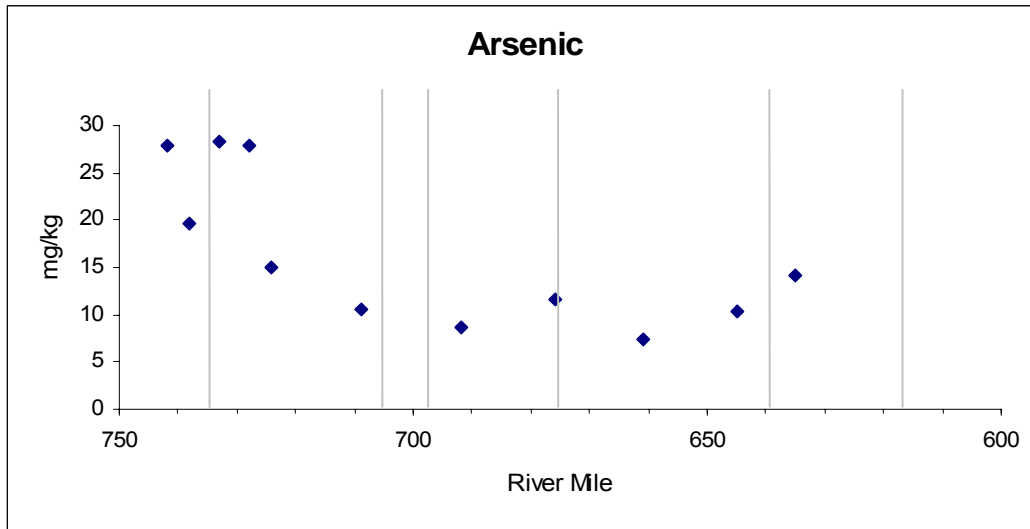


Figure 5-24. Longitudinal Distributions of Iron, Zinc, and Copper Concentrations in Surface Sediments (top 2-4 cm) of the UCR in 1986.

Source: Johnson et al. (1989).

Note: Grey Vertical Lines Represent Approximate River Mile of Stations Listed in the Side Table.



Station Approx.	River Mile
Northport	734
Mouth of Kettle River	706
Mouth of Colville River	698
Mouth of Stranger Creek	675
Mouth of Spokane River	639
Mouth of Sanpoil River	616

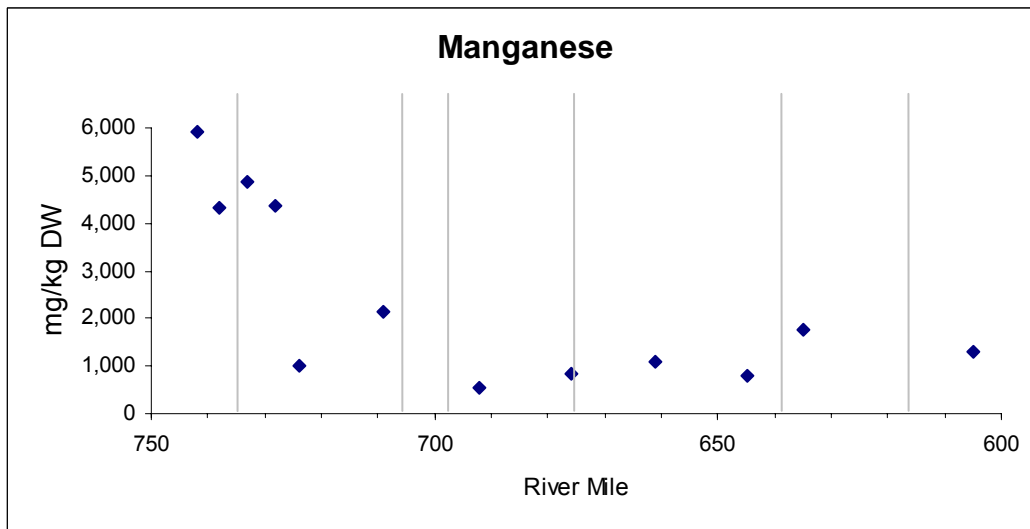
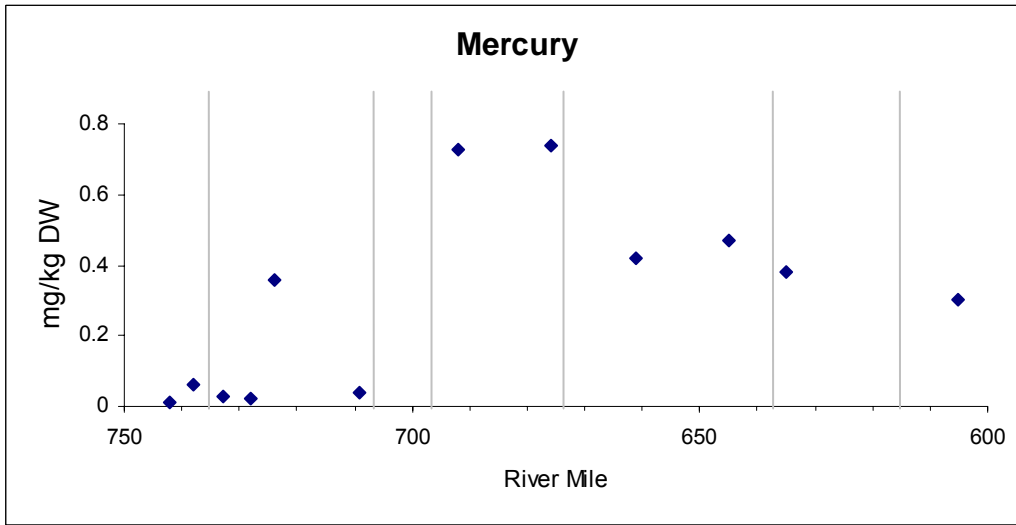
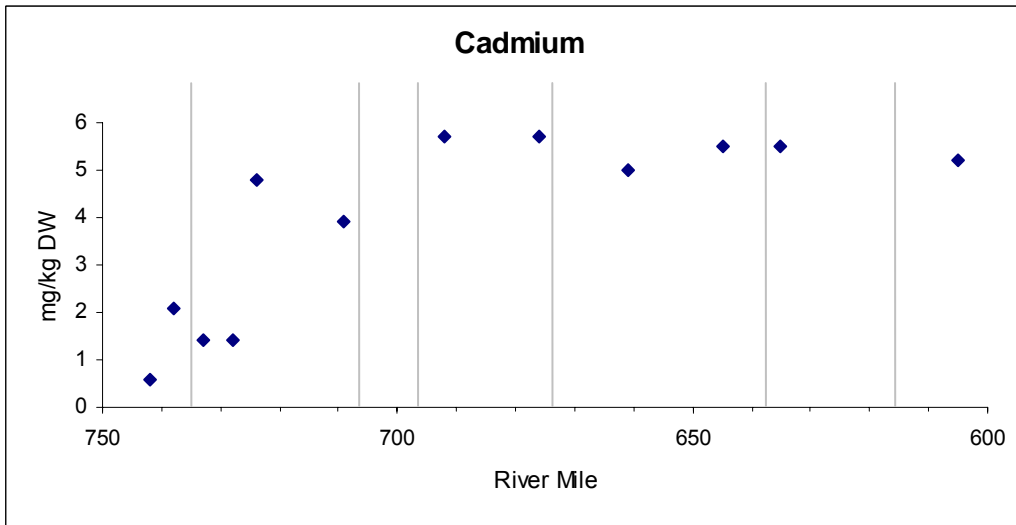


Figure 5-25. Longitudinal Distributions of Arsenic and Manganese Concentrations in Surface Sediments (top 2-4 cm) of the UCR in 1986.

Source: Johnson et al. (1989).

Note: Grey Vertical Lines Represent Approximate River Mile of Stations Listed in the Side Table.



Station Approx.	River Mile
Northport	734
Mouth of Kettle River	706
Mouth of Colville River	698
Mouth of Stranger Creek	675
Mouth of Spokane River	639
Mouth of Sanpoil River	616

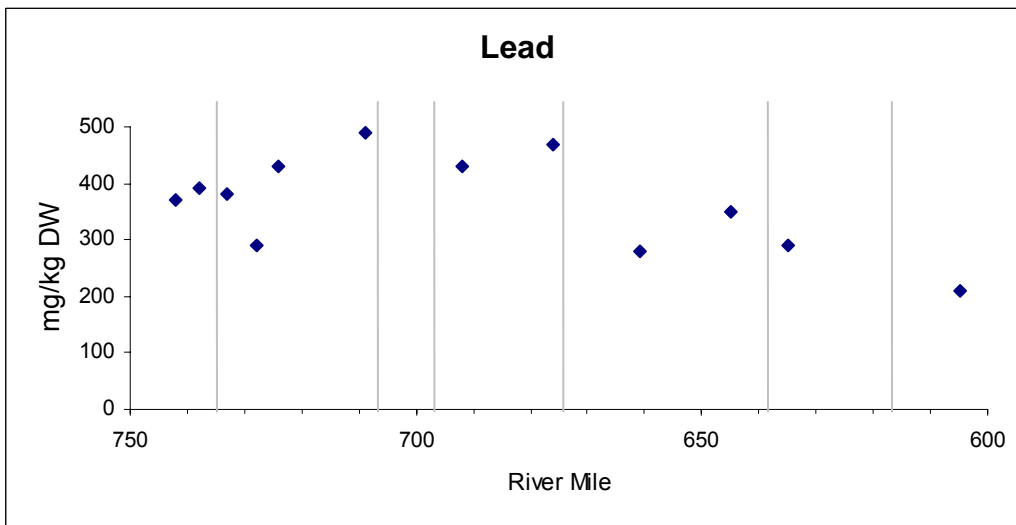


Figure 5-26. Longitudinal Distributions of Cadmium, Mercury, and Lead Concentrations in Surface Sediments (top 2-4 cm) of the UCR in 1986.

Source: Johnson et al. (1989).

Note: Grey Vertical Lines Represent Approximate River Mile of Stations Listed in the Side Table.

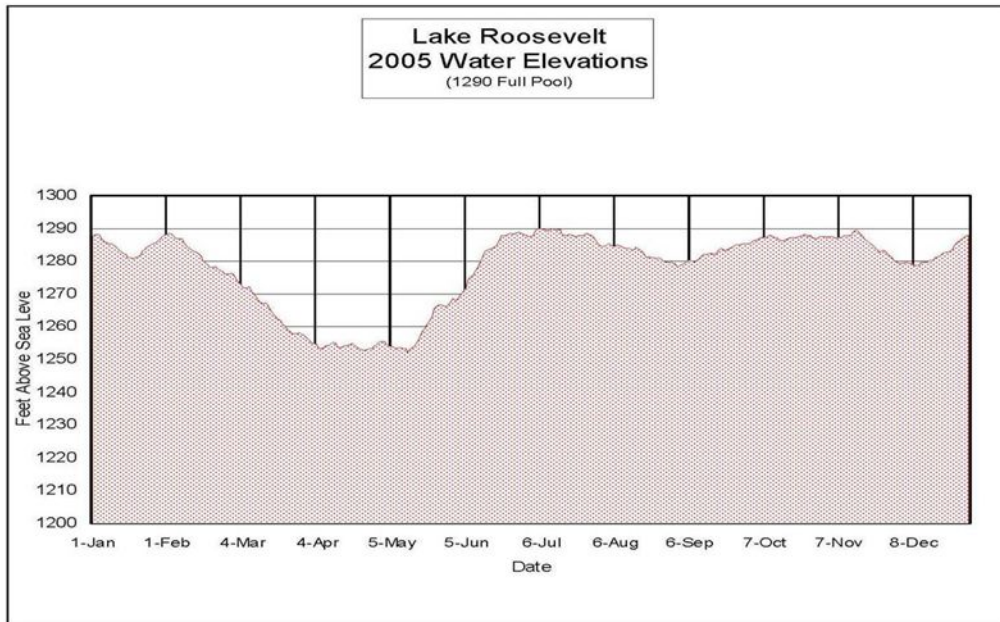
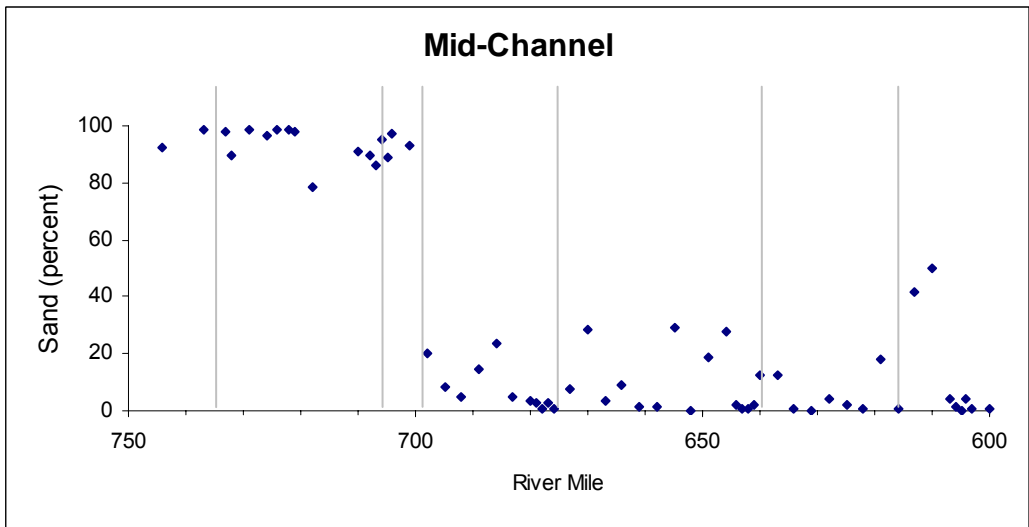
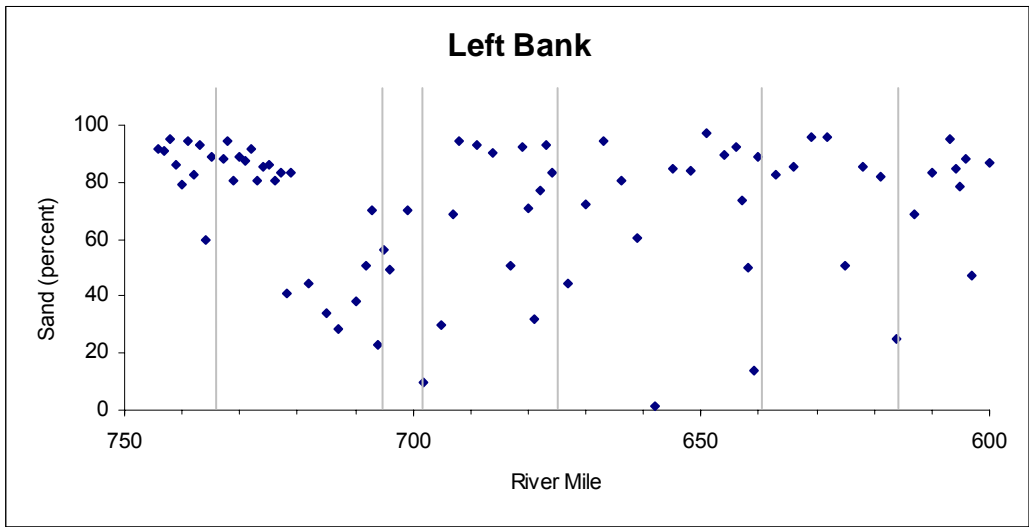


Figure 5-27. Sampling Period (April 14–May 3) for the 2005 Phase 1 Sediment Study in Relation to Water Elevations in the UCR.

Source: USEPA (2006h).



Station Approx.	River Mile
Northport 734	
Mouth of Kettle River	706
Mouth of Colville River	698
Mouth of Stranger Creek	675
Mouth of Spokane River	639
Mouth of Sanpoil River	616

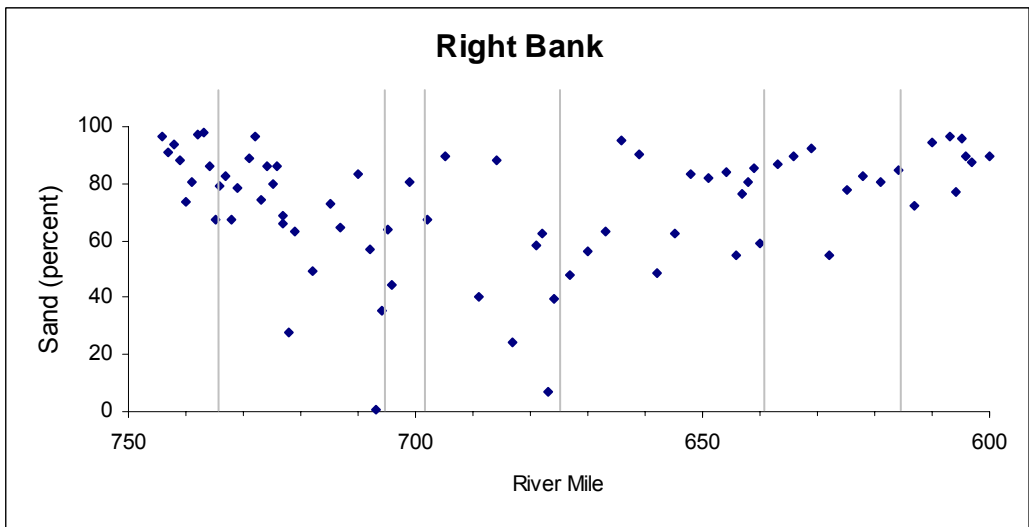
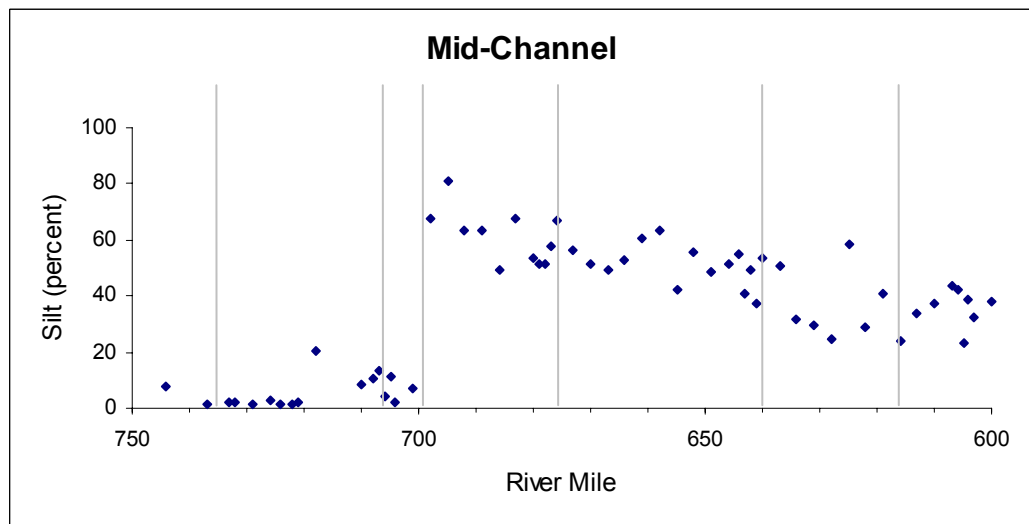
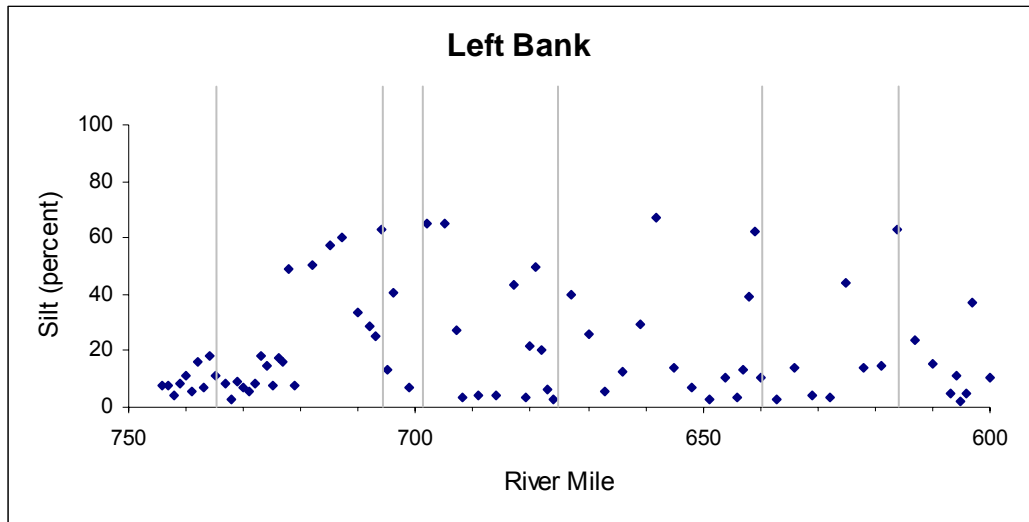


Figure 5-28. Longitudinal Distribution of Percent Sand in Surface Sediments (top 10-15 cm) of the UCR in 2005.

Source: USEPA (2006h).

Note: Grey Vertical Lines Represent Approximate River Mile of Stations Listed in the Side Table.



Station Approx.	River Mile
Northport 734	
Mouth of Kettle River	706
Mouth of Colville River	698
Mouth of Stranger Creek	675
Mouth of Spokane River	639
Mouth of Sanpoil River	616

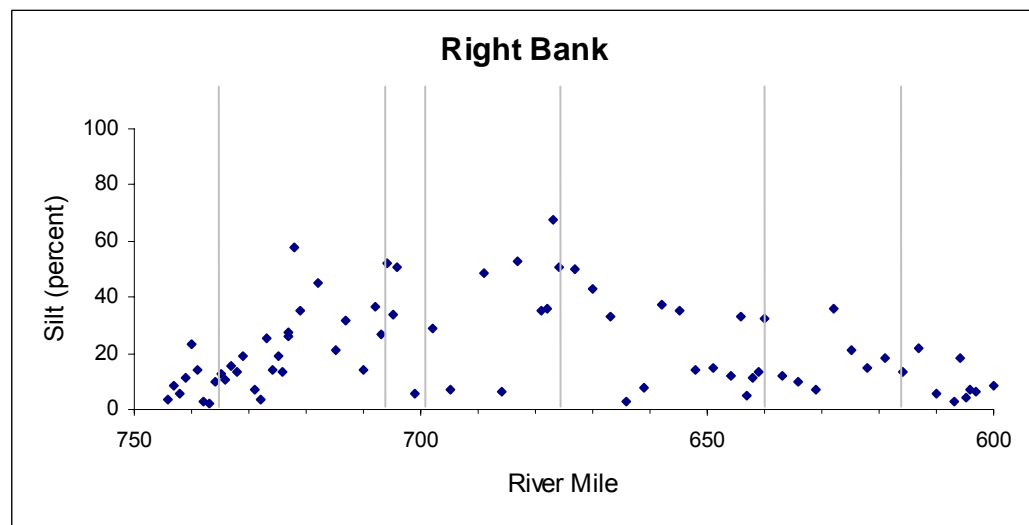
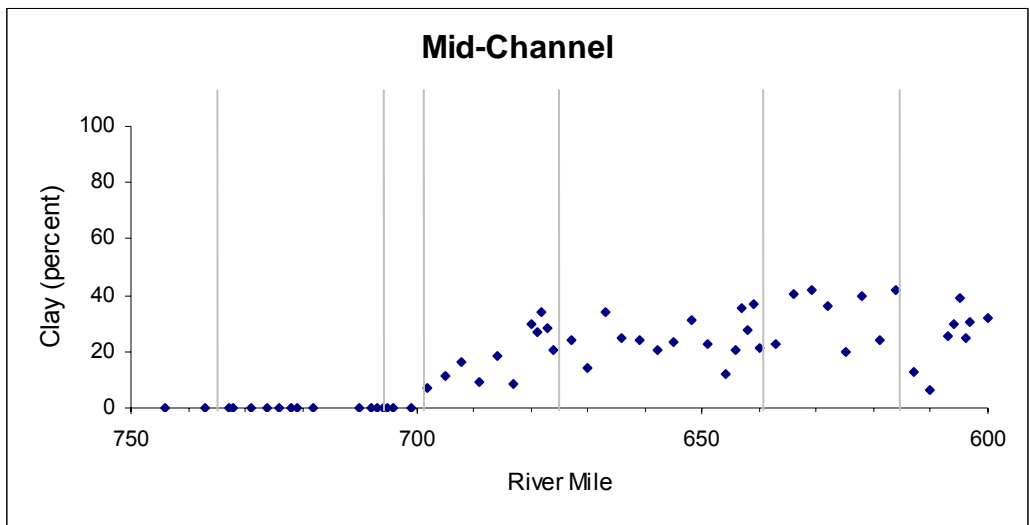
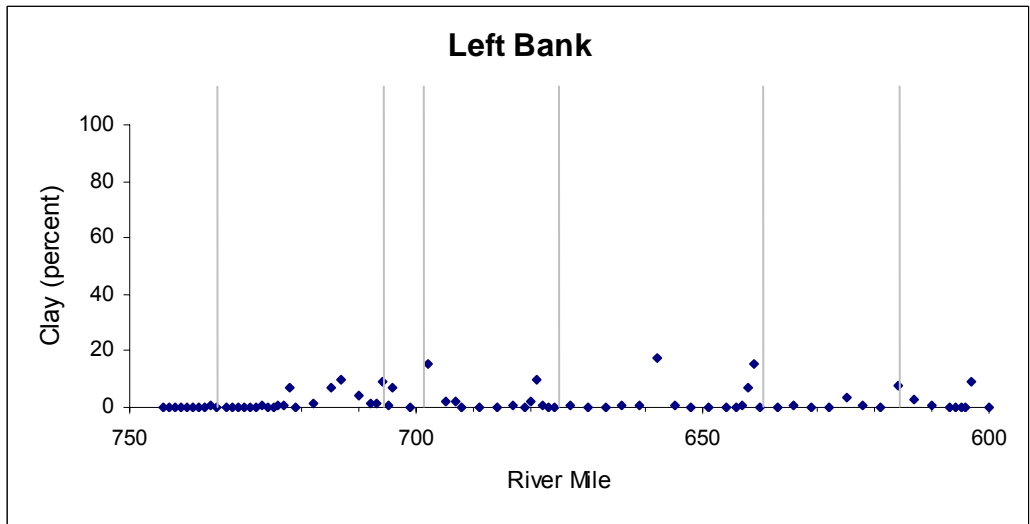


Figure 5-29. Longitudinal Distribution of Percent Silt in Surface Sediments (top 10-15 cm) of the UCR in 2005.

Source: USEPA (2006h).

Note: Grey Vertical Lines Represent Approximate River Mile of Stations Listed in the Side Table.



Station Approx.	River Mile
Northport 734	
Mouth of Kettle River	706
Mouth of Colville River	698
Mouth of Stranger Creek	675
Mouth of Spokane River	639
Mouth of Sanpoil River	616

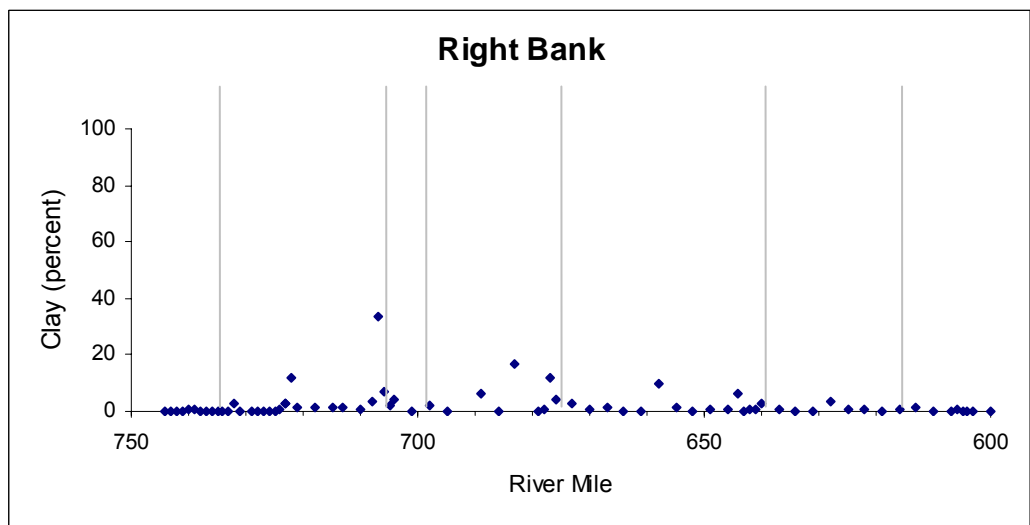
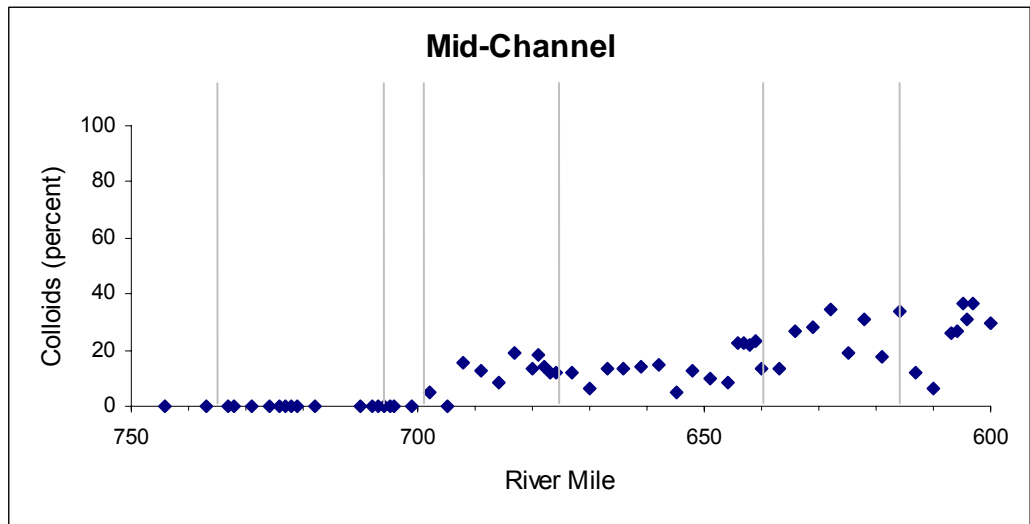
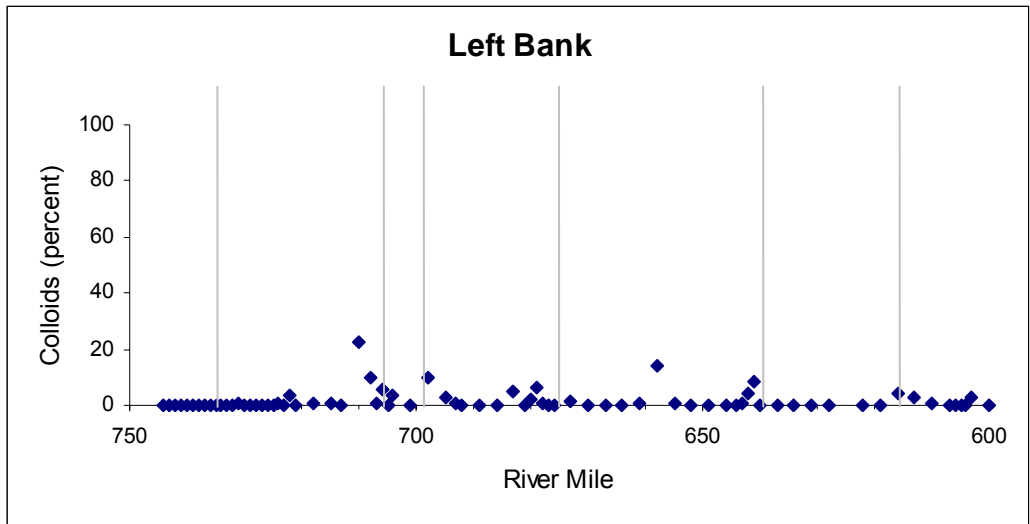


Figure 5-30. Longitudinal Distribution of Percent Clay in Surface Sediments (top 10-15 cm) of the UCR in 2005.

Source: USEPA (2006h).

Note: Grey Vertical Lines Represent Approximate River Mile of Stations Listed in the Side Table.



Station Approx.	River Mile
Northport 734	
Mouth of Kettle River	706
Mouth of Colville River	698
Mouth of Stranger Creek	675
Mouth of Spokane River	639
Mouth of Sanpoil River	616

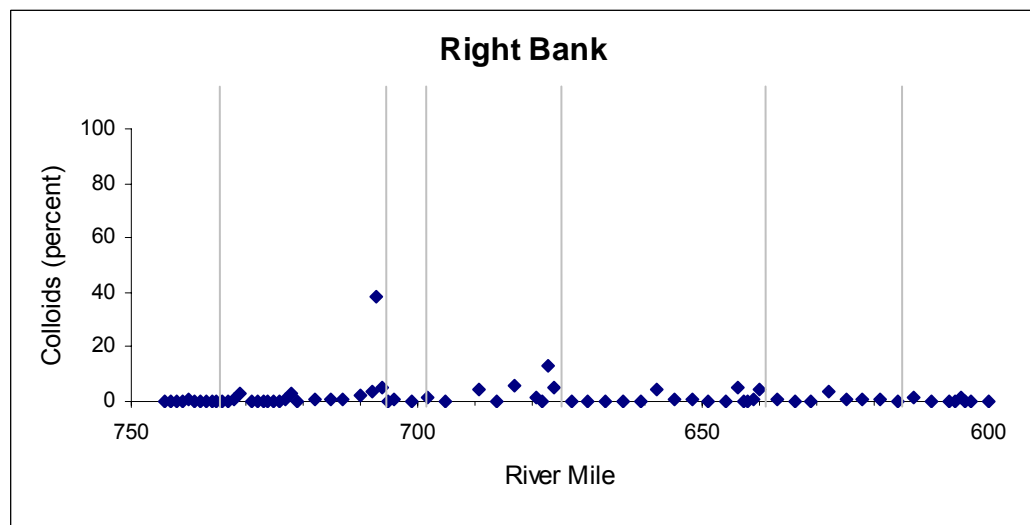
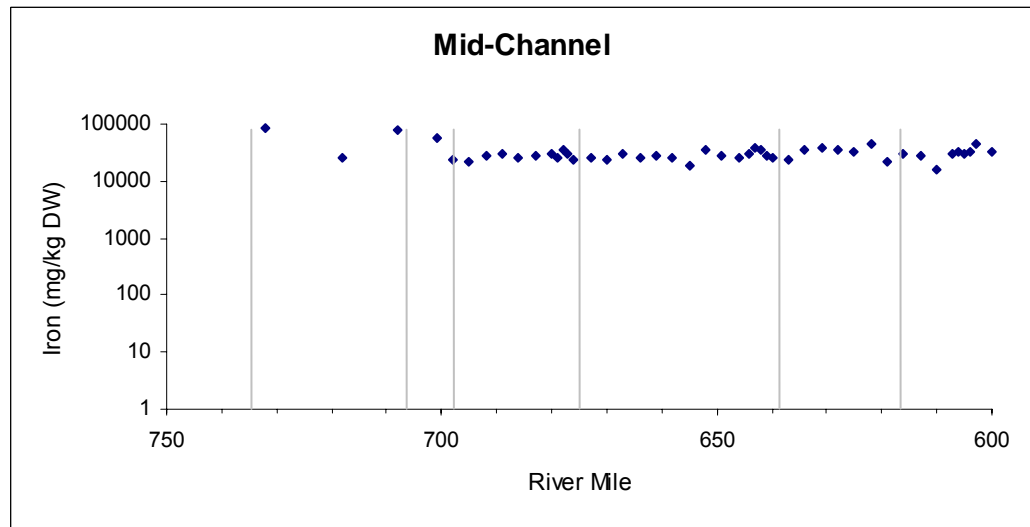
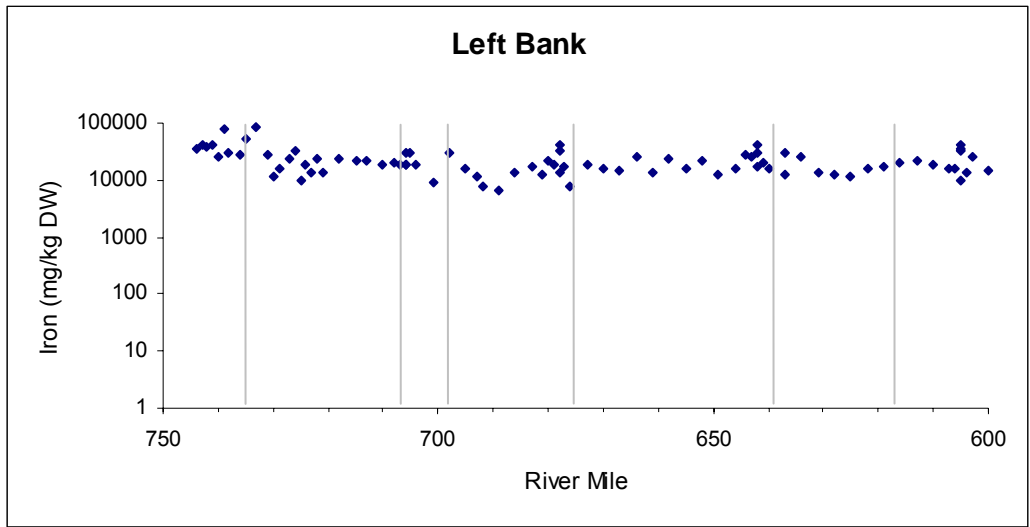


Figure 5-31. Longitudinal Distribution of Percent Colloids in Surface Sediments (top 10-15 cm) of the UCR in 2005.

Source: USEPA (2006h).

Note: Grey Vertical Lines Represent Approximate River Mile of Stations Listed in the Side Table.

Note: Colloids, which are not commonly reported for sediments, represent very fine particles <1um in diameter that do not settle.



Station Approx.	River Mile
Northport 734	
Mouth of Kettle River	706
Mouth of Colville River	698
Mouth of Stranger Creek	675
Mouth of Spokane River	639
Mouth of Sanpoil River	616

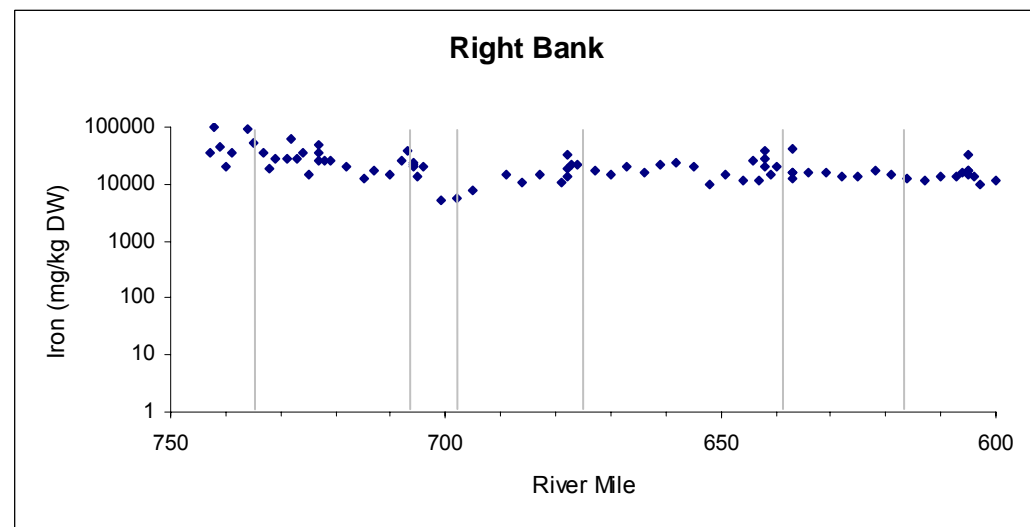
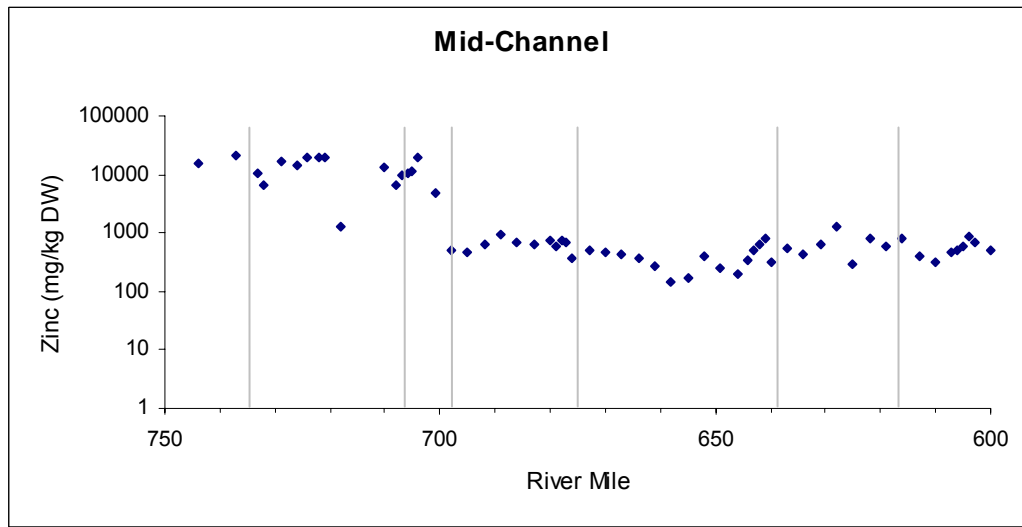
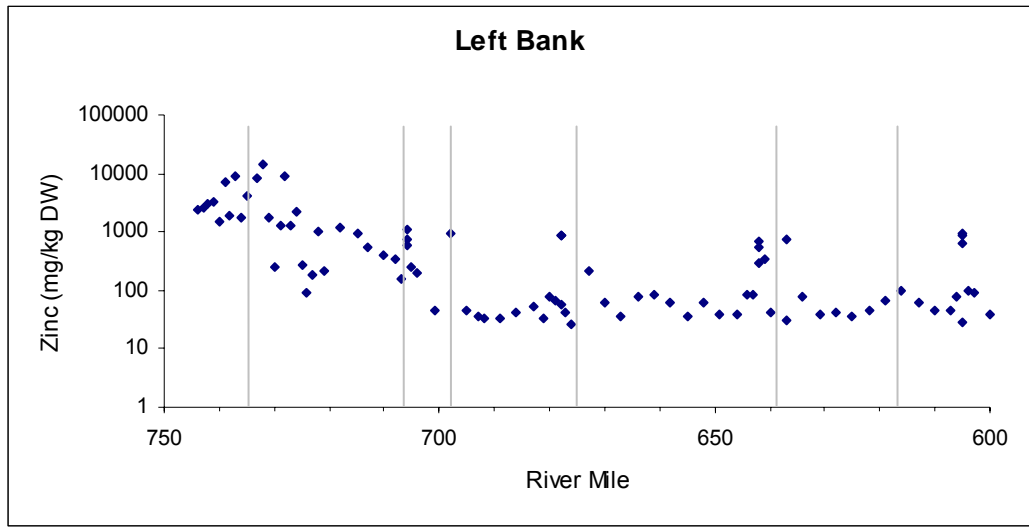


Figure 5-32. Longitudinal Distribution of Iron Concentrations in Surface Sediments (top 10-15 cm) of the UCR in 2005.

Source: USEPA (2006h).

Note: Grey Vertical Lines Represent Approximate River Mile of Stations Listed in the Side Table.



Station Approx.	River Mile
Northport 734	
Mouth of Kettle River	706
Mouth of Colville River	698
Mouth of Stranger Creek	675
Mouth of Spokane River	639
Mouth of Sanpoil River	616

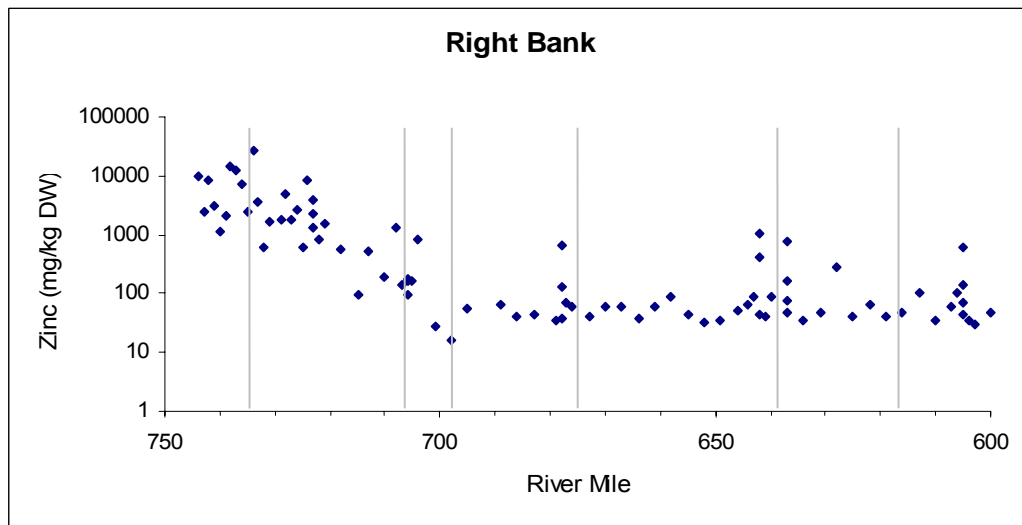
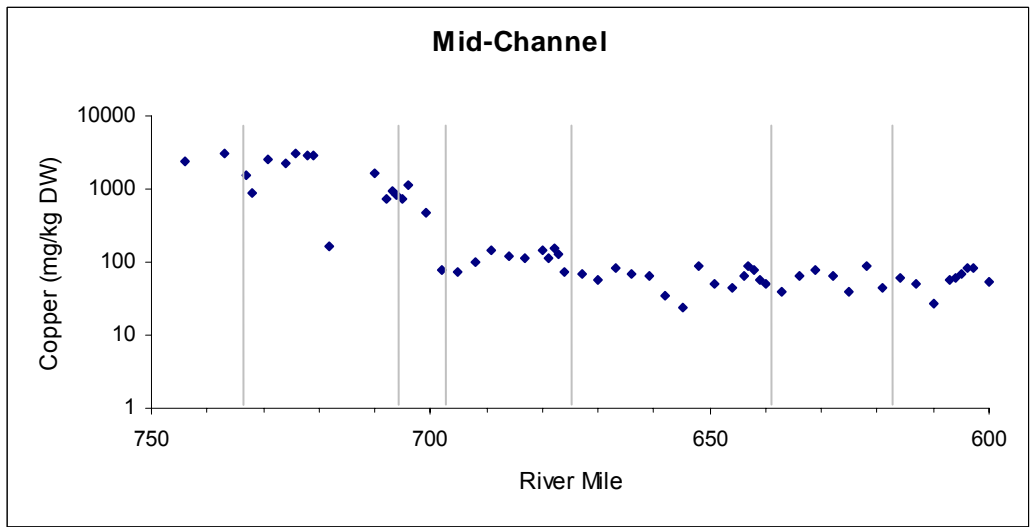
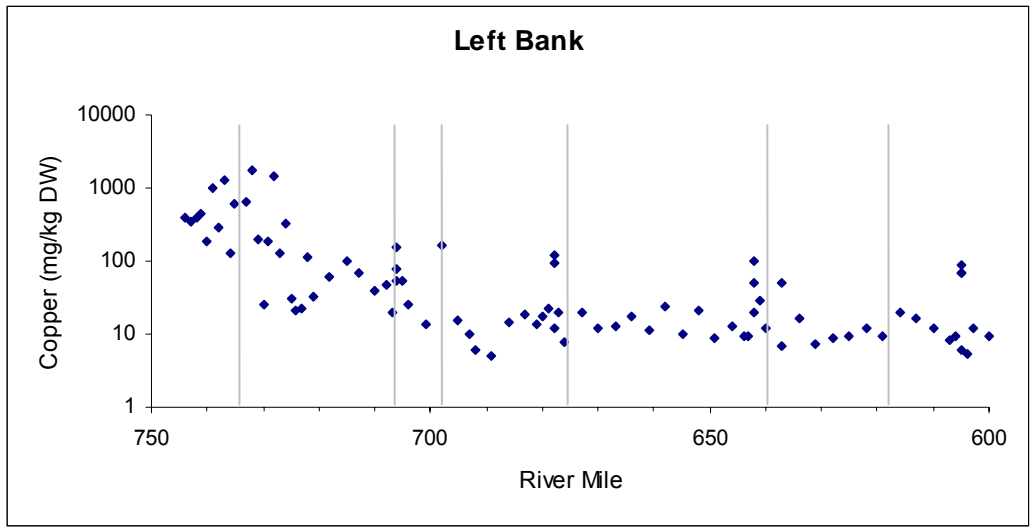


Figure 5-33. Longitudinal Distribution of Zinc Concentrations in Surface Sediments (top 10-15 cm) of the UCR in 2005.

Source: USEPA (2006h).

Note: Grey Vertical Lines Represent Approximate River Mile of Stations Listed in the Side Table.



Station Approx.	River Mile
Northport 734	
Mouth of Kettle River	706
Mouth of Colville River	698
Mouth of Stranger Creek	675
Mouth of Spokane River	639
Mouth of Sanpoil River	616

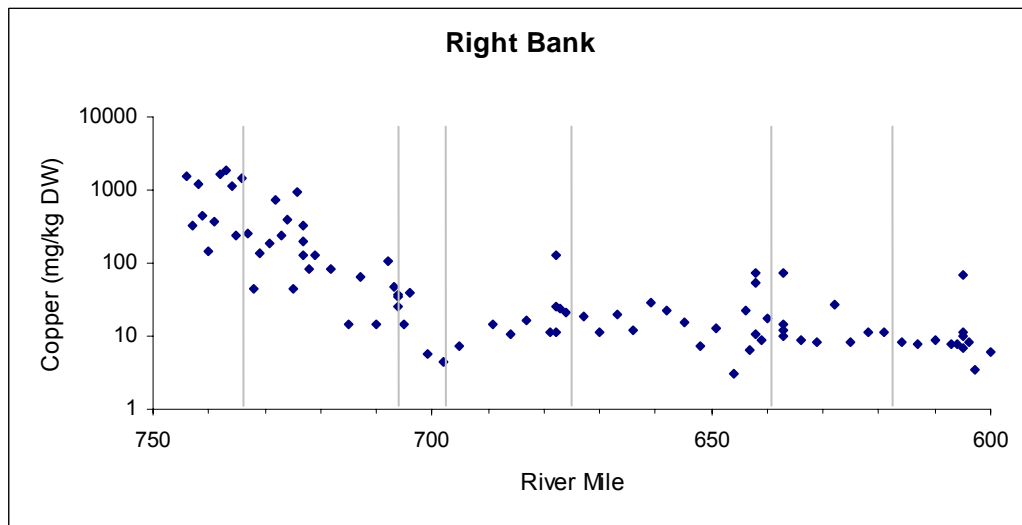
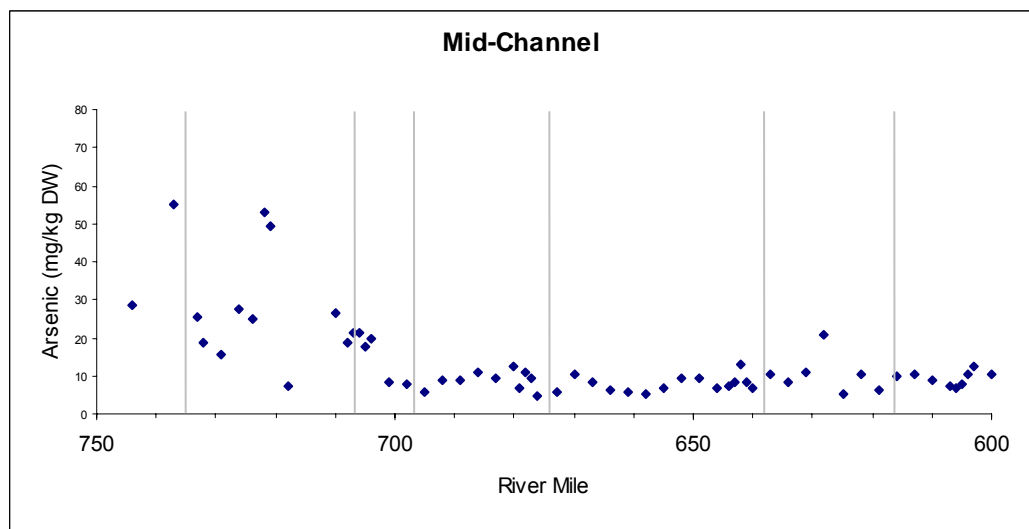
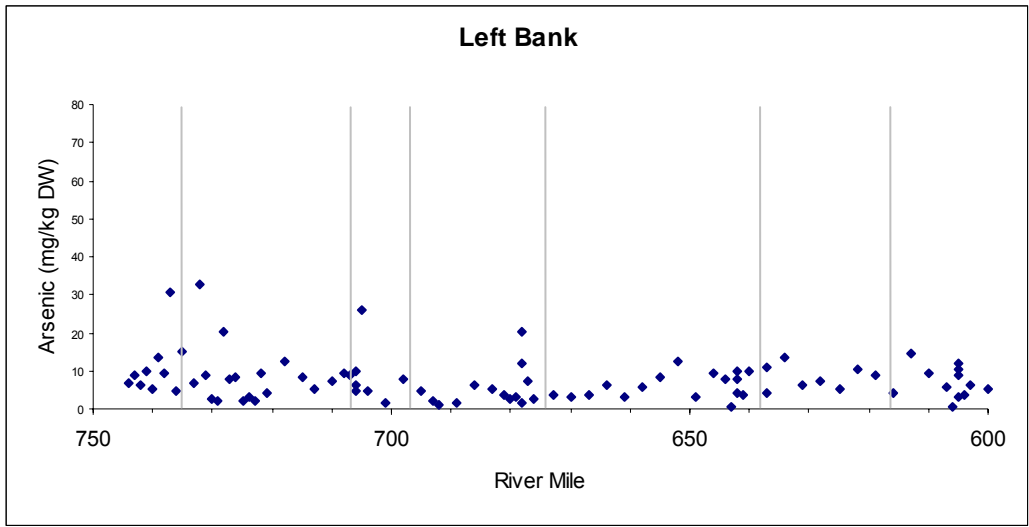


Figure 5-34. Longitudinal Distribution of Copper Concentrations in Surface Sediments (top 10-15 cm) of the UCR in 2005.

Source: USEPA (2006h).

Note: Grey Vertical Lines Represent Approximate River Mile of Stations Listed in the Side Table.



Station Approx.	River Mile
Northport 734	
Mouth of Kettle River	706
Mouth of Colville River	698
Mouth of Stranger Creek	675
Mouth of Spokane River	639
Mouth of Sanpoil River	616

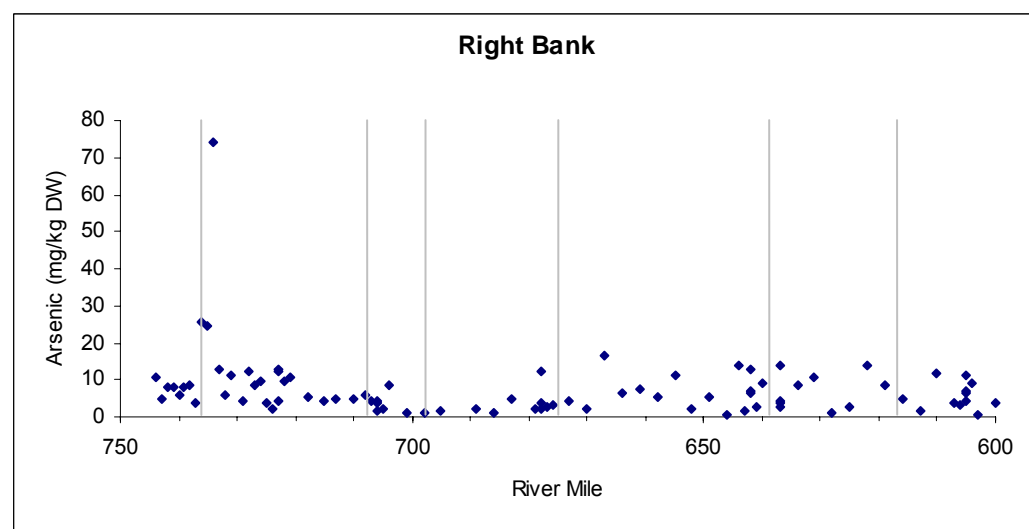
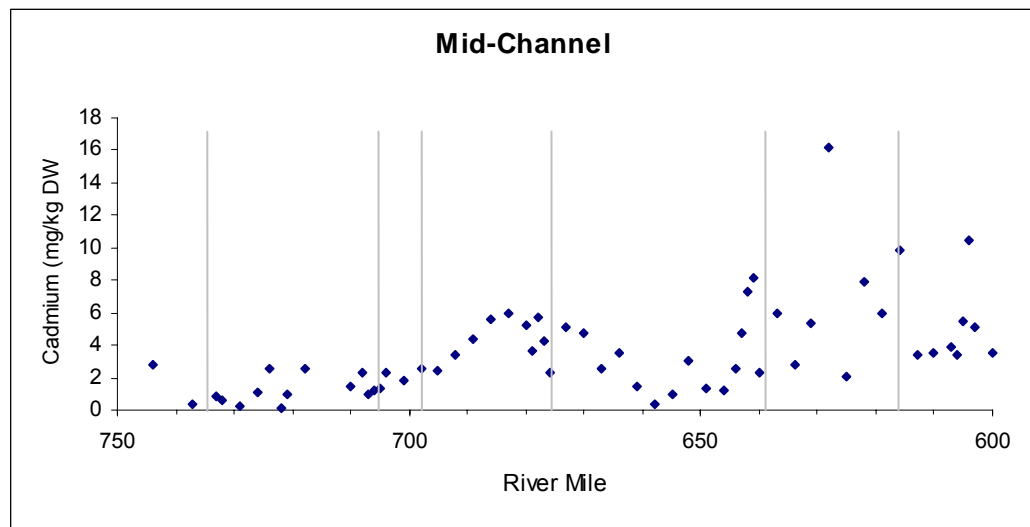
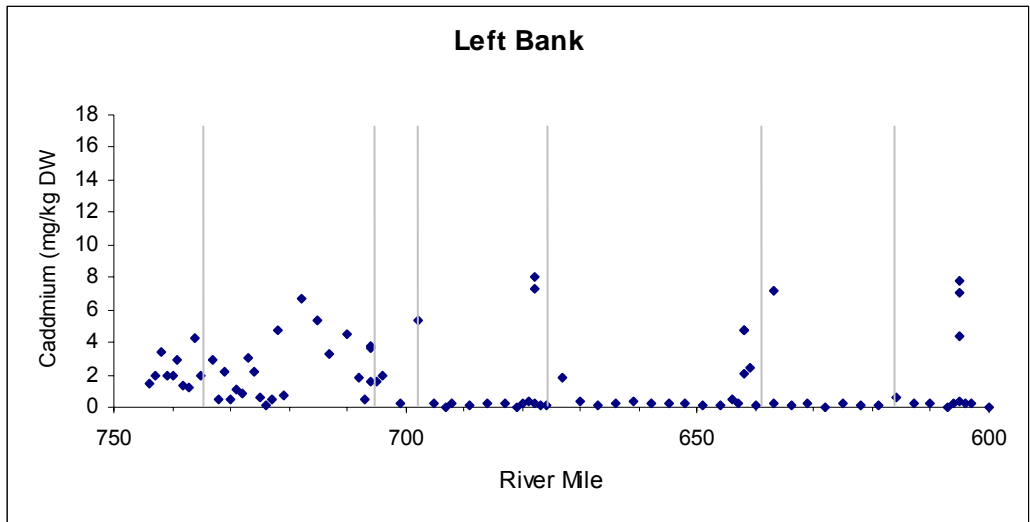


Figure 5-35. Longitudinal Distribution of Arsenic Concentrations in Surface Sediments (top 10-15 cm) of the UCR in 2005.

Source: USEPA (2006h).

Note: Grey Vertical Lines Represent Approximate River Mile of Stations Listed in the Side Table.



<u>Station Approx.</u>	<u>River Mile</u>
Northport 734	
Mouth of Kettle River	706
Mouth of Colville River	698
Mouth of Stranger Creek	675
Mouth of Spokane River	639
Mouth of Sanpoil River	616

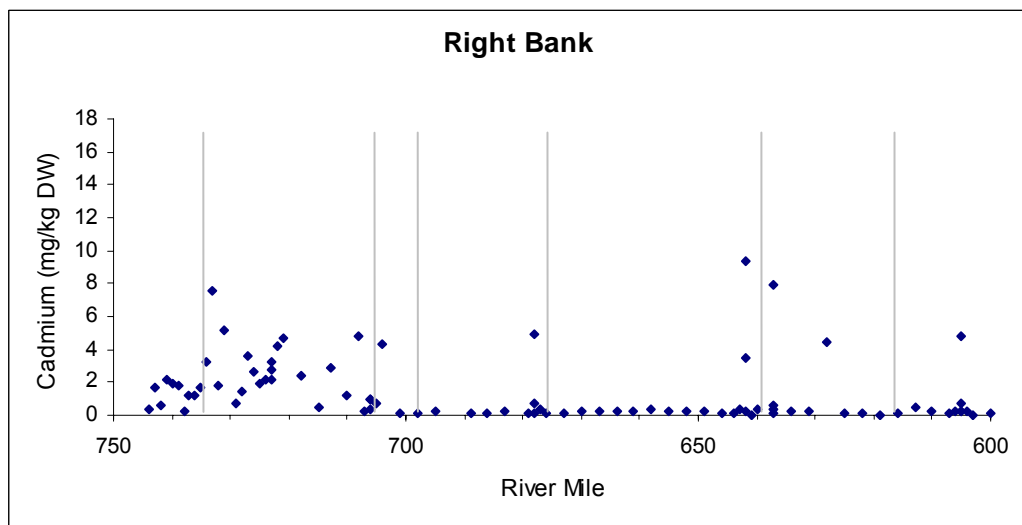
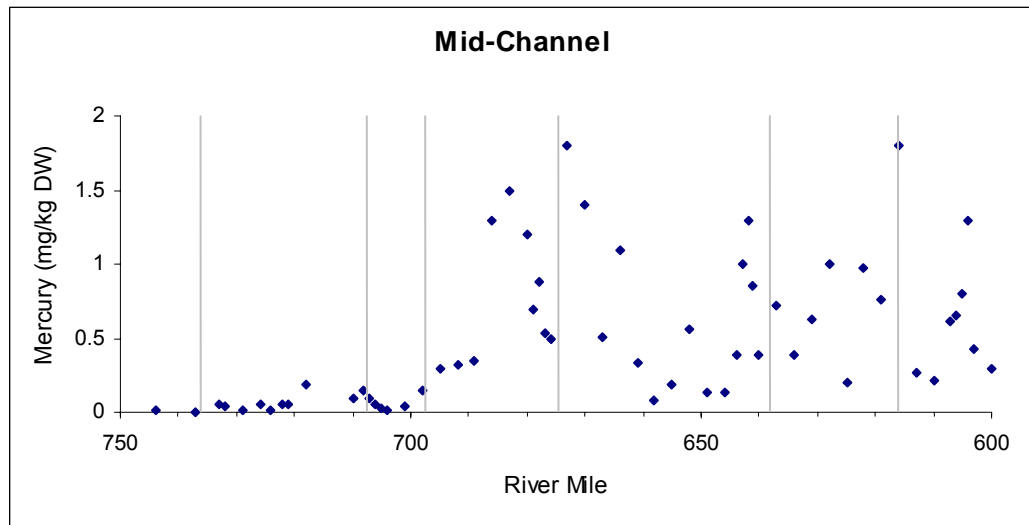
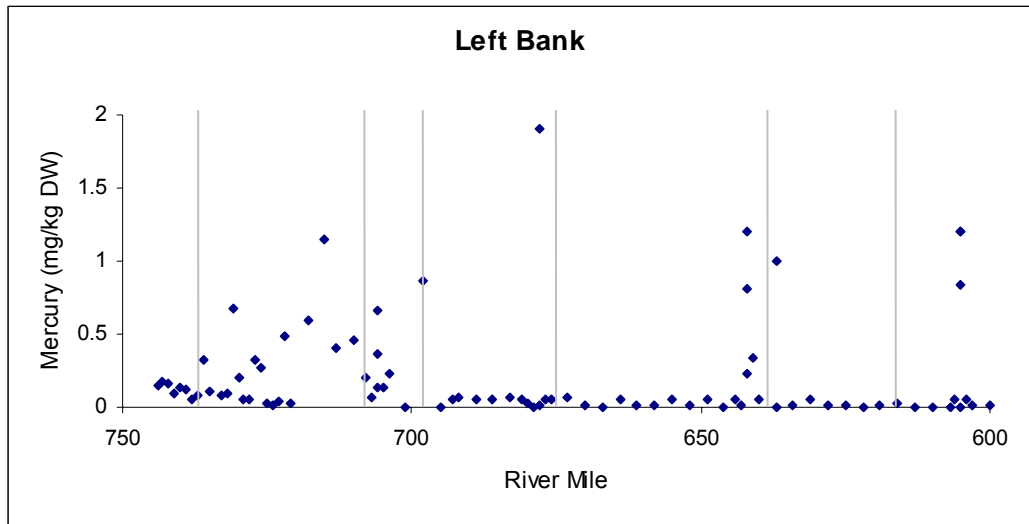


Figure 5-36. Longitudinal Distribution of Cadmium Concentrations in Surface Sediments (top 10-15 cm) of the UCR in 2005.

Source: USEPA (2006h).

Note: Grey Vertical Lines Represent Approximate River Mile of Stations Listed in the Side Table.



Station	Approx River Mile
Northport	734
Mouth of Kettle River	706
Mouth of Colville River	698
Mouth of Stranger Creek	675
Mouth of Spokane River	639
Mouth of Sanpoil River	616

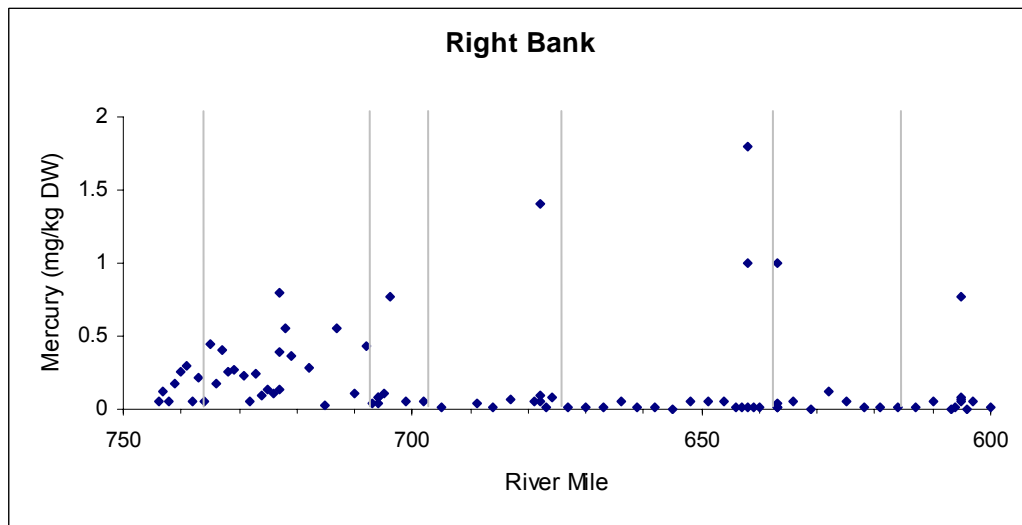
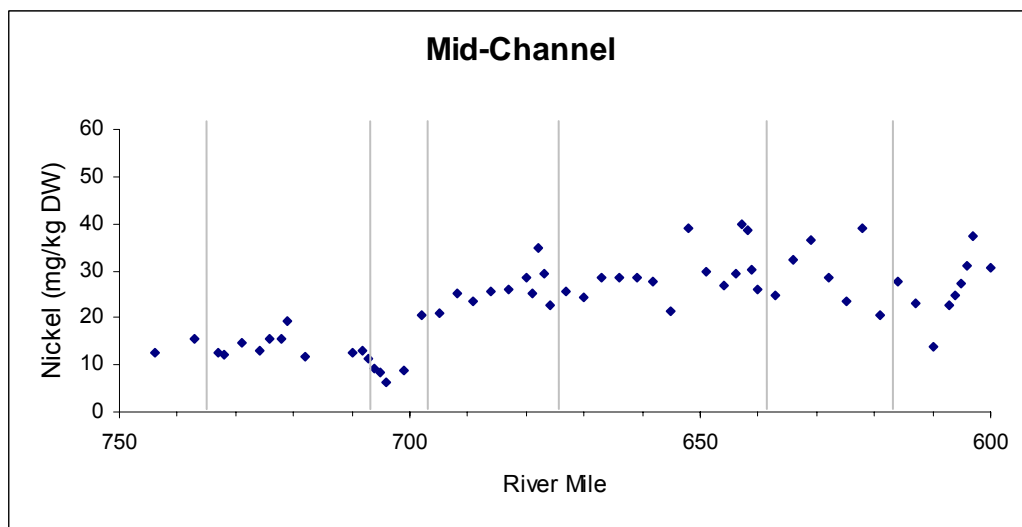
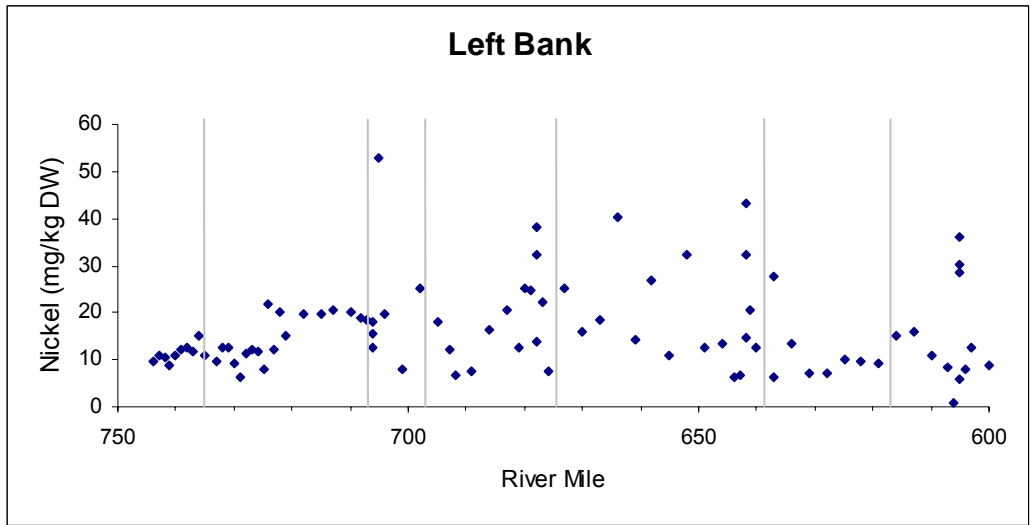


Figure 5-37. Longitudinal Distribution of Mercury Concentrations in Surface Sediments (top 10-15 cm) of the UCR in 2005.

Source: USEPA (2006h).

Note: Grey Vertical Lines Represent Approximate River Mile of Stations Listed in the Side Table.



Station Approx.	River Mile
Northport 734	
Mouth of Kettle River	706
Mouth of Colville River	698
Mouth of Stranger Creek	675
Mouth of Spokane River	639
Mouth of Sanpoil River	616

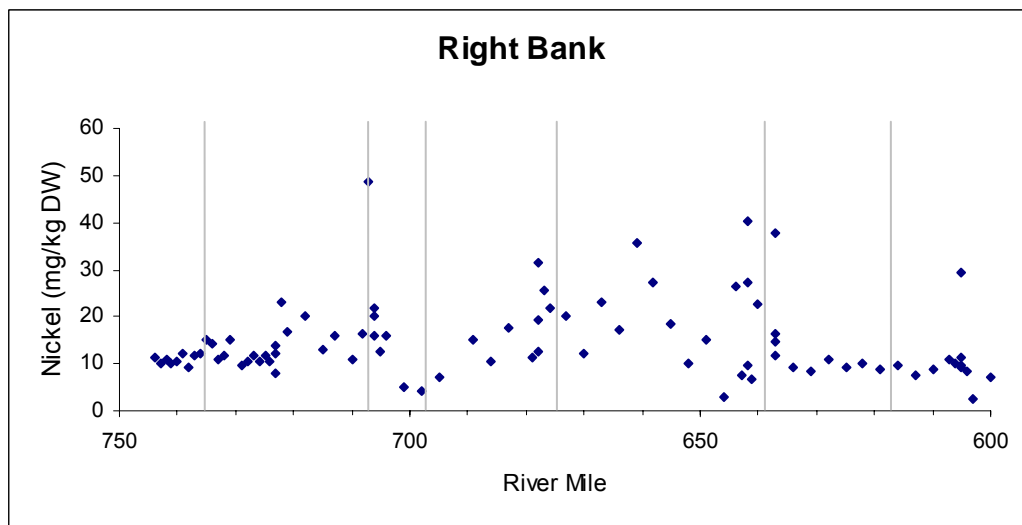
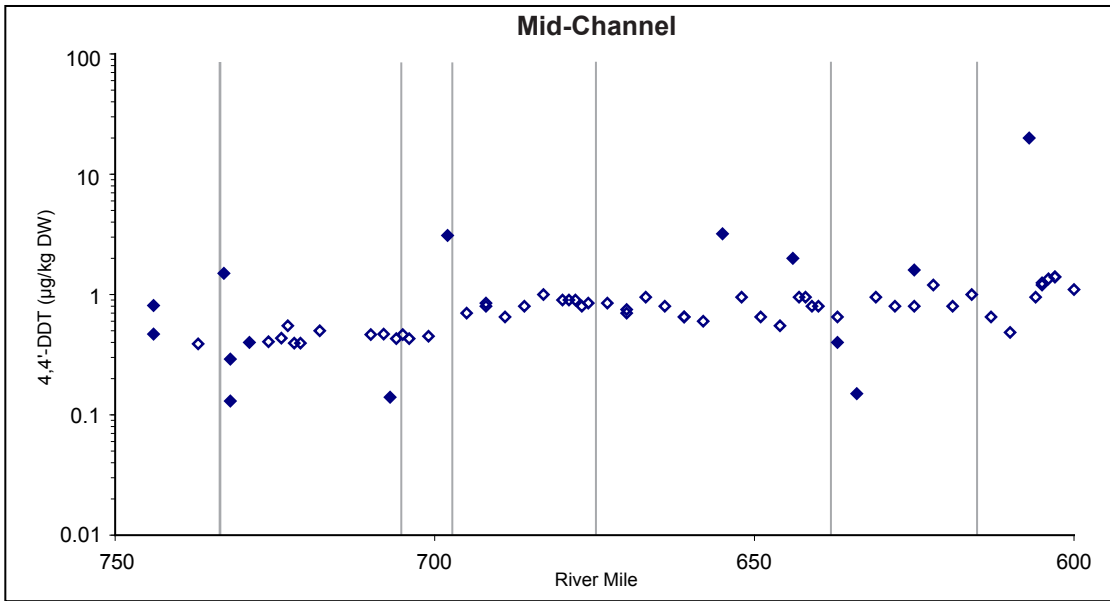
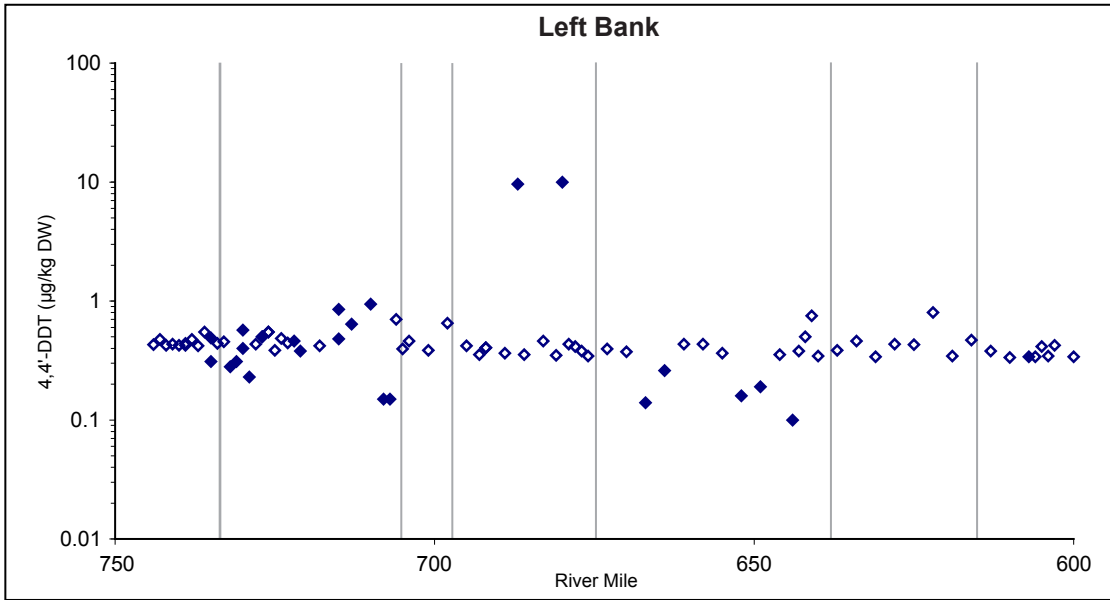


Figure 5-38. Longitudinal Distribution of Nickel Concentrations in Surface Sediments (top 10-15 cm) of the UCR in 2005.

Source: USEPA (2006h).

Note: Grey Vertical Lines Represent Approximate River Mile of Stations Listed in the Side Table.



