United States
Environmental
Protection Agency

Response Action Contract
Contract No. 68-W-98-228

BASIN ENVIRONMENTAL MONITORING PLAN

Bunker Hill Mining and Metallurgical Complex Operable Unit 3

March 2004

COEUR D'ALENE BASIN ENVIRONMENTAL MONITORING PLAN

Prepared by
URS Group, Inc.
1501 Fourth Avenue, Suite 1400
Seattle, Washington 98101

and

CH2M Hill
777 108th Avenue NE
Bellevue, Washington 98004

Prepared for
U.S. Environmental Protection Agency
Region 10
1200 Sixth Avenue
Seattle, Washington 98101
Contract No. 68-W-98-228
Work Assignment No. 095-RI-CO-I02Q

URS DCN 4162500.07190.05.a

March 26, 2004

CONCURRENCE PAGE

The U.S. Environmental Protection Agency, Idaho Department of Environmental Quality, Coeur d'Alene Tribe, Washington State Department of Ecology, Spokane Tribe, U.S. Fish and Wildlife Service, and the U.S. Geological Survey have participated in the development of the Coeur d'Alene Basin Environmental Monitoring Plan (BEMP) for the OU 3 ROD. The BEMP has been developed with the extensive involvement of the Coeur d'Alene Basin Environmental Improvement Commission's Technical Leadership Group and Monitoring Project Focus Team. The undersigned representatives concur that the monitoring plan is appropriate given the boundaries established by available funding to obtain technical data for the following purposes:

- Assessment of long-term basin-wide status and trends in surface water, soil/sediment and biota
- Evaluation of the overall effectiveness of the Selected Remedy
- Evaluation of progress toward cleanup benchmarks
- CERCLA-required five-year reviews.

Anne Dailey, USEPA EPA Project Manager	1/29/04 Date
Bruce Woods, USEPA EPA Quality Assurance Officer	20 Feb 04 Date
Luke Russell, IDEQ	2-11-04 Date
Phil Cernera, Coeur d'Alene Tribe	2-11-04 Date
John Roland, Washington Department of Ecology	1-29-04 Date
For Warren Seyler, Spokane Tribe	1-27-04 Date
Dan Audet, US Fish and Wildlife Service	1-29-04 Date
Paul Woods, US Geological Survey	2/11/04 Date

ENDORSEMENT OF THE BASIN ENVIRONMENTAL MONITORING PLAN BY BASIN ENVIRONMENTAL IMPROVEMENT PROJECT COMMISSION

The Coeur d'Alene Basin Environmental Improvement Project Commission ("the Basin Commission") was established "to implement the 2002 Record of Decision" to address heavy metal contamination in the Coeur d'Alene Basin. Commission board members include representatives from the State of Idaho, the State of Washington, the United States, the Coeur d'Alene Tribe, Shoshone County, Kootenai County, and Benewah County.

An overview of the Basin Environmental Monitoring Plan was presented to the Basin Commission at their November 2003 meeting. At the February 2004 Commission meeting, a motion supporting and endorsing implementation of the Coeur d'Alene Basin Environmental Monitoring Plan passed unanimously with a vote of 7-0.

ACKNOWLEDGEMENTS

The Coeur d'Alene Basin Environmental Monitoring Plan (BEMP) has benefited from a collaborative development effort involving many individuals and entities. Since January 2002, EPA has been working with Coeur d'Alene Basin stakeholders to collaboratively develop a long-term Basin environmental monitoring program. Organizations initially involved with EPA in development of the monitoring program include the Idaho Department of Environmental Quality, Washington Department of Ecology, Coeur d'Alene Tribe, Spokane Tribe, U.S. Fish and Wildlife Service, U.S. Geological Survey, and the Bureau of Land Management and EPA's contractor, URS Corporation.

Since establishment of the Coeur d'Alene Basin Environmental Improvement Project Commission ("Basin Commission") in August 2002, EPA has been working with the Commission and its support teams to develop this monitoring plan. The Monitoring Project Focus Team was established to focus on monitoring issues. Members were self-selected but included all of the parties involved in the initial monitoring work group established in January 2002 as well as additional participants. The BEMP has substantially benefited from the involvement of the many parties and different points of view.

A hearty thank you to the following individuals and organizations for their involvement, ideas and energy in development of the Coeur d'Alene Basin Environmental Monitoring Plan. It is a better plan for your involvement! Thanks, Anne Dailey

Luke Russell, IDEQ
Nick Zilka, IDEQ
Philip Cernera, Coeur d'Alene Tribe
Jack Gunderman, Coeur d'Alene Tribe
John Roland, Ecology
Paul Woods, USGS
Terry Maret, USGS
Steve Box, USGS
Dan Audet, USFWS
Jim Hansen, USFWS
Julie Campbell, USFWS
Fred Kirschner, Spokane Tribe
Randy Connolly, Spokane Tribe
David Fortier, BLM
Kathy Stangl, BLM
Jeff Johnson, USFS
Bob Kirkpatrick, USFS
Callie Ridolfi, Ridolfi Engineers
Tom Bowden, Ridolfi Engineers
Bruce Duncan, EPA
Bruce Woods, EPA
Bill Rust, Shoshone County
Clyde Sheppard, Kootenai County
Rogers Hardy, Benewah County
Lloyd Brewer, City of Spokane
Kathy Johnson, Johnson Environmental
John Snider, Citizens Coordinating Council
Kristy Johnson, Citizens Coord. Council
Bob Martinson, Citizens Coord. Council
Kathy Zanetti, Citizens Coord. Council
Toni Hardy, Citizens Coordinating Council
Connie Fudge, Citizens Coord. Council
Steven Hughes, URS Corporation
Kevin Lundmark, URS Corporation
Chuck Vita, URS Corporation
Dave Walker, URS Corporation
Jim Stefanoff, CH2M Hill
Jerry Lee, Terragraphics
Bryony Hansen, Golder Associates
Mark Sprenger, EPA
Bethany Grohs, EPA
Ben Cope, EPA

CONTENTS

CONTENTS (Continued)

CONTENTS (Continued)

CONTENTS (Continued)

FIGURES

TABLES

APPENDICES

ABBREVIATIONS AND ACRONYMS

AMD	acid mine drainage
AWQC	ambient water quality criteria
BEMP	Basin Environmental Monitoring Plan
BLM	Bureau of Land Management
BURP	Beneficial Use Reconnaissance Program
CCC	Citizen's Coordinating Council
CdA	Coeur d'Alene
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CIA	Central Impoundment Area
COC	chemical of concern
COEC	chemical of environmental concern
CSM	conceptual site model
CTP	central treatment plant
DQO	data quality objective
EcoRA	ecological risk assessment
EDD	electronic data deliverable
EPA	Environmental Protection Agency
FR	Federal Register
FS	feasibility study
IDEQ	Idaho Department of Environmental Quality
LMP	Lake Management Plan
NCP	National Contingency Plan
NWQL	National Water Quality Laboratory
OU	operable unit
PFT	project focus team
QA	quality assurance
RI	remedial investigation
RI/FS	remedial investigation/feasibility study
ROD	record of decision
ROW	right of way
SARA	Superfund Amendments and Reauthorization Act
SFCDR	South Fork Coeur d'Alene River
SIM	STORET Interface Module
SOP	standard operating procedure
STORET	EPA STOrage and RETrieval data management system
TLG	Technical Leadership Group
TWRI	Techniques of Water - Resources Investigations
UCFWO	Upper Columbia Fish and Wildlife Office
USC	United States Code

ABBREVIATIONS AND ACRONYMS (Continued)

USDA	United States Department of Agriculture
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
WQA	water quality assessment

EXECUTIVE SUMMARY

ES.1 INTRODUCTION

This document presents the Coeur d'Alene Basin Environmental Monitoring Plan (BEMP). Establishment of a Basin-wide environmental monitoring program is required under the 2002 Bunker Hill Mining and Metallurgical Complex Superfund Site Operable Unit 3 Record of Decision (see Section 12-6 of the ROD) for the Coeur d'Alene Basin (EPA 2002). The interim ROD describes the specific cleanup work that will be conducted in the Basin over the next 30 years.

The Basin is a large and diverse geographic area. Given the size and complexity of the Basin and the amount of historical mine waste present, it is clear that the cleanup will take many years. For environmental protection, an adaptive management approach has been adopted. The remedy selected in the ROD consists of approximately 30 years of prioritized actions designed to achieve tangible and measurable human health and environmental benefits. The actions described in the ROD are not expected to provide a full cleanup of the Basin. A key component of the adaptive management approach to cleanup of the Basin is the environmental monitoring program. Monitoring the river system and Basin will provide data to help evaluate cleanup efforts and to make adjustments and modifications where needed.

The ROD, and consequently the BEMP, is focused on the mining-related contamination in the river corridor and floodplain of the Basin. The Basin includes the South Fork of the Coeur d'Alene River and its tributaries (Upper Basin), the lower Coeur d'Alene River and associated lateral lakes area (Lower Basin), Coeur d'Alene Lake, and depositional areas of the Spokane River. A map of the Basin is presented in Figure ES-1.

ES.2 COLLABORATIVE DEVELOPMENT

Beginning in January 2002, the U.S. Environmental Protection Agency (EPA) started working with Basin stakeholders to collaboratively develop a long-term Basin environmental monitoring program. Organizations initially involved with EPA in development of the monitoring program include the Idaho Department of Environmental Quality (IDEQ), Washington Department of Ecology, Coeur d'Alene Tribe, Spokane Tribe, U.S. Fish and Wildlife Service (USFWS), U.S. Geological Survey (USGS), and the Bureau of Land Management (BLM). Media-specific workgroups were also established to focus on the specific monitoring needs regarding surface water, soil/sediment, biota and Coeur d'Alene Lake. The larger group and the smaller working groups had numerous discussions, teleconferences and several meetings to discuss the formulation of the environmental monitoring program.

Since establishment of the Coeur d'Alene Basin Environmental Improvement Project Commission ("the Basin Commission") in August 2002, EPA, together with the above stakeholders, has also been working with parties in the Commission and its support teams to continue development of the monitoring plan. The Monitoring Project Focus Team (PFT) was established to focus on monitoring issues. Members were self-selected but included nearly all of the parties involved in the initial monitoring workgroup established in January 2002, as well as additional participants from the Technical Leadership Group. Members of the Citizens' Coordinating Council (CCC) were invited to attend meetings to stay informed and provide input. Several CCC members indicated particular interest in the monitoring issues and in turn received all subsequent informational emails and conference call/meeting announcements.

ES.3 BEMP GOALS AND OBJECTIVES

The BEMP implements the environmental monitoring program established as part of the ecological component of the Bunker Hill Operable Unit 3 (OU 3) Selected Remedy. While an adequate monitoring program is critical to the successful implementation and evaluation of the remedy, the BEMP is limited to monitoring of ecological conditions in the Basin.

The major goal of the BEMP is to monitor and evaluate the progress of the remedy in terms of improving ecosystem conditions. Consistent with that goal, the BEMP will provide data relative to the following Basin-wide monitoring objectives:

- Assess long-term status and trends of surface water, soil, sediment, and biological resource conditions in the Basin
- Evaluate the effectiveness of the Selected Remedy
- Evaluate progress toward cleanup benchmarks
- Provide data for CERCLA-required five-year reviews of the progress on remedy implementation
- Improve understanding of Basin processes and variability to in turn improve the effectiveness and efficiency of subsequent remedial action implementation

Groundwater monitoring is not included in the BEMP because groundwater cleanup is not specifically addressed in the interim ROD. The importance of the interrelationship between groundwater and surface water is recognized and groundwater is anticipated to be an important component of remedial-action-specific effectiveness monitoring.

ES.4 MONITORING PLAN DESIGN

The BEMP design is founded on several primary "principles" that are intended to enhance the practicality, robustness, and cost-effectiveness while maintaining adequate technical rigor and effectiveness. First, the BEMP is based on the remedy selected in the ROD. The ROD identifies benchmarks that include key indicators of ecological improvement representing the broad range of ecological conditions in the Basin. These key indicators were selected based on the results of the remedial investigation, feasibility study, ecological risk assessment, supporting technical memoranda and stakeholder input.

The following key indicators of ecosystem change are the focus of the monitoring program:

- Dissolved and total metals and nutrients in surface water
- Metals in soil and sediment in riverine and riparian environments in the Upper Basin (Ninemile Creek, Pine Creek, and South Fork); in riverine, riparian, lacustrine, and palustrine environments in the Lower Basin; and selected sediment areas of the Spokane River
- Fish, macroinvertebrates, and aquatic habit in riverine environments
- Songbirds, riparian vegetation, and invertebrates in riparian environments
- Waterfowl in wetland environments
- Waterfowl and fish in lake environments

Second, the monitoring program uses parameters and sampling frequencies that are intended to be sensitive and responsive to the potential rates of relevant environmental changes in the Basin over the period of the remedy implementation. Given the large area of the Basin and the pace of remedy implementation over the 30-year time frame, it is anticipated that relevant changes in environmental media may occur relatively slowly. Consequently, many parameters will be monitored at relatively long intervals (e.g., five or ten years). The monitoring program includes more frequent (e.g., several times per year, annually, or event-triggered) sampling at key locations (e.g., South Fork near confluence with North Fork, Coeur d'Alene River near Coeur d'Alene Lake, etc.). These "sentinel" locations will provide data on potential short-term trends or "trend discontinuities" in the longer-term trends. The sentinel data also will be used to aid interpretation of data from the more spatially comprehensive, but less frequent, sampling events. This approach is anticipated to reduce the expense associated with sample collection and analysis, while maintaining adequate monitoring effectiveness in terms of sensitivity and responsiveness.

ES.5 BEMP MONITORING ACTIVITIES

The environmental monitoring identified in the BEMP includes sampling, testing, and evaluation of three primary media: surface water, soil/sediment, and biological resources. The specific monitoring activities, sample locations and schedules for the BEMP are summarized in the tables at the end of this section.

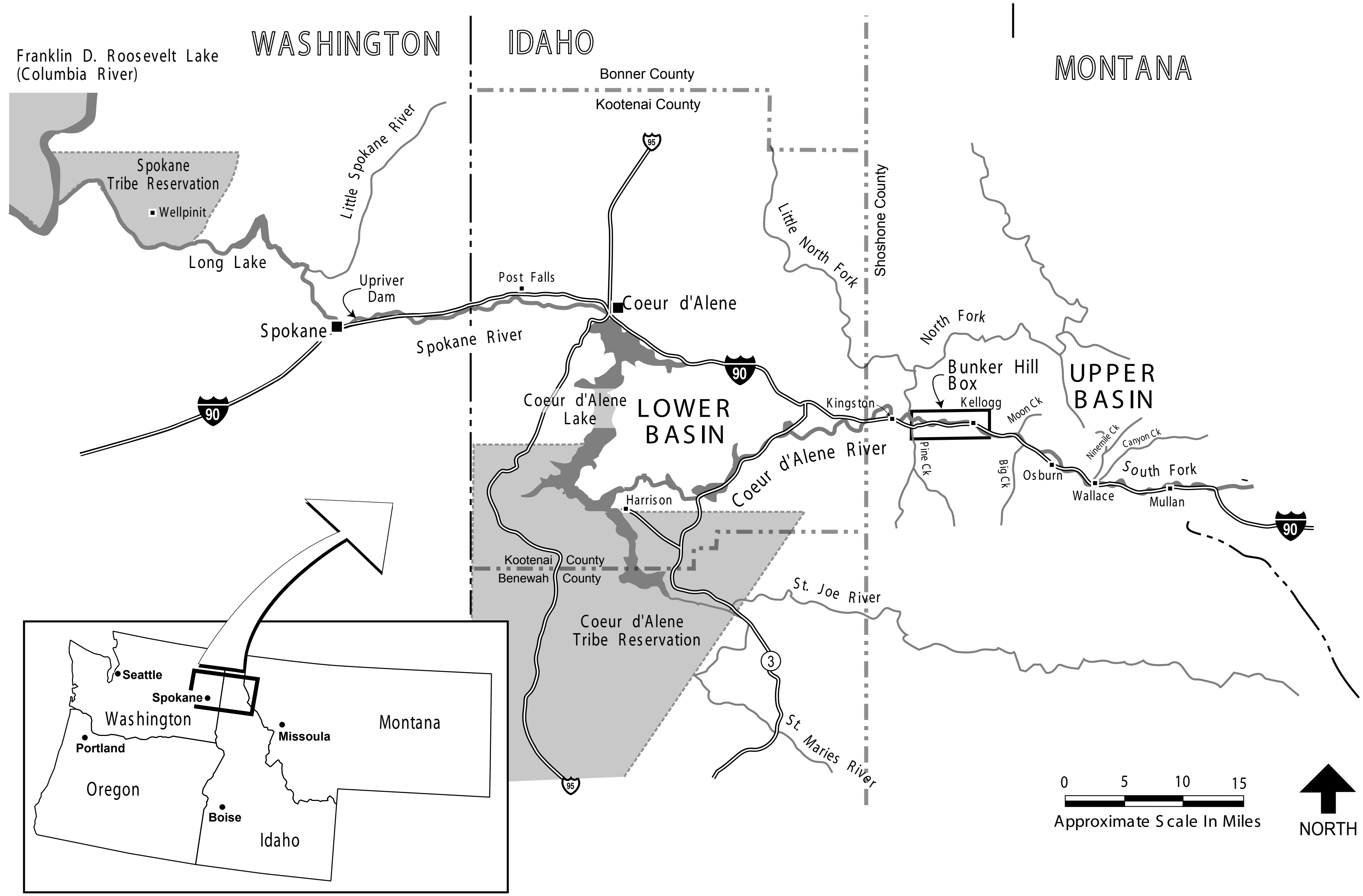
The monitoring effort represented by these tables includes many explicit tradeoffs that were made during development of the BEMP to achieve the goal of an annual monitoring cost of approximately $300,000 (present worth), as represented in the OU 3 ROD. The BEMP thus assumes that EPA will have an available yearly budget over the 30-year life of the remedy of approximately $300,000 present worth. EPA will establish Interagency Agreements with the USGS and USFWS to implement the monitoring program.

ES.6 RELATIONSHIP TO OTHER BASIN MONITORING

The BEMP will be integrated with remedial action effectiveness monitoring and monitoring conducted under other programs (e.g., Coeur d'Alene Lake Management Plan, State of Idaho Beneficial Use Reconnaissance Program monitoring, etc.). This approach is anticipated to reduce monitoring redundancy and enhance cost effectiveness. Remedial action effectiveness monitoring has been underway in the Bunker Hill Box (OUs 1 and 2) and will be initiated as OU 3 remedial actions are implemented. The monitoring conducted under the BEMP will be coordinated with the other monitoring efforts in the Basin to ensure as much commonality and compatibility as practical, given potentially different authorities, management goals, and jurisdictions.

ES.7 ADAPTIVE MANAGEMENT

The BEMP is anticipated to evolve over the 30-year remedy implementation timeframe. The monitoring program assumes an adaptive management approach will be used to guide that evolution while maintaining a sound scientific and technical basis. The adaptive management approach emphasizes "learning from experience" and is tied to the statutory five-year reviews.