Station	Approx. River Mile
Northport	734
Mouth of Kettle River	706
Mouth of Colville River	698
Mouth of Stranger Creek	675
Mouth of Spokane River	639
Mouth of Sanpoil River	616

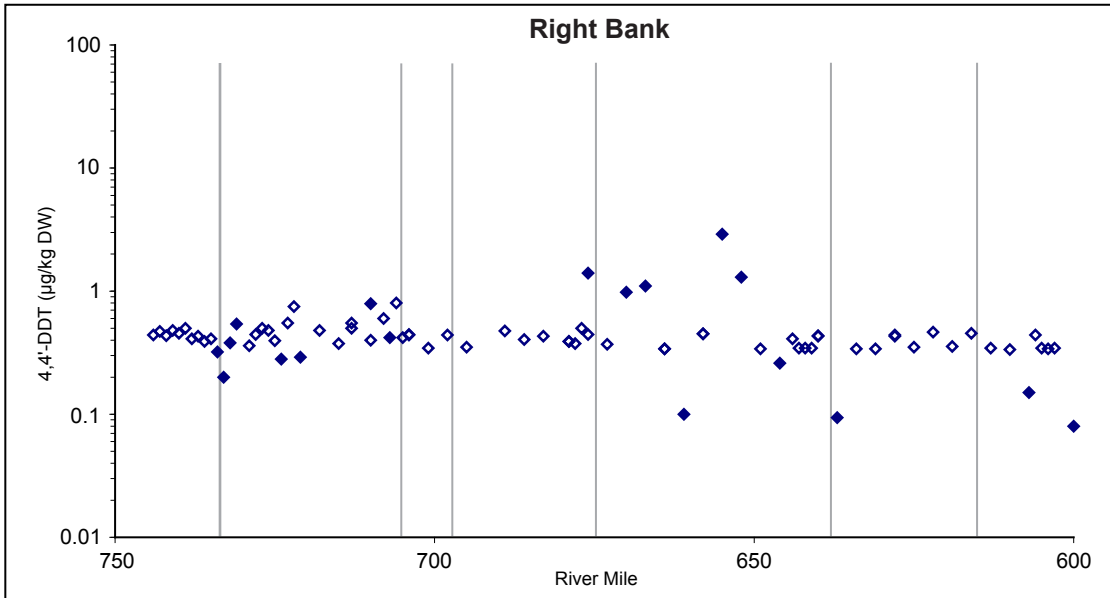
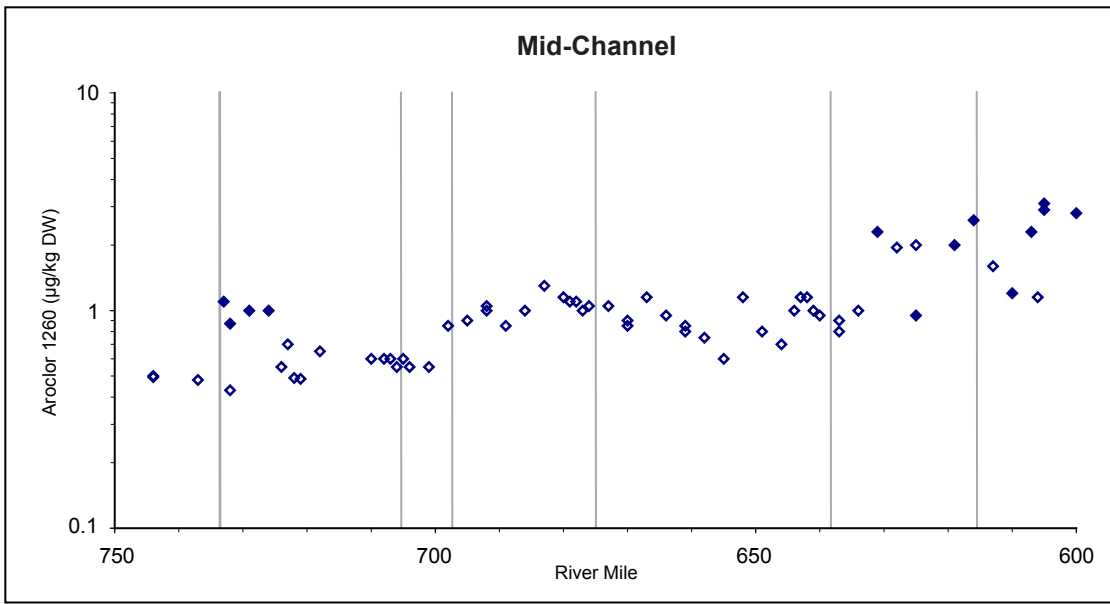
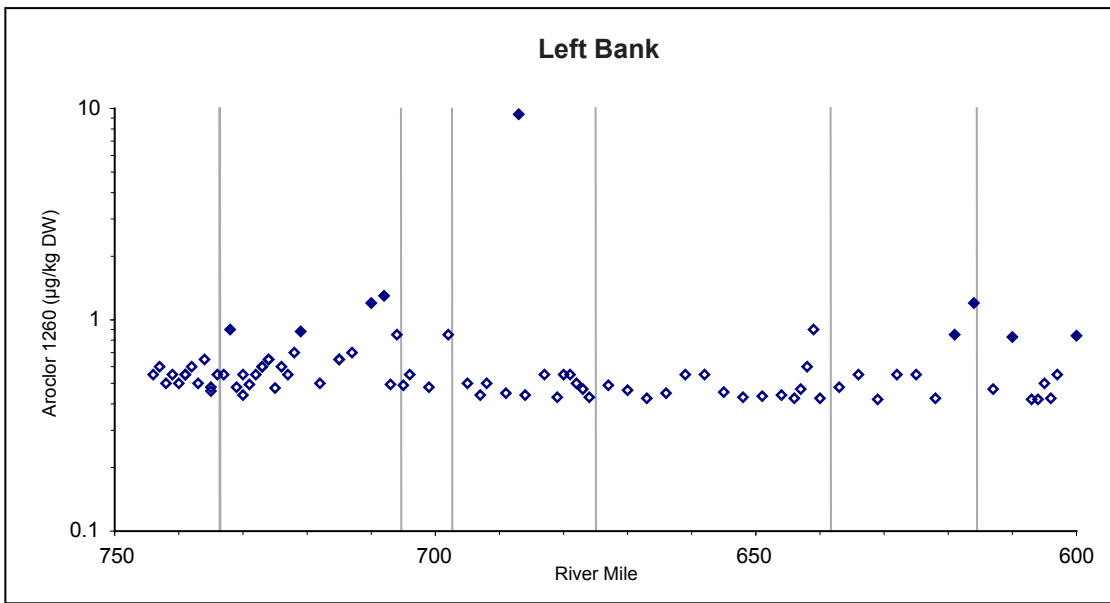


Figure 5-39. Longitudinal Distribution of 4,4'-DDT Concentrations (Dry Weight [DW]) in the UCR.
Source: USEPA (2006h).
Notes: Detected concentrations are solid data points.
 Grey vertical lines represent approximate river mile of stations listed in the side table.



Station	Approx. River Mile
Northport	734
Mouth of Kettle River	706
Mouth of Colville River	698
Mouth of Stranger Creek	675
Mouth of Spokane River	639
Mouth of Sanpoil River	616

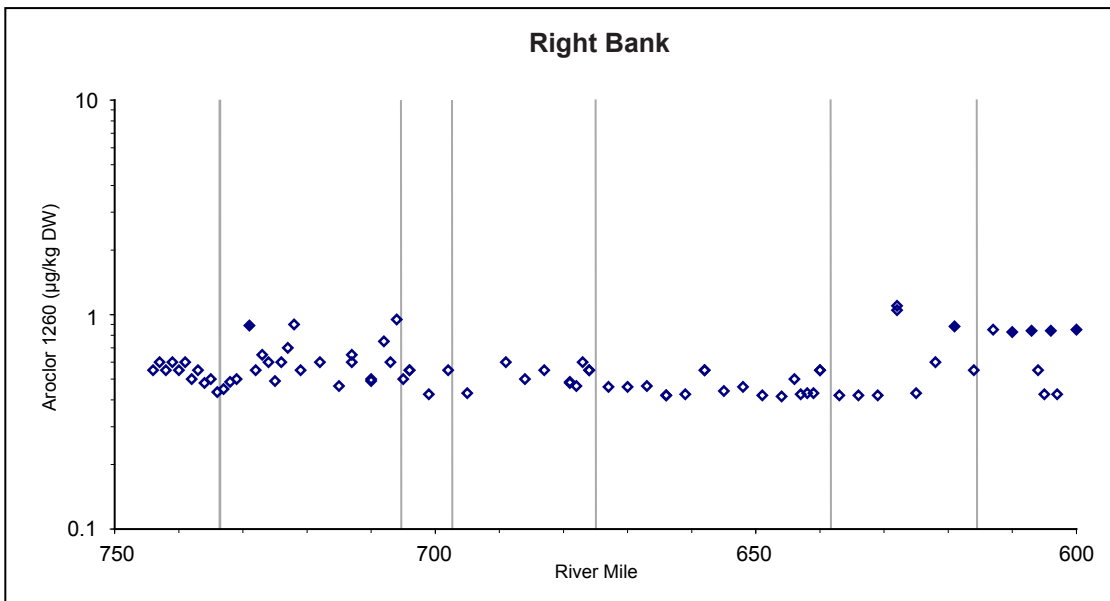
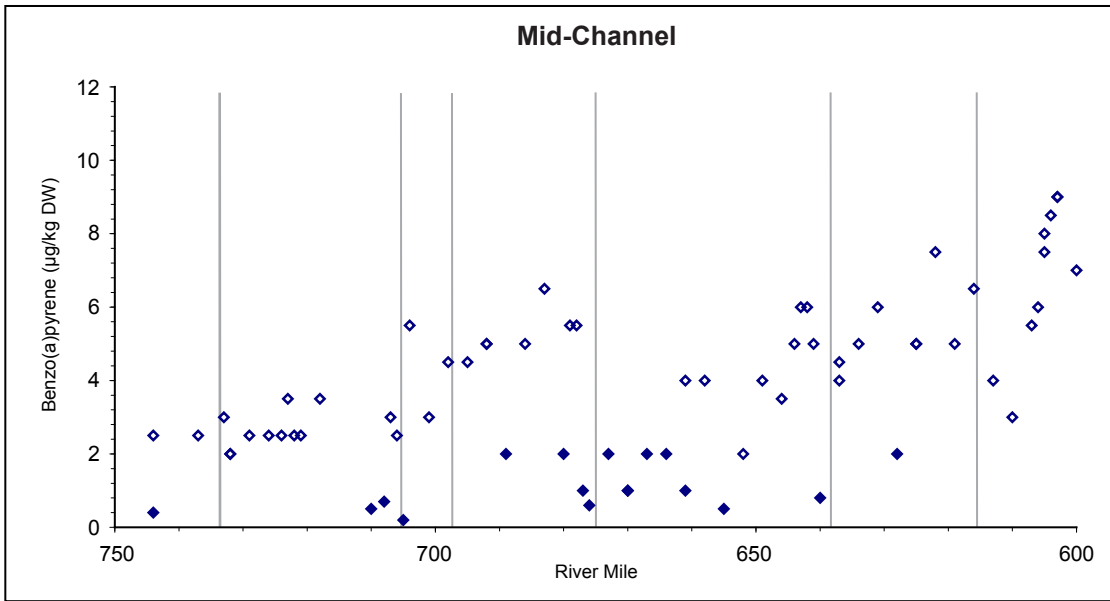
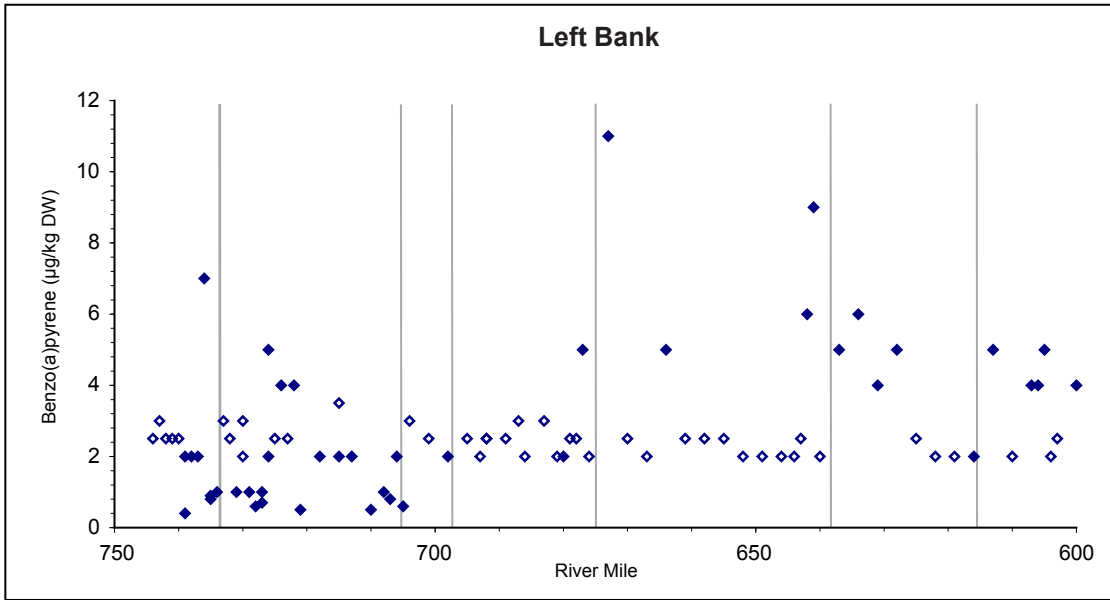


Figure 5-40. Longitudinal Distribution of Aroclor 1260 Concentrations (Dry Weight [DW]) in the UCR.

Source: USEPA (2006h).

Notes: Detected concentrations are solid data points.

Grey vertical lines represent approximate river mile of stations listed in the side table.



Station	Approx. River Mile
Northport	734
Mouth of Kettle River	706
Mouth of Colville River	698
Mouth of Stranger Creek	675
Mouth of Spokane River	639
Mouth of Sanpoil River	616

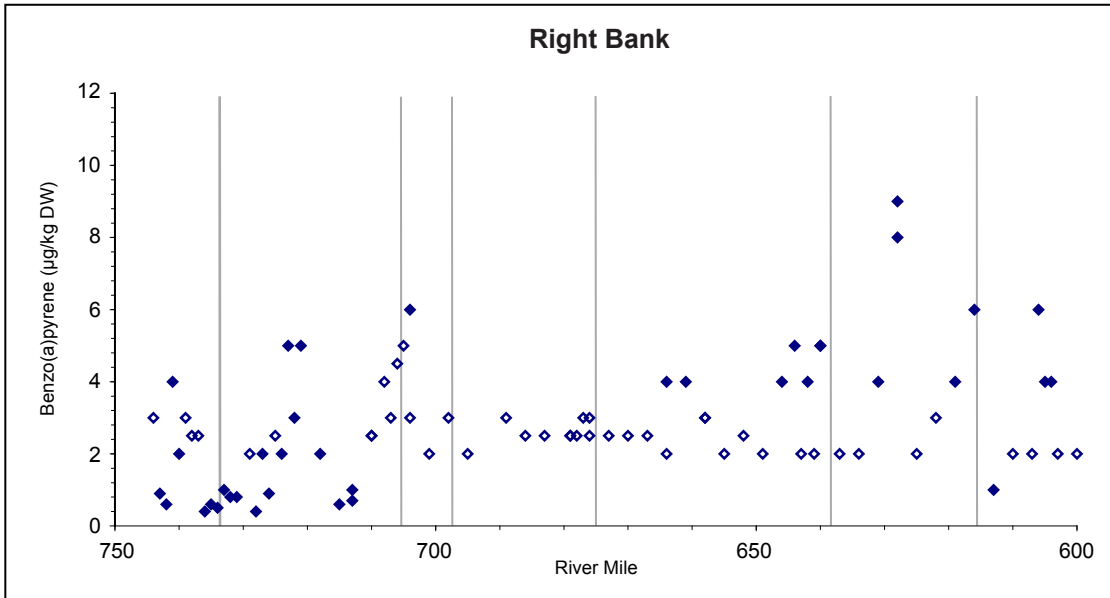


Figure 5-41. Longitudinal Distribution of Benzo(a)pyrene Concentrations (Dry Weight [DW]) in the UCR.
Source: USEPA (2006h).
Notes: Detected concentrations are solid data points.
 Grey vertical lines represent approximate river mile of stations listed in the side table.

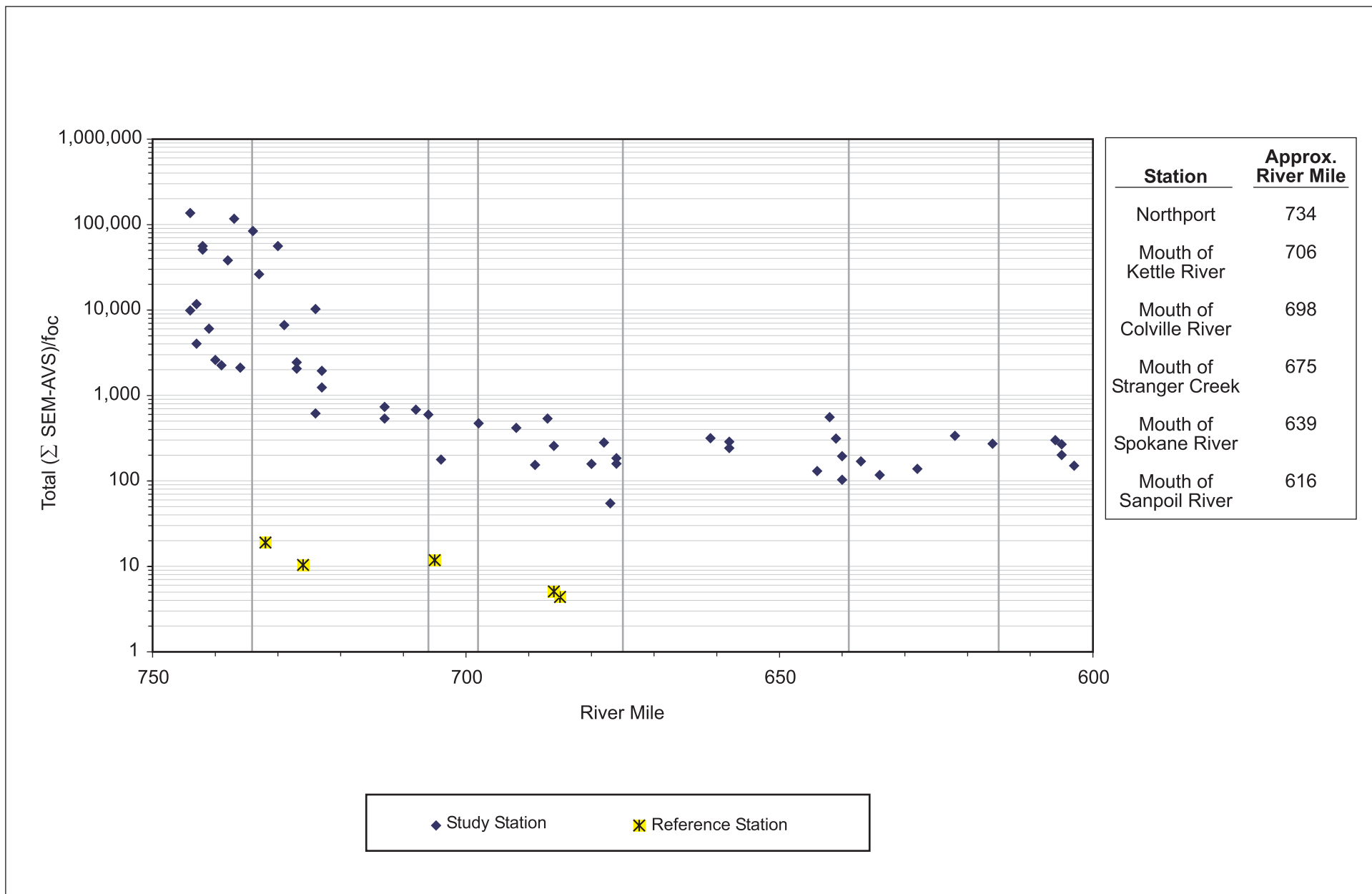


Figure 5-42. Spatial Variation in Organic Carbon-Normalized Concentrations of Total Simultaneously Extracted Metals and Acid Volatile Sulfides ($(\sum \text{SEM-AVS})/f_{\text{OC}}$) Reported by USEPA for UCR Sediments in 2005. **Note:** Grey vertical lines represent approximate river mile of stations listed in the side table.

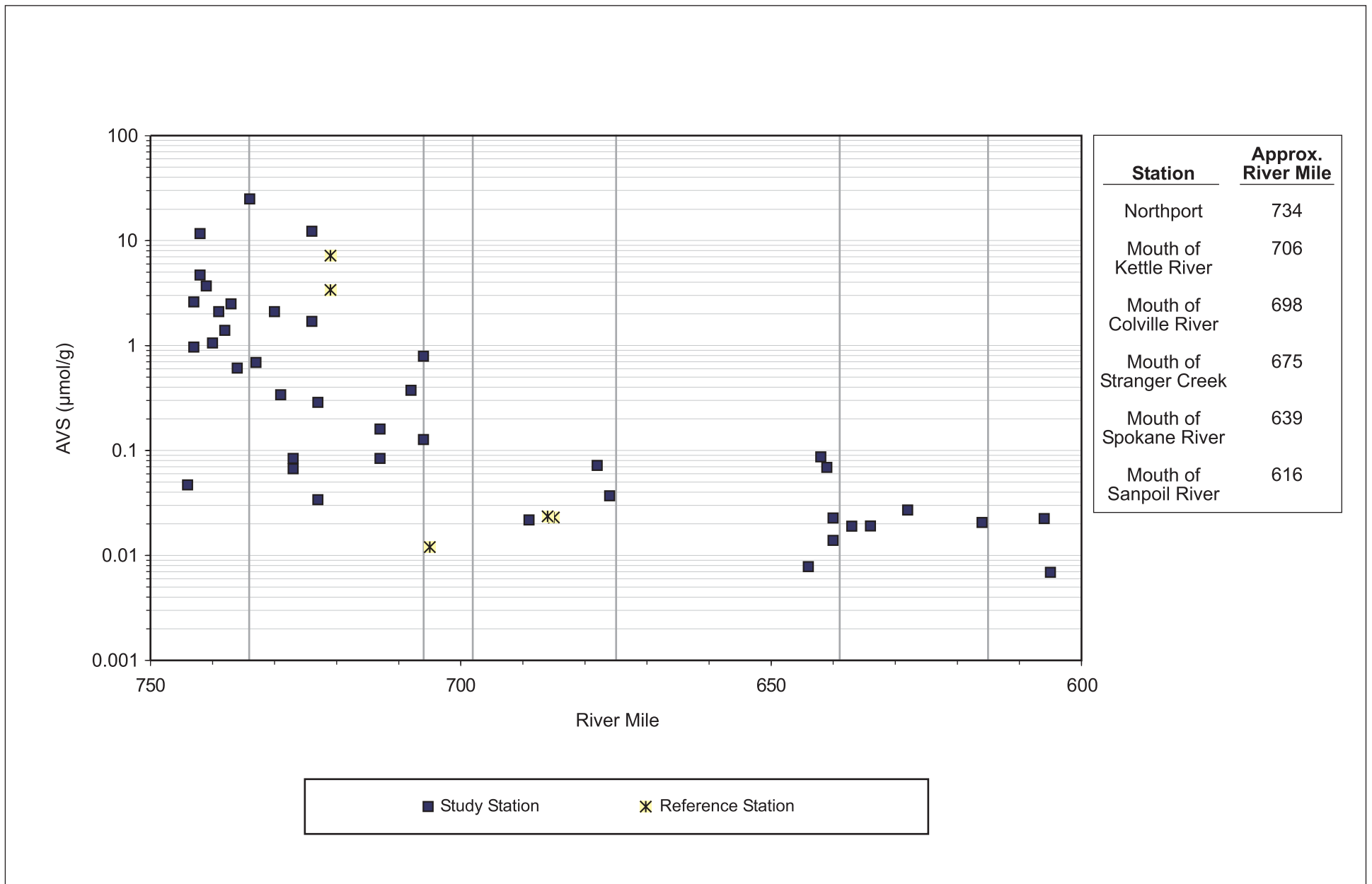


Figure 5-43. Spatial Variation in Acid Volatile Sulfide (AVS) Concentrations Reported by USEPA for UCR Sediments in 2005.
Notes: Grey vertical lines represent approximate river mile of stations listed in the side table. Non-detected values are not plotted.

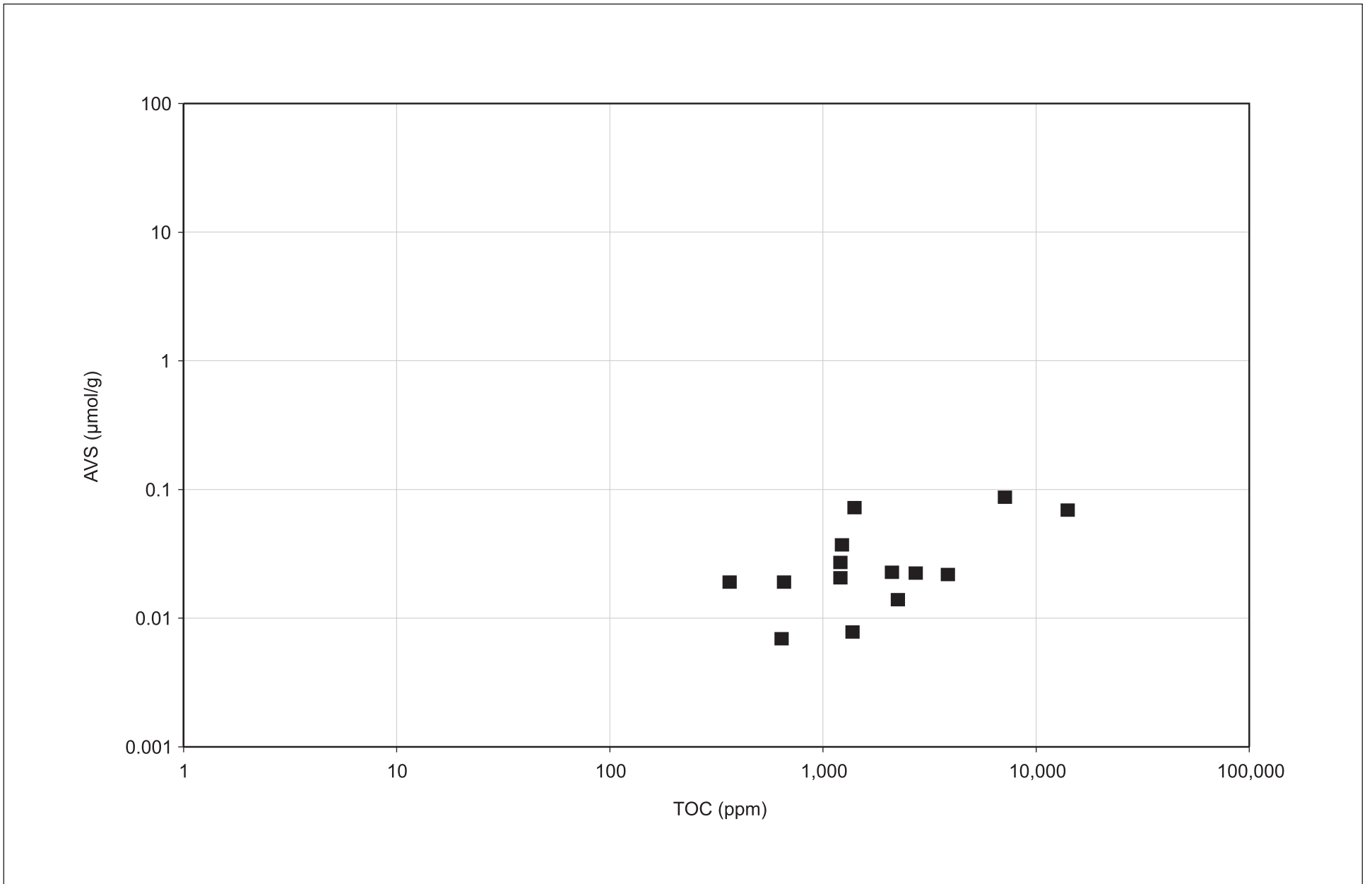


Figure 5-44. Relationship Between Acid Volatile Sulfide (AVS) and Total Organic Carbon (TOC) Concentrations in the UCR Between River Miles 603 and 698.
Source: USEPA (2006a).

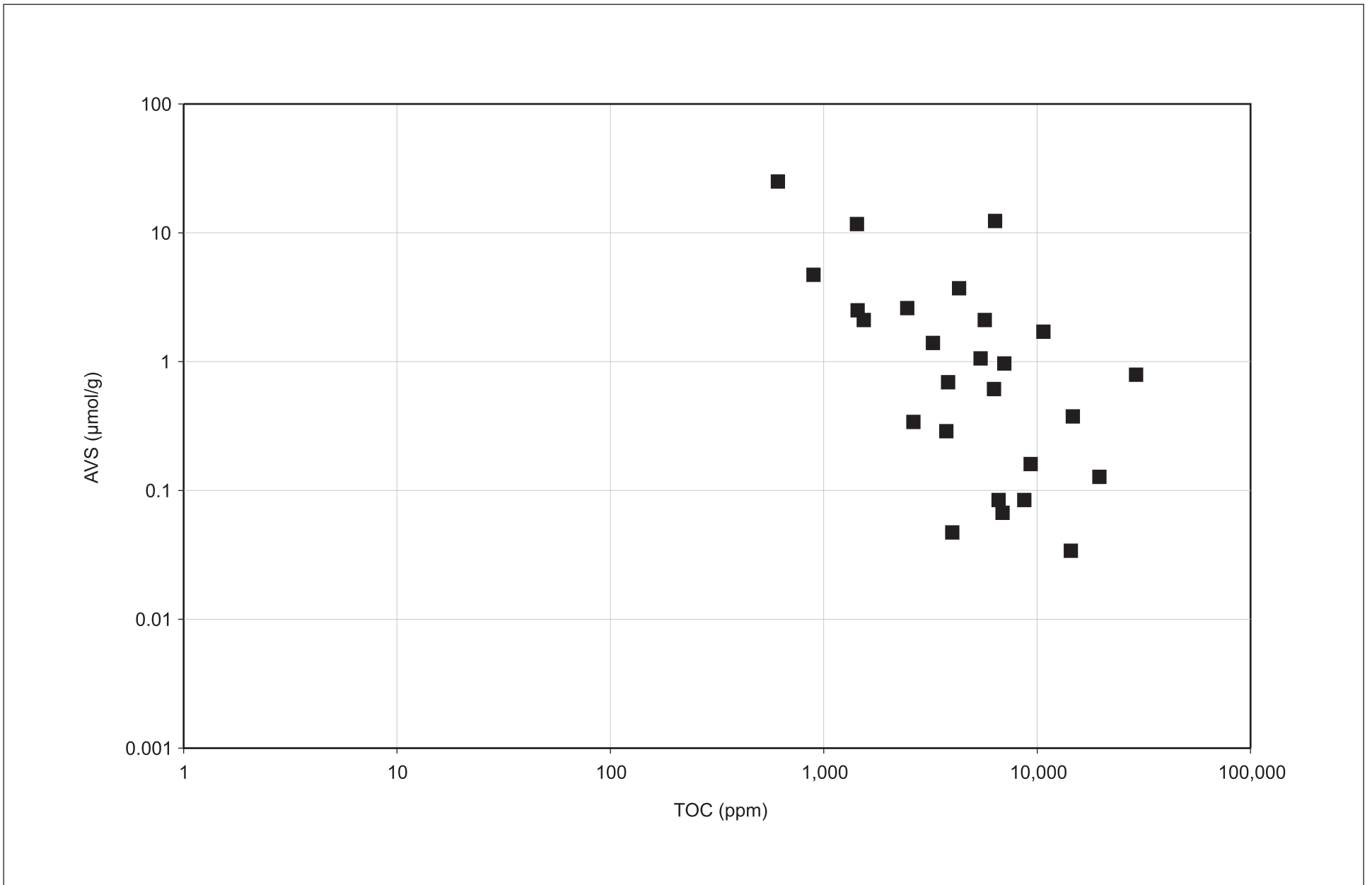


Figure 5-45. Relationship Between Acid Volatile Sulfide (AVS) and Total Organic Carbon (TOC) Concentrations in the UCR Between River Miles 704 and 744.
Source: USEPA (2006a).

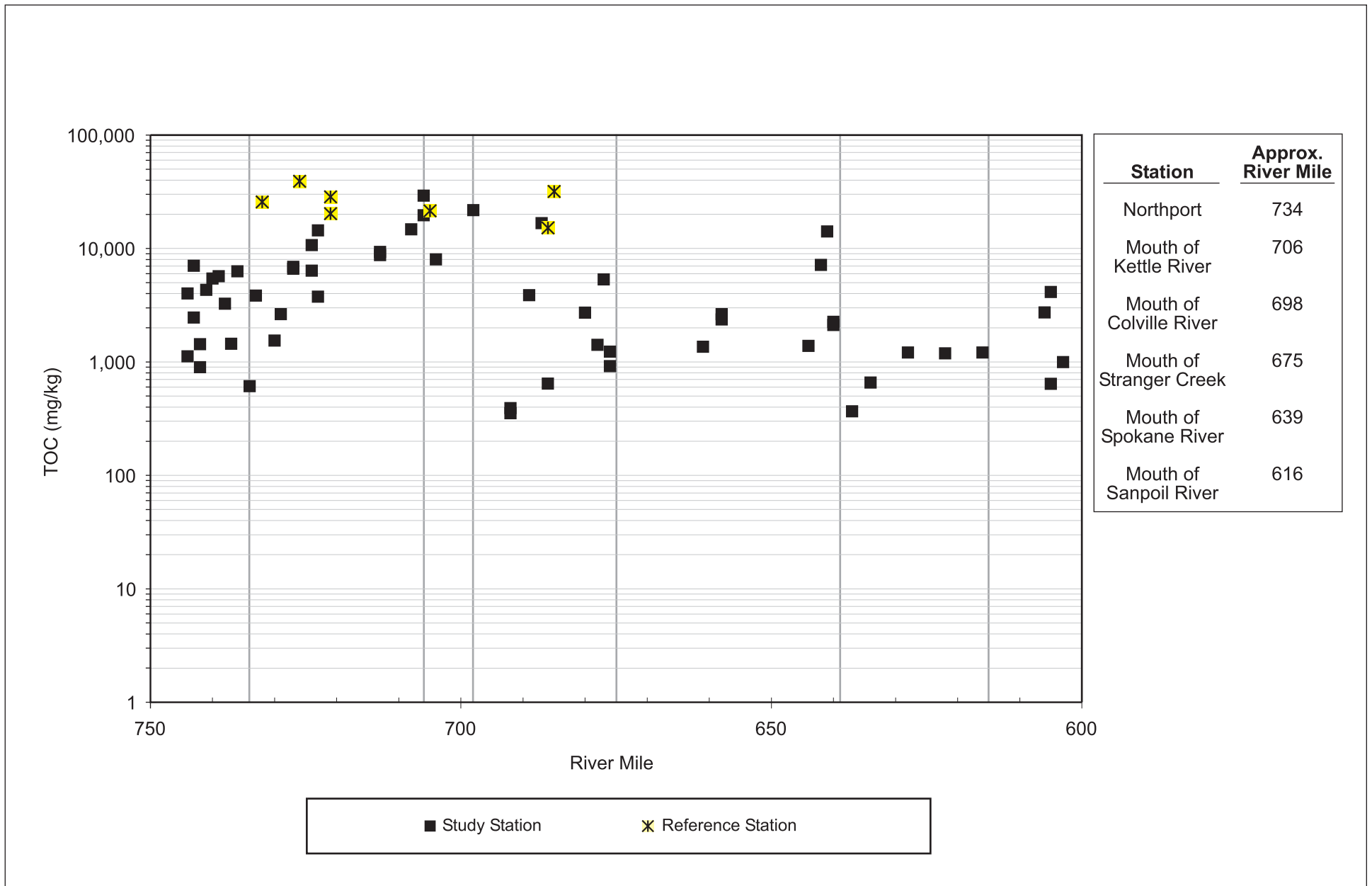


Figure 5-46. Spatial Variation in Total Organic Carbon (TOC) Concentrations Reported by USEPA for UCR Sediments in 2005.
Note: Grey vertical lines represent approximate river mile of stations listed in the side table.

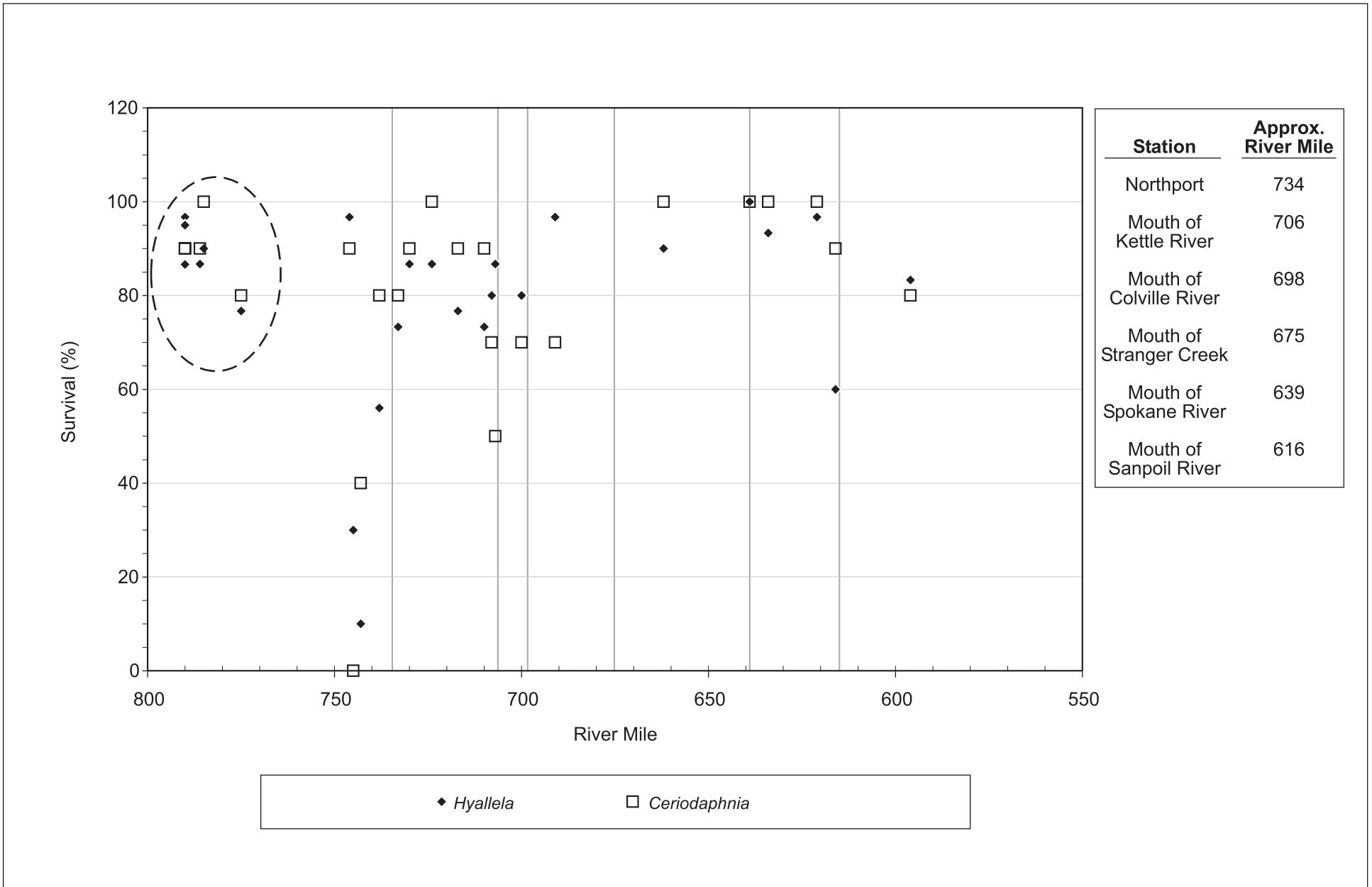


Figure 5-47. Survival of *Hyallela azteca* and *Ceriodaphnia dubia* in Sediments from the UCR.
Source: Bortleson et al. (2001).
Notes: Reference sites and laboratory controls are circled.
 Grey vertical lines represent approximate river mile of stations listed in the side table.

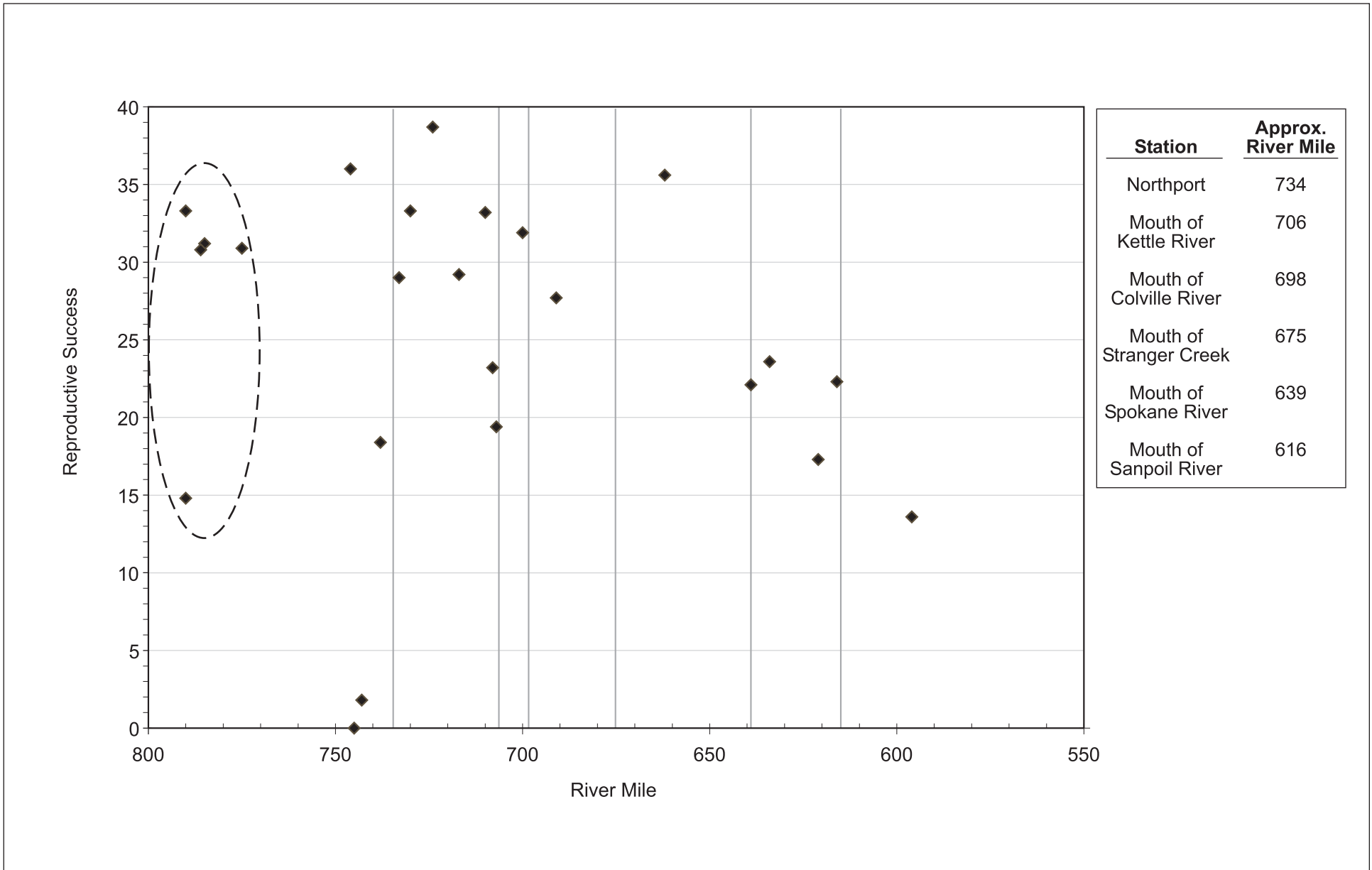


Figure 5-48. Reproductive Success (Mean Neonates Per Adult) of *Ceriodaphnia Dubia* in Sediments from the UCR.

Source: Bortleson et al. (2001).

Notes: Reference sites (on Lower Arrow Lake, Canada) and laboratory controls are circled.

Reproductive success is the mean number of neonates per adult.

Grey vertical lines represent approximate river mile of stations listed in the side table.

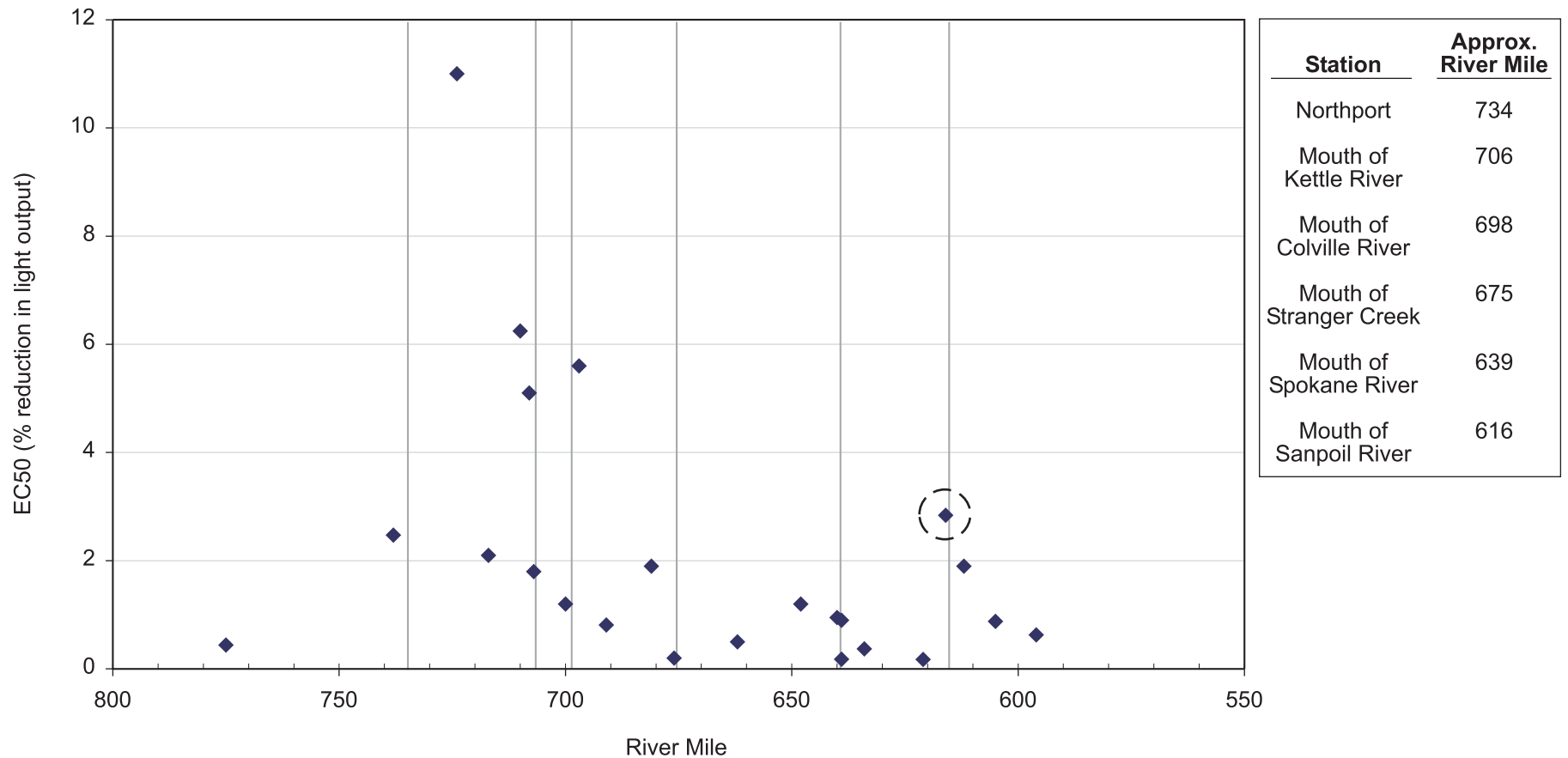


Figure 5-49. Median Reduction in Light Output of *Vibrio fischeri*.

Source: Bortleson et al. (2001).

Notes: *Vibrio fischeri* when exposed to dilutions of a mixture of 0.30 g of fine-grained sediment with dilution water (maximum dilution tested was 10%, so 11% value is assumed to have been an estimated value). Reference site (Sanpoil River) is circled (no data on laboratory controls were reported). EC50 is the median (50%) effective concentration. Grey vertical lines represent approximate river mile of stations listed in the side table.

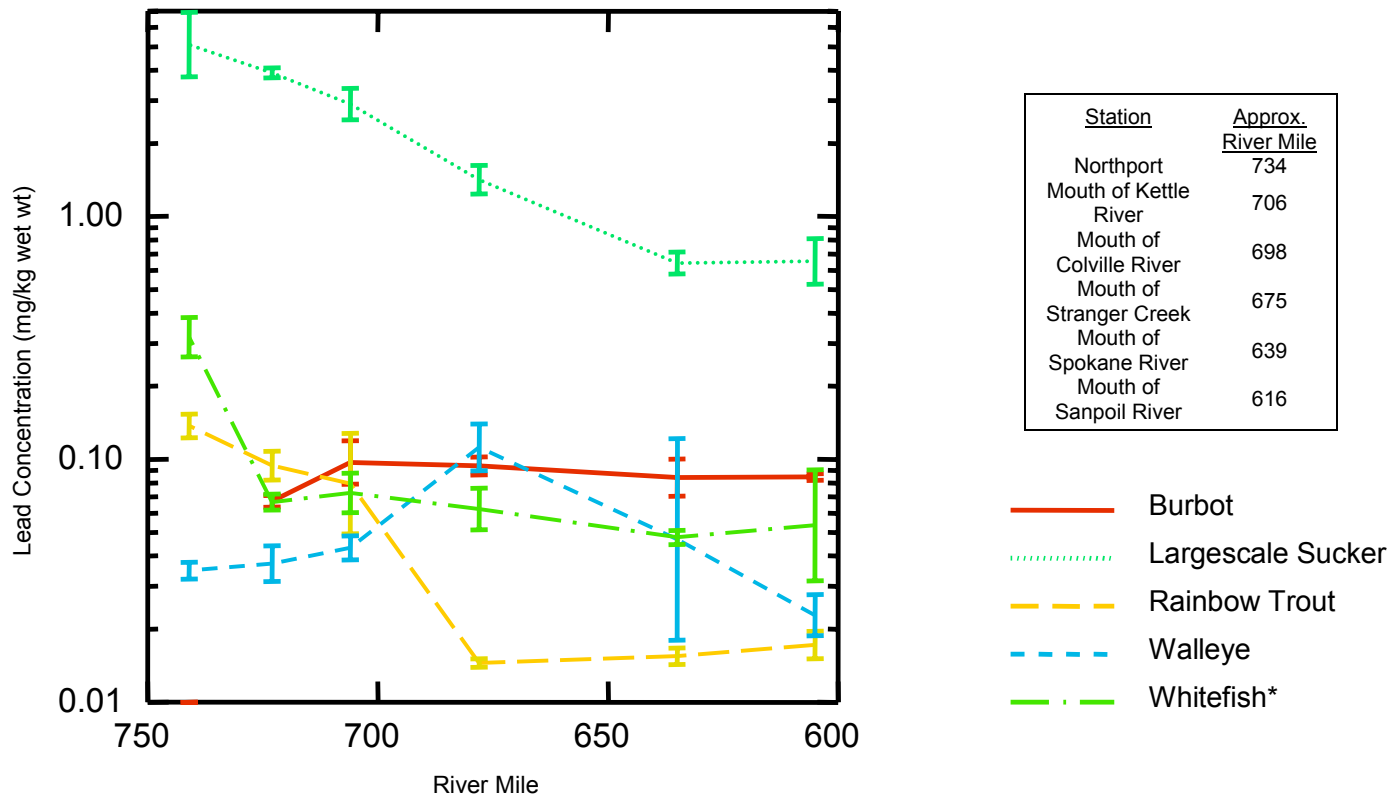


Figure 5-50. Mean Concentrations of Lead in Composite Samples of Largescale Sucker.

Notes:

- *Mountain Whitefish (RM 741 only), Lake Whitefish at other locations
- Lead concentrations in Largescale Sucker were ten times greater than in other species at any location on the UCR.
- Means are from 3 to 5 composite samples of 3 to 5 individuals.
- Bars indicate +/-standard error.

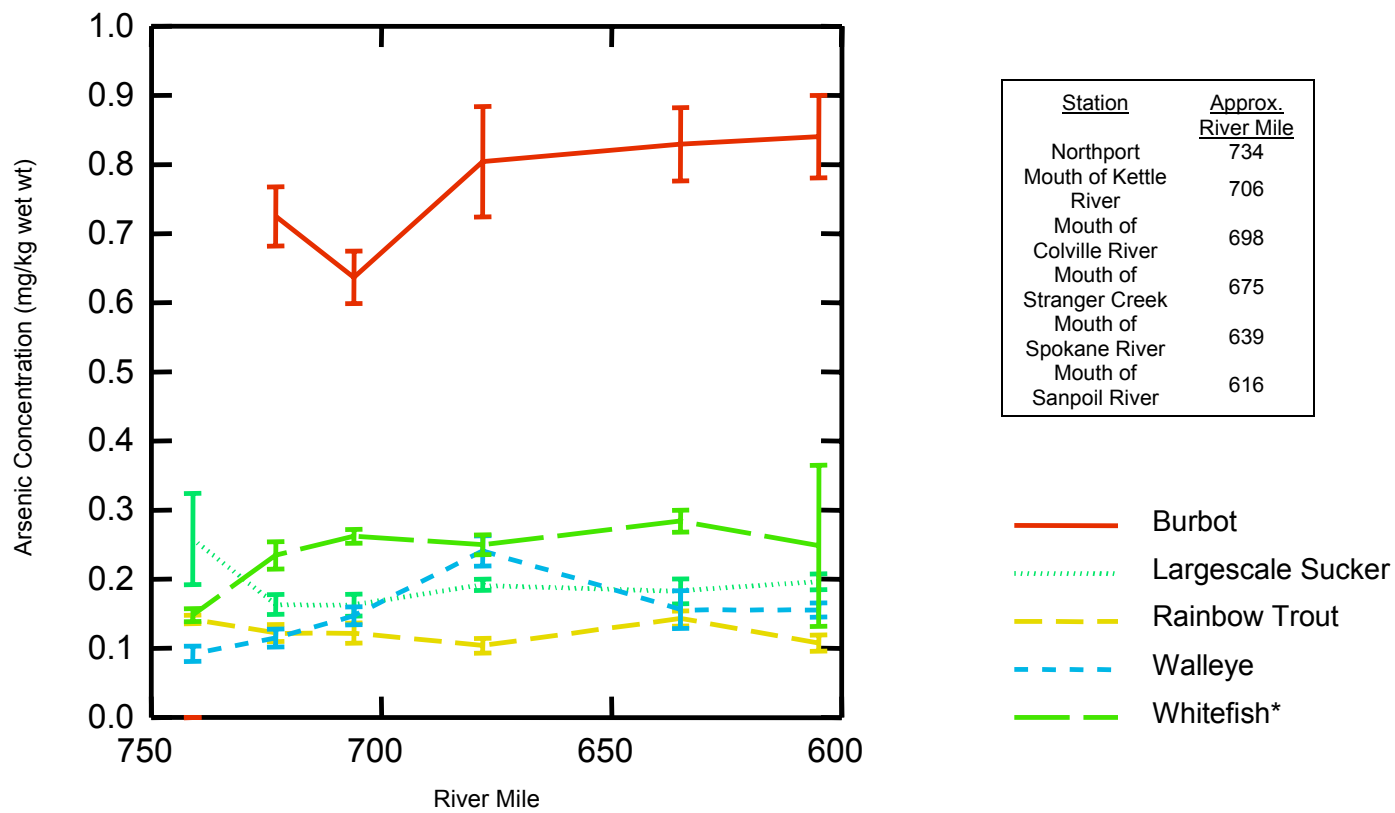


Figure 5-51. Mean Concentrations of Arsenic in Composite Samples of Burbot.
Notes: *Mountain Whitefish (RM 741 only), Lake Whitefish at other locations
 - Arsenic concentrations in Burbot were ten times greater than in other species at any location on the UCR.
 - Means are from 3 to 5 composite samples of 3 to 5 individuals.
 - Bars indicate +/-standard error.

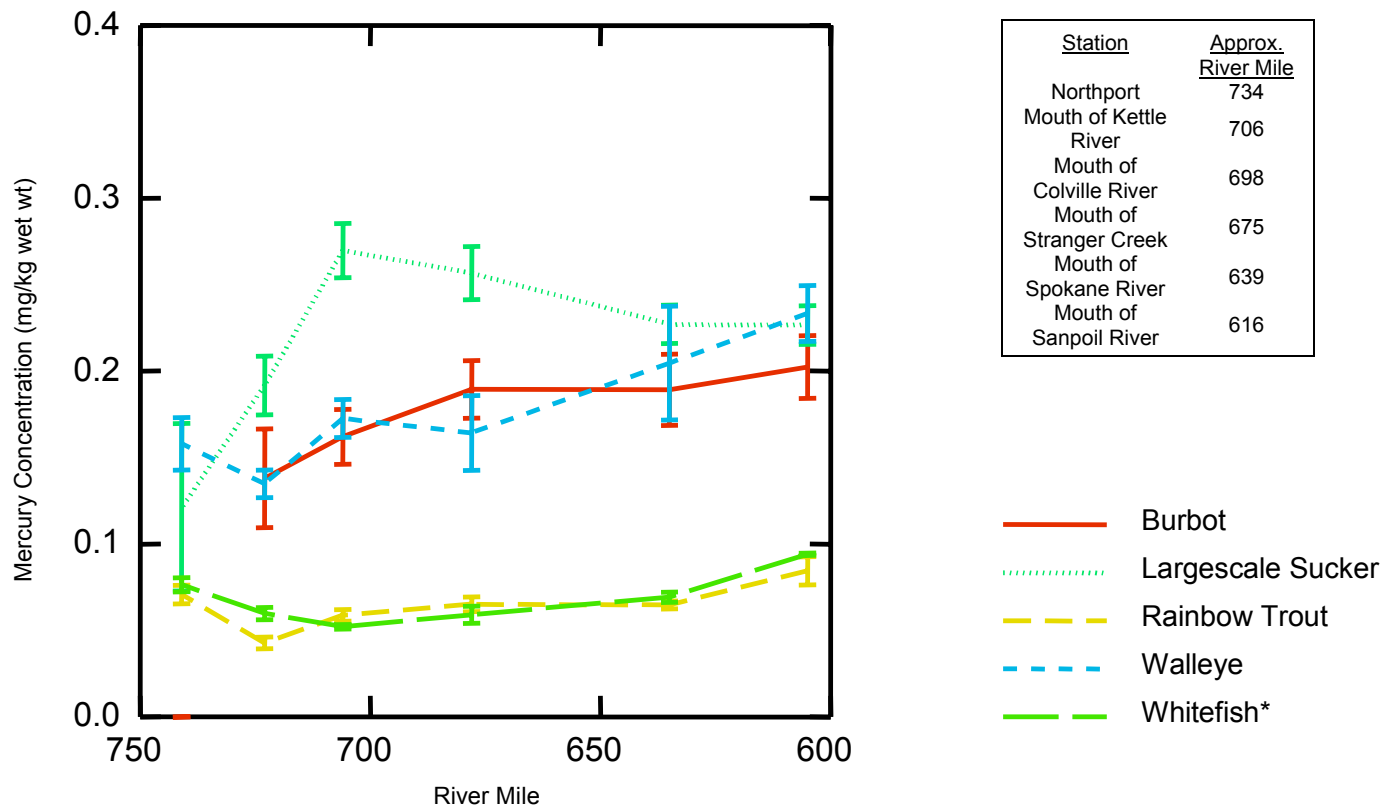


Figure 5-52. Mean Mercury Concentrations in Composite Samples of Fishes from the UCR Grouped by Dietary Preference.

Notes:

- *Mountain Whitefish (RM 741 only), Lake Whitefish at other locations
- Largescale Suckers are detritovores; Walleye and Burbot are piscivores; and Whitefish and Rainbow Trout are invertivores
- Means are from 3 to 5 composite samples of 3 to 5 individuals.
- Bars indicate +/- standard error.

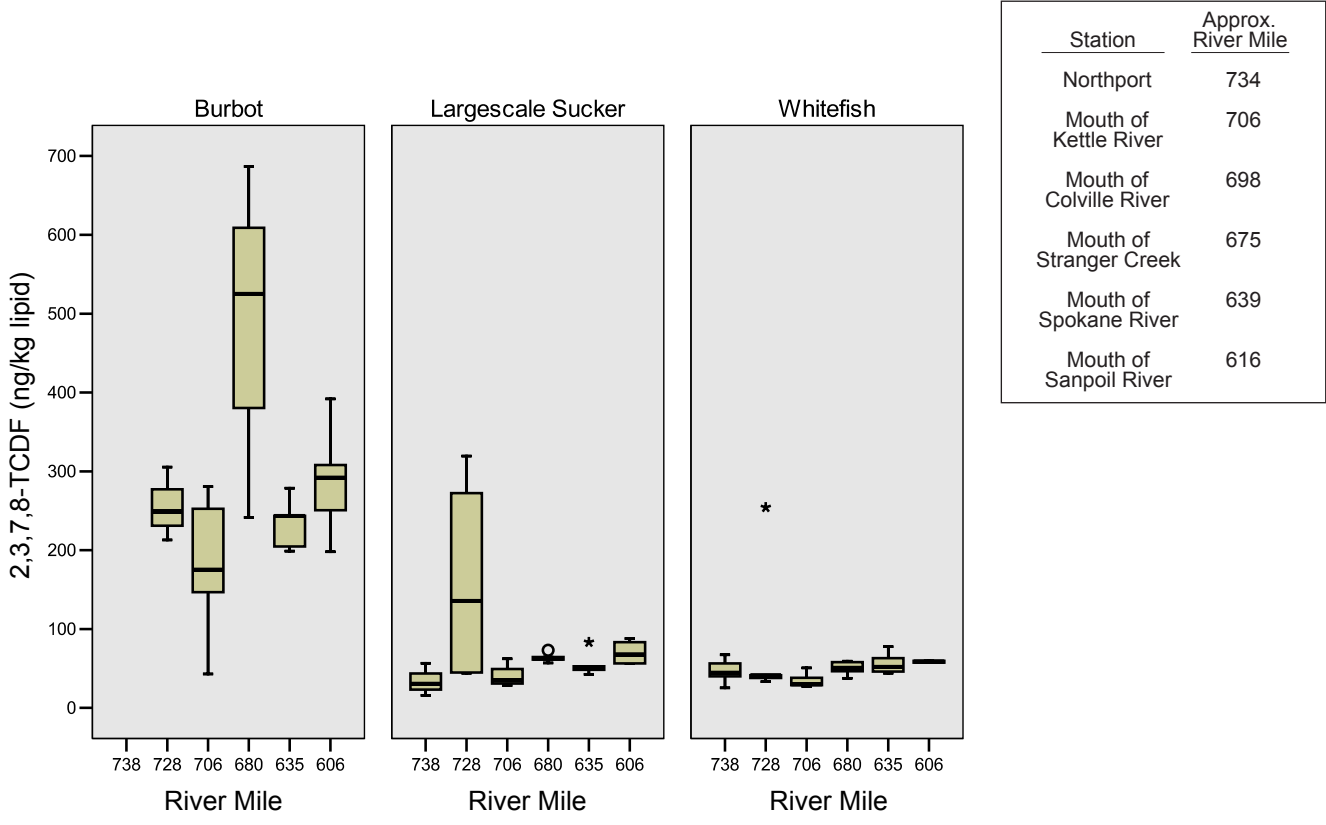
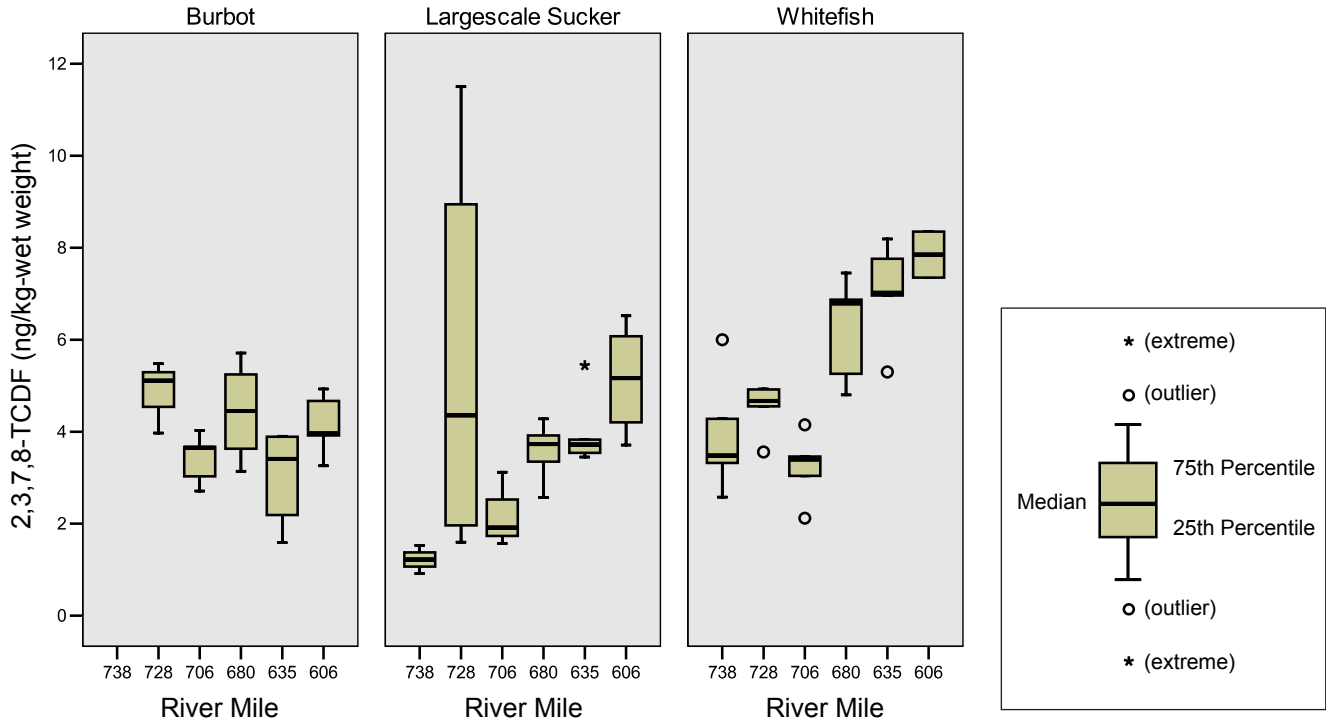


Figure 5-53. Comparison of Normal and Lipid Normalized 2,3,7,8-TCDF Concentrations in Whole Body Burbot, Largescale Sucker, and Whitefish by River Mile Collected in the UCR by EPA in 2005.

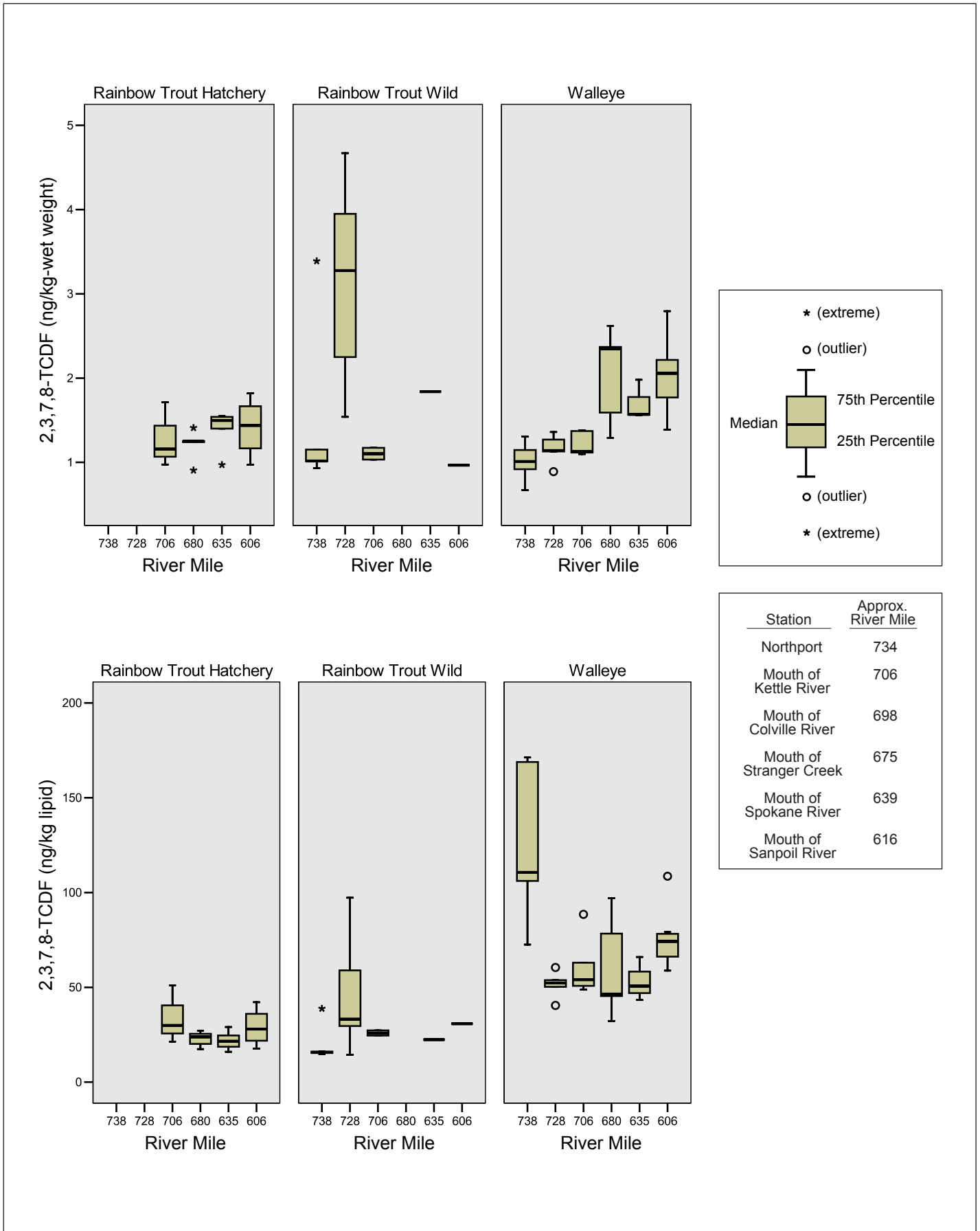


Figure 5-54. Comparison of Normal and Lipid Normalized 2,3,7,8-TCDF Concentrations in Whole Body Rainbow Trout and Walleye by River Mile Collected in the UCR by EPA in 2005.

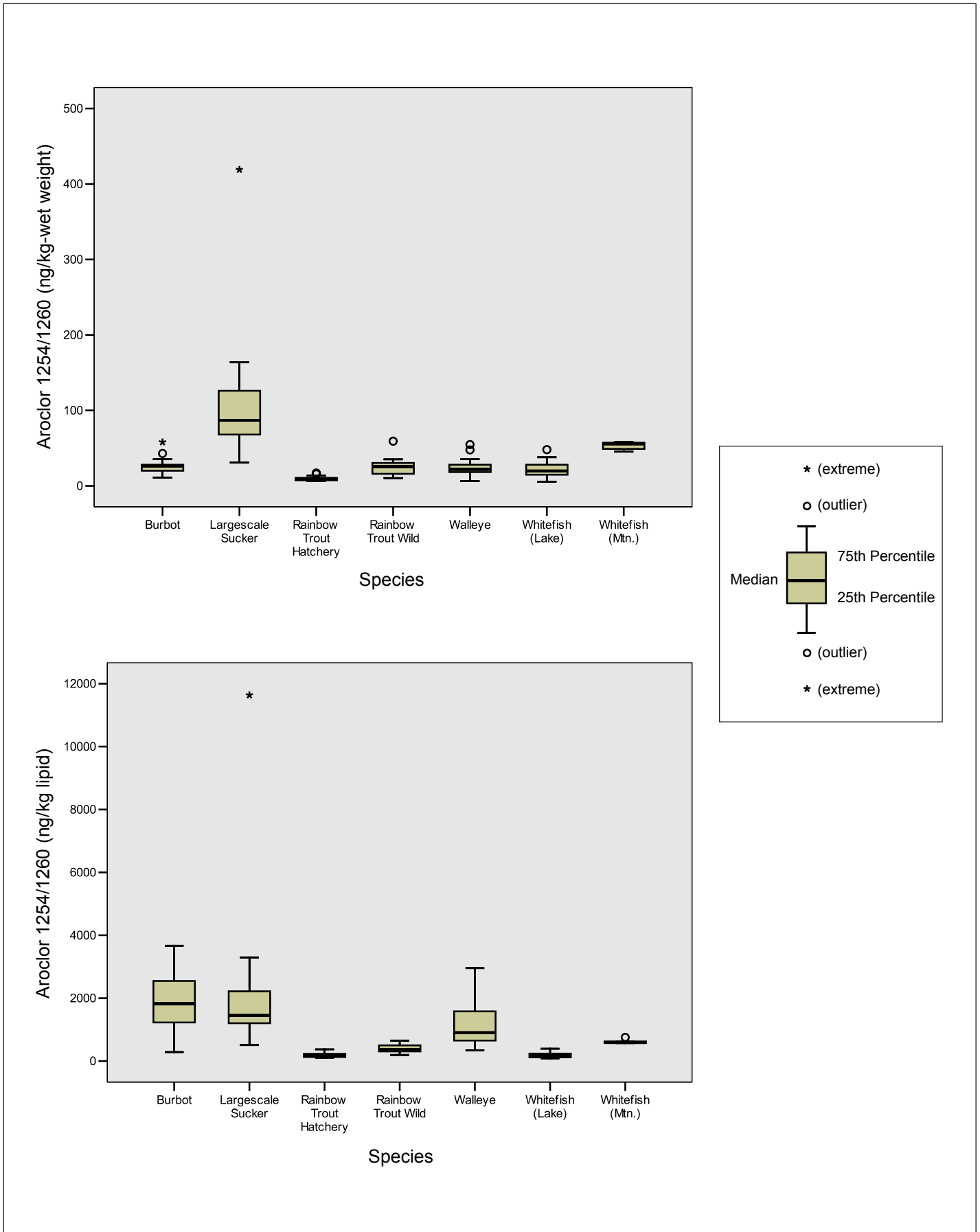


Figure 5-55. Comparison of Normal and Lipid Normalized Aroclor 1254/1260 Concentrations in Whole Body Fish Collected in the UCR by EPA in 2005.