EPA REGION 10

Coeur d'Alene Basin
ENVIRONMENTAL MONITORING PLAN
Doc. Control: 4162500.07190.05.a
March 26, 2004

Figure ES-1
Basin Study Area

Table ES-1
Surface Water Monitoring Program

Location	Station ID	USGS Station ID	IDEQ Station ID	Gaging Station Type	Sentinel Monitoring [a] (Annual)	ROD Benchmark Monitoring [a] (Every 5 years)	Fall Baseflow Monitoring [b] (Every Oct.)	Rationale
SFCDA above Canyon Creek (near Mullan at Deadman Gulch)	SF-208	12413040	None	Misc.	--	X	X	Supports ROD Benchmark Evaluation
Mouth of Canyon Creek	CC-287/ CC-288	12413125	CC-1	Standard	--	X	X	Supports ROD Benchmark Evaluation
Mouth of Ninemile Creek	NM-305	12413130	NM-1	Standard	--	X	X	Supports ROD Benchmark Evaluation
Upper E Fork Ninemile Creek (above Success Mine)	NM-295	124131265	ENM-3	Misc.	--	X	X	Supports ROD Benchmark Evaluation
Lower E Fork Ninemile Creek	NM-298	12413127	ENM-1	Misc.	--	X	X	Supports ROD Benchmark Evaluation
Elizabeth Park [c]	SF-268	12413210	SF-3	Standard	X	--	X	Sentinel Station, Load from SFCDR above Bunker Hill Box, Supports ROD Benchmark Evaluation
Smelterville [c]	SF-270	12413300	SF-2	Misc.	X	--	X	Sentinel Station, Load from SFCDR below CIA & Govt. Gulch
Pine Creek Below Amy Gulch	PC-339	12413445	None	Standard	--	X	X	Supports ROD Benchmark Evaluation
South Fork at Pinehurst [c]	SF-271	12413470	SF-1	Real-time	X	--	X	Sentinel Station, Load from SFCDR below Bunker Hill Box, supports ROD Benchmark Evaluation
Cataldo	LC-50	12413500	Cataldo	Real-time [e]	--	X	X	Upper Basin/Lower Basin River Character Transition
Harrison	L-C60	12413860	Harrison	Real-time (w/ suspended sediment)	X	--	X	Sentinel Station, Inflow to Lake
Spokane River at Outlet (See Note [d])	See Note [d]	See Note [d]	None	Misc. [e]	X	--	X	Sentinel Station, Outflow from Lake
Spokane River near Stateline	SR-55	12419500	None	Misc.	--	X	X	Required for WA State
NF CDR at Enaville	NF-50	12413000	None	Real-time	X	--	X	Sentinel Station, Load from North Fork CDR
St. Joe River at Mouth (Chatcolet)	SJ-60	12415130	None	Real-time (w/ suspended sediment)	X	--	X	Sentinel Station, Load from St. Joe River

Schedule for Sentinel (Annual) and Benchmark (Every 5 Years) Monitoring

Coeur d'Alene River, its Tributaries and St. Joe River
1. Fall Baseflow (early October)
2. Initial Flush after Baseflow (Fall)
3. Rain-on-snow (Winter or Early Spring)
4. Winter Baseflow (January - March)
5. Peak Snowmelt Runoff (late May. - Suspended sediment chemistry)
6. Hydrograph Recession 1 (mid-June)
7. Hydrograph Recession 2 (mid July)
8. Hydrograph Recession 3 (mid-August)

Spokane River
1. Mid-Fall Drawdown (mid-October)
2. Post-Fall Drawdown (late December)
3. Low Pool (mid-Winter)
4. Rain-on-snow (late Winter or early Spring)
5. Lake Filling (late April or early May)
6. Snowmelt Runoff Peak (late May)
7. Full Pool (mid July)
8. Full Pool, Maximum Productivity (late August)

Notes:

[a] Sentinel and benchmark station samples collected 8 times per year will be analyzed for total metals, dissolved metals, hardness, and nutrients. Metals analysis will include COECs (Cd, Pb, Zn; ROD Sect. 5.2.2). Nutrient analysis will include total and dissolved nitrogen and total and dissolved phosphorus. Samples collected during high flows (i.e. during peak snowmelt runoff in late May) will also be analyzed for suspended sediment grain size distribution metals.

[b] Benchmark stations sampled once a year will be analyzed for dissolved metals and hardness only. Metals analyses will include COECs (Cd, Pb, Zn; ROD Sect. 5.2.2).

[c] BEMP monitoirng within the Box will be coordinated with ongoing surface water / groundwater monitoring performed for the Box. Coordination of these programs (to the extent practical) will aid in the interpretation of monitoring results from the BEMP and the Box monitroinf programs.

[d] Discharge measurements to be taken at Post Falls gaging station (USGS Station No. 12419000); surface water sample to be collected at Lake Outlet. EPA Station ID for Lake Outlet is SR-5 and for Post Falls is SR-50.

[e] Funded by Idaho Water Resources

Table ES-2
Sediment Monitoring Program

Area	Sampling Description [a]
Sentinel Locations: Annual sampling to evaluate time-history trends (Fall)	
Upper Basin and Lower Basin : Surficial in-channel sediment from selected locations [b]	Composite surface samples
Spokane River : Near Stateline and near eastern boundary of Spokane Reservation	
Upper Basin, Lower Basin, and Spokane River: Water-suspended sediment sampling during high-flow conditions [c]	Filter residue from filtration of surface water samples collected during high flow events.
Basin-Wide Assessment ("Snapshot") Locations: Sampling every 10 years to evaluate aggregated, area-wide temporal averages (i.e. ratio analysis) (Fall)	
Upper Basin : Ninemile Creek, South Fork, Pine Creek	Composite surface sampling of in-channel and riparian sediment and soil.
Lower Basin : Floodplain and Harrison Delta [d]	Grid-based, composite surface sampling of riparian, lacustrine, and palustrine sediment deposits.
Spokane River: Mid and lower Long Lake [d]	Sediment core sampling

[a] Samples will be analyzed for grain size distributions of COEC metals (arsenic, cadmium, copper, lead, mercury, silver, and zinc). Sampling methods and analytical protocols for grain size distributions, sample digestion, and analysis are presented on BEMP Tables 5-1 and 5-2. (i.e. grain size distributions, sample digestion, and analytical methods). Suspended sediment monitoring locations and frequencies are presented on BEMP Table 4-1 (Surface Water Monitoring Program).

[b] In-channel (low water) locations include: 1) South Fork above Canyon Creek, 2) Mouth of Canyon Creek, 3) Upper East Fork Ninemile Creek, 4) Lower East Fork Ninemile Creek, 5) Mouth of Ninemile Creek, 6) Elizabeth Park, 7) Smelterville, 8) Pine Creek below Amy Gulch, 9) Pinehurst, 10) Enaville, 11) Cataldo, 12) Rose Lake, 13) Medimont, and 14) Harrison.

[c] Water-suspended sediment sampling locations and frequencies are presented on BEMP Table 4-1 (Surface Water Monitoring Program).

[d] Sampling at the Harrison delta and at Long Lake will be accomplished with a core sampler.

Table ES-3
Biological Resources Monitoring Program

Parameter	Representative Scale	Frequency	Location(s)
Riverine Habitat			
Fish diversity/ abundance	Representative habitats at segment level (or weir counts of migratory fish)	5-year	Ninemile Creek
			Pine Creek
			South Fork (Wallace to Elizabeth Park)
Fish Tissue Metal Levels (Upper Basin and Spokane River)	TBD	5-year	Ninemile Creek
			Pine Creek
			South Fork (Wallace to Elizabeth Park)
			Spokane River near Stnearelin[illegible]
Bull Trout Habitat/ Temp. and Other Aquatic Resources Assessment	TBD	Years 1 and 2, then every 5 years	Mainstem CdA River
Bull Trout Population Survey and Assessment of Other Aquatic Resources	TBD	Year 2 only	Areas of cold refuge (bull trout) and representative habitats in Mainstem CdA River (other aquatic resources)
Macroinvertebrate diversity/abundance	Quadrants in representative habitats	Twice per 5-years	Elizabeth Park (above Box)
			SFCdA at Pinehurst (below Box)
			Lower Basin
		5- year	Ninemile Creek
			Pine Creek
			South Fork (Wallace to Elizabeth Park)
			Spokane River near Stnearelin[illegible]
Macroinvertebrate tissue metal levels	Quadrants in representative habitats	5-year	Ninemile Creek
			Pine Creek
			South Fork (Wallace to Elizabeth Park)
			Spokane River near Stnearelin[illegible]
Aquatic habitat quality	Parameter dependent scale, representative habitats	5-year	Ninemile Creek
			Pine Creek
			South Fork (Wallace to Elizabeth Park)
			Spokane River near Stneareline
Lacustrine / Palustrine Habitat			
Waterfowl population	Wetland/lake units	3 Consecutive years @ 5 year intervals	Lower Basin
Waterfowl mortality	Mortality rate per unit effort (High use habitats)	5-year	Lower Basin
Waterfowl blood lead	Representative stations, Harrison Slough (sentinel area)	5-year	4 Stations (including Harrison Slough)
Riparian Habitat			
Riparian vegetation / invertebrates	Transects in representative locations	5-year	Ninemile Creek
			Pine Creek
			South Fork (Wallace to Elizabeth Park)
			Lower Basin
Songbird diversity/abundance	Point survey technique	5 Consecutive years @ 10-year intervals	Monitoring Avian Productivity & Survivability survey routes (MAPS) in Pine Creek and Lower Basin
Songbird blood lead	Representative stations	5-year	Ninemile Creek
			South Fork (Wallace to Elizabeth Park)
			Pine Creek
			Lower Basin (2 stations)

Table ES-4
Monitoring Program Summary

Location	Station Type	USGS Gaging Station Type	Surface Water			Sediment				Biological Resources													
										Riverine								Lacustrine/Palustrine			Riparian		
										Fish				Macroinvertebrates			Habitat	Waterfowl			Habitat	Songbirds	
			Sentinel Monitoring	Benchmark Monitoring	Low Flow	Surfical in-channel Sampling	In-channel, lacustrine, palustrine& riparain	Water-suspended Sediment at high flows (part of SW sampling)		Diversity/ Abundance	Tissue Metals Levels	Bull Trout Habitat Assessment [c] and Other Aquatic Resources	Bull Trout Pop. Survey [c]	Diversity/ Abundance	Diversity/ Abundance	Tissue Metals Levels	Aquatic Habitat Quality Assessment	Population Survey	Mortality Survey	Blood Lead	Riparian Veg. + Inverts	Diversity/ Abundance	Blood Lead
	Monitoring Frequency		Annual	5 Years	Annual	Annual	10 Years	Annual	5 Years	5 Years	5 Years	Years 1 & 2, then every 5 years	Year 2 only	2 per 5 years	5 Years	5 Years	5 Years	3 consec. yrs. every 5 yrs.	5 Years	5 Years	5 Years	5 consec. yrs. every 10 yrs.	5 Years
SFCDA above Canyon Creek	Benchmark	Misc.		X	X	X			X														
Mouth of Canyon Creek	Benchmark	Std.		X	X	X			X														
Ninemile Drainage							X			X	X				X	X	X				X		X
Mouth of Ninemile Creek	Benchmark	Std.		X	X	X			X														
Upper E. Fork Ninemile Creek	Benchmark	Misc.		X	X	X			X														
Lower E. Fork Ninemile Creek	Benchmark	Misc.		X	X	X			X														
SFCDA Drainage (Wallace-Elizabeth Park)							X			X	X				X	X	X				X		X
Elizabeth Park (above Box)	Sentinel/ Benchmark	Std.	X		X	X		X						X									
Smelterville	Sentinel	Misc.	X		X	X		X															
Pine Creek Drainage							X			X	X				X	X	X				X	X	X
Pine Creek below Amy Gulch	Benchmark	Real-time		X	X	X			X														
SFCDA at Pinehurst (below Box)	Sentinel/ Benchmark	Real-time	X		X	X		X						X									
NFCDA at Enaville	Sentinel	Real-time	X		X	X		X															
Lower Basin							X					X	X	X				X	X	X	X	X	X
Cataldo		Real-time [a]		X	X	X			X														
Rose Lake		NA				X																	
Medimont		NA				X																	
Harrison	Sentinel/ Benchmark	Real-time/SS	X		X	X	X [b]	X															
Spokane River at Outlet	Sentinel	Misc.	X		X			X															
Spokane River at Post Falls		Std. [a]																					
Spokane River near Stateline		Misc.		X	X	X			X		X				X	X	X						
Mid and lower Long Lake		NA					X [b]																
Near Eastern Boundary of Spokane Reservation		NA				X																	
St. Joe River at Mouth near Chatcolet	Sentinel	Real-time/SS	X		X			X															

[a] Funded by Idaho Water Resources
[b] Surface sediment sampling of Harrison delta and mid and lower Long Lake using a core sampler
[c] Bull trout habitat assessemnet to be performed years 1 and 2, then every 5 years. Surveying (electroshocking) locations will be identified based on habitat assessment (i.e. areas of cold refuge).

Notes:
Surface water samples to be analyzed for total and dissolved metals (Cd, Pb, Zn), suspended sediment, and nutrients.
Gaging station types:
- Standard - recording equipment that needs the data to be physically downloaded
- Real-time - satellite transmission of recording data
- Real-time/SS - satellite transmission of recording data plus suspended sediment data
- Miscellaneous - no actual gaging station but can measure instantaneous flow and estimate hourly flow

TableES-5
Monitoring Schedule

		Year	2004	2005*	2006	2007	2008	2009	2010*	2011	2012	2013	2014	2015*	2016	2017	2018
Media/Organism	**Activity**	**Location**	Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8	Y9	Y10	Y11	Y12	Y13	Y14	Y15
SURFACE WATER																	
Sentinel stations + annual low flow sampling		7 stations / 15 stations	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Benchmark stations		8 stations					X					X					X
SEDIMENT																	
Surfical sediment sampling + suspended sediment		16 areas	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Broader sediment sampling + coring		7 areas						X									
BIOLOGICAL RESOURCES																	
Waterfowl	Population survey	Lower Basin		X	X	X			X	X	X			X	X	X	
Waterfowl	Mortality Survey	Lower Basin				X					X					X	
Waterfowl	Blood Lead	4 stations					X					X					X
Songbird	Blood Lead	5 stations							X				X				X
Songbird	Population survey	2 MAPs	X	X	X	X	X						X	X	X	X	X
Riparian spp.	Riparian habitat	5 stations			X					X					X		
Aquatic Invertebrate	Diversity/adundance	3 locations	X	X				X	X				X	X			
Aquatic Invertebrate	Diversity/adundance	4 additional locations		X					X					X			
Aquatic Invertebrate	Tissue residues	4 locations		X					X					X			
Fish and invertebrate	Habitat assessment	3 locations		X			X					X					X
Fish	Diversity/abundance	3 locations			X					X					X		
Fish	Tissue residues	4 locations			X					X					X		
Bull trout	Habitat/temperature assessment	S.F.CdA and Mainstem	X	X					X					X			
Bull trout	Population survey	Areas of cold refuge		X													
REPORTING																	
Annual data report/assessment			X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Tech memo to support Five-Year Review report preparation									X					X			

Notes:
* Indicates the year that five-year reviews will need to be completed.

Table ES-5 (Continued)
Monitoring Schedule

		Year	2019	2020*	2021	2022	2023	2024	2025*	2026	2027	2028	2029	2030*	2031	2032	2033
Media/Organism	**Activity**	**Location**	Y16	Y17	Y18	Y19	Y20	Y21	Y22	Y23	Y24	Y25	Y26	Y27	Y28	Y29	Y30
SURFACE WATER																	
Sentinel stations + annual low flow sampling		7 stations / 15 stations	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Benchmark stations		8 stations					X					X					X
SEDIMENT																	
Surfical sediment sampling + suspended sediment		16 areas	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Broader sediment sampling + coring		7 areas	X										X				
BIOLOGICAL RESOURCES																	
Waterfowl	Population survey	Lower Basin		X	X	X			X	X	X			X	X	X	
Waterfowl	Mortality Survey	Lower Basin				X					X					X	
Waterfowl	Blood Lead	4 stations					X					X					X
Songbird	Blood Lead	5 stations						X					X				
Songbird	Population survey	2 MAPs						X	X	X	X	X					
Riparian spp.	Riparian habitat	5 stations			X					X					X		
Aquatic Invertebrate	Diversity/adundance	3 locations	X	X				X	X				X	X			
Aquatic Invertebrate	Diversity/adundance	4 additional locations		X					X					X			
Aquatic Invertebrate	Tissue residues	4 locations		X					X					X			
Fish and invertebrate	Habitat assessment	3 locations					X					X					X
Fish	Diversity/abundance	4 locations			X					X					X		
Fish	Tissue residues	4 locations			X					X					X		
Bull trout	Habitat/temperature assessment	S.F.CdA and Mainstem		X					X					X			
Bull trout	Population survey	Areas of cold refuge															
REPORTING																	
Annual data report/assessment			X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Tech memo to support Five-Year Review report preparation				X					X					X			

Notes:
* Indicates the year that five-year reviews will need to be completed.

1.0 INTRODUCTION

In September 2002, the U.S. Environmental Protection Agency (EPA) issued its interim plan to clean up mining contamination in the Bunker Hill Mining and Metallurgical Complex Superfund Site Operable Unit 3 ("the Coeur d'Alene Basin") (EPA 2002). The plan, or interim Record of Decision (ROD), came after several years of intensive studies to determine the extent of the contamination and the associated risks to people and the environment. The ROD describes the specific cleanup work that will be conducted in the Basin over the next 30 years at a cost of about $360 million.

The Basin is a large and diverse geographic area. Given the size and complexity of the Basin and the amount of historical mine waste present, it is clear that the cleanup will take many years. For environmental protection, an adaptive management approach has been adopted. The remedy selected in the ROD consists of approximately 30 years of prioritized actions designed to achieve tangible and measurable human health and environmental benefits. A key component of the adaptive management approach to cleanup of the Basin is the environmental monitoring program. Monitoring of the river system and Basin will provide data to help evaluate cleanup efforts and to make adjustments and modifications where needed.

The ROD, and consequently the Basin-wide environmental monitoring plan, is focused on the mining-related contamination in the river corridor and floodplain of the Basin. The Basin includes the South Fork of the Coeur d'Alene River and its tributaries (Upper Basin), the lower Coeur d'Alene River (Lower Basin), Coeur d'Alene Lake, and depositional areas of the Spokane River (Figure 1-1). Coeur d'Alene Lake is not included in the interim action and will be addressed in a future ROD. Under separate regulatory authorities, state, tribal, federal, and local governments are developing a lake management plan outside of Superfund focusing on nutrient management.

Establishment of a long-term Basin-wide environmental monitoring program is required under the ROD. We anticipate that the Basin environmental monitoring program will have two main components to address the various data needs, which include data needed to fulfill the five-year review requirements of the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA). The first component, which is the subject of this document, is a long-term status and trends assessment of surface water, soil, sediment, and biological resource conditions in the Basin. The second component is remedial action-specific effectiveness monitoring, which will be developed as part of the design of each remedial action conducted under the Operable Unit (OU) 3 ROD. While this monitoring plan will provide guidance regarding development of remedial action-specific effectiveness monitoring, the details for such monitoring will be addressed in the planning, design and implementation of each remedial action.

1.1 COLLABORATIVE DEVELOPMENT OF BASIN ENVIRONMENTAL MONITORING PLAN

Since January 2002, EPA has been working with Basin regulatory stakeholders to collaboratively develop a long-term Basin Environmental Monitoring Plan (BEMP). Organizations initially involved with EPA in development of the monitoring program include the Idaho Department of Environmental Quality (IDEQ), Washington Department of Ecology (Ecology), Coeur d'Alene Tribe, Spokane Tribe, U.S. Fish and Wildlife Service (USFWS), U.S. Geological Survey (USGS), and the Bureau of Land Management (BLM). Media-specific workgroups were established to focus on specific Basin needs regarding surface water, soil/sediment, biological resources and Coeur d'Alene Lake. The larger group and the smaller working groups have had numerous discussions, teleconferences and meetings to discuss the formulation of the environmental monitoring program.

The Coeur d'Alene Basin Environmental Improvement Project Commission (Basin Commission) was established in August 2002 by the Idaho legislature to implement the Basin ROD and the Coeur d'Alene Lake Management Plan (LMP). Since establishment of the Basin Commission, EPA has been working with parties in the Commission and its support teams to develop this draft monitoring plan. The Basin Commission established a Technical Leadership Group (TLG) and Citizens Coordinating Council (CCC) to provide the Basin Commissioners with recommendations regarding implementation of the ROD and LMP. Within the TLG, project-focused workgroups formed to tackle specific implementation issues. Among many workgroups formed, a Monitoring Project Focus Team was established to focus on monitoring issues. Members were self-selected but included nearly all of the parties involved in the initial monitoring workgroup established in January 2002, as well as additional participants from the TLG. Members of the Citizens Coordinating Council were invited to attend meetings to stay informed and provide input. Several CCC members indicated particular interest in the monitoring issues and in turn received all subsequent informational emails and conference call/meeting announcements.