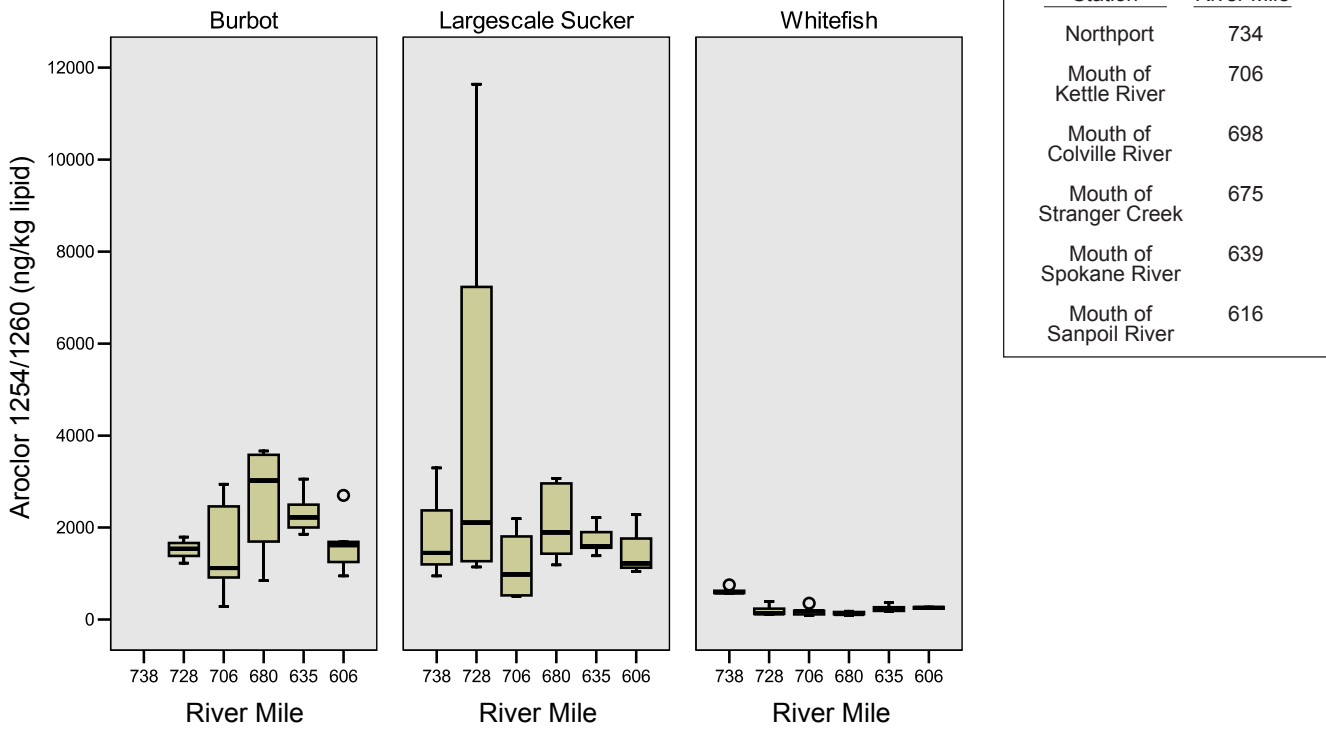
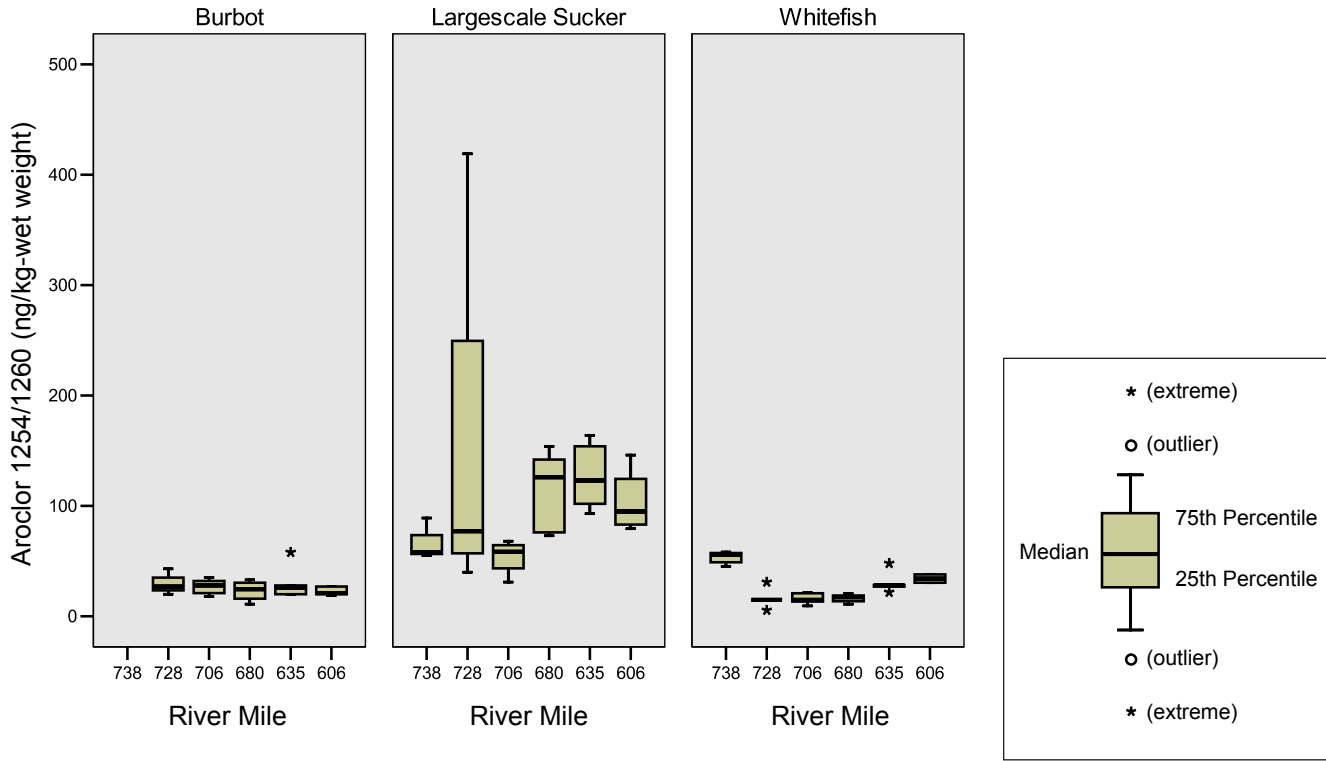


Figure 5-56. Comparison of Normal and Lipid Normalized Aroclor 1254/1260 Concentrations in Whole Body Burbot, Largescale Sucker, and Whitefish by River Mile Collected in the UCR by EPA in 2005.

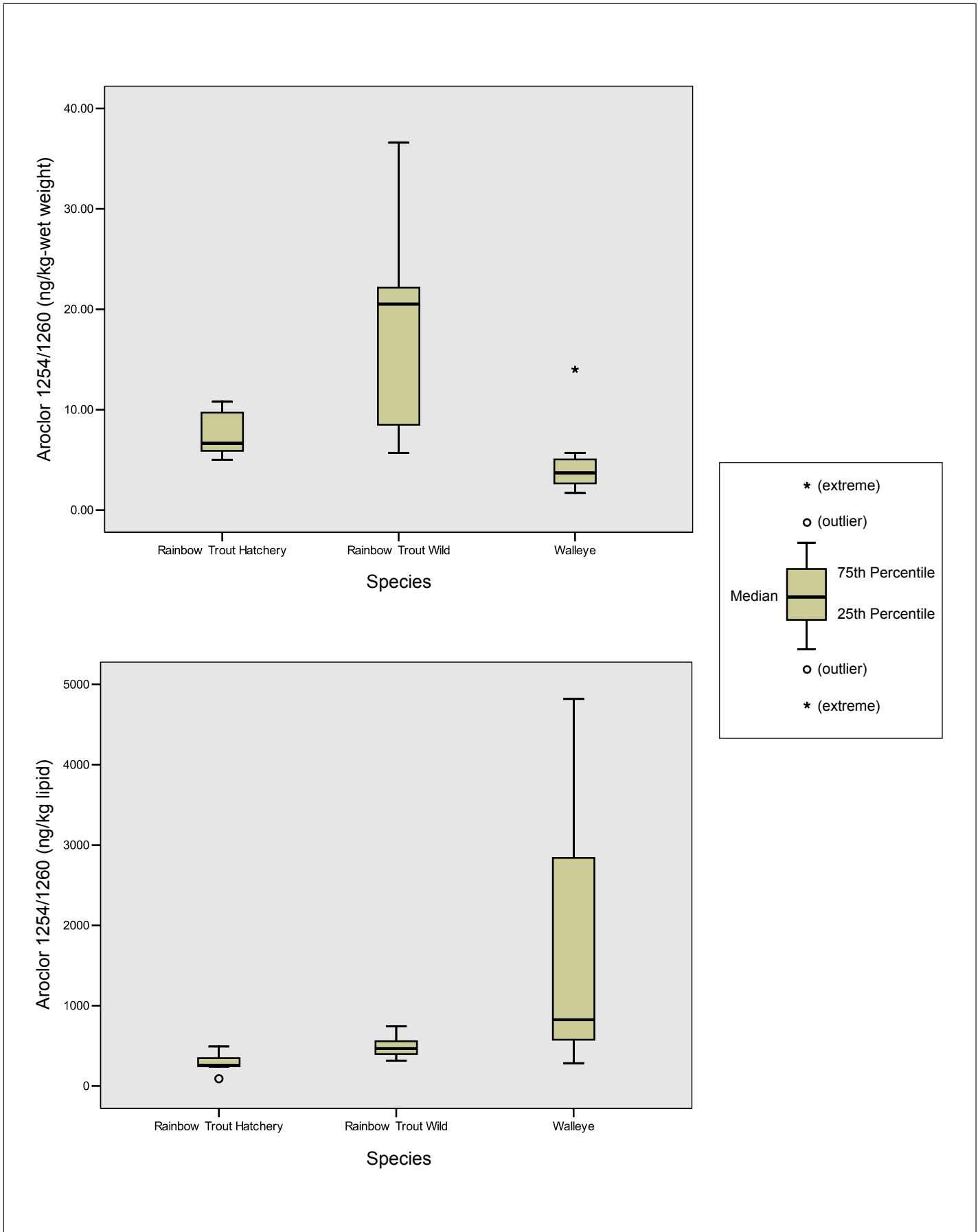


Figure 5-57. Comparison of Normal and Lipid Normalized Aroclor 1254/1260 Concentrations in Fillets of Rainbow Trout and Walleye Collected in the UCR by EPA in 2005.

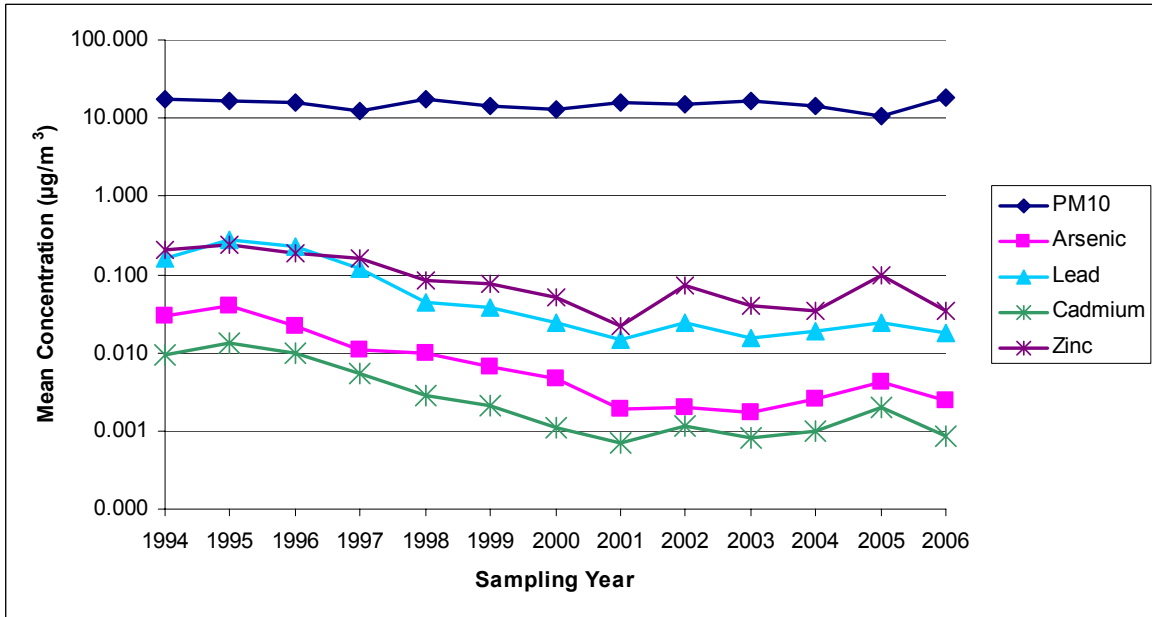


Figure 5-58. Mean Air Monitoring Concentrations for Northport from 1994-2006.
Source: TCM, Trail, B.C.
Note: 2006 sampling data ended in mid-August; all other sampling years were carried through December.

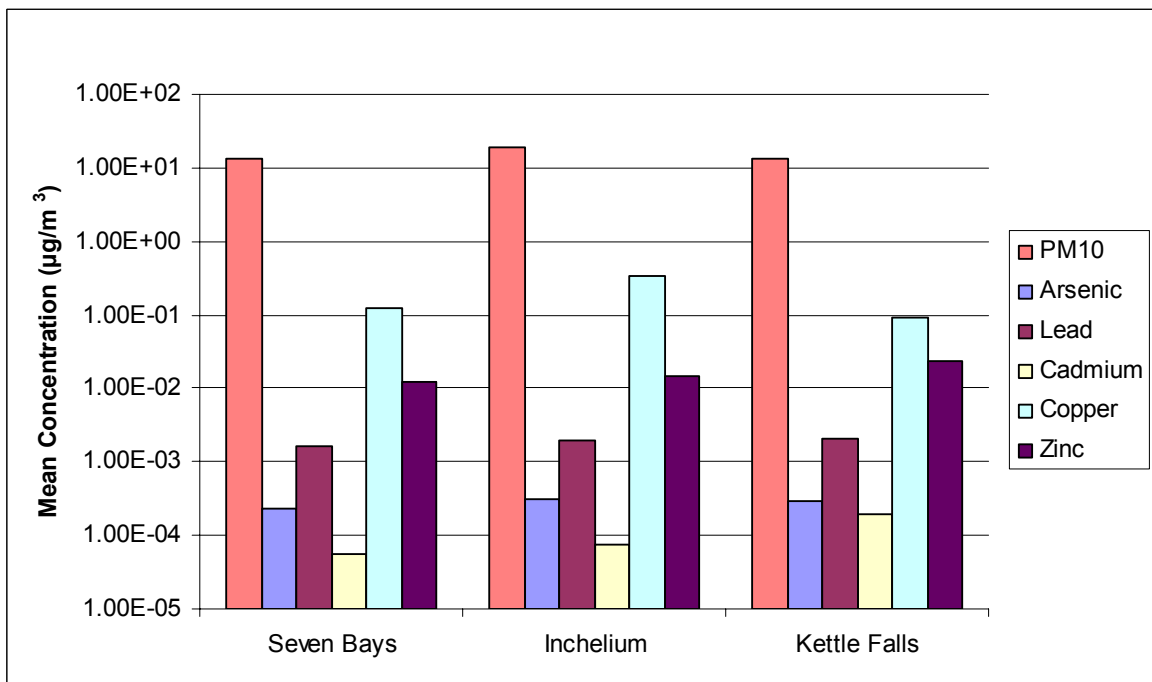


Figure 5-59. Mean Concentrations for Air Monitoring Results at Three Sampling Locations along UCR in 2002.
Source: Majewski and Kahle (2006).

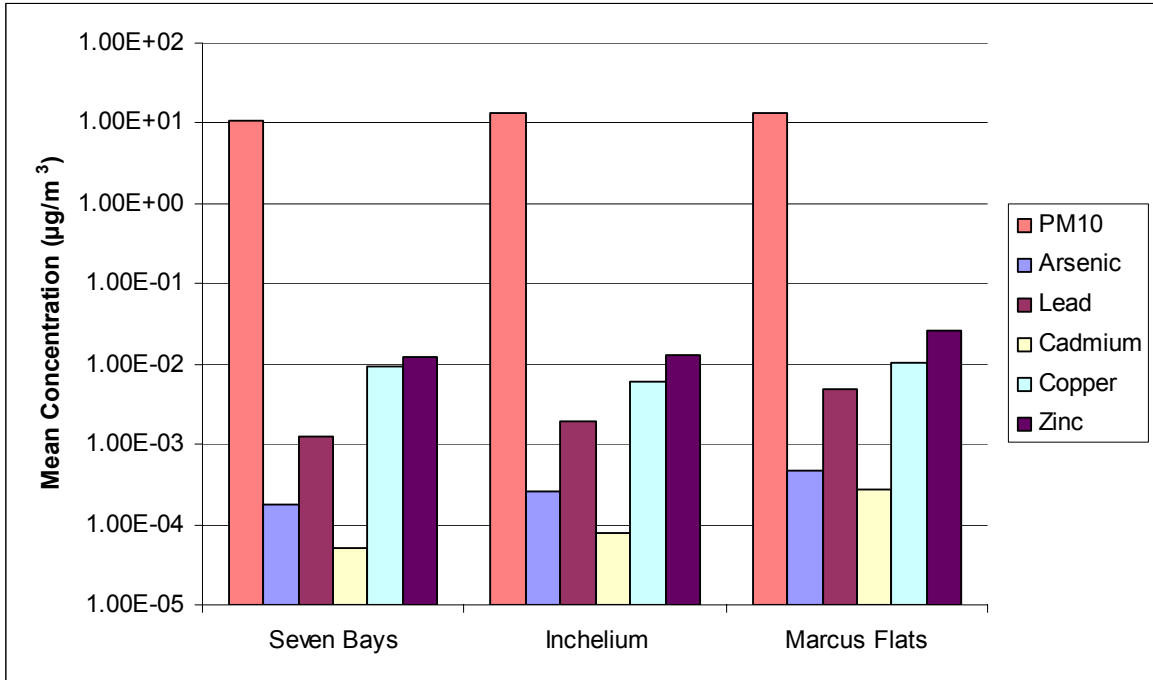


Figure 5-60. Mean Concentrations for Air Monitoring Results at Three Sampling Locations along UCR in 2003. **Source:** Majewski and Kahle (2006).

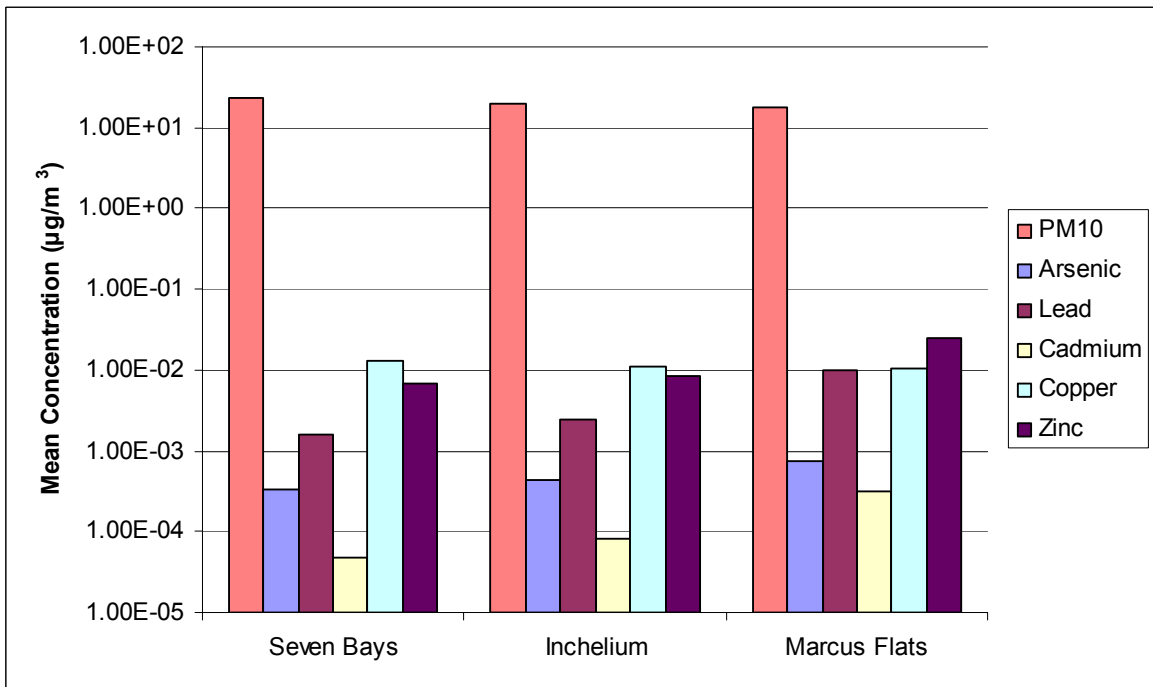


Figure 5-61. Mean Concentrations for Air Monitoring Results at Three Sampling Locations along UCR in 2004. **Source:** Majewski and Kahle (2006).

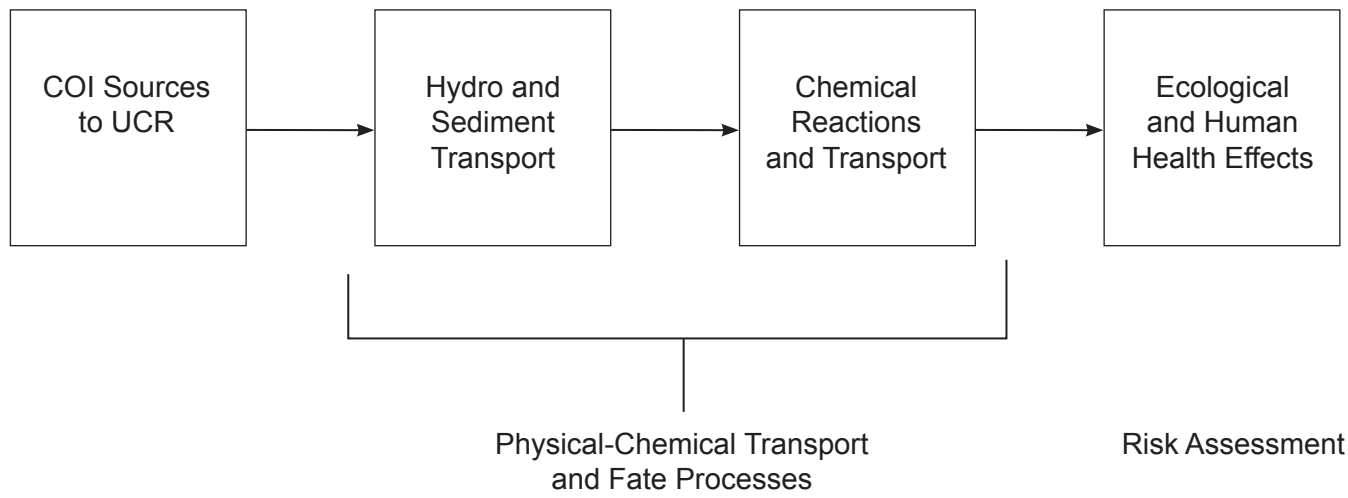


Figure 6-1. Components of a Generic Conceptual Site Model.

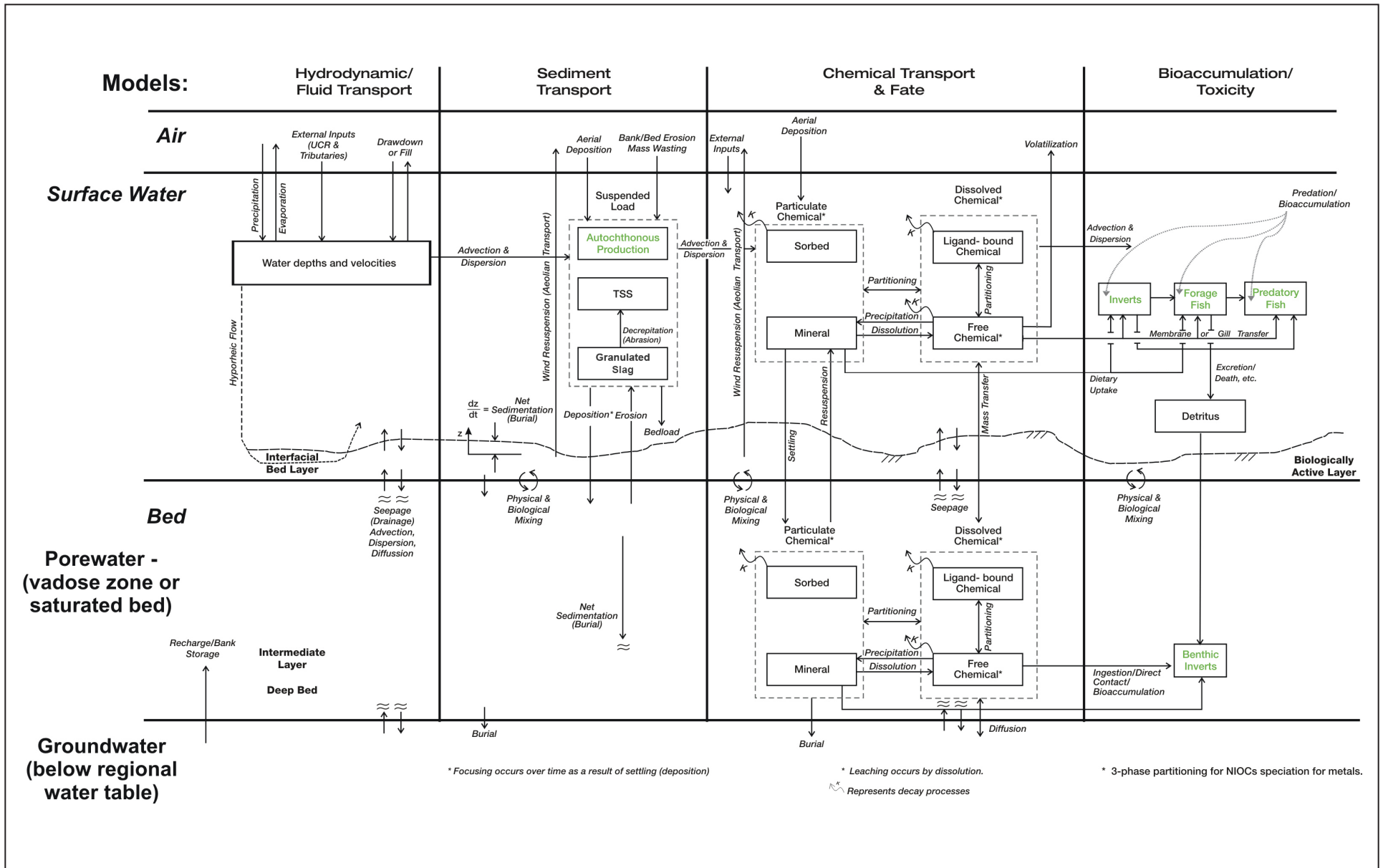


Figure 6-2. Preliminary Transport and Fate Conceptual Site Model.

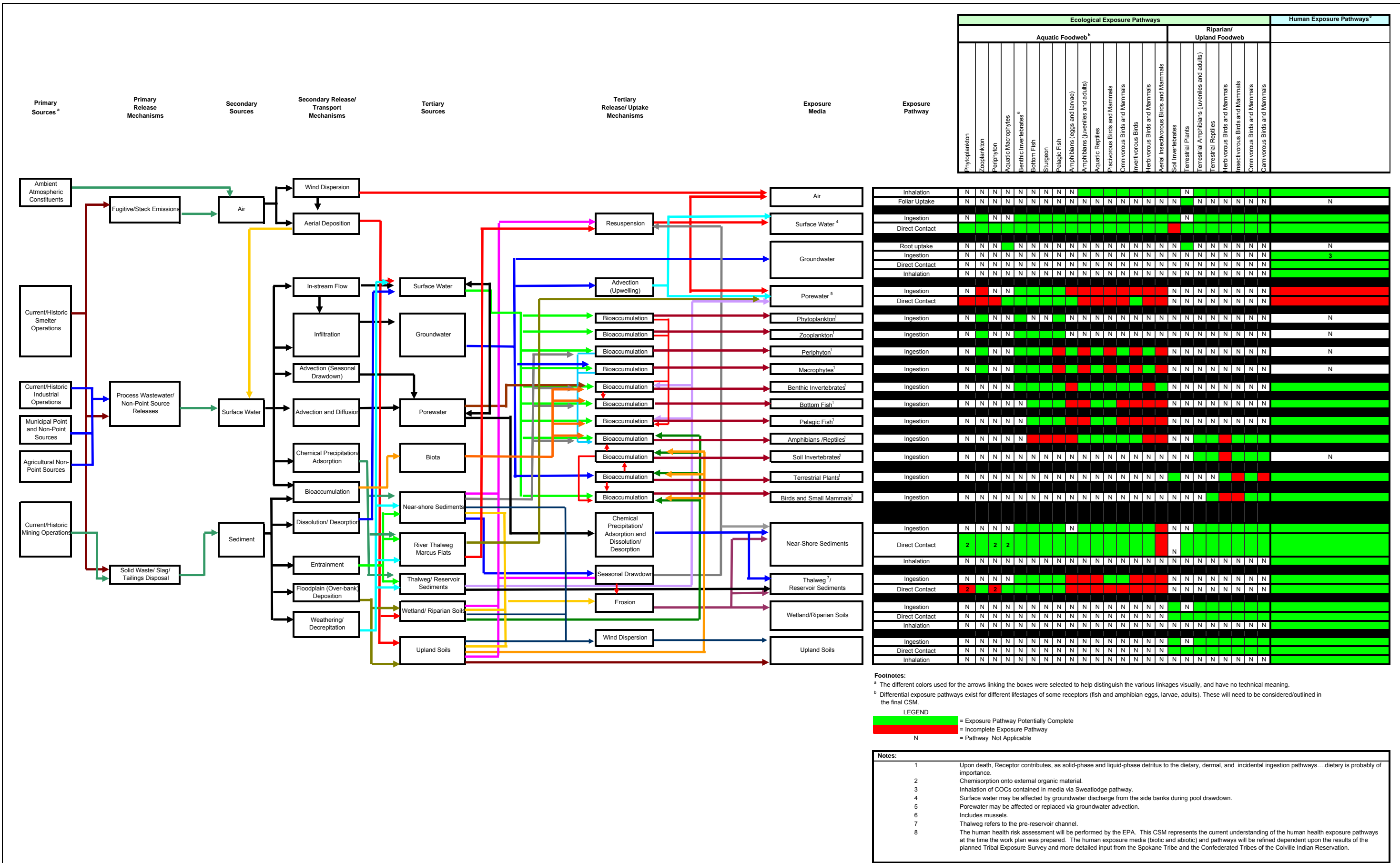


Figure 6-3. Preliminary Conceptual Site Model.

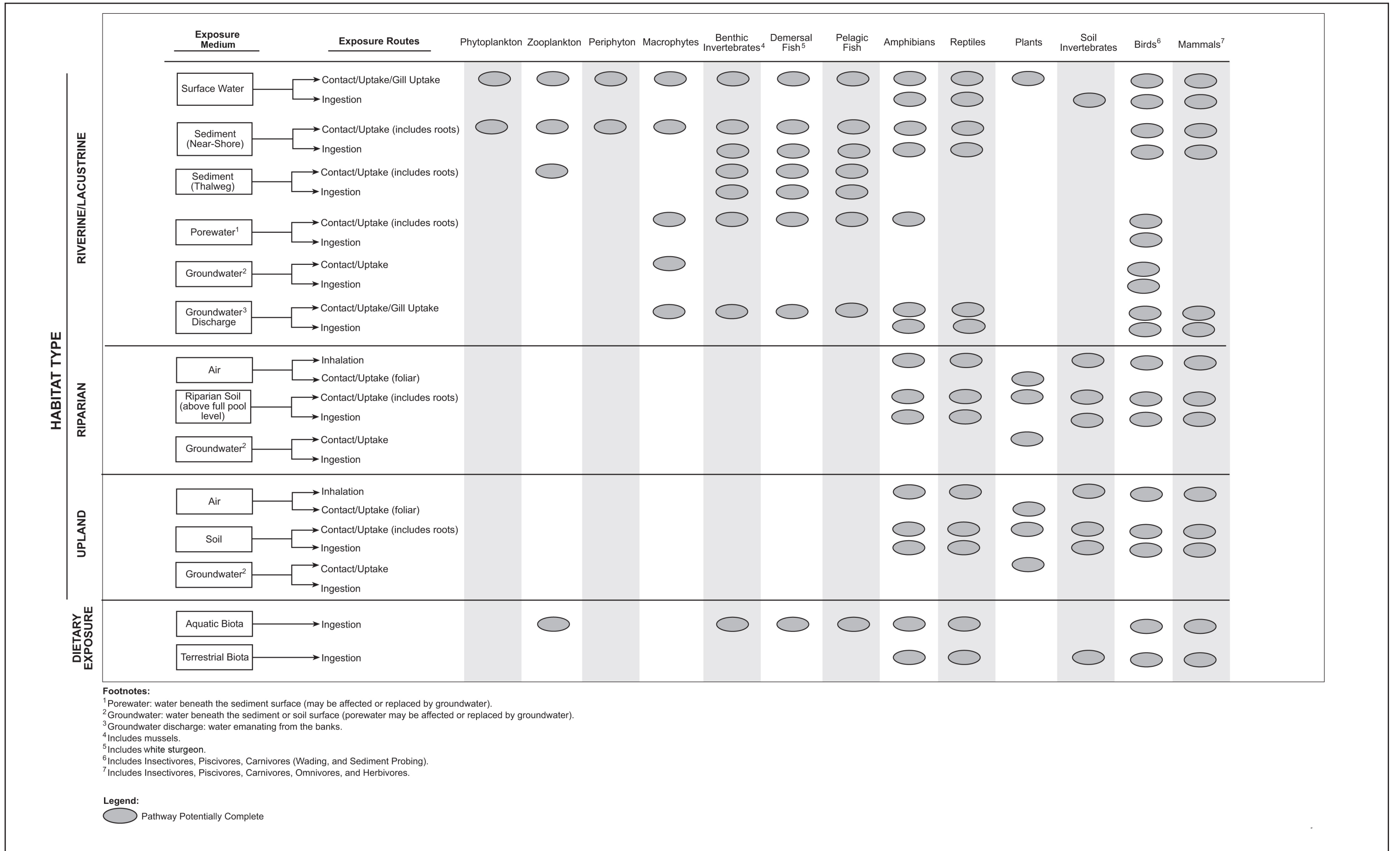


Figure 6-4. General Exposure Pathways and Receptor Groups.

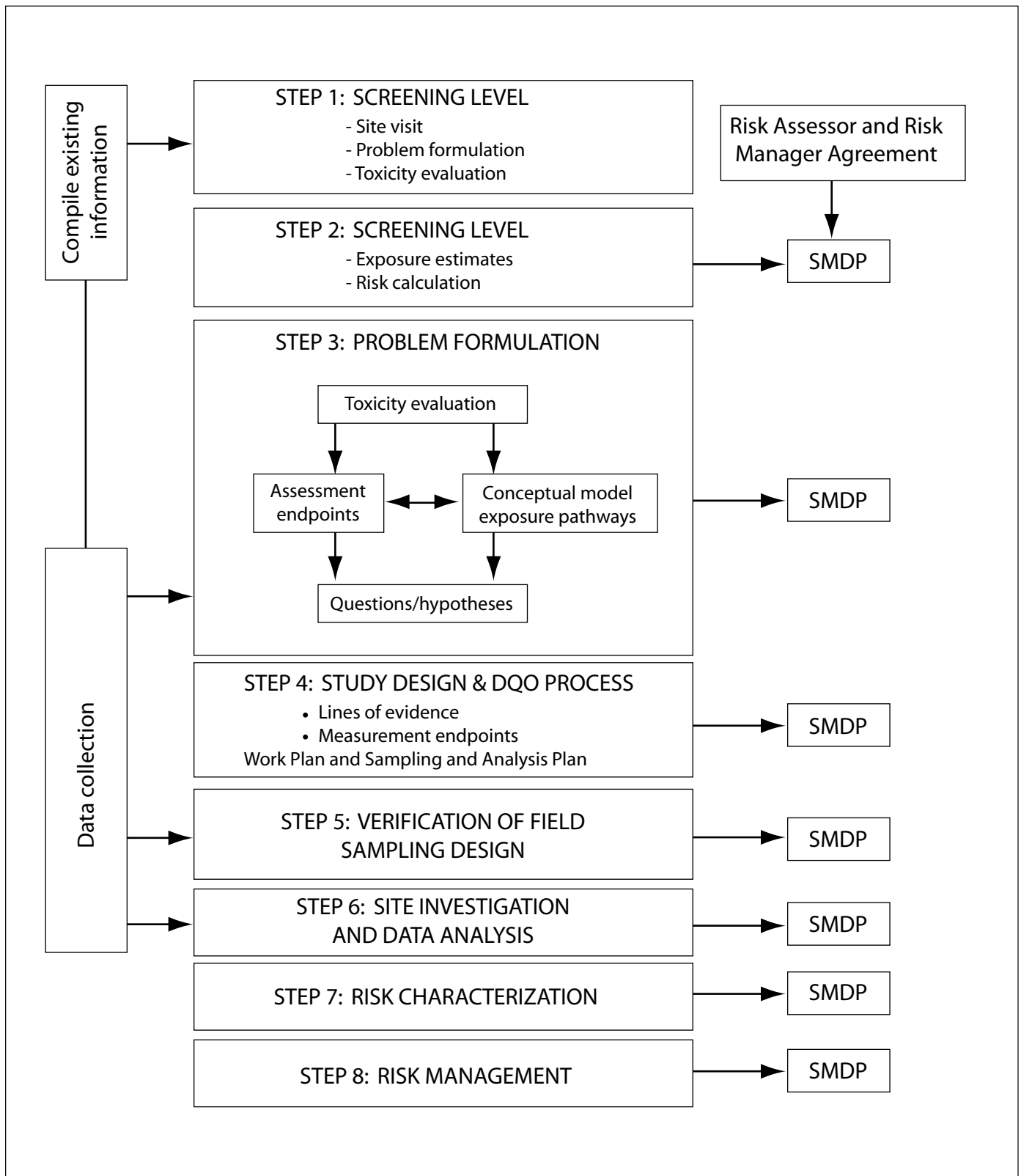


Figure 9-1. Superfund Eight-Step Ecological Risk Assessment Process.

Source: USEPA (1997a)

Note: SMDP = scientific management decision point; these are points in the ecological risk assessment process when the site project manager and scientific advisors decide upon what additional steps, if any, are necessary to take.

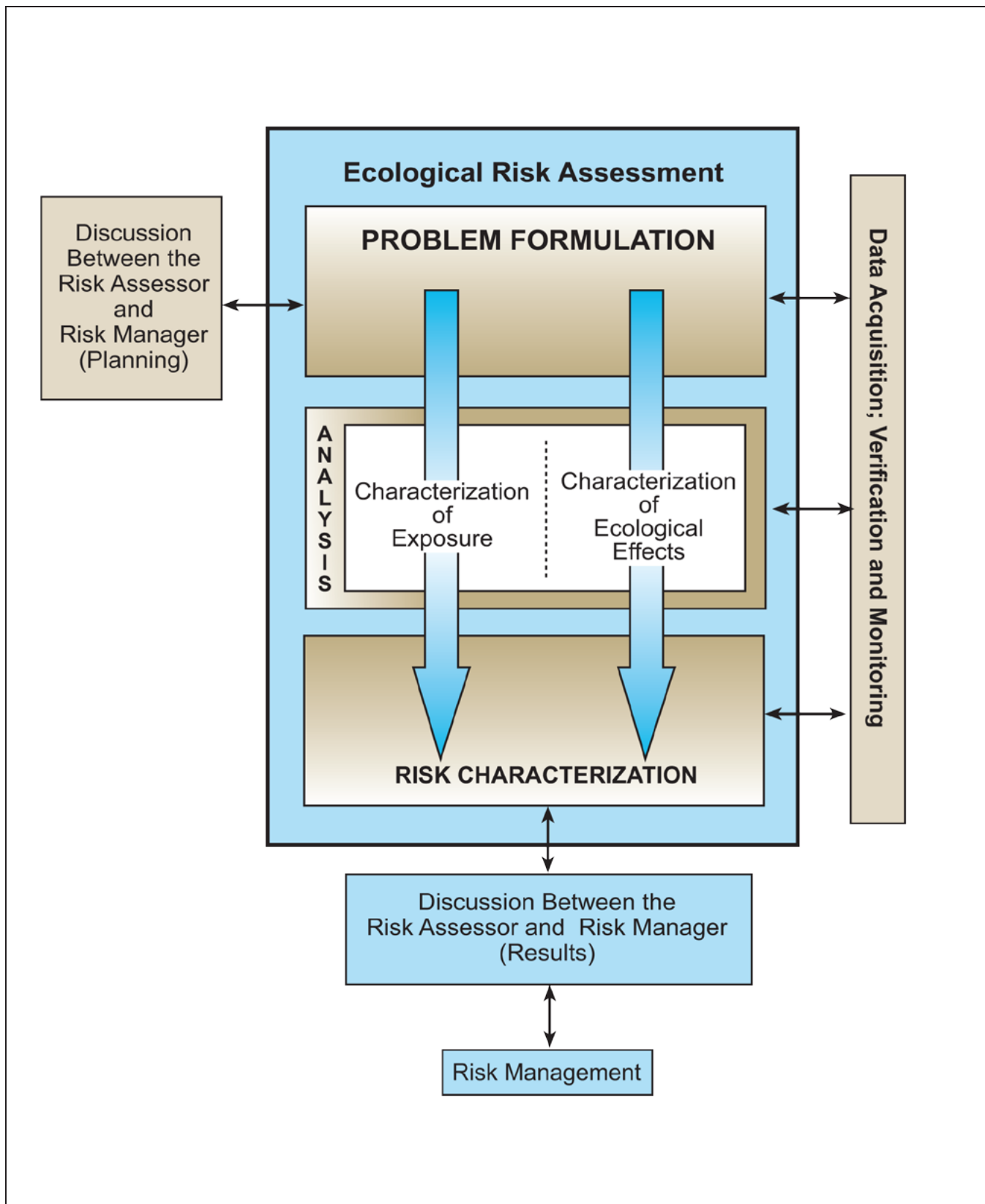


Figure 9-2. EPA Ecological Risk Assessment Framework. **Source:** USEPA (1998c).

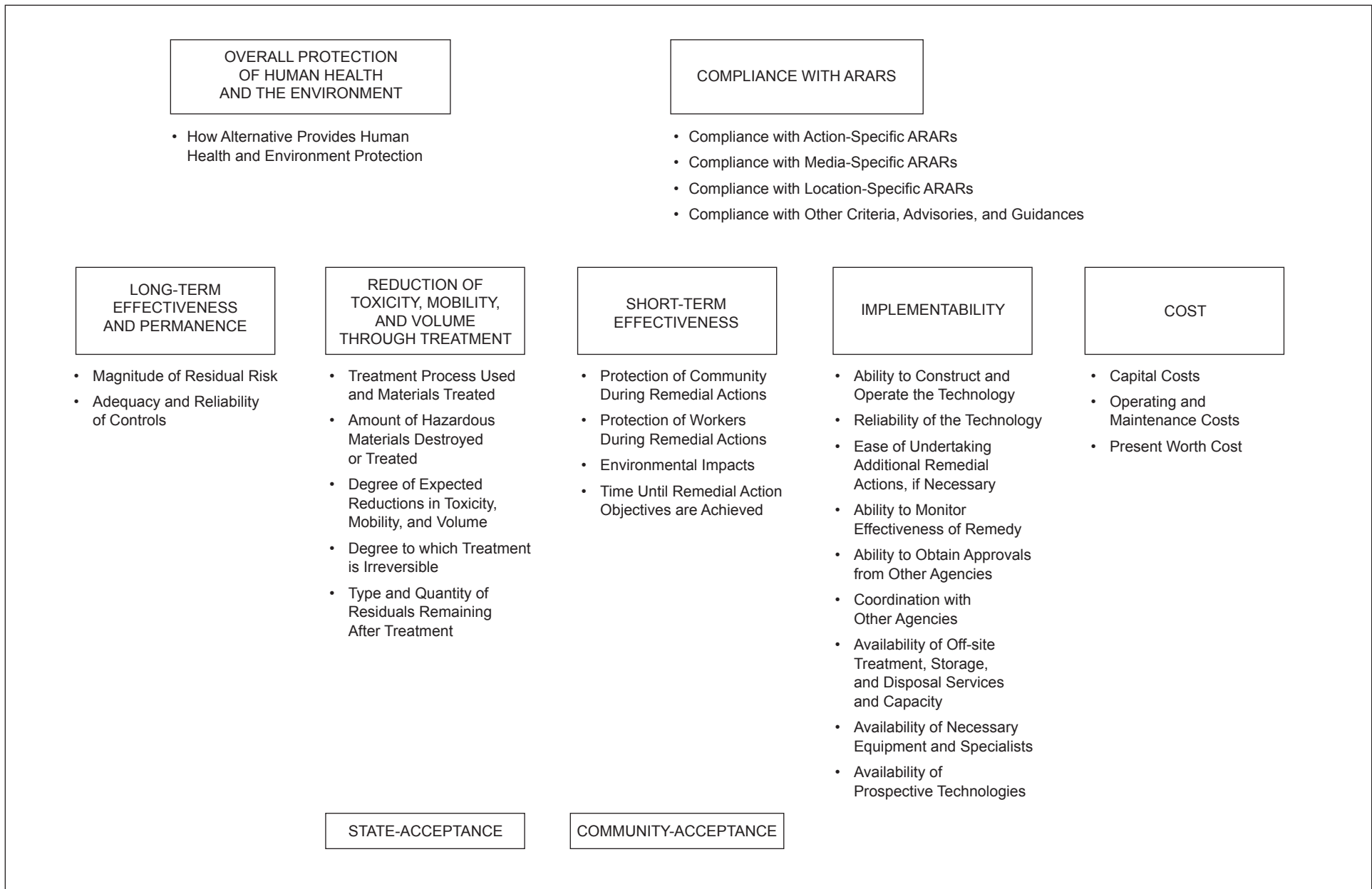


Figure 10-1. CERCLA Evaluation Criteria for Detailed Analysis of Alternatives during the RI/FS.

Source: Figure 6-2 of EPA RI/FS Guidance (USEPA 1988).

Note: State and Community Acceptance Criteria are assessed following comment on the RI/FS report and the proposed plan (USEPA 1988).

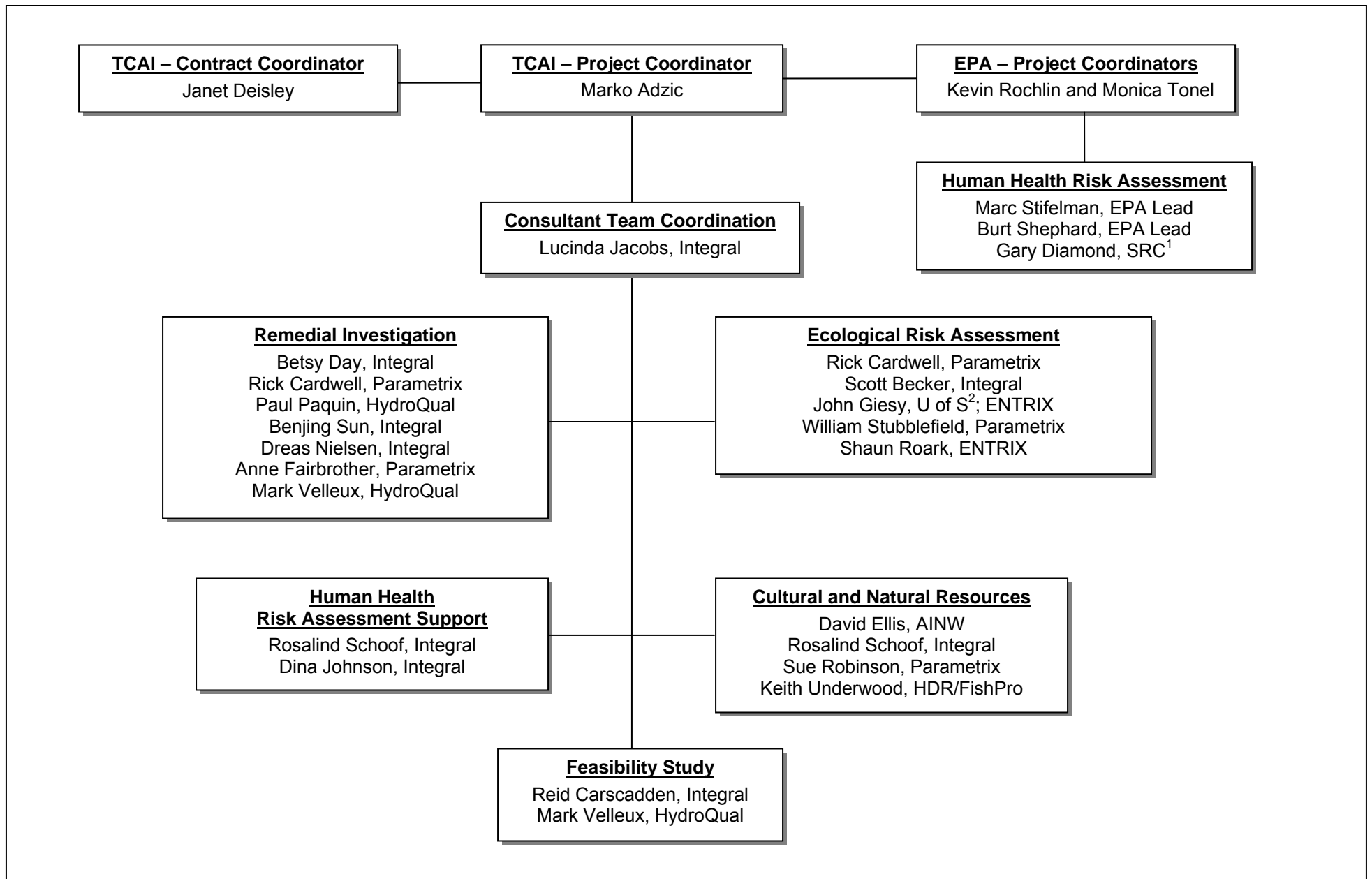


Figure 12-1. UCR Site RI/FS – Project Organization Chart.
Notes: ¹ SRC = Syracuse Research Corporation
² U of S = University of Saskatchewan

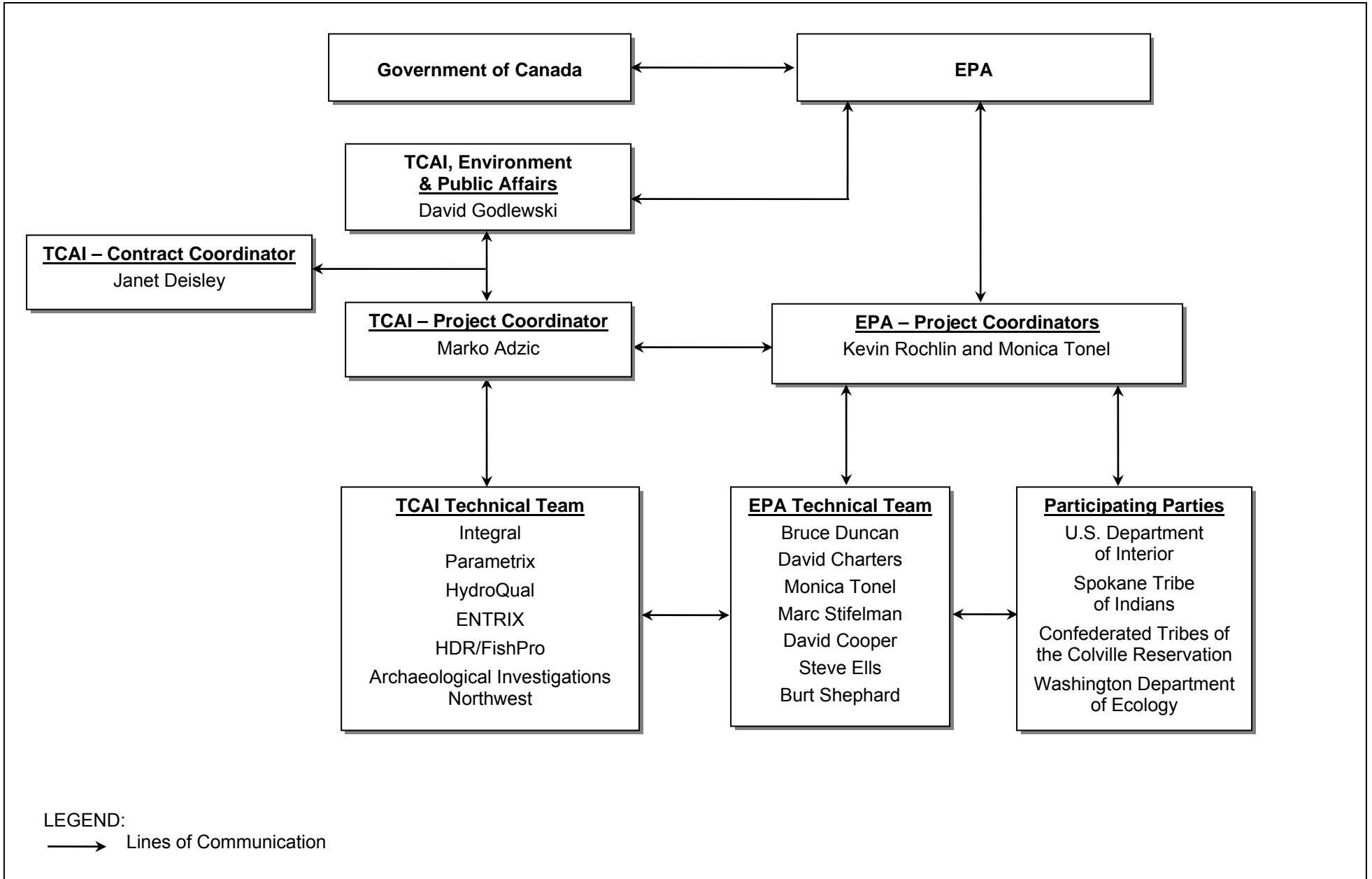
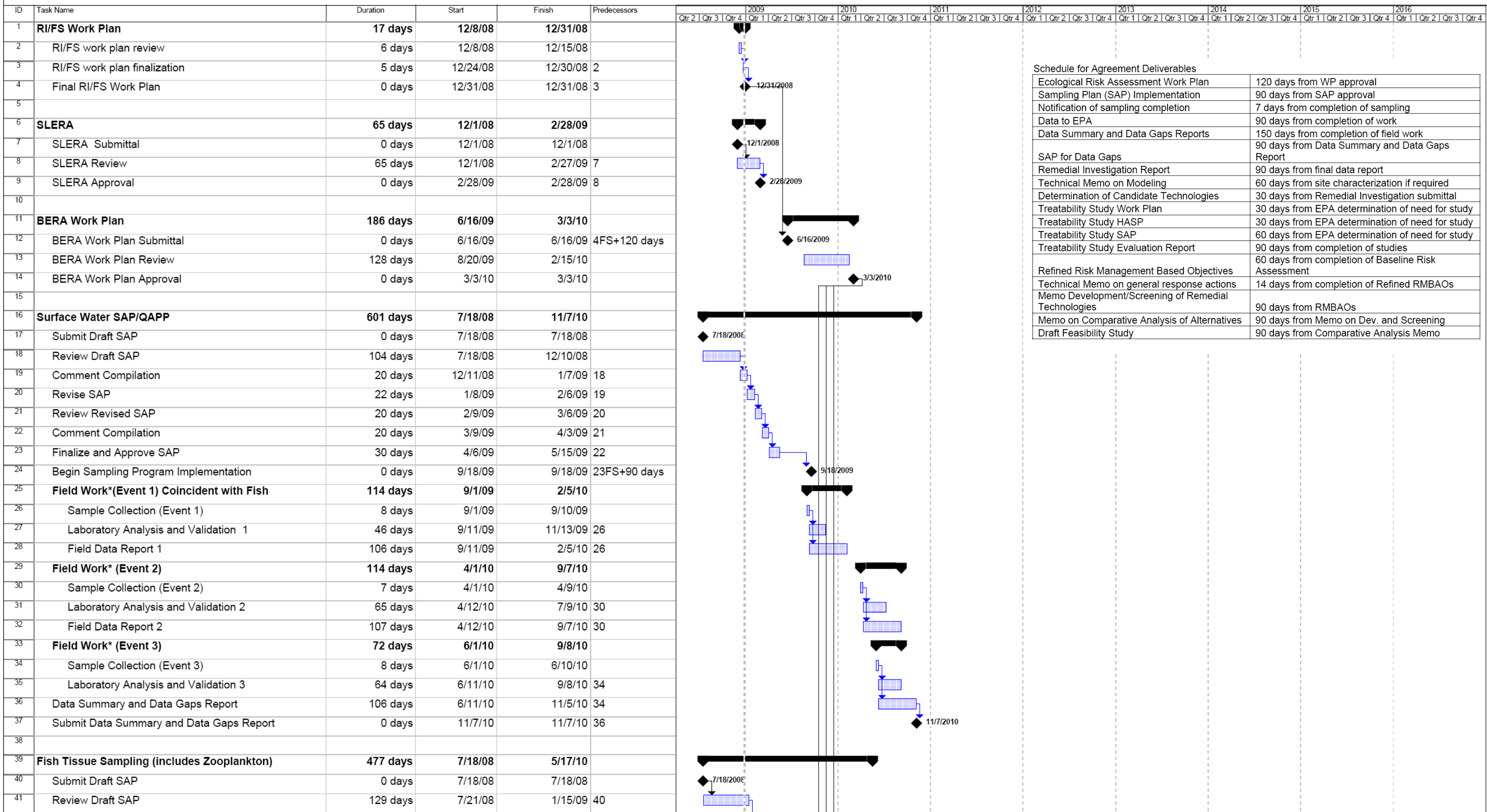


Figure 12-2. UCR Site RI/FS – Project Lines of Communication.

**Figure 12-3
Anticipated Schedule for Completion of RI/FS**



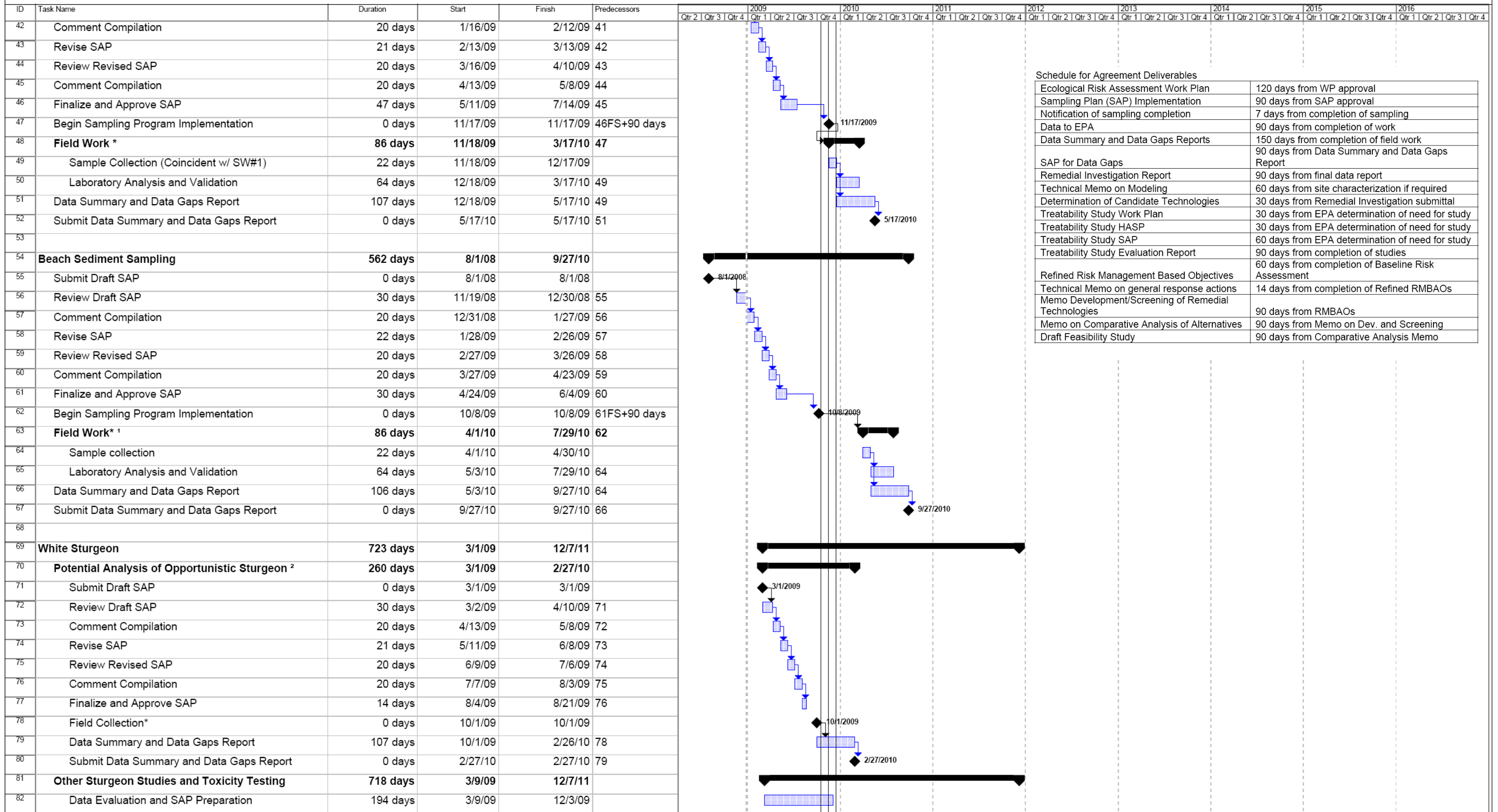
Schedule for Agreement Deliverables	
Ecological Risk Assessment Work Plan	120 days from WP approval
Sampling Plan (SAP) Implementation	90 days from SAP approval
Notification of sampling completion	7 days from completion of sampling
Data to EPA	90 days from completion of work
Data Summary and Data Gaps Reports	150 days from completion of field work
SAP for Data Gaps	90 days from Data Summary and Data Gaps Report
Remedial Investigation Report	90 days from final data report
Technical Memo on Modeling	60 days from site characterization if required
Determination of Candidate Technologies	30 days from Remedial Investigation submittal
Treatability Study Work Plan	30 days from EPA determination of need for study
Treatability Study HASP	30 days from EPA determination of need for study
Treatability Study SAP	60 days from EPA determination of need for study
Treatability Study Evaluation Report	90 days from completion of studies
Refined Risk Management Based Objectives	60 days from completion of Baseline Risk Assessment
Technical Memo on general response actions	14 days from completion of Refined RMBAOs
Memo Development/Screening of Remedial Technologies	90 days from RMBAOs
Memo on Comparative Analysis of Alternatives	90 days from Memo on Dev. and Screening
Draft Feasibility Study	90 days from Comparative Analysis Memo

Project: UCR RI/FS Date: 12/26/08

Progress
 Summary
 External Tasks
 Deadline
 Milestone
 Project Summary
 External Milestone

* Access agreements and permits must be obtained before sampling can begin
 a The actual studies that may be needed have not yet been determined. See Section 8.3
 1 Duration indicated here is conservative. Schedule will be revised following receipt of comments on the SAP in hopes of conducting field work in 2009 rather than 2010.
 2 The need for this study has not yet been determined. See Section 8.1.5
 3 Sediment studies includes spatial distribution, porewater, toxicity, and background

Figure 12-3 Anticipated Schedule for Completion of RI/FS



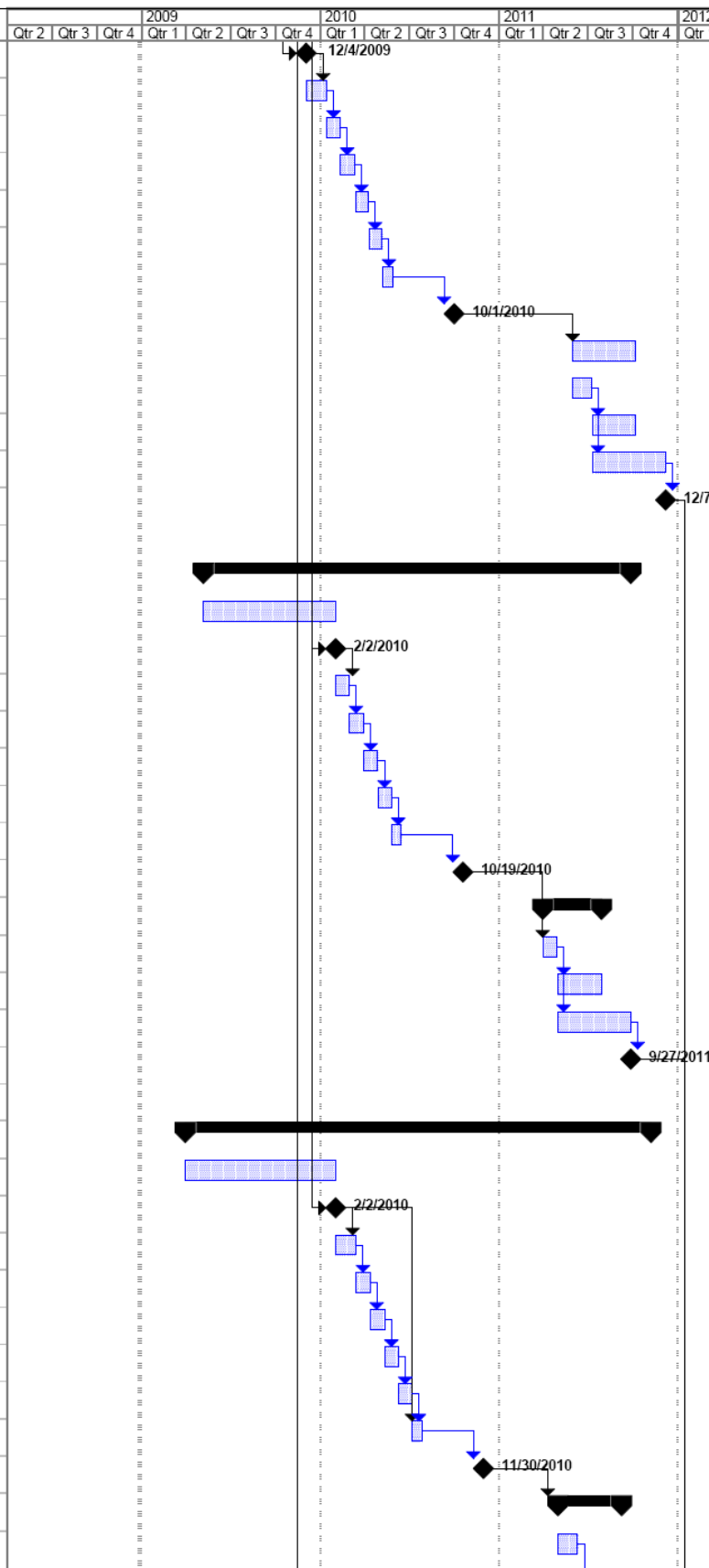
Ecological Risk Assessment Work Plan	120 days from WP approval
Sampling Plan (SAP) Implementation	90 days from SAP approval
Notification of sampling completion	7 days from completion of sampling
Data to EPA	90 days from completion of work
Data Summary and Data Gaps Reports	150 days from completion of field work
SAP for Data Gaps	90 days from Data Summary and Data Gaps Report
Remedial Investigation Report	90 days from final data report
Technical Memo on Modeling	60 days from site characterization if required
Determination of Candidate Technologies	30 days from Remedial Investigation submittal
Treatability Study Work Plan	30 days from EPA determination of need for study
Treatability Study HASP	30 days from EPA determination of need for study
Treatability Study SAP	60 days from EPA determination of need for study
Treatability Study Evaluation Report	90 days from completion of studies
Refined Risk Management Based Objectives	60 days from completion of Baseline Risk Assessment
Technical Memo on general response actions	14 days from completion of Refined RMBAOs
Memo Development/Screening of Remedial Technologies	90 days from RMBAOs
Memo on Comparative Analysis of Alternatives	90 days from Memo on Dev. and Screening
Draft Feasibility Study	90 days from Comparative Analysis Memo

Project: UCR RI/FS Date: 12/26/08	Task: Progress	Summary	External Tasks	Deadline	
	Split: Milestone	Project Summary	External Milestone		

* Access agreements and permits must be obtained before sampling can begin
¹ Duration indicated here is conservative. Schedule will be revised following receipt of comments on the SAP in hopes of conducting field work in 2009 rather than 2010.
² The need for this study has not yet been determined. See Section 8.1.5
³ Sediment studies includes spatial distribution, porewater, toxicity, and background

Figure 12-3 Anticipated Schedule for Completion of RI/FS

ID	Task Name	Duration	Start	Finish	Predecessors
83	Submit Draft SAP	0 days	12/4/09	12/4/09	14FS-90 days
84	Review Draft SAP	30 days	12/4/09	1/14/10	83
85	Comment Compilation	20 days	1/15/10	2/11/10	84
86	Revise SAP	21 days	2/12/10	3/12/10	85
87	Review Revised SAP	20 days	3/15/10	4/9/10	86
88	Comment Compilation	20 days	4/12/10	5/7/10	87
89	Finalization and Approve SAP	15 days	5/10/10	5/28/10	88
90	Begin Sampling Program Implementation	0 days	10/1/10	10/1/10	89FS+90 days
91	Field Work*	93 days	6/1/11	10/7/11	
92	Sample Collection	28 days	6/1/11	7/8/11	
93	Laboratory Analysis and Validation	65 days	7/11/11	10/7/11	92
94	Data Summary and Data Gaps Report	108 days	7/11/11	12/7/11	92
95	Submit Data Summary and Data Gaps Report	0 days	12/7/11	12/7/11	94
96					
97	Soil Sampling	623 days	5/8/09	9/27/11	
98	Data Evaluation and SAP Preparation	192 days	5/8/09	2/1/10	
99	Submit Draft SAP	0 days	2/2/10	2/2/10	14FS-30 days
100	Comment Compilation	20 days	2/2/10	3/1/10	99
101	Revise SAP	22 days	3/2/10	3/31/10	100
102	Review Revised SAP	20 days	4/1/10	4/28/10	101
103	Comment Compilation	20 days	4/29/10	5/26/10	102
104	Finalization and Approve SAP	14 days	5/27/10	6/15/10	103
105	Begin Sampling Program Implementation	0 days	10/19/10	10/19/10	104FS+90 days
106	Field Work	86 days	4/1/11	7/29/11	
107	Sample Collection	21 days	4/1/11	4/29/11	105
108	Laboratory Analysis and Validation	65 days	5/2/11	7/29/11	107
109	Data Summary and Data Gaps Report	107 days	5/2/11	9/27/11	107
110	Submit Data Summary and Data Gaps Report	0 days	9/27/11	9/27/11	109
111					
112	Sediment Sampling (multiple studies)³	679 days	4/1/09	11/7/11	
113	Data Evaluation and SAP Preparation	219 days	4/1/09	2/1/10	
114	Submit Draft SAPs	0 days	2/2/10	2/2/10	14FS-30 days
115	Review Draft SAPs	30 days	2/2/10	3/15/10	114
116	Comment Compilation	20 days	3/16/10	4/12/10	115
117	Revise SAPs	22 days	4/13/10	5/12/10	116
118	Review Revised SAPs	20 days	5/13/10	6/9/10	117
119	Comment Compilation	20 days	6/10/10	7/7/10	118
120	Finalization and Approve SAPs	14 days	7/8/10	7/27/10	114,119
121	Begin Sampling Program Implementation	0 days	11/30/10	11/30/10	120FS+90 days
122	Field Work (coincides w/ benthic tissue)	94 days	5/2/11	9/8/11	121
123	Sample Collection	30 days	5/2/11	6/10/11	



Ecological Risk Assessment Work Plan	120 days from WP approval
Sampling Plan (SAP) Implementation	90 days from SAP approval
Notification of sampling completion	7 days from completion of sampling
Data to EPA	90 days from completion of work
Data Summary and Data Gaps Reports	150 days from completion of field work
SAP for Data Gaps	90 days from Data Summary and Data Gaps Report
Remedial Investigation Report	90 days from final data report
Technical Memo on Modeling	60 days from site characterization if required
Determination of Candidate Technologies	30 days from Remedial Investigation submittal
Treatability Study Work Plan	30 days from EPA determination of need for study
Treatability Study HASP	30 days from EPA determination of need for study
Treatability Study SAP	60 days from EPA determination of need for study
Treatability Study Evaluation Report	90 days from completion of studies
Refined Risk Management Based Objectives	60 days from completion of Baseline Risk Assessment
Technical Memo on general response actions	14 days from completion of Refined RMBAOs
Memo Development/Screening of Remedial Technologies	90 days from RMBAOs
Memo on Comparative Analysis of Alternatives	90 days from Memo on Dev. and Screening
Draft Feasibility Study	90 days from Comparative Analysis Memo

Project: UCR RI/FS
Date: 12/26/08

Task Progress
Split Milestone
Summary Summary
Project Summary Project Summary
External Tasks External Tasks
External Milestone External Milestone
Deadline Deadline

* Access agreements and permits must be obtained before sampling can begin. ¹ Duration indicated here is conservative. Schedule will be revised following receipt of comments on the SAP in hopes of conducting field work in 2009 rather than 2010. ³ Sediment studies includes spatial distribution, porewater, toxicity, and background. ² The need for this study has not yet been determined. See Section 8.1.5. ^a The actual studies that may be needed have not yet been determined. See Section 8.3.

TABLES

TABLE 2-1
Preliminary Ecological RMAOs

Medium	Preliminary Risk-Management-Based Action Objective ^a
Soils	Reduce to acceptable levels the risks to plant communities that may be exposed to COCs in soil.
	Reduce to acceptable levels the risks to populations ^b of soil invertebrates that may be exposed to COCs in soil.
	Reduce to acceptable levels the risks to populations of birds, mammals, amphibians, and reptiles that feed on plants and/or soil invertebrates containing COCs, or that may directly ingest soils containing COCs.
Sediments ^c	Reduce to acceptable levels the risks to populations of fish that may be exposed to sediment-bound COCs.
	Reduce to acceptable levels the risks to populations of birds, mammals, amphibians, and reptiles that feed on aquatic resources.
	Reduce to acceptable levels the toxicity to benthic infauna that live in and on surface sediments.
	Mitigate or prevent dispersion of sediment COCs through aerial transport to uncontaminated locations where unacceptable resource exposure may occur.
Surface water	Reduce to acceptable levels the exposures of ecological receptors to COCs at water concentrations that exceed potential ARARs for surface water quality.
	Reduce to acceptable levels the risks to populations of birds, mammals, amphibians, and reptiles that feed on aquatic resources or ingest surface water with elevated levels of COCs.
	Reduce to acceptable levels the risks to populations of fish that may be exposed to COCs in surface water.

Note: This task reflects the March 11, 2007, draft of Technical Memorandum No. 1, which was revised in response to EPA comments. The one change made was the inclusion of amphibians and reptiles as potential receptors in solids, sediment, and surface water media.

^a The list of media and relevant pathways to be evaluated during the RI/FS process (e.g., problem formulation) will not be constrained by the preliminary RMAOs presented and discussed herein.

^b "Populations" refer to local groups of individuals common to the Site. Individual level analyses may need to be considered in the ERA.

^c Sediments are broadly defined as particles deposited by wind or water that are transported by water and accumulate in or immediately adjacent to surface water bodies. For this Site, sediment is defined to include particles at the bottom and sides of the UCR channels and reservoir, including beaches.

Table 2-2

Preliminary Identification of Potentially Applicable or Relevant and Appropriate Requirements for the UCR Site RI/FS

STATUTE ARAR Type	Citation	Summary
Federal ARARs		
CLEAN WATER ACT		
Location, Chemical	33 USC Section 1251 et seq. CWA Sections 303 and 304 40 CFR 131—Water Quality Standards Subpart D Federally Promulgated Water Quality Standards	Two kinds of water quality criteria have been developed: one for protection of human health, and another for protection of aquatic life. Includes establishment of TMDLs.
Chemical,, Action	CWA Sections 301 (b) and 402 (33 USC Section 1342) 40 CFR Part 122-EPA Administered Programs: The National Pollutant Discharge Elimination System 40 CFR Part 125—Criteria and Standards for the NPDES Subpart A—Criteria and Standards for Imposing Technology-Based Treatment Requirements	Discharge requirements under NPDES program including stormwater. Standards of control for direct discharges must meet technology-based requirements. BCT is applicable to conventional pollutants. BAT applies to toxic and non-conventional pollutants.
Location, Action	CWA Sections 401 and 404 (33 USC Sections 1341 and 1344) 40 CFR Part 230.404(b)(1)—Guidelines for Specification of Disposal Sites for Dredged or Fill Material 33 CFR Part 320—General Policies 33 CFR Part 323—Permit Requirements 33 CFR Part 325—Permit Requirements	Regulates discharge of dredged and fill material into waters of the United States.

Table 2-2

Preliminary Identification of Potentially Applicable or Relevant and Appropriate Requirements for the UCR Site RI/FS

STATUTE	ARAR Type	Citation	Summary
EXECUTIVE ORDERS	Chemical, Action	CWA Sections 301(b) and 402 (33 USC Section 1342) 40 CFR Part 122 – EPA Administered Programs: The National Pollutant Discharge Elimination System 40 CFR Part 125—Criteria and Standards for the NPDES Subpart A—Criteria and Standards for Imposing Technology-Based Treatment Requirements	Discharge requirements under NPDES program including stormwater. Standards of control for direct discharges must meet technology-based requirements. BCT is applicable to conventional pollutants. BAT applies to toxic and non-conventional pollutants.
	Location	40 CFR Part 6 Appendix A and Executive Orders 11988 and 11990, The Floodplain Management Order and Protection of Wetlands	Requires federally funded or authorized actions to minimize potential harm to wetlands and within flood plains, to avoid, if possible, adverse impacts associated with the destruction, loss or modification of wetlands and occupation, modification of floodplains, and to avoid, if possible, support of new construction in wetlands and floodplain development.
SAFE DRINKING WATER ACT	Chemical	42 USC Section 3000f et seq. 40 CFR Part 141—National Primary Drinking Water Regulations 40 CFR Part 143—National Secondary Drinking Water Regulations	Establishes standards designed to protect human health from the potential adverse effects of drinking water contaminants. MCLs are established for groundwater that is a current or potential source of drinking water.

Table 2-2

Preliminary Identification of Potentially Applicable or Relevant and Appropriate Requirements for the UCR Site RI/FS

STATUTE	ARAR Type	Citation	Summary
RIVERS AND HARBORS ACT OF 1899 (SECTION 10)	Location, Action	33 USC Section 401 et seq. 33 USC Section 403 including Section 10 33 CFR Part 320—General Regulatory Policies 33 CFR Part 322—Permits for Structures or Work in or Affecting Navigable Waters of the United States	Controls the alteration of navigable waters (i.e., waters subject to ebb and flow of the tide shoreward to the mean high water mark). Activities controlled include construction of structures such as piers, berms, and installation of pilings. Section 10 may be applicable for any action that may obstruct or alter a navigable waterway.
CLEAN AIR ACT	Chemical, Action, Location	42 USC Section 7401 et seq. 40 CFR Part 50 – National Primary and Secondary Ambient Air Quality Standards 40 CFR Part 60—Standards for Performance For New Stationary Sources	Regulates discharges to the air from stationary, mobile, and fugitive emission sources to protect ambient air quality
ENDANGERED SPECIES ACT	Location	16 USC Section 1536 et seq. 50 CFR Part 402—Interagency Cooperation Endangered Species Act of 1973 as amended	Federal agencies must ensure that actions they authorize, fund, or carry out are not likely to adversely modify or destroy critical habitat of endangered or threatened species. Actions authorized, funded, or carried out by federal agencies may not jeopardize the continued existence of endangered or threatened species as well as adversely modify or destroy their critical habitats.

Table 2-2

Preliminary Identification of Potentially Applicable or Relevant and Appropriate Requirements for the UCR Site RI/FS

STATUTE	ARAR Type	Citation	Summary
HAZARDOUS MATERIALS TRANSPORTATION ACT	Action	49 USC Section 801 et seq. Subchapter C—Hazardous Materials Regulations 49 CFR Parts 171–178	U.S. Department of Transportation regulations provide for packaging, documentation, and transport of hazardous waste and hazardous materials.
NATIONAL PARK SERVICE ORGANIC ACT/REDWOOD ACT	Location	16 USC Section 1 et seq. 16 USC Section 1a-1 36 CFR Part 2 Chapter I – Resource Protection, Public Use and Recreation	Establishes the purpose and use of the National Recreation Area and proscribes certain activities within the park. Directs the National Park Service “to promote and regulate the use of...national parks...by such means and measures as conform to the fundamental purpose of the said parks...which purpose is to conserve the scenery and the natural and historic objects and the wildlife therein...in such manner and by such means as will leave them unimpaired for the enjoyment of future generations” (16 USC 1). The Organic Act and the statute or statutes establishing LARO do not allow permanent or long-term restrictions on public access to Lake Roosevelt as a component of the selected remedial action.
HISTORIC SITES, BUILDINGS, AND ANTIQUITIES ACT	Location	16 USC 461 36 CFR 79 – Curation of Federally-Owned and Administered Archaeological Collections	This statute regulates actions that may impact landmarks included on the National Registry of National Landmarks.

Table 2-2

Preliminary Identification of Potentially Applicable or Relevant and Appropriate Requirements for the UCR Site RI/FS

STATUTE	ARAR Type	Citation	Summary
ARCHAEOLOGICAL RESOURCES PROTECTION ACT			
Location	16 USC Section 470 aa-mm 42 USC Section 1996 43 CFR Part 7—Protection of Archaeological Resources	Requires federal land managers to protect archaeological resources and provides for notification to Indian tribes of possible harm to sites on public land and tribal land.	
NATIVE AMERICAN GRAVES PROTECTION AND REPARATION ACT			
Location	25 USC Sections 3001–3013 43 CFR Part 10—Native American Graves Protection and Reparation Regulations	Requires federal agencies and museums which have possession of or control over Native American cultural items to compile an inventory of such items. Provides for procedures to follow when applicable cultural items are excavated intentionally or discovered inadvertently on federal or tribal lands. Prescribes when federal agencies and museums must return Native American cultural items. Also provides response actions for Indian graves on federal and tribal lands.	
MAGNUSON-STEVENS FISHERY CONSERVATION MANAGEMENT ACT			
Location	16 USC Section 1801 et seq. 50 CFR Part 600.905—Magnuson-Stevens Act Provisions	Requires that federal agencies consult with NMFS and/or USFWS on all activities undertaken that may adversely affect essential fish habitat.	
FISH AND WILDLIFE COORDINATION ACT			
Location	16 USC Section 661 et seq. 40 CFR Part 6.302 (g)—Fish and Wildlife Protection	This statute protects fish and wildlife due to the control or structural modification of a water body.	

Table 2-2

Preliminary Identification of Potentially Applicable or Relevant and Appropriate Requirements for the UCR Site RI/FS

STATUTE ARAR Type	Citation	Summary
MIGRATORY BIRD TREATY ACT		
Location	16 USC Sections 703–712 50 CFR Part 10.12	Makes it unlawful to take, import, export, possess, buy, sell purchase, or barter any migratory bird. "Take" is defined as pursuing, hunting, shooting, poisoning, wounding, killing, capturing, trapping, and collecting.
BALD AND GOLDEN EAGLE PROTECTION ACT		
Location	16 USC Section 668(A) 50 CFR Part 22—Eagle Permits	This statute controls the taking, possession, sale, purchase, barter, or offer to sell of bald and gold eagles for scientific, educational, depredation control and religious purposes of American Indian tribes. "Take" includes pursue, shoot, shoot at, poison, wound, kill, capture, trap, collect, molest or disturb.
Location	16 USC Section 668(A) 50 CFR Part 22—Eagle Permits	
TOXIC SUBSTANCES CONTROL ACT		
Chemical, Action	15 USC Section 53 et seq. 40 CFR Part 761—PCB Manufacturing, Processing, Distribution and Commerce and Use Prohibitions.	This statute includes requirements for storage and disposal of PCB wastes including remediation waste and contaminated dredged materials.

Table 2-2

Preliminary Identification of Potentially Applicable or Relevant and Appropriate Requirements for the UCR Site RI/FS

STATUTE	ARAR Type	Citation	Summary
ARCHAEOLOGICAL AND HISTORIC PRESERVATION ACT			
Location	16 U.S.C. §§ 469, <i>et seq.</i> 40 CFR § 6.301(c)	The statute and implementing regulations establish requirements for evaluation and preservation of historical and archaeological data, including Indian cultural and historic data, which may be destroyed through alteration of terrain as a result of federal construction projects or a federally licensed activity or program. If eligible scientific, prehistorical, or archaeological data are discovered during site activities, such data must be preserved in accordance with these requirements.	
SOLID WASTE DISPOSAL IN NATIONAL PARKS			
Location	16 U.S.C. §§ 460I <i>et seq.</i> 36 CFR Part 6	Applicable to the creation of any new solid waste disposal units within the boundary of the National Recreation Area. The regulations prohibit the operation of any solid waste disposal site, except as specifically provided for by the regulations. Among other things, this regulation does not allow the disposal within a NPS unit of solid waste containing specified materials including hazardous waste, PCBs, other CERCLA hazardous substances, or petroleum.	
NATIONAL PARK SERVICE REGULATIONS			
Location	36 CFR part 1	Prescribes certain activities within the units of the National Park and prohibiting any activities that may cause a nuisance.	

Table 2-2

Preliminary Identification of Potentially Applicable or Relevant and Appropriate Requirements for the UCR Site RI/FS

STATUTE ARAR Type	Citation	Summary
RESOURCE CONSERVATION AND RECOVERY ACT—SUBTITLE C Action	42 USC Section 6921 et seq. 40 CFR Part 260—Hazardous Waste Management System—General 40 CFR Part 261—Identification and Listing of Hazardous Waste 40 CFR Part 262—Standards Applicable to Generators of Hazardous Waste 40 CFR Part 263 – Standards Applicable to Transporters of Hazardous Waste 40 CFR Part 264 - Standards Applicable to Owners and Operators of Waste Treatment, Storage and Disposal Facilities 40 CFR 266 – Standards for the Management of Specific Hazardous Wastes and Specific Types of Hazardous Waste Management Facilities 40 CFR Part 268—Land Disposal Restrictions	Establishes identification and management of standards for hazardous wastes.
RECLAMATION ACT Location	43 USC Section 391 et seq.	Funded irrigation projects for the West and sets certain requirements for those using the water.
ACT OF AUGUST 30, 1935/ COLUMBIA BASIN PROJECT ACT Location	33 USC Section 540 et seq./ 16 USC Section 835 et seq. 16 USC Section 835 et seq.	Authorized the construction of Grand Coulee Dam
FLOOD CONTROL ACT OF 1944 Location	16 USC Section 460d	Amended the 1939 Reclamation Act and authorized construction, operation, and maintenance of public park and recreational facilities in reservoir areas

Table 2-2

Preliminary Identification of Potentially Applicable or Relevant and Appropriate Requirements for the UCR Site RI/FS

STATUTE ARAR Type	Citation	Summary
1961 COLUMBIA RIVER TREATY Location		Agreement between Canada and the U.S. to develop and share waterpower and storage facilities on the Columbia River
PACIFIC NORTHWEST ELECTRIC POWER PLANNING AND CONSERVATION ACT Location	16 USC Section 839-839 (h)	Addresses the impact of fish and wildlife from hydroelectric dams on the Columbia River and requires a program to protect, mitigate, and enhance fish and wildlife on the Columbia River
FEDERAL LAND POLICY AND MANAGEMENT ACT OF 1976 Location	43 USC 1701, et seq.	This act creates a uniform management scheme for public lands. Provides that, in managing public lands, the Secretary of Interior shall, by regulation or otherwise, take any action necessary to prevent unnecessary or undue degradation of the lands. Provides for multiple use and inventory, protection, and planning for cultural resources of public lands.
PACIFIC NORTHWEST COORDINATION AGREEMENT Action	The PNCA is an Agreement for the Coordination of Operations among Power systems of the Pacific Northwest signed on September 15, 1964 by the Corps, Bonneville Power Administration, the Bureau of Reclamation and the major generating utilities in the Pacific Northwest	The Agreement stipulates that "the parties agree to coordinate the operation of their respective Systems ... so as to make available to each System its optimum Firm Load Carrying Capacity, to provide optimum Firm Load Carrying Capability for the Coordinated Systems, and, consistent with these objectives, to produce the optimum amount of usable secondary energy for each System". It also outlines water storage and power transfer rights and obligations to all the participants to the Agreement.

Table 2-2

Preliminary Identification of Potentially Applicable or Relevant and Appropriate Requirements for the UCR Site RI/FS

STATUTE	ARAR Type	Citation	Summary
2008 NOAA FISHERIES BIOLOGICAL OPINION FOR THE OPERATION OF THE FEDERAL COLUMBIA RIVER POWER SYSTEM	Action	Endangered Species Act Section 7(a)(2) Consultation Consultation on Remand for Operation of the Federal Columbia River Power System11 Bureau of Reclamation Projects in the Columbia Basin and ESA Section 10(a)(1)(A) Permit for Juvenile Fish Transportation Program (Revised and reissued, pursuant to court order NWF v. NMFS, Civ. No. CV 01-640-RE (D. Oregon))	Biological opinion on the operation and maintenance of the Federal Columbia River Power System, 11 Bureau of Reclamation projects in the Columbia Basin, Juvenile Fish Transportation Program and their effects on ESA-listed salmon and steelhead. The analysis also fulfills the Essential Fish Habitat requirements under the Magnuson-Stevens Fishery Conservation and Management Act (MSA). The MSA, as amended by the Sustainable Fisheries Act of 1996 (Public Law 104-267), established procedures designed to identify, conserve, and enhance EFH for those species regulated under a Federal fisheries management plan. Federal agencies must consult with NOAA Fisheries on all actions or proposed actions (authorized, funded, or undertaken) that may adversely affect EFH.
STATE ARARS			
MODEL TOXICS CONTROL ACT			
	Chemical, Action	Chapter 70.105D RCW Chapter 173-340 WAC—Model Toxics Control Act—Clean-up	Establishes Washington State cleanup requirements at facilities where there has been a release or threatened release of hazardous substances that may pose a threat to human health or the environment.

Table 2-2

Preliminary Identification of Potentially Applicable or Relevant and Appropriate Requirements for the UCR Site RI/FS

STATUTE ARAR Type	Citation	Summary
DANGEROUS WASTE MANAGEMENT ACT		
Action	Chapter 70.105 RCW Chapter 173-303 WAC—Dangerous Waste Regulations	Establishes identification and management standards for dangerous wastes.
SOLID WASTE MANAGEMENT		
Action	Chapter 70.96 RCW Chapter 173-350 WAC-Solid Waste Handling standards	Regulates activities that involve the land disposal of solid waste
AIR POLLUTION CONTROL ACT		
Chemical, Action	Chapter 70.94 RCW Chapter 173-400 WAC—General Regulations for Air Pollution Sources Chapter 173-470 WAC – Ambient Air Quality Standards for Particulate Matter	Establishes controls for air pollution from air contaminant sources including requirements for particulate matter and fugitive dust sources.

Table 2-2

Preliminary Identification of Potentially Applicable or Relevant and Appropriate Requirements for the UCR Site RI/FS

STATUTE ARAR Type	Citation	Summary
NOISE CONTROL ACT Action	Chapter 70.107 RCW Chapter 73-60 WAC—Maximum Environmental Noise Levels	Sets maximum noise standards for activities in specific environments.
STATE HYDRAULIC CODE Action	Chapter 77.55 RCW Chapter 220-110 WAC—Hydraulic Code Rules	Establishes requirements for work that diverts, obstructs, or changes natural flow or bed of fresh waters.
INDIAN GRAVES AND RECORDS/ ARCHAEOLOGICAL SITES AND RESOURCES Location, Action	Chapter 27.44 RCW Chapter 27.53 RCW Chapter 25-48 WAC—Archaeological Excavation and Removal Permit	Approval process for excavation of archaeological materials and removal of Native American human remains by State Office of Archaeology and Historic Preservation on non federal and on Indian lands.
BALD EAGLE PROTECTION ACT Location, Action	RCW 77.12.655 WAC 232-12-292—Bald Eagle Protection Rules	Establishes buffer zones around nests and roost areas and preparation of Bald Eagle Mitigation Plans.
STATE WILDLIFE POLICY Action	RCW 77.12.047 Chapter 232-12-011 WAC—Wildlife Classified as Protected Shall Not Be Hunted or Fished Chapter 232-12-014 WAC—Wildlife Classified as Endangered Species	Establishes state list of endangered, threatened and sensitive species.

Table 2-2

Preliminary Identification of Potentially Applicable or Relevant and Appropriate Requirements for the UCR Site RI/FS

STATUTE ARAR Type	Citation	Summary
SHORELINE MANAGEMENT ACT		
Location, Action	RCW 90.58 Chapter 173-18 WAC Streams and Rivers Constituting Shorelines of the State Chapter 18-140 WAC Ferry County Chapter 18-260 WAC Lincoln County Chapter 18-370 WAC Stevens County	Establishes the streams and rivers that constitute the shorelines of the state that are subject to local shoreline requirements.
Location, Action	RCW 90.58.030 Chapter 173-22 WAC Adoption of Designation of Shorelands and Wetlands Associated with Shorelines of the State Chapter 173-22-0620 WAC Ferry County Chapter 173-22-0644 WAC Lincoln County Chapter 173-22-0666 Stevens County	Designates the wetlands associated with shorelines of the state that are subject to local wetlands requirements
FLOOD PLAIN MANAGEMENT		
Location, Action	RCW 86.16 Chapter 173-158 Flood Plain Management	Establishes requirements for construction that could increase the risks associated with flooding in a water body and establishes provisions for work in wetlands
SAFE DRINKING WATER ACT		
Location	Chapter 70.119 RCW WAC 246-290-310—Maximum Contaminant Levels and Maximum Residual Disinfectant Levels	Establishes drinking water maximum permissible levels of contaminants in drinking water based on prevention of adverse health risks.

Table 2-2

Preliminary Identification of Potentially Applicable or Relevant and Appropriate Requirements for the UCR Site RI/FS

STATUTE	ARAR Type	Citation	Summary
WATER POLLUTION CONTROL ACT			
Chemical, Action	Chapter 90.48 RCW Chapter 173-200 WAC—Water Quality Standards for Groundwaters of the State Chapter 173-201A WAC—Water Quality Standards for Surface Waters of the State of Washington Chapter 173-204 WAC—Sediment Management Standards Chapter 173-220 NPDES Permit Program Chapter 173-221A WAC—Wastewater Discharge Standards and Effluent Limitations Chapter 372-26 WAC—Columbia Basin Irrigation Area—Sewage and Waste	Establishes groundwater protection standards and surface water protection standards for waters of the state and waste discharge standards for discharge to waters of the state. Also outlines a process for establishing sediment management standards. Sets standards for discharge of waste products to the canals, drains, waterways, reservoirs, and groundwater of the Columbia Basin Irrigation Project Area.	
Tribal ARARs			
COLVILLE TRIBE LAW AND ORDER CODE			
Action, Location	Chapter 4-4— Cultural Resource Protection Colville Tribal Law and Order Code—Title 4 Natural Resources and Environment	Directs development of a register of archaeological and historic properties and a comprehensive plan for such places. Sets process for evaluating excavation and removal of these resources and sets a process for issuing a permit for excavation, removing, altering, damaging or otherwise adversely affecting archaeological resources or historic properties within the reservation.	

Table 2-2

Preliminary Identification of Potentially Applicable or Relevant and Appropriate Requirements for the UCR Site RI/FS

STATUTE	ARAR Type	Citation	Summary
	Chemical, Location	Chapter 4-8— Water Quality Standards Colville Tribal Law and Order Code—Title 4 Natural Resources and Environment	Establishes surface water protection standards for waters of the Colville Reservation
		40 CFR Part 131.35—Colville Confederated Tribes Indian Reservation – Water Quality Regulations	
	Chemical, Location	Chapter 4-16—Hazardous Substance Control Colville Tribal Law and Order Code—Title 4 Natural Resources and Environment	Provides for exemption of procedural requirements of applicable tribal laws and requires compliance with substantive requirements. Sets cleanup standards for surface water, groundwater, soil, and sediments.
FEDERALLY PROMULGATED WATER QUALITY STANDARDS			
	Location	40 CFR Part 131.35—Colville Confederated Tribes Indian Reservation – Water Quality Regulations	Federally promulgated water quality standards to ensure compliance with Section 303 (c) of the CWA. These standards establish water quality standards for point source discharges regulated under an NPDES permit
	Action , Location	Chapter 4-9—Hydraulics Project Permitting Colville Tribal Law and Order Code—Title 4 Natural Resources and Environment	Sets technical standards for in-water activities such as dredging and water diversion.

Table 2-2

Preliminary Identification of Potentially Applicable or Relevant and Appropriate Requirements for the UCR Site RI/FS

STATUTE	ARAR Type	Citation	Summary
LAW AND ORDER CODE OF THE SPOKANE TRIBE OF INDIANS	Action, Location	Chapter 4-15—Shoreline Management Colville Tribal Law and Order Code—Title 4 Natural Resources and Environment	Sets restrictions on use of shoreline resources of all bodies of water within the reservation
	Chemical, Location	Chapter 34 Hazardous Substances Control Act	Provides for exemption of procedural requirements of applicable tribal laws and requires compliance with substantive requirements. Sets cleanup standards for surface water, groundwater, soil, and sediments.
CONSTITUTION OF THE SPOKANE TRIBE	Chemical, Location	Chapter 30 Surface Water and Ground Water Protection	Sets water quality standards for surface waters and groundwater within the exterior boundaries of the reservation
	Chemical, Location	Articles II, V, VIII, IX and XI Spokane Tribe of Indians Surface Water Quality Standards Resolution 2003-259 March 7, 2003	Sets water quality standards to restore, maintain and protect the chemical, physical, biological, and cultural integrity of the surface waters of the Spokane Indian Reservation and to achieve a level of water quality that provides for the protection and propagation of fish and wildlife

Table 2-2

Preliminary Identification of Potentially Applicable or Relevant and Appropriate Requirements for the UCR Site RI/FS

Notes: Sediment cleanup levels are generally based on site-specific risk assessments, but may occasionally be based on ARARs (USEPA 2005).

ARAR	=	applicable or relevant and appropriate requirement
BA	=	biological assessment
BAT	=	best available technology economically achievable
BCT	=	best conventional pollution control technology
CERCLA	=	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	=	Code of Federal Regulations
CWA	=	Clean Water Act
MCL	=	maximum contaminant level
NMFS	=	National Marine Fisheries Service
NPDES	=	National Pollutant Discharge Elimination System
RCW	=	Revised Code of Washington
RI/FS	=	remedial investigation and feasibility study
TMDL	=	total maximum daily load
USC	=	United States Code
USFWS	=	U.S. Fish and Wildlife Service
WAC	=	Washington Administrative Code

Table 2-3
Preliminary Identification of To Be Considered Requirements for UCR Site RI/FS

TBC	Citation	Comment
FEDERAL GUIDANCE		
Surface Water	USEPA. 2006. National Recommended Water Quality Criteria. Office of Water. U.S. Environmental Protection Agency, Washington, DC. Available on line at: http://www.epa.gov/waterscience/criteria/wqcriteria.html .	Federal guidance that may be used in the development of the remedial investigation.
Sediment	USEPA. 2004. The Incidence and Severity of Sediment Contamination in Surface Waters of the United States. National Sediment Quality Survey, Second Edition. U. S. Environmental Protection Agency, Office of Science and Technology, Washington, D. C. EPA/823/R-04/007	Federal guidance that may be used in the development of the remedial investigation.
Fisheries	2004 Hanford Reach Fall Chinook Protection Program (Vemita Bar Agreement)	Preliminary TBC included at the request of EPA.
FEDERAL PLANS, POLICIES, AND AGREEMENTS		
Lake Roosevelt National Recreation Area General Management Plan	Lake Roosevelt National Recreation Area web site. http://www.nps.gov/laro . National Park Service, U.S. Department of the Interior, Washington, DC.	Describes the cultural, natural resource, and legislative history of the National Recreation Area and articulates the mission and purpose upon which park management decisions are to be based.
Lake Roosevelt Cooperative Management Agreement	Lake Roosevelt Cooperative Management Agreement (April 5, 1990) http://www.nps.gov/history/history/online_books/laro/adhi/adhiaie.htm	Coordinates management of the Lake Roosevelt Management Area
National Park Service Upper Columbia White Sturgeon Recovery Plan	National Park Service Management Policies 2001. NPS D1416, December 2000. Department of the Interior, Washington, D.C. <i>Upper Columbia White Sturgeon Recovery Plan</i> , Upper Columbia White Sturgeon Recovery Initiative, November 2002	Management of natural resource and cultural resources, including revegetation of disturbed lands. International effort to restore white sturgeon in Upper Columbia River.
STATE GUIDANCE		
Sediment	Ecology. 2003. Development of Freshwater Sediment Quality Values for Use in Washington State. Phase II Report: Development and Recommendation of Sediment Quality Values for Freshwater Sediments in Washington State. September 2003. Publication No. 03-09-088. Washington State Department of Ecology, Olympia, WA.	State guidance that may be used in the development of the remedial investigation.
Stormwater	Ecology. 2004. Stormwater Management Manual for Eastern Washington, October 2004.	State guidance that may be used in the development of the remedial investigation.

Table 2-3
Preliminary Identification of To Be Considered Requirements for UCR Site RI/FS

TBC	Citation	Comment
Other Guidance		
Surface Water	Canadian Council for the Ministry of the Environment. 2006. The CCME guidelines for the protection of aquatic life. Available at http://www.waterquality.ec.gc.ca/EN/navigation/3297/3301/3307.htm .	Canadian government guidance that may be used in the development of the remedial investigation.
Sediment	MacDonald, D. D., C. G. Ingersoll, and T. A. Berger. 2000. Development and Evaluation of Consensus-Based Sediment Quality Guidelines for Freshwater Ecosystems. Archives of Environmental Contamination and Toxicology. 39:20-31.	Scientific literature that may be used in the development of the remedial investigation.

Notes:

- TBC = To be considered
- EPA = U.S. Environmental Protection Agency
- CCME = Canadian Council for the Ministry of the Environment

Table 3-1. Demographics of Larger UCR Communities, Indian Reservations, and Adjacent Counties

Community ^a	Total Population (2000)	Median Age (years)	Percent Under 5 yrs	Percent 65 years and over	Percent White ^b	Percent Black or African American ^b	Percent American Indian/Alaska Native ^b	Percent Asian ^b	Per capita income in 1999 (dollars)
Coulee Dam	1,044	44.5	5	20.3	64.6	0.3	29.1	0.5	18,791
Grand Coulee	897	45.3	5.5	23.6	81.3	1.1	12.5	1.3	13,639
Hunters/Cedonia	306	41.5	4.2	15.4	87.6	0.3	4.6	0.3	9,759
Inchelium	389	32.9	5.4	10.5	20.3	0	76.6	0	14,728
Kettle Falls	1,527	34.4	8.3	15.8	91.3	0.1	3.9	0.2	13,614
Marcus	117	43.5	6	14.5	95.7	0	0.9	0.9	10,798
Northport	336	42.8	6	17.3	94.9	0	0.6	0.6	11,679
Colville Indian Reservation	7,587	--	--	--	32.6	0.2	59.7	0.1	--
Spokane Indian Reservation	2,004	--	--	--	18.5	0.3	76.5	0.6	--
Ferry County	7,260	--	4.8	14.5	80.6	0.2	16.6	0.2	15,019
Lincoln County	10,184	--	4.5	20.1	95.8	0.3	2.3	0.3	17,888
Stevens county	40,066	--	5.2	14.1	91.5	0.3	5.4	0.5	15,895

Notes: -- = no data available

^a Demographic data for towns was obtained from U.S. Census Bureau, American Factfinder website: <http://factfinder.census.gov> accessed on September 28, 2006 and July 9, 2007. Data for Indian reservations was obtained from Office of Financial Management, State of Washington, 2005 Data Book website: www.ofm.wa.gov/databook/population/pt06.asp accessed on October 10, 2006. Data for counties was obtained from U.S. Census Bureau QuickFacts website: <http://quickfacts.census.gov> accessed on October 10, 2006.

^b Percentage data for counties is based upon 2004 census, all other data is based upon 2000 census.

Table 3-2. Active Surface Water Rights within the Study Area with Potential Domestic Uses^a

Water Rights Document ID	File ID	Type	Year	Purpose	TRS
2095685	S3-163614CL	Claim L		DG IR	T29N/R35E-26
2095691	S3-163620CL	Claim L		DG IR	T34N/R26E-25
2096031	S3-160394CL	Claim L	1910	DG IR ST	T39N/R39E-23
2096376	S3-159759CL	Claim L		DG IR	T27N/R35E-07
2098156	S3-151738CL	Claim S		DG IR	T28N/R32E-07
2101632	S3-134109CL	Claim L	1917	DG	T36N/R37E-14
2103977	S3-120964CL	Claim L	1958	DG	T35N/R37E-10
2104330	S3-120465CL	Claim L	1973	DG	T35N/R37E-10
2106404	S3-110502CL	Claim L	1969	DG	T35N/R37E-10
2109587	S3-095460CL	Claim L	1959	DG	T35N/R37E-10
2112524	S3-080595CL	Claim S		DG IR	T35N/R37E-10
2112525	S3-080596CL	Claim S		DG IR	T35N/R37E-10
2118140	S3-053438CL	Claim S		DG	T30N/R36N-22
2118392	S3-050840CL	Claim S		DG IR ST	T37N/R38E-09
2120101	S3-044916CL	Claim L		DG	T35N/R37E-10
2124756	S3-022700CL	Claim L	1971	DG	T40N/R41E-09
2130228	S3-28591CWRIS	Cert	1989	DS	T27N/R34E-04
2130382	S3-27629CWRIS	Cert	1983	DS FR	T37N/R37E-28
2130601	S3-27202GWRIS	Cert	1982	DS	T28N/R33N-30
2130647	S3-27554GWRIS	Cert	1983	DM IR	T35N/R37E-29
2130836	S3-25471CWRIS	Cert	1977	DS FR	T36N/R37E-14
2131113	S3-25394GWRIS	Cert	1977	DS IR	T36N/R37E-02
2131268	S3-24688CWRIS	Cert	1975	DS	T40N/R40E-31
2132349	S3-01027CWRIS	Cert	1969	DS IR ST	T33N/R37E-30
2132407	S3-01346CWRIS	Cert	1964	DS IR	T35N/R37E-28
2132417	S3-01386CWRIS	Cert	1971	DS IR	T27N/R35E-18
2132610	S3-00822CWRIS	Cert	1971	CI DM	T27N/R35E-21
2135077	S3-*20403CWRIS	Cert	1967	DS	T35N/R37E-32
2135084	S3-*20462CWRIS	Cert	1967	DS FR	T37N/R37E-28
2135146	S3-*21066CWRIS	Cert	1968	DS	T35N/R37E-10
2135162	S3-*21270CWRIS	Cert	1968	DM	T36N/R37E-11
2135257	S3-*19491C	Cert	1966	DS IR	T35N/R37E-21
2135395	S3-*18484CWRIS	Cert	1964	DM IR	T36N/R37E-23
2135397	S3-*18486CWRIS	Cert	1964	DM	T37N/R38E-22
2135466	S3-*19225CWRIS	Cert	1965	DS IR	T32N/R37E-22
2135531	S3-*16460CWRIS	Cert	1960	DS IR	T36N/R37E-11
2135670	S3-*15062CWRIS	Cert	1958	DG IR	T28N/R31E-08
2135673	S3-*15100CWRIS	Cert	1958	DS IR	T37N/R38E-05
2135722	S3-*15256CWRIS	Cert	1959	DS IR	T37N/R38E-05
2135803	S3-*13347CWRIS	Cert	1955	DS IR	T37N/R38E-05
2135824	S3-*13568CWRIS	Cert	1955	DS IR ST	T28N/R32E-24
2135857	S3-*13791ALCWRIS	Cert	1956	DS IR	T28N/R33E-10
2136267	S3-*10256CWRIS	Cert	1951	DS	T33N/R37E-04
2136541	S3-*07143CWRIS	Cert	1946	DS IR	T38N/R38E-32
2136570	S3-*07692CWRIS	Cert	1947	CI DM	T27N/R35E-21
2136769	S3-*05763ALCWRIS	Cert	1942	DS IR ST	T28N/R33E-09
2136776	S3-*05936CWRIS	Cert	1943	DS IR	T35N/R37E-15
2143788	S3-29541	NewApp	1993	DM FR	T27N/R34E-02
2143788	S3-29541	NewApp	1993	DM FR	T27N/R34E-02
2143788	S3-29541	NewApp	1993	DM FR	T27N/R34E-02
2143887	S3-28530	Pmt	1988	DS IR	T28N/R33E-30
2125566	S3-017576CL	Claim L	1910	DG IR	T37N/R37E-17
2130430	S3-27977CWRIS	Cert	1985	DS ST	T38N/R37E-21

Table 3-2. Active Surface Water Rights within the Study Area with Potential Domestic Uses^a

Water Rights Document ID	File ID	Type	Year	Purpose	TRS
2130447	S3-28079C	Cert	1985	DS	T38N/R37E-21
2130504	S3-28433CWRIS	Cert	1987	DS FR	T37N/R37E-21
2130588	S3-27124GWRIS	Cert	1981	DS IR	T37N/R37E-33
2132493	S3-00176CWRIS	Cert	1968	DS FR	T37N/R37E-33
2136963	S3-*04189CWRIS	Cert	1936	DS	T38N/R37E-21
2098741	S3-147203CL	Claim L	1970	DG IR	T30N/R33E-33
2103455	S3-124892CL	Claim L		DC DG FR IR	T29N/R33E-16
2109377	S3-096741CL	Claim L	1971	DG FR IR	T29N/R33E-16
2109377	S3-01564CWRIS	Cert	1970	DM FR	T29N/R33E-16
2115714	S3-063315CL	Claim S		DG ST	T30N/R33E-28
2115715	S3-063316CL	Claim S		DG ST	T30N/R33E-28
2135396	S3-*18485CWRIS	Cert	1964	DM IR	T29N/R33E-04
2126642	S3-011442CL	Claim L	1972	DG	T28N/R37E-33
2130442	S3-28043CWRIS	Cert	1985	DS	T28N/R37E-33
2130745	S3-26559CWRIS	Cert	1980	DS	T28N/R37E-33
2130926	S3-25993CWRIS	Cert	1978	DS	T28N/R37E-33
2131197	S3-24199CWRIS	Cert	1975	DM	T28N/R37E-33
2131848	S3-22653CWRIS	Cert	1974	DS	T27N/R38E-31
2132074	S3-21008CWRIS	Cert	1973	DS FR	T28N/R37E-33
2132207	S3-20147CWRIS	Cert	1972	DS	T28N/R37E-33
2132317	S3-00851CWRIS	Cert	1971	DS	T28N/R37E-33
2135184	S3-*21464C	Cert	1969	DM IR	T28N/R37E-29
2135271	S3-*19650CWRIS	Cert	1966	DS IR	T27N/R39E-19
2135400	S3-*18572CWRIS	Cert	1964	DS	T27N/R38E-31

Notes:

DG = Domestic General

DM = Domestic Multiple

DS = Domestic Single

IR = Irrigation

ST = Stock water

FR = Fire Protection

CI = Commercial/Industrial

^aData provided by WA Department of Ecology

(Emails of June 27, 2007 and July 18, 2007 to S. FitzGerald, Integral Consulting Inc.).

Table 3-3. Public Water Systems Groundwater Wells and Springs within Five Miles of UCR/Lake Roosevelt Shoreline

PWS ID	System Name	Group	System Type	County	Source Type	Use
SPRINGS						
NP280	FORT SPOKANE CAMPGROUND	A	Transient Non-Community	LINCOLN	Spring	Permanent
4490	Upper Columbia RV Park & Campground	A	Transient Non-Community	STEVENS	Spring	Permanent
34737	BISBEE ACRES WATER ASSOCIATION	B	Group B	FERRY	Spring	Permanent
75825	SAN POIL BAY IMPROVEMENT ASSN INC	B	Group B	FERRY	Spring	Emergency
2190	TOWNSHIP CREEK WATER SYSTEM	B	Group B	FERRY	Spring	Permanent
41164	BROUGHER RANCH INC	B	Group B	LINCOLN	Spring	Permanent
26090	FORT SPOKANE STORE	B	Group B	LINCOLN	Spring	Permanent
17710	DAISY WATER SYSTEM	B	Group B	STEVENS	Spring	Permanent
26810	FRUITLAND WATER ASSN	B	Group B	STEVENS	Spring	Permanent
1649	MARBLE WATER SYSTEM	B	Group B	STEVENS	Spring	Permanent
18451	MY PARENTS ESTATE	B	Group B	STEVENS	Spring	Permanent
89080	TRAILS WEST SUBDIVISION	B	Group B	STEVENS	Spring	Permanent
WELLS						
8174	COLUMBIA CEDAR	A	Non-Transient, Non-Community	FERRY	Well(s)	Permanent
NP330	HAAG COVE CAMPGROUND	A	Transient Non-Community	FERRY	Well(s)	Permanent
35550	INCHELIUM WATER DISTRICT	A	Community	FERRY	Well(s)	Permanent and Emergency
NP495	KETTLE RIVER CAMPGROUND	A	Transient Non-Community	FERRY	Well(s)	Permanent
33489	LAKESIDE PARK	A	Community	FERRY	Well(s)	Permanent
51877	MARTIN CREEK COMMUNITY ASSN	A	Community	FERRY	Well(s)	Permanent
33301	NORTH LAKE ROOSEVELT RESORT	A	Transient Non-Community	FERRY	Well(s)	Permanent
73032	RIVERWOOD WATER SYSTEM	A	Community	FERRY	Well(s)	Permanent
7216	WATERING HOLE, THE	A	Transient Non-Community	FERRY	Well(s)	Permanent
15451	COULEE GRANDE-BANKS LK GOLF COURSE	A	Transient Non-Community	GRANT	Well(s)	Seasonal
22850	ELECTRIC CITY, TOWN OF	A	Community	GRANT	Well(s)	Permanent and Seasonal
28700	GRAND COULEE WATER DEPT, CITY OF	A	Community	GRANT	Well(s)	Permanent

Table 3-3. Public Water Systems Groundwater Wells and Springs within Five Miles of UCR/Lake Roosevelt Shoreline

PWS ID	System Name	Group	System Type	County	Source Type	Use
8114	SUNBANKS RESORT	A	Transient Non-Community	GRANT	Well(s)	Permanent
1852	DEER MEADOWS WATER COMPANY INC	A	Community	LINCOLN	Well(s)	Permanent
NP280	FORT SPOKANE CAMPGROUND	A	Transient Non-Community	LINCOLN	Well(s)	Seasonal
19928	HANSON HARBOR HOMEOWNERS ASSN	A	Community	LINCOLN	Well(s)	Permanent
NP335	HAWK CREEK CAMPGROUND	A	Transient Non-Community	LINCOLN	Well(s)	Permanent
NP470	KELLER FERRY CAMPGROUND	A	Transient Non-Community	LINCOLN	Well(s)	Permanent
HD340	KELLER FERRY LANDING	A	Transient Non-Community	LINCOLN	Well(s)	Permanent
NP469	KELLER FERRY MARINA	A	Transient Non-Community	LINCOLN	Well(s)	Permanent
45366	LAKEVIEW TERRACE MHP	A	Community	LINCOLN	Well(s)	Permanent
NP700	PORCUPINE BAY CAMPGROUND	A	Transient Non-Community	LINCOLN	Well(s)	Permanent
20116	RANTZ MARINE PARK	A	Transient Non-Community	LINCOLN	Well(s)	Permanent
23324	RIVER RUE WATER SYSTEM	A	Transient Non-Community	LINCOLN	Well(s)	Permanent
47283	ROOSEVELT LAKE RANCH	A	Community	LINCOLN	Well(s)	Permanent
77651	SEVEN BAYS ESTATES UNLIMITED	A	Community	LINCOLN	Well(s)	Permanent
NP810	SPRING CANYON CAMPGROUND	A	Transient Non-Community	LINCOLN	Well(s)	Permanent
23391	SUNNY HILLS WATER SYSTEM	A	Transient Non-Community	LINCOLN	Well(s)	Permanent
NP070	CAMP NABOR LEE	A	Transient Non-Community	STEVENS	Well(s)	Permanent
NP110	CLOVERLEAF CAMPGROUND	A	Transient Non-Community	STEVENS	Well(s)	Permanent
7664	COLUMBIA SCHOOL DISTRICT 206	A	Non-Transient, Non-Community	STEVENS	Well(s)	Permanent
NP240	EVANS CAMPGROUND	A	Transient Non-Community	STEVENS	Well(s)	Permanent

Table 3-3. Public Water Systems Groundwater Wells and Springs within Five Miles of UCR/Lake Roosevelt Shoreline

PWS ID	System Name	Group	System Type	County	Source Type	Use
23960	EVANS WATER SYSTEM	A	Community	STEVENS	Well(s)	Permanent
24162	EVERGREEN SCHOOL DISTRICT #205	A	Non-Transient, Non-Community	STEVENS	Well(s)	Permanent
26790	FRUITLAND BIBLE CAMP	A	Transient Non-Community	STEVENS	Well(s)	Permanent and Seasonal
NP300	GIFFORD CAMPGROUND	A	Transient Non-Community	STEVENS	Well(s)	Permanent
NP380	HUNTERS CAMPGROUND	A	Transient Non-Community	STEVENS	Well(s)	Permanent
34889	HUNTERS WATER DISTRICT	A	Community	STEVENS	Well(s)	Permanent and Emergency
NP460	KAMLOOPS ISLAND CAMPGROUND	A	Transient Non-Community	STEVENS	Well(s)	Permanent
38400	KETTLE FALLS WATER DEPT	A	Community	STEVENS	Well(s)	Permanent
NP610	MARCUS ISLAND CAMPGROUND	A	Transient Non-Community	STEVENS	Well(s)	Permanent
51550	MARCUS WATER DEPT	A	Community	STEVENS	Well(s)	Seasonal, Permanent, and Emergency
30434	MISSION RIDGE WATER SYSTEM	A	Community	STEVENS	Well(s)	Permanent
NP660	NORTH GORGE CAMPGROUND	A	Transient Non-Community	STEVENS	Well(s)	Permanent
61850	NORTHPORT WATER SYSTEM	A	Community	STEVENS	Well(s)	Permanent
NP780	SNAG COVE CAMPGROUND	A	Transient Non-Community	STEVENS	Well(s)	Permanent
3554	Union Gospel Mission Tshimakain	A	Transient Non-Community	STEVENS	Well(s)	Permanent
41379	WELLPINIT SCHOOL	A	Non-Transient, Non-Community	STEVENS	Well(s)	Permanent
99330	YE OLD COUNTRY STORE	A	Transient Non-Community	STEVENS	Well(s)	Permanent
34014	ANDERSON K. R. LOTS	B	Group B	FERRY	Well(s)	Permanent
AB500	AOY Cascade	B	Group B	FERRY	Well(s)	Permanent
8014	BOYDS TAVERN	B	Group B	FERRY	Well(s)	Permanent
38951	COLUMBIA RIVER WATER ASSOCIATION	B	Group B	FERRY	Well(s)	Permanent
34017	FREDRICKSON SHORT PLAT	B	Group B	FERRY	Well(s)	Permanent
6012	KENT WATER SYSTEM	B	Group B	FERRY	Well(s)	Permanent

Table 3-3. Public Water Systems Groundwater Wells and Springs within Five Miles of UCR/Lake Roosevelt Shoreline

PWS ID	System Name	Group	System Type	County	Source Type	Use
AA644	R GARDEN INTERNATIONAL	B	Group B	FERRY	Well(s)	Permanent and Emergency
6538	BROUGHER RANCH II	B	Group B	LINCOLN	Well(s)	Permanent
8271	BROUGHER RANCH III	B	Group B	LINCOLN	Well(s)	Permanent
8340	CAMPBELL BAY FARMS	B	Group B	LINCOLN	Well(s)	Permanent
AA087	CHAR-DONNIE	B	Group B	LINCOLN	Well(s)	Permanent
4298	COLUMBIA SPRINGS ESTATES	B	Group B	LINCOLN	Well(s)	Permanent
NP190	DETILLION CAMPGROUND	B	Group B	LINCOLN	Well(s)	Permanent
7944	FDR ESTATES #5	B	Group B	LINCOLN	Well(s)	Permanent
7961	FDR ESTATES #6	B	Group B	LINCOLN	Well(s)	Permanent
2484	HUNTER FAMILY WATER SYSTEM	B	Group B	LINCOLN	Well(s)	Permanent
4991	KUNZ WATER SYSTEM	B	Group B	LINCOLN	Well(s)	Permanent
5694	LAKE ROOSEVELT HIDEAWAY	B	Group B	LINCOLN	Well(s)	Permanent
AB219	Lakeview Catering	B	Group B	LINCOLN	Well(s)	Permanent
5403	LAKEVIEW HEIGHTS WATER SYSTEM	B	Group B	LINCOLN	Well(s)	Permanent
7007	LIVINGSTON, GEORGE WATER SYSTEM	B	Group B	LINCOLN	Well(s)	Permanent
24292	LONG LAKE OPERATORS VILLAGE	B	Group B	LINCOLN	Well(s)	Permanent
AB341	Pavlov Water System	B	Group B	LINCOLN	Well(s)	Permanent
6719	PORCUPINE BAY ESTATES	B	Group B	LINCOLN	Well(s)	Permanent
6719	PORCUPINE BAY ESTATES	B	Group B	LINCOLN	Well(s)	Permanent
196	PORTER WELL WATER SYSTEM	B	Group B	LINCOLN	Well(s)	Permanent
56364	ROCKY TOP ESTATES	B	Group B	LINCOLN	Well(s)	Permanent
AA482	ROOSEVELT VIEWS SUBDIVISION	B	Group B	LINCOLN	Well(s)	Permanent
38625	SQUAW CANYON PLAT III	B	Group B	LINCOLN	Well(s)	Permanent
51131	TARBERT WATER SYSTEM	B	Group B	LINCOLN	Well(s)	Permanent
6998	TRANQUIL ESTATES	B	Group B	LINCOLN	Well(s)	Permanent
AA292	WIND WALKER	B	Group B	LINCOLN	Well(s)	Permanent
2525	Azzarito / Fish	B	Group B	STEVENS	Well(s)	Permanent
6870	BISCEGLIA WATER SYSTEM	B	Group B	STEVENS	Well(s)	Permanent
7800	BOSSBURG WATER SYSTEM	B	Group B	STEVENS	Well(s)	Permanent
AA572	BUCK CANYON LODGE	B	Group B	STEVENS	Well(s)	Permanent
33856	CE MINERALS/CALHOUN MILL	B	Group B	STEVENS	Well(s)	Permanent
6224	CHINA BEND VINEYARDS	B	Group B	STEVENS	Well(s)	Permanent
AA168	CLEAR WATER	B	Group B	STEVENS	Well(s)	Permanent
3024	DRAKE S WATER COMPANY	B	Group B	STEVENS	Well(s)	Permanent
5320	ECHO RIDGE VETERINARY HOSPITAL	B	Group B	STEVENS	Well(s)	Permanent
2704	FRONTIER WATER SYSTEM	B	Group B	STEVENS	Well(s)	Permanent

Table 3-3. Public Water Systems Groundwater Wells and Springs within Five Miles of UCR/Lake Roosevelt Shoreline

PWS ID	System Name	Group	System Type	County	Source Type	Use
AA757	Gold Edge Estates	B	Group B	STEVENS	Well(s)	Permanent
4430	GOLDEN WATER SYSTEM	B	Group B	STEVENS	Well(s)	Permanent
2185	GRAHAM WELL	B	Group B	STEVENS	Well(s)	Permanent
2471	HARSIN/DRISKILL WATER SYSTEM	B	Group B	STEVENS	Well(s)	Permanent
2984	HAYES, LEON WTR. SYS.	B	Group B	STEVENS	Well(s)	Permanent
2539	JAMES WATER SYSTEM	B	Group B	STEVENS	Well(s)	Permanent
1804	JONES, ROBERT D. WATER SYSTEM	B	Group B	STEVENS	Well(s)	Permanent
3719	KINDER, VESTER C. WATER SYSTEM	B	Group B	STEVENS	Well(s)	Permanent
1664	MALONE WATER SYSTEM	B	Group B	STEVENS	Well(s)	Permanent
2491	MOORE WATER SYSTEM	B	Group B	STEVENS	Well(s)	Permanent
1577	PHILLIPS WATER SYSTEM	B	Group B	STEVENS	Well(s)	Permanent
8268	RED S WATER DISTRICT	B	Group B	STEVENS	Well(s)	Permanent
3743	RHOADES WELL	B	Group B	STEVENS	Well(s)	Permanent
2752	RHONDA S WATER SYSTEM	B	Group B	STEVENS	Well(s)	Permanent
7804	RICE CHURCH	B	Group B	STEVENS	Well(s)	Permanent
4112	RICKEY CANYON SUBDIVISION	B	Group B	STEVENS	Well(s)	Permanent
34825	ROBINSON WATER SYSTEM	B	Group B	STEVENS	Well(s)	Permanent
2839	SCRAPER, JOHN WATER SYSTEM	B	Group B	STEVENS	Well(s)	Permanent
NR720	SHEEP CREEK CAMPGROUND	B	Group B	STEVENS	Well(s)	Permanent
5283	SLONIKER & RAGLAND WATER SYSTEM	B	Group B	STEVENS	Well(s)	Permanent
41431	SNAG COVE WATER SYSTEM	B	Group B	STEVENS	Well(s)	Permanent
AA980	Stevens Co Fire District #12	B	Group B	STEVENS	Well(s)	Permanent
3252	VAN SICKLE, FAYE WTR. SYS.	B	Group B	STEVENS	Well(s)	Permanent
2769	VERY DEEP WELL WATER SYSTEM	B	Group B	STEVENS	Well(s)	Permanent
AB381	Victory Baptist Church	B	Group B	STEVENS	Well(s)	Permanent
3135	WEST, ROBERT L. WATER SYSTEM	B	Group B	STEVENS	Well(s)	Permanent
2524	WHITCOMB-DAVIS WATER SYSTEM	B	Group B	STEVENS	Well(s)	Permanent
NR900	WILLIAMS LAKE CAMP GROUND	B	Group B	STEVENS	Well(s)	Permanent

Source: Washington Dept. of Health, 2004 data (WDOH 2006a).

Note: System Name and Use entries are shown as provided by DOH.

Emergency = Any source that is approved by the department for emergency purposes only, is not used for routine or seasonal water demands, is physically disconnected, and is identified in the purveyor's emergency response plan.

Seasonal = A public water system source used on a regular basis, that is not a permanent or emergency source.

Permanent = A public water system supply source that is used regularly each year, and based on expected operational requirements of the system, will be used more than three consecutive months in any twelve-month period. For seasonal water systems that are in operation for less than three consecutive months per year, their sources shall also be considered to be permanent.

Table 3-4. Group A Water Systems with Mapped 10-Year Wellhead Protection Areas

PWSID	System Name	System Type	County	Use
8174	COLUMBIA CEDAR	Non-Transient, Non-Community	FERRY	Permanent
35550	INCHELIUM WATER DISTRICT	Community	FERRY	Permanent
33489	LAKESIDE PARK	Community	FERRY	Permanent
51877	MARTIN CREEK COMMUNITY ASSN	Community	FERRY	Permanent
73032	RIVERWOOD WATER SYSTEM	Community	FERRY	Permanent
22850	ELECTRIC CITY, TOWN OF	Community	GRANT	Permanent
45366	LAKEVIEW TERRACE MHP	Community	LINCOLN	Permanent
77651	SEVEN BAYS ESTATES UNLIMITED	Community	LINCOLN	Permanent
7664	COLUMBIA SCHOOL DISTRICT 206	Non-Transient, Non-Community	STEVENS	Permanent
23960	EVANS WATER SYSTEM	Community	STEVENS	Permanent
24162	EVERGREEN SCHOOL DISTRICT #205	Non-Transient, Non-Community	STEVENS	Permanent
34889	HUNTERS WATER DISTRICT	Community	STEVENS	Permanent
38400	KETTLE FALLS WATER DEPT	Community	STEVENS	Permanent
51550	MARCUS WATER DEPT	Community	STEVENS	Seasonal
30434	MISSION RIDGE WATER SYSTEM	Community	STEVENS	Permanent
61850	NORTHPORT WATER SYSTEM	Community	STEVENS	Permanent

Source: Washington Dept. of Health (WDOH 2006a, b).

Note: System Name and Use entries are shown as provided by DOH.

Table 3-5. Gaging Stations Used to Develop Water Budgets

Station	Gage	Latitude	Longitude	Long-Term Average Gage Flow (cfs)	Cumulative Long-Term Average Columbia River Flow (cfs)	Measured Long-Term Average Columbia River Flow (cfs)	Columbia River Gage ^a	Percent of Grand Coulee Outflow	Period of Record	Count of Daily Flow Values
Columbia River at Castlegar, B.C.	WSC 08NE002	49°19'56" N	117°40'33" W	42,725	42,725	42,725	1	40%	1913–1916 1961–1972	5,478
Kootenay Lake Outflow near Corra Linn, B.C.	WSC 08NJ158	49°28'1" N	117°27'54" W	27,761	70,486	71,101	2	26%	1937–2005	24,929
Pend Oreille River at International Boundary, WA (before entering Canada)	USGS 12398600	48°59'56" N	117°21'09" W	25,938	96,424	99,637	3	24%	1962–2007	15,917
Kettle River near Laurier, WA	USGS 12398600	48°59'56" N	117°21'09" W	2,928	99,352			3%	1929–2007	28,458
Colville River at Kettle Falls, WA	USGS 12409000	48°35'40" N	118°03'41" W	306	99,658			< 1 %	1922–2007	30,802
Spokane River at Long Lake, WA	USGS 12433000	47°50'12" N	117°50'25" W	7,670	107,328			7%	1939–2006	24,656
Sanpoil River near Keller, WA	USGS 12434500	48°05'04" N	118°41'25" W	261	107,589	107,806	4	< 1 %	1952–1974	3,969
Sanpoil River above Jack Creek at Keller, WA	USGS 12434590	48°05'04" N	118°41'25" W	261	107,589	107,806	4	< 1 %	2006–2007	284
Sanpoil River at Keller, WA	USGS 12435000	48°05'04" N	118°41'25" W	261	107,589	107,806	4	< 1 %	1911–1917	1,799

Note:

^a See Table 2-4.

Table 3-6. Water Budget for the UCR

Columbia River Gage	Station on the Columbia River	Gage	Latitude	Longitude	Long-Term Average Gage Flow (cfs)	Period of Record	Count of Daily Flow Values
1	Columbia River at Castlegar, B.C.	WSC 08NE002	49°19'56" N	117°40'33" W	42,725	1913–1916 1961–1972	5,478
2	Columbia River at Birchbank, B.C.	WSC 08NE049	49°10'40" N	117°42'59" W	71,101	1937–2006	25,294
3	Columbia River at International Boundary, WA ^a	USGS 12399500	49°00'03" N	117°37'42" W	99,637	1938–2007	25,355
4	Columbia River at Grand Coulee, WA	USGS 12436500	47°57'56" N	118°58'54" W	107,806	1923–2006	28,308

Notes: WSC = Water Survey of Canada
 USGS = United States Geological Survey
^aIncludes flow from the Pend Oreille River.

Table 3-7. Statistical Measures of Daily Discharge at the U.S.-Canadian Border

Statistical Measure	Time Interval		
	March 1, 1938 to December 21, 2005	March 1, 1938 to December 21, 1972	January 1, 1973 to December 31, 2005
Mean (cfs)	99,544	101,757	97,209
Median (cfs)	82,400	64,800	90,900
Mode (cfs)	101,000	101,000	102,000
Harmonic Mean (cfs)	72,603	62,689	87,154
Minimum (cfs)	21,200	21,200	21,500
Maximum (cfs)	549,000	549,000	302,000
25th Percentile (cfs)	57,400	44,600	74,500
75th Percentile (cfs)	115,000	127,000	112,000
Average deviation (cfs)	45,676	65,355	25,332
Standard deviation (cfs)	66,239	86,000	34,657
Coefficient of variation (cfs)	0.67	0.85	0.36
Areal mean discharge (cfs/mi ²)	1.67	1.71	1.63
Rainfall equivalent (in/y)	22.65	23.16	22.12

Notes: cfs = cubic feet per second
in. = inch
mi² = square mile
y = year

Table 3-8. Terrestrial Animal Species Present in the UCR RI/FS Study Area

Scientific Name	Common Name	Source of Occurrence Information					WDFW USE	Federal Status	State Status	Proposed State Status Listing	Culturally Important
Amphibians											
<i>Ambystoma macrodactylum</i>	Long-toed salamander		BPA	IC							
<i>Ambystoma tigrinum</i>	Tiger salamander	NPS	BPA	IC		IO		SM			
<i>Bufo boreas</i>	Western toad	NPS	BPA	IC			FC	SC			
<i>Bufo woodhousii</i>	Woodhouse's toad		BPA			IO		SM			
<i>Hyla regilla</i>	Pacific treefrog	NPS	BPA	IC							
<i>Spea intermontana</i>	Great basin spadefoot	NPS	BPA	IC							
<i>Rana catesbeiana</i>	Bullfrog		BPA	IC							
<i>Rana clamitans</i>	Green frog		BPA								
<i>Rana pipiens</i>	Northern leopard frog		BPA			IO	FC	SE			
<i>Rana luteiventris</i>	Columbia spotted frog		BPA	IC		IO	FC	SC	PS		
Reptiles											
<i>Chrysemys picta</i>	Painted turtle	NPS	BPA	IC							
<i>Elgaria coerulea</i>	Northern alligator lizard		BPA	IC							
<i>Phrynosoma douglassi</i>	Short-horned lizard	NPS	BPA	IC							
<i>Sceloporus graciosus</i>	Sagebrush lizard	NPS	BPA			IO	FC	SC			
<i>Sceloporus occidentalis</i>	Western fence lizard		BPA								
<i>Uta stansburiana</i>	Side-blotched lizard		BPA	IC							
<i>Eumeces skiltonianus</i>	Western skink		BPA	IC							
<i>Charina bottae</i>	Rubber boa		BPA	IC							
<i>Coluber constrictor</i>	Racer			IC							
<i>Hypsiglena torquata</i>	Night snake		BPA			WDFW	IO	SM			
<i>Pituophis catenifer</i>	Gopher snake	NPS	BPA	IC							
<i>Thamnophis elegans</i>	Western terrestrial garter snake	NPS	BPA	IC							
<i>Thamnophis ordinoides</i>	Northwestern garter snake		BPA								
<i>Thamnophis sirtalis</i>	Common garter snake		BPA	IC							
<i>Crotalus viridis</i>	Western rattlesnake	NPS	BPA	IC							
Birds											
<i>Gavia immer</i>	Common loon	NPS	BPA	xC	SAS	WDFW	B		SS	PT	
<i>Podilymbus podiceps</i>	Pied-billed grebe		BPA	IC							
<i>Podiceps auritus</i>	Horned grebe		BPA	IC			B	SM			
<i>Podiceps grisegena</i>	Red-necked grebe		BPA	IC			B	SM			
<i>Podiceps nigricollis</i>	Eared grebe		BPA	IC							
<i>Aechmophorus occidentalis</i>	Western grebe	NPS	BPA	IC			B	SC			
<i>Pelecanus erythrorhynchos</i>	American white pelican		BPA	IC			B,RSC	SE			
<i>Phalacrocorax auritus</i>	Double-crested cormorant			IC							
<i>Botaurus lentiginosus</i>	American bittern		BPA	IC							
<i>Ardea herodias</i>	Great blue heron	NPS	BPA	IC		WDFW	B	SM			
Birds (continued)											
<i>Nycticorax nycticorax</i>	Black-crowned night-heron		BPA	IC			B	SM			
<i>Cygnus columbianus</i>	Tundra swan			IC							
<i>Anser albifrons</i>	Greater white-fronted goose		BPA								
<i>Chen caerulescens</i>	Snow goose		BPA	IC							
<i>Chen rossii</i>	Ross' goose		BPA								
<i>Branta canadensis</i>	Canada goose	NPS	BPA	IC							
<i>Aix sponsa</i>	Wood duck		BPA	IC							
<i>Anas crecca</i>	Green-winged teal	NPS?	BPA	IC							
<i>Anas platyrhynchos</i>	Mallard	NPS	BPA	IC							
<i>Anas acuta</i>	Northern pintail	NPS	BPA	IC							
<i>Anas discors</i>	Blue-winged teal	NPS?	BPA	IC							
<i>Anas cyanoptera</i>	Cinnamon teal	NPS?	BPA	IC							
<i>Anas clypeata</i>	Northern shoveler		BPA	IC							
<i>Anas strepera</i>	Gadwall		BPA	IC							
<i>Anas americana</i>	American wigeon		BPA	IC							
<i>Aythya valisineria</i>	Canvasback		BPA	IC							
<i>Aythya americana</i>	Redhead	NPS	BPA	IC							
<i>Aythya collaris</i>	Ring-necked duck		BPA	IC							
<i>Aythya marila</i>	Greater scaup		BPA	xC	SAS						
<i>Aythya affinis</i>	Lesser scaup	NPS	BPA	IC							
<i>Histrionicus histrionicus</i>	Harlequin duck		BPA	IC							
<i>Melanitta fusca</i>	White-winged scoter		BPA	xC	SAS						
<i>Bucephala clangula</i>	Common goldeneye	NPS?	BPA	IC							
<i>Bucephala islandica</i>	Barrow's goldeneye	NPS?	BPA	IC							
<i>Bucephala albeola</i>	Bufflehead	NPS	BPA	IC							
<i>Lophodytes cucullatus</i>	Hooded merganser		BPA	IC							
<i>Mergus merganser</i>	Common merganser	NPS	BPA	IC							
<i>Mergus serrator</i>	Red-breasted merganser		BPA	xC	SAS						
<i>Oxyura jamaicensis</i>	Ruddy duck		BPA	IC							
<i>Cathartes aura</i>	Turkey vulture		BPA	IC			B,CR	SM			
<i>Pandion haliaetus</i>	Osprey	NPS	BPA	IC		WDFW	B	SM			
<i>Haliaeetus leucocephalus</i>	Bald eagle	NPS	BPA	IC		WDFW	B,RSC,CR			CCT	
<i>Circus cyaneus</i>	Northern harrier	NPS	BPA	IC							
<i>Accipiter striatus</i>	Sharp-shinned hawk		BPA	IC							
<i>Accipiter cooperii</i>	Cooper's hawk		BPA	IC							

Table 3-8. Terrestrial Animal Species Present in the UCR RI/FS Study Area

Scientific Name	Common Name	Source of Occurrence Information					WDFW USE	Federal Status	State Status	Proposed State Status Listing	Culturally Important
<i>Accipiter gentilis</i>	Northern goshawk		BPA	IC		WDFW	B	FC	SC	PS	
<i>Buteo swainsoni</i>	Swainson's hawk		BPA	IC			B		SM		
Birds (continued)											
<i>Buteo jamaicensis</i>	Red-tailed hawk	NPS	BPA	IC							
<i>Buteo regalis</i>	Ferruginous hawk		BPA	IC			B	FC	ST		
<i>Buteo lagopus</i>	Rough-legged hawk	NPS	BPA	IC							
<i>Aquila chrysaetos</i>	Golden eagle	NPS	BPA	IC		WDFW	B		SC	PS	CCT
<i>Falco sparverius</i>	American kestrel	NPS	BPA	IC							
<i>Falco columbarius</i>	Merlin		BPA	IC					SC		
<i>Falco peregrinus</i>	Peregrine falcon	NPS	BPA	IC		WDFW	B,RI	FC	SS		
<i>Falco rusticolus</i>	Gyrfalcon			IC			RI		SM		
<i>Falco mexicanus</i>	Prairie falcon	NPS	BPA	IC			B		SM		
<i>Perdix perdix</i>	Gray partridge	NPSH	BPA	IC							
<i>Alectoris chukar</i>	Chukar	NPS	BPA	xIC	SAS						
<i>Phasianus colchicus</i>	Ring-necked pheasant	NPS	BPA	IC							
<i>Dendragapus canadensis</i>	Spruce grouse		BPA	IC							
<i>Dendragapus obscurus</i>	Blue grouse	NPS	BPA	IC		WDFW					
<i>Bonasa umbellus</i>	Ruffed grouse	NPS	BPA	IC							
<i>Centrocercus urophasianus</i>	Sage-grouse	NPS	BPA	xIC*	xSAS		B,RSC	FC	ST	PS	
<i>Tympanuchus phasianellus</i>	Sharp-tailed grouse	*NPS	BPA	IC		WDFW	B,RSC	FC	ST	PS	CCT
<i>Meleagris gallopavo</i>	Wild turkey		BPA	IC							
<i>Meleagris gallopavo intermedia</i>	Rio Grande wild turkey					WDFW					
<i>Meleagris gallopavo merriami</i>	Merriam's wild turkey					WDFW					
<i>Callipepla californica</i>	California quail	NPS	BPA	xIC	SAS						
<i>Rallus limicola</i>	Virginia rail		BPA	IC							
<i>Porzana carolina</i>	Sora		BPA	IC							
<i>Fulica americana</i>	American coot	NPS	BPA	IC							
<i>Grus canadensis</i>	Sandhill crane		BPA				B,RLC		SE		
<i>Pluvialis squatarola</i>	Black-bellied plover		BPA	xIC	SAS						
<i>Charadrius semipalmatus</i>	Semipalmated plover		BPA	IC							
<i>Charadrius vociferus</i>	Killdeer	NPS	BPA	IC							
<i>Recurvirostra americana</i>	American avocet		BPA	IC							
<i>Tringa melanoleuca</i>	Greater yellowlegs	NPS?	BPA	IC							
<i>Tringa flavipes</i>	Lesser yellowlegs	NPS?	BPA	IC							
<i>Tringa solitaria</i>	Solitary sandpiper	NPS?	BPA	IC							
<i>Actitis macularia</i>	Spotted sandpiper	NPS?	BPA	IC							
<i>Bartramia longicauda</i>	Upland sandpiper	NPS?		IC			B,RI		SE		
<i>Numenius americanus</i>	Long-billed curlew	NPS?	BPA	IC			B,RSC		SM		
<i>Limosa fedoa</i>	Marbled godwit			IC							
<i>Calidris alba</i>	Sanderling		BPA								
Birds (continued)											
<i>Calidris pusilla</i>	Semipalmated sandpiper	NPS?	BPA	IC							
<i>Calidris mauri</i>	Western sandpiper	NPS?	BPA	IC							
<i>Calidris minutilla</i>	Least sandpiper	NPS?	BPA	IC							
<i>Calidris bairdii</i>	Baird's sandpiper	NPS?	BPA	IC							
<i>Calidris melanotos</i>	Pectoral sandpiper	NPS?	BPA	IC							
<i>Calidris alpina</i>	Dunlin		BPA	IC							
<i>Calidris himantopus</i>	Stilt sandpiper	NPS?	BPA	xIC	SAS						
<i>Limnodromus griseus</i>	Short-billed dowitcher			IC							
<i>Limnodromus scolopaceus</i>	Long-billed dowitcher		BPA	IC							
<i>Gallinago gallinago</i>	Common snipe	NPS	BPA	IC							
<i>Phalaropus tricolor</i>	Wilson's phalarope		BPA	IC							
<i>Phalaropus lobatus</i>	Red-necked phalarope			IC							
<i>Larus philadelphia</i>	Bonaparte's gull	NPS?	BPA	IC							
<i>Larus delawarensis</i>	Ring-billed gull	NPS?	BPA	IC							
<i>Larus californicus</i>	California gull	NPS?	BPA	IC							
<i>Larus argentatus</i>	Herring gull	NPS?	BPA	IC							
<i>Larus glaucescens</i>	Glaucous-winged gull	NPS?	BPA	IC							
<i>Sterna hirundo</i>	Common tern		BPA	IC							
<i>Sterna forsteri</i>	Forster's tern		BPA	IC			B		SM		
<i>Chlidonias niger</i>	Black tern		BPA	IC			B	FC	SM		
<i>Columba livia</i>	Rock dove		BPA	IC							
<i>Columba fasciata</i>	Band-tailed pigeon	NPS?	BPA								
<i>Zenaida macroura</i>	Mourning dove	NPS	BPA	IC							
<i>Tyto alba</i>	Barn owl	NPS	BPA	IC							
<i>Otus flammeolus</i>	Flammulated owl		BPA	IC			B,RI		SC	PS	
<i>Otus kennicottii</i>	Western screech owl	NPS	BPA	IC							
<i>Bubo virginianus</i>	Great horned owl	NPS	BPA	IC							
<i>Nyctea scandiaca</i>	Snowy owl		BPA	IC			RI		SM		
<i>Surnia ulula</i>	Northern hawk owl		BPA	IC							
<i>Glaucidium gnoma</i>	Northern pygmy owl		BPA	IC							
<i>Athene cunicularia</i>	Burrowing owl		BPA	IC			B	FC	SC	PS	
<i>Strix varia</i>	Barred owl		BPA	IC			B				
<i>Strix nebulosa</i>	Great gray owl		BPA	IC			IO		SM		

Table 3-8. Terrestrial Animal Species Present in the UCR RI/FS Study Area

Scientific Name	Common Name	Source of Occurrence Information					WDFW USE	Federal Status	State Status	Proposed State Status Listing	Culturally Important
<i>Asio otus</i>	Long-eared owl		BPA	IC							
<i>Asio flammeus</i>	Short-eared owl	NPS	BPA	IC							
<i>Aegolius funereus</i>	Boreal owl		BPA	IC		B		SM			
<i>Aegolius acadicus</i>	Northern saw-whet owl	NPS	BPA	IC							
Birds (continued)											
<i>Chordeiles minor</i>	Common nighthawk		BPA	IC							
<i>Phalaenoptilus nuttallii</i>	Common poorwill		BPA	IC							
<i>Chaetura vauxi</i>	Vaux's swift		BPA	IC		B, CR		SC	PS		
<i>Aeronautes saxatalis</i>	White-throated swift		BPA	IC							
<i>Archilochus alexandri</i>	Black-chinned hummingbird	NPS?	BPA	IC							
<i>Stellula calliope</i>	Calliope hummingbird	NPS?	BPA	IC							
<i>Selasphorus rufus</i>	Rufous hummingbird	NPS?	BPA	IC							
<i>Ceryle alcyon</i>	Belted kingfisher	NPS	BPA	IC							
<i>Melanerpes lewis</i>	Lewis' woodpecker		BPA	IC		WDFW	B	SC	PS		
<i>Sphyrapicus nuchalis</i>	Red-naped sapsucker			IC							
<i>Sphyrapicus thyroideus</i>	Williamson's sapsucker		BPA	IC							
<i>Picoides pubescens</i>	Downy woodpecker	NPS?	BPA	IC							
<i>Picoides villosus</i>	Hairy woodpecker	NPS?	BPA	IC							
<i>Picoides albolarvatus</i>	White-headed woodpecker	NPS?	BPA	IC		WDFW	B,RI	SC	PS		
<i>Picoides tridactylus</i>	Three-toed woodpecker	NPS?	BPA	IC			B,RI	SM			
<i>Picoides arcticus</i>	Black-backed woodpecker	NPS?	BPA	IC			B,RI	SC			
<i>Colaptes auratus</i>	Northern flicker		BPA	IC							
<i>Dryocopus pileatus</i>	Pileated woodpecker	NPS?	BPA	IC			B	SC	PS		
<i>Contopus borealis</i>	Olive-sided flycatcher		BPA	IC				FC			
<i>Contopus sordidulus</i>	Western wood-pewee		BPA	IC							
<i>Empidonax traillii</i>	Willow flycatcher		BPA	IC				FC			
<i>Empidonax minimus</i>	Least flycatcher		BPA	IC							
<i>Empidonax hammondi</i>	Hammond's flycatcher		BPA	IC							
<i>Empidonax oberholseri</i>	Dusky flycatcher		BPA	IC							
<i>Empidonax occidentalis</i>	Cordilleran flycatcher			IC							
<i>Sayornis saya</i>	Say's phoebe		BPA	IC							
<i>Myiarchus cinerascens</i>	Ash-throated flycatcher		BPA	xC	xSAS		B	SM			
<i>Tyrannus verticalis</i>	Western kingbird		BPA	IC							
<i>Tyrannus tyrannus</i>	Eastern kingbird		BPA	IC							
<i>Eremophila alpestris</i>	Horned lark		BPA	IC							
<i>Tachycineta bicolor</i>	Tree swallow	NPS?	BPA	IC							
<i>Tachycineta thalassina</i>	Violet-green swallow	NPS?	BPA	IC							
<i>Stelgidopteryx serripennis</i>	Northern rough-winged swallow	NPS?	BPA	IC							
<i>Riparia riparia</i>	Bank swallow	NPS?	BPA	IC							
<i>Hirundo pyrrhonota</i>	Cliff swallow	NPS?	BPA	IC							
<i>Hirundo rustica</i>	Barn swallow	NPS?	BPA	IC							
<i>Perisoreus canadensis</i>	Gray jay	NPS?	BPA	IC							
Birds (continued)											
<i>Cyanocitta stelleri</i>	Steller's jay	NPS?	BPA	IC							
<i>Cyanocitta cristata</i>	Blue jay	NPS?	BPA	xC	xSAS						
<i>Nucifraga columbiana</i>	Clark's nutcracker		BPA	IC							
<i>Pica pica</i>	Black-billed magpie	NPS	BPA	IC							
<i>Corvus brachyrhynchos</i>	American crow	NPS	BPA	IC							
<i>Corvus corax</i>	Common raven	NPS	BPA	IC							
<i>Poecile atricapillus</i>	Black-capped chickadee	NPS?	BPA	IC							
<i>Poecile gambeli</i>	Mountain chickadee	NPS?	BPA	IC							
<i>Poecile hudsonicus</i>	Boreal chickadee	NPS?	BPA	IC			B	SM			
<i>Poecile rufescens</i>	Chestnut-backed chickadee	NPS?	BPA	IC							
<i>Sitta canadensis</i>	Red-breasted nuthatch		BPA	IC							
<i>Sitta carolinensis</i>	White-breasted nuthatch		BPA	IC							
<i>Sitta pygmaea</i>	Pygmy nuthatch		BPA	IC							
<i>Certhia americana</i>	Brown creeper		BPA	IC							
<i>Salpinctes obsoletus</i>	Rock wren		BPA	IC							
<i>Catherpes mexicanus</i>	Canyon wren		BPA	xC*	SAS						
<i>Troglodytes aedon</i>	House wren		BPA	IC							
<i>Troglodytes troglodytes</i>	Winter wren		BPA	IC							
<i>Cistothorus palustris</i>	Marsh wren		BPA	IC							
<i>Cinclus mexicanus</i>	American dipper		BPA	IC							
<i>Regulus satrapa</i>	Golden-crowned kinglet		BPA	IC							
<i>Regulus calendula</i>	Ruby-crowned kinglet		BPA	IC							
<i>Sialia mexicana</i>	Western bluebird		BPA	IC			B	SM			
<i>Sialia currucoides</i>	Mountain bluebird		BPA	IC							
<i>Myadestes townsendi</i>	Townsend's solitaire		BPA	IC							
<i>Catharus fuscescens</i>	Veery		BPA	IC							
<i>Catharus ustulatus</i>	Swainson's thrush		BPA	IC							
<i>Catharus guttatus</i>	Hermit thrush		BPA	IC							
<i>Turdus migratorius</i>	American robin	NPS	BPA	IC							
<i>Ixoreus naevius</i>	Varied thrush		BPA	IC							
<i>Dumetella carolinensis</i>	Gray catbird		BPA	xC	SAS						

Table 3-8. Terrestrial Animal Species Present in the UCR RI/FS Study Area

Scientific Name	Common Name	Source of Occurrence Information				WDFW USE	Federal Status	State Status	Proposed State Status Listing	Culturally Important
<i>Oreoscoptes montanus</i>	Sage thrasher			IC		B		SC	PS	
<i>Anthus rubescens</i>	American pipit		BPA	IC						
<i>Bombycilla garrulus</i>	Bohemian waxwing		BPA	IC						
<i>Bombycilla cedrorum</i>	Cedar waxwing		BPA	IC						
<i>Lanius excubitor</i>	Northern shrike		BPA	IC						
<i>Lanius ludovicianus</i>	Loggerhead shrike		BPA	IC		B	FC	SC	PS	
Birds (continued)										
<i>Sturnus vulgaris</i>	European starling		BPA	IC						
<i>Vireo solitarius</i>	Solitary vireo		BPA	IC						
<i>Vireo gilvus</i>	Warbling vireo		BPA	IC						
<i>Vireo olivaceus</i>	Red-eyed vireo		BPA	IC						
<i>Vermivora peregrina</i>	Tennessee warbler		BPA	xIC	xSAS					
<i>Vermivora celata</i>	Orange-crowned warbler		BPA	IC						
<i>Vermivora ruficapilla</i>	Nashville warbler		BPA	IC						
<i>Dendroica petechia</i>	Yellow warbler		BPA	IC						
<i>Dendroica coronata</i>	Yellow-rumped warbler		BPA	IC						
<i>Dendroica townsendi</i>	Townsend's warbler		BPA	IC						
<i>Setophaga ruticilla</i>	American redstart		BPA	IC						
<i>Seiurus noveboracensis</i>	Northern waterthrush		BPA	IC				SM		
<i>Oporornis tolmiei</i>	Macgillivray's warbler		BPA	IC						
<i>Geothlypis trichas</i>	Common yellowthroat		BPA	IC						
<i>Wilsonia pusilla</i>	Wilson's warbler		BPA	IC						
<i>Icteria virens</i>	Yellow-breasted chat		BPA	IC						
<i>Piranga ludoviciana</i>	Western tanager		BPA	IC						
<i>Pheucticus melanocephalus</i>	Black-headed grosbeak		BPA	IC						
<i>Passerina amoena</i>	Lazuli bunting		BPA	IC						
<i>Passerina cyanea</i>	Indigo bunting		BPA							
<i>Pipilo erythrophthalmus</i>	Rufous-sided towhee		BPA	IC						
<i>Spizella arborea</i>	American tree sparrow	NPS?	BPA	IC						
<i>Spizella passerina</i>	Chipping sparrow	NPS?	BPA	IC						
<i>Spizella pallida</i>	Clay-colored sparrow	NPS?	BPA	xIC	xSAS					
<i>Spizella breweri</i>	Brewer's sparrow	NPS?	BPA	IC						
<i>Poocetes gramineus</i>	Vesper sparrow	NPS?	BPA	IC						
<i>Chondestes grammacus</i>	Lark sparrow	NPS?	BPA	IC						
<i>Amphispiza belli</i>	Sage sparrow	NPS?		IC		B		SC	PS	
<i>Passerculus sandwichensis</i>	Savannah sparrow	NPS?	BPA	IC						
<i>Ammodramus savannarum</i>	Grasshopper sparrow	NPS?	BPA	IC		B		SM		
<i>Passerella iliaca</i>	Fox sparrow	NPS?	BPA	IC						
<i>Melospiza melodia</i>	Song sparrow	NPS?	BPA	IC						
<i>Melospiza lincolni</i>	Lincoln's sparrow	NPS?	BPA	IC						
<i>Zonotrichia albicollis</i>	White-throated sparrow	NPS?	BPA	IC						
<i>Zonotrichia atricapilla</i>	Golden-crowned sparrow	NPS?	BPA	xIC	SAS					
<i>Zonotrichia leucophrys</i>	White-crowned sparrow	NPS?	BPA	IC						
<i>Zonotrichia querula</i>	Harris' sparrow	NPS?	BPA	IC						
Birds (continued)										
<i>Junco hyemalis</i>	Dark-eyed junco	NPS?	BPA	IC						
<i>Calcarius lapponicus</i>	Lapland longspur			IC						
<i>Plectrophenax nivalis</i>	Snow bunting		BPA	IC						
<i>Dolichonyx oryzivorus</i>	Bobolink		BPA	IC				SM		
<i>Agelaius phoeniceus</i>	Red-winged blackbird	NPS?	BPA	IC						
<i>Sturnella neglecta</i>	Western meadowlark	NPS?	BPA	IC						
<i>Xanthocephalus xanthocephalus</i>	Yellow-headed blackbird	NPS?	BPA	IC						
<i>Euphagus carolinus</i>	Rusty blackbird	NPS?	BPA	xIC	xSAS					
<i>Euphagus cyanocephalus</i>	Brewer's blackbird	NPS?	BPA	IC						
<i>Molothrus ater</i>	Brown-headed cowbird		BPA	IC						
<i>Icterus galbula</i>	Northern oriole		BPA	IC						
<i>Leucosticte tephrocotis</i>	Gray-crowned rosy-finch		BPA	IC						
<i>Pinicola enucleator</i>	Pine grosbeak		BPA	IC						
<i>Carpodacus purpureus</i>	Purple finch	NPS?	BPA	xIC	xSAS					
<i>Carpodacus cassinii</i>	Cassin's finch	NPS?	BPA	IC						
<i>Carpodacus mexicanus</i>	House finch	NPS?	BPA	IC						
<i>Loxia curvirostra</i>	Red crossbill		BPA	IC						
<i>Loxia leucoptera</i>	White-winged crossbill		BPA	IC						
<i>Carduelis flammea</i>	Common redpoll		BPA	IC						
<i>Carduelis pinus</i>	Pine siskin		BPA	IC						
<i>Carduelis tristis</i>	American goldfinch	NPS?	BPA	IC						
<i>Coccothraustes vespertinus</i>	Evening grosbeak		BPA	IC						
<i>Passer domesticus</i>	House sparrow	NPS?	BPA	IC						
Mammals										
<i>Sorex cinereus</i>	Masked shrew	NPS?	BPA	IC						
<i>Sorex vagrans</i>	Vagrant shrew	NPS?	BPA	IC						
<i>Sorex monticolus</i>	Dusky shrew	NPS?	BPA							
<i>Sorex palustris</i>	Water shrew	NPS?	BPA	IC						
<i>Sorex bendirii</i>	Pacific water shrew	NPS?	BPA			IO		SM		

Table 3-8. Terrestrial Animal Species Present in the UCR RI/FS Study Area

Scientific Name	Common Name	Source of Occurrence Information					WDFW USE	Federal Status	State Status	Proposed State Status Listing	Culturally Important
<i>Sorex trowbridgii</i>	Trowbridge's shrew	NPS?	BPA	xC							
<i>Sorex merriami</i>	Merriam's shrew	NPS?	BPA	IC		IO		SC	PS		
<i>Sorex hoyi</i>	Pygmy shrew	NPS?	BPA	IC		IO		SM	PS		
<i>Neurotrichus gibbsii</i>	Shrew-mole		BPA	xC							
<i>Scapanus townsendii</i>	Townsend's mole		BPA								
<i>Scapanus orarius</i>	Coast mole		BPA	xC							
<i>Myotis lucifugus</i>	Little brown myotis	NPS?	BPA	IC							
<i>Myotis yumanensis</i>	Yuma myotis	NPS?	BPA	IC		B,CR	FC				
Mammals (continued)											
<i>Myotis evotis</i>	Long-eared myotis	NPS?	BPA	IC		B,CR	FC	SM			
<i>Myotis thysanodes</i>	Fringed myotis	NPS?	BPA	IC		B,CR	FC	SM			
<i>Myotis volans</i>	Long-legged myotis	NPS?	BPA	IC		B,CR	FC	SM			
<i>Myotis californicus</i>	California myotis	NPS?	BPA	IC							
<i>Myotis ciliolabrum</i>	Small-footed myotis	NPS?	BPA	IC		B,CR	FC	SM			
<i>Lasionycteris noctivagans</i>	Silver-haired bat	NPS?	BPA	IC							
<i>Eptesicus fuscus</i>	Big brown bat	NPS?	BPA	IC							
<i>Lasiurus borealis</i>	Red bat	NPS?	BPA			B,IO		SM			
<i>Lasiurus cinereus</i>	Hoary bat	NPS?	BPA	IC							
<i>Euderma maculatum</i>	Spotted bat	NPS?		IC		B,CR		SM	SM		
<i>Corynorhinus townsendii</i>	Townsend's big-eared bat	NPS?	BPA	IC	WDFW	B,CR	FC	SC	PT		
<i>Corynorhinus townsendii townsendii</i>	Pacific Townsend's big-eared bat	NPS?			WDFW	B,CR	FC	SC	PT		
<i>Antrozous pallidus</i>	Pallid bat	NPS?	BPA	IC		B,CR		SM			
<i>Ochotona princeps</i>	Pika		BPA	IC							
<i>Brachylagus idahoensis</i>	Pygmy rabbit		BPA	IC		IO	FE	SE			
<i>Sylvilagus nuttallii</i>	Nuttall's cottontail	NPS	BPA	IC							
<i>Lepus americanus</i>	Snowshoe hare		BPA	IC							
<i>Lepus townsendii</i>	White-tailed jack rabbit		BPA	IC		IO		SC			
<i>Tamias minimus</i>	Least chipmunk	NPS?	BPA	IC							
<i>Tamias amoenus</i>	Yellow-pine chipmunk	NPS?	BPA	IC							
<i>Tamias townsendii</i>	Townsend's chipmunk	NPS?	BPA								
<i>Tamias ruficaudus</i>	Red-tailed chipmunk	NPS?	BPA	IC		IO		SM			
<i>Marmota flaviventris</i>	Yellow-bellied marmot	NPS	BPA	IC							
<i>Marmota caligata</i>	Hoary marmot			IC							
<i>Spermophilus washingtoni</i>	Washington ground squirrel		BPA	xC		IO	FC	SC			
<i>Spermophilus columbianus</i>	Columbian ground squirrel	NPS	BPA	IC							
<i>Spermophilus beecheyi</i>	California ground squirrel		BPA	xC							
<i>Spermophilus lateralis</i>	Golden-mantled ground squirrel		BPA	IC							
<i>Sciurus niger</i>	Fox squirrel		BPA								
<i>Sciurus griseus</i>	Western gray squirrel		BPA	xC		IO	FC	ST			
<i>Tamiasciurus hudsonicus</i>	Red squirrel	NPS	BPA	IC							
<i>Tamiasciurus douglasii</i>	Douglas' squirrel		BPA	xC							
<i>Glaucomys sabrinus</i>	Northern flying squirrel		BPA	IC							
<i>Thomomys talpoides</i>	Northern pocket gopher	NPS?	BPA	IC							
<i>Thomomys mazama</i>	Mazama (Western) pocket gopher	NPS?	BPA			IO	FC	SC			
<i>Perognathus parvus</i>	Great basin pocket mouse		BPA	IC							
<i>Castor canadensis</i>	Beaver	NPS	BPA	IC						CCT	
Mammals (continued)											
<i>Reithrodontomys megalotis</i>	Western harvest mouse		BPA	IC							
<i>Peromyscus maniculatus</i>	Deer mouse		BPA	IC							
<i>Neotoma cinerea</i>	Bushy-tailed woodrat		BPA	IC							
<i>Clethrionomys gapperi</i>	Southern red-backed vole	NPS?	BPA	IC							
<i>Clethrionomys californicus</i>	Western red-backed vole	NPS?	BPA	xC							
<i>Phenacomys intermedius</i>	Heather vole	NPS?	BPA	IC							
<i>Microtus pennsylvanicus</i>	Meadow vole	NPS?	BPA	IC							
<i>Microtus montanus</i>	Montane vole	NPS?	BPA	IC							
<i>Microtus townsendii</i>	Townsend's vole	NPS?	BPA								
<i>Microtus longicaudus</i>	Long-tailed vole	NPS?	BPA	IC							
<i>Microtus oregoni</i>	Creeping vole	NPS?	BPA	xC							
<i>Microtus richardsoni</i>	Water vole	NPS?	BPA	IC							
<i>Lagurus curtatus</i>	Sagebrush vole	NPS?	BPA	IC		IO		SM			
<i>Ondatra zibethicus</i>	Muskrat	NPS	BPA	IC							
<i>Synaptomys borealis</i>	Northern bog lemming			IC		IO		SM			
<i>Rattus norvegicus</i>	Norway rat	NPS?	BPA								
<i>Mus musculus</i>	House mouse	NPS?	BPA								
<i>Zapus princeps</i>	Western jumping mouse	NPS?	BPA	IC							
<i>Erethizon dorsatum</i>	Porcupine	NPS	BPA	IC							
<i>Canis latrans</i>	Coyote	NPS	BPA	IC							
<i>Canis lupus</i>	Gray wolf				WDFW	IO	FT	SE			
<i>Vulpes vulpes</i>	Red fox		BPA	IC							
<i>Ursus americanus</i>	Black bear	NPS	BPA	IC						CCT	
<i>Ursus arctos</i>	Grizzly bear		BPA	xC	WDFW	IO	FT	SE		CCT	
<i>Procyon lotor</i>	Raccoon	NPS	BPA	IC							
<i>Martes americana</i>	Marten		BPA	IC							

Table 3-8. Terrestrial Animal Species Present in the UCR RI/FS Study Area

Scientific Name	Common Name	Source of Occurrence Information					WDFW USE	Federal Status	State Status	Proposed State Status Listing	Culturally Important
<i>Martes pennanti</i>	Fisher		BPA	xIC			IO	FC	SE	PS	
<i>Mustela erminea</i>	Ermine			IC							
<i>Mustela frenata</i>	Long-tailed weasel		BPA	IC							
<i>Mustela vison</i>	Mink	NPS	BPA	IC							
<i>Gulo gulo</i>	Wolverine		BPA	IC			IO	FC	SC		
<i>Taxidea taxus</i>	Badger	NPS	BPA	IC							
<i>Spilogale gracilis</i>	Spotted skunk		BPA								
<i>Mephitis mephitis</i>	Striped skunk	NPS	BPA	IC							
<i>Lutra canadensis</i>	River otter	NPS	BPA	IC							
<i>Felis concolor</i>	Mountain lion	NPS	BPA								
<i>Lynx canadensis</i>	Lynx		BPA	IC			IO	FT	ST		
Mammals (continued)											
<i>Lynx rufus</i>	Bobcat	NPS	BPA	IC							
<i>Cervus elaphus</i>	Elk	NPS									CCT
<i>Cervus elaphus nelsoni</i>	Rocky Mountain elk		BPA	IC		WDFW					CCT
<i>Odocoileus hemionus hemionus</i>	Mule deer	NPS	BPA	IC		WDFW					CCT
<i>Odocoileus virginianus</i>	White-tailed deer	NPS	BPA	IC							CCT
<i>Odocoileus virginianus ochrourus</i>	Northwest white-tailed deer					WDFW					CCT
<i>Alces alces</i>	Moose	NPS	BPA	xIC		WDFW					CCT
<i>Rangifer tarandus</i>	Woodland caribou			IC			IO	FE	SE		
<i>Oreamnos americanus</i>	Mountain goat			IC							
<i>Ovis canadensis</i>	Bighorn sheep					WDFW					

Sources:

- CCT (Confederated Tribes of the Colville Reservation)
- NPS (National Park Service) = Hebner et al. (2000)
- BPA (Bonneville Power Administration) = Creveling and Renfrow (1986)
- IC (Interior Columbia Basin Ecosystem Management Project) = Cassidy et al. (1997) and Marcot et al. (2003)
- SAS (Seattle Audubon Society) = Seattle Audubon Society (2006)
- WDFW (Washington Department of Fish and Wildlife) = WDFW (2006)
- USFWS (U.S. Fish and Wildlife Service) = USFWS (2007)
- WSDOT (Washington State Department of Transportation) = WSDOT (2007)

Notes:

- NPS = specifically identified in NPS document, w/ or w/o scientific name; e.g., northern saw-whet owl.
- NPSH = NPS document lists Hungarian partridge, which is a subspecies of gray partridge present in eastern Washington.
- NPS? = general species identified in NPS document; e.g., pocket gophers (*Thomomys* spp.). All species within the group identified that were also identified in the BPA document were marked using this code.
- BPA = specifically identified in BPA document
- IC = species range as shown in GIS coverage from Cassidy et al. 1997 overlaps preliminary analysis area (verified from updated map in Marcot et al. 2003).
- xIC = species range as shown in GIS coverage from Cassidy et al. 1997 does not overlap preliminary analysis area (verified from updated map in Marcot et al. 2003).
- xIC* = species range as shown in GIS coverage from Cassidy et al. 1997 slightly overlaps preliminary analysis area around Grand Coulee Dam.
- SAS = species ranges as shown in Bird Web map overlaps preliminary analysis area. Bird Web was checked for each bird species coded as present in NPS or BPA document and not present in Cassidy et al. 1997 and Marcot et al. 2003.
- xSAS = species ranges as shown in Bird Web map does not overlap preliminary analysis area. Bird Web was checked for each bird species coded as present NPS or BPA document and not present in Cassidy et al. 1997 and Marcot et al. 2003.
- WDFW = identified in WDFW's Priority Habitats and Species database within the preliminary analysis area.