1.2 GOAL AND OBJECTIVES

The environmental monitoring program is established as part of the selected remedy and will be critical to the successful implementation and evaluation of the remedy. The goal of the BEMP is to evaluate the success of the 2002 Coeur d'Alene Basin ROD in remediating the historic mining waste contamination and improving ecosystem conditions. The BEMP does not, however, conduct basic research to investigate fundamental phenomena or develop mechanistic (physico-chemical process-based) spatial-temporal performance models of the selected remedy.

The monitoring program provides data relative to the following Basin-wide monitoring objectives:

- Assess long-term status and trends of surface water, soil, sediment, and biological resource conditions in the Basin
- Evaluate the effectiveness of the selected remedy
- Evaluate progress toward cleanup benchmarks
- Provide data for CERCLA-required five-year reviews of the progress on remedy implementation
- Improve understanding of Basin processes and variability to in turn improve the effectiveness and efficiency of subsequent remedial action implementation

Basin monitoring data will be integrated with effectiveness monitoring data collected in the Basin to gain a better understanding of Basin conditions and how to improve the cleanup effort.

Effectiveness monitoring data will include, at a minimum, data collected at specific remedial actions implemented under the OU 3 ROD as well as data collected within Coeur d'Alene Lake under the LMP and the Bunker Hill Box OUs 1 and 2, a 21-square-mile area surrounding the smelting operations (Figure 1-1). All data that may help understand Basin processes and provide information to guide effective implementation of the selected remedy will be included in the future data analyses.

1.3 SCOPE OF BASIN-WIDE MONITORING PROGRAM

1.3.1 Media Addressed

The scope of the environmental monitoring program includes three primary media:

- Surface water
- Soil and sediment
- Biological resources

The OU 3 selected remedy for environmental protection consists of interim measures and does not include remediation of Basin-wide groundwater contamination. However, groundwater monitoring will also be conducted to the extent necessary to address surface water issues and gain a better understanding of Basin-wide issues. The importance of the inter-relationship between groundwater and surface water is recognized and it is expected that the remedial action-specific effectiveness monitoring often will include a groundwater monitoring component.

1.3.2 Geographic Scope

The geographic area covered by the monitoring plan includes the area addressed in the OU 3 ROD. Specifically, the plan includes the Upper Basin (the South Fork and its tributaries, with monitoring of the North Fork limited to surface water samples collected near its confluence with the South Fork), the lower Coeur d'Alene River and Lateral Lakes area (Lower Basin), and the Spokane River. Since the OU 3 ROD does not cover Coeur d'Alene Lake, lake monitoring is not part of the monitoring plan.

Coeur d'Alene Lake surface water, sediment, and biological resources are addressed in a separate Lake Monitoring Plan, which is a component of the Coeur d'Alene Lake Management Plan (LMP) (see Section 1.7 of this plan). The Lake Monitoring Plan is intended to provide data and information to assess the effectiveness of the LMP. Accordingly, monitoring of the lake conducted under the Basin-wide monitoring program is limited to the inflow and outflow of the lake. The data collected via the Lake Monitoring Plan will be integrated as appropriate into the analysis of Basin conditions, as will other effectiveness monitoring conducted in the Basin.

1.4 SITE BACKGROUND

To provide a context for the BEMP, this section briefly describes the history of the site. There is substantial detailed information regarding site background in many documents including the Basin RI/FS (EPA 2001a; EPA 2001b) and Basin Ecological Risk Assessment (EPA 2001c).

The historic mining and processing of metal-rich ores within North Idaho's Coeur d'Alene Basin began more than 100 years ago and has produced widespread metal contamination of soil, sediment, water, and biota within the Basin. The Basin has been one of the leading silver, lead, and zinc-producing areas in the world. The BLM has identified nearly 900 mining or milling-related features in the region surrounding the South Fork Coeur d'Alene River. Mining-related activities generated tailings, waste rock, concentrates, and smelter emissions. In addition, the water that drains from many abandoned adits contains elevated levels of metals. Mining, milling, and smelting practices resulted in substantial portions of the Basin containing elevated concentrations of metals that are potentially hazardous to humans and to plants and animals. The primary metals of concern include lead and arsenic for human health and cadmium, lead, and zinc for ecological receptors.

Most of the tailings were transported downstream, particularly during high flow events, and deposited as lenses of tailings or as tailings/sediment mixtures in the beds, banks, floodplains and lateral lakes of the Upper/Lower Basin and Coeur d'Alene Lake. Some fine-grained material washed through Coeur d'Alene Lake and was deposited as sediment within the Spokane River flood channel. The estimated total mass and extent of the impacted materials (primarily sediments) exceeds 100 million tons dispersed over thousands of acres.

The EPA has identified three operable units within the Bunker Hill Facility: the populated areas of the Bunker Hill Box (OU 1); the non-populated areas of the Box (OU 2); and mining-related contamination in the broader Coeur d'Alene Basin (OU 3). While this monitoring plan focuses on environmental monitoring in OU 3, the data gathered from monitoring programs within the Bunker Hill Box and Coeur d'Alene Lake will contribute to the understanding of the Basin as a whole. Monitoring associated with human health remedies, as well as other monitoring programs within the Basin, will be addressed during the five-year review of remedy implementation.

1.4.1 Bunker Hill Box

1.4.1.1 *Operable Unit 1 (Populated Areas of the Bunker Hill Box)*

The populated areas of the Bunker Hill Box (OU 1) includes the residential and commercial properties, rights-of way (ROWs), and public use areas in the towns of Kellogg, Wardner, Smelterville, Pinehurst, and several smaller unincorporated communities. Cleanup activities began in OU 1, as this was the area of greatest concern for human health exposure. The 1991 ROD addressed the residential soils component of OU 1 and other aspects were covered as part of a ROD issued in 1992, primarily for OU 2. Much of the focus of activities in OU 1 has been to remediate residential yards, schools, daycares, commercial properties and ROWs with contaminated soil. A five-year review of OU 1 was completed in 2000 and further describes OU 1 cleanup activities (EPA 2000a).

1.4.1.2 *Operable Unit 2 (Non-populated Areas of the Bunker Hill Box)*

Operable Unit 2 comprises the non-populated areas of the Box and includes the former industrial complex and mine operations area, river floodplain, hillsides, various creeks and gulches, surface water and groundwater, the Central Impoundment Area, and the Bunker Hill Mine and associated acid mine drainage (AMD). Site potentially responsible parties performed various removal activities pursuant to orders prior to a 1992 ROD, including smelter stabilization efforts, hillsides revegetation, and fugitive dust control. There have been two amendments to the 1992 ROD (1996 and 2001). A five-year review of OU 2 was completed in 2000 (EPA 2000b).

Much of the Bunker Hill Box is underlain by mine tailings, and substantial metal loads enter the South Fork Coeur d'Alene River as it passes through the Box. Based on estimated average values, about 1,550 pounds per day of dissolved zinc (about 53 percent of the total Upper Basin load) comes from sources inside the Bunker Hill Box. As noted above, OU 2 includes the Bunker Hill Mine and associated AMD, which contains very large loads of metals. The Central Treatment Plant (CTP) has not been significantly upgraded since it was built in 1974. The 2001 ROD amendment addressed issues concerning the CTP.

Due to the location and impacts of OU 2, integration of the OU 2 environmental monitoring data with the Basin-wide data will be critical to understanding the Basin-wide environmental monitoring.

1.4.2 Operable Unit 3 (Coeur d'Alene Basin)

The risks posed to human and environmental health by historic mining contamination prompted the EPA to conduct a Remedial Investigation/Feasibility Study (RI/FS) of the Coeur d'Alene Basin (EPA 2001a, EPA 2001b). The RI/FS began in 1998 and resulted in the Coeur d'Alene Basin ROD, which was issued in September 2002. The remedial actions selected in the ROD for OU 3 focus largely on mining-related contamination within the floodplains and river corridors of the Basin, exclusive of the populated (OU 1) and unpopulated areas (OU 2) within the Bunker Hill Box.

A selected remedy for Lake Coeur d'Alene is not included in the interim ROD (see Section 12.3 of the ROD). As an alternative to remedial action, the Idaho DEQ and Coeur d'Alene Tribe are formulating a revised nutrient-control Lake Management Plan, or LMP, outside of Superfund and having the objective of using separate state, tribal and local regulatory authorities to protect lake quality and control metals mobility. The revised LMP is expected to improve upon an LMP first developed in 1995, prior to the Basin-wide Superfund Remedial Investigation efforts, and assure effective implementation. A draft of revisions underwent public review and comment in April 2003. The final revised plan is pending. One important component of the LMP revision effort is the inclusion of an environmental monitoring program to assess effectiveness. A nutrient-driven monitoring plan for the lake is expected to be incorporated within the LMP revisions.

1.5 LEGAL REQUIREMENTS FOR MONITORING

The remedy selected by the interim action ROD is not the final remedy and recognizes that some contamination will remain on site into perpetuity. Under Section 121(c) of CERCLA, as amended by the Superfund Amendments and Reauthorization Act (SARA) of 1986, and under the Superfund implementation regulations, if contamination remains on site then post-response reviews are required every five years in perpetuity to ensure protection of human health and the environment. The EPA further interpreted this requirement in the National Contingency Plan (NCP) (40 CFR 300.430(f)(4)(ii)), which states that if contaminants remain on site above levels that allow for unlimited use and unrestricted exposure, then the lead agency must review the action at least every five years. The preamble to the National Contingency Plan (NCP) states that the focus of the five-year review should be an assessment of monitoring data to evaluate whether the remedy continues to provide for adequate, risk-based protection of human health and the environment (55 FR 8730, March 8, 1990). Additional authority regarding monitoring gives the EPA authority to undertake monitoring to identify threats (42 U.S.C. 9604(b)) and defines remedial actions as inclusive of any monitoring reasonably required to ensure that such actions protect the public health, welfare, and the environment.

1.6 FIVE-YEAR REVIEWS AND ADAPTIVE MANAGEMENT

An important objective of the monitoring program is to provide data for five-year reviews, including evaluation of progress toward the benchmarks of the selected remedy. The five-year review process under CERCLA focuses on answering the following three questions (EPA 2001d):

- Is the remedy functioning as intended by the decision documents?
- Are the exposure assumptions, toxicity data, cleanup levels, and remedial action objectives used at the time of remedy selection still valid?
- Has any other information come to light that could call into question the protectiveness of the remedy?

Five-year reviews for all site operable units are conducted on a unified schedule to present a comprehensive picture of site status. The next five-year review is due in September 2005 and subsequent reviews will be due every five years thereafter for the foreseeable future.

Remedial action performance will be evaluated, in part, by comparing the long-term monitoring data to the benchmarks of the selected remedy. The monitoring hypotheses for this monitoring program have been developed to answer questions relating to progress toward benchmarks of the selected remedy, where possible, and the timing of monitoring events will be selected with consideration of five-year review data needs. Effectiveness monitoring data will be used to complement the long-term monitoring data during five-year review evaluations.

The ROD calls for an adaptive management framework to remedy implementation, and a component of the five-year review is anticipated to be an adaptive management review. Under the adaptive management process, which is described in Section 6 of this document, the BEMP data will be analyzed and interpreted in order to evaluate remedy performance against the ROD benchmarks, which are the expectations of remedy performance. These evaluations and the experience gained from remedy implementation may help identify and guide "course corrections" that improve remedy performance or cost-effectiveness. Specific efforts include detecting trends or major trend discontinuities, which may signal a need to update critical assumptions or change management practices, potentially including the BEMP itself.

1.7 OTHER MONITORING ACTIVITIES

1.7.1 Bunker Hill Box

In the Bunker Hill Box, a water quality assessment (WQA) program and biological resources monitoring are being implemented under the OU 2 ROD. The primary goal of the WQA program is to determine the effect that remedial actions have had on water quality in the Box and to aid future remedial action decisions, in particular the control of dissolved metals reaching the South Fork Coeur d'Alene River. In order to achieve this with any degree of certainty, a better understanding of metal concentrations and loads entering, moving within, and exiting the Box is needed. Two parallel objectives include better defining the overall Box contribution to the Basin metal loads and better defining where the load is originating from within the Box. The latter objective is necessary to help determine what effect, if any, individual remedial actions have had on water quality, and where additional remedial activities may be needed in the future to reduce metals loading from the Box.

There are currently 80 wells in the Box monitoring network, including 23 that were installed in 2003. Until recently, there were not enough data points to effectively evaluate trends or even patterns within the data. When combined with water level measurements, patterns are now appearing. Work is underway to evaluate the historical data on each well to see if and where these patterns hold. This evaluation also should lead to the reduction of monitoring frequency where results are consistent (such as the deeper aquifer), and the deletion of some wells altogether where information is duplicated. One question that will be much harder to answer is how any trends observed using recent data (past 8 years) might be influenced by other significant site activities, such as the treatment plant going online in the early 1970s. It may be too early to notice trends due to specific remedial actions due to the "noise" caused by the treatment plant both prior to, and after, going online.

Surface water sampling is being conducted at the mouths of tributaries throughout the Box. Metals loading from surface water sources is calculated at 13 different stations and, as of this year, will be coordinated with USGS sampling data collected along several points of the South Fork of the Coeur d'Alene River in the Box. Gaining and losing reaches of the river add to the complexity of surface water/groundwater evaluations. The WQA team is scheduled to complete additional measurements of low-flow groundwater seepage along the South Fork of the Coeur d'Alene River in 2004 to help better understand this relationship. The impact of the Central Impoundment Area (CIA) cap on the reach where the CIA seeps have historically been located is of primary interest. The USGS completed these measurements in 1999 prior to installation of the cap. A comparison with 2004 measurements, after five years of CIA dewatering has taken place, will aid in the effectiveness evaluation of that particular remedial activity.

Biological monitoring of the non-populated areas of the Bunker Hill Box is being conducted to assess the effectiveness of the remedies as they relate to biological resources (wildlife, fish and other aquatic resources, plants, and associated habitats) and to provide data to inform future remedial actions. All studies are currently implemented by the USFWS under an inter-agency agreement with EPA (USFWS 2001, 2002). The investigations include:

- Songbird and waterfowl surveys
- Songbird and waterfowl blood collection
- Small mammal population surveys and metals evaluation
- Amphibian/reptile surveys
- Fish population surveys and metals evaluation
- Aquatic and riparian habitat evaluation
- Wetland vegetation mapping
- Floodplain and riparian community sampling
- Riparian vegetation community sampling
- Wildlife fecal evaluation

The biological resources monitoring is being conducted at several locations within the Box, including Smelterville Flats, hillsides, gulches, and the South Fork Coeur d’Alene River.

1.7.2 Coeur d’Alene Lake

As noted above, Coeur d’Alene Lake is not included in the OU 3 ROD. The Idaho DEQ and Coeur d’Alene Tribe are working with local, state, and federal parties to develop a lake monitoring plan as part of a revised Lake Management Plan (LMP) (CLCC 1996). The Basin-wide monitoring plan described herein includes stations relative to the lake as needed to characterize the mass balance of metals and nutrients in the lake for long-term status and trends. The BEMP includes surface water monitoring stations at the mouths of the major tributaries and the outflow from the Lake. Additional monitoring designed to assess the effectiveness of the LMP is expected to be included within the LMP monitoring program. Results from the LMP effectiveness monitoring will be incorporated into evaluations of Basin conditions.

1.7.3 Human Health

The focus of this plan is environmental monitoring. The monitoring conducted under this plan will provide data that can be used for assessing progress toward protecting human health, particularly for exposures related to recreational and subsistence uses. The plan, however, is not designed to monitor protection of human health in the community and residential areas of the Basin upstream of Coeur d'Alene Lake. The selected remedy includes a lead health intervention program that will provide for monitoring of human health in the community and residential areas.

The selected remedy also includes monitoring of aquatic food sources, such as fish and water potatoes, for protection of human health. The Basin-wide environmental monitoring program will draw on these monitoring results as part of the evaluation of biological resource conditions in the Basin.

1.7.4 Remedial Action Effectiveness Monitoring

Action-specific effectiveness monitoring will focus on specific areas (tributaries, river reaches, etc.) that have been addressed by remedial actions. By comparison, the long-term status and trends monitoring program will address basin-wide conditions by monitoring a limited number of strategic locations. The long-term monitoring plan was designed to integrate effectiveness monitoring with status and trends monitoring results. The effectiveness and long-term monitoring plans will be integrated by coordinating monitoring to generate comparable data (same timeframe or synoptic) and using common sampling locations, where possible. Effectiveness monitoring, while not detailed in this plan, will incorporate similar monitoring hypotheses as those presented in this plan. The adaptive management approach will maximize the utility of effectiveness monitoring data through comparison of results to expectations. The BEMP relies on and anticipates the systematic performance of action-specific effectiveness monitoring across the Basin.

1.7.5 Monitoring Activities Under Other Programs

In addition to the monitoring related to the Superfund activities noted above, a variety of non-CERCLA monitoring efforts, either on-going or in the process of being developed, are occurring in the Coeur d'Alene Basin. To the extent possible, the monitoring conducted under the BEMP will be coordinated and linked with the other monitoring efforts to ensure as much commonality as practical, given potentially different authorities, management goals, and jurisdictions. Examples of other monitoring efforts include, but are not limited to, monitoring that the state water quality program does for 303(d) listing of impaired water bodies, IDEQ's Beneficial Use Reconnaissance Program (BURP), and IDEQ and U.S. Forest Service effectiveness monitoring programs.

1.8 DATA QUALITY OBJECTIVES

Data quality objectives (DQOs) are qualitative and quantitative statements that:

- Clarify the study objective
- Define the most appropriate type of data to collect
- Determine the most appropriate conditions from which to collect the data
- Specify tolerable limits on decision errors that will be used as the basis for establishing the quantity and quality of data needed to support the decision

The Basin environmental monitoring program uses the DQO process, which is a strategic planning approach based on the scientific method to prepare for a data collection activity (EPA 1994, EPA 2000c). The DQO process provides a systematic procedure for defining the criteria that a data collection design should satisfy, including when to collect samples, where to collect samples, the tolerable level of decision error for the study, and how many samples to collect, while balancing risk and cost in an acceptable manner. The data quality assessment process is a comparison of the implemented sampling approach and resulting analytical data against the sampling and data quality requirements specified by the DQOs. The results are meant to determine whether the data are of adequate quality and quantity to support the decision-making process.

The DQO process will assure that the type, quantity, and quality of environmental data used in decision-making will be appropriate for the intended application, resulting in environmental decisions that are technically and scientifically sound and legally defensible. In addition, the DQO process will guard against committing resources to data collection efforts that do not support a defensible decision. To this end, DQOs will be evaluated as part of the adaptive management process as part of the five-year process.