WDFW Use Codes:

- B = breeding
- CR = communal roost
- IO = individual occurrence
- RI = regular occurring individual
- RLC = regular large concentration
- RSC = regular small concentrations

Federal Status Codes:

- FC = federal candidate
- FE = federal endangered
- FT = federal threatened

State Status Codes:

- SC = state candidate
- SE = state endangered
- SM = state monitor
- SS = state sensitive
- ST = state threatened

Proposed State Status Codes:

- PS = proposed sensitive
- PT = proposed threatened

Table 3-9. Aquatic Species Present in the UCR RI/FS Study Area

Scientific Name	Common Name	Source of Occurrence Information	WDFW USE	Federal Status	State Status
Invertebrates					
<i>Anodonta californiensis</i>	California floater	WDFW	IO	FC	SC
Fish					
<i>Acipenser transmontanus</i>	White sturgeon	StreamNet, BPA1			
<i>Acrocheilus alutaceus</i>	Chiselmouth	BPA2			
<i>Catostomus catostomus</i>	Longnose sucker	BPA1			
<i>Catostomus columbianus</i>	Bridgelip sucker	BPA1			
<i>Catostomus macrocheilus</i>	Largescale sucker	BPA1			
<i>Coregonus clupeaformis</i>	Lake whitefish	BPA1			
<i>Cottus</i> spp.	Sculpin	BPA3			
<i>Cyprinus carpio</i>	Carp	BPA1			
<i>Ictalurus natalis</i>	Yellow bullhead	BPA2			
<i>Ictalurus nebulosus</i>	Brown Bullhead	LRF			
<i>Ictalurus punctatus</i>	Channel Catfish	LRF			
<i>Lepomis gibbosus</i>	Pumpkinseed	BPA2			
<i>Lota lota</i>	Burbot	BPA1			
<i>Micropterus dolomieu</i>	Smallmouth bass	BPA1			
<i>Micropterus salmoides</i>	Largemouth bass	BPA1			
<i>Mylocheilus caurinus</i>	Peamouth	BPA1			
<i>Oncorhynchus clarki</i>	Cutthroat	BPA2			
<i>Oncorhynchus mykiss</i>	Rainbow trout	BPA1			
<i>Oncorhynchus nerka</i>	Kokanee (landlocked sockeye)	BPA1			
<i>Oncorhynchus tshawytscha</i>	Chinook salmon (Upper Columbia)	BPA2		FE	SC
<i>Perca flavescens</i>	Yellow perch	BPA1			
<i>Pomoxis nigromaculatus</i>	Black crappie	BPA1			
<i>Prosopium williamsoni</i>	Mountain whitefish	BPA1			
<i>Ptychocheilus oregonensis</i>	Northern pikeminnow	BPA1			
<i>Richardsonius balteatus</i>	Redside shiner	BPA2			
<i>Salmo trutta</i>	Brown trout	BPA1			
<i>Salvelinus confluentus</i>	Bull trout (Columbia Basin)	StreamNet, BPA2		FT	SC
<i>Salvelinus fontinalis</i>	Brook trout	BPA1			
<i>Sander vitreous</i>	Walleye	BPA1			
<i>Tinca tinca</i>	Tench	BPA1			

Sources:

BPA (Bonneville Power Administration) = Lee et al. (2006)

StreamNet = StreamNet (2006)

LRF (Lake Roosevelt Forum) = LRF (2006c)

WDFW (Washington Department of Fish and Wildlife) = WDFW (2006)

Notes: There are no proposed state status listings for aquatic species.**Occurrence source coding:**

BPA1 = fish species captured during 2004 monitoring (Table 29 of source document).

BPA2 = fish species captured during monitoring conducted prior to 2004 but not in 2004 (Table 92 of source document).

BPA3 = sculpins captured during 2004 monitoring (Table 29 of source document), but individuals not identified to specific species.

StreamNet = fish species distribution maintained by StreamNet (migration for white sturgeon; use unknown for bull trout).

WDFW = identified in WDFW's Priority Habitats and Species database within the preliminary analysis area.

WDFW Use Codes:

IO = individual occurrence

Federal Status Codes:

FC = federal candidate

FE = federal endangered

FT = federal threatened

State Status Codes:

SC = state candidate

Proposed State Status Codes:

PS = proposed sensitive

PT = proposed threatened

Table 4-1.
Reported Spills and Permit Limit Exceedances from the Trail Facility to the Columbia River

Year	Constituent	Spill Date	Quantity/Concentration	Permit Limit ^a	Location	Information Source(s) ^b	
1980	Hg	March 19	7000 kg/day	0.258 kg/day		3	
	NH ₃ HSO ₃	July 13	500 gallons			3	
	H ₂ SO ₄ (93%)	November 1	30 tonnes			3	
	P ₂ O ₅	November 4	24 tonnes			3	
1981	Zn	April 23	9500 kg/day	9070 kg/day		3	
	H ₂ SO ₄ (93%)	May 4	25-30 tonnes			3	
	NH ₃ HSO ₃	May 13	4000 gallons			3	
	H ₂ SO ₄ (93%)	August 4	53 tonnes			3	
	H ₂ SO ₄ (93%)	October 6	40 tonnes			3	
1987	H ₂ SO ₄ (50%)	September 2	15 tonnes			1	
1988	Zn solution (150 g/L)	November 25	5 tonnes (surface spill)			1	
1989	As	July 17	Unknown (surface spill)			1	
	Gypsum and H ₃ PO ₄	July 16	Unknown (surface spill)			1	
	Neutral thickener	May 1	60,000 L			1	
	Yellow substance	August 18	305 meters long			1	
1990	Hg	March 6	14 kg			1	
	Zn	September 4	Unknown (electrolyte)			1	
	Sulfuric acid (H ₂ SO ₄)	January 20	unknown (93%)			1	
		April 26	300-400 gal (93%)		Sewer 08	2	
		June 11	909 L			1	
		August 23	> 30 tonnes		Outfall III	2	
August 24	16,000 L			1			
1991	Cd	May 7	0.070 mg/L		Outfall III	2	
		May 7	0.090 mg/L		Outfall II	2	
		November 5	0.07 mg/L	0.05 mg/L		3	
	Hg	March 6	0.056 mg/L		Outfall 07	2	
		July 18	0.014 mg/L	0.01 mg/L		3	
	Pb	February 5	0.53 mg/L		Outfall II	2	
		March 6	1.80 mg/L		Outfall 07	2	
		March 6	0.56 mg/L		Outfall II	2	
		August 14	1.7 mg/L	1 mg/L		3	
	Zn	January 30	576 kg			1	
		February 11	4,546 L (sulfide residue)			1	
		April 21	220 L (solution 160 g/L)			1	
		September 17	8.5 mg/L	5 mg/L		3	
		October 1	8.2 mg/L	5 mg/L		3	
		November 5	5.8 mg/L	5 mg/L		3	
		December 3	7.3 mg/L	5 mg/L		3	
		December 7	881 L (electrolyte)			1	
	Copper Sulfate (CuSO ₄)	February 5	3,000 L			1	
		Sulfuric acid (H ₂ SO ₄)	March 16	4.54 tonnes			1
			April 13	1,000 L (15%)			1
April 13			Unknown (160 g/L)			1	
September 16			132 to 176 L			1	
Phosphoric acid (H ₃ PO ₄)		February 7	0.9 to 1.8 tonnes			1	
		April 2	15 tonnes			1	
		April 6	1.35 tonnes			1	
		June 15	2 tonnes (weak)			1	
		June 21	Unknown			1	
		June 24	2.72 to 3.63 tonnes (27%)			1	
Phosphates (PO ₄ ³⁻)		June 21	6.7 tonnes			1	
Total suspended solids (TSS)		December 20	1165.3 kg/day		Outfall III	2	
		January 16	157.0 mg/L		Outfall II	2	
		September 17	39 mg/L			3	
		October 1	12475 mg/L			3	
		November 5	10989 mg/L			3	
		December 3	18670 mg/L			3	
Flow		June 18	426600 m ³ /day		Outfall II	2	
Partially treated slag		August 24	50 tonnes (approximate)		Columbia River	2	
Zinc slurry/ pressure leach slurry	May 13	22.7 L			1		
	December 20	2,273 L			1		
NaHSO ₄	September 16	20 L/min, quantity unknown			1		
NH ₃ -N	May 13	90.9 L (ammonia)			1		
	August 14	45 mg/L			3		
	September 17	40 mg/L			3		
	November 5	40 mg/L			3		
Coal dust/ water	August 1	220 L			1		
Furnace oil	September 9	50 tonnes			1		
1992	Hg	June 24	6.8-10 kg/day	1.05 kg/day		3	

Table 4-1.
Reported Spills and Permit Limit Exceedances from the Trail Facility to the Columbia River

Year	Constituent	Spill Date	Quantity/Concentration	Permit Limit ^a	Location	Information Source(s) ^b	
		September 30	15 kg 60 kg/day	1.05 kg/day		1 3	
		October 1	60 kg/day	0.55 kg/day		3	
		December 2	0.014 mg/L 0.014 mg/L	0.005 mg/L	Outfall III	2 3	
		December 16	0.021 mg/L 0.21 mg/L	0.005 mg/L	Outfall III	2 3	
	Zn	April 20	25,000 L (electrolyte)			1	
		May 23	350 L (electrolyte) (surface spill) 214.1 kg/day	63.7 kg/day		1 3	
	H₂SO₄ (93%)	January 8	100-150 L			3	
		March 3	NA			3	
		March 7	1 gallon			3	
		March 19	20 gallons			3	
		April 14	30 gallons			3	
		April 18	100 gallons			3	
		August 4	5-10 gallons			3	
		November 3	434 kg 450 kg			1 3	
		December 16	25 to 30 tonnes 2.5 tonnes			1 3	
	H₂SO₄ (93.5%)	June 8	20 L			3	
	H₂SO₄ (98 %)	September 5	10-15 gallons			3	
	Sulfuric acid (H₂SO₄)	February 6	400 L			3	
		February 22	250 gallons			3	
		July 14	20 L			3	
		August 3	Unknown (surface spill)			1	
		October 2	20-50 gallons			3	
		December 4	10-15 gallons			3	
	H₃PO₄ (21 %)	May 25	5 tonnes			3	
		May 26	5 tonnes			1	
	H₃PO₄ (27%)	May 8	NA			3	
	Phosphoric acid (H₃PO₄)	March 1	NA			3	
		March 14	NA			3	
		April 20	NA			3	
		June 26	NA			3	
		July 10	1.5 tonnes			3	
		July 11	Unknown			1	
		August 10	1500 L			3	
		September 4	NA			3	
	Phosphates (PO₄³⁻)	March 11	Unknown			1	
		April 2	Unknown			1	
	NH₃SO₄	April 9	150 gallons			3	
	SO₃	May 15	40 gallons			3	
	Ammonium bisulphite (NH₄HSO₃)	June 4	15 gallons			3	
		September 14	30-40 gallons			3	
		December 20	15-20 gallons			3	
		December 22	400 L			3	
	Ammonium sulfate (NH₄SO₄)	December 8	12.3 tonnes 12 tonnes			1 3	
		December 11	12 tonnes			1	
	SO₄	October 2	50-100 gallons			3	
	Sulfide leach residue	April 22	Unknown (surface spill)			1	
	Return acid, calcine	July 1	20 gallons			3	
	ESSO Teresso 68 oil/ Compressor oil	July 23	25 L			1	
		July 28	25-30 L			3	
	Transformer oil Voltesso 35	December 17	200 L			3	
	1993	As	September 4	60 to 65 kg (dissolved)			1
			September 5	Unknown		Outfall III	2
			December 9	22 kg (dissolved)			1
		Hg	January 5	up to 7 kg			1
			January 6	0.13 mg/L	0.005 mg/L	Outfall III	2, 3
			January 8	0.013 mg/L	0.005 mg/L	Outfall III	2, 3
			January 12	0.014 mg/L	0.005 mg/L	Outfall III	2, 3
			April 25	0.028 mg/L	0.005 mg/L	Outfall III	2, 3
			May 1	0.012 mg/L	0.005 mg/L	Outfall III	2, 3
			June 4	0.018 mg/L	0.005 mg/L	Outfall III	2, 3
			June 10	18 kg 0.030 mg/L 0.3 mg/L	0.005 mg/L	Outfall III	1 2 3
			June 14	0.014 mg/L	0.005 mg/L	Outfall III	2, 3
			June 15	0.032 mg/L	0.005 mg/L	Outfall III	2, 3
			June 16	0.014 mg/L	0.005 mg/L	Outfall III	2, 3
			June 20	0.014 mg/L	0.005 mg/L	Outfall III	2, 3
			June 21	0.01 mg/L	0.005 mg/L	Outfall III	2, 3
			June 23	0.027 mg/L	0.005 mg/L	Outfall III	2, 3
			June 28	0.011 mg/L	0.005 mg/L	Outfall III	2, 3

Table 4-1.
Reported Spills and Permit Limit Exceedances from the Trail Facility to the Columbia River

Year	Constituent	Spill Date	Quantity/Concentration	Permit Limit ^a	Location	Information Source(s) ^b	
		July 6	0.011 mg/L	0.005 mg/L	Outfall III	2, 3	
		August 11	0.011 mg/L	0.005 mg/L	Outfall III	2, 3	
		August 21	0.023 mg/L	0.005 mg/L	Outfall III	2, 3	
		Cd oxide (CdO)	November 3	Unknown			1
		Zn sulfate (150 g/L)	January 7	600 kg			1
		Ammonia (NH₃)	March 14	Unknown			1
		Sulfuric Acid (H₂SO₄)	January 7	13,000 tonnes (50 g/L)			1
July 30	10 tonnes				1		
1994	As	February 9	20 kg 21 kg/day	NA		1 3	
		February 9	0.22 mg/L 0.02 mg/L; 2.1 kg/day	0.05 mg/L; 5.5 kg/day	Outfall III	2 3	
		March 7	0.18 mg/L		Outfall III	2	
		June 7	0.06 mg/L		Outfall III	2	
		October 17	Unknown		Outfall III	2	
		November	0.06 mg/L (once)		Outfall III	2	
		"1994"	0.10 tonnes		Outfall II	2	
	Cd	March 4	0.09 mg/L		Outfall II	2	
		1994	0.19 tonnes		Outfall II	2	
		1994	0.02 tonnes		Outfall I	2	
	Hg	February 10	1.3 kg			1	
		March 4	0.022 mg/L		Outfall II	2	
		July 4	< 1 kg < 1 kg/day	0.56 kg/day		1 3	
		August 14	0.014 mg/L	0.01 mg/L		3	
		October 2	0.006 mg/L		Outfall III	2	
		October 18	0.006 mg/L		Outfall III	2	
		October 20	0.006 mg/L		Outfall III	2	
		November	16 exceedances		Outfall III	2	
		December 18	0.011 (units NA)		Outfall III	2	
		December 19	0.009 (units NA)		Outfall III	2	
	December 21	0.011 (units NA)		Outfall III	2		
	Pb	March 4	1.50 mg/L		Outfall II	2	
	Chlorine	March 5	< 1 kg			1	
	Zn oxide (ZnO)	October 24	unknown			1	
	Ammonia (NH₃)	October 5	3,500 kg			1	
	Ammonium sulfate (NH₄SO₄)	June 1	2 m ³			1	
		June 13	Unknown			1	
	TSS	March 4	89.0 mg/L		Outfall II	Outfall II	2
		1994	5791 tonnes		Outfall I	Outfall I	2
	Flow rate	November	all samples exceedances		Outfall I	Outfall I	2
	1995	As	June 25	12.5 kg/day	11 kg/day		3
		Cd	February 27	NA	3.9 kg/day		3
			March 10	70 kg (dissolved) 102 kg/day 102 kg/day; 0.001 mg/L	60 kg/day, 0.05 mg/L	Outfall III	1 2 3
June 25			4.2 kg/day	4 kg/day		3	
Cu		June 25	11.5 kg/day	5.5 kg/day		3	
Hg		February 5	0.3375 kg/day 0.34 kg/day; 2.8 E-06 mg/L	0.15 kg/day; 0.005 mg/L	Outfall II	2 3	
		February 26	0.1804 kg/day 0.18 kg/day; 1.7 E-06 mg/L	0.55 kg/day; 0.005 mg/L	Outfall II	2 3	
		March 9	0.2350 kg/day 0.24 kg/day; 2.2 E-06 mg/L	0.55 kg/day; 0.005 mg/L	Outfall II	2 3	
		March 26	0.6768 kg/day 0.68 kg/day; 6.0 E-06 mg/L	0.55 kg/day; 0.005 mg/L	Outfall III	2 3	
		March 27	0.7659 kg/day 0.77 kg/day; 7.0 E-06 mg/L	0.55 kg/day; 0.005 mg/L	Outfall III	2 3	
		April 3	0.6957 kg/day 0.70 kg/day; 8.0 E-06 mg/L	0.55 kg/day; 0.005 mg/L	Outfall III	2 3	
		April 4	0.9636 kg/day 0.96 kg/day; 1.1 E-05 mg/L	0.55 kg/day; 0.005 mg/L	Outfall III	2 3	
		April 5	0.6624 kg/day	0.55 kg/day; 0.005 mg/L	Outfall III	2 3	
		May 5	0.3496 kg/day	0.55 kg/day; 0.005 mg/L	Outfall II	2	
		May 6	0.4440 kg/day 0.35 kg/day	0.55 kg/day; 0.005 mg/L	Outfall II	2 3	
		May 7	0.44 kg/day; 3.7 E-06 mg/L	0.15 kg/day; 0.005 mg/L		3	
		May 15	0.8280 kg/day 0.83 kg/day; 6.4 E-06 mg/L	0.55 kg/day; 0.005 mg/L	Outfall III	2 3	
		May 16	0.7688 kg/day 0.77 kg/day; 5.5 E-06 mg/L	0.55 kg d	Outfall III	2 3	
		May 22	1.0413 kg/day 1.04 kg/day; 7.0 E-06 mg/L	0.55 kg d	Outfall III	2 3	
		May 31	0.2330 kg/day 0.23 kg/day; 1.3 E-06 mg/L	0.55 kg d	Outfall II	2 3	
		Pb	June 25	63.8 kg/day	27.5 kg/day		3
Zn		June 13	960 kg 960 kg/day 960 kg/day; 0.005 mg/L	150 kg/day; 5 mg/L	Outfall III	1 2 3	
		June 13	1321 kg/day	550 kg/day		3	
		June 25	407.6 kg/day	150 kg/day		3	

Table 4-1.
Reported Spills and Permit Limit Exceedances from the Trail Facility to the Columbia River

Year	Constituent	Spill Date	Quantity/Concentration	Permit Limit ^a	Location	Information Source(s) ^b	
	H ₂ SO ₄	June 25	~1,000 L 3000-5000 L 3000-5000 L		Outfall III	1 2 3	
	Slag	December 7	75 tonnes			3	
	Coal dust (suspected)	May 22	Unknown			1	
1996	As	January 22	0.32 kg/day	0.1 kg/day	Pond/ cooling water ^{††}	2, 3	
		January 28	0.18 kg/day	0.1 kg/day	pond	2, 3	
		February 4	0.14 kg/day	0.1 kg/day	pond	2, 3	
	Cd	January 10	0.87 kg/day	0.5 kg/day	Cooling water	2, 3	
		January 22	0.14 kg/day, 0.82 kg/day	0.1 kg/day, 0.5 kg/day	Pond/ cooling water	2, 3	
		February 27	0.01 kg 3.75 kg/day 3.75 kg/day	2.75 kg/day	Outfall II	1 2 3	
	Hg	January 26	0.0115 kg/day	0.009 kg/day	Pond	2, 3	
		February 26	0.0199 kg/day	0.009 kg/day	Pond	2, 3	
	Pb	February 27	0.3 kg			1	
	Zn	January 17	40,000 L (& sulfuric acid) 2074 kg 2074 kg/day	150 kg/day		Outfall III	1 2 3
		January 22	39.66 kg/day	20 kg/day		Pond/ cooling water	2, 3
		February 9	31.52 kg/day	20 kg/day		Pond	2, 3
		February 21	16.2 kg/day	5 kg/day		Cooling water	2, 3
		February 21	25 kg/day	20 kg/day			3
		February 27	0.5 kg 35 kg/day	20 kg/day		Pond	1 2, 3
	TSS	January	6431 kg/day			Pond	2
		February	6375 kg/day			Pond	2
		February 15	3459 kg/day			Outfall III	2
		February 21	6987 kg/day			Cooling water	2
	Pb fume slurry	February 26	3 m ³			1	
	Slag/slurry	May 10	25 tonnes 35 tons (estimated) 35 tonnes			Columbia	1 2 3
		November 8	35 tonnes (barren) 35 tonnes			River (unknown)	1 2, 3
	Na ₂ CO ₃	February 27	3 m ³				1
NH ₃ -N	February 9	30 mg/L				3	
White solution & foam	April 7	Unknown				1	
White discoloration	May 23	Unknown				1	
White oxide dust	December 31	Unknown				1	
1997	Cd	March 13	3,000 kg (incl. Hg, dissolved) 40 kg 40 kg/day	3 kg/day	Outfall 07	1 2 3	
		March 25	22 kg 22 kg/day	3 kg/day		1 3	
		March 26	25 kg/day		Outfall III	2	
	Hg	March 13	3,000 kg (incl. Cd, dissolved) 8.9 kg 8.9 kg/day	0.55 kg/day	Outfall 07	1 2 3	
		December 12	Unknown		Outfall II	2	
		December 17	700 L (incl. Zn)			1	
	Pb	March 13	1450 kg 1450 kg/day	17.13 kg/day	Outfall 07	2 3	
	Zn	July 23	500 kg (as Zn slurry)		Outfall III	1, 2	
		December 17	700 L (incl. Hg)			1	
	TSS	March 13	3200 kg		Outfall 07	2	
	H ₂ SO ₄	May 20	Unknown (as acidic solution) 600 kg 600 kg/day		Outfall III	1 2 3	
July 23		4500 L		Outfall III	2		
1998	As	March 6	5 m ³ (in slurry) 23 kg/day	15 kg/day	Outfall III	1 2, 3	
		March 7	23 kg/day	15 kg/day		3	
		June 1	20 kg/day		Outfall II	2	
		June 2	20.36 kg (total As) 20.36 kg/day	15 kg/day		1 3	
		November 24	20 kg			1	
	Cd	May 3	15 kg (in solution) 15 kg/day 15 kg/day; 0.0002 mg/L	2.75 kg/day; 0.022 mg/L	Outfall II	1 2 3	
		December 25	3 kg 6.5 kg/day; 0.08 mg/L		Outfall III	1 2	
		December 26	4.5 kg/day 6.5 kg/day; 0.08 mg/L	3 kg/day; 0.03 mg/L	Outfall II	2 3	
	Cu	July 30	15 kg/day	8 kg/day	Outfall II	2, 3	
	Tl	July 21	129 kg/day	NA	Outfall III	2, 3	
		October 12	100 kg/day	NA	Unknown	2, 3	
	Zn	December 25	87 kg			1	
		December 26	177 kg/day; 2.2 mg/L	90 kg/day; 0.9 mg/L		3	
	Slag cooling water/slag, granulated slag	August 20	~25,000 L (slag, Pb, Zn, H ₂ O) Unknown 1.9 m ³			Outfall II	1 2 3
		October 24	15 min duration			Unknown	1, 2
Granulated slag/ Barren slag/	January 9	unknown 1-3 m ³			Unknown	2 3	

Table 4-1.
Reported Spills and Permit Limit Exceedances from the Trail Facility to the Columbia River

Year	Constituent	Spill Date	Quantity/Concentration	Permit Limit ^a	Location	Information Source(s) ^b	
	slurry	April 7	1 tonne 1-1.5 tonnes 1 tonnes		05 sewer	1 2 3	
1999	Cd	March 24	3.53 kg/day; 0.040 mg/L	3 kg/day; 0.03 mg/L	Outfall III	2, 3	
		March 25	4.01 kg/day; 0.045 mg/L	3 kg/day; 0.03 mg/L	Outfall III	2, 3	
		March 27	3.32 kg/day; 0.040 mg/L	3 kg/day; 0.03 mg/L	Outfall III	2, 3	
		September 22	6.04 kg/day; 0.073 mg/L	2.75 kg/day; 0.061 mg/L	Outfall II	2, 3	
		September 24	5.8 kg/day; 0.06 mg/L	3 kg/day; 0.03 mg/L		3	
		September 25	5.8 kg/day; 0.061 mg/L	3 kg/day; 0.03 mg/L	Outfall III	2	
		October 7	3.48 kg/day	2.75 kg/day	Outfall II	2, 3	
		October 11	2.86 kg/day	2.75 kg/day	Outfall II	2, 3	
	Ti	April 17	67.2 kg/day; 0.7 mg/L	NA		3	
		April 18	67.2 kg		Outfall III	2	
		April 18	196 kg 196 kg/day; 2.1 mg/L	NA	Outfall III	2 3	
		April 19	201 kg 201 kg/day; 2.1 mg/L	NA	Outfall III	2 3	
		April 20	136 kg 136 kg/day; 1.5 mg/L	NA	Outfall III	2 3	
		April 21	72.7 kg 72.7 kg/day; 0.8 mg/L	NA	Outfall III	2 3	
		April 22	56.0 kg 56 kg/day; 0.6 mg/L	NA	Outfall III	2 3	
		April 23	39.0 kg 39 kg/day; 0.4 mg/L	NA	Outfall III	2 3	
		Zn	October 4	165 kg/day; 1.90 mg/L 165 kg/day; 1.9 mg/L	75 kg/day; 1.4 mg/L	Outfall II	2 3
	October 7		106 kg/day	90 kg/day		3	
		Fume contaminated water	July 23	unknown		Columbia River	2
	2000	Cd	February 9	3.74 kg/day	2.75 kg/day	Outfall II	2, 3
February 18			10.5 kg 10.5 kg/day; 0.12 mg/L	2.75 kg/day; 0.06 mg/L	Outfall II	1 2, 3	
Ti		October 8	43 kg 43 kg/day		Outfall III		
		October 10	34 kg 34 kg/day		Outfall III		
		October 11	31 kg 31 kg/day		Outfall III		
Zn		February 18	350 kg 349 kg/day; 4.0 mg/L 350 kg/day; 4 mg/L	75 kg/day; 1.4 mg/L	Outfall II	1 2 3	
		March 31	693 µg/L	900 µg/L		3	
		April 4	1810 µg/L	900 µg/L		3	
			March 28	up to 1.9 tonnes 1.9 tonnes		Outfall IV	2 3
Flow rate		July 25	> 125,000 m ³ d ⁻¹		Outfall II	2	
		July 26	> 125,000 m ³ d ⁻¹		Outfall II	2	
		July 29	> 125,000 m ³ d ⁻¹		Outfall II	2	
		July 30	> 125,000 m ³ d ⁻¹		Outfall II	2	
		Low pH alarm	April 18	NA			3
2001	Hg	May 8	1.42 kg/day	0.55 kg/day		3	
	Zn	January 31	529.7 kg/day 529.7 kg/day; 6.6 mg/L	75 kg/day; 1.4 mg/L		2 3	
		November 26	Unknown	90 kg/day	Unknown	2, 3	
	Oil	May 27	10 L 22 L			1 3	
	LC50 bioassay	December 3	failed		Outfall II	2	
2002	Cd	October 21	5.4 kg/day		Outfall II	2	
	LC50 bioassay	February 19	failed		Outfall IV	2	
		June 19	failed		Outfall II	2	
pH	January 15	8.3		Outfall IV	2		
2003	Zn	January 8	99.5 kg/day	75 kg/day	Outfall II	2, 3	
2008	As, Zn, Pb, Cd	April 17	233 kg Zn 66 kg Pb 2.1 kg Cd 3.4 kg As	NA	Not listed	4	
	Pb, hydrofluoric acid	May 28	940 kg Pb	NA	Not listed	5	

^aPermit limit listed in Table E1-4, Draft Upper Columbia River RI/FS Work Plan (TCAI, 2007)

^bSources:

1 – USEPA, 2003. Based on Environment Canada Spilltracker Database, as provided in MacDonald 1997 and personal communication with Environment Canada staff.

2 – CCT, 2004. Based on Freedom of Information and Privacy Act (FOIPA) documents produced by the Canadian Government to CCT.

3 – TCAI, 2007. Based on facility information provided by TCAI and records maintained by the B.C. Ministry of the Environment.

4 - National Response Center report

5 - Environment Canada notice

As – arsenic mg/L – milligrams per liter

Cd – cadmium µg/L – micrograms per liter

Cu – copper kg – kilograms

Hg – mercury kg/day – kilograms per day

Pb – lead L – liter

Ti – titanium m³ - cubic meter

TSS – total suspended solids m³/day – cubic meters per day

Zn – zinc tonne - 1,000 kilograms (also known as a short ton)

Table 4-2. Summary of Permits Issued to the Trail Facility by the B.C. Government Authorizing Onsite Activities and/or Discharges

Permit No.	Applicable Facility Operations	General Description
Air		
PA-02691	Lead Operations	Governs atmospheric emissions from the smelter furnaces and the lead refinery.
PA-02692	Zinc Operations	Governs atmospheric emissions from roasters, acid plants leaching circuit, and electrolytic/melting plants.
PA-02690	Fertilizer Operations	Governs atmospheric emissions from fertilizer operations and other operations located in the Warfield Complex.
Water		
PE-02753	Metallurgical Liquid Effluents	Governs effluent discharges from all on-site operations through Metallurgical Plant Combined Outfalls II, III, and IV.
PE-02407 License No. 11790	Waneta Dam Effluent Water Rights	Governs and permits discharge from a septic system into septic tile fields. License to divert water from the Columbia River to Trail Operations (industrial and domestic uses).
Material Management Permits		
PR-11898	Slag Disposal	Permit to store barren slag at the Duncan Flats storage site. Although this permit is active, the storage facility has never been established given that ferrous granules are now sold to the cement industry.
PS-08310	Arsenic Storage	Permit to store arsenic containing materials at Duncan Flats. All wastes are contained in a lined facility (top and bottom), equipped with water collection system.
PS-11532	Thallium and Calomel Storage	Permit to operate an indoor storage facility for mercury and thallium containing materials resulting from on-site metallurgical operations.
AS-16033	Tellurium	Approval to discharge tellurium containing slag from the lead refinery but is now classified as a product (i.e., ferrous granules) and is sold to the cement industry. Therefore no longer applicable.
Landfill Permits		
PR-05175	Warfield Landfill	Permit to operate a non-hazardous waste landfill situated adjacent to the Warfield Operations.
PR-03423	Haley Gully	Permit to operate a non-hazardous waste landfill situated adjacent to the Warfield Operations. This landfill is no longer in use.
Hazardous and Special Waste Management		
PS-08672	Waste Solvent Storage	Permit to operate a waste solvent facility for the collection and safe temporary storage of such materials generated in the Tadanac/Warfield Operations. All materials are appropriately disposed off-site at licensed facilities as required.
PS-08443	Polychlorinated Biphenyl Storage	Permit to operate a storage facility for the temporary storage of PCB-containing materials (e.g., transformers) being phased out of all on-site operations.

Table 4-3. Summary of TRI Facilities and Associated Chemicals in the Vicinity of the Study Area

WRIA	Facility	Facility Reporting Years ^a	County	Reported compounds	Onsite Releases			Other/Offsite Disposal
					Air ^b	Land ^c	Water ^d	
ADDY	NORTHWEST ALLOYS INC	1996-2003	STEVENS	LEAD	x	x		x
				AMMONIA	x	x		x
				COPPER	x			x
				HYDROCHLORIC ACID (1995 AND AFTER "ACID AEROSOLS" ONLY)	x			
ALMIRA	LINCOLN MUTUAL SERVICE INC # 1	1999-2005	LINCOLN	1,2,4-TRIMETHYLBENZENE				
				BENZENE				
				ETHYLBENZENE				
				TOLUENE				
				XYLENE (MIXED ISOMERS)				
COLVILLE	ALADDIN HEARTH PRODS.	1996-1999	STEVENS	CHROMIUM	x			
				COPPER	x			
				LEAD	x			
				MANGANESE	x			
				NICKEL	x			
				TOLUENE	x			x
				ZINC COMPOUNDS	x			
COLVILLE	HEARTH & HOME TECHNOLOGIES	2000-2004	STEVENS	NICKEL	x			x
				CHROMIUM	x			x
COLVILLE	STIMSON LUMBER CO ARDEN OPERATION	2001-2005	STEVENS	LEAD COMPOUNDS	x	x		x
CURLEW	ECHO BAY INC. K2 MINE	2000-2005	FERRY	MERCURY COMPOUNDS		x		
INCHELIUM	INCHELIUM TRIBAL WOOD TREATMENT	1996-1997, 2000-2001	FERRY	LEAD COMPOUNDS	x	x		x
				ARSENIC COMPOUNDS	x			x
				CHROMIUM COMPOUNDS	x			x
				COPPER COMPOUNDS	x			x
				CHROMIUM COMPOUNDS(EXCEPT CHROMITE ORE MINED IN THE TRANSVAAL REGION)				
				DIOXIN AND DIOXIN-LIKE COMPOUNDS	x			x
KETTLE FALLS	BOISE CASCADE LLC KETTLE FALLS PLYWOOD MILL	1998-2005	STEVENS	LEAD	x			x
				METHANOL	x			
				LEAD	x			x
KETTLE FALLS	BOISE CASCADE LLC KETTLE FALLS LUMBER	2001-2005	STEVENS	DIOXIN AND DIOXIN-LIKE COMPOUNDS	x			x
				LEAD COMPOUNDS	x			x
				LEAD	x			
REPUBLIC	KETTLE RIVER OPERATIONS MILL	1998-2005	FERRY	COPPER COMPOUNDS	x	x		
				CYANIDE COMPOUNDS		x		x
				NITRATE COMPOUNDS	x	x		
				AMMONIA	x	x		
				LEAD COMPOUNDS	x	x		
				MANGANESE	x	x		x
				NITRIC ACID	x			

Table 4-3. Summary of TRI Facilities and Associated Chemicals in the Vicinity of the Study Area

WRIA	Facility	Facility Reporting Years ^a	County	Reported compounds	Onsite Releases			Other/Offsite Disposal
					Air ^b	Land ^c	Water ^d	
REPUBLIC	LAMEFOOT MINE	1998, 2000-200	FERRY	NITRATE COMPOUNDS	x	x		x
				MERCURY COMPOUNDS	x	x		
				LEAD COMPOUNDS		x		

Notes: x = release reported
blank cell = reported value of zero or not reported
The table includes summary listing of all sites in Ferry, Lincoln, and Stevens Counties (1996-2005).
WRIA = Watershed Resources Inventory Areas; definition of these areas is available from Ecology (<http://www.ecy.wa.gov/apps/watersheds/wriapages/>).

^aThe information provided is a summary of the reporting period; releases indicated may not have occurred in all reporting years.

^bAir releases are any release from a smoke stack, fugitive emissions, or from a non-point source at a facility. Releases of this type are measured in pounds.

^cLand releases are any spill on the facility grounds that are not directly connected to a sewer by an impermeable surface, any intentional release applied as a treatment or farm chemical, any surface impoundments, or any on-site landfills.

^dWater releases include releases to streams, either as direct discharge or as a percentage of storm runoff.

Table 4-4. Current Non-municipal General Permit Facilities That Discharge to WRIs in UCR Drainage Basin⁸

WRIA	Facility Type	Facility	City	County	Permit	Issue Date	Expiration Date
COLVILLE	Industrial	CHEWELAH BASIN SKI CORPORATION	Chewelah	Stevens	ST0008046C	19-May-04	18-May-09
COLVILLE	Industrial	EQUINOX RESOURCES INC	Colville	Stevens	ST0005287B	11-Dec-98	30-Jun-03
COLVILLE	Industrial	STIMSON LUMBER COMPANY	Colville	Stevens	WA0045527B	3-Dec-03	30-Jun-08
COLVILLE	Industrial	VAAGEN BROS LUMBER INC	Colville	Stevens	ST0008093A	24-Mar-05	23-Mar-10
COLVILLE	Sand And Gravel	B & W EXCAVATING AND CONSTRUCTION	Valley	Stevens	WAG500091A	25-Jun-07	24-Jun-12
COLVILLE	Sand And Gravel	CHEWELAH ASPHALT COMPANY	Chewelah	Stevens	WAG507153B	5-Jan-05	4-Feb-10
COLVILLE	Sand And Gravel	COLVILLE VALLEY CONCRETE 3RD STREET	Colville	Stevens	WAG507015C	5-Jan-05	4-Feb-10
COLVILLE	Sand And Gravel	COLVILLE VALLEY CONCRETE HAWKINS	Colville	Stevens	WAG507139B	5-Jan-05	4-Feb-10
COLVILLE	Sand And Gravel	DAWSON TRUCKING INC	Valley	Stevens	WAG507131B	5-Jan-05	4-Feb-10
COLVILLE	Sand And Gravel	INLAND NORTHWEST COMPANY	Springdale	Stevens	WAG507141B	5-Jan-05	4-Feb-10
COLVILLE	Sand And Gravel	KNIFE RIVER	Colville	Stevens	WAG507047C	5-Jan-05	4-Feb-10
COLVILLE	Sand And Gravel	LANE MT. SILICA COMPANY	Valley	Stevens	WAG507006C	5-Jan-05	4-Feb-10
COLVILLE	Sand And Gravel	LOON LAKE SAND & GRAVEL	Loon Lake	Stevens	WAG507085C	5-Jan-05	4-Feb-10
COLVILLE	Sand And Gravel	PUGH BROTHERS CONSTRUCTION, INC.	Colville	Stevens	WAG500081A	5-Jan-05	4-Feb-10
COLVILLE	Sand And Gravel	WA DOT SP-W-6458 MILL CREEK	Colville	Stevens	WAG507099C	5-Jan-05	4-Feb-10
COLVILLE	Stormwater Industrial	COLMAC COIL MFG INC	Colville	Stevens	SO3000036D	21-Aug-02	20-Sep-07
COLVILLE	Stormwater Industrial	COLMAC INDUSTRIES INC	Colville	Stevens	SO3000037D	21-Aug-02	20-Sep-07
COLVILLE	Stormwater Industrial	UNITED PARCEL SERVICE COLVILLE	Colville	Stevens	SO3003251C	21-Aug-02	20-Sep-07
COLVILLE	Stormwater Industrial	VAAGEN BROS LUMBER INC COLVILLE	Colville	Stevens	SO3002389D	21-Aug-02	20-Sep-07
COLVILLE	Stormwater Industrial	WASTE MGMT OLSONS HAULING CO	Addy	Stevens	SO3003989C	21-Aug-02	20-Sep-07
KETTLE	Sand And Gravel	BUCKHORN MTN BORROW SITE	Curlew	Ferry	WAG507172A	5-Jan-05	4-Feb-10
KETTLE	Sand And Gravel	STOTTS CONSTRUCTION INC	Curlew	Ferry	WAG507010C	5-Jan-05	4-Feb-10
KETTLE	Sand And Gravel	WA DOT PS-FY-63 CURLEW PIT	Curlew	Ferry	WAG507154B	5-Jan-05	4-Feb-10
KETTLE	Stormwater Construction	BUCKHORN MOUNTAIN BORROW AREA	Curlew	Ferry	WAR007756A	16-Nov-05	16-Dec-10
LAKE ROOSEVELT (LOWER)	Sand And Gravel	LINCOLN COUNTY DEPT OF PUBLIC WORKS	Davenport	Lincoln	WAG500017B	5-Jan-05	4-Feb-10
LAKE ROOSEVELT (LOWER)	Sand And Gravel	S AND W ROCK PRODUCTS	Davenport	Lincoln	WAG500056A	25-Jun-99	6-Aug-04
LAKE ROOSEVELT (UPPER)	Industrial	AVISTA CORP KETTLE FALLS GENERATING	Kettle Falls	Stevens	WA0045217C	18-Nov-02	30-Nov-08
LAKE ROOSEVELT (UPPER)	Industrial	BOISE CASCADE KF PLYWOOD MILL	Kettle Falls	Stevens	ST0005262D	1-Jul-03	30-Jun-08
LAKE ROOSEVELT (UPPER)	Industrial	BOISE CASCADE KF SAWMILL	Kettle Falls	Stevens	ST0008007D	24-Mar-05	23-Mar-10
LAKE ROOSEVELT (UPPER)	Sand And Gravel	WA DOT PS-FY-91 TROUT CREEK	Kettle Falls	Stevens	WAG507113C	5-Jan-05	4-Feb-10
LAKE ROOSEVELT (UPPER)	Sand And Gravel	WA DOT QS-W-157 MINGO MT QUARRY	Kettle Falls	Stevens	WAG507169A	5-Jan-05	5-Feb-10
LAKE ROOSEVELT (UPPER)	Stormwater Industrial	KETTLE FALLS LUMBER	Kettle Falls	Stevens	SO3000188D	21-Aug-02	20-Sep-07
SANPOIL	Industrial	HECLA MINING CO	Republic	Ferry	ST0005270D	31-Aug-00	31-Aug-05
SANPOIL	Industrial	KINROSS GOLD CORPORATION	Republic	Ferry	ST0008033C	30-Jun-04	31-Jul-09
SANPOIL	Sand And Gravel	ALPINE CONCRETE - TORBOY PIT	Republic	Ferry	WAG507075C	5-Jan-05	4-Feb-10
SANPOIL	Sand And Gravel	ALPINE CONCRETE & EXCAVATION INC	Republic	Ferry	WAG507059C	5-Jan-05	4-Feb-10
SANPOIL	Sand And Gravel	FERRY COUNTY PUBLIC WORKS	Republic	Ferry	WAG500080A	5-Jan-05	4-Feb-10
SANPOIL	Sand And Gravel	GIDDINGS PIT (NORTH)	Republic	Ferry	WAG507106C	5-Jan-05	4-Feb-10
SANPOIL	Sand And Gravel	KINROSS GOLD CORPORATION PIT	Republic	Ferry	WAG507086C	5-Jan-05	4-Feb-10
SANPOIL	Stormwater Construction	HECLA FILL PROJECT	Republic	Ferry	WAR007461A	16-Nov-05	16-Dec-10
SANPOIL	Stormwater Industrial	HECLA MINING COMPANY REPUBLIC	Republic	Ferry	SO3001539D	21-Aug-02	20-Sep-07
SANPOIL	Stormwater Industrial	KETTLE RIVER JOINT VENTURE	Republic	Ferry	SO3001184D	21-Aug-02	20-Sep-07
SPOKANE (LOWER)	Fish	FORD HATCHERY	Ford	Stevens	WAG137012D	22-Apr-05	1-Jun-10
SPOKANE (LOWER)	Industrial	DAWN MINING COMPANY	Ford	Stevens	ST0005230D	7-Jan-03	30-Jun-07
SPOKANE (LOWER)	Sand And Gravel	ALLIED MINERALS	Springdale	Stevens	WAG507134B	5-Jan-05	4-Feb-10
SPOKANE (LOWER)	Sand And Gravel	CONTINENTAL EXCAVATORS ALLISON PIT	Tumtum	Stevens	WAG507088C	5-Jan-05	4-Feb-10

Notes:

The Sand and Gravel general permit provides coverage for discharges of process water, stormwater, and mine dewatering water associated with sand and gravel operations, rock quarries, and similar mining operations, including stockpiles of mined materials (Ecology 2005).

Industrial stormwater general permits cover a variety of industry types; monitoring requirements vary by industry (Ecology 2007).

WRIA = Watershed Resources Inventory Areas; definition of these areas is available from Ecology (<http://www.ecy.wa.gov/apps/watersheds/wriapages/>).

⁸ Only facilities in Stevens, Ferry, and Lincoln Counties are shown. Data accessed July 27, 2007 from Ecology's Water Quality Permit Life Cycle System (WPLCS), available at <http://www.ecy.wa.gov/programs/wq/permits/wplcs/index.html#WPLCS>.

Table 4-5. Ecology Municipal General Permit Facilities That Discharge to WRIAs in UCR Drainage Basin ^a

WRIA	Facility	City	County	Permit #	Issue Date	Expiration Date
COLVILLE	ADDY/BLUE CREEK SEWER SYSTEM	Addy	Stevens	ST0008084A	6-May-02	5-May-07
COLVILLE	CHEWELAH WWTP	Chewelah	Stevens	WA0023604C	4-Apr-06	30-Apr-11
COLVILLE	COLVILLE STP	Colville	Stevens	WA0022616B	29-Jun-01	30-Jun-06
COLVILLE	LOON LAKE SEWER DIST #4	Loon Lake	Stevens	ST0008019D	31-Oct-05	30-Oct-10
COLVILLE	SPRINGDALE WWTP	Springdale	Stevens	ST0005385D	30-Sep-02	29-Sep-07
COLVILLE	WAITTS LAKE SEWER SYSTEM	Valley	Stevens	ST0008056C	12-May-03	11-May-08
KETTLE	CURLEW JOBS CORP CENTER	Curlew	Ferry	ST0005396B	18-Sep-02	17-Sep-07
LAKE ROOSEVELT (LOWER)	DAVENPORT STP	Davenport	Lincoln	WA0045578A	11-Jan-06	31-Jan-11
LAKE ROOSEVELT (LOWER)	SEVEN BAYS ESTATES UNLIMITED	Davenport	Lincoln	ST0005373E	17-May-04	16-May-09
SANPOIL	REPUBLIC STP	Republic	Ferry	ST0008020D	27-Sep-06	30-Oct-11
LAKE ROOSEVELT (UPPER)	KETTLE FALLS STP	Kettle Falls	Stevens	ST0005297D	25-May-06	31-May-11

Notes:

Information in the table above was downloaded from the Ecology Water Quality Permit Life Cycle System (WPLCS) database, available at: <http://www.ecy.wa.gov/programs/wq/permits/wplcs/index.html#WPLCS>. Data accessed July 27, 2007.

^aOnly facilities in Stevens, Ferry, and Lincoln Counties are included in this table.

STP = Sewage Treatment Plant.

WWTP = Wastewater Treatment Plant.

WRIA = Watershed Resources Inventory Areas; definition of these areas is available from Ecology (<http://www.ecy.wa.gov/apps/watersheds/wriapages/>).

Table 5-1. Combined Summary Statistics for Conventional Parameters Analyzed at Four Upper Columbia River Stations and Four Columbia River Tributary Stations

Parameter	Minimum	Average	Maximum	Median	SD	Date Range
Alkalinity (mg/L as CaCO ₃)	0.1	55.1	185.0	56	15.8	1962-2006
Calcium, dissolved (mg/L)	<0.1	19.2	260.0	19	7.6	1951-2006
Chloride, total (mg/L)	<0.1	2.1	17.7	1.8	1.9	1959-1999
Dissolved organic carbon (mg/L)	0.9	1.7	10.0	1.4	1.5	1978-2000
Hardness (mg/L)	0.1	65.2	130.0	66	13	1951-2006
Magnesium, dissolved (mg/L)	<0.1	4.5	20.9	4.2	2.2	1951-2006
pH Total (s.u.)	5.2	-- ^a	9.1	7.8	--	1951-2006
Sodium, dissolved (mg/L)	<0.1	2.0	44.6	1.5	2.3	1959-2002

Notes:

^a Not applicable, pH is an intensive parameter that is reported in log units and cannot be averaged.

SD = standard deviation

Table 5-2. Summary Statistics for Selected Surface Water Conventional Parameters Sampled Between 2000 to Present at the Birchbank, Waneta, and Northport Stations

Summary Statistic	Alkalinity (mg/L as CaCO ₃)			Hardness (mg/L as CaCO ₃)		
	Birchbank	Waneta	Northport	Birchbank	Waneta	Northport
Average	51.2	52.7	ND	59.5	61.5	66.5
Standard deviation	16.2	13.2	ND	18.4	14.8	4.7
Coefficient of variation	32%	25%	ND	31%	24%	7%
Maximum	66.4	66.5	ND	75	77	77.3
Minimum	0.1	0.1	ND	0.13	0.23	58.3
Count	207	348	0	194	324	35

Summary Statistic	Dissolved Calcium (mg/L)			Dissolved Magnesium (mg/L)		
	Birchbank	Waneta	Northport	Birchbank	Waneta	Northport
Average	17.6	18.1	18.3	3.9	4.1	4.3
Standard deviation	5.0	4.0	1.1	1.1	0.9	0.3
Coefficient of variation	28%	22%	6%	28%	22%	8%
Maximum	22.1	22.7	19.8	5.1	5.1	4.71
Minimum	0.02	0.01	16.9	0.02	0.05	3.85
Count	203	343	7	203	343	7

Summary Statistic	pH (s.u.)			Dissolved Organic Carbon (mg/L)		
	Birchbank	Waneta	Northport	Birchbank	Waneta	Northport
Average	7.6	7.6	8.1	ND	ND	1.3
Standard deviation	0.6	0.5	0.3	ND	ND	0.2
Coefficient of variation	8%	7%	3%	ND	ND	14%
Maximum	8.1	8.13	8.65	ND	ND	1.6
Minimum	5.2	5.2	7.4	ND	ND	1.1
Count	205	344	136	0	0	7

Source: Data from USGS (2003b), Ecology (2003), and Environmental Canada (2006).

Table 5-3. Summary of Surface Water Metals Data

Water Body	Sample Location	Date(s)	Reference
Upstream of Upper Columbia River (North of Border)			
Columbia River	Birchbank	1983-2006	Env. Canada
	Waneta	1979-2005	Env. Canada
Pend Oreille River	International Boundary	1997-2004	Env. Canada
	Waneta	1979-2007	Env. Canada
Upper Columbia River			
Columbia River	Northport (RM 735)	1951-2005	EIM, NWIS
	Little Dalles (RM 728)	1989	(Johnson 1991b)
	Castle Rock (RM 645)	1989	(Johnson 1991b)
	At Marcus Island (RM 708)	1986	(Johnson et al. 1988)
	At Gifford (RM 677)	1986	(Johnson et al. 1988)
	At Seven Bays (RM 634)	1986	(Johnson et al. 1988)
	Mid-lake (surface)	1980	STORET
	Mid-lake (50 ft)	1980	STORET
	French Point Rocks	1989	(Johnson 1991b)
	Swawilla Basin	1989	(Johnson 1991b)
Downstream of Upper Columbia River (Below Grand Coulee Dam)			
Columbia River	Below Grand Coulee Dam (RM 596)	1986	(Johnson et al. 1988)
Tributaries to Upper Columbia River			
Alder Creek	Hwy. 25 Bridge	1986	(Johnson et al. 1988)
Big Sheep Creek	Mouth	1986	(Johnson et al. 1988)
Cleveland Mine	Unknown	1999	EIM
Colville River	At Hwy. 25 Bridge	1986	(Johnson et al. 1988)
	At RM 5.0	1986	(Johnson et al. 1988)
Deep Creek	At mouth	1986	(Johnson et al. 1988)
	South Fork	2001	(USEPA 2002)
Deep Creek Tributary	Tributary	2001	(USEPA 2002)
Flume Creek	South Fork	2001	(USEPA 2002)
	Sullivan Mine	2001	(USEPA 2002)
Hall Creek	At mouth	1986	(Johnson et al. 1988)
Hunters Creek	Lake Roosevelt	1986	(Johnson et al. 1988)
Kettle River	At Hedlund Bridge	1986	(Johnson et al. 1988)
	1.3 mi above Barstow	1986	(Johnson et al. 1988)
	Near Barstow	1971-2005	EIM
Onion Creek	Near Northport	1990-95	EIM
	At mouth	1986	(Johnson et al. 1988)
Sanpoil River	At mouth	1986	(EIM; Johnson et al. 1988)
	13 mi south of Republic	1990-95	EIM
	Arm	1989	(EIM; Johnson 1991)
Spokane River	At Long Lake Dam	1986	(Johnson et al. 1988)
	Arm	1989	(Johnson 1991b)
	USGS at Long Lake	1998-99	NWIS
Tom Bush Creek Tributary	Unknown	2001	(USEPA 2002)
Unnamed tributary to Hunter's Creek	Unknown	2001	(USEPA 2002)
Unnamed tributary to Onion Creek	Unknown	2001	(USEPA 2002)

Notes: RM = River mileEIM = Ecology Environmental Information Management System (www.ecy.wa.gov/EIM)Env. Canada = Environment Canada Water Quality Database (<http://waterquality.ec.gc.ca/waterqualityweb/searchtext.aspx>)NWIS = National Water Information System (<http://nwis.waterdata.usgs.gov/wa/nwis/>)STORET = USEPA Storage and Retrieval Database (<http://www.epa.gov/storet/index.html>)

Columbia River data for Waneta and Birchbank are maintained by Environmental Canada, while the majority of the data for Washington State sampling locations are maintained by the USGS and Ecology.

Table 5-4. Cross-Sectional Distributions of Grain-Size Parameters, TOC, and Metals in Surface Sediments Collected from the UCR in 2005

River Mile ^a	Station Location on Transect	Grain-Size Parameters and TOC (percent)				
		Sand	Silt	Clay	Colloids	TOC
RM 706						
	Left Bank	22.6	62.7	9.3	5.4	1.2
	Left Channel	55.0	41.4	3.6	0	1.1
	Left Channel	78.9	17.6	0.4	3.1	0.1
	Mid-Channel	95.4	4.5	0.1	0	0.3
	Right Channel	31.8	58.0	6.8	3.4	2.2
	Right Channel	34.6	54.6	7.8	2.6	3.3
	Right Bank	35.2	52.2	7.1	5.2	2.9
RM 678						
	Left Bank	77.0	20.6	0.9	0.7	0.1
	Left Channel	0.9	38.5	40.7	19.8	1.6
	Left Channel	1.4	48.0	35.3	14.7	1.6
	Mid-Channel	0.6	51.7	33.8	13.9	2.0
	Right Channel	1.4	56.2	29.6	12.8	1.7
	Right Channel	20.8	68.1	8.7	2.4	0.5
	Right Bank	62.2	36.0	0.9	0	0.1
RM 642						
	Left Bank	49.8	39.2	7.0	4.0	0.7
	Left Channel	3.0	48.1	27.9	20.2	1.2
	Left Channel	0.4	38.8	35.9	24.9	1.1
	Mid-Channel	1.0	49.4	27.7	21.7	1.0
	Right Channel	0.8	53.5	26.7	18.8	0.9
	Right Channel	2.6	48.7	26.3	22.4	1.0
	Right Bank	80.8	11.4	0.4	0.2	0.2
RM 637						
	Left Bank	82.6	2.6	0.04	<0.1	0.1
	Left Channel	3.2	35.8	30.0	31.0	1.3
	Left Channel	0.6	33.8	37.8	27.8	1.2
	Mid-Channel	12.8	51.0	22.7	13.5	0.8
	Right Channel	88.1	11.2	0.4	0.2	0.2
	Right Channel	74.9	22.3	1.5	1.3	0.3
	Right Bank	86.9	12.2	0.4	0.5	0.1
RM 605						
	Left Bank	78.3	2.2	0.02	<0.1	0.1
	Left Channel	0.6	24.8	39.7	34.7	1.6
	Left Channel	0.6	22.9	37.8	38.8	1.6
	Left Channel	0.4	21.9	38.8	38.8	1.6
	Mid-Channel	0.3	23.4	39.3	36.8	1.8
	Right Channel	0.8	28.8	38.7	31.7	1.8
	Right Channel	92.6	5.4	0.1	0.1	0.1
	Right Channel	70.4	26.0	1.8	1.8	0.4
	Right Bank	95.6	4.3	0.04	0.1	0.1

Table 5-4. (continued)

River Mile ^a	Station Location on Transect	Metals (mg/kg dry weight) ^b					
		Iron	Zinc	Copper	Cadmium	Mercury	Lead
RM 706							
	Left Bank	18,800	764	78.8	3.8	0.66	197
	Left Channel	29,400	1,120	151	3.6	0.37	188
	Left Channel	19,000	590	53.1	1.6	0.13	77.3
	Mid-Channel	111,000	10,300	819	1.2	0.05	412
	Right Channel	24,400	173	37.8	1.0	0.09	38.5
	Right Channel	21,900	160	34.0	1.0	0.08	31.1
	Right Bank	19,500	97.5	26.2	0.4	0.04	14.7
RM 678							
	Left Bank	13,500	58.7	11.8	0.3	0.01	9.7
	Left Channel	41,300	855	117	7.3	1.9	362
	Left Channel	31,700	873	96.6	8.0	2.4	379
	Mid-Channel	36,300	742	152	5.7	0.9	310
	Right Channel	33,300	663	128	4.9	1.4	274
	Right Channel	18,800	127	25.0	0.7	0.09	28.0
	Right Bank	13,100	36.9	11.6	0.1	0.06	4.6 U
RM 642							
	Left Bank	16,900	292	19.9	2.1	0.2	82.4
	Left Channel	31,200	669	51.6	4.7	0.8	214
	Left Channel	40,900	563	97.5	4.8	1.2	208
	Mid-Channel	35,100	640	77.2	7.3	1.3	254
	Right Channel	38,300	1,040	74.0	9.4	1.8	363
	Right Channel	28,100	404	52.6	3.5	1.0	148
	Right Bank	19,700	43.0	10.8	0.3	0.07	7.9 U
RM 637							
	Left Bank	12,400	30.9	3.5 U	0.3 U	0.01	5.7
	Left Channel	30,600	762	49.6	7.2	1.0	190
	Left Channel	40,700	798	75.2	7.9	1.0	243
	Mid-Channel	24,200	560	39.8	5.9	0.7	146
	Right Channel	12,600	73.5	10.1	0.4	0.04	17.0
	Right Channel	15,700	165	12.2	0.6	0.02	24.7
	Right Bank	16,400	46.6	14.2	0.04 U	0.01	8.3
RM 605							
	Left Bank	9,830	27.9	3.0 U	0.3 U	0.01	3.9
	Left Channel	34,500	628	70.9	4.4	0.8	168
	Left Channel	41,300	920	86.1	7.1	1.2	249
	Left Channel	33,700	874	69.2	7.8	1.2	242
	Mid-Channel	30,000	608	68.2	5.5	0.8	155
	Right Channel	31,800	633	68.0	4.8	0.8	150
	Right Channel	15,000	72.8	6.8	0.3	0.07	10.4 U
	Right Channel	17,800	140	11.5	0.7	0.08	16.8
	Right Bank	16,700	45.8	9.7	0.3 U	0.06	7.5 U

Table 5-4. (continued)

River Mile ^a	Metalloids (mg/kg dry weight) ^b					
	Antimony	Arsenic	Chromium	Manganese	Nickel	Uranium
RM 706						
Left Bank	1.9 U	4.5	21.3	317	15.5	115.0
Left Channel	4.8	10.0	25.2	418	18.2	13.6 U
Left Channel	2.9	6.2	16.7	267	12.6	13.1 U
Mid-Channel	13.6	21.3	44.0	2,260	9.2	10.2 U
Right Channel	2.6	4.5	29.9	357	22.0	17.6 U
Right Channel	2.2	3.9	28.0	307	20.0	23.9 U
Right Bank	7.0 U	1.4	24.9	276	15.9	23.4 U
RM 678						
Left Bank	0.4	1.6	16.9	268	13.9	12.6 U
Left Channel	4.6	20.2	52.8	1,150	38.0	24.6 U
Left Channel	4.2	11.9	44.2	721	32.2	9.2 U
Mid-Channel	6.4	11.0	50.8	655	34.8	11.3 U
Right Channel	4.2	12.2	45.9	820	31.3	26.2 U
Right Channel	2.0	3.9	22.8	469	19.3	16.2 U
Right Bank	rd	2.3	15.5	258	12.6	10.8 U
RM 642						
Left Bank	rd	4.1	17.9	314	14.8	12.2 U
Left Channel	rd	7.8	38.2	758	32.3	14.0 U
Left Channel	rd	10.0	54.7	1,000	43.2	21.7 U
Mid-Channel	rd	13.0	50.0	1,060	38.6	18.2 U
Right Channel	rd	12.8	53.0	779	40.2	20.3 U
Right Channel	rd	6.8	33.6	857	27.2	26.3 U
Right Bank	rd	6.2	13.7	222	9.8	10.4 U
RM 637						
Left Bank	rd	3.9	8.3	214	6.4	11.7 U
Left Channel	7.6 U	11.0	36.4	712	27.7	25.2 U
Left Channel	9.3 U	13.7	48.4	956	37.8	31.0 U
Mid-Channel	rd	10.2	30.2	565	24.9	18.4 U
Right Channel	rd	2.9	13.2	336	11.8	12.1 U
Right Channel	rd	3.7	16.3	392	14.8	10.0 U
Right Bank	rd	4.5	17.6	285	16.5	9.6 U
RM 605						
Left Bank	rd	1.5 U	6.4	138	5.7	12.4 U
Left Channel	rd	9.0	35.4	1,140	28.7	31.5 U
Left Channel	rd	11.7	45.7	1,680	35.9	38.7 U
Left Channel	rd	10.2	41.2	1,220	30.2	42.2 U
Mid-Channel	rd	7.6	34.2	1,180	27.3	38.1 U
Right Channel	rd	11.0	34.5	1,210	29.2	35.3 U
Right Channel	rd	6.3	10.7	275	9.6	9.4 U
Right Channel	rd	4.2	13.5	243	11.3	10.0 U
Right Bank	rd	7.0	11.1	339	9.4	10.0 U

Source: USEPA (2006h)

Notes: U = undetected; non-detects are reported at one half their detection limit; field duplicates averaged with primary sample (no U data qualifier for averaged values with one detected value)

rd = rejected data; data determined to be unusable during the QA review.

= Elevated values relative to other locations on each transect.

^a River miles are those used by USEPA 2006h. See text for explanation

^b Metals and metalloids listed are those identified as chemicals of interest in the USEPA (2006j) screening evaluation.

Table 5-5. Mean Metals Concentrations in Surface Sediments of Beaches Sampled along the UCR in 2005

Beach	River Mile ^a	Metals (mg/kg dry weight)						Metalloids (mg/kg dry weight)					
		Iron	Zinc	Copper	Cadmium	Mercury	Lead	Antimony	Arsenic	Chromium	Manganese	Nickel	Uranium
Black Sand Beach	742	200,000 *	15,800 *	2,060 *	1.2	0.23	261 *	37.7 *	22.8 *	117 *	3,470 *	11.3	76.9 *
Northport Boat Launch ^c	735	99,000 *	8,050 *	1,130 *	2.5	0.1	251 *	24.1 *	14.1 *	62.0 *	1,870 *	13.1	10.5 U
Dalles Orchard	729	100,000 *	7,890 *	1,160 *	2.2	0.05	203 *	22.8 *	18.1 *	66.9 *	1,990 *	11.0	10.1 U
North Gorge Campground	718	23,000	1,037	124	3.2 *	0.28 *	169	3.4	8.4	20.9	292	14.0	10.4 *
Marcus Island Campground	708	18,000	572	40.8	4.8 *	0.4 *	183	2.6	6.4	17.7	212	15.2 *	9.8
Kettle Falls Swim Beach ^c	700	12,100	41.5	12.3	0.2	0.07	6.6	0.9 U	1.6	11.6	235	11.4	9.6 U
Haag Cove	697	12,000	386	18.5	4.3 *	0.39 *	127	1.4	1.5	15.3	179	11.8	12.0 U
French Rocks Boat Launch	690	11,000	85.4	13.1	0.4	0.03	20.4	0.4 U	2.5	12.6	213	11.8	9.4
Cloverleaf Branch	675	16,800	203	19.8	1.9	0.10	56.3	1.2	4.2	21.1	287	17.7 *	11.4 U
AA Campground	673	17,100	107	15.6	0.6	0.03	20.0	1.4	4.1	18.7	266	16.4 *	11.8 U
Roger Bar Campground	658	8,150	33.9	7.1	0.1	0.05 U	4.5	rd	1.5	9.5	129	8.1	8.2 U
Columbia Campground ^c	642	15,700	165	12.8	0.7	0.06	29.2	1.1	4.6	14.5	212	12.1	10.8
Lincoln Mill Boat Ramp	633	12,300	30.7	9.6	0.1 U	0.05 U	5.1	rd	6.2	8.3	258	7.5	6.5 *
Keller Ferry No. 2	615	14,700	40.1	8.1	0.3 U	0.06 U	5.6	rd	4.5	11.2	231	9.3	6.7
Spring Canyon Campground	600	14,900	47.4	6.4	0.3 U	0.06 U	6.6	0.5 U	8.8	9.4	220	7.7	8.6

Source: USEPA (2006a)

Notes: * = Asterisks denote the three highest concentrations for each metal.

U = undetected; one-half the undetected value was used to calculate the average value.

rd = rejected data; data determined to be unusable during the QA review.

^a River miles are those used by USEPA 2006a. See text for explanation.

^b Metals and metalloids listed are those identified as chemicals of interest in the USEPA (2006d) screening evaluation.

^c Concentrations listed are averages for discrete grab and composite samples.

Table 5-6. Vertical Distributions of Metals in the Sediment Core Collected at RM 693 in the UCR in 1986

Core Depth (cm)	Metals/Metalloids (mg/kg dry weight)							
	Iron	Zinc	Copper	Cadmium	Mercury	Lead	Arsenic	Manganese
0 - 5	29,900	2,110	128	5.1	0.98	499	8.9	523
5 - 10	30,300	1,470	64	5.1	0.84	545	11.4	535
10 - 15 ^a	27,600	2,810	81	4.7	1.12	1,190	33.0	625
15 - 20 ^b	27,800	2,730	85	5.2	1.08	1,140	27.6	621
20 - 25	26,000	2,720	88	5.1	1.98	1,040	16.4	625
25 - 30	18,300	660	49	4.7	0.24	439	10.6	431
30 - 35	18,200	65	13	0.22	<0.01	6	2.1	260
35 - 40	18,000	53	13	0.12	<0.01	4	1.0	255
40 - 45	18,400	57	16	0.14	<0.01	5	2.9	288
45 - 50	19,000	53	17	0.1	<0.01	3	0.6	288

Source: Johnson et al. (1989)

Notes:

^a The peak cesium-137 concentration was found in this horizon.

^b The first detected cesium-137 concentrations were found in this horizon was assumed to represent 1954.