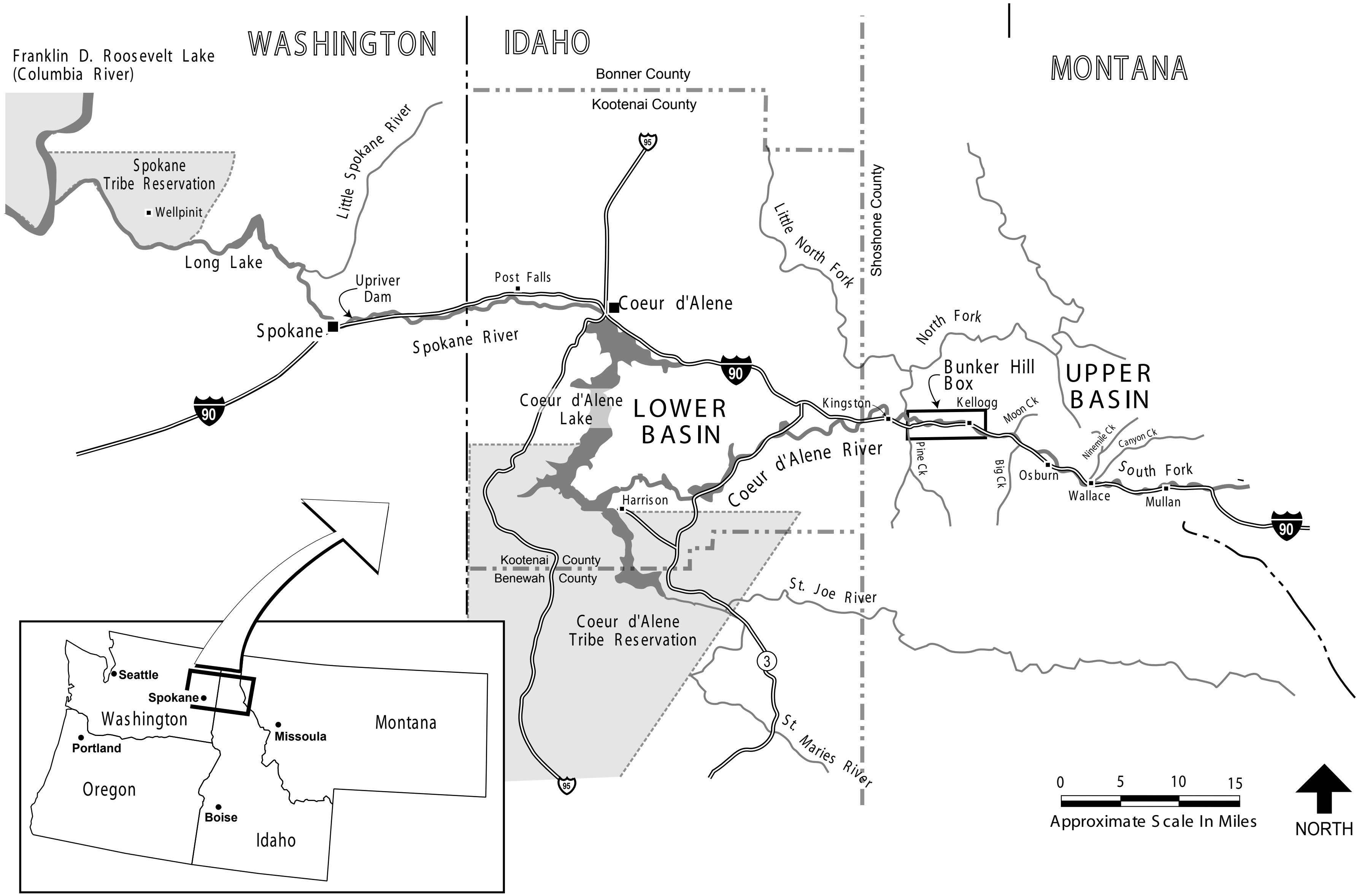
A detailed description of the DQO process is presented in Appendix B.

1.9 REPORT ORGANIZATION

The BEMP is presented in the following sections.

- Section 2.0 **Summary of Basin Model and Processes** describes the conceptual model used in the Basin RI/FS, ecological exposure pathways and receptors, and baseline (pre-remediation) conditions in surface water, groundwater, soil and sediment, and biological resources.
- Section 3.0 **Monitoring Assumptions, Approach, Hypotheses, and Benchmarks** describes the framework for development of the media-specific monitoring plans, which includes the working assumptions of Basin processes, the monitoring approach, specific monitoring hypotheses, and the ecological benchmarks identified in the ROD.
- Section 4.0 **Basin-Wide Environmental Monitoring Program** describes the media-specific monitoring plans for surface water, soil and sediment, and biological resources.
- Section 5.0 **Data Collection Methods** provides a general description of field sample and data collection methods and laboratory analysis methods.

- Section 6.0 **Evaluation and Interpretation of Sampling Results** describes the range of techniques that may be used to evaluate and interpret the media-specific monitoring data.
- Section 7.0 **Data Management and Reporting** describes the methods used to manage the monitoring data and present the monitoring results.
- Section 8.0 **References** provides citations for references used in this report.



EPA REGION 10

Coeur d'Alene Basin
ENVIRONMENTAL
MONITORING PLAN

Doc. Control: 4162500.07190.05.a
March 26, 2004

Figure 1-1
Basin Study Area

2.0 SUMMARY OF BASIN MODEL AND PROCESSES

This section sets the stage for development of the environmental monitoring plan, and summarizes the conceptual model used in the Basin RI/FS, ecological exposure pathways and receptors, and baseline (pre-remediation) conditions in surface water, groundwater, soil and sediment, and biological resources.

2.1 CONCEPTUAL SITE MODEL

The Basin Conceptual Site Model (CSM) was developed to summarize the sources of contamination, mechanisms of contaminant release, pathways of contaminant release and transport, and the ways in which humans and ecological resources are exposed to contaminants. The CSM provides a basis for assembling information about the Basin and data from diverse sources into a structure that allows systematic analysis of specific sources of contamination at an adequate level of detail, while maintaining an understanding of the overall context of the effects of all of the important sources of contamination. The underlying structure of the CSM was used in the RI/FS as a way of organizing, presenting, and analyzing site information. The detailed CSM is published under separate cover (CH2M Hill 2000) and is summarized in Part 1, Sections 2.0 and 3.3 of the RI (EPA 2001a).

To facilitate analysis of processes at work in the Basin, parts of the Basin with similar geomorphology, stream gradients, and amounts and types of mining wastes were grouped into five CSM units. Subsequently, the model was refined and simplified through use of four geographical areas. The areas have a fairly large geographic coverage, but are sufficiently homogeneous that types of waste sources, mechanisms of release and transport of waste, and the ecological resources affected by the release of contaminants are similar in each area. The four areas are listed below and shown in Figures 2-1 and 2-2.

- Upper Basin (CSM Units 1 and 2)
- Lower Basin (CSM Unit 3)
- Coeur d'Alene Lake (CSM Unit 4)
- Spokane River (CSM Unit 5)

The areas are described in greater detail in the following subsections.

The conceptual model is intended to be dynamic, and data collected during long-term monitoring will provide a basis for improving our understanding of Basin processes and conditions. As such, the model will be updated or modified as needed and appropriate to support the evolving understanding of Basin processes and the effects of the selected remedy on Basin conditions. This evolution is consistent with the principles of adaptive management or "learning from experience."

2.1.1 Upper Basin

The Upper Basin includes the high- and mid-gradient watersheds of the South Fork above its confluence with the North Fork (Figure 2-1)[1]. Upper Basin tributary watersheds include Canyon Creek, Ninemile Creek, Moon Creek, Big Creek, and Pine Creek. The Upper Basin contains most of the mine and mill sites that are the primary sources of continuing releases of metals from mining waste to the Coeur d'Alene River system.

The Upper Basin is also the location of some of the larger physical disturbances that have resulted from human use. These include the towns of Wallace and Kellogg, several smaller communities, former railroads, the Kellogg Airport, Interstate 90 (I-90) and the 21-square-mile Bunker Hill Superfund Site. To accommodate the infrastructure, and to make room for storing and disposing of mining wastes in the floodplain, the channel of the South Fork has been moved, channelized, armored, and otherwise altered, with only a few reaches still resembling a natural river. The river valley is wide enough through most the reach below Wallace to accommodate varying amounts of groundwater flow, and the exchange of surface and groundwater are important processes for adding dissolved metals (mainly zinc and cadmium) to the South Fork.

2.1.2 Lower Basin

The Lower Basin is the entire lower valley of the Coeur d'Alene River from the confluence of the North Fork and South Fork to the mouth of the river at Harrison (Figure 2-1). It includes the entire floodplain, lateral lakes, and associated wetlands. In the Lower Basin, the river form is low gradient with meanders; but the meanders are not very active because of natural and enhanced levees in many places, armoring to protect roads, bridges, and railroad beds in a few places, and very low current velocities created by backwater conditions from impoundment of Coeur d'Alene Lake.

Mining-related wastes within the Lower Basin are found in secondary sources that include the beds and banks of the river, contaminated floodplain soils, surface water, and groundwater. Concentrations of metals in surface water in the Lower Basin are lower than in the South Fork because of dilution by the larger North Fork. Groundwater contaminated with metals is believed to be an important source of metals loading within the Lower Basin; however, the locations and mechanisms of groundwater loading are not fully understood. Contaminated soils and sediments occur throughout the Lower Basin, with levels of contamination and depth of contamination generally being higher near the river and in lateral lakes where flows from the river enter during floods.

---

[1] The North Fork watershed was not included in the remedy selected in the ROD; however, this plan includes one sampling location within the North Fork watershed (Enaville) to aid interpretation of monitoring data.

2.1.3 Coeur d'Alene Lake

Coeur d'Alene Lake is shown in Figure 2-1. The Coeur d'Alene River is the overwhelmingly dominant source of metals to Coeur d'Alene Lake. Metals enter the lake from the river in the dissolved phase or associated with colloids, suspended solids, and bed load solids.

A varying fraction of the metals entering Coeur d'Alene Lake are retained within the lake. Retention (input from the Coeur d'Alene River minus output to the Spokane River) of particulate metals is high. In lakebed sediments, the highest concentrations of lead, which enters the lake mainly in association with suspended and bedload sediments, are present near the delta at Harrison. Retention of dissolved metals entering the lake is lower. Zinc and cadmium, which enter the lake mainly as dissolved metals, have lower concentrations in deep-water sediments near the delta than in deep-water sediments at the north end of the lake near Coeur d'Alene. Settling of zinc and cadmium depends on the metals being converted to particulate form and settling to the lakebed. This conversion can result from physical (adsorption), chemical (complexation), and biological (assimilation) processes.

Water entering the lake from the Coeur d'Alene River is often of a different temperature than the water in the lake. Depending on the differences in density caused by the different temperatures, the metals-contaminated plume might sink or float without completely mixing with lake water. Incomplete mixing due to overflow, such as may occur during spring runoff when river water temperatures are higher than lake water temperatures, can result in lower retention of metals and higher loads to the Spokane River.

Nutrient input to Coeur d'Alene Lake has been raised as an issue with regard to release of metals from contaminated lakebed sediment. The trophic status (level of nutrient enrichment and phytoplankton production) of Coeur d'Alene Lake could change to the point where increased production of phytoplankton could cause reductions of oxygen levels in the deeper waters of the lake. This could allow the release of metals associated with oxyhydroxide precipitates found on the surface of the lake sediments. Nutrient enrichment of the lake water would be the most likely cause of increased phytoplankton production.

2.1.4 Spokane River

The Spokane River study area for the RI/FS extends from Coeur d'Alene Lake downstream to Fort Spokane on the Spokane Arm of Lake Roosevelt (Figure 2-2). The area included for ecological and human health actions in the ROD extends from the Idaho/Washington border to Upriver Dam near the city of Spokane.

Metals discharged from Coeur d'Alene Lake in dissolved and particulate form are carried down the Spokane River. Concentrations of dissolved metals decrease and alkalinity increases with distance down the Spokane River during lower flows due to the inflow of groundwater. Some of the particulate metals are deposited as sediments at shoreline sites and behind dams on the river.

Dissolved metals in the river water also interact with sediments and partition out of the water column. The concentrations of metals in the sediment deposits generally decrease from upstream to downstream.

2.2 ECOLOGICAL EXPOSURE

2.2.1 Exposure Media

The media that have been identified as either primary or secondary sources of contamination include the following:

- Sediment – alluvium and other materials typically covered by water
- Soil – includes alluvium and other materials that may have been transported by water to their present location and are typically not covered by water during low (base) flow conditions.
- Surface water
- Groundwater

The OU 3 ROD selected remedy for environmental protection consists of interim measures and does not address the groundwater contamination in the Basin.

2.2.2 Exposure Pathways

Exposure pathways are the routes by which humans and living natural resources (receptors) may be exposed to metals from the mining waste. As explained in more detail within Section 2.6 of the Coeur d'Alene Basin Ecological Risk Assessment (EPA 2001c), the routes by which ecological receptors may be exposed to chemicals of concern (COCs) in the Coeur d'Alene Basin include:

- Birds and mammals - ingestion of soil-sediment, surface water, and food
- Fish - ingestion and direct contact with sediment and surface water
- Benthic invertebrates - ingestion and direct contact with sediment or surface water
- Aquatic plants - root uptake and direct contact with sediment and surface water
- Amphibians - direct contact with surface water and soil-sediment
- Terrestrial plants - root uptake from soil-sediment
- Terrestrial invertebrates - ingestion and direct contact with soil-sediment
- Soil processes - direct contact of microbes with soil-sediment

2.2.3 Habitats and Receptors

Within the Basin, ecological risks to plants and animals associated with mining-related hazardous substances were evaluated within six habitat types. The occurrence of these habitats within different portions of the Basin varies, and the typical species associated with the habitats also vary from one portion of the Basin to another.

The habitats and typical species or receptors include:

- **Riverine** habitat includes the wetlands and deepwater habitats within the channels of creeks and rivers of the Upper Basin, Lower Basin, and Spokane River. Typical fish expected to occur in this habitat include westslope cutthroat and bull trout, sculpin, mountain whitefish, and, in some portions of the Basin, introduced species such as rainbow, brook, and brown trout. In lower-elevation areas typical fish species include chinook salmon, smallmouth bass, northern squawfish, and sucker. Characteristic wildlife species include salamanders, common merganser, osprey, bald eagle, spotted sandpiper, American dipper, water shrew, raccoon, mink, and river otter.
- **Lacustrine** habitat includes wetlands and deepwater habitats that occur in depressions (such as the lateral lakes and Coeur d'Alene Lake) or in dammed river channels (such as the Spokane River upstream of Post Falls Dam). Most plants occur as phytoplankton or as submerged vegetation. Typical fish include many of the same ones as in riverine habitat, plus the largemouth bass, yellow perch, and northern pike. Characteristic birds and mammals include tundra swan, lesser scaup, common goldeneye, common merganser, osprey, bald eagle, tree swallow, little brown myotis (bats), and river otter.
- **Palustrine** habitat includes wetlands that are dominated by trees, shrubs, and other persistent emergent wetland plants. This habitat occurs in smaller areas within the Upper Basin, Coeur d'Alene Lake, and the Spokane River, relative to larger areas within the Lower Basin. Typical plants include wild rice, water potato, equisetum (horsetail), cattail, cottonwood, and willow. Characteristic wildlife species include spotted frog, salamanders, great blue heron, Canada goose, tundra swan, wood duck, mallard, bald eagle, common snipe, little brown myotis (bats), raccoon, mink, beaver, muskrat, and white-tailed deer.
- **Riparian** habitat is terrestrial habitat that is associated with one of the previously mentioned wetland habitats, most often the riverine habitat. It occurs along stream channels and around lakes within the Upper Basin, Coeur d'Alene Lake, and the Spokane River, but is much more extensive in the Lower Basin. Typical plants include reed canary grass, cow-parsnip, spiraea, cottonwood, alder, and willow. Common wildlife include salamander, spotted frog, northern harrier, American kestrel, wild turkey, great horned owl, Swainson's thrush, American robin, song

sparrow, shrew, long-legged myotis (bats), raccoon, mink, white-tailed deer, muskrat, mice, and vole.

- **Agricultural** habitat includes portions of the Lower Basin that are used mostly for pasture and hay fields. Redtop, reed canary grass, oats, and barley are typical plants in this habitat, which may be seasonally flooded and used by waterfowl and other wetland species. Common wildlife species include Canada goose, northern harrier, wild turkey, common snipe, American robin, shrew, white-tailed deer, mice, and vole.
- **Upland** habitat occurs outside the floodplains of the creeks and the South Fork within the Upper Basin. Typical plants include grasses, shrubs, pine, hemlock, red cedar, Douglas-fir, and Rocky Mountain maple. Representative birds and mammals include American kestrel, ruffed grouse, wild turkey, great horned owl, Swainson's thrush, shrew, mule deer (which also serves as a surrogate for elk), mouse, and vole.

All of the bird species mentioned above are protected under the Migratory Bird Treaty Act except the wild turkey. Other receptors are considered to be "special-status species," which include federally listed endangered or threatened species, those identified by the USFWS as species of concern, state-listed sensitive plant species, and culturally significant plant species. Examples include the bald eagle, black tern, gray wolf, lynx, bull trout, westslope cutthroat trout, spotted frog, Ute ladies'-tresses, and water potato.

2.2.4 Key Biological Indicators

The results of the ecological risk assessment (EcoRA) were used to identify key indicators of ecosystem health. These key indicators can be used to develop a focused monitoring plan for biological resources within the Basin. Biological indicators were identified on a habitat-basis based on their abundance and response to environmental conditions. The key biological indicators identified for the primary Basin habitats include:

- Riverine habitat – aquatic macroinvertebrates, fish, aquatic habitat assessment
- Lacustrine/palustrine habitat – waterfowl
- Riparian habitat – songbirds, terrestrial macroinvertebrates, riparian vegetation

2.3 BASELINE ENVIRONMENTAL CONDITIONS

For the purpose of the BEMP, the conditions in the Basin at the signing of the ROD (9/12/02) are considered to represent baseline conditions. Monitoring data collected under the BEMP will be compared to these baseline conditions to evaluate any changes in the status or trends in the Basin. The baseline environmental conditions were evaluated for the three primary media addressed by the BEMP: surface water, soil/sediment, and biological resources.

Environmental conditions in the Basin were evaluated extensively during the development of the RI/FS and EcoRA. These documents relied on historical data collected by the mining companies, resource trustees, IDEQ, USGS, BLM, and others, as well as investigations conducted on behalf of EPA during the RI/FS process. When combined with subsequent and ongoing monitoring performed by USGS, USFWS, and others, these sources collectively form the data set for baseline environmental conditions in the Basin.

The BEMP baseline surface water and soil and sediment conditions were evaluated in terms of both averages and confidence intervals, assuming that the data fit lognormal distributions. This approach is consistent with the analyses performed for the RI/FS, EcoRA, and associated technical memoranda. Data sets also were evaluated for trends over time; however, baseline trends were generally discernable only for surface water at selected locations. Evaluation of the status and trends of biological resources in the Basin was limited by the amount and types of available data.

Baseline environmental conditions by media are presented on Tables 2-1 through 2-4. A detailed presentation of the calculation methods, data sources and calculation results is included in Appendix C. The following sections summarize baseline environmental conditions for surface water, soil/sediment and biological resources.

2.3.1 Baseline Surface Water Conditions

Transport of zinc and cadmium occurs primarily as dissolved metals, while lead travels primarily as particulate loading. Baseline surface water conditions are therefore presented for dissolved cadmium, dissolved zinc, and total lead. Baseline surface water status and trends for dissolved zinc, dissolved cadmium and total lead concentrations and loads for selected locations are summarized in Table 2-1. The source dataset for these analyses is the database compiled during the RI/FS and typically includes water quality data through water year 1999 (September 30, 1999). Table 2-1 presents the baseline concentrations as described by standard statistical analyses of the data (e.g. average, minimum, maximum, median, etc.) as well as by lognormal probabilistic analyses of the data, consistent with approach taken for the RI/FS. Baseline trend analysis results are presented as the slopes from least-squares linear regressions of the data sets. Additional detail on the background and methodology for the lognormal analyses is provided in Appendix C and in the Probabilistic Analysis of Post-Remediation Metal Loading Technical Memorandum (EPA 2001e).

Ambient water quality criteria (AWQC) ratio[2] baseline status and trend results for selected locations are presented on Table 2-2. The AWQC ratios are a primary metric for the fishery tiers cited in the benchmarks of the selected remedy (see OU 3 ROD Section 12.2.3). The data sources for Table 2-2 differ from Table 2-1 in that some of the early RI water quality sample

[2] The AWQC ratio is the concentration of a chemical in surface water divided by the ambient water quality criterion. Ambient water quality criteria are hardness-dependent for several metals, including cadmium and zinc.

analyses did not include hardness (from which hardness-dependent AWQC are calculated for cadmium, and zinc). The RI database was supplemented with more recent data from the USGS in order to characterize baseline AWQC ratio status and trends. Similar analyses (e.g. "statistical" and "lognormal") were performed on the AWQC ratio data set. Calculation details are provided in Appendix C.