Table 5-7. Vertical Distributions of Metals in Sediment Cores Collected from the UCR in 2005

Analyte	Depth (ft)	River Mile ^a							
		708	704	692	676	661	644	637	605
Grain-Size Parameters and TOC (percent)									
Sand	0 - 0.5	96.2	98.3	8.6	10.4	11.8	10.6	1.2	nd
	0.5 - 1	98.3	98.5	18.0	5.6	21.2	66.8	1.0	1.2
	1 - 3	97.1	98.8	41.4	9.0	16.7	71.7	81.7	25.0
	3 - 5	96.0	97.9	90.9	9.2	1.6	67.2	80.2	31.8
	5 - 7	93.8	98.3	23.2	4.4	4.8	70.4	nd	nd
	7 - 9	nd	98.1	nd	nd	nd	nd	nd	nd
Silt	0 - 0.5	3.8	1.7	71.1	55.6	69.7	38.4	33.6	nd
	0.5 - 1	1.7	1.5	71.2	54.8	66.2	31.0	47.5	26.7
	1 - 3	2.9	1.2	51.6	47.3	68.3	26.7	17.5	57.0
	3 - 5	3.9	2.1	8.5	45.3	75.8	31.2	18.9	46.7
	5 - 7	6.0	1.7	63.0	43.8	80.0	28.4	nd	nd
	7 - 9	nd	1.9	nd	nd	nd	nd	nd	nd
Clay	0 - 0.5	0.02	0.01	10.0	26.0	11.5	31.3	35.6	nd
	0.5 - 1	0.01	0.01	6.5	28.3	8.7	1.0	24.8	37.5
	1 - 3	0.01	0.01	4.7	29.1	9.6	1.0	0.3	9.0
	3 - 5	0	0.02	0.1	25.5	13.8	0.8	0.3	10.0
	5 - 7	0.06	0.02	10.8	29.5	9.5	0.6	nd	nd
	7 - 9	nd	0.01	nd	nd	nd	nd	nd	nd
Colloids ^b	0 - 0.5	0.02	0.03	10.0	8.1	7.1	19.7	29.6	nd
	0.5 - 1	0	0.03	4.1	11.3	3.9	1.2	26.7	34.6
	1 - 3	0	0.01	2.3	14.6	5.4	0.6	0.6	9.0
	3 - 5	0.02	0.02	0.1	11.5	8.9	0.8	0.6	5.6
	5 - 7	0	0.02	3.1	16.1	5.7	0.6	nd	nd
	7 - 9	nd	0.02	nd	nd	nd	nd	nd	nd
TOC	0 - 0.5	0.1	0.1	3.2	1.0	0.7	0.8	1.2	nd
	0.5 - 1	0.2	0.1	2.5	0.7	0.4	0.4	1.0	1.1
	1 - 3	0.2	0.1	1.7	0.6	0.4	0.1	0.4	0.5
	3 - 5	0.1	0.1	0.4	0.0	0.2	0.1	0.3	0.2
	5 - 7	0.1	0.1	1.7	0.6	0.1	0.1	nd	nd
	7 - 9	nd	0.2	nd	nd	nd	nd	nd	nd

Table 5-7. (continued)

Analyte	Depth (ft)	River Mile ^a							
		708	704	692	676	661	644	637	605
Key Metals (mg/kg dry weight)									
Iron	0 - 0.5	256,000	128,000	28,700	29,400	24,400	34,500	33,100	nd
	0.5 - 1	266,000	127,000	27,000	28,800	19,700	13,700	26,900	34,000
	1 - 3	168,000	119,000	22,300	29,300	22,000	14,300	14,700	18,700
	3 - 5	227,000	127,000	40,100	30,000	23,100	15,600	13,600	17,300
	5 - 7	206,000	126,000	31,200	30,400	20,100	12,500	nd	nd
	7 - 9	nd	128,000	nd	nd	nd	nd	nd	nd
Zinc	0 - 0.5	23,500	11,700	1,120	1,040	457	1,230	635	nd
	0.5 - 1	24,800	11,700	981	1,710	439	55.2	927	1,210
	1 - 3	13,800	11,100	1,450	1,890	545	30.9	46.1	80.5
	3 - 5	18,100	12,100	4,020	2,120	193	35.8	37.1	48.3
	5 - 7	17,300	12,500	1,530	1,960	75.3	32.8	nd	nd
	7 - 9	nd	12,600	nd	nd	nd	nd	nd	nd
Copper	0 - 0.5	2170	829	101	98.5	43.3	70.7	60.8	nd
	0.5 - 1	2240	831	129	68.5	34.4	11.9	41.5	60.8
	1 - 3	1330	789	104	84.6	35.05	11.3	9.2	19.45
	3 - 5	1810	875	314.5	120	28	11.8	9.5	15.4
	5 - 7	1950	884	79.8	94.3	21.6	11.4	nd	nd
	7 - 9	nd	873	nd	nd	nd	nd	nd	nd
Cadmium	0 - 0.5	4.4	0.3	8.0	5.5	3.6	12.7	5.4	nd
	0.5 - 1	4.4	0.2	5.0	14.2	3.8	0.3	9.3	11.3
	1 - 3	3.9	0.4	5.4	13.2	4.9	0.1	0.1	0.4
	3 - 5	3.5	0.3 U	3.6	14.1	1.6	0.3 U	0.1	0.1
	5 - 7	4.4	0.3 U	9.8	17.9	0.5	0.1	nd	nd
	7 - 9	nd	0.5	nd	nd	nd	nd	nd	nd
Mercury	0 - 0.5	0.04	0.02	1.6	1.5	0.5	1.5	0.81	nd
	0.5 - 1	0.5	0.01	0.5	2.4	0.6	0.02	0.83	1.0
	1 - 3	0.03	0.02	1.7	2.7	0.6	0.01	0.01 U	0.052
	3 - 5	0.1	0.02	0.06	3.2	0.4	0.01	0.01 U	0.01
	5 - 7	0.03	0.01	0.98	2.3	0.05	0.01	nd	nd
	7 - 9	nd	0.01	nd	nd	nd	nd	nd	nd
Lead	0 - 0.5	1,150	382	288	330	162	841	180	nd
	0.5 - 1	1,140	378	214	690	165	10.8	261	462
	1 - 3	471	431	216	1,010	234	5.4	7.9	20.0
	3 - 5	524	439	550	1,050	96.2	5.3	6.2	8.9
	5 - 7	633	542	367	1,230	22.6	4.4	nd	nd
	7 - 9	nd	498	nd	nd	nd	nd	nd	nd

Table 5-7. (continued)

Analyte	Depth (ft)	River Mile ^a							
		708	704	692	676	661	644	637	605
Other Metals (mg/kg dry weight)									
Antimony	0 - 0.5	42.5	14.2	7.2 U	rd	rd	rd	5.6 U	nd
	0.5 - 1	28.5	12.2	5.7 U	rd	rd	rd	0.7	7.6 U
	1 - 3	16.9	11.4	5.1 U	rd	rd	rd	3.5 U	4.2 U
	3 - 5	38.7	11.9	3.8	rd	rd	rd	3.7 U	3.2 U
	5 - 7	39.1	12.0	0.4 U	rd	rd	rd	nd	nd
	7 - 9	nd	13.0	nd	nd	nd	nd	nd	nd
Arsenic	0 - 0.5	12.8	5.8	5.3	9.0	8.1	15.9	9.9	nd
	0.5 - 1	11.0	6.1	4.4	17.5	6.9	1.0 U	12.7	15.5
	1 - 3	2.9	5.3	2.9	14.3	8.9	0.6 U	2.4	4.8
	3 - 5	3.2	7.7	7.5	17.8	7.4	0.8 U	3.1	4.6
	5 - 7	1.0	10.3	9.0	17.3	7.1	0.6 U	nd	nd
	7 - 9	nd	8.8	nd	nd	nd	nd	nd	nd
Chromium	0 - 0.5	107	43.2	33.4	41.8	29.1	38.3	40.1	nd
	0.5 - 1	109	41.6	32.0	33.3	24.1	13.9	30.4	35.4
	1 - 3	70.0	37.6	21.5	32.6	27.0	14.9	12.0	15.1
	3 - 5	88.1	43.9	19.0	33.5	28.9	16.0	11.2	16.6
	5 - 7	99.4	42.6	21.4	37.6	25.6	14.7	nd	nd
	7 - 9	nd	43.2	nd	nd	nd	nd	nd	nd
Manganese	0 - 0.5	4,460	2,300	487	553	437	735	829	nd
	0.5 - 1	4,690	2,270	497	526	362	265	654	953
	1 - 3	3,040	2,180	391	617	405	189	201	441
	3 - 5	3,770	2,380	822	719	428	212	221	344
	5 - 7	3,790	2,380	499	728	349	212	nd	nd
	7 - 9	nd	2,490	nd	nd	nd	nd	nd	nd
Nickel	0 - 0.5	11.0	7.6	27.5	28.1	25.8	32.8	32.0	nd
	0.5 - 1	11.0	7.7	24.4	26.0	22.0	12.1	24.4	30.5
	1 - 3	9.6	6.6	14.1	27.0	23.6	11.8	9.3	13.1
	3 - 5	10.1	7.6	10.2	26.7	26.0	12.6	9.6	14.4
	5 - 7	12.0	7.6	19.3	29.6	22.8	12.4	nd	nd
	7 - 9	nd	7.4	nd	nd	nd	nd	nd	nd
Uranium	0 - 0.5	11.7 U	78.4	23.8 U	22.2 U	12.8 U	16.0 U	26.5 U	nd
	0.5 - 1	10.6 U	74.5	18.9 U	17.2 U	11.6 U	9.8 U	20.9 U	25.3 U
	1 - 3	9.4 U	61.9	16.8 U	16.2 U	11.0 U	10.7 U	11.3 U	8.5 U
	3 - 5	10.4 U	20.4	12.0 U	18.1 U	12.0 U	10.5 U	12.2 U	10.6 U
	5 - 7	12.2 U	42.5	15.0 U	16.2 U	10.0 U	10.0 U	nd	nd
	7 - 9	nd	89.6	nd	nd	nd	nd	nd	nd

Source: USEPA (2006h)

Notes: nd = No data; sample was not collected at the indicated sample depth.

U = undetected; non-detects are reported at one half their detection limit; field duplicates averaged with primary sample (no U data qualifier for averaged values with one detected value)

rd = rejected data; data determined to be unusable during the QA review.

a River miles are those used by USEPA 2006h. See text for explanation.

b Colloids, which are not commonly reported for sediments, represent very fine particles < 1µm in diameter that do not settle.

 = Elevated concentrations relative to other horizons in each core. Sand ≥ 50%; silt ≥ 30%; clay ≥ 15%; colloids ≥ 10%; TOC ≥ 1.0%

Sand ≥ 50%; silt ≥ 30%; clay ≥ 15%; colloids ≥ 10%; TOC ≥ 1.0%

Table 5-8. Vertical Distribution of Organic Compounds in Phase I Core Samples of UCR Sediments

Analyte (mg/kg dw) ^a	Depth (ft)	River Mile								
		708	704	692	676	661	644	637	622	605
2,3,7,8-TCDD	0 to 0.5	--	0.000031 U	0.00050 J	--	0.00028 J	--	0.00059 J	--	--
	0.5 to 1	--	0.000013 U	0.00024	--	0.00022 J	--	0.00040 J	--	0.00050 J
	1 to 3	--	0.000011 U	0.00053 J	--	0.00013 J	--	0.000019 U	--	0.000020 U
	3 to 5	--	0.000017 U	0.000085 J	--	0.000021 U	--	0.000017 U	--	0.000021 U
	5 to 7	--	0.000032 U	0.00032 J	--	0.000029 U	--	--	--	--
	7 to 9	--	0.000020 U	--	--	--	--	--	--	--
2,3,7,8-TCDF	0 to 0.5	--	0.00044	0.028	--	0.017	--	0.053	--	--
	0.5 to 1	--	0.00045	0.014	--	0.019	--	0.020	--	0.027
	1 to 3	--	0.00042	0.052	--	0.0021	--	0.00017 J	--	0.00014 J
	3 to 5	--	0.00045	0.003	--	0.00015 J	--	0.000076 J	--	0.000045 U
	5 to 7	--	0.00045	0.0037	--	0.000051 U	--	--	--	--
	7 to 9	--	0.00040	--	--	--	--	--	--	--
2,4'-DDE	0 to 0.5	0.39 U	0.35 U	0.80 U	0.85 U	0.60 U	0.60 U	0.95 U	0.40 U	--
	0.5 to 1	0.39 U	0.35 U	0.70 U	0.60 U	0.50 U	0.47 U	0.70 U	0.39 U	0.90 U
	1 to 3	0.37 U	0.32 J	0.55 U	0.65 U	0.48 U	0.43 U	0.42 U	0.39 U	0.45 U
	3 to 5	0.36 U	0.35 U	0.42 U	0.65 U	0.47 U	0.42 U	0.41 U	0.39 U	0.41 U
	5 to 7	0.41 U	0.35 U	0.55 U	0.60 U	0.44 U	0.43 U	--	0.38 U	--
	7 to 9	--	0.38 U	--	--	--	--	--	0.38 U	--
2,4'-DDT	0 to 0.5	0.39 U	0.35 U	0.80 U	0.85 U	0.60 U	0.60 U	0.95 U	0.40 U	--
	0.5 to 1	0.39 U	0.35 U	0.70 U	0.60 U	0.50 U	0.47 U	0.70 U	0.39 U	0.90 U
	1 to 3	0.37 U	0.36 U	0.55 U	0.65 U	0.48 U	0.43 U	0.42 U	0.39 U	0.45 U
	3 to 5	0.36 U	0.37 U	0.42 U	0.65 U	0.47 U	0.42 U	0.41 U	0.39 U	0.41 U
	5 to 7	0.41 U	0.35 U	0.55 U	0.60 U	0.44 U	0.43 U	--	0.38 U	--
	7 to 9	--	0.38 U	--	--	--	--	--	0.38 U	--
4,4'-DDD	0 to 0.5	0.39 U	0.35 U	0.80 U	0.85 U	0.60 U	0.60 U	0.95 U	0.40 U	--
	0.5 to 1	0.39 U	0.35 U	0.70 U	0.60 U	0.50 U	0.47 U	0.70 U	0.39 U	0.90 U
	1 to 3	0.37 U	0.36 U	0.55 U	0.65 U	0.48 U	0.43 U	0.42 U	0.39 U	0.45 U
	3 to 5	0.36 U	0.37 U	0.42 U	0.65 U	0.47 U	0.42 U	0.41 U	0.39 U	0.41 U
	5 to 7	0.41 U	0.35 U	0.55 U	0.60 U	0.44 U	0.43 U	--	0.38 U	--
	7 to 9	--	0.38 U	--	--	--	--	--	0.38 U	--
4,4'-DDE	0 to 0.5	0.39 U	0.16 J	0.80 U	0.85 U	0.60 U	0.60 U	0.95 U	0.40 U	--
	0.5 to 1	0.39 U	0.35 U	0.16 J	0.60 U	0.50 U	0.47 U	0.43	0.39 U	0.90 U

Table 5-8. Vertical Distribution of Organic Compounds in Phase I Core Samples of UCR Sediments

Analyte (mg/kg dw) ^a	Depth (ft)	River Mile								
		708	704	692	676	661	644	637	622	605
4,4'-DDT	1 to 3	0.37 U	0.81	0.55 U	0.65 U	0.48 U	0.43 U	0.42 U	0.39 U	0.45 U
	3 to 5	0.36 U	0.37 U	0.42 U	0.65 U	0.47 U	0.42 U	0.41 U	0.39 U	0.41 U
	5 to 7	0.41 U	0.35 U	0.55 U	0.60 U	0.44 U	0.43 U	--	0.38 U	--
	7 to 9	--	0.38 U	--	--	--	--	--	0.38 U	--
	0 to 0.5	0.39 U	0.35 U	1.0 J	0.85 U	0.60 U	0.60 U	0.95 U	0.40 U	--
	0.5 to 1	0.39 U	0.35 U	0.70 U	0.60 U	0.50 U	0.47 U	0.70 U	0.39 U	0.90 U
	1 to 3	0.37 U	2.6	0.55 U	0.65 U	0.48 U	0.43 U	0.42 U	0.39 U	0.45 U
	3 to 5	0.36 U	0.37 U	0.42 U	0.65 U	0.47 U	0.42 U	0.41 U	0.39 U	0.41 U
	5 to 7	0.41 U	0.35 U	0.55 U	0.60 U	0.44 U	0.43 U	--	0.38 U	--
Aldrin	7 to 9	--	0.38 U	--	--	--	--	--	0.38 U	--
	0 to 0.5	0.19 U	0.17 U	0.38 U	0.42 U	0.29 U	0.29 U	0.47 U	0.20 U	--
	0.5 to 1	0.20 U	0.17 U	0.34 U	0.31 U	0.25 U	0.23 U	0.35 U	0.19 U	0.44 U
	1 to 3	0.19 U	0.18 U	0.27 U	0.32 U	0.24 U	0.21 U	0.21 U	0.19 U	0.22 U
	3 to 5	0.18 U	0.18 U	0.21 U	0.33 U	0.23 U	0.21 U	0.20 U	0.19 U	0.20 U
	5 to 7	0.21 U	0.18 U	0.26 U	0.29 U	0.22 U	0.21 U	--	0.19 U	--
Aroclor 1016	7 to 9	--	0.19 U	--	--	--	--	--	0.19 U	--
	0 to 0.5	0.48 U	0.43 U	0.95 U	1.1 U	--	0.75 U	1.2 U	1.0 U	--
	0.5 to 1	0.49 U	0.44 U	0.85 U	0.80 U	0.65 U	0.60 U	0.90 U	0.95 U	2.2 U
	1 to 3	0.46 U	0.45 U	0.70 U	0.80 U	0.60 U	0.55 U	0.53 U	0.95 U	1.1 U
	3 to 5	0.44 U	0.46 U	0.50 U	0.80 U	0.60 U	0.50 U	0.50 U	0.95 U	1.0 U
	5 to 7	0.50 U	0.44 U	0.65 U	0.75 U	0.55 U	0.50 U	--	0.95 U	--
Aroclor 1260	7 to 9	--	0.47 U	--	--	--	--	--	0.95 U	--
	0 to 0.5	0.48 U	0.43 U	0.95 U	1.1 U	--	0.75 U	1.2 U	1.0 U	--
	0.5 to 1	0.49 U	0.44 U	0.85 U	0.80 U	0.65 U	0.60 U	0.90 U	0.95 U	2.2 U
	1 to 3	0.46 U	0.45 U	0.70 U	0.80 U	0.60 U	0.55 U	0.53 U	0.95 U	1.1 U
	3 to 5	0.44 U	0.46 U	0.50 U	0.80 U	0.60 U	0.50 U	0.50 U	0.95 U	1.0 U
	5 to 7	0.50 U	0.44 U	0.65 U	0.75 U	0.55 U	0.50 U	--	0.95 U	--
Benzo(a)anthracene	7 to 9	--	0.47 U	--	--	--	--	--	0.95 U	--
	0 to 0.5	2.5 U	2.0 U	0.80 J	6.0 J	3.5 U	0.30 J	0.50 J	2.5 U	--
	0.5 to 1	2.5 U	2.0 U	0.70 J	3.0 J	0.50 J	6.0	4.5 U	2.5 U	5.5 U
	1 to 3	2.5 U	2.5 U	2.0 J	4.0 J	0.50 J	5.0	2.5 U	2.5 U	2.8 U
	3 to 5	0.30 J	2.5 U	1.7 U	3.0 J	3.0 U	5.0	2.5 U	2.5 U	2.5 U

Table 5-8. Vertical Distribution of Organic Compounds in Phase I Core Samples of UCR Sediments

Analyte (mg/kg dw) ^a	Depth (ft)	River Mile								
		708	704	692	676	661	644	637	622	605
	5 to 7	0.60 J	2.0 U	3.5 U	3.0 J	3.0 U	5.0	--	2.5 U	--
	7 to 9	--	2.5 U	--	--	--	--	--	2.5 U	--
Benzo(a)pyrene	0 to 0.5	2.5 U	2.0 U	0.80 J	3.0 J	3.5 U	7.0	6.0 U	2.5 U	--
	0.5 to 1	2.5 U	4.0	4.5 U	4.0 U	3.0 U	6.0	4.5 U	2.0 J	5.5 U
	1 to 3	2.5 U	2.5 U	3.0 J	3.0 J	3.0 U	6.0	2.3 J	3.0 J	2.8 U
	3 to 5	2.0 U	5.0	2.5 U	3.0 J	3.0 U	7.0	2.5 U	1.0 J	2.5 U
	5 to 7	2.5 U	2.0 U	3.5 U	3.0 J	3.0 U	5.0	--	2.5 U	--
	7 to 9	--	5.0	--	--	--	--	--	2.5 U	--
Benzo(b)fluoranthene	0 to 0.5	2.5 U	2.0 U	4.5 U	5.5 U	3.5 U	7.0	6.0 U	2.5 U	--
	0.5 to 1	2.5 U	4.0	4.5 U	4.0 U	3.0 U	6.0	4.5 U	2.5 U	5.5 U
	1 to 3	2.5 U	2.5 U	3.0 J	4.0 U	3.0 U	5.0	2.5 U	2.5 U	2.8 U
	3 to 5	2.0 U	5.0	2.5 U	4.0 U	3.0 U	5.0	2.5 U	2.5 U	2.5 U
	5 to 7	2.5 U	2.0 U	3.5 U	3.5 U	3.0 U	5.0	--	2.5 U	--
	7 to 9	--	5.0	--	--	--	--	--	2.5 U	--
Benzo(k)fluoranthene	0 to 0.5	2.5 U	2.0 U	4.5 U	11	7.0	7.0	6.0 U	2.5 U	--
	0.5 to 1	2.5 U	4.0	4.5 U	8.0	6.0	6.0	4.5 U	2.5 U	5.5 U
	1 to 3	2.5 U	2.5 U	2.0 J	8.0	6.0	5.0	2.5 U	2.5 U	2.8 U
	3 to 5	2.0 U	5.0	2.5 U	8.0	6.0	5.0	2.5 U	2.5 U	2.5 U
	5 to 7	2.5 U	2.0 U	7.0	7.0	6.0	5.0	--	2.5 U	--
	7 to 9	--	5.0	--	--	--	--	--	2.5 U	--
Chrysene	0 to 0.5	2.5 U	2.0 U	2.0 J	12	0.30 J	0.90 J	0.90 J	2.5 U	--
	0.5 to 1	2.5 U	2.0 U	1.0 J	6.0 J	1.0 J	0.20 J	4.5 U	2.5 U	5.5 U
	1 to 3	0.20 J	0.20 J	3.0 J	8.0	0.85 J	5.0	2.5 U	2.5 U	2.8 U
	3 to 5	0.30 J	2.5 U	2.3 J	7.0	0.50 J	5.0	2.5 U	2.5 U	2.5 U
	5 to 7	0.80 J	2.0 U	3.0 J	7.0	3.0 U	5.0	--	2.5 U	--
	7 to 9	--	2.5 U	--	--	--	--	--	2.5 U	--
Dibenzo(a,h)anthracene	0 to 0.5	2.5 U	2.0 U	4.5 U	5.5 U	3.5 U	7.0	6.0 U	2.5 U	--
	0.5 to 1	2.5 U	4.0	4.5 U	0.60 J	3.0 U	6.0	4.5 U	2.5 U	5.5 U
	1 to 3	2.5 U	2.5 U	3.5 U	2.0 J	3.0 U	5.0	2.5 U	2.5 U	2.8 U
	3 to 5	2.0 U	5.0	2.5 U	1.0 J	3.0 U	5.0	2.5 U	2.5 U	2.5 U
	5 to 7	2.5 U	2.0 U	3.5 U	3.5 U	3.0 U	5.0	--	2.5 U	--
	7 to 9	--	5.0	--	--	--	--	--	2.5 U	--

Table 5-8. Vertical Distribution of Organic Compounds in Phase I Core Samples of UCR Sediments

Analyte (mg/kg dw) ^a	Depth (ft)	River Mile								
		708	704	692	676	661	644	637	622	605
Indeno[1,2,3-cd]pyrene	0 to 0.5	2.5 U	2.0 U	0.80 J	3.0 J	3.5 U	7.0	0.90 J	2.5 U	--
	0.5 to 1	2.5 U	4.0	0.70 J	2.0 J	0.50	6.0	4.5 U	2.5 U	0.90 J
	1 to 3	2.5 U	2.5 U	3.0 J	4.0 U	1.8 J	5.0	2.5 U	2.5 U	2.8 U
	3 to 5	0.20 J	5.0	0.50 J	4.0 U	3.0 U	5.0	2.5 U	2.5 U	2.5 U
	5 to 7	2.5 U	2.0 U	3.5 U	3.0 J	3.0 U	5.0	--	2.5 U	--
	7 to 9	--	5.0	--	--	--	--	--	2.5 U	--

Source: USEPA (2006h)

Notes: -- = not sampled

J = Estimated DDD = Dichlorodiphenyldichloroethane

U = Undetected DDE = Dichlorodiphenyldichloroethylene

DDT = Dichlorodiphenyltrichloroethane

^a Non-detects are reported at one-half their detection limit; field duplicates averaged with primary sample (no U data qualifier for averaged values with one detected value); dry weight (dw).

Table 5-9. Metal/Metalloid Concentrations and Hardness Measured in Porewater in Studies Conducted in August 1989 (Johnson 1991b), September 2002 (Cox et al. 2005), and September 2004 (Paulson et al. 2006)

Sample Location	River Mile ^a	Horizon	Porewater metal/metalloid concentration (µg/L)					Porewater hardness (mg/L as CaCO ₃)	
			Zn	Cu	Pb	As	Cd		Hg
Johnson (1991b)									
Little Dalles	728.1	≤ 2 cm	645	22	490	7.6	3.6	0.51	224
French Pt. Rocks	692.2	≤ 2 cm	116	16	294	19	3.4	0.036	343
Castle Rock	644.8	≤ 2 cm	38	6	41	20	1.7	0.063	234
Swawilla Basin	604.9	≤ 2 cm	59	3.1	34	13	1.4	0.038	213
Spokane River Arm	7.8	≤ 2 cm	90	3.7	18	53	1.4	0.004	157
Sanpoil River Arm	3.9	≤ 2 cm	24	4.5	15	25	0.65	0.023	177
Cox et al. (2005)									
Near Marcus Flats	705	0-1	12	3.8	2.9	4.1	0.68	NA ^b	68 ^c
Near Marcus Flats	705	1-2	10	2.7	8	6	0.25	NA	69
Near Marcus Flats	705	1-2	4.9	1	4.6	18	0.07	NA	57
French Rocks	692	0-1	13	4.2	6.5	26	0.26	NA	114
French Rocks	692	1-2	3.7	1.9	3	16	0.08	NA	128
French Rocks	692	9-11	4.2	2.1	3.8	15	0.06	NA	157
Near Hunters	668	0-1	6.6	1.6	1.4	15	0.08	NA	76
Near Hunters	668	1-2	3.8	1.3	2	24	0.04	NA	75
Near Hunters	668	9-11	26	1.1	2	20	0.03	NA	102
Near Hunters	668	9-11	3.4	1	1.4	24	0.03	NA	101
Near Hunters	668	18-20	40	1.8	1.3	11	<0.02	NA	145
Paulson et al. (2006)^d									
LR-7	735.3	0-2	18.8	9.2	2.7	<1	<0.1	NA	69.8
LR-6	721.8	0-2	12.5	1.9	4.9	3.3	<0.1	NA	81.5
LR-5	711.3	0-2	10.6	0.8	3.2	7.3	<0.1	NA	150
LR-5A	710.2	0-2	3.3	<0.5	2.4	7.6	<0.1	NA	104
LR-4	683.2	0-2	2.7	1.6	1.2	2	0.14	NA	84
LR-4A	683.3	0-2	4.7	<0.5	1.9	6.2	<0.1	NA	61
LR-3	664.2	0-2	13.4	1.85	3.8	1.5	0.48	NA	60.7
LR-2	625.1	0-2	6.8	0.78	0.77	11.5	<0.1	NA	70.4
LR-1	600.6	0-2	13.9	2.4	1.26	2	0.34	NA	91.9
SA-8		0-2	4.4	0.55	0.53	20.8	<0.1	NA	84

Notes:

^a River miles are as provided by authors, and/or based on coordinates provided.

^b NA = No data available.

^c Hardness for porewaters sampled by Cox et al. (2005) were calculated according to APHA (1994):
Hardness, mg equivalent CaCO₃/L = (2.497*Ca, mg/L)+(4.118*Mg, mg/L).

^d Results shown are the median concentrations of all replicates, as reported in Paulson et al. (2006).

Table 5-10. Metal/Metalloid Concentrations Measured in Porewater by Paulson et al. (2006)

Sample Location	River Mile ^a	Horizon	Replicate ID	Porewater metal/metalloid concentration (µg/L)					
				Zn	Cu	Pb	As	Cd	Hg
LR-7	735.3	0-2	AB	22.8	10.2	2.6	<1	<0.1	NA
			CDEF	14.8	8.1	2.7	<1	<0.1	NA
LR-6	721.8	0-2	A	7.3	0.9	2.6	3.0	<0.1	NA
			B	21.3	1.9	5.3	4.0	<0.1	NA
			C	16.0	3.4	4.9	4.2	<0.1	NA
			D	12.5	1.4	3.2	3.3	<0.1	NA
			E	11.6	3.0	5.8	3.3	<0.1	NA
LR-5	711.3	0-2	A	4.4	1.0	4.4	5.7	<0.1	NA
			B	16.6	0.5	2.0	3.2	0.13	NA
			C	14.8	1.1	3.2	8.4	<0.1	NA
			D	10.6	0.6	4.8	7.3	<0.1	NA
			E	7.0	<0.5	1.2	12.2	0.11	NA
LR-5A	710.2	0-2	PW	3.3	<0.5	2.4	7.6	<0.1	NA
LR-4	683.2	0-2	DF	<2.5	1.1	0.8	2.0	<0.1	NA
			I	2.8	1.4	1.0	2.0	<0.1	NA
			BE	<2.5	1.9	1.5	3.2	0.18	NA
			G	3.2	2.1	1.4	2.0	0.2	NA
			CH	2.7	1.6	1.2	2.0	0.14	NA
LR-4A	683.3	0-2	PW	4.7	<0.5	1.9	6.2	<0.1	NA
LR-3	664.2	0-2	A	8.9	1.0	6.6	3.5	0.21	NA
			C	13.4	1.8	5.2	2.0	0.39	NA
			D	15.3	2.9	2.4	<1	0.97	NA
			E	13.3	1.9	1.0	<1	0.56	NA
			B	6.1	8.5	3.0	13.3	<0.1	NA
LR-2	625.1	0-2	C	6.8	0.7	0.8	11.5	<0.1	NA
			D	7.5	0.8	0.6	5.7	<0.1	NA
			B	16.8	3.2	1.6	2.0	0.37	NA
LR-1	600.6	0-2	ACD	11.0	1.6	0.9	2.0	0.31	NA
			B	16.8	3.2	1.6	2.0	0.37	NA
SA-8		0-2	A	<2.5	<0.5	0.3	22.5	<0.1	NA
			B	3.1	<0.5	0.4	17.8	<0.1	NA
			C	5.5	<0.5	0.7	27.4	<0.1	NA
			D	4.4	0.6	1.0	19.1	<0.1	NA

Notes: NA = No data available

^a River miles are based on coordinates provided.

Table 5-11. Porewater Concentrations of Metals Measured by EPA in UCR Sediments in April 2005

Station	RM	Hardness	Dissolved Concentration in Porewater, µg/L																								
		Dissolved mg/L as CaCO ₃	Al	Sb	As	Ba	Be	Cd	Ca	Cr	Co	Cu	Fe	Pb	Mg	Mn	Hg	Ni	K	Se	Ag	Na	Th	U	V	Zn	
Study Station																											
RM603A1(X1)	603	117	--	--	--	159	--	--	32,500	3.2	--	--	118	--	8,710	12.8	0.2	--	1,630	--	--	5,070	--	--	7.6	29.2	
RM605A1(X1)	605	95	--	--	--	189	--	0.31	27,100	15.7	--	--	--	--	6,570	6	0.2	9.8	730	--	--	3,400	--	--	5.4	63.7	
RM605A2(X8)	605	175	--	--	--	308	--	0.06	50,700	5.4	2.5	2.3	223	5.2	11,700	3,650	0.019	6.8	1,550	--	--	4,980	--	--	7	84.2	
RM606A1(X3)	606	245	--	--	15.5	311	--	0.43	70,700	12.7	7	--	9,990	--	16,600	12,800	0.2	7.1	2,350	10.6	--	4,930	6.8	--	10.6	69.3	
RM616A1(X3)	616	224	--	--	--	278	--	0.51	65,000	7	--	--	130	2.4	14,900	5,120	0.2	5	2,560	--	--	6,750	--	--	12.7	53	
RM622A1(X3)	622	313	--	--	31.5	350	--	0.65	93,000	36.3	3.7	2.1	187	--	19,600	4,380	0.021	27.2	3,010	--	--	4,080	--	--	13.4	160	
RM628A1(X1)	628	210	--	--	--	323	--	0.25	63,500	5.8	--	1.6	111	--	12,500	2,510	0.2	4.7	1,200	--	--	4,680	--	--	8.4	62.6	
RM634A1(X1)	634	156	--	--	--	102	--	0.85	45,300	36.5	--	1.6	165	--	10,500	38.5	0.2	26.1	2,360	--	--	2,960	--	--	6.3	142	
RM637A1(X1)	637	78	--	--	--	34.5	--	--	23,600	3.1	--	--	--	--	4,730	4.8	0.2	--	1,360	--	--	2,380	--	--	2.7	9.5	
RM640A1(X3)	640	334	--	--	--	269	--	0.3	96,200	6.7	4.2	--	--	--	22,800	5,680	0.2	5.6	1,270	--	--	4,650	--	--	13.7	39.1	
RM640A1(X3)	640	315	--	--	--	345	--	0.27	91,400	5.8	--	--	--	--	21,100	4,740	0.2	4.7	936	--	--	5,350	--	--	12.8	73.3	
RM641A1(X1)	641	198	--	--	12	271	--	0.45	56,000	7.9	5.9	--	3,340	5.7	14,100	5,760	0.2	6	1,300	--	--	4,610	--	--	8.2	83.4	
RM642A1(X1)	642	111	--	--	8.1	326	--	1.8	31,300	4.4	--	8.3	1,880	45.4	7,880	2,260	0.12	3.5	1,440	--	--	5,340	--	--	3.8	116	
RM644A1(X3)	644	149	248	--	--	168	--	--	42,800	9	--	--	173	--	10,300	7.8	0.2	5.4	600	--	--	3,940	--	--	7.1	50.7	
RM658A1(X3)	658	182	282	--	--	216	--	0.3	54,000	1.4	--	5.5	198	--	11,400	651	0.2	--	1,890	--	--	3,730	--	--	--	45.9	
RM658A1(X3)	658	161	473	--	--	189	--	0.27	47,400	1.6	--	5.6	424	--	10,400	702	0.014	--	1,700	--	--	3,220	--	--	--	39.6	
RM661A1(X1)	661	174	45	--	--	176	--	--	49,700	0.99	--	--	--	--	12,000	456	0.2	--	1,990	--	--	3,550	--	--	--	26.8	
RM676A1(X3)	676	170	--	--	--	243	--	--	50,100	1.5	0.84	5.5	--	--	10,800	2,110	--	3.4	2,190	--	--	11,700	--	--	2.6	37.3	
RM676A1(X3)	676	191	--	--	5.7	255	--	--	56,900	2.1	1.4	7.1	102	5	11,800	2,710	--	3.6	2,110	--	--	7,850	--	--	2.1	42	
RM677A1(X3)	677	192	--	--	5	350	--	--	57,700	2	1.4	5.5	114	2	11,700	2,800	0.015	3.8	2,110	--	--	7,850	--	--	--	64.8	
RM678A1(X1)	678	177	--	--	--	285	--	--	60,600	1.2	--	5.3	--	--	6,300	966	0.019	--	2,600	--	--	5,210	--	--	2.1	60.5	
RM680A1(X1)	680	173	--	--	--	221	--	--	52,500	--	--	3.4	--	--	10,200	151	--	--	1,500	--	--	3,750	--	--	--	43.8	
RM686A1(X3)	686	158	--	--	--	206	--	--	48,200	--	--	3.3	--	--	9,160	296	0.017	--	2,100	--	--	4,220	--	--	2.1	60.3	
RM687A1	687	123	595	--	7.5	280	--	3.9	33,300	1.2	1	20.9	359	24.8	9,590	766	0.26	--	1,660	--	--	4,740	--	--	--	89.2	
RM689A1(X3)	689	152	312	--	6.4	86.2	--	0.46	46,900	1.9	--	10.1	236	11.1	8,490	2320	0.042	--	1,690	--	--	3,240	--	--	1.7	18.1	
RM692A1(X1)	692	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	
RM698A1(X1)	698	153	366	--	--	148	--	4	45,400	0.99	--	36.4	459	45.7	9,530	802	0.34	--	1,640	--	--	3,080	--	--	--	37.7	

Table 5-11. (continued)

Station	RM	Hardness		Dissolved Concentration in Porewater, µg/L																						
		Dissolved mg/L as CaCO ₃	Al	Sb	As	Ba	Be	Cd	Ca	Cr	Co	Cu	Fe	Pb	Mg	Mn	Hg	Ni	K	Se	Ag	Na	Th	U	V	Zn
Study Station																										
RM704A1(X1)	704	192	--	--	9.6	136	--	0.78	56,500	2.1	1.1	7.1	401	4.4	12,400	2,690	0.029	--	2,050	--	--	3,070	--	--	--	16.9
RM706A1(X1)	706	135	--	--	--	353	--	2.1	39,200	4	--	18.9	907	50.8	8,930	1,320	--	11.8	1,580	--	--	4,090	--	--	--	200
RM706A2(X7)	706	203	--	--	--	313	--	--	62,400	1.3	0.65	2.4	239	--	11,400	1,440	0.023	--	2,500	--	--	4,910	--	--	--	81.2
RM708A1(X3)	708	439	--	--	6.7	732	--	--	162,000	1.2	--	1.9	2,950	--	8,360	1,990	--	--	3,170	--	--	4,980	--	--	--	34.7
RM708X1	708	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
RM713A1(X3)	713	213	--	--	--	259	--	--	59,400	1.8	--	3.3	--	--	15,600	2,210	0.2	--	2,030	--	--	2,990	--	--	--	39.7
RM713A1(X3)	713	208	44.9	--	--	326	--	--	58,400	1.6	--	5	--	2.3	15,000	2,070	0.2	--	1,990	--	--	3,100	--	--	--	69.7
RM723A1(X1)	723	419	47.7	--	--	503	--	--	120,000	3	--	5.9	--	--	29,000	2,780	0.2	--	4,860	12.5	--	10,900	--	--	2.1	46.9
RM723A2(X3)	723	389	--	--	--	546	--	--	111,000	1.1	--	5.3	--	--	27,100	470	0.2	--	3,830	9.5	--	6,850	--	27.7	--	34.2
RM724A1(X1)	724	337	--	--	--	550	--	--	89,900	1.4	--	6.9	--	4.8	27,200	376	0.2	--	5,260	--	--	9,590	--	--	1.5	59.1
RM724A2(X3)	724	510	--	--	9.6	734	--	0.84	153,000	3.5	--	70.3	--	--	31,000	4,140	0.019	5.1	4,770	12.3	--	6,850	--	--	1.9	103
RM727A1(X1)	727	238	--	--	--	424	--	0.48	75,600	4.2	--	7.4	--	5.3	12,000	2,110	0.021	--	1,930	--	--	4,850	--	--	4.8	104
RM727A1(X1)	727	230	--	--	--	404	--	0.45	73,100	4.2	--	7.6	--	7.1	11,500	1,940	0.021	--	1,850	--	--	4,710	--	--	5.7	97.2
RM729A1(X1)	729	230	--	8	--	418	--	0.9	69,700	4.7	--	19.4	232	4.8	13,600	1,370	0.02	--	1,980	--	--	5,960	--	--	7.1	133
RM730A1	730	141	--	7.7	--	152	--	0.5	42,300	3.9	--	10.7	--	3.1	8,580	22.2	0.02	4.1	880	--	--	2,780	--	--	3.7	94.7
RM733A1(X1)	733	227	--	--	--	150	--	0.96	65,900	4.4	--	38.5	--	--	15,200	2,880	0.2	3.4	2,340	--	--	3,790	--	--	7.6	138
RM734A1	734	89	72.3	18.3	--	187	--	--	26,600	--	--	14	461	8.6	5,400	16.9	0.086	--	986	--	--	2,900	--	--	--	112
RM736A1(X1)	736	363	87.9	--	--	457	--	--	113,000	2.1	4.6	--	--	--	19,600	2,520	0.2	--	4,640	--	--	4,260	--	--	--	59
RM737A1(X3)	737	78	--	27.8	--	172	--	--	22,900	--	--	12	--	--	5,060	4.9	0.015	--	799	--	--	2,730	--	--	--	50.3
RM738A1(X3)	738	81	--	15.9	--	255	--	--	23,500	1.1	--	13	--	--	5,320	4.2	0.2	--	921	--	--	3,050	--	--	--	70.7
RM739A1(X3)	739	579	--	--	--	694	--	--	164,000	4.5	5.3	2.2	1,660	--	41,100	6,060	0.2	--	8,830	20.7	--	7,400	--	--	--	51.7
RM740A1(X1)	740	388	--	--	--	382	--	0.37	108,000	--	2.6	13.8	--	--	28,700	1,010	0.016	--	3,690	11	--	5,630	--	--	--	147
RM741A1(X3)	741	315	--	--	--	478	--	0.65	98,600	--	2.9	23	--	--	16,600	1,270	--	4.5	5,230	--	--	6,340	--	42.2	--	492
RM742A1(X1)	742	152	--	7.1	--	256	--	0.67	46,900	117	2.7	21.6	392	--	8,570	138	0.02	81.1	2,120	--	--	4,130	--	--	--	188
RM742A2(X5)	742	137	--	9.6	--	309	--	--	39,900	--	--	32.4	116	2.3	8,950	13.7	0.026	--	1,560	--	--	4,390	--	--	--	96.3
RM743A1(X1)	743	199	--	--	--	532	--	1.4	56,700	2	--	58.1	--	--	13,900	2,050	0.036	--	3,510	--	--	5,000	--	--	--	274
RM743A2(X3)	743	153	--	--	--	389	--	0.29	49,900	--	--	23.1	138	2.5	6,970	17.3	0.021	--	2,080	--	--	4,160	--	--	--	221
RM744A1(X1)	744	158	--	20.9	--	199	--	0.38	48,700	--	--	24.1	121	2.4	8,830	5.8	0.027	3.8	2,290	--	--	3,950	--	--	--	162
RM744A2(X3)	744	120	--	32.4	--	77.8	--	--	36,400	--	--	20.4	115	--	7,140	4.1	0.016	--	1,490	--	--	3,110	--	--	--	61.5

Table 5-11. (continued)

Study Station	RM	Hardness Dissolved mg/L as										Dissolved Concentration in Porewater, µg/L														
		CaCO ₃	Al	Sb	As	Ba	Be	Cd	Ca	Cr	Co	Cu	Fe	Pb	Mg	Mn	Hg	Ni	K	Se	Ag	Na	Th	U	V	Zn
Reference Station ^a																										
RM685R1	685	488	--	--	--	384	--	--	142,000	22.9	--	3.5	239	--	32,500	1,950	0.2	18.1	6,990	17.7	--	12,800	--	--	--	94
RM685R1	685	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
RM686R1	686	198	--	--	--	296	--	0.26	61,300	40.7	--	3.6	582	--	10,900	733	0.2	26.3	2,590	--	--	6,290	--	--	--	132
RM686R1	686	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
RM705R1	705	279	99.9	--	--	234	--	--	74,800	2.7	--	3.3	636	--	22,500	3,410	0.2	--	3,810	10.5	--	8,280	--	23.8	--	51.5
RM705R1	705	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
RM721R1	721	357	51.6	--	--	299	--	--	106,000	2.2	--	2.8	--	22,500	1,900	0.2	--	4,550	--	--	6,440	--	--	--	--	57.5
RM721R1	721	362	87.5	--	--	237	--	--	107,000	1.9	--	2.2	--	22,900	1,980	0.2	--	4,280	--	--	6,320	--	--	--	--	42.2
RM721R1	721	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
RM726R1	726	342	--	--	--	261	--	--	106,000	--	--	2.6	--	18,800	199	0.2	--	5,000	--	--	5,460	--	--	--	--	46.8
RM726R1	726	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
RM732R1	732	322	--	--	--	232	--	--	75,700	1	--	1.7	--	32,200	449	0.2	--	3,910	19.8	--	4,130	--	--	--	--	24.4
RM732R1	732	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--

Notes:

^a RM685 = Cheweka Creek, RM686 = Barnaby Creek, RM705 = Nancy Creek, RM721 = Flat Creek, RM726 = Crown Creek, RM732 = Fivemile Creek

Table 5-12. Elements Measured in Porewater by EPA in 2005 in Relation to Detection Limits (DL) and Frequency of Detection

Element	DL (µg/L)	Detection Frequency (%)
Aluminum	43.6-200	23
Antimony	60	14.8
Arsenic	10	18
Barium	86.2-189	100
Beryllium	0.11-5	0
Cadmium	5	50.8
Calcium	NR (5,000) ^a	100
Chromium	10	82
Cobalt	0.67-50	26.2
Copper	25	82
Iron	57.2-97.7	52.5
Lead	10	34.4
Magnesium	NR (5,000)	100
Manganese	13.7	100
Mercury	0.2	90.2
Nickel	40	39.3
Potassium	NR (5,000)	100
Selenium	35	14.8
Silver	10	0
Sodium	3,070-4,980	100
Thallium	25	1.6
Uranium		4.9
Vanadium	50	44.3
Zinc	9.5-53	100

Note:

^a NR = not reported in electronic data. The value in parentheses is from Table A-3f of USEPA (2005a).

Table 5-13. Analytical Results for Simultaneously Extracted Metals (SEM), Acid Volatile Sulfides (AVS), and Total Organic Carbon (TOC) Measured in UCR Sediments by EPA in 2005

Station	RM	Cadmium-SEM ($\mu\text{mol/g}$)	Copper-SEM ($\mu\text{mol/g}$)	Lead-SEM ($\mu\text{mol/g}$)	Nickel-SEM ($\mu\text{mol/g}$)	Zinc-SEM ($\mu\text{mol/g}$)	Σ SEM ($\mu\text{mol/g}$)	Sulfide-AVS ($\mu\text{mol/g}$)	TOC mg/kg	Σ SEM-AVS ($\mu\text{mol/g}$)	(Σ SEM-AVS)/foc ($\mu\text{mol/g}$)
Study Station											
RM603A1(X1)	603	0.0021	0.0677	0.0212	0.0341	0.1499	0.275	--	996	0.28	276.1
RM605A1(X1)	605	0.001	0.0378	0.0097	--	0.1361	0.1845	--	641	0.18	287.9
RM605A2(X8)	605	0.0056	0.0456	0.055	0.0204	1.1075	1.2342	--	4,130	1.23	298.8
RM606A1(X3)	606	--	0.0362	0.0405	--	0.8414	0.9181	--	2,730	0.92	336.3
RM616A1(X3)	616	0.0018	0.0441	0.0251	--	0.3503	0.4213	--	1,210	0.42	348.1
RM622A1(X3)	622	0.0025	0.0708	0.0473	--	0.4008	0.5214	--	1,190	0.52	438.2
RM628A1(X1)	628	--	0.0283	0.0179	--	0.1943	0.2405	0.027	1,210	0.21	176.4
RM634A1(X1)	634	0.0007	0.0346	0.0188	--	0.0964	0.1505	--	658	0.15	228.7
RM637A1(X1)	637	--	0.022	0.0101	--	0.0811	0.1132	--	366	0.11	309.4
RM640A1(X3)	640	--	0.0677	0.0642	0.1209	0.24	0.4928	--	2,110	0.49	233.5
RM640A1(X3)	640	0.0018	0.0818	0.0618	0.1107	0.4513	0.7074	0.0139	2,250	0.69	308.2
RM641A1(X1)	641	0.0214	0.2203	0.3407	0.1209	4.4975	5.2008	0.069	14,100	5.13	364
RM642A1(X1)	642	0.0302	0.2738	0.4764	--	4.0691	4.8496	0.087	7,160	4.76	665.2
RM644A1(X3)	644	0.0018	0.071	0.041	--	0.1882	0.302	0.0078	1,380	0.29	213.2
RM658A1(X3)	658	0.0052	0.1574	0.0883	0.1993	0.6394	1.0896	--	2,630	1.09	414.3
RM658A1(X3)	658	0.0076	0.62	0.077	2.5549	0.6792	3.9387	--	2,360	3.94	1669
RM661A1(X1)	661	0.0011	0.0928	0.0767	0.4514	0.4314	1.0534	--	1,360	1.05	774.6
RM676A1(X3)	676	0.0012	0.0913	0.028	0.0732	0.1698	0.3635	--	918	0.36	395.9
RM676A1(X3)	676	0.0014	0.1007	0.0343	0.0681	0.2325	0.4371	0.037	1,230	0.4	325.3
RM677A1(X3)	677	0.0047	0.1763	0.056	0.1277	0.2922	0.6569	--	5,330	0.66	123.2
RM678A1(X1)	678	0.0023	0.192	0.0454	0.8091	0.4681	1.5168	0.072	1,410	1.44	1024.7
RM680A1(X1)	680	0.0024	0.0834	0.0449	0.0511	0.4299	0.6116	--	2,710	0.61	225.7

Table 5-13. (continued)

Station	RM	Cadmium-SEM ($\mu\text{mol/g}$)	Copper-SEM ($\mu\text{mol/g}$)	Lead-SEM ($\mu\text{mol/g}$)	Nickel-SEM ($\mu\text{mol/g}$)	Zinc-SEM ($\mu\text{mol/g}$)	Σ SEM ($\mu\text{mol/g}$)	Sulfide-AVS ($\mu\text{mol/g}$)	TOC mg/kg	Σ SEM-AVS ($\mu\text{mol/g}$)	(Σ SEM-AVS)/foc ($\mu\text{mol/g}$)
Study Station											
RM686A1(X3)	686	0.0011	0.0378	0.0208	0.0123	0.1652	0.2371	--	644	0.24	368.1
RM687A1	687	0.0391	0.5051	2.1718	0.0937	8.9491	11.7588	--	16,700	11.76	704.1
RM689A1(X3)	689	0.0038	0.1558	0.0714	0.0647	0.618	0.9138	0.0218	3,870	0.89	230.5
RM692A1(X1)	692	0.0008	--	0.0125	0.0078	--	0.0211	--	353	0.02	59.9
RM692A1(X1)	692	0.0009	--	0.015	0.0095	0.1637	0.1891	--	391	0.19	483.5
RM698A1(X1)	698	0.0356	2.0143	1.168	0.1192	10.2799	13.617	--	21,700	13.62	627.5
RM704A1(X1)	704	0.0098	0.2172	0.2042	0.0766	1.4273	1.935	--	8,000	1.94	241.9
RM706A1(X1)	706	0.0302	1.0182	1.1728	0.1039	11.8097	14.1348	0.127	19,600	14.01	714.7
RM706A2(X7)	706	0.002	0.1967	0.0569	0.0511	0.5584	0.8652	0.79	29,100	0.08	2.6
RM708A1(X3)	708	0.016	0.8702	0.695	0.0681	10.387	12.0364	0.375	14,700	11.66	793.3
RM713A1(X3)	713	0.0142	0.4532	0.584	--	5.1553	6.2067	0.16	9,320	6.05	648.8
RM713A1(X3)	713	0.0151	1.0056	0.8301	1.8055	6.5015	10.1577	0.084	8,710	10.07	1156.6
RM723A1(X1)	723	0.0178	0.9662	0.4778	0.0647	7.5723	9.0988	0.2873	3,750	8.81	2349.7
RM723A2(X3)	723	0.0214	1.7782	0.9363	0.7767	17.8981	21.4107	0.034	14,400	21.38	1484.5
RM724A1(X1)	724	0.0081	0.8482	0.3538	0.2129	8.2913	9.7142	1.7	10,700	8.01	749
RM724A2(X3)	724	0.016	5.0042	0.7867	0.0477	77.5	83.3546	12.3	6,350	71.05	11189.7
RM727A1(X1)	727	0.0187	1.3895	0.8977	0.0698	14.2573	16.6331	0.067	6,890	16.57	2404.4
RM727A1(X1)	727	0.016	1.5359	0.8784	--	16.2154	18.6457	0.084	6,600	18.56	2812.4
RM729A1(X1)	729	--	1.7625	0.3494	--	17.8981	20.01	0.34	2,630	19.67	7479.1
RM730A1	730	0.024	4.1387	1.2452	--	88.5	93.9079	2.1	1,540	91.81	59615.5
RM733A1(X1)	733	0.0205	5.3032	2.5097	--	101.2697	109.1031	0.69	3,830	108.41	28306.3
RM734A1	734	0.0196	3.9027	0.6805	0.0221	76.3347	80.9596	25	609	55.96	91887.7

Table 5-13. (continued)

Station	RM	Cadmium-SEM ($\mu\text{mol/g}$)	Copper-SEM ($\mu\text{mol/g}$)	Lead-SEM ($\mu\text{mol/g}$)	Nickel-SEM ($\mu\text{mol/g}$)	Zinc-SEM ($\mu\text{mol/g}$)	Σ SEM ($\mu\text{mol/g}$)	Sulfide-AVS ($\mu\text{mol/g}$)	TOC mg/kg	Σ SEM-AVS ($\mu\text{mol/g}$)	(Σ SEM-AVS)/foc ($\mu\text{mol/g}$)
Study Station											
RM736A1(X1)	736	0.0151	1.3345	0.7867	0.5996	13.8749	16.6107	0.61	6,280	16	2547.9
RM737A1(X3)	737	0.0222	13.8325	0.6419	0.3662	171.3324	186.1953	2.5	1,440	183.7	127566.1
RM738A1(X3)	738	0.0133	--	0.0555	0.448	125.5928	126.1096	1.394	3,250	124.72	38374
RM739A1(X3)	739	0.016	1.5894	0.4537	0.2265	14.9304	17.216	2.1	5,690	15.12	2656.6
RM740A1(X1)	740	0.0081	1.8569	0.4078	1.223	15.1752	18.671	1.0584	5,430	17.61	3243.6
RM741A1(X3)	741	0.0066	3.0529	0.5792	0.0443	29.8302	33.5131	3.7	4,310	29.81	6917.2
RM742A1(X1)	742	0.0084	5.2718	0.7915	0.0477	54.9182	61.0375	4.7	896	56.34	62876.7
RM742A2(X5)	742	--	6.8454	0.6178	0.0409	84.5954	92.0995	11.642	1,430	80.46	56264
RM743A1(X1)	743	0.0125	2.9742	0.806	0.063	29.3713	33.227	0.9646	7,020	32.26	4595.8
RM743A2(X3)	743	0.0081	3.6352	0.6178	0.0443	31.5129	35.8182	2.6	2,460	33.22	13503.3
RM744A1(X1)	744	0.0048	3.9814	0.6322	0.0477	39.6206	44.2867	0.047	4,000	44.24	11059.9
RM744A2(X3)	744	--	15.4062	0.7095	0.0784	152.6694	168.8634	--	1,120	168.86	150770.9
Reference Station^a											
RM685R1	685	0.0029	0.0504	0.0208	--	0.1622	0.2362	--	31,800	0.24	7.4
RM686R1	686	--	0.0315	0.0092	--	0.101	0.1416	--	15,200	0.14	9.3
RM705R1	705	0.0011	0.0818	0.0169	0.0221	0.2646	0.3866	0.012	21,400	0.37	17.5
RM721R1	721	0.0047	0.1165	0.0531	0.0477	0.3733	0.5952	7.2	28,500	--6.6	--231.7
RM721R1	721	0.0036	0.2219	0.0512	0.7137	0.4253	1.4156	3.4	20,300	--1.98	--97.8
RM726R1	726	0.0069	0.3541	0.1071	0.7988	0.4069	1.6738	--	39,100	1.67	42.8
RM732R1	732	0.0133	0.0551	0.1062	0.138	0.488	0.8006	--	25,700	0.8	31.2

Notes: foc (fraction of organic carbon) Represents Normalization for Sediment TOC

^a RM685 = Cheweka Creek, RM686 = Barnaby Creek, RM705 = Nancy Creek, RM721 = Flat Creek, RM726 = Crown Creek, RM732 = Fivemile Creek

Table 5-14. Results of Sediment Toxicity Bioassays of UCR Bulk Sediments

Location	Little Dalles	French Pt. Rocks	Castle Rock	Swawilla Basin	Spokane River Arm	Sanpoil River Arm	Lab Control
Sampling Date (1989)	Aug. 16	Aug. 16	Aug. 15	Aug. 17	Aug. 15	Aug. 14	NA
River Mile	728.1	692.2	645	604.9	7.8	3.9	NA
Depth (ft)	40	87	80	80	80	80	NA
<i>Daphnia</i> , % survival ^b							
Elutriate ^c	84	86	88	90	98	78	96
solid phase ^d	100	100	73 ^a	92 ^a	99	96	99
<i>Hyalella</i> , % survival ^b							
solid phase ^d	88	90	80 ^a	70 ^a	86	90	96
Microtox, light output (EC50, n=3)	>100	77	>100	>100	57	>100	--

Source: Johnson, pers. Comm. (1991)

Notes: -- = no data available

NA = Not applicable.

^a Stated by the author to be significantly different from control

^b Mean % survival, n=5 replicates at 20 animals each

^c Elutriates were prepared by mixing a 1:4 ratio of sediment and water for 30 minutes, letting settle overnight, and decanting the elutriate for the bioassay

^d bulk sediment

Table 5-15. Sediment Toxicity Test Results Reported by Bortleson et al. (2001)

Site Name ^a	River Mile	<i>H. azteca</i>		<i>C. dubia</i>				Microtox EC50 (%)
		7-day survival (%)		7-day survival (%)		7-day neonates produced per female		
		Mean	SD	Mean	SD	Mean	SD	
Grand Couleee Dam RB	596	83.3	5.8	80	NR	13.6	10.7	0.63
Swawilla Basin LB	605	--	--	--	--	--	--	0.88
Keller Ferry RB	612	--	--	--	--	--	--	1.90
Sanpoil R. MS	616	60	26.5	90	NR	22.3	9.7	2.84
Whitestone Crk. MS	621	96.7	5.8	100	NR	17.3	6.9	0.17
Seven Bays RB	634	93.3	11.6	100	NR	23.6	6.2	0.37
Spokane R MS	639	--	--	--	--	--	--	0.18
Spokane R. LB	639	100	0	100	NR	22.1	3.1	0.90
Fort Spokane	640	--	--	--	--	--	--	0.95
Ninemile Creek RB	648	--	--	--	--	--	--	1.20
Hunters LB	662	90	10	100	NR	35.6	7	0.50
Gifford MS	676	--	--	--	--	--	--	0.20
Cheweka Crk LB	681	--	--	--	--	--	--	1.90
French Point Rocks MS	691	96.7	5.8	70	NR	27.7	15.5	0.81
Haag Cove RB	697	--	--	--	--	--	--	5.60
Colville R. MS	700	80	17.3	70	NR	31.9	12.6	1.20
West Kettle Falls LB	702	--	--	--	--	--	--	1.90
Kettle R. RB1	707	86.7	5.8	50	NR	19.4	19	1.80
Marcus Island MS	708	80	10	70	NR	23.2	18.2	5.10
Summer Island RB1 & RB2	710	73.3	20.8	90	NR	33.2	5	6.24
Bossborg RB	717	76.7	5.8	90	NR	29.2	4.8	2.10
China Bend RB	724	86.7	5.8	100	NR	38.7	2.8	11.00
Onion Crk. LB	730	86.7	5.8	90	NR	33.3	16.9	--
Fivemile Crk. LB	733	73.3	25.2	80	NR	29	10.2	--
Goodeve Crk. RB	738	56	11.6	80	NR	18.4	8.7	2.47
Auxiliary LB	743	10	10	40	NR	1.8	3	--
Boundary LB	745	30	10	0	NR	0	0	--
Pend D'Oreille R. LB	746	96.7	5.8	90	NR	36	12.6	--
Kootenay R. MS	775	76.7	25.2	80	NR	30.9	12.7	0.44
Lower Arrow Lake, Canada LB1	785	90	10	100	NR	31.2	5.5	--
Lower Arrow Lake, Canada LB2	786	86.7	5.8	90	NR	30.8	14.2	--
Laboratory Control 1	790	96.7	5.8	90	NR	14.8	10.2	--
Laboratory Control 2	790	86.6	5.8	90	NR	33.3	12.8	--
Laboratory Control 3	790	95	7.1	--	--	--	--	--

Source: Bortleson et al. (2001)

Notes: NR = Not reported by authors
SD = One standard deviation

Values represent percentage dilutions. Geometric means were calculated when Bortleson et al. (2001) reported replicate measurements for a site. When a replicate measurement was reported for the site as being nontoxic (e.g., Summer Island RB2), it was set equal to the highest dilution tested: 10%, for calculating the geometric mean. Data for two tributaries indicated to be "minor" were not included. All data shown reflect Microtox response in fine-grained sediments.

^a RB = sample collected at right bank; LB = collected at left bank; MS = collected at midstream. Numbers represent sample replicates.

Table 5-16. Toxicity of UCR Sediments to *Chironomus dilutus* (formerly *tentans*), *Hyalella azteca*, and *Vibrio fischeri*

Site Name	River Mile	<i>H. azteca</i>	<i>C. dilutus</i>	
		10-day survival (%)	20-day survival (%)	20-day, growth ^a , surviving organisms only
Lower Arrow Lake	782	71.3 ± 22.3	76.3 ± 10.6	1.18 ± 0.15
Boundary	745	66.3 ± 21.3	70.0 ± 12.0	1.05 ± 0.19
Auxiliary Gauge	743	56.3 ± 15.1	2.5 ± 4.6	1.08 ± 1.36
Goodeve Creek	738	50.0 ± 15.1	0.0 ± 0.0	0.00 ± 0.0
Kettle River	707/4.3 ^b	68.8 ± 28.0	51.3 ± 36.4	2.23 ± 1.15
Castle Rock	645	72.5 ± 12.8	62.5 ± 10.4	1.55 ± 0.34
Whitestone Creek	621	92.5 ± 11.6	55.0 ± 20.0	1.36 ± 0.18
Sanpoil River	616/7.2	70.0 ± 19.3	53.8 ± 27.7	1.09 ± 0.18
Swawilla Basin	605	75.0 ± 16.0	60.0 ± 16.0	1.25 ± 0.28
Grand Coulee Dam	596	71.3 ± 17.3	63.8 ± 23.3	1.57 ± 0.52

Notes:

^a Values shown represent milligrams dry weight (mg dw).

^bThe value to right of the slash is assumed to denote the distance up into the arm from the centerline of Lake Roosevelt.

Table 5-17. Results of Sediment Toxicity Tests Conducted in the UCR by EPA in 2005

Study Station	RM	<i>C. dubia</i>				<i>C. dilutus</i>				<i>H. azteca</i>			
		Average Survival (%)	SD Survival (%)	Average Young/Female	SD, Young/Female	Average Growth (mg)	SD Growth (mg)	Average Survival (%)	SD Survival (%)	Average Growth (mg)	SD Growth (mg)	Average Survival (%)	SD Survival (%)
RM603A1(X1)	603	100	0	12	3	1.9	0.25	71.3	9.9	0.32	0.05	96.3	7.4
RM605A1(X1)	605	100	0	25.8	3.6	1.81	0.7	77.5	17.5	0.49	0.07	92.5	8.9
RM605A2(X8)	605	90	31.6	23.3	9.3	1.85	0.25	81.3	9.9	0.33	0.05	93.8	7.4
RM606A1(X3)	606	100	0	25.4	3.6	2.04	0.94	72.5	27.6	0.42	0.07	93.8	7.4
RM616A1(X3)	616	100	0	25.3	3.5	2.22	0.8	83.8	9.2	0.48	0.07	96.3	7.4
RM622A1(X3)	622	100	0	23.5	3.4	1.82	0.28	77.5	13.9	0.52	0.09	95	10.7
RM628A1(X1)	628	70	48.3	18.6	11.2	1.93	0.44	87.5	11.7	0.52	0.05	83.8	25.6
RM634A1(X1)	634	60	51.7	8.2	8.2	1.92	0.62	80	15.1	0.37	0.05	91.3	8.3
RM637A1(X1)	637	100	0	28.5	3.3	1.79	0.38	77.5	10.4	0.45	0.05	96.3	5.2
RM640A1(X3)	640	90	31.6	13.2	5.3	2.52	0.54	60	23.9	0.4	0.07	96.3	7.4
RM641A1(X1)	641	100	0	25.6	5	1.93	0.3	86.3	15.1	0.35	0.06	95	7.6
RM642A1(X1)	642	100	0	20.8	8.2	1.97	0.28	66.3	30.2	0.3	0.06	96.3	7.4
RM644A1(X3)	644	100	0	16.1	3.2	1.82	0.57	70	23.9	0.34	0.06	92.5	17.5
RM658A1(X3)	658	100	0	18	4.7	1.78	0.43	80	14.1	0.41	0.04	98.8	3.5
RM661A1(X1)	661	100	0	23.3	4.9	1.84	0.23	81.3	8.3	0.35	0.03	97.5	4.6
RM676A1(X3)	676	100	0	19.2	5.1	2.1	0.62	46.3	27.2	0.35	0.03	92.5	11.6
RM677A1(X3)	677	100	0	22.9	4.4	1.99	0.35	42.5	24.3	0.28	0.09	90	14.1
RM678A1(X1)	678	100	0	26.9	4.6	1.93	0.57	71.3	18.9	0.33	0.07	97.5	4.6
RM680A1(X1)	680	90	31.6	20.7	6.4	2.17	0.52	38.8	25.9	0.33	0.09	96.3	7.4
RM686A1(X3)	686	80	42.2	20.5	11.7	1.83	0.29	72.5	19.8	0.59	0.14	93.8	9.2
RM687A1	687	90	31.6	20.1	7.5	1.62	0.36	73.8	17.7	0.27	0.06	93.8	10.6
RM689A1(X3)	689	90	31.6	22	8.5	2.37	0.79	50	26.7	0.37	0.06	93.8	5.2
RM692A1(X1)	692	100	0	27	2.2	1.83	0.28	72.5	16.7	0.41	0.08	95	5.3
RM698A1(X1)	698	80	42.2	19.8	10.8	1.75	0.56	67.5	24.3	0.29	0.04	96.3	7.4
RM704A1(X1)	704	100	0	25	2.8	2.02	1.01	62.5	26.6	0.38	0.06	96.3	5.2
RM706A1(X1)	706	80	42.2	18.7	8.8	1.69	0.24	68.8	22.3	0.31	0.05	95	7.6
RM706A2(X7)	706	80	42.2	23	5.6	2.05	0.53	55	25.6	0.33	0.05	95	5.3
RM708A1(X3)	708	70	48.3	23.8	9.3	1.65	0.33	70	22.7	0.34	0.05	92.5	7.1
RM713A1(X3)	713	100	0	21.4	6.1	2.23	0.7	75	20.7	0.33	0.05	100	0
RM723A1(X1)	723	100	0	27.5	5.4	2.14	0.36	83.8	11.9	0.65	0.04	96.3	5.2
RM723A2(X3)	723	100	0	25	4.7	1.96	0.41	83.8	10.6	0.42	0.07	95	7.6
RM724A1(X1)	724	100	0	26.8	2.7	2.13	0.79	56.3	19.2	0.37	0.05	98.8	3.5
RM724A2(X3)	724	100	0	25.8	3.4	2.44	0.69	65	22.7	0.64	0.1	95	7.6
RM727A1(X1)	727	90	31.6	22.2	8.4	1.74	0.2	92.5	11.7	0.41	0.03	97.5	4.6
RM729A1(X1)	729	100	0	25.8	5.1	2.01	0.27	90	7.6	0.45	0.06	92.5	7.1
RM730A1	730	100	0	23.1	6.1	1.96	0.24	82.5	14.9	0.34	0.05	86.3	10.6
RM733A1(X1)	733	100	0	26.8	4.4	1.76	0.24	83.8	13	0.5	0.09	91.3	11.3
RM734A1	734	90	31.6	22.5	8.4	1.61	0.29	81.3	8.3	0.23	0.06	86.3	10.6

Table 5-17. Results of Sediment Toxicity Tests Conducted in the UCR by EPA in 2005

Study Station	RM	<i>C. dubia</i>				<i>C. dilutus</i>				<i>H. azteca</i>			
		Average Survival (%)	SD Survival (%)	Average Young/Female	SD, Young/Female	Average Growth (mg)	SD Growth (mg)	Average Survival (%)	SD Survival (%)	Average Growth (mg)	SD Growth (mg)	Average Survival (%)	SD Survival (%)
RM736A1(X1)	736	70	48.3	18.9	11.1	1.94	0.29	81.3	11.3	0.34	0.04	88.8	11.3
RM737A1(X3)	737	50	52.7	3.7	7.6	1.47	0.26	82.5	17.5	0.19	0.04	90	13.1
RM738A1(X3)	738	0	0	0	0	1.14	0.27	67.5	14.9	0.18	0.03	86.3	13
RM739A1(X3)	739	100	0	21.6	4.3	2.04	0.22	72.5	12.8	0.46	0.06	91.3	6.4
RM740A1(X1)	740	100	0	23	5.7	2.08	0.35	75	10.7	0.51	0.1	97.5	4.6
RM741A1(X3)	741	100	0	24.8	2.8	2.18	0.82	67.5	26	0.46	0.06	80	12
RM742A1(X1)	742	100	0	10	8.9	1.18	0.28	82.5	15.8	0.27	0.07	88.8	11.3
RM742A2(X5)	742	90	31.6	19	9.1	1.31	0.37	73.8	20	0.32	0.04	95	5.3
RM743A1(X1)	743	90	31.6	25.8	3.6	1.6	0.32	82.5	14.9	0.49	0.07	91.3	8.3
RM743A2(X3)	743	100	0	20	4.4	1.43	0.29	80	17.7	0.32	0.08	81.3	8.3
RM744A1(X1)	744	80	42.2	22.6	8.2	1.98	0.35	61.3	13.6	0.35	0.04	83.8	13
RM744A2(X3)	744	80	42.2	18.5	10.7	1.31	0.31	76.3	11.9	0.17	0.05	75	9.3
Reference Stations ^a													
RM685R1	685	100	0	21.6	3.9	2.03	0.31	72.5	12.8	0.53	0.07	98.8	3.5
RM685R1	685					1.91	0.22	88.8	12.5	0.47	0.06	95	7.6
RM686R1	686	80	42.2	20.2	11.3	1.94	0.41	70	16.9	0.41	0.02	96.3	5.2
RM686R1	686	100	0	26.5	2.5	2.15	0.47	75	15.1	0.42	0.06	93.8	14.1
RM705R1	705	90	31.6	25.3	9.8	2.2	0.19	75	14.1	0.53	0.04	97.5	4.6
RM705R1	705	100	0	23.5	5.5	2.12	0.39	70	16.9	0.58	0.05	96.3	7.4
RM721R1	721	80	42.2	19.7	8.5	1.94	0.33	81.3	15.5	0.39	0.04	97.5	4.6
RM721R1	721	100	0	23.6	6.2	1.93	0.2	66.3	11.9	0.43	0.03	100	0
RM726R1	726	90	31.6	21.7	10.1	1.98	0.26	81.3	12.5	0.52	0.09	97.5	4.6
RM726R1	726	100	0	23.8	5.5	2	0.32	67.5	11.7	0.58	0.05	96.3	5.2
RM732R1	732	90	31.6	22.2	7.6	1.96	0.24	78.8	17.3	0.5	0.05	95	5.3
RM732R1	732	100	0	22.1	6.4	1.95	0.25	70	7.6	0.58	0.04	96.3	5.2

Notes: SD = Standard deviation

^aRM685 = Cheweka Creek, RM686 = Barnaby Creek, RM705 = Nancy Creek, RM721 = Flat Creek, RM726 = Crown Creek, RM732 = Fivemile Creek

Table 5-18. Summary of Fish Tissue Residue Studies Conducted in the UCR

Collection Dates	Organization/Reference	UCR Collection Areas (River Mile)	Species	Sample Types	Chemical Analyses			
					Metals (including Hg)	Pesticides	Dioxins /Furans	PCBs
1969 - 1986	(USGS 2006)	Grand Coulee	largescale sucker, bridgelip sucker, carp, channel catfish, black crappie, longnose sucker, chiselmouth, largemouth bass, smallmouth bass, mountain whitefish, peamouth, northern squawfish, walleye, white crappie, yellow perch	whole body composites (5 per composite)	X	X		X
September 5, 1984	Ecology (Hopkins et al. 1985)	Northport	bridgelip sucker	fillet composites (number per composite unspecified)	X	X		X
September 23 – 26, 1986	Ecology (Johnson et al. 1988)	Northport (732) Gifford (680) Seven Bays (635)	largescale sucker walleye, lake whitefish, rainbow trout, yellow perch, white sturgeon	whole body individuals muscle tissue from individuals	X			
May 27 – July 18, 1989	Ecology (Johnson et al. 1989)	Marcus Island Colville River	white sturgeon, walleye	muscle tissue (individuals)	X (Hg only)		X	
June 26 – 28, 1990	Ecology (Johnson et al. 1991a)	Northport (733) China Bend (722) Marcus Island (709) French Pt. Rocks (697) Hunters (661) Grand Coulee (600)	largescale sucker	whole body composites (5 per composite)		X	X	X
May – October 1990	Ecology (Johnson et al. 1991b)	Northport to Kettle Falls (700 – 735) Seven bays to Spring Canyon (600-673)	walleye, rainbow trout, white sturgeon, lake whitefish, kokanee, burbot	muscle tissue composites (4-5 per composite) liver and egg samples (individuals)			X	
October 6, 1993	Ecology (Serdar et al. 1994)	Kettle Falls Kettle Falls Northport	lake whitefish largescale suckers	muscle tissue composites (4-5 per composite) egg samples (individuals) whole body (individuals)			X	
					X			

Table 5-18 (continued)

Collection Dates	Organization/Reference	UCR Collection Areas (River Mile)	Species	Sample Types	Chemical Analyses			
					Metals (including Hg)	Pesticides	Dioxins /Furans	PCBs
May – June 1994	USGS (Munn et al. 1995)	Northport to Kettle Falls Spokane River to Grand Coulee	walleye, rainbow trout, smallmouth bass	fillet (individuals) fillet composites (2-8 per composite)	X			
July 11 – August 7, 1994	(EVS 1998)	Northport Kettle Falls Seven Bays Spring Canyon	kokanee, lake whitefish, rainbow trout, smallmouth bass, walleye, white sturgeon	fillet w/ skin fillet w/out skin dorsal muscle w/out skin scaled w/ skin composites (4-8 per composite) and individuals			X	X
November 1997	USGS (Hinck et al. 2004)	Northport Grand Coulee	largescale sucker, walleye, rainbow trout	whole body composites (2-10 per composite)	X	X		X ^a
Summer and Fall 1998	USGS (Munn 2000)	Northport to Kettle Falls Spokane River to Grand Coulee	walleye, rainbow trout, mountain whitefish	fillet (individuals)	X (Hg only)		X	X ^a
September – October 2005	USEPA (2005d, 2006e)	Above Northport (735-741) Below Northport (720– 734) Above Kettle Falls (702-707) Inchelium (673-689) Seven Bays (633-637) Above Spring Canyon (601-610)	burbot, largescale sucker, lake whitefish, mountain whitefish, walleye, rainbow trout	whole body composites (3-5 per composite) fillet and offal composites (3-5 per composite) whole body composites w/out gi tract (3-5 per composite) GI tract composites (3-5 per composite)	X		X	X ^a

Notes:^a Includes PCB Congeners.

Table 5-19. Summary of Historical Measurements of Inorganic and Organic Compounds in UCR Fish Tissues

Species	Sample Type ^a	Reference	Collection Year(s)	Inorganics (mg/kg-ww)						Dioxins/Furans (ng/kg-ww)		PCB Aroclors (ug/kg-ww)		
				As	Cd	Cu	Hg	Pb	Se	Zn	2,3,7,8-TCDD	2,3,7,8-TCDF	Aroclor 1254	Aroclor 1260
Black Crappie	WB-C	USGS 2006	1969-1986	6 (<0.05-0.5) ^b	6 (<0.01-0.14)	3 (0.27-0.54)	7 (0.05-0.27)	6 (<0.01-0.19)	3 (0.4-0.56)	3 (26.9-33.0)	n/a	n/a	7 (<50-900)	4 (<50-100)
Bridgelip Sucker	WB-C	USGS 2006	1969-1986	3 (0.18-0.27)	3 (0.07-0.28)	n/a	5 (0.02-0.12)	3 (0.53-1.0)	3 (0.2-0.26)	n/a	n/a	n/a	7 (<100-700)	4 (<100-4800)
	F-C	Hopkins et al. 1985	1984	2 (<0.03)	2 (0.1-0.71)	2 (1.8-2.1)	2 (0.05-0.07)	2 (4.3-8.1)	n/a	2 (29.0-30.5)	n/a	n/a	n/a	2 (90-97)
Burbot	M-C	Johnson et al. 1991b	1990	n/a	n/a	n/a	n/a	n/a	n/a	n/a	2 (<0.1-<0.1)	2 (2.7-2.9)	n/a	n/a
Carp	WB-C	USGS 2006	1969-1986	17 (<0.05-0.35)	17 (<0.05-1.8)	4 (1.11-1.42)	20 (<0.01-0.24)	17 (<0.1-0.4)	9 (0.22-0.99)	4 (75.4-112.4)	n/a	n/a	24 (<100-1900)	13 (<100-300)
Channel Catfish	WB-C	USGS 2006	1969-1986	5 (<0.05-0.61)	5 (<0.05-0.13)	n/a	7 (0.08-0.9)	5 (<0.1-0.21)	2 (0.07-0.18)	n/a	n/a	n/a	8 (<100-1400)	3 (<100-500)
Chiselmouth	WB-C	USGS 2006	1969-1986	2 (0.11 - 0.14)	2 (0.04-0.11)	2 (1.17-1.33)	2 (0.02-0.03)	2 (0.15-0.19)	2 (0.37-0.51)	2 (33.5-35.1)	n/a	n/a	2 (100-200)	2 (<100-200)
Kokanee	M-C	Johnson et al. 1991b	1990	n/a	n/a	n/a	n/a	n/a	n/a	n/a	2 (0.7-0.9)	2 (42.1-63.3)	n/a	n/a
	F-I	EVS 1998	1994	n/a	n/a	n/a	n/a	n/a	n/a	n/a	8 (<0.08-<0.16)	8 (1.78-6.74)	8 (26.6-85.4)	8 (9.9-19.3)
	F-C	EVS 1998	1994	n/a	n/a	n/a	n/a	n/a	n/a	n/a	4 (<0.1-<0.13)	4 (2.76-3.13)	4 (27.8-37.7)	4 (9.7-13.9)
Lake Whitefish	M-I	Johnson et al. 1988	1986	3 (<0.02-0.28)	3 (<0.01-0.01)	3 (0.44-0.6)	3 (0.07-0.12)	3 (0.03-0.04)	n/a	3 (3.4-4.5)	n/a	n/a	n/a	n/a
	M-C	Johnson et al. 1991b	1990	n/a	n/a	n/a	n/a	n/a	n/a	n/a	12 (0.5-2.7)	12 (41.6-205)	n/a	n/a
	M-C	Serdar et al. 1994	1990-1993	n/a	n/a	n/a	n/a	n/a	n/a	n/a	18 (0.18-2.3)	18 (2.6-157)	n/a	n/a
	F-C	EVS 1998	1994	n/a	n/a	n/a	n/a	n/a	n/a	n/a	3 (<0.06-<0.14)	3 (3.78-15.6)	3 (35.2-50.6)	3 (16.1-40)
	F-I	EVS 1998	1994	n/a	n/a	n/a	n/a	n/a	n/a	n/a	8 (<0.07-<1.41)	8 (1.6-125.9)	8 (13-156)	8 (5.3-38.8)
	M-I	EVS 1998	1994	n/a	n/a	n/a	n/a	n/a	n/a	n/a	5 (<0.13-<1.37)	5 (3.25-6.77)	n/a	n/a
	M-C	EVS 1998	1994	n/a	n/a	n/a	n/a	n/a	n/a	n/a	5 (<0.12-0.67)	5 (0.3-64)	5 (18.8-81.8)	5 (6.5-28.3)
Largemouth Bass	WB-C	USGS 2006	1969-1986	1 (<0.05)	1 (<0.05)	n/a	1 (0.18)	1 (<0.1)	1 (0.1)	n/a	n/a	n/a	1 (<100)	1 (<100)
Largescale Sucker	WB-C	USGS 2006	1969-1986	45 (<0.05-0.61)	45 (<0.003-0.6)	23 (<0.43-3.57)	49 (<0.01-0.3)	45 (0.3-2.57)	33 (0.06-0.55)	23 (14.1-60.1)	n/a	n/a	55 (<50-3000)	38 (<50-300)
	WB-I	Johnson et al. 1988	1986	12 (<0.02-0.3)	12 (0.22-0.43)	12 (0.62-6.4)	12 (0.08-0.25)	12 (0.24-7.34)	n/a	12 (20.9-86.7)	n/a	n/a	n/a	n/a
	WB-C	Johnson et al. 1991a	1990	n/a	n/a	n/a	n/a	n/a	n/a	n/a	6 (0.92-2.6)	6 (16.8-48.1)	n/a	n/a
	WB-I	Serdar et al. 1994	1993	n/a	30 (0.23-1.0)	30 (0.74-20.1)	30 (0.07-0.35)	30 (1.7-23.3)	n/a	30 (15.5-136)	n/a	n/a	n/a	n/a
WB-C	Hinck et al. 2004	1997	4 (<0.21-0.52)	4 (0.31-0.46)	4 (1.24-3.46)	4 (0.08-0.15)	4 (0.68-9.29)	4 (<0.26-0.31)	4 (34.8-50.9)	n/a	n/a	n/a	n/a	
Longnose Sucker	WB-C	USGS 2006	1969-1986	2 (0.07-0.09)	2 (0.05-0.06)	2 (1.1-2.2)	2 (0.03-0.04)	2 (0.14-0.24)	2 (0.22-0.25)	2 (17.5-19.5)	n/a	n/a	2 (<50)	2 (<50)
Mountain Whitefish	WB-C	USGS 2006	1969-1986	1 (0.12)	1 (0.07)	1 (0.59)	2 (0.06-0.19)	1 (0.1)	1 (0.47)	1 (18.8)	n/a	n/a	2 (100-800)	1 (100)
	F-I	Munn 2000	1998	n/a	n/a	n/a	n/a	n/a	n/a	n/a	5 (0.04-0.12)	5 (0.87-6.26)	n/a	n/a
Northern Squawfish	WB-C	USGS 2006	1969-1986	14 (<0.05-0.31)	14 (0.01-1.7)	2 (0.6)	16 (<0.01-1.2)	14 (<0.1-0.3)	11 (0.11-0.4)	2 (24-30)	n/a	n/a	19 (<100-4600)	8 (<100-1200)
Peamouth	WB-C	USGS 2006	1969-1986	2 (0.07-0.08)	2 (0.03)	2 (0.75-1.08)	2 (0.02-0.03)	2 (0.05-0.09)	2 (0.45-0.47)	2 (19.7-24.6)	n/a	n/a	2 (100)	2 (<100-100)
Rainbow Trout (wild)	M-I	Johnson et al. 1988	1986	2 (<0.02-0.12)	2 (0.01-0.04)	2 (0.4-0.44)	2 (0.04)	2 (0.05-0.07)	n/a	2 (4.6-5.5)	n/a	n/a	n/a	n/a
	M-C	Johnson et al. 1991b	1990	n/a	n/a	n/a	n/a	n/a	n/a	n/a	12 (<0.1-1.6)	12 (3.7-53.2)	n/a	n/a
	F-C	Munn et al. 1995	1994	6 (<0.1)	6 (<0.03)	6 (0.28-0.68)	6 (0.16-0.24)	6 (<0.05-0.1)	6 (<0.2-0.37)	6 (4.1-15.8)	n/a	n/a	n/a	n/a
	F-C	EVS 1998	1994	n/a	n/a	n/a	n/a	n/a	n/a	n/a	7 (<0.04-<0.23)	7 (0.09-1.89)	7 (15.2-49.1)	7 (6.3-71.8)
	F-I	EVS 1998	1994	n/a	n/a	n/a	n/a	n/a	n/a	n/a	24 (<0.07-<0.24)	24 (0.22-7.1)	16 (9.2-68.7)	16 (4.7-164)
	WB-C	Hinck et al. 2004	1997	2 (<0.31)	2 (<0.06)	2 (1.1-1.11)	2 (<0.06)	2 (0.22-0.29)	2 (0.42-0.43)	2 (19.5-22.9)	n/a	n/a	n/a	n/a
Smallmouth Bass	F-I	Munn 2000	1998	n/a	n/a	n/a	n/a	n/a	n/a	n/a	16 (<0.01-0.1)	16 (0.2-2.03)	16 (8.8-49)	16 (2.4-39)
	WB-C	USGS 2006	1969-1986	n/a	n/a	n/a	2 (0.14-0.27)	n/a	n/a	n/a	n/a	n/a	3 (<100-600)	1 (200)
	F-C	Munn et al. 1995	1994	5 (0.14)	5 (<0.03)	5 (0.36-0.41)	5 (0.17-0.62)	5 (<0.05-0.06)	5 (0.25-0.31)	5 (5.3-6.1)	n/a	n/a	n/a	n/a
F-C	EVS 1998	1994	n/a	n/a	n/a	n/a	n/a	n/a	n/a	9 (<0.09-<0.17)	9 (<0.15-4.1)	9 (4.7-7.9)	9 (2.6-7.2)	
Walleye	WB-C	USGS 2006	1969-1986	9 (<0.03-0.22)	9 (0.03-0.16)	3 (0.3-0.37)	11 (0.08-0.15)	9 (0.03-0.22)	7 (0.21-0.34)	3 (12.7-13.4)	n/a	n/a	13 (<100-3600)	7 (<100-400)
	M-I	Johnson et al. 1988	1986	11 (<0.02-0.16)	11 (<0.01-0.02)	11 (0.08-0.48)	11 (0.07-0.36)	11 (0.01-0.11)	n/a	11 (3.5-4.5)	n/a	n/a	n/a	n/a
	M-I	Johnson 1989	1989	n/a	n/a	n/a	n/a	24 (0.05-0.24)	n/a	n/a	n/a	n/a	n/a	n/a
	M-I	Johnson 1990	1989	n/a	n/a	n/a	n/a	n/a	n/a	n/a	2 (0.21-4.0)	2 (8.9-326)	n/a	n/a
	M-C	Johnson et al. 1991b	1990	n/a	n/a	n/a	n/a	n/a	n/a	n/a	12 (<0.1-0.32)	12 (0.9-6.0)	n/a	n/a
	F-C	Munn et al. 1995	1994	3 (<0.1-0.12)	3 (<0.03)	3 (0.27-0.38)	34 (0.11-0.44)	3 (<0.05-0.07)	3 (0.23-0.39)	3 (4.6-5.2)	n/a	n/a	n/a	n/a
	F-C	EVS 1998	1994	n/a	n/a	n/a	n/a	n/a	n/a	n/a	11 (<0.08-0.55)	11 (0.08-1.57)	11 (3.3-88.8)	11 (3.8-31.5)
	F-I	EVS 1998	1994	n/a	n/a	n/a	n/a	n/a	n/a	n/a	8 (<0.05-<0.11)	8 (0.08-0.61)	8 (7.4-29.4)	8 (3.8-27.3)
	WB-C	Hinck et al. 2004	1997	1 (<0.25)	1 (<0.05)	1 (0.53)	1 (0.15)	1 (<0.1)	1 (0.32)	1 (14.3)	n/a	n/a	n/a	n/a
	F-I	Munn 2000	1998	n/a	n/a	n/a	16 (0.1-0.22)	n/a	n/a	n/a	n/a	n/a	n/a	n/a
White Crappie	WB-C	USGS 2006	1969-1986	2 (0.12-0.22)	2 (0.01)	2 (0.52-0.57)	2 (0.06-0.07)	2 (0.04-1.37)	2 (0.22-0.73)	2 (15.6-28.8)	n/a	n/a	3 (<100-4600)	1 (2900)
White Sturgeon	M-I	Johnson et al. 1988	1986	1 (0.24)	1 (0.01)	n/a	1 (0.12)	1 (0.04)	n/a	1 (3.4)	n/a	n/a	n/a	n/a
	M-I	Johnson 1989	1989	n/a	n/a	n/a	10 (0.02-0.1)	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	M-I	Johnson 1990	1989	n/a	n/a	n/a	n/a	n/a	n/a	n/a	2 (<0.1-2.2)	2 (3.9-221)	n/a	n/a
	M-C	Johnson et al. 1991b	1990	n/a	n/a	n/a	n/a	n/a	n/a	n/a	4 (0.8-4.4)	4 (72.5-222)	n/a	n/a
	F-C	EVS 1998	1994	n/a	n/a	n/a	n/a	n/a	n/a	n/a	2 (<0.15-<0.18)	2 (16.1-24.5)	2 (15-77)	2 (12.6-103)
Yellow Perch	WB-C	USGS 2006	1969-1986	7 (<0.03-0.25)	7 (0.01-0.07)	6 (0.34-0.56)	7 (0.03-0.05)	7 (0.02-0.16)	6 (0.34-1.16)	6 (19.1-28.5)	n/a	n/a	7 (<100-300)	7 (<50-200)
	M-I	Johnson et al. 1988	1986	1 (<0.02)	1 (0.01)	1 (1.32)	1 (0.4)	1 (0.11)	n/a	1 (9.4)	n/a	n/a	n/a	n/a

Notes: n/a = No data is available. F-I = Fillet tissue of individual fish M-I = Muscle tissue of individual fish WB-I = Whole body of individual fish
^a Sample Type coding F-C = Fillet tissue of multiple fish (composite) M-C = Muscle tissue of multiple fish (composite) WB-C = Whole body of multiple fish (composite)
^b Data is reported as the sample size (minimum - maximum measured concentration)

Table 5-21. Summary of Detected, Nondetected, and Qualified Values in the Inorganic Analyses Reported in the 2005 EPA Fish Tissue Analysis

	Al	Ag	As	Ba	Be	Ca	Cd	Co	Cr	Cu	Fe	Hg	K	Mg	Mn	Na	Ni	Pb	Sb	Se	Tl	U	V	Zn
BB	D	ND	D	D	ND	Dj	D	D	D	D	D	D	D	D	D	D	D	D	ND	D	ND	D	*	D
LS	Dj	ND	D	Dj	ND	Dj	Dj	D	Dj	Dj	D	D	D	D	Dj	D	D	Dj	*	D	ND	D	*	Dj
LW	*	ND	D	D	ND	Dj	*	Djk	Dj	D	D	D	D	D	Dj	Djk	D	D	ND	D	ND	*	*	D
MW	D	ND	D	D	ND	D	D	D	D	Dj	Dj	D	D	D	D	Dj	D	D	ND	D	ND	D	ND	Dj
RH	*	ND	*	*	ND	Dj	*	D	D	D	D	D	D	D	D	D	*	*	ND	D	ND	*	*	D
RW	*	ND	D	*	ND	Dj	*	*	D	D	D	D	D	Dj	D	D	*	*	ND	D	ND	*	*	D
WE	*	ND	D	*	ND	D	*	D	D	D	D	D	D	D	D	D	D	*	ND	D	*	*	ND	D

- Notes:** D = all samples were above detection limits
 ND = all sample for the species-element combination were below method detection limit
 Dj = all samples were above detection but some or all were reported as estimates
 Djk = all samples were above detection but some were reported as biased estimates
 * = some values were reported at the detection limit, while others were above the detection limit
 BB = burbot
 LS = largescale sucker
 LW = lake whitefish
 MW = mountain whitefish
 RH = rainbow trout, hatchery origin
 RW = rainbow trout, wild origin
 WE = walleye

Table 5-20. Description of 2005 EPA Study Design, Including Fish Collection Locations and Number of Composite Samples, Tissue Types, and Individuals Sampled

Location Description			Composite Samples					Individuals	
Collection Area	River Mile	Landmark	Whitefish	Walleye	Rainbow Trout		Burbot	Largescale Sucker	Largescale Sucker Gut (metals only)
					Hatchery	Wild			
1	741	U.S. Border - 744	5 mountain whitefish	5 fillet	none	5 fillet	0	2	5
		Black Sand Beach - ??		5 offal		5 offal			
1A	735	Big Sheep Creek- 735	none	none	none	none	none	1	5
		Northport - 734							
2	723	Marble - 726	5 lake whitefish	5	none	5	3	4	0
		China Bend - 723							
3	706	Kettle River - 706	5 lake whitefish	5 fillet	2 fillet	2 fillet	5	4	5
		Colville River - 698		5 offal		2 offal			
4	678	Gifford/Inchelium - 675	5 lake whitefish	5	5	0	4	5	0
		Stranger Creek - 675							
5	635	Spokane River - 639	5 lake whitefish	3	5	1	5	5	0
		Hawk Creek - 634							
6	605	Sanpoil River - 615	5 lake whitefish	5 fillet	4 fillet	1 fillet	5	4	5
		Spring Canyon - 599		5 offal		1 fillet			
				2 whole body	4 offal	1 offal			

Table 5-22. Summary Statistics for 2,3,7,8-TCDF, Aroclor 1254/1260, and Total PCB Congeners in Fish Tissues Collected by EPA in 2005

Analyte		Collection Area =					
		1 River Mile = 738	2 728	3 706	4 680	5 635	6 606
Burbot (whole body)							
Lipids (%)	median	-	2.20	2.30	1.00	1.40	1.60
	mean	-	1.97	2.72	0.98	1.28	1.50
	se	-	0.34	0.93	0.15	0.20	0.17
2,3,7,8-TCDF (ng/kg-ww)	median	-	5.11	3.65	4.45	3.41	3.96
	mean	-	4.85	3.42	4.44	3.00	4.15
	se	-	0.45	0.24	0.54	0.47	0.30
2,3,7,8-TCDF (ng/kg lipid)	median	-	249.09	175.22	525.10	243.33	291.88
	mean	-	255.80	179.66	494.60	233.79	288.15
	se	-	26.90	42.01	92.58	14.60	32.19
Aroclor 1254/1260 (ug/kg-ww)	median	-	27.00	28.00	24.50	26.00	21.00
	mean	-	30.00	26.87	23.25	30.40	22.80
	se	-	6.81	3.26	4.77	7.08	1.74
Aroclor 1254/1260 (ug/kg lipid)	median	-	1538.46	1120.00	3022.73	2222.22	1615.38
	mean	-	1519.13	1544.95	2639.57	2326.40	1640.58
	se	-	163.21	498.21	646.82	211.56	296.20
Total PCB Congeners (ug/kg-ww)	median	-	27.89	26.68	14.87	22.96	24.78
	mean	-	27.89	26.68	14.87	22.96	24.78
	se	-	-	-	-	-	-
Total PCB Congeners (ug/kg lipid)	median	-	1267.67	2223.07	2478.74	1640.14	2477.58
	mean	-	1267.67	2223.07	2478.74	1640.14	2477.58
	se	-	-	-	-	-	-
Walleye (whole body)							
Lipids (%)	median	2.54	2.20	3.11	3.50	3.10	3.50
	mean	2.18	2.25	3.06	3.66	3.23	3.57
	se	0.39	0.09	0.28	0.42	0.19	0.36
2,3,7,8-TCDF (ng/kg-ww)	median	1.01	1.14	1.13	2.35	1.57	2.06
	mean	1.01	1.16	1.22	2.04	1.70	2.03
	se	0.11	0.08	0.06	0.26	0.14	0.18
2,3,7,8-TCDF (ng/kg lipid)	median	110.62	52.31	54.02	46.47	50.65	74.24
	mean	125.90	51.47	61.02	59.90	53.33	75.78
	se	19.20	3.24	7.30	11.99	6.68	6.17
Aroclor 1254/1260 (ug/kg-ww)	median	24.80	27.00	10.63	18.30	28.00	27.69
	mean	25.00	31.13	10.22	18.58	27.33	31.50
	se	2.95	4.49	1.20	0.99	3.48	4.39
Aroclor 1254/1260 (ug/kg lipid)	median	2058.93	1285.71	446.76	468.57	916.67	839.18
	mean	2228.22	1392.02	758.12	532.67	842.47	809.53
	se	294.51	206.91	341.70	64.06	82.67	41.90
Total PCB Congeners (ug/kg-ww)	median	124.87	38.39	37.46	37.03	35.65	37.82
	mean	124.87	38.39	37.46	37.03	35.65	37.82
	se	121.17	-	-	-	-	-
Total PCB Congeners (ug/kg lipid)	median	4956.05	1693.89	1464.19	726.11	990.41	1248.49
	mean	4956.05	1693.89	1464.19	726.11	990.41	1248.49
	se	1589.70	-	-	-	-	-
Walleye (fillet)							
Lipids (%)	median	0.11	-	0.40	-	-	0.60
	mean	0.15	-	0.42	-	-	0.54
	se	0.03	-	0.04	-	-	0.06
2,3,7,8-TCDF (ng/kg-ww)	median	0.33	-	0.36	-	-	0.65
	mean	0.30	-	0.36	-	-	0.62
	se	0.03	-	0.02	-	-	0.06
2,3,7,8-TCDF (ng/kg lipid)	median	185.45	-	77.00	-	-	113.71
	mean	224.19	-	88.89	-	-	118.18
	se	40.77	-	11.65	-	-	13.57
Aroclor 1254/1260 (ug/kg-ww)	median	5.20	-	2.60	-	-	3.70
	mean	4.86	-	4.76	-	-	3.48
	se	0.43	-	2.31	-	-	0.49
Aroclor 1254/1260 (ug/kg lipid)	median	3200.00	-	625.00	-	-	750.00
	mean	3534.74	-	1377.33	-	-	687.38
	se	523.17	-	823.69	-	-	130.93
Total PCB Congeners (ug/kg-ww)	median	9.04	-	5.73	-	-	6.00
	mean	9.04	-	5.73	-	-	6.00
	se	0.77	-	-	-	-	-
Total PCB Congeners (ug/kg lipid)	median	5894.33	-	1433.13	-	-	1498.87
	mean	5894.33	-	1433.13	-	-	1498.87
	se	1627.72	-	-	-	-	-

Table 5-22. Summary Statistics for 2,3,7,8-TCDF, Aroclor 1254/1260, and Total PCB Congeners in Fish Tissues Collected by EPA in 2005

Analyte		Collection Area =					
		1 River Mile = 738	2 728	3 706	4 680	5 635	6 606
Walleye (offal)							
Lipids (%)	median	4.50	-	5.50	-	-	6.00
	mean	3.88	-	5.24	-	-	6.22
	se	0.70	-	0.44	-	-	0.97
2,3,7,8-TCDF (ng/kg-ww)	median	1.65	-	1.88	-	-	3.14
	mean	1.60	-	1.93	-	-	3.19
	se	0.18	-	0.07	-	-	0.45
2,3,7,8-TCDF (ng/kg lipid)	median	46.67	-	35.42	-	-	48.31
	mean	44.79	-	38.17	-	-	52.04
	se	5.53	-	4.45	-	-	3.36
Aroclor 1254/1260 (ug/kg-ww)	median	41.40	-	15.00	-	-	48.00
	mean	41.70	-	14.74	-	-	57.98
	se	5.52	-	2.57	-	-	11.36
Aroclor 1254/1260 (ug/kg lipid)	median	1151.92	-	301.59	-	-	907.69
	mean	1143.35	-	276.66	-	-	920.47
	se	110.93	-	35.22	-	-	46.82
Total PCB Congeners (ug/kg-ww)	median	452.49	-	68.76	-	-	63.02
	mean	452.49	-	68.76	-	-	63.02
	se	-	-	-	-	-	-
Total PCB Congeners (ug/kg lipid)	median	8537.46	-	1494.82	-	-	1050.26
	mean	8537.46	-	1494.82	-	-	1050.26
	se	-	-	-	-	-	-
Wild Rainbow Trout (whole body)							
Lipids (%)	median	6.58	7.60	4.70	-	8.20	3.86
	mean	7.09	7.93	4.70	-	8.20	3.86
	se	0.54	1.07	0.54	-	-	-
2,3,7,8-TCDF (ng/kg-ww)	median	1.02	3.28	1.10	-	1.84	0.97
	mean	1.50	3.14	1.10	-	1.84	0.97
	se	0.47	0.56	0.07	-	-	-
2,3,7,8-TCDF (ng/kg lipid)	median	15.72	33.21	25.91	-	22.44	30.79
	mean	20.14	46.69	25.91	-	22.44	30.79
	se	4.67	14.54	1.36	-	-	-
Aroclor 1254/1260 (ug/kg-ww)	median	27.39	27.90	12.19	-	16.00	10.37
	mean	34.04	28.41	12.19	-	16.00	10.37
	se	6.64	1.83	0.03	-	-	-
Aroclor 1254/1260 (ug/kg lipid)	median	425.92	335.53	289.80	-	195.12	322.22
	mean	495.60	383.20	289.80	-	195.12	322.22
	se	55.26	51.56	34.57	-	-	-
Total PCB Congeners (ug/kg-ww)	median	39.21	63.80	8.94	-	13.14	-
	mean	39.21	63.80	8.94	-	13.14	-
	se	-	-	-	-	-	-
Total PCB Congeners (ug/kg lipid)	median	646.12	952.24	227.05	-	160.25	-
	mean	646.12	952.24	227.05	-	160.25	-
	se	-	-	-	-	-	-
Wild Rainbow Trout (fillet)							
Lipids (%)	median	4.45	-	2.45	-	-	1.40
	mean	4.43	-	2.45	-	-	1.40
	se	0.47	-	0.35	-	-	-
2,3,7,8-TCDF (ng/kg-ww)	median	0.63	-	0.76	-	-	0.56
	mean	0.96	-	0.76	-	-	0.56
	se	0.37	-	0.08	-	-	-
2,3,7,8-TCDF (ng/kg lipid)	median	16.15	-	31.34	-	-	39.93
	mean	20.01	-	31.34	-	-	39.93
	se	5.17	-	1.23	-	-	-
Aroclor 1254/1260 (ug/kg-ww)	median	21.30	-	8.50	-	-	5.70
	mean	24.39	-	8.50	-	-	5.70
	se	3.09	-	0.30	-	-	-
Aroclor 1254/1260 (ug/kg lipid)	median	504.88	-	352.38	-	-	407.14
	mean	557.49	-	352.38	-	-	407.14
	se	53.23	-	38.10	-	-	-
Total PCB Congeners (ug/kg-ww)	median	23.15	-	5.32	-	-	-
	mean	23.15	-	5.32	-	-	-
	se	-	-	-	-	-	-
Total PCB Congeners (ug/kg lipid)	median	746.63	-	253.51	-	-	-
	mean	746.63	-	253.51	-	-	-
	se	-	-	-	-	-	-

Table 5-22. Summary Statistics for 2,3,7,8-TCDF, Aroclor 1254/1260, and Total PCB Congeners in Fish Tissues Collected by EPA in 2005

Analyte		Collection Area =					
		1 River Mile = 738	2 728	3 706	4 680	5 635	6 606
Wild Rainbow Trout (offal)							
Lipids (%)	median	9.90	-	6.70	-	-	6.30
	mean	9.84	-	6.70	-	-	6.30
	se	0.84	-	0.60	-	-	-
2,3,7,8-TCDF (ng/kg-ww)	median	1.46	-	1.41	-	-	1.37
	mean	2.07	-	1.41	-	-	1.37
	se	0.59	-	0.05	-	-	-
2,3,7,8-TCDF (ng/kg lipid)	median	15.31	-	21.08	-	-	21.75
	mean	20.30	-	21.08	-	-	21.75
	se	4.28	-	1.22	-	-	-
Aroclor 1254/1260 (ug/kg-ww)	median	35.00	-	15.50	-	-	15.00
	mean	44.04	-	15.50	-	-	15.00
	se	10.51	-	0.50	-	-	-
Aroclor 1254/1260 (ug/kg lipid)	median	342.86	-	233.89	-	-	238.10
	mean	432.91	-	233.89	-	-	238.10
	se	72.52	-	28.41	-	-	-
Total PCB Congeners (ug/kg-ww)	median	54.50	-	12.33	-	-	-
	mean	54.50	-	12.33	-	-	-
	se	-	-	-	-	-	-
Total PCB Congeners (ug/kg lipid)	median	550.51	-	202.20	-	-	-
	mean	550.51	-	202.20	-	-	-
	se	-	-	-	-	-	-
Hatchery Rainbow Trout (whole body)							
Lipids (%)	median	-	-	3.66	5.20	6.30	5.39
	mean	-	-	4.92	5.34	6.53	5.38
	se	-	-	1.39	0.22	0.75	0.09
2,3,7,8-TCDF (ng/kg-ww)	median	-	-	1.16	1.25	1.50	1.44
	mean	-	-	1.28	1.21	1.39	1.42
	se	-	-	0.22	0.08	0.11	0.18
2,3,7,8-TCDF (ng/kg lipid)	median	-	-	29.91	23.85	21.54	27.97
	mean	-	-	34.12	22.81	21.97	28.95
	se	-	-	8.83	1.77	2.28	5.10
Aroclor 1254/1260 (ug/kg-ww)	median	-	-	7.70	7.50	9.20	12.09
	mean	-	-	8.47	8.24	10.04	12.34
	se	-	-	1.03	0.95	1.90	1.45
Aroclor 1254/1260 (ug/kg lipid)	median	-	-	223.79	146.15	121.15	259.21
	mean	-	-	212.52	155.55	162.23	272.66
	se	-	-	21.77	19.59	40.45	39.79
Total PCB Congeners (ug/kg-ww)	median	-	-	15.60	11.26	9.10	17.29
	mean	-	-	15.60	11.26	9.10	17.29
	se	-	-	-	-	-	-
Total PCB Congeners (ug/kg lipid)	median	-	-	429.29	229.89	97.18	354.45
	mean	-	-	429.29	229.89	97.18	354.45
	se	-	-	-	-	-	-
Hatchery Rainbow Trout (fillet)							
Lipids (%)	median	-	-	2.00	-	-	2.35
	mean	-	-	4.97	-	-	2.41
	se	-	-	3.02	-	-	0.13
2,3,7,8-TCDF (ng/kg-ww)	median	-	-	0.73	-	-	0.82
	mean	-	-	0.85	-	-	0.80
	se	-	-	0.16	-	-	0.17
2,3,7,8-TCDF (ng/kg lipid)	median	-	-	32.65	-	-	30.92
	mean	-	-	33.44	-	-	33.21
	se	-	-	15.72	-	-	7.80
Aroclor 1254/1260 (ug/kg-ww)	median	-	-	6.10	-	-	8.03
	mean	-	-	7.03	-	-	8.14
	se	-	-	1.52	-	-	1.18
Aroclor 1254/1260 (ug/kg lipid)	median	-	-	250.00	-	-	317.55
	mean	-	-	220.65	-	-	341.95
	se	-	-	68.04	-	-	57.91
Total PCB Congeners (ug/kg-ww)	median	-	-	8.28	-	-	8.54
	mean	-	-	8.28	-	-	8.54
	se	-	-	-	-	-	-
Total PCB Congeners (ug/kg lipid)	median	-	-	435.55	-	-	388.28
	mean	-	-	435.55	-	-	388.28
	se	-	-	-	-	-	-

Table 5-22. Summary Statistics for 2,3,7,8-TCDF, Aroclor 1254/1260, and Total PCB Congeners in Fish Tissues Collected by EPA in 2005

Analyte		Collection Area = River Mile =					
		1 738	2 728	3 706	4 680	5 635	6 606
Hatchery Rainbow Trout (offal)							
Lipids (%)	median	-	-	5.00	-	-	8.75
	mean	-	-	4.87	-	-	8.74
	se	-	-	0.24	-	-	0.22
2,3,7,8-TCDF (ng/kg-ww)	median	-	-	1.59	-	-	2.17
	mean	-	-	1.71	-	-	2.11
	se	-	-	0.26	-	-	0.17
2,3,7,8-TCDF (ng/kg lipid)	median	-	-	36.14	-	-	24.33
	mean	-	-	35.08	-	-	24.30
	se	-	-	4.51	-	-	2.34
Aroclor 1254/1260 (ug/kg-ww)	median	-	-	5.00	-	-	8.75
	mean	-	-	4.87	-	-	8.74
	se	-	-	0.24	-	-	0.22
Aroclor 1254/1260 (ug/kg lipid)	median	-	-	9.70	-	-	17.10
	mean	-	-	9.93	-	-	17.03
	se	-	-	0.56	-	-	1.69
Total PCB Congeners (ug/kg-ww)	median	-	-	22.04	-	-	26.23
	mean	-	-	22.04	-	-	26.23
	se	-	-	-	-	-	-
Total PCB Congeners (ug/kg lipid)	median	-	-	423.79	-	-	319.87
	mean	-	-	423.79	-	-	319.87
	se	-	-	-	-	-	-
Whitefish (whole body)							
Lipids (%)	median	8.30	12.00	10.90	11.70	13.25	13.40
	mean	8.57	10.28	9.61	12.42	13.45	13.40
	se	0.46	2.28	1.15	0.62	0.89	0.60
2,3,7,8-TCDF (ng/kg-ww)	median	3.48	4.67	3.40	6.79	7.02	7.85
	mean	3.93	4.53	3.23	6.23	7.05	7.85
	se	0.58	0.25	0.33	0.51	0.49	0.50
2,3,7,8-TCDF (ng/kg lipid)	median	44.43	41.00	29.97	50.68	52.00	58.53
	mean	46.69	81.59	34.94	50.40	56.55	58.53
	se	7.18	43.20	4.36	3.98	6.21	1.11
Aroclor 1254/1260 (ug/kg-ww)	median	55.70	15.00	15.00	17.30	28.10	34.25
	mean	53.11	16.28	16.03	16.30	30.64	34.25
	se	2.52	4.11	2.26	1.75	4.50	3.75
Aroclor 1254/1260 (ug/kg lipid)	median	590.36	136.36	184.85	117.69	210.37	254.85
	mean	623.94	199.80	186.20	133.19	243.20	254.85
	se	33.84	53.43	46.85	17.36	35.20	16.57
Total PCB Congeners (ug/kg-ww)	median	97.35	25.97	24.80	22.24	37.07	47.28
	mean	97.35	25.97	24.80	22.24	37.07	47.28
	se	-	-	-	-	-	-
Total PCB Congeners (ug/kg lipid)	median	1280.97	1854.83	218.82	190.12	322.38	369.34
	mean	1280.97	1854.83	218.82	190.12	322.38	369.34
	se	-	-	-	-	-	-
Largescale Sucker (whole body)							
Lipids (%)	median	4.00	3.55	5.00	5.20	7.70	7.45
	mean	4.17	3.81	6.03	5.66	7.52	7.40
	se	0.90	0.53	1.74	0.59	0.96	0.52
2,3,7,8-TCDF (ng/kg-ww)	median	1.22	4.36	1.92	3.73	3.72	5.17
	mean	1.22	5.45	2.13	3.57	4.00	5.14
	se	0.18	2.27	0.34	0.29	0.37	0.60
2,3,7,8-TCDF (ng/kg lipid)	median	30.50	135.56	34.92	62.68	51.81	67.59
	mean	34.32	158.63	40.12	63.71	55.76	69.84
	se	11.95	68.45	7.57	2.65	7.10	7.98
Aroclor 1254/1260 (ug/kg-ww)	median	58.00	77.00	58.50	126.00	123.00	95.00
	mean	67.33	153.25	54.00	114.20	127.20	103.83
	se	10.87	89.02	8.05	16.81	13.95	14.90
Aroclor 1254/1260 (ug/kg lipid)	median	1450.00	2109.88	981.23	1893.33	1597.40	1221.49
	mean	1898.19	4250.38	1166.28	2109.38	1733.20	1443.11
	se	713.90	2490.46	401.90	388.03	146.56	282.46
Total PCB Congeners (ug/kg-ww)	median	104.96	126.86	108.81	152.31	133.85	172.39
	mean	104.96	126.86	108.81	152.31	133.85	172.39
	se	-	-	-	-	-	-
Total PCB Congeners (ug/kg lipid)	median	3887.52	2393.65	989.16	2929.10	1738.31	2693.54
	mean	3887.52	2393.65	989.16	2929.10	1738.31	2693.54
	se	-	-	-	-	-	-

Notes: "-" = No data collected

E = Estimated from fillet and offal tissues

U = Not-detected

Table 5-23. Frequency of Detection of Analytes in Fish Tissues (all species) Collected by EPA in 2005

Analyte	Tissue Type								
	Whole Body			Fillet			Offal		
	N	N (Detected)	FOD (%)	N	N (Detected)	FOD (%)	N	N (Detected)	FOD (%)
Dioxins/Furans									
1,2,3,4,6,7,8-HpCDF	105	4	4%	30	3	10%	30	2	7%
1,2,3,4,7,8,9-HpCDF	105	0	0%	30	0	0%	30	0	0%
1,2,3,4,7,8-HxCDF	105	1	1%	30	2	7%	30	1	3%
1,2,3,6,7,8-HxCDF	105	2	2%	30	1	3%	30	1	3%
1,2,3,7,8,9-HxCDF	105	1	1%	30	0	0%	30	0	0%
1,2,3,7,8-PeCDF	105	7	7%	30	4	13%	30	4	13%
2,3,4,6,7,8-HxCDF	105	2	2%	30	0	0%	30	1	3%
2,3,4,7,8-PeCDF	105	12	11%	30	3	10%	30	0	0%
2,3,7,8-TCDF	105	104	99%	30	20	67%	30	28	93%
OCDF	105	3	3%	30	2	7%	30	1	3%
1,2,3,4,7,8-HxCDD	105	4	4%	30	0	0%	30	1	3%
1,2,3,6,7,8-HxCDD	105	34	32%	30	0	0%	30	11	37%
1,2,3,7,8,9-HxCDD	105	9	9%	30	1	3%	30	1	3%
1,2,3,4,6,7,8-HpCDD	105	30	29%	30	12	40%	30	22	73%
1,2,3,7,8-PeCDD	105	19	18%	30	3	10%	30	2	7%
2,3,7,8-TCDD	105	9	9%	30	0	0%	30	0	0%
OCDD	105	14	13%	30	16	53%	30	11	37%
PCB Aroclors									
PCB-1016	105	2	2%	30	0	0%	30	0	0%
PCB-1221	105	0	0%	30	0	0%	30	0	0%
PCB-1232	105	0	0%	30	0	0%	30	0	0%
PCB-1242	105	0	0%	30	0	0%	30	0	0%
PCB-1248	105	0	0%	30	0	0%	30	0	0%
PCB-1254/1260	105	105	100%	30	30	100%	30	30	100%
PCB-1262	105	0	0%	25	0	0%	25	0	0%
PCB-1268	105	0	0%	25	0	0%	25	0	0%
PCB Congeners									
2-MoCB (1)	24	6	25%	8	2	25%	7	5	71%
3-MoCB (2)	24	1	4%	8	0	0%	7	0	0%
4-MoCB (3)	24	1	4%	8	1	13%	7	0	0%
2,2'-DiCB (4)	24	16	67%	8	0	0%	7	3	43%
2,3-DiCB (5)	24	0	0%	8	0	0%	7	0	0%
2,3'-DiCB (6)	24	4	17%	8	1	13%	7	3	43%
2,4-DiCB (7)	24	1	4%	8	0	0%	7	1	14%
2,4'-DiCB3 (8)	24	6	25%	8	1	13%	7	2	29%
2,5-DiCB (9)	24	1	4%	8	1	13%	7	0	0%
2,6-DiCB (10)	24	1	4%	8	0	0%	7	0	0%
3,3'-DiCB (11)	24	8	33%	8	1	13%	7	4	57%
3,4-DiCB (12)	24	3	13%	8	0	0%	7	2	29%
3,5-DiCB (14)	24	0	0%	8	0	0%	7	0	0%
4,4'-DiCB (15)	24	7	29%	8	1	13%	7	3	43%
2,2',3-TrCB (16)	24	18	75%	8	0	0%	7	6	86%
2,2',4-TrCB (17)	24	20	83%	8	2	25%	7	7	100%
2,2',5-TrCB3 (18)	24	22	92%	8	3	38%	7	7	100%
2,2',6-TrCB (19)	24	16	67%	8	3	38%	7	5	71%
2,3,3'-TrCB (20)	24	24	100%	8	5	63%	7	7	100%
2,3,4-TrCB (21)	24	21	88%	8	4	50%	7	6	86%
2,3,4'-TrCB (22)	24	20	83%	8	2	25%	7	7	100%
2,3,5-TrCB (23)	24	1	4%	8	0	0%	7	0	0%
2,3,6-TrCB (24)	24	12	50%	8	2	25%	7	4	57%
2,3',4-TrCB (25)	24	23	96%	8	3	38%	7	7	100%
2,3',5-TrCB (26)	24	24	100%	8	4	50%	7	7	100%
2,3',6-TrCB (27)	24	22	92%	8	4	50%	7	5	71%
2,4',5-TrCB (31)	24	24	100%	8	4	50%	7	7	100%
2,4',6-TrCB (32)	24	20	83%	8	1	13%	7	7	100%
2',3,5-TrCB (34)	24	16	67%	8	0	0%	7	1	14%
3,3',4-TrCB (35)	24	3	13%	8	1	13%	7	0	0%
3,3',5-TrCB (36)	24	1	4%	8	0	0%	7	0	0%
3,4,4'-TrCB (37)	24	19	79%	8	2	25%	7	7	100%
3,4,5-TrCB (38)	24	3	13%	8	0	0%	7	0	0%

Table 5-23. Frequency of Detection of Analytes in Fish Tissues (all species) Collected by EPA in 2005

Analyte	Tissue Type								
	Whole Body			Fillet			Offal		
	N	N (Detected)	FOD (%)	N	N (Detected)	FOD (%)	N	N (Detected)	FOD (%)
PCB Congeners									
3,4',5'-TrCB (39)	24	15	63%	8	4	50%	7	3	43%
2,2',3,3'-TeCB (40)	24	22	92%	8	5	63%	7	7	100%
2,2',3,4'-TeCB (41)	24	18	75%	8	3	38%	7	6	86%
2,2',3,4'-TeCB (42)	24	24	100%	8	8	100%	7	7	100%
2,2',3,5'-TeCB (43)	24	17	71%	8	5	63%	7	2	29%
2,2',3,5'-TeCB3 (44)	24	24	100%	8	8	100%	7	7	100%
2,2',3,6'-TeCB (45)	24	22	92%	8	2	25%	7	7	100%
2,2',3,6'-TeCB (46)	24	16	67%	8	3	38%	7	4	57%
2,2',4,5'-TeCB (48)	24	24	100%	8	4	50%	7	7	100%
2,2',4,5'-TeCB (49)	24	24	100%	8	8	100%	7	7	100%
2,2',4,6'-TeCB (50)	24	24	100%	8	4	50%	7	6	86%
2,2',5,5'-TeCB3 (52)	24	24	100%	8	8	100%	7	7	100%
2,2',6,6'-TeCB (54)	24	3	13%	8	0	0%	7	0	0%
2,3,3',4'-TeCB (55)	24	21	88%	8	5	63%	7	6	86%
2,3,3',4''-TeCB (56)	24	23	96%	8	7	88%	7	7	100%
2,3,3',5'-TeCB (57)	24	10	42%	8	2	25%	7	1	14%
2,3,3',5'-TeCB (58)	24	10	42%	8	2	25%	7	4	57%
2,3,3',6'-TeCB (59)	24	24	100%	8	7	88%	7	6	86%
2,3,4,4'-TeCB (60)	24	24	100%	8	8	100%	7	7	100%
2,3,4,5'-TeCB (61)	24	24	100%	8	8	100%	7	7	100%
2,3,4',5'-TeCB (63)	24	23	96%	8	8	100%	7	6	86%
2,3,4',6'-TeCB (64)	24	24	100%	8	8	100%	7	7	100%
2,3',4,4'-TeCB3 (66)	24	24	100%	8	8	100%	7	7	100%
2,3',4,5'-TeCB (67)	24	16	67%	8	3	38%	7	5	71%
2,3',4,5'-TeCB (68)	24	22	92%	8	4	50%	7	7	100%
2,3',5,5'-TeCB (72)	24	22	92%	8	8	100%	7	6	86%
2,3',5',6'-TeCB (73)	24	15	63%	8	7	88%	7	5	71%
3,3',4,4'-TeCB3,6 (77) **	24	23	96%	8	4	50%	7	7	100%
3,3',4,5'-TeCB (78)	24	0	0%	8	1	13%	7	0	0%
3,3',4,5'-TeCB (79)	24	24	100%	8	8	100%	7	7	100%
3,3',5,5'-TeCB (80)	24	0	0%	8	0	0%	7	0	0%
3,4,4',5'-TeCB6 (81) **	24	2	8%	8	1	13%	7	2	29%
2,2',3,3',4'-PeCB (82)	24	21	88%	8	8	100%	7	7	100%
2,2',3,3',5'-PeCB (83)	24	20	83%	8	7	88%	7	7	100%
2,2',3,3',6'-PeCB (84)	24	24	100%	8	7	88%	7	7	100%
2,2',3,4,4'-PeCB (85)	24	24	100%	8	8	100%	7	7	100%
2,2',3,4,5'-PeCB (86)	24	24	100%	8	8	100%	7	7	100%
2,2',3,4,6'-PeCB (88)	24	24	100%	8	8	100%	7	7	100%
2,2',3,4,6'-PeCB (89)	24	10	42%	8	1	13%	7	3	43%
2,2',3,4',5'-PeCB (90)	24	24	100%	8	8	100%	7	7	100%
2,2',3,5,5'-PeCB (92)	24	24	100%	8	8	100%	7	7	100%
2,2',3,5,6'-PeCB (93)	24	19	79%	8	7	88%	7	6	86%
2,2',3,5,6'-PeCB (94)	24	10	42%	8	0	0%	7	1	14%
2,2',3,5',6'-PeCB (95)	24	23	96%	8	8	100%	7	7	100%
2,2',3,6,6'-PeCB (96)	24	14	58%	8	1	13%	7	3	43%
2,2',3',4,6'-PeCB (98)	24	21	88%	8	5	63%	7	6	86%
2,2',4,4',5'-PeCB (99)	24	24	100%	8	8	100%	7	7	100%
2,2',4,5',6'-PeCB (103)	24	21	88%	8	8	100%	7	6	86%
2,2',4,6,6'-PeCB (104)	24	1	4%	8	0	0%	7	0	0%
2,3,3',4,4'-PeCB3,6 (105) **	24	23	96%	8	8	100%	7	7	100%
2,3,3',4,5'-PeCB (106)	24	5	21%	8	1	13%	7	2	29%
2,3,3',4',5'-PeCB (107)	24	22	92%	8	8	100%	7	7	100%
2,3,3',4,6'-PeCB (109)	24	23	96%	8	8	100%	7	7	100%
2,3,3',4',6'-PeCB (110)	24	23	96%	8	8	100%	7	7	100%
2,3,3',5,5'-PeCB (111)	24	9	38%	8	2	25%	7	4	57%
2,3,3',5,6'-PeCB (112)	24	20	83%	8	7	88%	7	7	100%
2,3,4,4',5'-PeCB6 (114) **	24	22	92%	8	6	75%	7	7	100%
2,3',4,4',5'-PeCB3,6 (118) **	24	23	96%	8	8	100%	7	7	100%
2,3',4,5,5'-PeCB (120)	24	20	83%	8	7	88%	7	6	86%
2,3',4,5',6'-PeCB (121)	24	6	25%	8	1	13%	7	1	14%
2',3,3',4,5'-PeCB (122)	24	0	0%	8	0	0%	7	0	0%

Table 5-23. Frequency of Detection of Analytes in Fish Tissues (all species) Collected by EPA in 2005

Analyte	Tissue Type								
	Whole Body			Fillet			Offal		
	N	N (Detected)	FOD (%)	N	N (Detected)	FOD (%)	N	N (Detected)	FOD (%)
PCB Congeners									
2',3,4,4',5-PeCB6 (123) **	24	21	88%	8	5	63%	7	7	100%
3,3',4,4',5-PeCB3,6 (126) **	24	17	71%	8	5	63%	7	7	100%
3,3',4,5,5'-PeCB (127)	24	4	17%	8	0	0%	7	3	43%
2,2',3,3',4,4'-HxCB3 (128)	24	24	100%	8	8	100%	7	6	86%
2,2',3,3',4,5-HxCB (129)	24	24	100%	8	8	100%	7	7	100%
2,2',3,3',4,5'-HxCB (130)	24	22	92%	8	8	100%	7	7	100%
2,2',3,3',4,6-HxCB (131)	24	16	67%	8	4	50%	7	3	43%
2,2',3,3',4,6'-HxCB (132)	24	23	96%	8	8	100%	7	7	100%
2,2',3,3',5,5'-HxCB (133)	24	24	100%	8	8	100%	7	7	100%
2,2',3,3',5,6-HxCB (134)	24	22	92%	8	8	100%	7	7	100%
2,2',3,3',5,6'-HxCB (135)	24	24	100%	8	8	100%	7	7	100%
2,2',3,3',6,6'-HxCB (136)	24	23	96%	8	8	100%	7	7	100%
2,2',3,4,4',5-HxCB (137)	24	23	96%	8	8	100%	7	7	100%
2,2',3,4,4',6-HxCB (139)	24	23	96%	8	8	100%	7	7	100%
2,2',3,4,5,5'-HxCB (141)	24	24	100%	8	8	100%	7	7	100%
2,2',3,4,5,6-HxCB (142)	24	0	0%	8	0	0%	7	0	0%
2,2',3,4,5,6'-HxCB (143)	24	7	29%	8	2	25%	7	2	29%
2,2',3,4,5',6-HxCB (144)	24	24	100%	8	8	100%	7	7	100%
2,2',3,4,6,6'-HxCB (145)	24	0	0%	8	0	0%	7	0	0%
2,2',3,4',5,5'-HxCB (146)	24	24	100%	8	8	100%	7	7	100%
2,2',3,4',5,6-HxCB (147)	24	24	100%	8	8	100%	7	7	100%
2,2',3,4',5,6'-HxCB (148)	24	13	54%	8	4	50%	7	6	86%
2,2',3,4',6,6'-HxCB (150)	24	8	33%	8	1	13%	7	3	43%
2,2',3,5,6,6'-HxCB (152)	24	4	17%	8	1	13%	7	0	0%
2,2',4,4',5,5'-HxCB3 (153)	24	24	100%	8	8	100%	7	7	100%
2,2',4,4',5',6-HxCB (154)	24	23	96%	8	7	88%	7	6	86%
2,2',4,4',6,6'-HxCB (155)	24	16	67%	8	4	50%	7	3	43%
2,3,3',4,4',5-HxCB6 (156) **	24	24	100%	8	8	100%	7	7	100%
2,3,3',4,4',6-HxCB (158)	24	23	96%	8	8	100%	7	7	100%
2,3,3',4,5,5'-HxCB (159)	24	15	63%	8	4	50%	7	2	29%
2,3,3',4,5,6-HxCB (160)	24	0	0%	8	0	0%	7	0	0%
2,3,3',4,5',6-HxCB (161)	24	1	4%	8	0	0%	7	0	0%
2,3,3',4',5,5'-HxCB (162)	24	16	67%	8	7	88%	7	7	100%
2,3,3',4',5',6-HxCB (164)	24	23	96%	8	5	63%	7	6	86%
2,3,3',5,5',6-HxCB (165)	24	0	0%	8	0	0%	7	0	0%
2,3',4,4',5,5'-HxCB6 (167) **	24	24	100%	8	8	100%	7	7	100%
3,3',4,4',5,5'-HxCB3,6 (169) **	24	10	42%	8	1	13%	7	0	0%
2,2',3,3',4,4',5-HpCB3 (170)	24	24	100%	8	8	100%	7	7	100%
2,2',3,3',4,4',6-HpCB (171)	24	24	100%	8	8	100%	7	7	100%
2,2',3,3',4,5,5'-HpCB (172)	24	24	100%	8	8	100%	7	7	100%
2,2',3,3',4,5,6'-HpCB (174)	24	22	92%	8	8	100%	7	7	100%
2,2',3,3',4,5',6-HpCB (175)	24	22	92%	8	4	50%	7	6	86%
2,2',3,3',4,6,6'-HpCB (176)	24	21	88%	8	8	100%	7	7	100%
2,2',3,3',4',5,6-HpCB (177)	24	21	88%	8	8	100%	7	7	100%
2,2',3,3',5,5',6-HpCB (178)	24	24	100%	8	8	100%	7	7	100%
2,2',3,3',5,6,6'-HpCB (179)	24	24	100%	8	8	100%	7	7	100%
2,2',3,4,4',5,5'-HpCB3 (180)	24	24	100%	8	8	100%	7	7	100%
2,2',3,4,4',5,6-HpCB (181)	24	2	8%	8	2	25%	7	1	14%
2,2',3,4,4',5,6'-HpCB (182)	24	18	75%	8	4	50%	7	4	57%
2,2',3,4,4',5',6-HpCB (183)	24	24	100%	8	8	100%	7	7	100%
2,2',3,4,4',6,6'-HpCB (184)	24	12	50%	8	3	38%	7	5	71%
2,2',3,4,5,6,6'-HpCB (186)	24	0	0%	8	0	0%	7	0	0%
2,2',3,4',5,5',6-HpCB3 (187)	24	24	100%	8	8	100%	7	7	100%
2,2',3,4',5,6,6'-HpCB (188)	24	14	58%	8	1	13%	7	4	57%
2,3,3',4,4',5,5'-HpCB6 (189) **	24	21	88%	8	7	88%	7	7	100%
2,3,3',4,4',5,6-HpCB (190)	24	23	96%	8	8	100%	7	7	100%
2,3,3',4,4',5',6-HpCB (191)	24	18	75%	8	7	88%	7	5	71%
2,3,3',4,5,5',6-HpCB (192)	24	0	0%	8	0	0%	7	0	0%
2,2',3,3',4,4',5,5'-OoCB (194)	24	24	100%	8	8	100%	7	7	100%
2,2',3,3',4,4',5,6-OoCB3 (195)	24	24	100%	8	8	100%	7	7	100%
2,2',3,3',4,4',5,6'-OoCB (196)	24	24	100%	8	8	100%	7	7	100%

Table 5-23. Frequency of Detection of Analytes in Fish Tissues (all species) Collected by EPA in 2005

Analyte	Tissue Type								
	Whole Body			Fillet			Offal		
	N	N (Detected)	FOD (%)	N	N (Detected)	FOD (%)	N	N (Detected)	FOD (%)
PCB Congeners									
2,2',3,3',4,4',6,6'-OxCB (197)	24	24	100%	8	6	75%	7	7	100%
2,2',3,3',4,5,5',6-OxCB (198)	24	24	100%	8	8	100%	7	7	100%
2,2',3,3',4,5',6,6'-OxCB (201)	24	24	100%	8	8	100%	7	7	100%
2,2',3,3',5,5',6,6'-OxCB (202)	24	24	100%	8	8	100%	7	7	100%
2,2',3,4,4',5,5',6-OxCB (203)	24	24	100%	8	8	100%	7	7	100%
2,2',3,4,4',5,6,6'-OxCB (204)	24	0	0%	8	0	0%	7	0	0%
2,3,3',4,4',5,5',6-OxCB (205)	24	21	88%	8	4	50%	7	7	100%
2,2',3,3',4,4',5,5',6-NoCB3 (206)	24	24	100%	8	8	100%	7	7	100%
2,2',3,3',4,4',5,6,6'-NoCB (207)	24	22	92%	8	6	75%	7	7	100%
2,2',3,3',4,5,5',6,6'-NoCB (208)	24	24	100%	8	7	88%	7	7	100%
DeCB3 (209)	24	23	96%	8	7	88%	7	5	71%

Notes: N = Sample size

FOD = Frequency of detection

** PCB congener is a dioxin-like compound

Table 5-24. Northport Air Monitoring Concentrations (Arithmetic Mean, $\mu\text{g}/\text{m}^3$) from 1994 to 2006

Year	PM10	Arsenic	Lead	Cadmium	Zinc
1994	1.78E+01	2.95E-02	1.61E-01	9.13E-03	2.06E-01
1995	1.69E+01	4.07E-02	2.82E-01	1.31E-02	2.39E-01
1996	1.58E+01	2.17E-02	2.30E-01	9.71E-03	1.91E-01
1997	1.25E+01	1.09E-02	1.17E-01	5.53E-03	1.61E-01
1998	1.71E+01	9.88E-03	4.29E-02	2.86E-03	8.56E-02
1999	1.45E+01	6.61E-03	3.84E-02	2.10E-03	7.57E-02
2000	1.30E+01	4.67E-03	2.47E-02	1.08E-03	5.17E-02
2001	1.55E+01	1.89E-03	1.48E-02	6.86E-04	2.22E-02
2002	1.48E+01	2.04E-03	2.46E-02	1.15E-03	7.16E-02
2003	1.70E+01	1.72E-03	1.55E-02	8.00E-04	4.03E-02
2004	1.41E+01	2.57E-03	1.92E-02	9.91E-04	3.46E-02
2005	1.05E+01	4.13E-03	2.45E-02	1.97E-03	9.93E-02
2006	1.87E+01	2.38E-03	1.76E-02	8.38E-04	3.48E-02

Source: TCM, Trail Facility.

Notes: 2006 sampling data ended in mid-August; all other sampling years were carried through December.

Table 5-25. Mean Concentrations ($\mu\text{g}/\text{m}^3$) for Air Monitoring Results at Three Sampling Locations along UCR in 2002

Site	PM10	Arsenic	Lead	Cadmium	Copper	Zinc
Inchelium	1.86E+01	3.15E-04	2.00E-03	7.30E-05	3.42E-01	1.49E-02
Kettle Falls	1.37E+01	2.91E-04	2.04E-03	1.88E-04	9.44E-02	2.29E-02
Seven Bays	1.34E+01	2.38E-04	1.68E-03	5.50E-05	1.24E-01	1.24E-02

Table 5-26. Mean Concentrations ($\mu\text{g}/\text{m}^3$) for Air Monitoring Results at Three Sampling Locations along UCR in 2003

Site	PM10	Arsenic	Lead	Cadmium	Copper	Zinc
Inchelium	1.35E+01	2.63E-04	1.89E-03	7.80E-05	6.17E-03	1.29E-02
Marcus Flats	1.33E+01	4.81E-04	4.77E-03	2.77E-04	1.04E-02	2.62E-02
Seven Bays	1.07E+01	1.79E-04	1.25E-03	5.00E-05	9.19E-03	1.20E-02

Table 5-27. Mean Concentrations ($\mu\text{g}/\text{m}^3$) for Air Monitoring Results at Three Sampling Locations along UCR in 2004

Site	PM10	Arsenic	Lead	Cadmium	Copper	Zinc
Inchelium	2.02E+01	4.43E-04	2.46E-03	8.40E-05	1.12E-02	8.66E-03
Marcus Flats	1.80E+01	7.39E-04	1.01E-02	3.16E-04	1.02E-02	2.54E-02
Seven Bays	2.28E+01	3.32E-04	1.59E-03	4.90E-05	1.27E-02	6.97E-03

Table 6-1. Initial Chemicals of Interest

Chemical Group	Analyte(s)
Common Metals and Metalloids	Aluminum, Antimony, Arsenic, Barium, Beryllium, Boron, Cadmium, Calcium, Chromium, Cobalt, Copper, Fluoride, Iron, Lead, Magnesium, Manganese, Mercury, Molybdenum, Nickel, Potassium, Selenium, Silicon, Silver, Sodium, Sulfur, Tin, Thallium, Uranium, Vanadium, Zinc
Other Metals and Metalloids	Bismuth, Cerium, Cesium, Dysprosium, Erbium, Europium, Gadolinium, Gallium, Germanium, Gold, Holmium, Indium, Lanthanum, Lithium, Lutetium, Neodymium, Niobium, Praseodymium, Rubidium, Samarium, Scandium, Strontium, Tantalum, Tellurium, Thorium, Thulium, Titanium, Tungsten, Ytterbium, Yttrium, Zirconium
Semivolatile Organic Compounds (SVOCs)	1,1'-Biphenyl, 1,2,4-Trichlorobenzene, 1,2-Dichlorobenzene, 1,3-Dichlorobenzene, 1,4-Dichlorobenzene, 2,2'-oxybis(1-chloropropane), 2,4,5-Trichlorophenol, 2,4,6-Trichlorophenol, 2,4-Dichlorophenol, 2,4-Dimethylphenol, 2,4-Dinitrophenol, 2,4-Dinitrotoluene, 2,6-Dinitrotoluene, 2-Chloronaphthalene, 2-Chlorophenol, 2-Methylphenol (o-cresol), 2-Nitroaniline, 2-Nitrophenol, 3,3'-Dichlorobenzidine, 3-Nitroaniline, 4,6-Dinitro-2-methylphenol, 4-Bromophenyl-phenylether, 4-Chloro-3-methylphenol, 4-Chloroaniline, 4-Chlorophenyl-phenyl ether, 4-Methylphenol (p-cresol), 4-Nitroaniline, 4-Nitrophenol, Acetophenone, Benzaldehyde, Benzoic acid, Benzyl alcohol, bis(2-Chloroethoxy)methane, Bis(2-chloroethyl)ether, Bis(2-ethylhexyl)phthalate, Butyl benzyl phthalate, Caprolactam, Carbazole, Dibenzofuran, Diethyl phthalate, Dimethyl phthalate, Di-n-butyl phthalate, Di-n-octylphthalate, 1-Phenyl-ethanone, Hexachlorobenzene, Hexachlorocyclopentadiene, Hexachloroethane, Isophorone, Nitrobenzene, N-Nitrosodi-n-propylamine, N-Nitrosodiphenylamine, Pentachlorophenol, Perchlorocyclopentadiene, Phenol
Polycyclic Aromatic Hydrocarbons (PAHs)	High Molecular Weight PAHs: Benzo(a)anthracene, Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(ghi)perylene, Benzo(k)fluoranthene, Chrysene, Dibenzo(a,h)anthracene, Indeno[1,2,3-cd]pyrene Low Molecular Weight PAHs: Anthracene, 2-Methylnaphthalene, Acenaphthene, Acenaphthylene, Fluoranthene, Fluorene, Naphthalene, Phenanthrene, Pyrene
Pesticides	2,4'-DDD, 2,4'-DDE, 2,4'-DDT, 4,4'-DDD, 4,4'-DDE, 4,4'-DDT, Aldrin, alpha-BHC, alpha-Chlordane, Atrazine, beta-BHC, cis-Nonachlor, delta-BHC, Dieldrin, Endosulfan I, Endosulfan II, Endosulfan sulfate, Endrin, Endrin aldehyde, Endrin ketone, gamma-BHC (Lindane), gamma-Chlordane, Heptachlor, Heptachlor epoxide, Hexachlorobenzene, Hexachlorobutadiene, Methoxychlor, Oxychlordane, Toxaphene, trans-Nonachlor
Polychlorinated Biphenyls (PCBs)	Aroclor 1016, Aroclor 1221, Aroclor 1232, Aroclor 1242, Aroclor 1248, Aroclor 1254, Aroclor 1260, PCB Congeners (209 forms)
Polybrominated Diphenylethers (PBDEs)	PBDE-47, PBDE-66, PBDE-71, PBDE-99, PBDE-100, PBDE-138, PBDE-153, PBDE-154, PBDE-183, PBDE-184, PBDE-191, PBDE-209
Polychlorinated Dibenzo-p-Dioxins (PCDDs)	1,2,3,4,6,7,8-Heptachlorodibenzodioxin, 1,2,3,4,7,8-Hexachlorodibenzodioxin, 1,2,3,6,7,8-Hexachlorodibenzodioxin, 1,2,3,7,8,9-Hexachlorodibenzodioxin, 1,2,3,7,8-Pentachlorodibenzodioxin, 2,3,7,8-Tetrachlorodibenzodioxin, Octachlorodibenzodioxin
Polychlorinated Dibenzofurans (PCDFs)	1,2,3,4,6,7,8-Heptachlorodibenzofuran, 1,2,3,4,7,8,9-Heptachlorodibenzofuran, 1,2,3,4,7,8-Hexachlorodibenzofuran, 1,2,3,6,7,8-Hexachlorodibenzofuran, 1,2,3,7,8-Pentachlorodibenzofuran, 1,2,3,7,8-Pentachlorodibenzofuran, 2,3,4,6,7,8-Hexachlorodibenzofuran, 2,3,4,7,8-Pentachlorodibenzofuran, 2,3,7,8-Tetrachlorodibenzofuran (TCDF), Octachlorodibenzofuran

Note:

This list was generated based on a review of analytes evaluated in the following investigations: Bortelson et al. 2001; Cox et al. 2005; Paulson et al. 2006; USEPA 2002a,b, 2003, 2006h; Ecology 2001, 2006a,b; Golding 1996; G3 Consulting Ltd. 2001; TCAI 2007.

TABLE 7-1
RI/FIS Field Studies

Study	Planning	Target Implementation
Surface Water	2008	2009 - 2010
Fish Tissue Sampling (includes Zooplankton)	2008	2009 - 2010
Beach Sediment Study	2008	2009 - 2010
Opportunistic Sturgeon ¹	2009	2009
Other Sturgeon Studies and Toxicity Testing	2009	2010 - 2011
Resource Use and Consumption Survey	2008	2009
Upstream Sources Study	2009 (paper study, no field work)	
Soil Sampling	2009	2010 - 2011
Sediment Sampling	2009	2010 - 2011
Aquatic Resources and Benthic Tissue Sampling	2009	2010 - 2011
Additional Studies ²	2012	2012 - 2013

¹The need for this study has not yet been determined.

²The actual studies that may be needed have not yet been determined.

Table 8-1

Overview of Studies Specified in the SOW, Rationale, Dependencies Assigned, Proposed Field Year if Appropriate, and RI/FS Element

Row Number	SOW Section Number	What		Why		When	Remedial Investigation/ Feasibility Study Element
		Description in Statement of Work	Sub-elements	Project-Wide	Dependencies/ Adaptive Management	Proposed Field Year, If Implemented ^a	
1	2.1	Project database and data management system		Database, GIS and associated data management procedures will be required for storage, manipulation, display and dissemination of data throughout the Remedial Investigation/Feasibility Study	None	Throughout RI/FS	Database
2	3.1	Problem formulation		Identify objectives for risk assessment, identify assessment endpoints; present conceptual models, identify analysis plan	Will be refined throughout the risk process	Throughout RI/FS	RI/FS work plan, SLERA, BERA work plan
3	3.1.1	Sediment and contaminant transport and fate	Bathymetry	Identify current topography of UCR bottom substrates in areas susceptible to erosion and deposition of granulated slag	Presence of unacceptable risk	2012	Transport and Fate Survey
4	N/A		Side-scan sonar (not cited in SOW Section 3.1.1)	Generate map of sediment characteristics (cobble, granulated slag, silt) in select areas of Site	Presence of unacceptable risk	2012	Transport and Fate Survey
5	3.1.1		Sediment profile imaging	Sediment grain size mapping, benthic habitat mapping, visual identification of granulated slag	None	2011	Aquatic Resource Study
6	3.1.1		Acoustic Doppler current profiling	Input data for hydrodynamic modeling	Determination of need for additional hydrodynamic modeling, based on presence of unacceptable risk	2012	Transport and Fate Survey
7	3.1.1		Sediment chemistry	Nature and extent data gaps, identification of sources, characterization of potential sediment sources (tributaries, bank sloughing). Includes measures of bioavailability and geochemical fractions	None	2011	Sediment Study
8	N/A		Floodplain soils	Evaluate possible transport of contaminated sediment onto floodplains prior to construction	None	2011	Soil Study

Table 8-1

Overview of Studies Specified in the SOW, Rationale, Dependencies Assigned, Proposed Field Year if Appropriate, and RI/FS Element

Row Number	SOW Section Number	What		Why		When	Remedial Investigation/ Feasibility Study Element
		Description in Statement of Work	Sub-elements	Project-Wide	Dependencies/ Adaptive Management	Proposed Field Year, If Implemented ^a	
				of upriver dams in the 1970s			
9	3.1.1		Chemical analysis of granulated slag	Nature and extent; potential future releases of COIs	Evaluation of existing granulated slag data in BERA work plan and identification of data gap	2011	Sediment Study
10	3.1.1		Transport and fate modeling	Predict potential transport of COIs in the future	Determination of erosion potential in areas with unacceptable risk	2012	Modeling Report
11	3.1.2	Sources of contaminants and sediments	Sediment sources	Understand sources of COIs and sediments. See Row 7	None	2011	Sediment Study
12	3.1.2		Groundwater sources	Evaluate whether upland contamination impacts groundwater	Determination of upland footprint that is likely to impact groundwater	2011	Soil Study
13	3.1.3	Initial (Tier 1) delineation of upland aerial footprint reflecting atmospheric deposition of Trail facility emissions and Lake Roosevelt sediment	Modeling smelter emissions and beach dust	Delineate probable aerial extent (footprint) of deposition from Trail facility and/or dust from high wind events impacting UCR sediments. Identify areas where COIs are elevated significantly above background.	Evaluation of available soils data in the BERA work plan; consensus on need for modeling; availability of data needed for modeling	2010 2011	BERA Work Plan
14	3.1.4	Screening level risk assessment and data gaps analysis (HHRA)		Initial conservative screening of risk to humans	To be performed by EPA	NA	HHRA Work Plan
15	3.2.1	Characterization of background concentrations in UCR environmental media		Identify in-water and upland background concentrations for comparison to data from the UCR. Should be representative of the range of physical and habitat conditions being	Evaluation of available data for background conditions in the BERA work plan. For soils, establishment	2009 2010 2011	Sediment Study, Surface Water Study, Soil Study

Table 8-1

Overview of Studies Specified in the SOW, Rationale, Dependencies Assigned, Proposed Field Year if Appropriate, and RI/FS Element

Row Number	SOW Section Number	What		Why		When	Remedial Investigation/ Feasibility Study Element
		Description in Statement of Work	Sub-elements	Project-Wide	Dependencies/ Adaptive Management	Proposed Field Year, If Implemented ^a	
				evaluated.	of emissions footprint significantly above background in BERA work plan based on existing soils data.		
16	3.2.2	Tribal and recreational consumption and resource use surveys	Tribal consumption and use survey	Support development of exposure scenarios in the HHRA	This task will be conducted by the EPA and/or the Tribes as set forth in the SOW	NA	Consumption and Use Surveys
17	3.2.2		General public consumption and use survey	Support development of exposure scenarios in the HHRA	Collaboration with National Parks Service and EPA to develop survey	NA	Consumption and Use Surveys
18	3.2.3	Sediment, beaches, surface water, fish, and mussel tissue sampling	Surface sediment spatial data gap investigation	See Row 7	See Row 7	2011	Sediment Study
19	3.2.3		Beach investigation	The spatial distribution of COIs in beach sediments sampled by EPA in 2005 needs refinement, and additional beaches not sampled by EPA have been identified as data gaps	None	2009 2010	Beach Sediment Study
20	3.2.3		Surface water investigation	Spatial and temporal distributions of surface water COIs and associated parameters in the UCR and major tributaries (above the influence of the UCR) are unknown. Data will be used to assess exposure to both human and ecological receptors.	None	2009 2010	Surface Water Study
21	3.2.3		Fish tissue	Food source for humans and wildlife. Existing data, for large-sized fish, supports HHRA. Data gap exists for smaller fish and other indicator species to support the BERA.	BERA work plan that will identify key fish receptors and prey items, and data gaps	2009	Fish Tissue Study

Table 8-1

Overview of Studies Specified in the SOW, Rationale, Dependencies Assigned, Proposed Field Year if Appropriate, and RI/FS Element

Row Number	SOW Section Number	What		Why		When	Remedial Investigation/ Feasibility Study Element
		Description in Statement of Work	Sub-elements	Project-Wide	Dependencies/ Adaptive Management	Proposed Field Year, If Implemented ^a	
22	3.2.3		Mussel tissue	Potential food source for humans and wildlife	Information on mussel bed locations	2011	Aquatic Resource study
23	3.2.4	Biological surveys of terrestrial vegetation and wildlife		Support exposure assessment for the HHRA in areas where exposures may occur	Decision to conduct Terrestrial ERA; Follows tribal and recreational use surveys. Conduct with Upland Plant Survey (Row 68)	2012	Terrestrial Resource Study
24	3.2.5	Terrestrial soil and vegetation residue sampling and analysis		Support exposure assessment for the BERA and HHRA in areas where exposures may occur; refine footprint of upland contamination	Decision to conduct terrestrial ERA. Follows tribal and recreational use surveys. Conduct with Upland Plant Survey (Row 68)	2012	Terrestrial Tissue Study
25	3.2.6	Tier 2 delineation of upland aerial footprint reflecting atmospheric deposition of Trail facility emissions and Lake Roosevelt sediment	Soil sampling	Fill data gaps and/or confirm model predictions.	BERA work plan that will contain evaluation of available soils data; Tier 1 delineation of upland aerial footprint; and identification of data gaps	2011	Soil Study
26	3.2.7	Mercury methylation, bioaccumulation and fate study		Determine sources and processes governing the distribution of methyl mercury.	BERA work plan that will evaluate available mercury data in the UCR and region; sediment bioavailability data; surface water data	2012	Mercury Study
27	3.2.8	Bioaccessibility Study		Evaluate the potential bioaccessible fraction of lead (at a minimum) in soil, beach sediment, fish, mussels and	EPA will prepare a HHRA work plan that will address potential need for	2012	Specialty Terrestrial Study

Table 8-1

Overview of Studies Specified in the SOW, Rationale, Dependencies Assigned, Proposed Field Year if Appropriate, and RI/FS Element

Row Number	SOW Section Number	What		Why		When	Remedial Investigation/ Feasibility Study Element
		Description in Statement of Work	Sub-elements	Project-Wide	Dependencies/ Adaptive Management	Proposed Field Year, If Implemented ^a	
				surface water.	bioaccessibility study		
28	3.2.9	Oral bioavailability study		Establish more accurate estimates of the relative bioavailability of metals	May be conducted following possible bioaccessibility study (Row 27)	2012	Specialty Terrestrial Study
29	4.1.1 (see also 3.1.1)	Transport and fate of contaminants and particulates as suspended solids and bedded sediments		See Rows 3-10	See Rows 3-10	2012	Transport and Fate Survey
30	4.1.2 (see also 3.1.2)	Sources of contaminants and sediments in the riverine and lacustrine reaches		See Row 11	See Row 11	2011	Sediment Study
31	4.1.3	Tiered screening level risk assessments (<i>i.e.</i> , <i>SLERA</i> and subsequent refinements)		Refine CSMs, COPCs	New data	2009	BERA Work Plan
32	4.2.1	Sampling design		Sampling design, including locations, rational analyses, and timing to address DQOs for each investigation to ensure collection of appropriate and valid data	Identification of data gaps in Remedial Investigation/Feasibility Study work plan and BERA work plan; increased levels of refinement and understanding	2008–2012	Sampling and Analysis Plans
33	4.2.2	Characterization of background concentrations of metals and		Identify suitable aquatic reference sites and background conditions	Evaluation of available data in the BERA work plan; identification of key	2009-2011	Surface Water Study, Sediment Study, Fish Tissue Study, Soil Study

Table 8-1

Overview of Studies Specified in the SOW, Rationale, Dependencies Assigned, Proposed Field Year if Appropriate, and RI/FS Element

Row Number	SOW Section Number	What		Why		When	Remedial Investigation/ Feasibility Study Element
		Description in Statement of Work	Sub-elements	Project-Wide	Dependencies/ Adaptive Management	Proposed Field Year, If Implemented ^a	
		other contaminants in water, animals and sediments			species in the BERA work plan. Include in sampling designs for surface water, fish tissue, mussel tissue and sediments. (see Rows 7, 21, 22)		
34	4.2.3 (see also 3.2.3)	Characterization of surface water quality	Surface water investigation	See Row 20	See Row 20	2009-2010	Surface Water Study
35	4.2.3 (See also 4.3.1)		Surface water toxicity testing	Determine if surface water poses unacceptable risk to organisms	BERA work plan; surface water sampling and data evaluation/refinement	2012	BERA Work Plan
36	4.2.4	Characterization of sediment and sediment porewater	Sediment chemistry	See Row 7	See Row 7	2011	Sediment Study
37	4.2.4		Porewater chemistry	Characterize porewater chemistry and sediment/porewater relationship	None	2011	Sediment Study
38	4.2.5	Biological survey of aquatic invertebrate community		Identify relative abundance and diversity of benthic species in the UCR. Ground-truth macroinvertebrates observed in sediment profile imaging (SPI) images	Conduct concurrently with SPI survey (row 5)	2011	Aquatic Resource Study
39	4.2.6	Aquatic macroinvertebrate, amphibian and plankton contaminant (<i>tissue</i>) sampling and analysis	Aquatic invertebrates and plankton	Assess potential risk to these receptors and their predators	None	2009-2011 2014	Surface Water Study, Sediment Study BERA
40			Amphibians	Assess potential risk to these receptors and their predators	None	2011 2014	Aquatic Resource Study BERA
41	4.2.7	Bioavailability of metals and other contaminants in surface water	Biotic ligand model or water effects ratios	Additional approach for estimating bioavailability	Additional uncertainty/data gaps related to bioavailability; BERA work plan; surface	2009-2012	Surface Water Study, Sediment Study, Modeling Recommendation

Table 8-1

Overview of Studies Specified in the SOW, Rationale, Dependencies Assigned, Proposed Field Year if Appropriate, and RI/FS Element

Row Number	SOW Section Number	What		Why		When	Remedial Investigation/ Feasibility Study Element
		Description in Statement of Work	Sub-elements	Project-Wide	Dependencies/ Adaptive Management	Proposed Field Year, If Implemented ^a	
		and sediment porewater			water chemistry, sediment chemistry, porewater chemistry		
42	4.3.1	Surface water toxicity to sensitive indicator Organisms		See Row 35	See Row 35	2012	Surface Water toxicity
43	4.3.2	Identification of cause-effect relationships using toxicity identification evaluations		Determine cause of toxicity or adverse effects	BERA work plan; presence of toxicity in sediment; determination that TIE is relevant to management decision.	2012	Specialty Aquatic Study
44	4.3.3	Sediment toxicity to sensitive indicator organisms		Determine site specific relevance of SQGs	BERA work plan, surface sediment data, risk management decision	2012	Sediment Study
45	4.3.4	Laboratory dietary toxicity tests with fish		Assess potential risk to fish from dietary exposure	BERA work plan, benthic tissue data (Row 39), fish habitat use survey (Row 47), fish diet survey (Row 46), dietary exposure analysis, and risk management decision	2012	Specialty Aquatic Study
46	4.3.5	Fish diets		Assess potential dietary exposures in indicator fish species associated with unacceptable risk	BERA work plan. Coordinate with Fish Tissue Study (Row 21)	2009	Fish Tissue Study
47	4.3.6	Fish habitat use survey		Identify habitats of indicator fish species	BERA work plan; conduct concurrently with fish tissue collection (Row 21)	2011	Aquatic Resource study
48	4.3.7	Contaminant avoidance by		Possible reason for fish not inhabiting foraging or	BERA work plan, fish habitat use survey	2012	Specialty Aquatic Study