2.3.2 Baseline Groundwater Conditions

Groundwater data are available for selected locations in the Basin; however, the data set is not comprehensive. The natural spatial variability of groundwater quality complicates the evaluation of baseline conditions within the basin. The limited groundwater data collected during the RI/FS are included in the RI database. Relative metals loading contributions and reductions via surface water/groundwater interaction may be inferred from mass balances of surface water metals loading within reaches along the river and its tributaries. Ongoing groundwater monitoring in the Box will continue to be potentially useful for gaining a better understanding of Basin processes. While groundwater monitoring is not explicitly included in the BEMP, the importance of the groundwater-surface water inter-relationship is recognized. Accordingly, groundwater monitoring will likely be an important component of remedial action-specific monitoring.

2.3.3 Baseline Soil and Sediment Conditions

The baseline status of soil and sediment concentrations was evaluated for the following areas: the Upper Basin, the Lower Basin, and the Spokane River. Baseline soil and sediment conditions are summarized in Table 2-3. When possible, baseline conditions were evaluated using surface soil and/or sediment samples included in the database for the RI (EPA 2001a). When the RI database was used for the development of summary statistics presented in Table 2-3, all RI surface soil and/or sediment samples were included for the given area, including samples that may represent background conditions. Future comparisons of sampling results to baseline conditions should include an evaluation of the comparability of the respective data sets.

In the Upper Basin and Lower Basin, surface soil and sediment data from only those areas that will be sampled as part of the soil and sediment-monitoring program (Section 4) were used to characterize baseline conditions. These areas include Ninemile Creek (segments NM02 and NM04), South Fork Coeur d'Alene River (segments USF01, MG01, and MG02), Pine Creek (segments PC01 and PC03), and the Lower Basin (CSM Unit 3). This limitation was used to increase the comparability between the baseline and monitoring data sets.

Baseline conditions for in-channel soil and sediment for the Spokane River near the Washington state line and near the eastern boundary of the Spokane Reservation are presented in Table 2-3 from the report: "The effect of mining and related activities on the sediment-trace element geochemistry of Lake Coeur d'Alene, Idaho, USA, Part III: Downstream effects; the Spokane River Basin" (Grosbois et al. 2001). This report contains data for grab samples of in-channel deposits collected along the Spokane River which were collected and analyzed in the same manner as in-channel samples collected for the soil and sediment monitoring program (Section 4).

Baseline conditions for sediment cores near the Harrison delta were evaluated based on sediment analytical data in the RI database for Segment 6 of the lower Coeur d'Alene River. The RI database does not contain sediment core data for mid and lower Long Lake. The baseline conditions presented on Table 2-3 for sediment in mid and lower Long Lake are the analytical results for three cores collected from Long Lake as reported by Grosbois et al., 2001.

Baseline *trends* in soil and sediment concentrations have not been quantitatively evaluated at this time. Bookstrom, et al. (2002) presents historical sediment concentration information for the Lower Basin. The annual sediment-monitoring program (as described in Section 4) will provide a means for evaluating time-trends in soil/sediment quality at key locations within the Basin. The availability of representative baseline concentration data for annual sampling locations will be evaluated after the precise annual sampling locations are defined during the first sampling event.

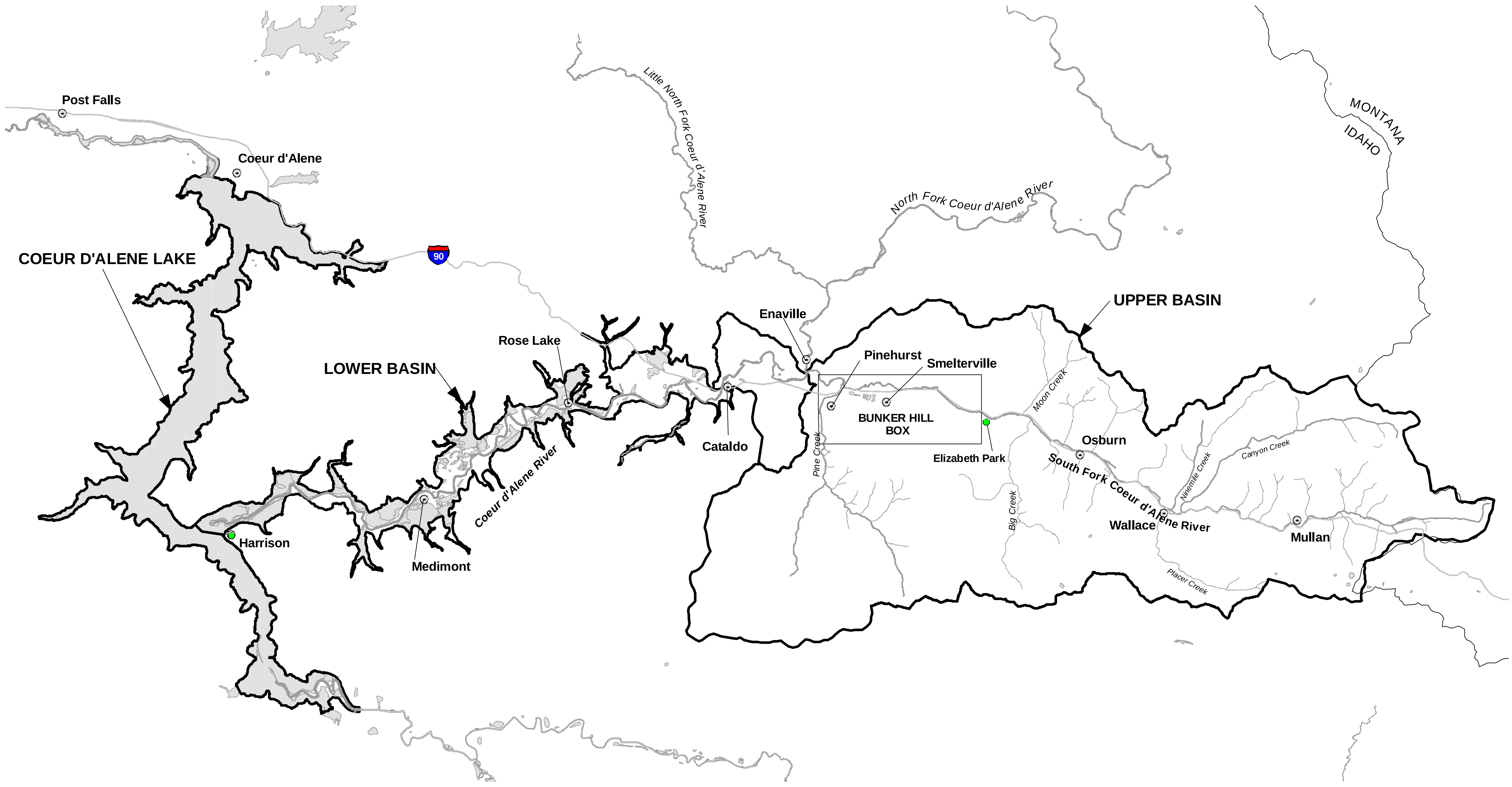
2.3.4 Baseline Biological Resources Conditions

Baseline status data exist to varying degrees for the biological resources monitoring parameters. Multiple groups have performed biological resources monitoring over time, and several reports have compiled and evaluated historical results. Notably, the Interim Fisheries Benchmarks Tech Memo (EPA 2001f), EcoRA (EPA 2001c), and Natural Resource Damage Assessment (Stratus 2000) address biological resource conditions in the Basin. The Fisheries Tech Memo summarizes a majority of the riverine biological resource and physical habitat conditions within the Basin, including descriptions of fishery tiers and characterization of current conditions as developed for the benchmarks of the ROD.

Baseline conditions for several biological resource monitoring components (e.g. songbird diversity/abundance, bull trout habitat and populations) have not been established or have a very limited baseline dataset. Other biological resources may have available baseline data; however, the data collection methods are not consistent with the methods specified for the BEMP. The working assumption for these groups of monitoring components is that the first round of monitoring results will serve as a baseline for comparison of subsequent monitoring data.

The data pool available for biological resources does not currently allow for an evaluation of time trends in the Basin.

Table 2-4 summarizes the sources of data available for biological resources baseline conditions. The available baseline data table includes references for existing data, which may be considered during the evaluation and interpretation of biological resources data collected under the BEMP.



Legend

Streams

I-90

City

0 2.5 5 Miles

N:\envlmntr\maps\longtermmonitoring\longtermmonitoring_study area-2.mxd

EPA REGION 10

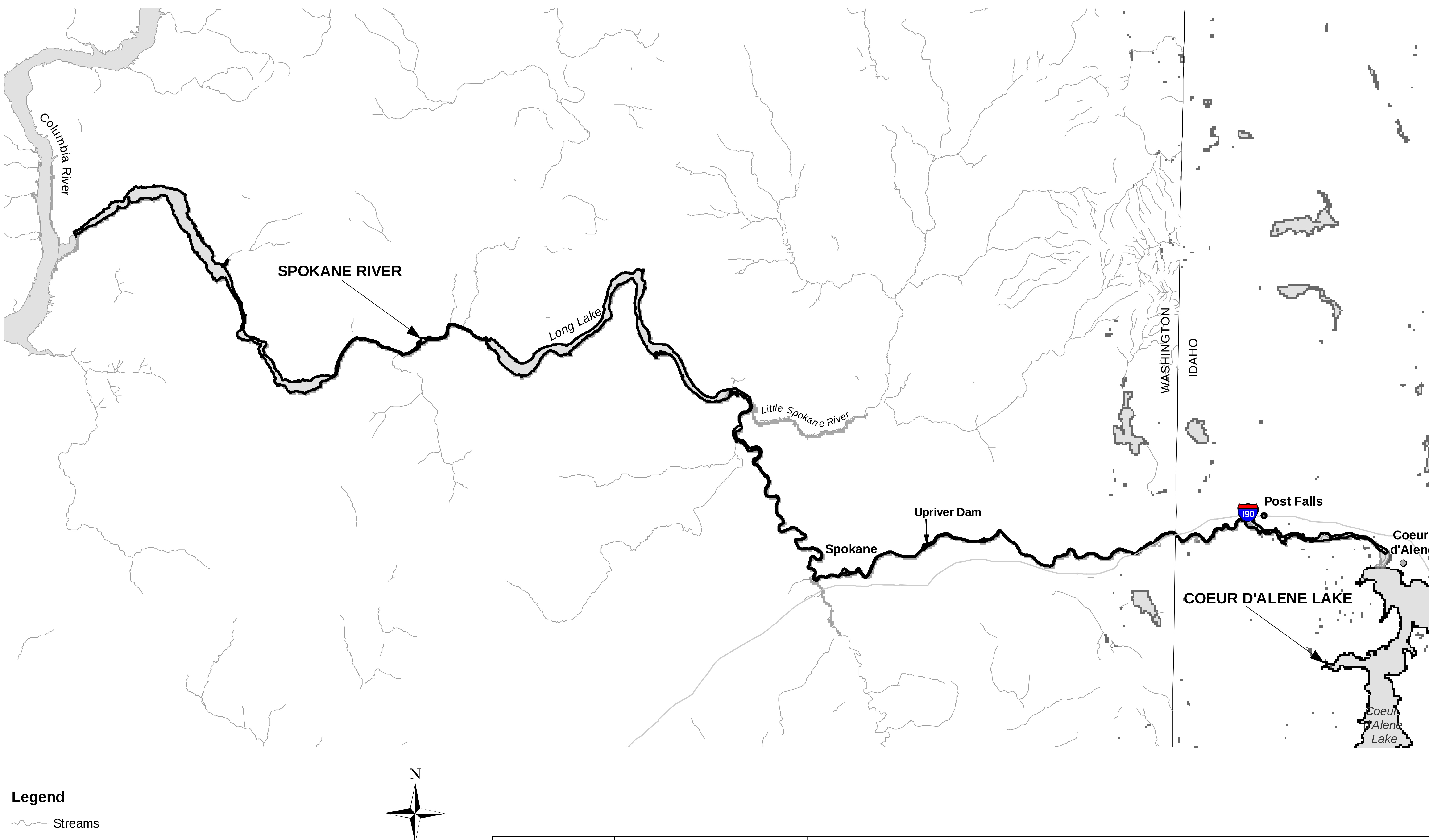
095-RI-CO-102Q
Coeur d'Alene Basin Environmental Monitoring Plan

DCN 4162500.07190.05.a

March 26, 2004

Figure 2-1

Map of Upper Basin, Lower Basin, and Coeur d'Alene Lake
Coeur d'Alene Basin Environmental Monitoring Plan



N:\envlmntr\maps\longtermmonitoring\longtermmonitoring_study area_csm5-2.mxd

EPA REGION 10

095-RI-CO-102Q
Coeur d'Alene Basin Environmental Monitoring Plan

DCN 4162500.07190.05.a

March 26, 2004

Figure 2-2

Map of Spokane River
Coeur d'Alene Basin Environmental Monitoring Plan

Table 2-1
Baseline Surface Water Metal Loads and Concentrations

				Statistical Summary of Historical Data								Lognormal Analysis Results for Historical Data			Historical Time-Trend Analysis			
Location	**Station ID**	**USGS Station ID**	**Water Quality Parameter [a]**	**RI Data Range**	**Number of Data Points**	**Minimum**	**Maximum**	**Median**	**Average**	**SD**	**CV**	**Expected Value**	**CV**	**R^2**	**Expected Slope E[B]; ln[X] = B[t] + a**	**R^2**	**95% LCL[B]**	**95% UCL[B]**
South Fork CdA River above Canyon Creek (Deadman Gulch)	SF-208	12413040	dis Cd conc.	5/16/91 - 8/31/99	19	0	1	1	0	0	0.43	1	2.34	0.54	0.22	0.31	-0.12	0.56
			dis Cd load	5/16/91 - 8/31/99	19	0	1	0	0	0	1.12	0	4.25	0.95	0.32	0.24	-0.27	0.91
			dis Zn conc.	5/16/91 - 8/31/99	19	3	59	8	11	13	1.12	12	1.09	0.92	-0.02	0.00	-0.37	0.32
			dis Zn load	5/16/91 - 8/31/99	19	0	24	4	4	5	1.19	5	1.81	0.93	0.08	0.03	-0.38	0.54
			tot Pb conc.	5/16/91 - 8/31/99	19	1	13	3	4	4	0.85	5	1.10	0.97	0.08	0.06	-0.26	0.43
			tot Pb load	5/16/91 - 8/31/99	19	0	26	1	3	6	1.85	5	4.68	0.97	0.19	0.07	-0.50	0.87
Mouth of Canyon Creek	CC-287/ CC-288	12413123	dis Cd conc.	10/5/91 - 8/30/99	92	4	200	20	22	21	0.96	22	0.74	0.93	-0.07	0.04	-0.18	0.04
			dis Cd load	10/5/91 - 8/30/99	92	1	559	3	10	58	5.59	6	1.20	0.78	0.12	0.08	-0.02	0.26
			dis Zn conc.	10/5/91 - 8/30/99	93	451	7,240	2,640	2,869	1,481	0.52	2,996	0.71	0.95	-0.10	0.10	-0.20	0.00
			dis Zn load	10/5/91 - 8/30/99	93	142	2,998	480	558	415	0.74	556	0.67	0.98	0.05	0.02	-0.06	0.15
			tot Pb conc.	10/5/91 - 8/30/99	93	0	2,000	61	135	233	1.73	174	1.99	0.71	0.09	0.03	-0.09	0.27
			tot Pb load	10/5/91 - 8/30/99	93	0	4,132	11	80	428	5.32	49	3.14	0.91	0.24	0.10	-0.01	0.48
Mouth of Ninemile Creek	NM-305	12413130	dis Cd conc.	5/15/91 - 9/1/99	96	6	48	21	21	8	0.37	22	0.48	0.93	-0.06	0.10	-0.13	0.01
			dis Cd load	5/15/91 - 9/1/99	96	0	10	1	2	1	0.90	2	0.86	0.96	0.04	0.01	-0.09	0.16
			dis Zn conc.	5/15/91 - 9/1/99	96	864	7,460	3,155	3,364	1,356	0.40	3,411	0.47	0.97	-0.06	0.07	-0.13	0.02
			dis Zn load	5/15/91 - 9/1/99	96	45	1,678	180	275	248	0.90	276	0.92	0.98	0.06	0.03	-0.07	0.19
			tot Pb conc.	5/15/91 - 9/1/99	98	5	800	67	93	98	1.06	92	0.80	0.88	0.03	0.01	-0.08	0.14
			tot Pb load	5/15/91 - 9/1/99	98	0	529	4	18	61	3.31	13	2.63	0.93	0.13	0.04	-0.10	0.36
Upper E Fork Ninemile Creek	NM-295	None	dis Cd conc.	5/16/91 - 11/15/98	18	4	60	14	15	11	0.74	16	0.68	0.88	0.14	0.24	-0.07	0.35
			dis Cd load	5/16/91 - 11/15/98	18	0	1	1	1	0	0.62	1	0.91	0.95	0.14	0.14	-0.15	0.44
			dis Zn conc.	5/16/91 - 11/15/98	18	1,390	11,800	2,595	2,972	2,265	0.76	2,995	0.61	0.84	0.11	0.18	-0.09	0.31
			dis Zn load	5/16/91 - 11/15/98	18	31	236	114	116	69	0.60	125	0.88	0.91	0.11	0.09	-0.18	0.40
			tot Pb conc.	5/16/91 - 11/15/98	18	13	74	20	23	14	0.59	23	0.50	0.81	0.06	0.08	-0.11	0.23
			tot Pb load	5/16/91 - 11/15/98	18	0	3	1	1	1	0.84	1	1.30	0.92	0.06	0.02	-0.34	0.46
Lower E Fork Ninemile Creek	NM-298	12413127	dis Cd conc.	10/27/93 - 9/1/99	50	6	90	42	40	18	0.45	43	0.66	0.89	-0.07	0.07	-0.20	0.06
			dis Cd load	10/27/93 - 9/1/99	50	0	6	1	1	1	0.83	1	0.77	0.97	0.07	0.05	-0.09	0.22
			dis Zn conc.	10/27/93 - 9/1/99	50	867	14,000	7,075	6,710	2,997	0.45	7,136	0.69	0.90	-0.06	0.05	-0.20	0.08
			dis Zn load	10/27/93 - 9/1/99	50	45	1,006	157	211	180	0.85	210	0.79	0.95	0.08	0.06	-0.08	0.23
			tot Pb conc.	10/27/93 - 9/1/99	50	48	4,000	162	264	542	2.05	234	0.88	0.85	-0.10	0.10	-0.26	0.06
			tot Pb load	10/27/93 - 9/1/99	50	1	109	4	10	18	1.86	9	1.41	0.92	0.04	0.01	-0.20	0.28
Elizabeth Park	SF-268	12413210	dis Cd conc.	5/15/91 - 8/30/99	67	1	14	6	7	3	0.46	7	0.61	0.94	-0.04	0.04	-0.15	0.07
			dis Cd load	5/15/91 - 8/30/99	67	3	34	8	9	6	0.67	9	0.68	0.97	0.03	0.02	-0.09	0.16
			dis Zn conc.	5/15/91 - 8/30/99	67	184	1,780	876	947	425	0.45	976	0.59	0.95	-0.05	0.07	-0.16	0.05
			dis Zn load	5/15/91 - 8/30/99	67	413	3,865	1,128	1,264	779	0.62	1,284	0.69	0.96	0.02	0.01	-0.10	0.15
			tot Pb conc.	5/15/91 - 8/30/99	67	5	526	14	37	83	2.24	32	1.58	0.69	0.09	0.07	-0.09	0.28
			tot Pb load	5/15/91 - 8/30/99	67	2	4,500	15	216	744	3.45	130	5.89	0.88	0.17	0.07	-0.18	0.52
Smelterville	SF-270	12413300	dis Cd conc.	10/29/93 - 3/9/99	45	3	31	10	11	6	0.52	11	0.52	0.98	-0.01	0.00	-0.13	0.11
			dis Cd load	10/29/93 - 3/9/99	45	3	63	13	16	12	0.77	16	0.9	0.98	0.08	0.03	-0.11	0.27
			dis Zn conc.	10/29/93 - 3/9/99	45	524	2,640	1,600	1,625	665	0.41	1,674	0.55	0.92	-0.04	0.02	-0.16	0.08
			dis Zn load	10/29/93 - 3/9/99	45	719	7,179	1,735	2,081	1,278	0.61	2,104	0.64	0.97	0.04	0.02	-0.10	0.19
			tot Pb conc.	10/29/93 - 3/9/99	45	8	542	21	48	90	1.88	43	1.26	0.77	0.14	0.08	-0.07	0.34
			tot Pb load	10/29/93 - 3/9/99	45	4	2,272	28	143	386	2.70	116	3.43	0.93	0.22	0.06	-0.16	0.59
Pine Creek Below Amy Gulch	PC-339	12413445	dis Cd conc.	5/16/98 - 8/31/99	16	0	1	1	1	0	0.26	1	0.37	0.45	NA*	NA*	NA*	NA*
			dis Cd load	5/16/98 - 8/31/99	16	0	4	1	1	1	1.01	2	4.02	0.93	NA*	NA*	NA*	NA*
			dis Zn conc.	5/16/98 - 8/31/99	16	35	168	96	96	41	0.43	102	0.64	0.89	NA*	NA*	NA*	NA*
			dis Zn load	5/16/98 - 8/31/99	16	10	572	120	158	169	1.07	212	2.32	0.96	NA*	NA*	NA*	NA*
			tot Pb conc.	5/16/98 - 8/31/99	14	1	31	1	5	8	1.79	5	2.52	0.77	NA*	NA*	NA*	NA*
			tot Pb load	5/16/98 - 8/31/99	14	0	223	2	24	57	2.44	59	26.75	0.97	NA*	NA*	NA*	NA*