Table 8-1

Overview of Studies Specified in the SOW, Rationale, Dependencies Assigned, Proposed Field Year if Appropriate, and RI/FS Element

Row Number	SOW Section Number	What		Why		When	Remedial Investigation/ Feasibility Study Element
		Description in Statement of Work	Sub-elements	Project-Wide	Dependencies/ Adaptive Management	Proposed Field Year, If Implemented ^a	
		fish		reproductive areas	(Row 47); sediment chemistry (Row 7)		
49	4.3.8	Species of special interest study		Declining numbers of white sturgeon	Recommendations from the transboundary sturgeon recovery team ^a on studies of potential contaminant toxicity to sturgeon	2011	Sturgeon Toxicity Test
50	4.3.9	Food web modeling		Predict potential effects of remediation on tissue concentrations of fish and other higher trophic level organisms	BERA work plan, fish tissue data (Row 21), benthic tissue data (Row 39), plankton tissue data (Row 39), fish diets (Row 46)	2012	BERA Work Plan, Modeling Recommendation
51	4.4.1	Field confirmation of laboratory/ office/model estimates of risk		Field verification of predicted risk	Contradictory lines of evidence	2012	Field Verification Study
52	4.4.2	Definition of risks to receptor populations		Determination of population level effects based on predicted risk		2012	Population Assessment Study
53	5.1.1	Designation of upland study area		See Row 13	See Row 13	2009	BERA Work Plan
54	5.1.2	Sediment transport and metal and other contaminants fate		See Rows 3-10	See Rows 3-10	2012	Transport and Fate Survey
55	5.1.3	Sources of metals and other contaminants		See Rows 8 and 25	See Rows 8 and 25	2011	Soil Study
56	5.1.4	Screening-level risk assessment		See Row 31	See Row 31	2009	RI/FS Work Plan, SLERA, BERA Work

Table 8-1

Overview of Studies Specified in the SOW, Rationale, Dependencies Assigned, Proposed Field Year if Appropriate, and RI/FS Element

Row Number	SOW Section Number	What		Why		When	Remedial Investigation/ Feasibility Study Element
		Description in Statement of Work	Sub-elements	Project-Wide	Dependencies/ Adaptive Management	Proposed Field Year, If Implemented ^a	
		and data gaps analysis					Plan
57	5.2.1	Characterization of background metal and other contaminant concentrations in UCR environmental media		See Row 33	See Row 33	2009 2010 2011	Surface Water Study, Sediment Study, Fish Tissue Study, Soil Study
58	5.2.2	Sediment sampling		See Row 7	See Row 7	2011	Sediment Study
59	5.2.3	Surface water sampling		See Row 20	See Row 20	2009-2010	Surface Water Study
60	5.2.4	Aquatic and terrestrial animal community survey	Aquatic-dependent wildlife and terrestrial wildlife associated with <u>floodplain</u> soil	Understand relative abundance and occurrence of wildlife foods; identify species for potential future sampling	BERA work plan including key wildlife species and their food habits	2012	Terrestrial Resource Study
61			Aquatic-dependent wildlife and terrestrial wildlife associated with <u>upland</u> soil	Understand relative abundance and occurrence of wildlife foods; identify species for potential future sampling	BERA work plan including key wildlife species and their food habits	2012	Terrestrial Resource Study
62	5.2.5	Aquatic and terrestrial animal residue sampling	Aquatic-dependent wildlife	Assess potential exposures to wildlife species through dietary uptake	Conduct during aquatic-dependent wildlife survey (Row 60 and/or 61) and amphibian survey (Row 64)	2012	Sediment Study, Terrestrial Tissue Study, Fish Tissue Study
63	5.2.5		Terrestrial wildlife	Assess potential exposures to wildlife species through dietary uptake	Conduct with terrestrial wildlife survey (Row 60 and/or 61)	2012	Terrestrial Resource Study

Table 8-1

Overview of Studies Specified in the SOW, Rationale, Dependencies Assigned, Proposed Field Year if Appropriate, and RI/FS Element

Row Number	SOW Section Number	What		Why		When	Remedial Investigation/ Feasibility Study Element
		Description in Statement of Work	Sub-elements	Project-Wide	Dependencies/ Adaptive Management	Proposed Field Year, If Implemented ^a	
64	5.2.6	Amphibian and reptile survey	Amphibian and reptile distributions	Understand distribution of amphibians for potential tissue residue sampling	BERA work plan and identification of amphibians and reptiles as key receptors or as prey of key receptors	2012	Terrestrial Resource Study
65			Amphibian and reptile tissue residues	Assess potential exposures to wildlife from dietary uptake	BERA work plan and identification of amphibians and reptiles as key receptors or as prey of key receptors	2012	Terrestrial Tissue Study
66	5.2.7	Fish tissue sampling		Assess potential exposures to wildlife species through dietary uptake. See Row 21	See Row 21	2009	Fish Tissue Study
67	5.2.8	Upland plant survey		Characterize potential habitat of terrestrial wildlife	BERA work plan and identification of key wildlife receptors	2012	Terrestrial Resource Study
68	5.2.9	Soil and vegetation sampling		Evaluate effects of COI exposures to wildlife	Conduct with upland plant survey (Row 67)	2012	Terrestrial Tissue Study
69	5.2.10	Bioaccessibility study		See Row 27	See Row 27	2012	Specialty Terrestrial Study
70	5.3.1	Early life stage amphibian toxicity tests		Assess potential toxicity to amphibians	Identification of amphibians as key receptors in BERA work plan; surface water investigation (Row 20), amphibian survey (Row 64)	2012	Specialty Terrestrial Study
71	5.3.2	Plant germination studies		Assess potential toxicity to plants	Existing soils evaluation relative to phytotoxicity benchmarks in BERA work plan.	2012	Specialty Terrestrial Study
72	5.3.3	Earthworm toxicity studies		Assess potential toxicity to soil invertebrates	Existing soil evaluation in BERA	2012	Specialty Terrestrial Study

Table 8-1

Overview of Studies Specified in the SOW, Rationale, Dependencies Assigned, Proposed Field Year if Appropriate, and RI/FS Element

Row Number	SOW Section Number	What		Why		When	Remedial Investigation/ Feasibility Study Element
		Description in Statement of Work	Sub-elements	Project-Wide	Dependencies/ Adaptive Management	Proposed Field Year, If Implemented ^a	
					work plan		
73	N/A	BERA Workplan		Incorporates analyses of previous data, decision rules and criteria for conducting additional studies, and more detailed specifications and schedules for those studies.	Remedial Investigation/Feasibility Study work plan, SLERA	2009	BERA Work Plan
74	N/A	Aquatic risk assessment (BERA)		Assess risk to aquatic receptors	Dependent on completion of sampling, analyses and modeling, as needed	2014	BERA
75	N/A	Terrestrial risk assessment (BERA)		Assess risk to terrestrial receptors	Dependent on completion of sampling, analyses and modeling, as needed	2014	BERA
76	N/A	Early removal action		Demonstrate feasibility of removal action	Consensus on area for limited removal action	2014	Early Action Plan
77		Remedial investigation report		Per EPA guidance	BERAs and HHRA	2014	Remedial Investigation
78		Feasibility Study report		Per EPA guidance	Remedial Investigation report	2015	Feasibility Study
<p>Note:</p> <p>^a Due to dependencies, EPA and TCAI may conclude that some studies are not necessary, or that studies not in this table are needed. In addition, EPA and TCAI may conclude that some field studies may extend beyond the year indicated.</p>							

Table 12-1. Contact Information for Key Personnel Working on the UCR Site RI/FS

Organization and Name	Contact Information
Teck Cominco American Incorporated	
<i>Project Manager</i>	
Marko Adzic	Phone: 509-892-2585 E-mail: marko.adzic@teckcominco.com
U.S. Environmental Protection Agency, Headquarters and Region 10	
Kevin Rochlin	Phone: 206-553-2106 E-mail: rochlin.kevin@epa.gov
Monica Tonel	Phone: 206-553-0323 E-mail: tonel.monica@epa.gov
Bruce Duncan	Phone: 206-553-0218 E-mail: duncan.bruce@epa.gov
Marc Stifelman	Phone: 206-553-6979 E-mail: stifelman.marc@epa.gov
David Charters	Phone: 732-906-6825 E-mail: charters.davidw@epa.gov
David Cooper	Phone: 415-972-3247 E-mail: cooper.david@epa.gov
Steve Ells	Phone: 703-603-8822 E-mail: ells.steve@epa.gov
Burt Shephard	Phone: 206-553-6359 E-mail: shepard.burt@epa.gov
U.S. Department of the Interior, National Park Service	
Dan Audet	Phone: 509-536-1246 E-mail: daniel_audet@nps.gov
State of Washington, Department of Ecology	
John Roland	Phone: 509-329-3581 E-mail: jrol461@ecy.wa.gov
The Confederated Tribes of the Colville Reservation	
Patti Bailey	Phone: 509-634-2415 E-mail: patti.bailey@colvilletribes.com
Garry Passmore	Phone: 509-634-2426 E-mail: garry.passmore@colvilletribes.com
Spokane Tribe of Indians	
Randall Connolly	Phone: 509-626-4425 E-mail: connolly@spokanetribe.com

Table 12-2. Project Mailing List for the UCR RI/FS

Mailing Address		
Mr. Kevin Rochlin U.S. EPA, Region 10 1200 Sixth Avenue (ECL-111) Suite 900 Seattle, WA 98101	Mr. Stephen J. Ells <u>For Courier Service</u> U.S. EPA, One Potomac Yard S. 2777 S. Crystal Drive 5th Floor, Cubicle #5237 Arlington, VA 22202	Mr. Don Hurst Toxics Cleanup Manager Office of Environmental Trust Colville Confederated Tribes 1 Colville Street P.O. Box 150 Nespelem, WA 99155
Mr. Bruce Duncan U.S. EPA, Region 10 1200 Sixth Avenue (OEA-095) Suite 900 Seattle, WA 98101	Mr. Jim Stefanoff CH2M HILL 9 South Washington Street Suite 400 Spokane, WA 99201-3709	Mr. Chris Ingersoll Columbia Environmental Research Center 4200 New Haven Road Columbia, MO 65201
Ms. Cara Steiner-Riley U.S. EPA, Region 10 1200 Sixth Avenue (ORC-158) Suite 900 Seattle, WA 98101	Mr. John Roland Washington Department of Ecology North 4601 Monroe Street Spokane, WA 99205-1295	Mr. Steve Cox U.S. Geological Survey 934 Broadway, Suite 300 Tacoma, WA 98402
Elizabeth McKenna U.S. EPA, Region 10 1200 Sixth Avenue (ORC-158) Suite 900 Seattle, WA 98101	Mr. Len O'Garro WA State Department of Health Office of Environmental Health Assessments 243 Israel Road SW Tumwater, WA 98501	Mr. Patrick Moran U.S. Geological Survey 934 Broadway, Suite 300 Tacoma, WA 98402
Ms. Jeanne O'Dell U.S. EPA, Region 10 1200 Sixth Avenue (ETPA-081) Suite 900 Seattle, WA 98101	Ms. Patti Bailey Environmental Planner Office of Environmental Trust Colville Confederated Tribes 1 Colville Street, P.O. Box 150 Nespelem, WA 99155	Mr. Roy Irwin Water Resources Division National Park Service 1201 Oakridge Dr., Suite 250 Fort Collins, CO 80525
Mr. David Charters U.S. EPA, Emergency Response Team 2890 Woodbridge Avenue Bldg. #18, MS101 Edison, NJ 08837	Ms. Patti Bailey Colville Confederated Tribes 76 Hemming Road Inchelium, WA 99155	Mr. Mark Curry Industrial Economics 2067 Massachusetts Avenue Cambridge, MA 02140
Mr. Marc Stifelman U.S. EPA, Region 10 1200 Sixth Avenue (OEA-095) Suite 900 Seattle, WA 98101	Mr. Gary Passmore, Director Office of Environmental Trust Colville Confederated Tribes 1 Colville Street P.O. Box 150 Nespelem, WA 99155	Mr. Nelson Beyer Patuxent Wildlife Research Center BARC - East Building 308 10300 Baltimore Avenue Beltsville, MD 20705
Mr. Stephen J. Ells <u>For Postal Service</u> U.S. EPA, OSRTI, 5204P 1200 Pennsylvania Ave. N.W. Washington, D.C. 20460		Mr. Don Steffek U.S. Fish and Wildlife Service 911 NE 11th Avenue Portland, OR 97232

Table 12-2. Project Mailing List for the UCR RI/FS

Mailing Address		
Mr. Tim Personius Bureau of Reclamation 1150 North Curtis Road, Suite 100 Boise, ID 93706-1234	Ms. Cynthia Barton U.S. Geological Survey 934 Broadway, Suite 300 Tacoma, WA 98402	Mr. Randy Connolly <u>For Postal Service</u> Department of Natural Resources Spokane Tribe of Indians P.O. Box 100 Wellpinit, WA 99040 <u>For Courier Service</u> Department of Natural Resources Spokane Tribe of Indians 6290-B Ford-Wellpinit Road Wellpinit, WA 99040
Mr. Bill Wiley Bureau of Indian Affairs 911 NE 11th Avenue Portland, OR 97232-4181	Debbie Bird National Park Service 1008 Crest Drive Coulee Dam, WA 99116	Mr. Dan Audet Bureau of Land Management 1103 N. Fancher Road Spokane, WA 99212
Ms. Camille Pleasants, Director Tribal Historic Preservation Office History/Archaeology Program Colville Confederated Tribes 1 Colville Street, P.O. Box 150 Nespelem, WA 99155	Dr. Glenn E. Harris British Columbia Ministry of Environment Environment Management Branch P.O. Box 9342 Stn Prov Govt Victoria, B.C. V8W 9M1	Mr. Jim Hansen U.S. Fish and Wildlife Service 11103 Montgomery Drive Spokane, WA
Ms. Valerie Lee, President Environment International, Ltd. 5505 34th Avenue NE Seattle, WA 98105	Bill Brattin Syracuse Research Center 999 18th Street, Suite 1975 Denver, CO 80202	Mr. Rich Henry U.S. Fish and Wildlife Service c/o EPA - Emergency Response Team 2890 Woodbridge Avenue Edison, NJ 08837
Ms. Pam Bridgen, Toxicologist Environment International, Ltd. 5505 34th Avenue NE Seattle, WA 98105	Bill Thayer Syracuse Research Center 7502 Round Pond Road North Syracuse, NY 13212	
Mr. Chris Thompson Environment International, Ltd. 5505 34th Avenue NE Seattle, WA 98105	Lynn Woodbury Syracuse Research Center 999 18th Street, Suite 1975 Denver, CO 80202	
Mr. Fred Kirschner <u>For Postal Service</u> P.O. Box 312 Valleyford, WA 99036 <u>For Courier Service</u> 12211 East Old Paulouse Highway Valleyford, WA 99036	Gary Diamond Syracuse Research Center 8191 Cedar St. Akron, NY 14001	
Ms. Sheri Sears Resident Fish Biologist Fish and Wildlife Department Colville Confederated Tribes 1 Colville Street P.O. Box 150 Nespelem, WA 99155	Mark Follansbee Syracuse Research Center 162 U.S. Route 1 Scarborough, ME 04074	
	Mr. Robert Towne Bureau of Land Management 1103 N. Fancher Road Spokane, WA 99212	

Table 12-3. Project Schedule^a

	Milestone ^b	Schedule ^c
Scoping	Final RI/FS Work Plan	Within 30 days after receipt of EPA's RI/FS Work Plan comments
	BERA Work Plan	Within 120 days after EPA approves the RI/FS Work Plan
2007/2008 Field Studies	SAP for Surface Water Study	Within 60 days after receipt of EPA's RI/FS Work Plan comments
	SAP for Beach Sediment Study	Within 90 days after receipt of EPA's RI/FS Work Plan comments
	SAP for Recreational Consumption and Use Surveys	Within 120 days after receipt of EPA's RI/FS Work Plan comments
	SAP for Aquatic Resource Study	Within 120 days after receipt of EPA's RI/FS Work Plan comments
	SAP for Sturgeon Study	Within 180 days after receipt of EPA's RI/FS Work Plan comments
	SAP for 2008 Floodplain Soil Study	Within 180 days after receipt of EPA's RI/FS Work Plan comments
	SAP for Sediment Study	Within 210 days after receipt of EPA's RI/FS Work Plan comments
	SAP for Fish Tissue Study	Within 210 days after receipt of EPA's RI/FS Work Plan comments
	Field Sampling Programs	Sampling will be initiated within 90 days of EPA approval of each SAP, or as provided in the EPA-approved SAP (e.g., to accommodate seasonal, water level, or other constraints on sampling dates)
	Validated Data Submittals	Within 90 days of receipt of all laboratory data packages for each study
Data Reports	Within 150 days of submission of validated data to EPA for each study	
Scoping	BERA Refinement of preliminary contaminants of concern (Step 3.2, First Iteration)	Draft report within 150 days of receipt of data from 2007-2008 field studies
2009 Field Studies	Sampling and Analysis Plans	As required, within 90 days of EPA and TCAI determination that additional sampling is needed
	Field Sampling Programs	Sampling will be initiated within 90 days of EPA approval of each SAP, or as provided in the EPA-approved SAP (e.g., to accommodate seasonal, water level, or other constraints on sampling dates)
	Validated Data Submittals	Within 90 days of receipt of all laboratory data packages for each survey
	Data Reports	Within 150 days of submission of validated data to EPA for each survey
Scoping	BERA Refinement of preliminary contaminants of concern (Step 3.2; Second Iteration)	Draft report within 150 days of receipt of data from 2009 field studies

Table 12-3. Project Schedule^a

	Milestone ^b	Schedule ^c
2010 Field Studies		
	Sampling and analysis plans	As required, within 90 days of EPA and TCAI determination that additional sampling is needed
	Field Sampling Programs	Sampling will be initiated within 90 days of EPA approval of each SAP, or as provided in the EPA-approved SAP (e.g., to accommodate seasonal, water level, or other constraints on sampling dates)
	Validated Data Submittals	Within 90 days of receipt of all laboratory data packages for each study
	Data Reports	Within 150 days of submission of validated data to EPA for each study
	Preliminary Site Characterization Summary Report	Within 150 days after EPA approves the final data reports for required and EPA-approved studies and any other studies identified by EPA and TCAI
Additional RI/FS Studies and Reporting		
	Technical Memorandum on Modeling of Site Characteristics	Within 60 days of the initiation of Site characterization
	SAP for other technical studies identified by EPA and TCAI	Within 90 days after EPA and TCAI determine the need for the study
	Field Sampling Programs	Sampling will be initiated within 90 days of EPA approval of each SAP, or as provided in the EPA-approved SAP
	Validated Data Submittals	Within 90 days of receipt of all laboratory data packages for each study
	Data Reports	Within 150 days of submission of validated data to EPA for each study
	Baseline Risk Assessment Report (BERA)	Within 120 days after EPA approves the Preliminary Site Characterization Summary Report
	Remedial Investigation Report	Within 90 days after EPA approves the Site Characterization Summary Report
	Technical Memorandum on Determination of Candidate Technologies and of the Need for Treatability Testing	Within 30 days of the submittal of the Remedial Investigation Report
	Treatability Testing Work Plan	Within 30 days after EPA determines treatability testing is required, or as otherwise specified by EPA
	Treatability Study Sampling and Analysis Plan	Within 60 days of receiving notice from EPA of the need for a separate or revised QAPP for treatability testing
	Treatability Study Health and Safety Plan	Within 30 days of receiving notice from EPA of the need for a revised HSP for treatability testing
	Treatability Study Cultural Resources Coordination Plan	Within 14 days of completion of the Treatability Study SAP
	Treatability Study Evaluation Report	Within 90 days of completion of any treatability testing
	Technical Memorandum on Refined Risk-Based Management Action Objectives (RMAOs) ^d	Within 60 days of submitting the BERA
	Technical Memorandum on General Response Actions ^d	Within 14 days of EPA approval of the Refined RMAOs

Table 12-3. Project Schedule^a

Milestone ^b	Schedule ^c
Technical Memorandum on the Development and Preliminary Screening of Remedial Technologies	Within 90 days of EPA approval on the Refined RMAOs
Technical Memorandum on Comparative Analysis	Within 90 days of submission of the Technical Memorandum on the Development and Preliminary Screening of Remedial Technologies
Feasibility Study Report	Within 90 days of submission of the Technical Memorandum on Comparative Analysis

Notes:

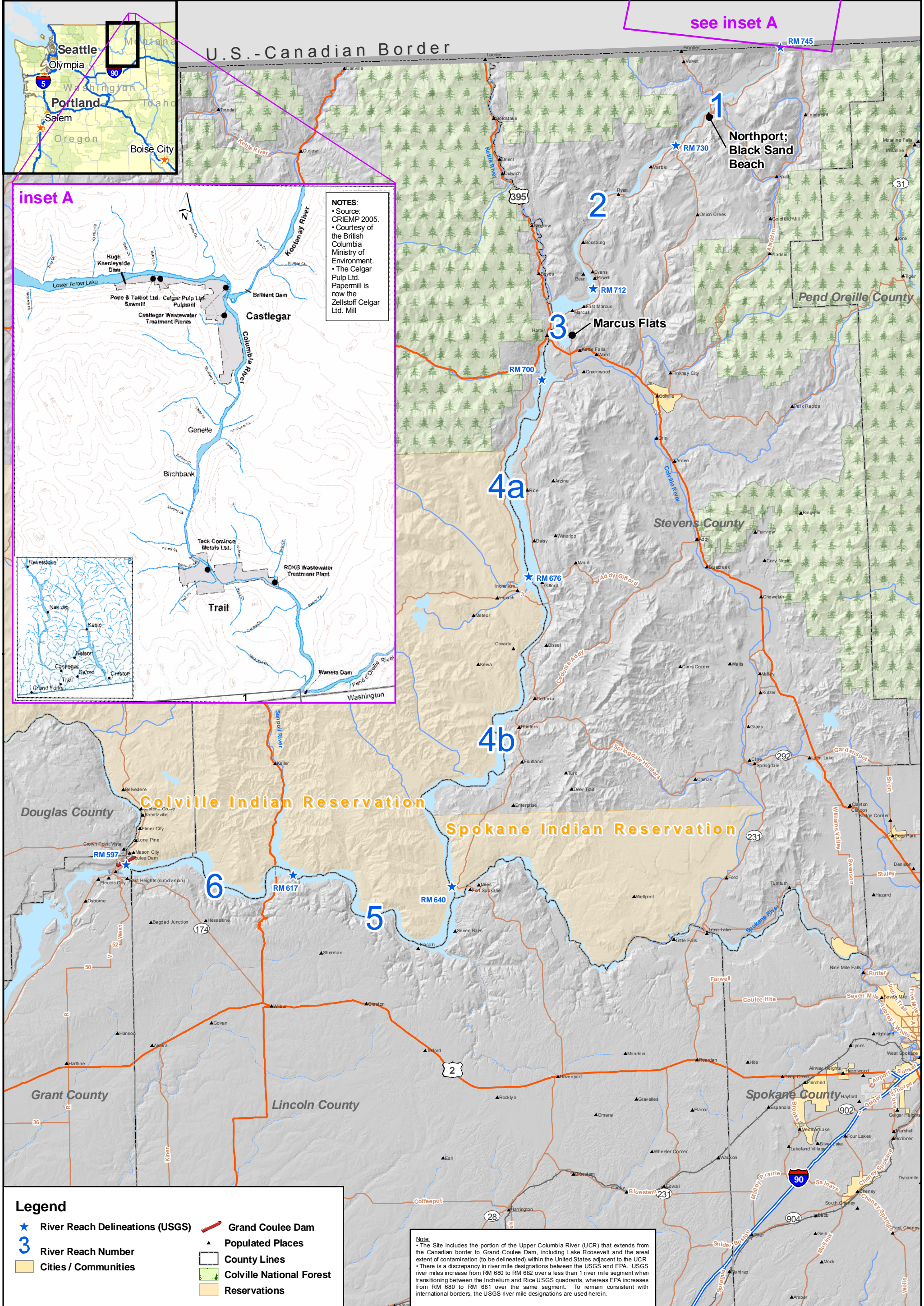
^a Schedules for SAPs were developed based on seasonality of sampling. All other dates are directly from the Agreement.

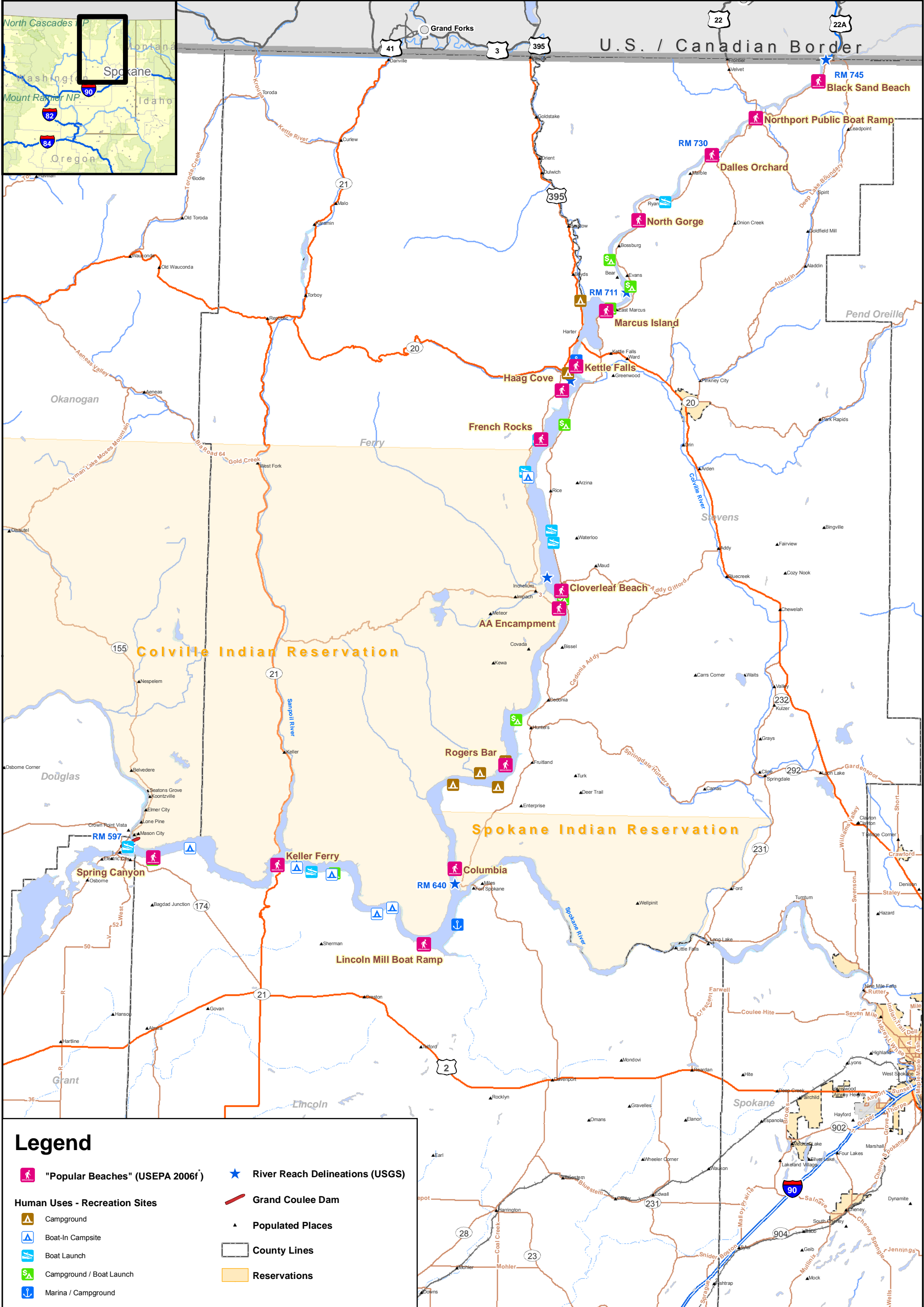
^b Documents are draft reports unless otherwise indicated.

^c Final documents will be submitted to EPA within 30 days of receipt of all final EPA comments unless otherwise noted.

^d A revised technical memorandum will be due within 14 days of receipt of EPA comments.

MAPS

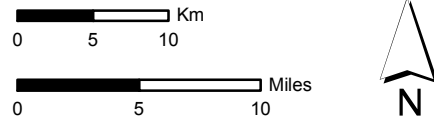




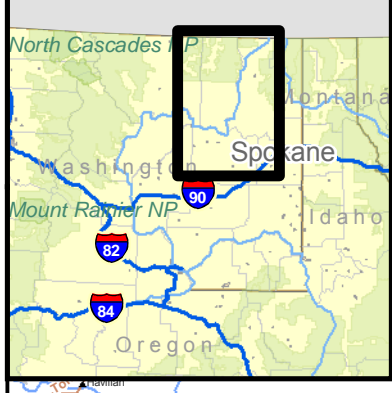
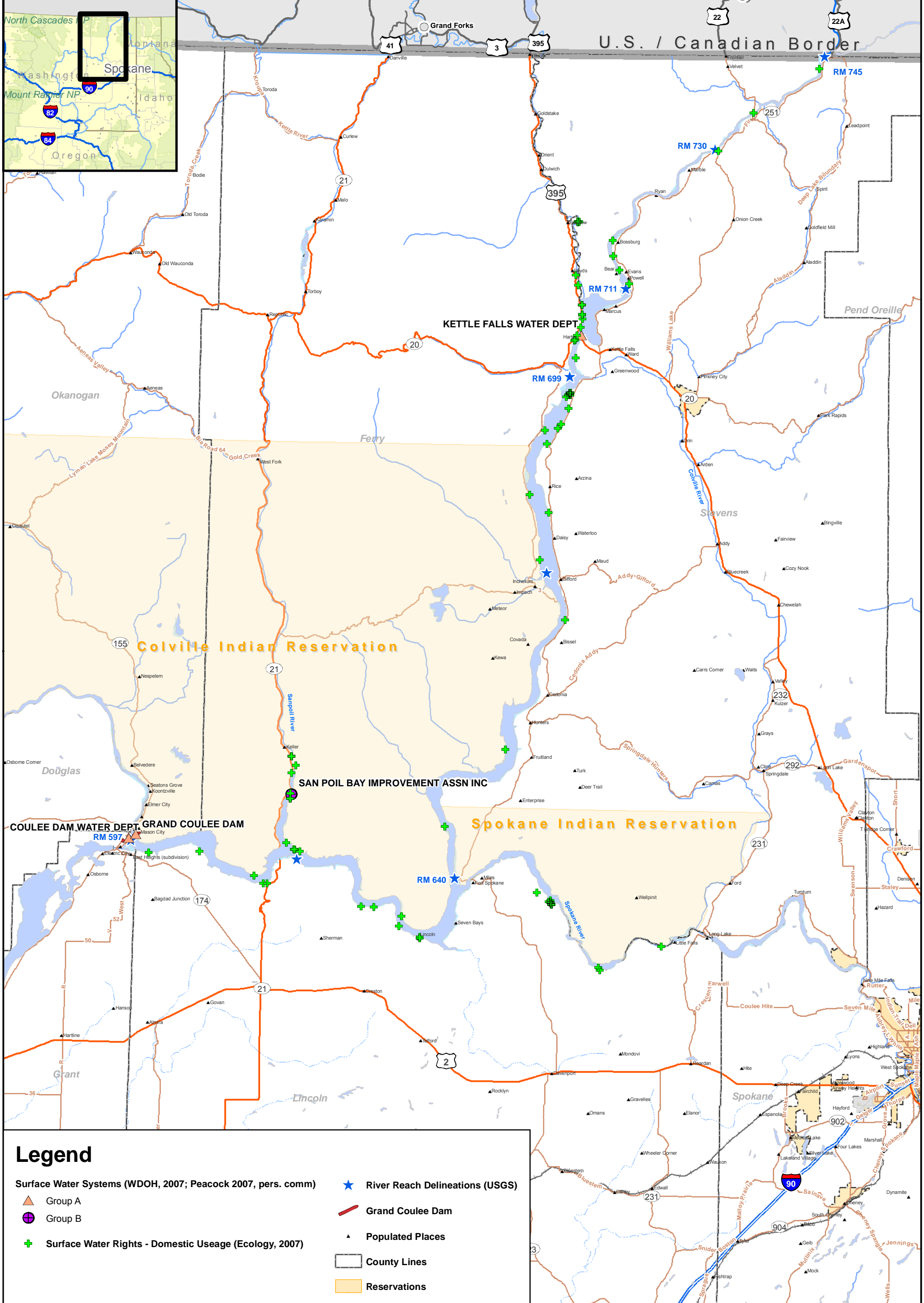
Legend

- "Popular Beaches" (USEPA 2006f)
- River Reach Delineations (USGS)
- Campground
- Boat-In Campsite
- Boat Launch
- Campground / Boat Launch
- Marina / Campground
- Grand Coulee Dam
- Populated Places
- County Lines
- Reservations

Integral Parametrix



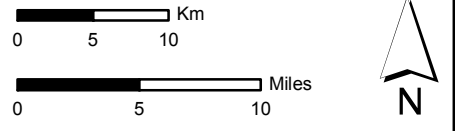
Map 3-1 High Use Beach and Developed Recreational Areas Upper Columbia River, WA



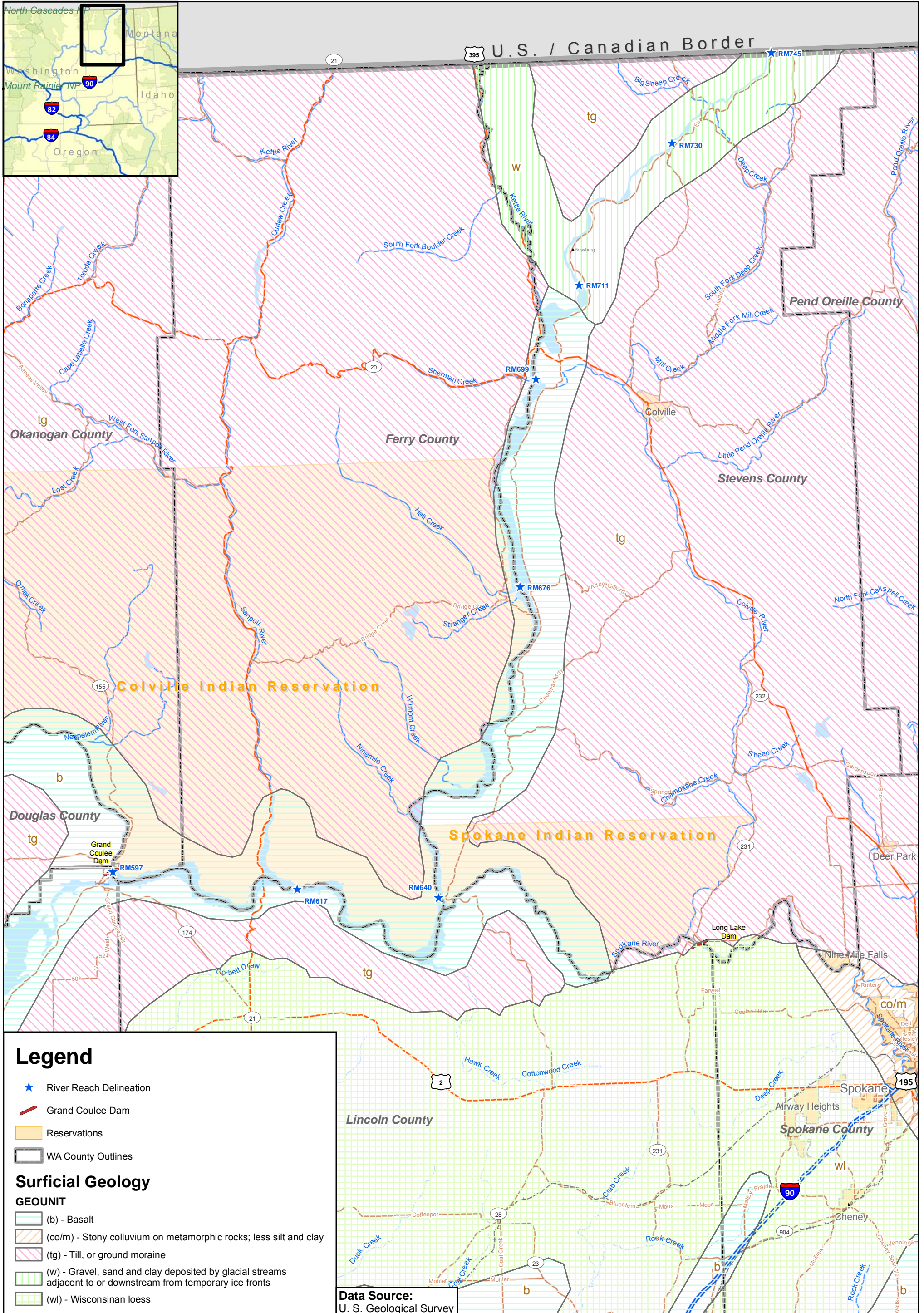
Legend

- | | |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p>Surface Water Systems (WDOH, 2007; Peacock 2007, pers. comm)</p> <ul style="list-style-type: none"> ▲ Group A ⊕ Group B + Surface Water Rights - Domestic Usage (Ecology, 2007) | <ul style="list-style-type: none"> ★ River Reach Delineations (USGS) — Grand Coulee Dam ▲ Populated Places County Lines Reservations |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

Integral Parametrix



Map 3-2 Public Surface Water Systems and Domestic Supply Surface Water Rights
Upper Columbia River, WA



Legend

- ★ River Reach Delineation
- Grand Coulee Dam
- Reservations
- WA County Outlines

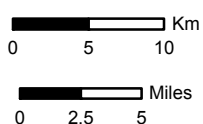
Surficial Geology

GEOUNIT

- (b) - Basalt
- (co/m) - Stony colluvium on metamorphic rocks; less silt and clay
- (tg) - Till, or ground moraine
- (w) - Gravel, sand and clay deposited by glacial streams adjacent to or downstream from temporary ice fronts
- (wl) - Wisconsinan loess

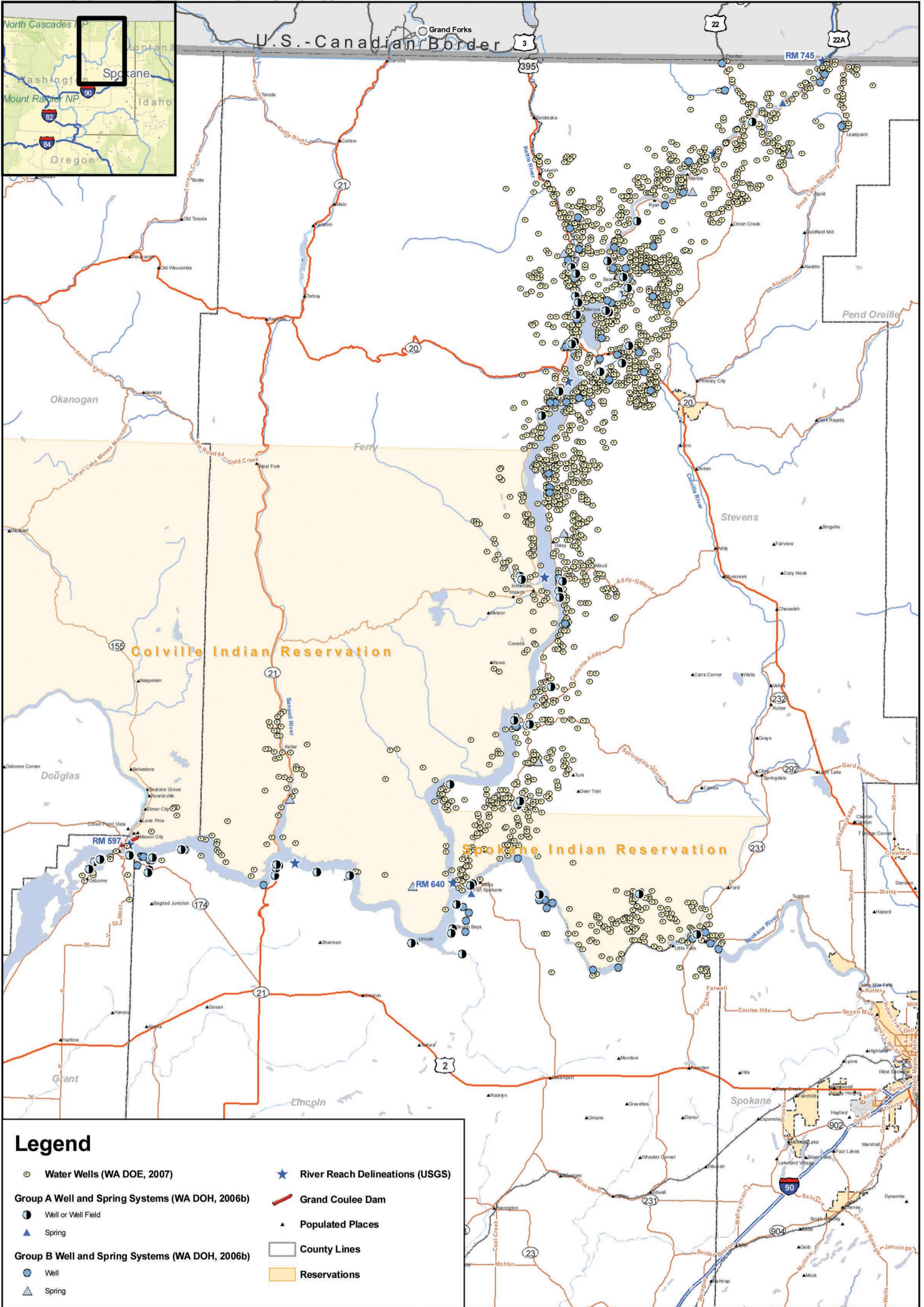
Data Source:
U. S. Geological Survey

Integral Parametrix

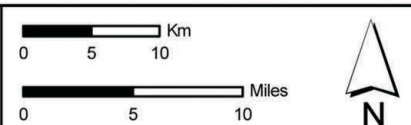


Map 3-3 Surficial Geology

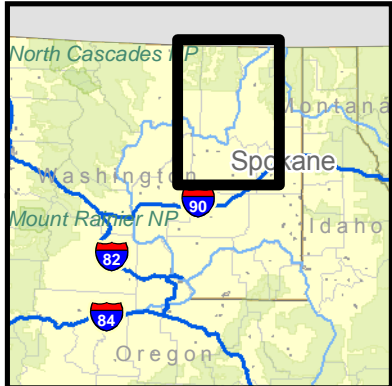
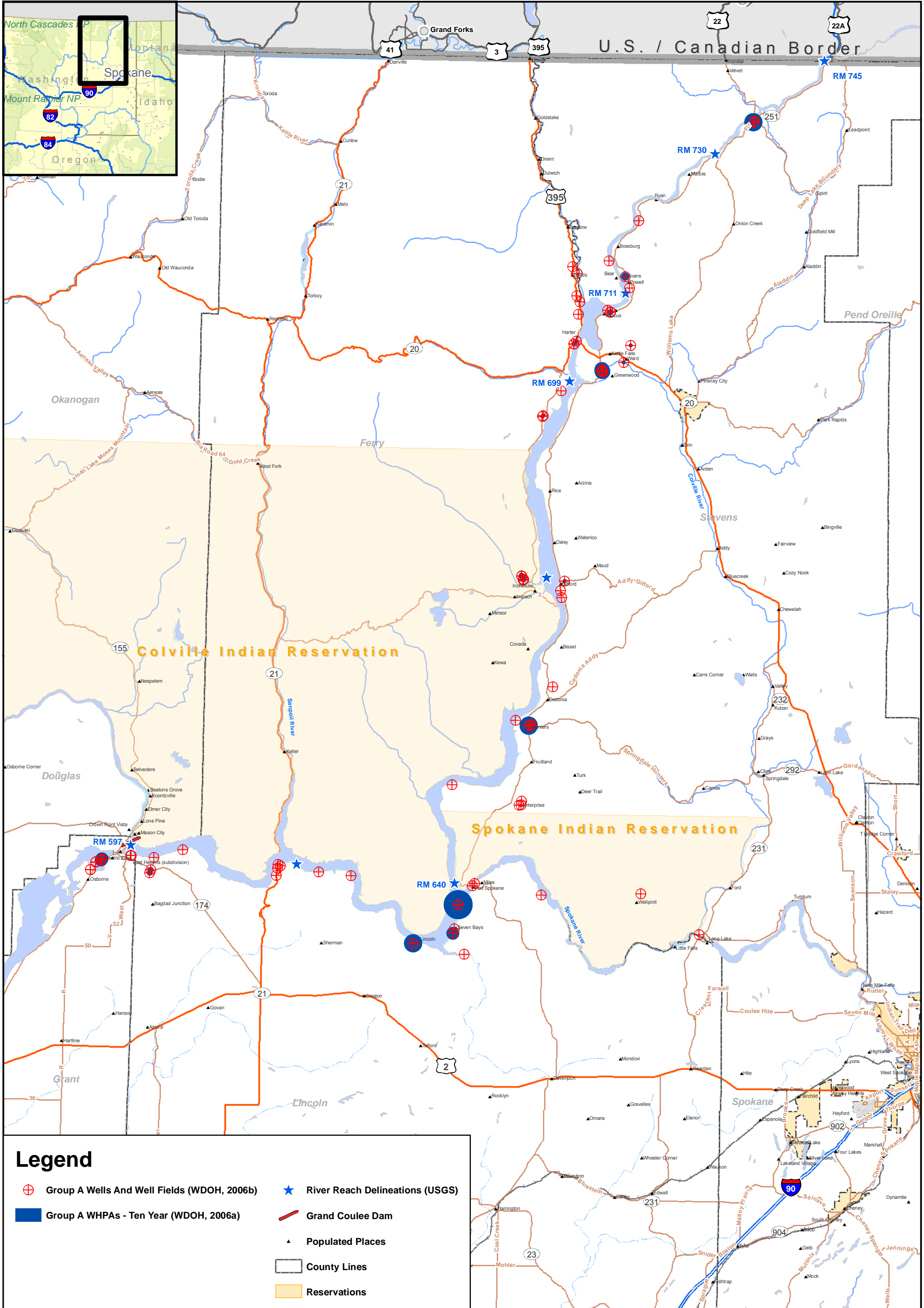
Upper Columbia River, WA



Integral Parametrix



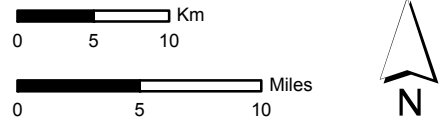
Map 3-4 Residential and Non-residential Wells and Springs Within Five Miles of the Study Area Shoreline Upper Columbia River, WA



Legend

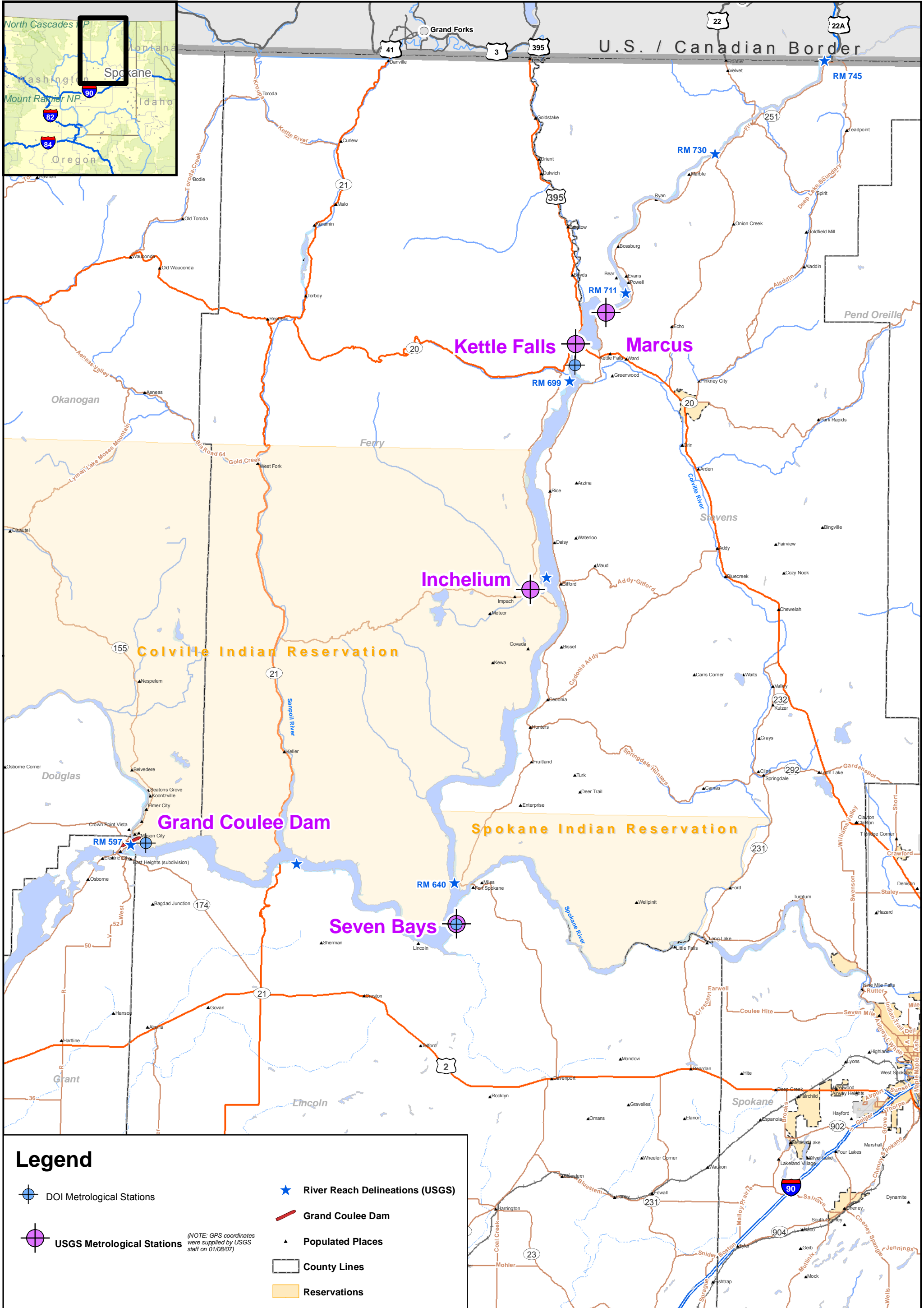
- ⊕ Group A Wells And Well Fields (WDOH, 2006b)
- ★ River Reach Delineations (USGS)
- Group A WHPAs - Ten Year (WDOH, 2006a)
- Grand Coulee Dam
- ▲ Populated Places
- County Lines
- Reservations

Integral Parametrix



Map 3-5

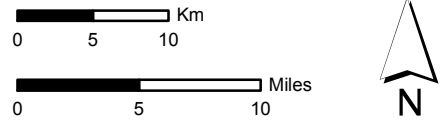
**Ten Year Well Head Protection Areas (WHPAs)
Within Five Miles of the Study Area Shoreline**
Upper Columbia River, WA

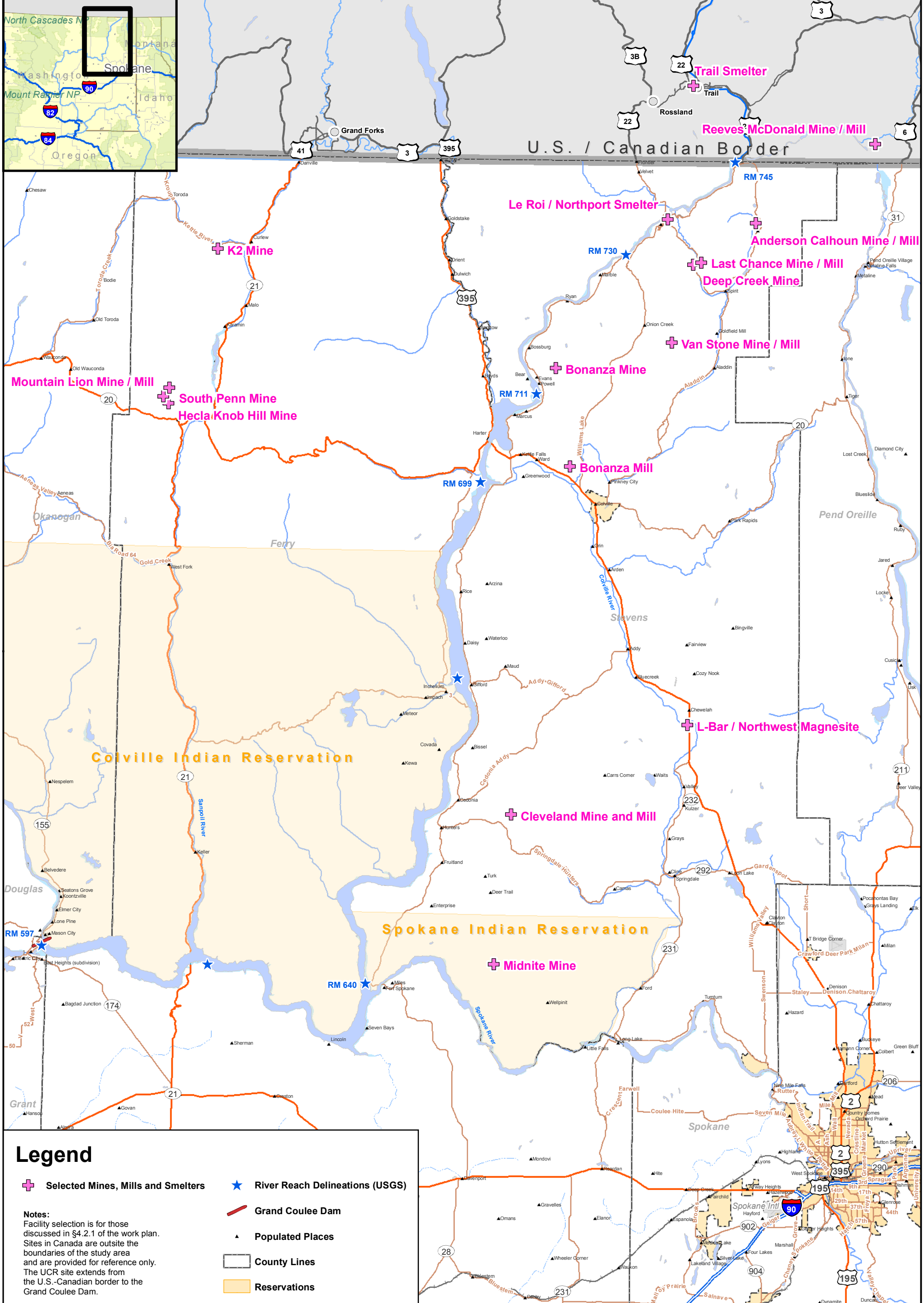


Legend

- River Reach Delineations (USGS)
 - Grand Coulee Dam
 - USGS Meteorological Stations
 - Populated Places
 - County Lines
 - Reservations
 - DOI Metrological Stations
- (NOTE: GPS coordinates were supplied by USGS staff on 01/08/07)

Integral Parametrix

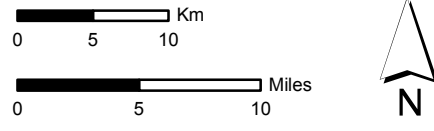




Legend

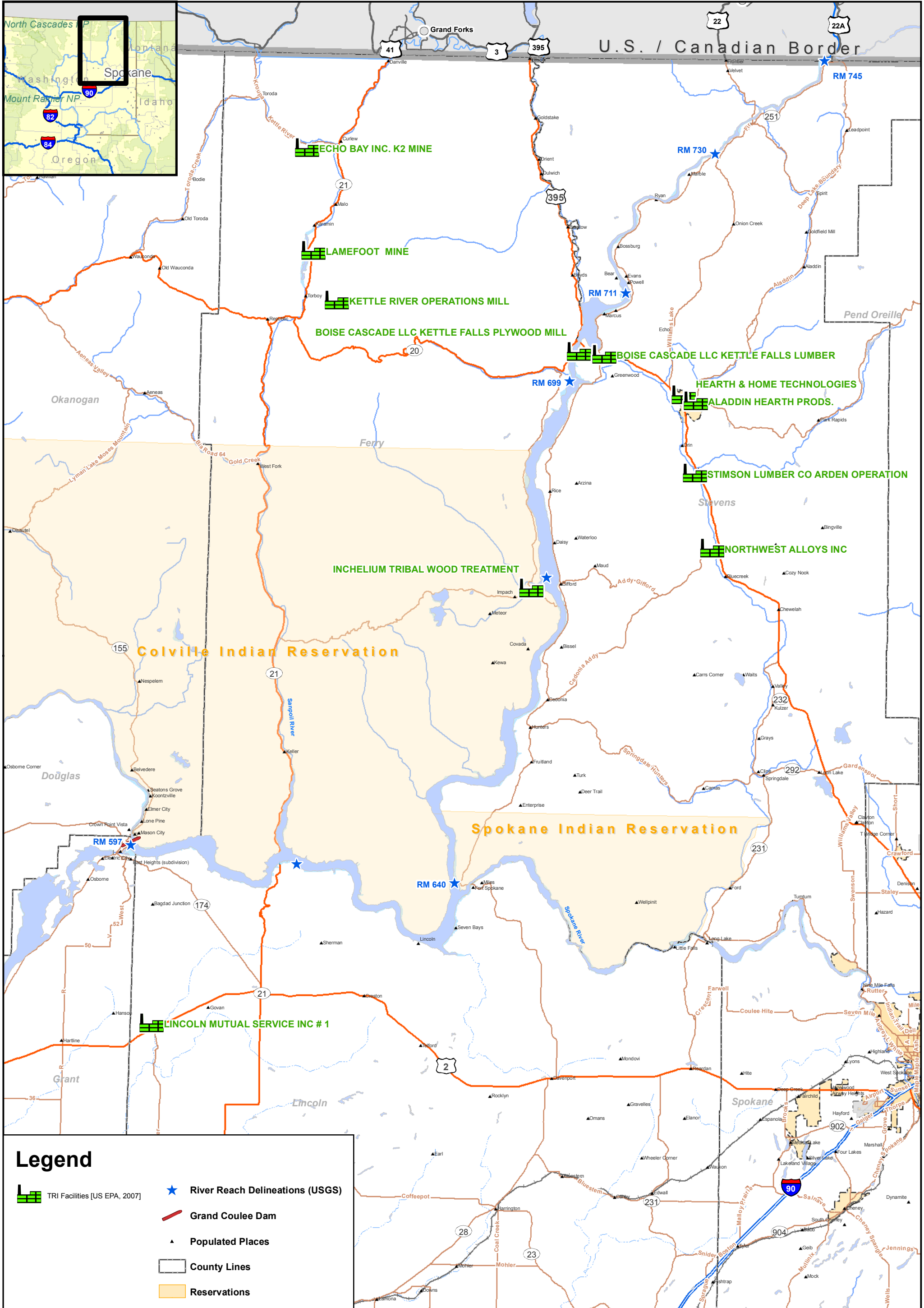
- + Selected Mines, Mills and Smelters
 - ★ River Reach Delineations (USGS)
 - Grand Coulee Dam
 - ▲ Populated Places
 - County Lines
 - Reservations
- Notes:**
 Facility selection is for those discussed in §4.2.1 of the work plan. Sites in Canada are outside the boundaries of the study area and are provided for reference only. The UCR site extends from the U.S.-Canadian border to the Grand Coulee Dam.

Integral Parametrix



Map 4-1

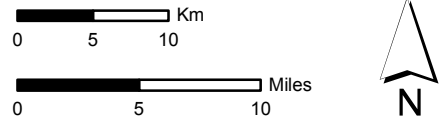
Mine, Mill, and Smelting Facilities in the Vicinity of the Study Area
 Upper Columbia River, WA



Legend

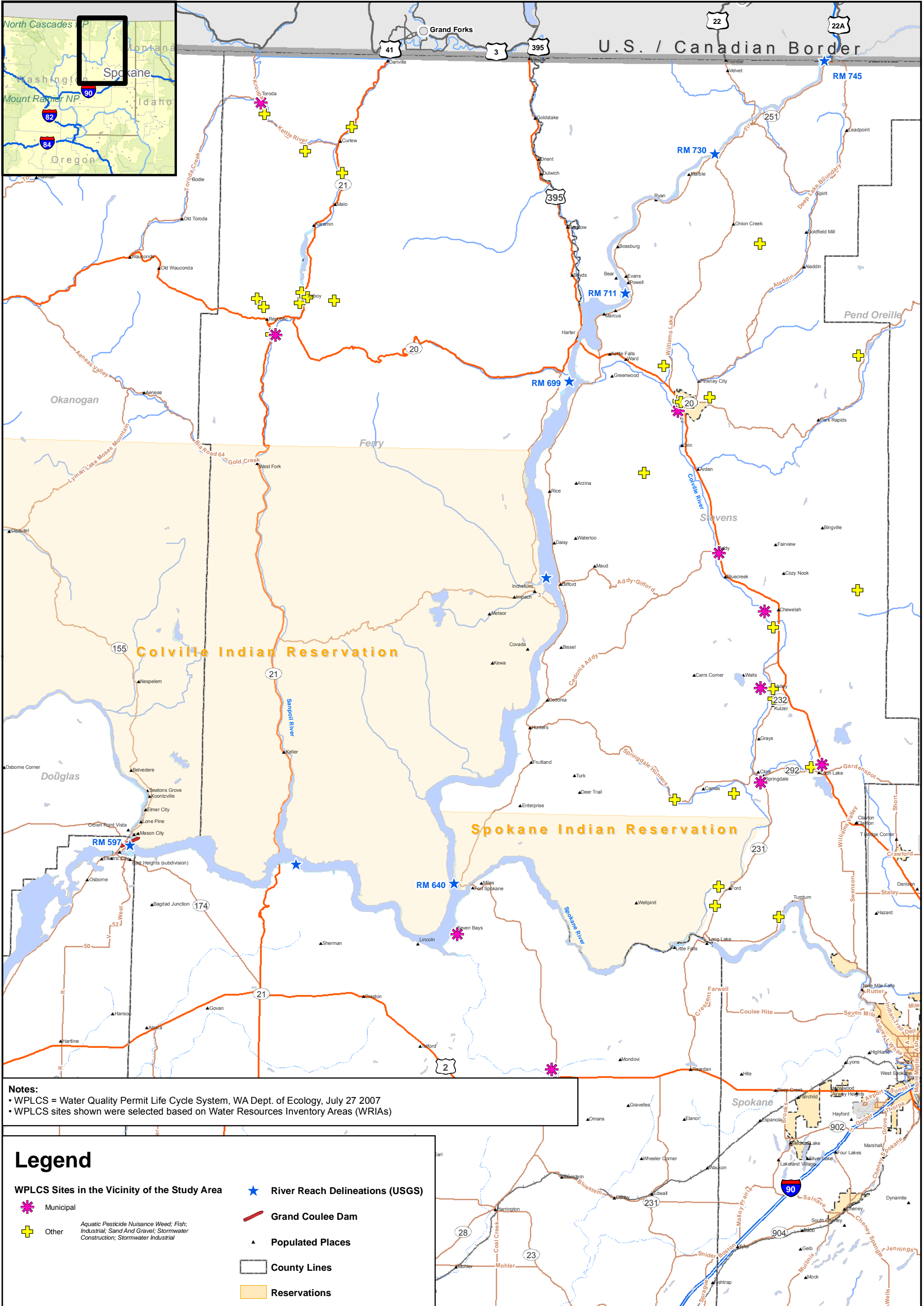
- TRI Facilities [US EPA, 2007]
- River Reach Delineations (USGS)
- Grand Coulee Dam
- Populated Places
- County Lines
- Reservations

Integral Parametrix



Map 4-2

TRI Reporting Facilities (1996 to 2005)
in the Vicinity of the Study Area
Upper Columbia River, WA



Notes:
 • WPLCS = Water Quality Permit Life Cycle System, WA Dept. of Ecology, July 27 2007
 • WPLCS sites shown were selected based on Water Resources Inventory Areas (WRIAs)

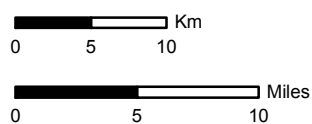
Legend

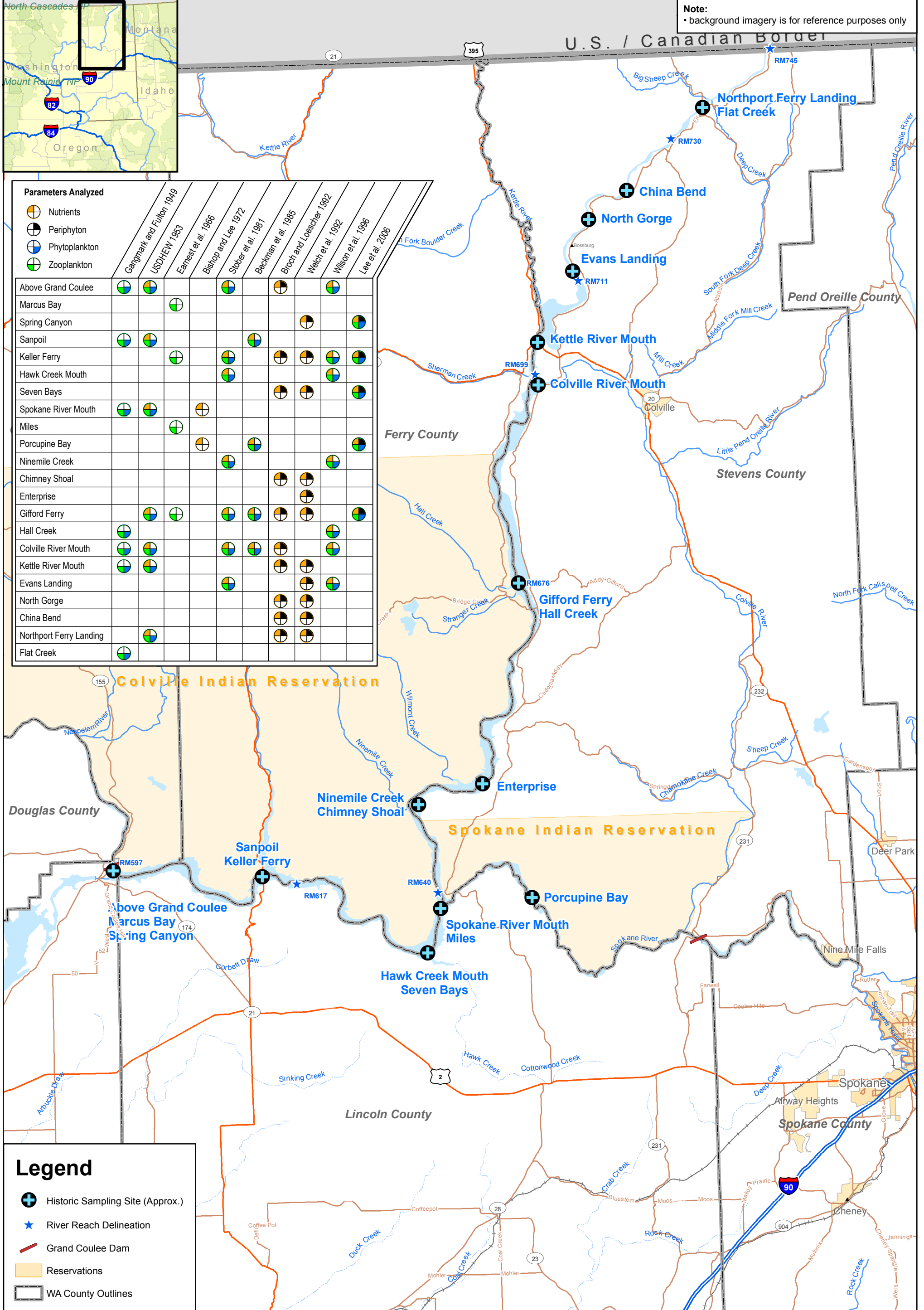
WPLCS Sites in the Vicinity of the Study Area

- ✱ Municipal
 - + Other
- Aquatic Pesticide Nuisance Weed; Fish; Industrial; Sand And Gravel; Stormwater Construction; Stormwater Industrial*

- ★ River Reach Delineations (USGS)
- Grand Coulee Dam
- ▲ Populated Places
- County Lines
- Reservations

Integral Parametrix





Note:
 • background imagery is for reference purposes only

Parameters Analyzed	Study Period / Source									
	Gangmark and Fulton 1949	USDHEW 1953	Earnest et al. 1966	Bishop and Lee 1972	Slober et al. 1981	Beckman et al. 1985	Broch and Loescher 1992	Weich et al. 1992	Wilson et al. 1996	Lee et al. 2006
+	+	+	+	+	+	+	+	+	+	+
○										
○										
○										
+										
Above Grand Coulee	+	+								
Marcus Bay										
Spring Canyon										
Sanpoil	+	+								
Keller Ferry										
Hawk Creek Mouth										
Seven Bays										
Spokane River Mouth	+	+								
Miles										
Porcupine Bay										
Ninemile Creek										
Chimney Shoal										
Enterprise										
Gifford Ferry										
Hall Creek	+	+								
Colville River Mouth	+	+								
Kettle River Mouth	+	+								
Evans Landing										
North Gorge										
China Bend										
Northport Ferry Landing										
Flat Creek	+									

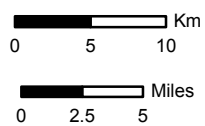
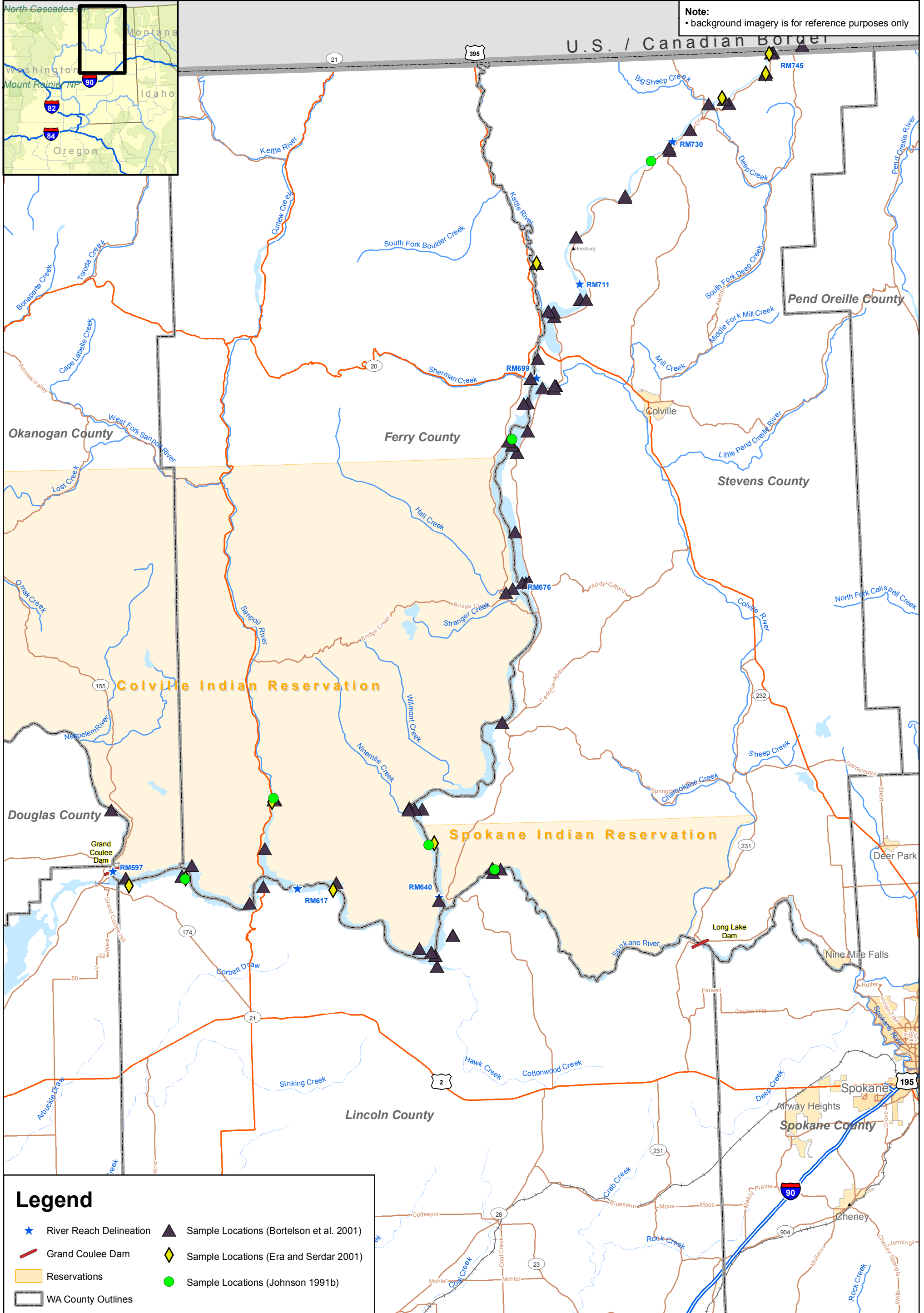
Legend

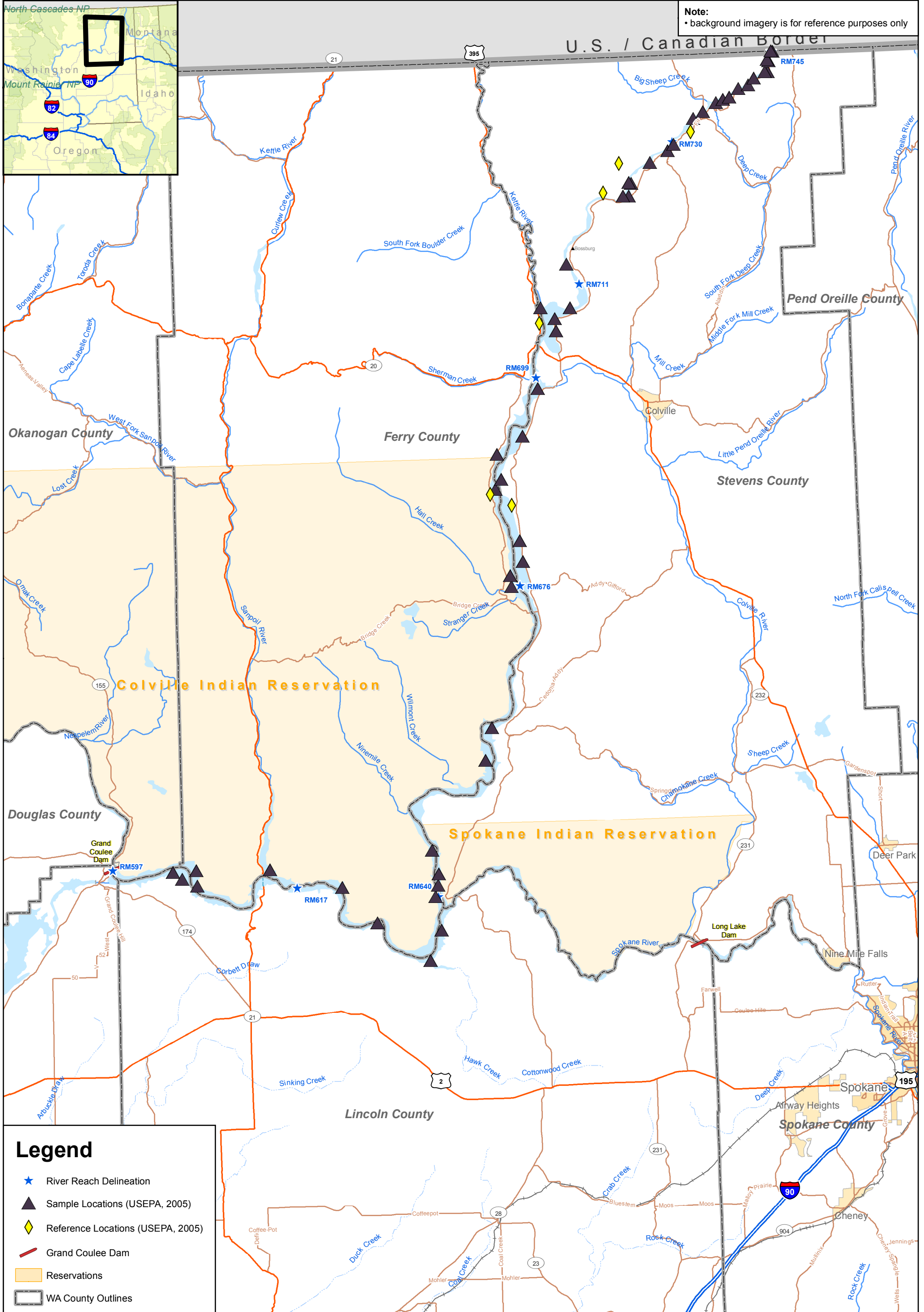
- ⊕ Historic Sampling Site (Approx.)
- ★ River Reach Delineation
- Grand Coulee Dam
- Reservations
- WA County Outlines

Integral Parametrix



Map 5-1. Approximate Historic Sampling Sites of Nutrients, Periphyton, Phytoplankton, and Zooplankton





Note:
 • background imagery is for reference purposes only

Legend

- ★ River Reach Delineation
- ▲ Sample Locations (USEPA, 2005)
- ◆ Reference Locations (USEPA, 2005)
- Grand Coulee Dam
- Reservations
- WA County Outlines

Integral Parametrix



Map 5-4 UCR Locations Sampled by USEPA for Porewater SEM/AVS and for Toxicity to Benthic Invertebrates in April 2005.
 Upper Columbia River, WA