Table 2-1 (Continued)
Baseline Surface Water Metal Loads and Concentrations

				Statistical Summary of Historical Data								Lognormal Analysis Results for Historical Data			Historical Time-Trend Analysis			
Location	**URS Station ID**	**USGS Station ID**	**Water Quality Parameter [a]**	**RI Data Range**	**Number of Data Points**	**Minimum**	**Maximum**	**Median**	**Average**	**SD**	**CV**	**Expected Value**	**CV**	**R^2**	**Expected Slope E[B]; ln[X] = B[t] + a**	**R^2**	**95% LCL[B]**	**95% UCL[B]**
Sout Fork at Pinehurst	SF271	12413150	dis Cd conc.	5/15//91 - 9/7/99	108	2	60	8	9	6	0.70	9	0.63	0.95	0.02	0.01	-0.07	0.11
			dis Cd load	5/15//91 - 9/7/99	108	3	220	18	21	23	1.09	21	0.87	0.98	0.05	0.03	-0.07	0.17
			dis Zn conc.	5/15//91 - 9/7/99	111	227	2,920	351	1,388	676	0.49	1,429	0.63	0.96	-0.03	0.02	-0.12	0.06
			dis Zn load	5/15//91 - 9/7/99	111	642	8,456	1,280	2,892	1,596	0.55	2,921	0.61	0.99	0.01	0.00	-0.08	0.09
			tot Pb conc.	5/15//91 - 9/7/99	68	13	790	26	63	126	1.99	56	1.34	0.81	0.11	0.12	-0.05	0.28
			tot Pb load	5/15//91 - 9/7/99	68	9	17,808	51	583	2,328	4.00	369	5.53	0.92	0.16	0.06	-0.18	0.49
Cataldo	LC50	12413500	dis Cd conc.	12/9/92 - 10/20/99	101	0	6	2	2	1	0.44	3	1.32	0.63	0.01	0.00	-0.12	0.15
			dis Cd load	12/9/92 - 10/20/99	101	0	107	18	24	21	0.88	27	1.32	0.94	-0.01	0.00	-0.18	0.15
			dis Zn conc.	12/9/92 - 10/20/99	102	51	809	342	370	187	0.51	354	0.61	0.94	-0.01	0.00	-0.10	0.09
			dis Zn load	12/9/92 - 10/20/99	102	133	10,191	3,011	3,315	2,080	0.63	3,217	0.72	0.94	-0.02	0.01	-0.14	0.09
			tot Pb conc.	10/29/96 - 10/20/99	44	4	355	9	25	61	2.39	21	1.43	0.76	-0.31	0.09	-0.53	-0.09
			tot Pb load	10/29/96 - 10/20/99	44	10	43,737	75	1,639	7,061	4.31	708	6.78	0.87	-0.56	0.08	-1.01	-0.12
Harrison	LC60	12413860	dis Cd conc.	10/6/92 - 9/9/99	91	1	5	2	2	1	0.37	2	0.37	0.95	-0.05	0.07	-0.11	0.01
			dis Cd load	10/6/92 - 9/9/99	91	2	165	18	28	29	1.04	29	1.39	0.99	-0.01	0.00	-0.19	0.17
			dis Zn conc.	10/6/92 - 9/9/99	91	90	920	322	342	148	0.43	344	0.48	0.99	-0.04	0.04	-0.12	0.04
			dis Zn load	10/6/92 - 9/9/99	91	500	18,153	2,868	4,028	3,263	0.81	4,187	1.02	0.99	-0.01	0.00	-0.15	0.14
			tot Pb conc.	10/29/96 - 9/9/99	32	15	430	30	54	84	1.55	52	1.08	0.77	0.16	0.04	-0.07	0.38
			tot Pb load	10/29/96 - 9/9/99	32	30	24,753	328	1,920	5,382	2.80	1,509	4.11	0.93	0.35	0.04	-0.14	0.83
Spokane River at Lake Outlet / Post Falls [b]	SR5/ SR50	12419500	dis Cd conc.	11/11/97 - 9/7/99	14	0	1	1	1	0	0.37	1	0.48	0.71	NA*	NA*	NA*	NA*
			dis Cd load	11/11/97 - 9/7/99	10	1	112	10	21	32	1.47	27	2.56	0.97	NA*	NA*	NA*	NA*
			dis Zn conc.	11/11/97 - 9/7/99	14	26	91	72	65	21	0.33	67	0.49	0.87	NA*	NA*	NA*	NA*
			dis Zn load	11/11/97 - 9/7/99	10	79	6,971	1,138	2,209	2,252	1.02	3,654	3.29	0.96	NA*	NA*	NA*	NA*
			tot Pb conc.	11/11/97 - 9/7/99	14	1	6	2	2	2	0.70	3	0.90	0.97	NA*	NA*	NA*	NA*
			tot Pb load	11/11/97 - 9/7/99	10	4	675	39	109	194	1.78	157	4.63	0.96	NA*	NA*	NA*	NA*
Spokane River near Stateline [c]	SR55	12419500	dis Cd conc.	4/15/99 - 9/9/99	6	1	1	1	1	0	0.35	NA	NA	NA	NA*	NA*	NA*	NA*
			dis Cd load	4/15/99 - 9/9/99	6	2	80	17	33	33	1.00	NA	NA	NA	NA*	NA*	NA*	NA*
			dis Zn conc.	4/15/99 - 9/9/99	6	24	90	44	51	23	0.44	NA	NA	NA	NA*	NA*	NA*	NA*
			dis Zn load	4/15/99 - 9/9/99	6	82	5,420	2,339	2,482	2,150	0.87	NA	NA	NA	NA*	NA*	NA*	NA*
			tot Pb conc.	4/15/99 - 9/9/99	6	1	4	2	2	1	0.50	NA	NA	NA	NA*	NA*	NA*	NA*
			tot Pb load	4/15/99 - 9/9/99	6	4	314	85	123	120	0.98	NA	NA	NA	NA*	NA*	NA*	NA*
North Fork at Enaville	NF50	12413000	dis Cd conc.	3/21/90 - 9/8/99	40	1	2	1	1	0	0.57	1	0.69	0.28	-0.07	0.37	-0.14	0.00
			dis Cd load	11/18/92 - 9/8/99	19	1	30	5	9	9	1.00	12	2.11	0.96	0.01	0.00	-0.51	0.53
			dis Zn conc.	3/21/90 - 9/8/99	40	2	66	10	10	10	1.02	10	0.91	0.94	-0.09	0.12	-0.27	0.10
			dis Zn load	11/18/92 - 9/8/99	19	4	895	101	169	219	1.29	236	2.99	0.98	-0.13	0.05	-0.72	0.47
			tot Pb conc.	1/19/92 - 9/8/99	59	0	17	1	2	3	1.70	2	1.69	0.85	-0.12	0.09	-0.34	0.10
			tot Pb load	12/9/92 - 9/8/99	41	0	761	5	56	154	2.75	64	8.49	0.97	-0.07	0.01	-0.60	0.47

[a] Units for metal concentrations are µg/L; units for metal loads are lbs/day.

[b] Results for Spokane River at Lake outlet (SR5) and Spokane River at Post Falls (SR50) are combined.

[c] Additional data collected by Washington Dept. of Ecology will be accessed and integrated with the RI baseline data.

Notes:
Historical data is not available for St. Joe River at Mouth (SJ60) because it is a new station.
NA - Lognormal analyses were not performed for Spokane River near Stateline (SR55) due to limited data set (6 data points).
NA* - Historical time-trend analyses were not performed for Pine Creek below Amy Gulch (PC339), Spokane River at Lake outlet/Post Falls (SR5/SR50), and Spokane River near Stateline (SR55) were not performed due to the limited time period of monitoring data.
SD - Standard Deviation
CV - Coefficient of Variation
R^2 - Coefficient of determination (represents the "goodness of fit" of the data to assumed distribnution or trendline)
Expected Slope E[B] - The estimated slope for the time trend of ln[X] = B[t] + a; where: [X] = Metal concentration or load, [t] = time (years), B = slope and a = intercept.
95% LCL[B] & 95% UCL[B] - Estimated lower and upper confidence levels on the true slope evaluated at 95% (one-sided) confidence. These levels are the bounds of the nominal 90% confidence interval on the true slope based on available data and assuming no data auto-correlation effects. Testing and correcting for auto-correlation effects could change the slope estimates, including the 95% confidence limits.

Table 2-2
Baseline Surface Water AWQC Ratios and Associated Metals Concentrations and Loads

Location	Station ID	USGS Station ID	Statistical Summary of Historical Data										Historical Time-Trend Analysis			
			Data Range	Number of Data Points	Water Quality Parameter [a]	Minimum	Maximum	Median	Average	SD	CV	Expected Slope E[B]; ln[X] = B[t]+a	R^2	95% LCL[B]	95% UCL[B]
Mouth of Canyon Creek	CC-287/ CC-288	12413123	10/27/93 - 9/19/01	75	**dis Zn AWQC Ratio**	**20.0**	**94**	**47**	**50**	**16**	**0.33**	**-0.032**	**0.044**	**-0.096**	**0.033**
					dis Zn Conc	451	7,240	2,710	2,809	1,383	0.49	-0.054	0.038	-0.172	0.063
					dis Zn Load	154	2,998	435	532	424	0.80	-0.022	0.006	-0.140	0.096
Elizabeth Park	SF-268	12413210	10/29/93 - 9/19/01	71	**dis Zn AWQC Ratio**	**8**	**22**	**13**	**13**	**3**	**0.20**	**0.004**	**0.002**	**-0.036**	**0.044**
					dis Zn Conc	184	1,580	941	908	328	0.36	-0.026	0.017	-0.117	0.064
					dis Zn Load	305	4,136	970	1,139	763	0.67	-0.023	0.007	-0.144	0.099
Sout Fork at Pinehurst	SF-271	12413150	11/18/92 - 9/19/01	105	**dis Zn AWQC Ratio**	**8**	**27**	**15**	**16**	**4**	**0.25**	**-0.054**	**0.278**	**-0.089**	**-0.019**
					dis Zn Conc	227	2,540	1,210	1,263	588	0.47	-0.054	0.056	-0.144	0.035
					dis Zn Load	598	8,456	2,317	2,626	1,610	0.61	-0.034	0.018	-0.135	0.066
Harrison	LC-60	12413860	10/6/94 - 9/9/99	61	**dis Zn AWQC Ratio**	**5**	**26**	**7**	**8**	**3**	**0.40**	**-0.058**	**0.079**	**-0.123**	**0.006**
					dis Zn Conc	90	920	305	334	151	0.45	-0.063	0.043	-0.159	0.034
					dis Zn Load	581	12,968	3,328	3,986	2,916	0.73	-0.012	0.001	-0.187	0.162

Notes and Definitions:

[a] Units for metal concentrations are µg/L; untits for metal loads are lbs/day. AWQC ratios are unitless.

AWQC - Ambient Water Quality Criteria for dissolved zinc (chronic), as published in the National Recommended Water Quality Criteria - Correction, EPA 822-ZZ-99-001, April 1999.

$AWQC_{(H)} = 0.986 * \exp(0.8473 * \ln(H) + 0.7614)$

where: $AWQC_{(H)}$ = Chronic ambient water quality criteria for dissolved zinc (µg/L)

H = Hardness (mg/L)

dis Zn AWQC Ratio - Ratio of measured dissolved zinc concentration to the calculated AWQC. Note that AWQC ratios are a primary metric for fisheries benchmarks. The data set used for the anaylses summarized above is limited to water quality results tat include both dissolved zinc and water hardness measurements.

SD - Standard Deviation

CV - Coefficient of Variation

Expected Slope E[B] - The estimated slope for the time trend of ln[X] = B[t] + a; where: [X] = Metal concentration or load, [t] = time (years), B = slope and a = intercept.

R^2 - Coefficient of determination (represents the "goodness of fit" of the data to assumed distribnution or trendline)

95% LCL[B] & 95% UCL[B] - The lower and upper confidence levels of the slope evaluated at 95% confidence. These levels are the bounds of the 90% confidence interval on the true slope based on available data.

Table 2-3
Baseline Soil and Sediment Metal Concentrations

Soil/Sediment Monitoring Locations	Baseline Data Source	Sample Type	Size Fraction	Cadmium # Samples	Cadmium Min Date	Cadmium Max Date	Cadmium Average	Cadmium Min	Cadmium Max	Cadmium Median	Cadmium CV	Lead # Samples	Lead Min Date	Lead Max Date	Lead Average	Lead Min	Lead Max	Lead Median	Lead CV	Zinc # Samples	Zinc Min Date	Zinc Max Date	Zinc Average	Zinc Min	Zinc Max	Zinc Median	Zinc CV
Sentinel Locations: Annual sampling to evaluate time-history trends																											
Upper Basin and Lower Basin : Selected in-channel locations [a]	Not Available - Exact locations for sampling are TBD	Composite surface samples of in-channel deposits	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Spokane River near Stateline	Grosbois et al. 2001 Upper Spokane River [b]	Grab sample of in-channel deposits	Bulk	15	1998-1999		5.8	0.8	23	-	-	15	1998-1999		320	21	1200	-	-	15	1998-1999		1200	2800	510	-	-
			<63 um	15	1998-1999		22	5.9	38	-	-	15	1998-1999		1000	36	2900	-	-	15	1998-1999		3500	1900	6400	-	-
Spokane River near eastern boundary of Spokane Reservation	Grosbois et al. 2001 Post Long Lake [b]		Bulk	8	1998-1999		1.9	0.1	6.8	-	-	8	1998-1999		22	56	9	-	-	8	1998-1999		310	39	940	-	-
			<63 um	8	1998-1999		1.5	0.3	2.6	-	-	8	1998-1999		39	24	60	-	-	8	1998-1999		340	130	660	-	-
Basin-Wide Assessment ("Snapshot") Locations: Sampling every 10 years to evaluate aggregated, area-wide temporal averages (i.e. ratio analysis)																											
Upper Basin : Ninemile Creek, South Fork, Pine Creek	Ninemile Creek: RI data, segs. NM02 & NM04	Area-wide Composite of RI Surface Soil/Sediment Sample Results	-	74	12/14/97	1/1/00	25	0.12	530	9	2.87	74	12/14/97	1/1/00	7714	10.7	59600	3265	1.69	77	12/14/97	1/1/00	10368	55.1	269000	1570	3.68
	South Fork: RI data, segs. USF01, MG01, MG02		-	542	1/1/97	1/1/00	10	0.06	225	4	1.94	542	1/1/97	1/1/00	2562	19	65700	527	2.26	542	1/1/97	1/1/00	1568	15	39400	507	1.95
	Pine Creek: RI data, segs. PC01& PC03		-	60	7/14/94	12/15/97	5	0.04	82.6	1	2.26	60	7/14/94	12/15/97	1625	5.16	8260	714	1.31	60	7/14/94	12/15/97	1285	10	8990	742.5	1.28
Lower Basin : Floodplain	RI data: CSM Unit 3		-	1257	1/1/91	1/1/00	30	0.01	105	26	0.80	1252	1/1/91	1/1/00	3621	18.1	29200	3415	0.74	1260	1/1/91	1/1/00	3183	0.07	21800	2440	0.97
Harrison Delta	RI data: LCDR Seg 06	Core samples	-	92	7/11/95	12/18/97	30 [c]	0.28 [c]	96.4 [c]	-	0.74 [c]	92	7/11/95	12/18/97	4050	10.7	19900	-	0.99	92	7/11/95	12/18/97	3160	45.4	11500	-	0.83
Mid and lower Long Lake	Grosbois et al. 2001 Long Lake Cores [b]	Core sample SRC-1 (mid Long Lake)	-	-	1998-1999		23	0.2	50	25	-	-	1998-1999		280	26	880	180	-	-	1998-1999		1800	63	2900	1800	-
		Core sample SRC-2 (lower Long Lake)	-	-	1998-1999		23	0.2	48	30	-	-	1998-1999		460	17	1600	320	-	-	1998-1999		1900	80	3400	2400	-
		Core sample SRC-3 (lower Long Lake)	-	-	1998-1999		27	6.6	75	25	-	-	1998-1999		530	180	1800	340	-	-	1998-1999		2300	990	3800	2200	-

[a] In-channel (low water) locations include: 1) South Fork above Canyon Creek, 2) Mouth of Canyon Creek, 3) Lower East Fork Ninemile Creek, 4) Mouth of Ninemile Creek, 5) Elizabeth Park, 6) Smelterville, 7) Pine Creek below Amy Gulch, 8) Pinehurst, 9) Enaville, 10) Cataldo, 11) Rose Lake, 12) Medimont, and 13) Harrison.

[b] Data Source = Grosbois, C.A., A.J. Horowitz, J.J. Smith and K.A. Elrick. 2001. The effect of mining and related activities on the sediment-trace element geochemistry of Lake Coeur d'Alene, Idaho, USA. Part III, Downstream effects; the Spokane River Basin. Hydrological Processes v. 15 no. 5. April 15.

[c] Statistical summaries for cadmium are based on detected values only. Cadmium was detected in 80 out of 92 samples. Lead and zinc were detected in all samples analyzed.

Notes:
Soil/sediment metals concentrations are in mg/kg.

Table 2-4
Summary of Available Baseline Data for Biological Resources

Parameter	Location(s)	Baseline Data Source(s)
Riverine Habitat		
Fish diversity/ abundance	Ninemile Creek, Pine Creek, South Fork (Wallace to Elizabeth Park)	Baseline data summarized in Fisheries Tech Memo (2001) Includes 1994-1998 NRT survey data, 1995-1998 BURP survey data, 2000 NAWQA data, and USFS 1993 survey data
		Maret and MacCoy, 2002
		Mebane et al., 2002
		R2 Resource Consultants in Report of Injury Assessment - Stratus Consulting 2000
Fish Tissue Metal Levels (Upper Basin and Spokane River)	Ninemile Creek, Pine Creek, South Fork (Wallace to Elizabeth Park), Spokane River near Stateline	Maret & Skinner, 2000 (1998 Data) NFCdA @ Enaville; SFCdA @ Mullan, Pinehurst; St. Joe @ Calder; SR @ 7-Mile
		Maret & Dutton, 1999 (1974- 1996 data) NFCdA @ Enaville; SFCdA @ Mullan, Silverton, E Park, Pinehurst; CdA @ Cataldo, Rose Lk; St. Joe @ St. Maries; SR @ Post Falls, UR Dam, 9-Mile.
		Bowers et al., 2003
		Farag et al., 1998
		USGS 1998-1999 cooperative study of Spokane River with WA Dept. of Ecology (MacCoy & Maret, 2003)
Bull Trout Habitat/ Temp. and Other Aquatic Resources Assessment	SFCdA River, Mainstem CdA River	Avista Temperature and Bathometric studies in 2003, State and Federal Agency fish population data - high concentrations of trout in small localized areas.
Bull Trout Population Survey and Assessment of Other Aquatic Resources	Areas of cold refuge (bull trout); Representative habitats in SFCdA and Mainstem CdA River (other aquatic resources) - Few areas in SFCdA	No Baseline Available
Macroinvertebrate diversity/abundance	Ninemile Creek, Pine Creek, SFCdA Wallace to Elizabeth Park (above Box), SFCdA at Pinehurst, Lower Basin, Spokane River near Stateline	Baseline data summarized in Fisheries Tech Memo (2001) Includes 1994-1998 NRT survey data, 1995-1998 BURP survey data, 2000 NAWQA data, and USFS 1993 survey data
		Maret et al., 2001
		Table 8-5 Report of Injury Assessment - Stratus Consulting, 2000
		USGS 1998-1999 cooperative study of Spokane River with WA Dept. of Ecology
Macroinvertebrate tissue metal levels	Ninemile Creek, Pine Creek, South Fork (Wallace to Elizabeth Park), Spokane River near Stateline	Farag et al., 1998
		Farag et al., 1999
		NAWQA and BURP
		Woodward et al., 1997
		USGS 1998-1999 cooperative study of Spokane River with WA Dept. of Ecology
Aquatic habitat quality	Ninemile Creek, Pine Creek, South Fork (Wallace to Elizabeth Park), Spokane River near Stateline	Baseline data summarized in Fisheries Tech Memo (2001) Includes 1994-1998 NRT survey data, 1995-1998 BURP survey data, 2000 NAWQA data, and USFS 1993 survey data
		Maret and MacCoy, 2002
Lacustrine / Palustrine Habitat		
Waterfowl population	Lower Basin	Audet et al. 1999 (Wildlife Use and Mortality Investigation in CdA Basin: 1992-1997 data)
Waterfowl mortality	Lower Basin	Audet et al. 1999 (Wildlife Use and Mortality Investigation in CdA Basin: 1992-1997 data); Beyer et al. 2000 (Relation of Waterfowl Poisoning to Sediment Lead concentrations in CdA Basin)
Waterfowl blood lead	4 Stations (including Harrison Slough)	Henny et al. 1999,
		Beyer et al., 2000
		Blus et al., 1995
		Page Pond IAG Monitoring Reports
Riparian Habitat		
Riparian vegetation / invertebrates	Ninemile Creek, Pine Creek, South Fork (Wallace to Elizabeth Park), Spokane River near Stateline	PLANNED - Avista/Parametrix Wetland & Riparian Habitat Mapping and Assessment (SR to Cataldo)
		EcoRA Appendix K Attachment 1
		Potential aerial photos. None known at present
Songbird diversity/abundance	Basin - 2 Monitoring Avian Productivity & Survivability survey routes (MAPS)	No MAPS Baseline Available
		Pacific Northwest MAPS database. Not CdA specific, but regional averages
Songbird blood lead	Ninemile Creek, Pine Creek, South Fork (Wallace to Elizabeth Park), Lower Basin (2 stations)	USFWS Sample collection complete; report has not been completed.
		Johnson et al. 1999
		Blus et al., 1995
		UCFWO data

3.0 MONITORING ASSUMPTIONS, APPROACH, HYPOTHESES, AND BENCHMARKS

This section uses information developed in RI/FS and EcoRA, and presented in Section 2 of this document, to develop a framework for the environmental monitoring program. First, this information is interpreted and presented as statements of the current understanding of Basin-wide processes, termed "working assumptions." Second, the approach used to formulate a Basin-wide monitoring plan that is robust, yet practical and cost-effective, is presented. Third, statistically testable monitoring hypotheses based on the monitoring objectives identified in Section 1 are presented. Finally, the ecological benchmarks that are identified in the ROD and used to measure progress of the remedy are presented.

3.1 CURRENT WORKING ASSUMPTIONS REGARDING BASIN OBSERVATIONS

As a basis for refinement of the conceptual site model during long-term monitoring, a number of working assumptions have been developed using the analyses performed during the RI, FS, EcoRA, and the Probabilistic Post-Remediation Metals Loading Tech Memo (EPA 2001e). These working assumptions are general enough to be observable on a Basin-wide scale and summarize an evolving understanding of Basin-wide processes. The working assumptions are summarized below and further explanation and rationale are provided in Table 3-1.

1. Metals concentrations in the Basin are generally decreasing with time.

2. River flow and metals concentrations (and therefore metals loading) are approximately log-normally distributed.

3. Location-dependent statistical correlations exist between metals concentrations and loads, hardness, and river discharge.

4. Dissolved zinc is an indicator for other dissolved metals.

5. Total lead is an indicator for total metals.

6. Surface water/groundwater interactions result in a net increase in dissolved metals loads in surface water.

7. The AWQC ratios (the ratio of concentration to AWQC) are less variable than measured concentration or calculated loading. Statistical evidence of a decreasing trend is stronger for AWQC ratios than for concentrations or loads (see Table 2-2). There is also evidence, based on the RI data set, that AWQC ratios are not correlated with discharge except at very high discharges and the variability

(as measured by the coefficient of variation) is less for AWQC ratios than for concentrations. AWQC ratios are federal criteria as of the signing of the ROD. Site-specific or other criteria can only be used as a basis if incorporated into the ROD by official amendment.

8. Portions of the Basin upstream from mining-related impacts support aquatic biota populations comparable to reference streams.

9. Ecological conditions are degraded in mining-impacted stream segments.

10. Ingestion of lead-contaminated soil and sediment is the injury pathway to migratory birds in the Basin.

11. Coeur d'Alene Lake is a partial sink for metals from the Coeur d'Alene River.

The assumptions of the conceptual model (CH2M Hill 2000) summarize the current understanding of processes in the Basin, and, as additional information is gathered, the assumptions of the model will be revised whenever necessary. The working assumptions of the model form the foundation for the hypotheses that will be tested by the long-term monitoring program. While the assumptions of the model have been developed to describe Basin-wide processes in terms of scientifically testable and reasonably quantifiable components, the long-term monitoring program does not directly focus on proving or disproving these assumptions.

3.2 MONITORING APPROACH AND PRINCIPLES

The BEMP is founded on several primary principles that are intended to enhance the practicality, robustness, and cost-effectiveness while maintaining adequate technical rigor and effectiveness. The principles are summarized in this section.

First, the BEMP is based on the remedy selected in the ROD. The ROD identifies benchmarks that include key indicators of ecological improvement representing the broad range of ecological conditions in the Basin. These key indicators were selected based on the results of the RI/FS (EPA 2001a and b), EcoRA (EPA 2001c), and supporting technical memoranda (EPA 2001e and f) and stakeholder input. These key indicators of environmental improvement are the focus of the monitoring program; they include:

- Dissolved and total metals and nutrients in surface water
- Metals in soil and sediment in riverine and riparian environments in the Upper Basin (Ninemile Creek, Pine Creek, and South Fork); in riverine, riparian, lacustrine, and palustrine environments in the Lower Basin; and depositional areas of the Spokane River

- Fish, macroinvertebrates, and aquatic habitat in riverine environments
- Songbirds, riparian vegetation, and invertebrates in riparian environments
- Waterfowl in wetland environments
- Waterfowl and fish in lake environments

The monitoring program uses parameters and sampling frequencies that are intended to be sensitive and responsive to the potential rates of relevant environmental changes in the Basin over the period of the remedy implementation. Given the large area of the Basin and the pace of remedy implementation over the 30-year timeframe, it is anticipated that relevant changes in environmental media will occur relatively slowly. Consequently, many parameters will be monitored at a relatively long interval (e.g., five or ten years). The monitoring program includes more frequent (e.g., several times per year, yearly, or event-triggered) sampling at key locations (e.g., South Fork near confluence with North Fork; Coeur d'Alene River near Coeur d'Alene Lake). These "sentinel" locations will provide data to fill any gaps on potential short-term trends or trend discontinuities that could be used to aid interpretation of data from the more comprehensive, but less frequent, sampling events and to help anticipate any developing changes in longer-term trends. This approach is anticipated to reduce the expense associated with sample collection and analysis while maintaining adequate monitoring effectiveness in terms of sensitivity and responsiveness.

The BEMP will be integrated with remedial action effectiveness monitoring (e.g., the Box) and monitoring conducted under other programs (e.g., Lake Management Plan monitoring of Coeur d'Alene Lake and State of Idaho BURP monitoring). This approach is anticipated to reduce monitoring redundancy and enhance cost effectiveness.

Finally, it is anticipated the BEMP will evolve over the 30-year remedy implementation timeframe. The monitoring program assumes an adaptive management approach will be used to guide that evolution while maintaining a sound scientific and technical basis. The adaptive management approach emphasizes learning from experience and is tied to the statutory five-year reviews.

3.3 MONITORING HYPOTHESES

This section presents the hypotheses that will be tested during the long-term Basin-wide monitoring program. Practical, data-testable hypotheses were developed in order to answer specific questions related to Basin-wide conditions, including temporal trends and correlations between key monitoring parameters and stations. For this monitoring program the *null hypothesis* was selected to represent standard, base conditions while the *monitoring hypothesis* (or the alternative hypothesis) represents a change (typically a decrease) from base conditions. This places the burden of proof on demonstrating that conditions have changed, thereby rejecting the hypothesis that there has been no change. The hypotheses selected for testing under this Basin-wide monitoring plan therefore have a null hypothesis of "there is no change" vs. the to-be-tested monitoring hypothesis (alternative hypothesis) of "there is a change," typically "there is a decrease." Methods of evaluating the hypotheses are described in Section 6.

Specific monitoring hypotheses were developed based on the data needs identified in ROD Section 12.6. These nine hypotheses will become the focus of the Coeur d'Alene Basin environmental monitoring program:

1. **There is a decrease in dissolved zinc and/or cadmium concentrations in surface water** from the recent historic trend or pre-remediation condition.

2. **There is a decrease in particulate lead concentrations in the flood plain soils/sediment, levees, and riverbed sediments** from the recent historic trend or pre-remediation condition.

3. **There is a decrease in particulate lead loads and concentrations in surface water** from the recent historic trend or pre-remediation condition.

4. **There is a decrease in zinc AWQC ratios** (dissolved zinc concentration divided by AWQC for zinc) from the recent historic trend or pre-remediation condition. Cadmium will be tested as well. Note that AWQC ratios (using zinc as an indicator metal) is the metric used in the ROD to characterize surface water quality for ecological risk.

5. **There is an improvement in biotic benchmarks** from the recent historic trend or pre-remediation condition. Biotic benchmarks were established in the ROD (EPA 2002) and focus on indicators such as fish, songbirds, and waterfowl. Biological benchmark monitoring under the BEMP will evaluate improvements in biological resources on a habitat basis through the monitoring of habitat-specific indicators. The specific habitat indicators include:

   - Riverine habitat – aquatic macroinvertebrates, fish, aquatic habitat assessment
   - Lacustrine / palustrine habitat – waterfowl
   - Riparian habitat – songbirds, terrestrial macroinvertebrates, riparian vegetation

6. **There is a change in metals retention in Coeur d'Alene Lake** from the recent historic pre-remediation condition. The hypothesis of "there has been a statistically significant increase in metal retention in the lake based on the yearly net difference in outflow load minus inflow load" will be tested against a null hypothesis of no change. The hypothesis that retention has decreased also will be tested. That is, the hypothesis of "there has been a statistically significant

decrease in metal retention in the lake based on the yearly net difference in outflow load minus inflow load" will be tested against a null hypothesis of no change. The trend of retention over time will also be statistically analyzed.

7. **Implementation of the remedy has resulted in unwanted impacts to the system** such as recontamination, nutrient loading, excess sedimentation, etc. Specific, statistically testable hypotheses have yet to be determined for these factors. Recall that the monitoring hypothesis is representative of a deviation from base conditions. To evaluate any unwanted impacts to the system, post-remediation data (sedimentation, recontamination, nutrient loading etc.) would be evaluated against pre-remediation trends or conditions to determine whether or not there is sufficient evidence to reject the null hypothesis of "implementation of the remedy has NOT resulted in unwanted impacts to the system." This hypothesis is consistent with the approach of evaluating a monitoring hypothesis of *change* versus a null hypothesis of *no change*.

8. **There has been progress toward achieving benchmarks of the selected remedy.** This "meta hypothesis" will consider the hypothesis testing results from monitoring hypotheses 1 through 7 together with results of hypothesis testing of the location-specific numeric ROD benchmarks for the selected remedy. Table 3-2 summarizes the location-specific numeric benchmarks from ROD Table 12.2-1. The numeric benchmarks that will be tested as part of monitoring hypotheses 8 are the zinc and cadmium AWQC ratios associated with fishery-tier benchmarks in Ninemile Creek, Pine Creek, and the SFCDR above Elizabeth Park; the 50% reduction in dissolved metal [zinc] load from Canyon Creek to SFCDR; and the 50% reduction in yearly lead load discharged to the Spokane River. For each of these location-specific numeric benchmarks, the monitoring (alternative) hypothesis will be that the benchmark has been achieved—tested against the conservative, presumptive null hypotheses that the benchmark has *not* been achieved. The BEMP will not test the numeric benchmarks for lead concentration reductions to 530 mg/kg in the Lower Basin wetland and lake sediments that are part of the selected remedy. These benchmarks will be tested as part of the effectiveness monitoring associated with the individual cleanup actions that are implemented (as part of the selected remedy) to achieve those benchmarks.

The monitoring hypotheses evaluate BEMP data against a null hypothesis (of no change) in terms of time-history *trends,* aggregated temporal *averages,* or *both*, depending on data characteristics and/or availability. In particular, where available data do not support an estimate of a trend, aggregated temporal averages will be used.

The "best available" baseline data that will be used in the analysis and testing of trends and averages (or other measures) represent the recent historic record that was used in the RI/FS and

ROD. The baseline data is summarized in Section 2.3. Note that the quantity and quality of the baseline data vary between parameters to be evaluated under the monitoring hypotheses. Baseline data analyses are included in Appendix C.

There is not a monitoring hypothesis addressing groundwater quality in the Basin. Groundwater is not specifically addressed under the ROD; however, groundwater monitoring will likely be an important component of remedial action-specific effectiveness monitoring at various locations throughout the Basin. As future remedial action effectiveness monitoring data become available, it may be possible to incorporate the data into a better understanding of groundwater processes within the Basin. Relative contributions or reductions in metals loading to the river or its tributaries may also be inferred from metals loading mass balances on specific reaches. Mass balance calculations using surface water monitoring data may also illustrate the relative effects of surface water/groundwater interactions in different areas within the Basin.

3.4 BENCHMARKS

The priority ecological actions included in the interim remedy were selected to achieve measurable ecological benchmarks, which are near-term objectives that will serve as landmarks and measurements to evaluate the progress of the remedy toward achievement of long-term goals (see Table 12.2-1 of the ROD, EPA 2002). The identification of benchmarks and prioritization of actions were based on knowledge gained during the RI/FS process and extensive consultations with governmental stakeholders with expertise in local environmental conditions and wildlife habitat. Key areas of focus included identification of benchmarks that would be achievable within the time period of the Selected Remedy, appropriate measures of success, and actions necessary to achieve the benchmarks. These discussions drew heavily on the large amount of environmental data collected over time (e.g., water quality data and fish surveys) and the extensive experience of stakeholders in the Basin. The benchmarks are shown on Table 3-2 of this document.

In the ROD, the selected remedy and the expected outcomes of remedy implementation are identified by geographic unit and media type (see ROD Section 12). The qualitative and quantitative measures of the expected outcomes are called benchmarks. Progress toward the benchmarks will be considered during five-year reviews as part of the long-term monitoring adaptive management framework, in which the performance expectations will be compared to the observed outcomes of the completed actions. The benchmarks are listed in Table 3-2.

Table 3-1
Conceptual Model Working Assumptions

Working Assumption	Explanation and Rationale	Reference
1. Metals concentrations are generally decreasing with time.	Natural attenuation, source depletion and previous and ongoing remediation activities within the Basin contribute to the trend of generally decreasing metals concentrations in surface water, groundwater and soil/sediment.	EPA 2001e 7/9/02 Basin-Wide LTM Meeting
2. River discharge and metals concentrations (and therefore metals loading) are approximately lognormally distributed.	The lognormal distribution is a pattern commonly found in the natural world. Lognormal distributions "fit" the available measurements of stream flows and metal concentrations and loadings in the Basin.	RI Part 1 Section 5.0 RI Part 2 EPA 2001e
3. Location-dependent statistical correlations exist between metals concentrations and loads, hardness, and discharge.	Dissolved metal concentrations *decrease* but dissolved metal loading *increases* during high flows. Total metal concentrations increase during high flows. This is primarily due to increased sediment/particulate content during high flows. Linear regression between ln (flow) and hardness performed using available data; allows prediction of hardness values given flow.	RI Parts 2 through 6 RI Parts 2 through 6 Woods (2000b) TMDL Appendix I (EPA and IDEQ 2000) EPA 2001e
4. Dissolved zinc is an indicator for other dissolved metals.	There is generally a positive correlation between dissolved zinc concentrations and dissolved concentrations of the other 8 COC metals in the upper and midgradient watersheds. Also, Zinc is the most ubiquitous of the COC metals. Dissolved zinc occurs at much higher concentrations the dissolved cadmium and lead. Zinc is relatively mobile.	RI Part 2, Section 4.0 EPA 2001e, Section 1.4
5. Total lead is an indicator for other total metals.	There is a positive correlation pattern between total lead concentrations and total metals concentrations in the upper and midgradient watersheds.	RI Part 2, Section 4.0
6. Surface water/groundwater interactions result in a net increase in dissolved metals loads in surface water in the Basin.	In general, where rivers widen into floodplains there is a tendency for surface water to discharge to groundwater. Conversely, in areas where the river channel narrows groundwater tends to discharge metals to surface water, principally in the dissolved phase. Metals concentrations in groundwater are generally higher than in surface water at a given location.	RI Part 1 Section 3.0
7. AWQC ratios (ratio of concentration to AWQC) are less variable than C or L	AWQC ratios have less noise and are more reliable than concentration or loading data. AWQC ratios not correlated w/ discharge (Q) except at high Q ($Q>\sim 2*Q_{AVERAGE}$)	7/9/02 Basin-Wide LTM Meeting

Table 3-1 (Continued)
Conceptual Model Working Assumptions

Working Assumption	Explanation and Rationale	Reference
8. Portions of the Basin upstream from mining-related impacts support aquatic biota populations comparable to reference streams.	Habitat structure and diversity in Basin areas upstream from mining are comparable to conditions in reference streams. Macroinvertebrate abundance and diversity in these areas are comparable to or exceed those in reference streams. Fish populations in these areas are primarily composed of native species with multiple year classes present, and abundance approaches or exceeds reference benchmarks (<0.1 fish/meter^2)	EcoRA Section 2.3.3 EcoRA Appendix K Maret and MacCoy (2002)
9. Richness and population abundance of fish species and benthic macroinvertebrate taxa are reduced in mining-affected stream segments.	Ambient water quality criteria are commonly exceeded for cadmium, lead and zinc in mining-affected stream segments. Habitat conditions for aquatic species are poor due to stream channelization, lack of riparian vegetation, and alteration of stream-bottom substrates in mining-affected stream segments.	EcoRA Section 2.3.3 Stratus 2000 NAWQA Data. including Maret and MacCoy (2002)
10. Ingestion of lead-contaminated soil and sediment is the injury pathway to migratory birds in the Basin.	In the Basin, lead poisoning (primarily due to ingestion of contaminated sediments) is responsible for an estimated 96 percent of the total tundra swan mortality, compared to 20 to 30 percent (primarily due to ingestion of lead shot) at the Pacific flyway and national level.	EcoRA Stratus 2000
11. Coeur d'Alene Lake is currently a sink for metals from the Coeur d'Alene River.	Mass balance calculations (Woods 2000a) indicate that more metals enter Coeur d'Alene Lake on an annual basis from the Coeur d'Alene River than exit the lake to the Spokane River. This assessment is consistent with the current understanding of the trophic status of the lake.	RI Part 1 Section 3.0 RI Part 5

Notes:
AWQC ratio = ratio of concentration to ambient water quality criteria
C = concentration
COC = chemical of concern
EcoRA = ecological risk assessment
L = load
Ln =- natural logarithm
LTM = long-term monitoring
NAWQA = National Water Quality Assessment
Q = discharge
RI = risk assessment
TMDL = total maximum daily load

Table 3-2
Ecological Benchmarks of the Selected Remedy

Area		Benchmark
Upper Basin		**Reduce potential for recontamination of downstream remedies and reduce metals load to Coeur d'Alene Lake and the Spokane River** Reduce metals and nutrient loads from groundwater to the South Fork
Canyon Creek		**Reduce metals toxicity to downstream aquatic receptors** Reduce dissolved metals load discharging to the South Fork by at least 50% Reduce particulate lead and sediment loading during high flows
Ninemile Creek	East Fork headwaters to above Success	**Improve conditions to allow natural reestablishment of a salmonid fishery** Tier 2 to 3+ fishery (see fishery tier definitions at end of table). Reestablish fishery in 1.7 miles of 13 miles of streams in the Basin that are devoid of fish. Reduce dissolved metals concentrations to less than 7 times chronic AWQC with mitigation of mining impacts on riverine areas. Protect riverine and riparian receptors Mitigate mining impacts on riparian areas along 1.7 miles of stream. Risks to riparian receptors will be mitigated using removal and replacement with clean soil or capping with clean soil to isolate contaminants and reduce or eliminate exposure pathways.
	East Fork above Success to confluence	**Improve conditions to allow natural reestablishment of a migratory corridor for adult and juvenile fish** Tier 1 fishery. Reduce dissolved metals concentrations to less than 20 times acute AWQC.
	Mainstem Ninemile Creek.	**Improve conditions to allow natural reestablishment of an adult salmonid fishery** Tier 1 fishery. Reduce dissolved metals concentrations to less than 20 times acute AWQC.
Pine Creek		**Improve conditions to allow natural increases in salmonid populations and improve spawning and rearing** Tier 3+ fishery. Protect riverine and riparian receptors Mitigate mining impacts on riparian areas at locations of hot spot removal/capping. Risks to riparian receptors will be mitigated using removal and replacement with clean soil or capping with clean soil to isolate contaminants and reduce or eliminate exposure pathways.
South Fork (above Elizabeth Park)		**Improve conditions to support a higher fish density** Tier 2+ to 3+ fishery at >0.1 fish/square meter Initial protection of riverine and riparian receptors Mitigate mining impacts on riparian areas at locations of hot spot removal/capping. Risks to riparian receptors will be mitigated using removal and replacement with clean soil or capping with clean soil to isolate contaminants and reduce or eliminate exposure pathways.
South Fork (Elizabeth Park to confluence including the Bunker Hill Box)		**Reduce metals loading to surface water**

Table 3-2 (Continued)
Ecological Benchmarks of the Selected Remedy

Area	Benchmark
Lower Basin Stream Banks and Beds, including the Harrison Delta (Riparian and Riverine)	**Reduce particulate lead loading in the river** Reduce lead load entering into Lake Coeur d'Alene and the Spokane River, with emphasis on peak discharge events. Estimated reduction in high-flow load needed is at least 50% to reduce year-round lead concentrations to below chronic AWQC in the Spokane River. Reduce soil toxicity for songbirds, small mammals, and riparian plants Mitigate risks to riparian receptors along 33.4 miles of river by removing contaminated bank wedges from a 30-foot wide zone (122 acres). Remove contaminated bank wedges and cap with clean topsoil to enhance vegetation establishment and isolate contaminants from receptors.
Lower Basin Floodplain	**Wetlands: Reduce sediment toxicity and waterfowl mortality** Increase feeding area with lead concentration <530 mg/kg by 1,169 acres (of a total of 5,829 wetland acres with lead exceeding 530 mg/kg). Potentially increase feeding area by an additional 1,500 acres through conversion of agricultural land. Lakes: Reduce sediment toxicity to diving ducks, dabbling ducks, and warm- and cold-water fishes Reduce lead concentration in whole brown bullhead fish (as an indicator species) by remediating 1,859 of 5,979 acres of lake with lead exceeding 530 mg/kg. Riparian: Reduce soil toxicity for riparian receptors

Source: EPA 2002, Table 12.2-1 of the ROD

Fishery Tier definitions:
Tier 0: No migrating or resident fish observed.
Tier 1: Presence of migrating fish only, no fish observed during resident fish surveys (expected to be achieved at concentrations below 20x acute AWQC).
Tier 2: Presence of resident salmonids (trout) of any species, sculpin absent (expected to be achieved at concentrations from 7x to 10x chronic AWQC).
Tier 3: Presence of 3 or more year classes of resident salmonids, including young of the year (YOY), sculpin absent (expected to be achieved at concentrations between 3x and 7x chronic AWQC).
Tier 4: Presence of 3 or more year classes of resident salmonids, including YOY, and sculpin (expected to be achieved at concentrations between 1x and 3x chronic AWQC).
Tier 5: Presence of 5 salmonid age classes, including YOY, sculpin, and bull trout. Fauna dominated by native species at high densities (0.1 to >0.3 fish/m^2) (least impacted watersheds with concentrations <1x chronic AWQC).
\+ presence of adult trout (>150mm).
Note: For the definitions of fisheries tiers, AWQC are equal to the EPA-approved State of Idaho water quality standards for cadmium and zinc. The concentration ranges are unaffected by the 2001 update to the cadmium criteria.

4.0 BASIN-WIDE ENVIRONMENTAL MONITORING PROGRAM

4.1 MONITORING PROGRAM DESIGN

Design of the BEMP implements the monitoring approach and principles discussed in Section 3.2 and will be used to evaluate the monitoring hypotheses presented in Section 3.3. The design intent is to develop sampling designs that provide the monitoring information needed for remedy documentation and evaluation consistent with the mandates of the ROD. Consistent with this monitoring mandate, the BEMP sampling designs represent observational studies not experimental studies, as the BEMP does not implement designed experiments.

Many trade-offs were made during the development of this monitoring plan. These trade-offs were necessary in order to keep the monitoring plan realistically achievable in terms of schedule, budget, and evaluation and interpretation of results. Within the anticipated limits of available funding, the sampling designs aim to provide sufficient information to assess Basin environmental conditions and measure progress toward and attainment of the ecological benchmarks identified in the ROD.

The sampling designs were developed using an iterative process where candidate designs are proposed and then analyzed, evaluated, and refined with the aim of reasonably optimizing performance, cost-effectiveness, and practicality. Performance means a sampling design's ability or effectiveness at providing information to assess Basin environmental conditions and measure progress toward and attainment of the ecological benchmarks identified in the ROD. Cost-effectiveness means that the sampling design provides adequate performance at minimum cost. Practicality means that the sampling design can be reasonably implemented in the field and that "adequate performance and cost-effectiveness" considers real or potential practical constraints and opportunities, including funding. Achieving adequate performance, cost-effectiveness, and practicality are utilitarian aims that require scientific and engineering knowledge and judgment.

Performance and relative cost-effectiveness can be quantified. Performance is quantified by subjecting candidate sampling designs to statistical power analyses. The power analyses quantify the statistical effectiveness of a given sampling design for hypothesis testing, characterizing uncertainty in true values, and establishing DQOs. Relative cost-effectiveness is quantified by comparing statistical effectiveness with the number of samples defined by the sampling design. It should be noted that both statistical effectiveness and the number of samples in a given sampling design will vary over time during the implementation period of the monitoring program. Results of the power analyses for candidate sampling designs are interpreted and evaluated in terms of performance, cost-effectiveness, and practicality, as discussed in the previous paragraph. The statistical power analyses are documented in Appendix D.

One very important implication from the statistical power analyses documented in Appendix D is the diminishing increase in statistical power resulting from increasing sampling frequency. The power analyses indicated that surface water and sediment sampling significantly more frequent than called for in this section would provide only a relatively modest (and not cost-effective) increase in the capability to detect subtle changes or trends in measured monitoring parameters at a given monitoring location or area. This implication applies generally to metal concentrations, loads, AWQC ratios, or the like. Very simply, increased sampling frequency cannot compensate for the time period (duration) of monitoring needed to reliably detect subtle effects that manifest slowly over time.

Furthermore, the power analyses indicated that for detecting long-term changes and trends with a given total sampling effort, cost-effectiveness and statistical power generally increase with the time between sampling events. While timely results over the 30-year monitoring period is required, the most cost-effective monitoring having the greatest statistical power will likely occur towards the end of the 30-year monitoring period. However, if at any time results from the BEMP suggest modifications should be made to the sampling plans identified in this section, the BEMP can be modified, consistent with a strategy of adaptive management.

4.2 MEDIA-SPECIFIC MONITORING PROGRAMS

This section describes the media-specific monitoring programs for surface water, soil and sediment, and biological resources. Where appropriate, monitoring activities for the various media will be co-located (for example, at locations with selected remedy benchmarks or surface water "sentinel" locations) to aid in data interpretation, minimize redundancy, and maximize information generated. Monitoring programs for surface water, soil and sediment, and biological resources are presented in Tables 4-1, 4-2, and 4-3, respectively. The following sections describe the specific monitoring programs for each medium. Tables 4-4 and 4-5 summarize the BEMP and schedule for implementation over the next 30 years. Sampling, data collection, and analytical methods for the monitoring programs are discussed in Section 5.

4.2.1 Surface Water

The surface water-monitoring program is designed to evaluate six of the BEMP monitoring hypotheses discussed in Section 3.3.

- **Monitoring Hypothesis 1.** There is a decrease in dissolved zinc and cadmium concentrations in surface water from the recent historic trend or pre-remediation condition.
- **Monitoring Hypothesis 3.** There is a decrease in particulate lead loads and concentrations in surface water from the recent historic trend or pre-remediation condition.

- **Monitoring Hypothesis 4.** There is a decrease in zinc AWQC ratios (dissolved metal concentration divided by AWQC) from the recent historic trend or pre-remediation condition.
- **Monitoring Hypothesis 6.** There is an improvement in metals retention in Coeur d'Alene Lake from the recent historic pre-remediation condition.
- **Monitoring Hypothesis 7.** Implementation of the remedy has resulted in "unwanted" impacts to the system such as recontamination, nutrient loading, excess sedimentation, etc.
- **Monitoring Hypothesis 8.** There has been progress toward achieving benchmarks of selected remedy.

Surface water monitoring data will also aid in interpretation of biological resources (specifically with respect to fisheries by providing information on the AWQC ratio) and understanding groundwater processes.

Monitoring locations were selected based on relevance to the above monitoring hypotheses. The selected remedy includes surface water benchmarks for AWQC ratios, dissolved metals loading, and/or particulate metals loading in the Canyon Creek, Ninemile Creek, Pine Creek, and South Fork watersheds, as well as in the Lower Basin.

A combination of surface water sampling frequencies is employed to obtain the required data in a cost-effective manner. Given the large area of the Basin and the pace of remedy implementation over the 30-year time frame, relevant changes in environmental media may occur relatively slowly. Consequently, monitoring at some stations may be conducted at a relatively long interval (e.g., five years) without compromising the ability to detect changes over time. Monitoring frequency designs include a combination of both fixed-interval sampling events and event-triggered sampling (such as rain on snow events). The fixed-interval monitoring frequencies are designed to evaluate Basin-wide conditions during both stable and transient periods of the Basin and lake hydrographs. This approach provides data to evaluate the monitoring hypotheses and improves the understanding of concentration and load versus discharge relationships in the Basin. The frequency designs are based on the Basin conceptual model, the benchmarks of the selected remedy, and the results of the statistical power analyses presented in Appendix D.

The surface water monitoring program includes annual sampling at key "sentinel" locations within the Basin. These "sentinel" locations will provide data on potential short-term trends or "trend discontinuities" in the longer-term trends. The seven locations identified as "sentinel" monitoring locations (Elizabeth Park, Smelterville, South Fork at Pinehurst, North Fork at Enaville, Harrison, St. Joe River at mouth, and Spokane River at Lake outlet) will be monitored eight times annually to provide information relative to Basin-wide conditions and mass balances of metals, nutrient, and sediment loading. The eight sampling events are based on the respective hydrographs for the Basin and lake and are summarized on Table 4-1. Surface water samples collected eight times per year at sentinel stations will be analyzed for total and dissolved metals, hardness, suspended sediment, and nutrients. Total and dissolved metals analyses will include the chemicals of environmental concern (COECs) cadmium, lead, and zinc (ROD Section 5.2.2). Nutrient analysis will include total and dissolved nitrogen, and total and dissolved phosphorus.

The sentinel data also will be used to aid interpretation of data from the more spatially comprehensive, but less frequent, sampling events. This approach is anticipated to reduce the expense associated with sample collection and analysis while maintaining adequate monitoring effectiveness in terms of sensitivity and responsiveness.

Other locations in the Basin will be sampled less frequently (at 5-year intervals) to support ROD benchmark evaluation for the 5-year review process. "Benchmark" locations will be monitored eight times a year every five years to evaluate progress toward the benchmarks of the selected remedy (see Table 3-2). Benchmark locations include South Fork above Canyon Creek, Canyon Creek at mouth, upper East Fork Ninemile Creek, lower East Fork Ninemile Creek, Ninemile Creek at mouth, Pine Creek below Amy Gulch, Cataldo, and Spokane River at the Washington state line. Samples collected eight times a year every fifth year at Benchmark stations will be analyzed for the same suite of parameters as the sentinel station samples.

The 5-year monitoring at benchmark stations will be supplemented with an annual low-flow sampling event. The low-flow sampling event will be conducted every year at all monitoring stations (sentinel and benchmark) to provide information on trends of dissolved metals concentrations and loads and inter-annual variability within the Basin. Dissolved metals concentrations and loads typically exhibit the least variability during low-flow conditions, and trends in these parameters should be easier to detect using monitoring data collected during these relatively stable conditions. Surface water samples collected once per year during low-flow at benchmark stations will be analyzed for dissolved cadmium, lead, zinc, and hardness only.

Water samples collected during high flows (i.e., during peak snowmelt runoff or during rain-on-snow events) will be analyzed for total metals content of suspended sediment if sufficient suspended sediment is present in the water. Suspended sediment metals analyses will be performed on the filter residue from a 0.45 μm filter and the analytes will include the COECs for sediment: arsenic, cadmium, copper, lead, mercury, silver, and zinc (ROD Section 5.2.2). Sample preparation and analysis of the suspended sediment will be consistent with the soil/sediment preparation and analytical methods described in Section 5.2.

Metals and nutrient retention in Coeur d'Alene Lake will be evaluated based on mass balance results of loads measured at monitoring stations at the mouth of the St. Joe River, the Coeur d'Alene River at Harrison, and the Spokane River at the lake outlet. Monitoring at the lake outlet assumes discharge measurements from the existing USGS gauging station at Post Falls coupled with surface water sampling at the outlet, upstream of metals and nutrients inputs from the City of Post Falls wastewater treatment plant and other urban sources. Changes to discharge as a result of groundwater/surface water interaction along the Spokane River between the lake outlet and Post Falls have not been quantified at this time. However, the largest loadings occur with high flow, and surface water/groundwater interaction differences are expected to be negligible compared to the total discharges at these times when most of the annual load passes these two stations. Future studies planned by USGS are aimed at quantifying flow relationships between the two locations. Evaluation of Lake Coeur d'Alene data collected under the BEMP will be coordinated with data collected under the Lake Management Plan.

The surface water-monitoring program is summarized in Table 4-1. Surface water monitoring locations are shown in Figure 4-1. Surface water sample collection and analytical methods are discussed in Section 5.

4.2.2 Soil and Sediment

The soil and sediment-monitoring program is designed to evaluate three of the BEMP monitoring hypotheses discussed in Section 3.3.

- **Monitoring Hypothesis 2.** There is a decrease in particulate lead concentrations in the flood plain soils/sediment, levees, and riverbed sediments from the recent historic trend or pre-remediation condition.
- **Monitoring Hypothesis 7**. Implementation of the remedy has resulted in "unwanted" impacts to the system such as recontamination or excess sedimentation.
- **Monitoring Hypothesis 8**. There has been progress toward achieving benchmarks of selected remedy.

The benchmarks evaluated by the soil and sediment monitoring program include those related to improvements in soil and sediment quality in the Ninemile Creek, Pine Creek, and South Fork watersheds, the Lower Basin, and the Spokane River above Upriver Dam.

The monitoring hypotheses and benchmarks will be evaluated primarily using comprehensive "snapshots" of Basin soil and sediment conditions at 10, 20, and 30 years from the date of the ROD. Samples will be collected from Upper Basin in-channel and floodplain (riparian) depositional areas, Lower Basin floodplains, and selected Spokane River in-channel or near-shore depositional areas. In the Upper Basin, samples will be collected from areas potentially affected by remedial actions selected in the ROD (Ninemile Creek, Pine Creek, and the South Fork). Composite samples will be collected at all locations to increase statistical power and reduce monitoring costs. In addition to BEMP sediment sampling, remedial action effectiveness monitoring is expected to occur in areas where sediment-focused remedial action is planned. The ROD includes sediment-related remedial actions at several locations, including Upriver Dam and selected Spokane River beaches. It is anticipated that performance monitoring will be an important component of remedial action sediment or shoreline effectiveness monitoring associated with these actions.

In addition to the in-channel, shoreline and floodplain depositional sampling, core samples will be collected from mid-Long Lake and lower Long Lake along the Spokane River and near the Harrison Delta in Coeur d'Alene Lake every 10 years. At each location, the three cores will be located in the same general area (representing a potential geologic substratum of the lake) but no less than approximately 100 meters from each other (i.e., outside the range of potential short-range autocorrelations). Each core will be subjected to stratigraphic analysis that may include age dating, with details to be determined at the time the coring is planned. The sampling locations and three sampling points will be determined at the time the coring is planned. For the purpose of the BEMP, it is anticipated that results from the Long Lake coring will be pooled to represent the lake statistical sample, but that potential differences between the two locations will be analyzed and evaluated.

The 10-year comprehensive sampling programs will be augmented by annual "sentinel" sampling at key Basin locations. These sentinel samples will provide information on the inter-annual variability of sediment transported to and within the Lower Basin and provide valuable information for evaluation of potential unwanted impacts of remedy implementation (monitoring hypothesis 7). The sentinel locations will include in-channel and floodplain locations (sampling of the floodplain locations would be triggered by flood events). If practical, sediment traps will be used to collect sediment from the current year or flood event.

In addition to the comprehensive (10-year) and annual sediment sampling programs, sediment transport within the basin by surface water will be evaluated as a component of the surface water monitoring program. During surface water sampling at high-flow events, water samples will be collected and filtered to separate the water-suspended sediment. Water-suspended sediment (collected as filter residue) will be prepared and analyzed following the same procedures as other sediment samples collected for the BEMP.

Samples will be analyzed for the seven metals determined in the EcoRA to be COECs for sediment (arsenic, cadmium, copper, lead, mercury, silver, and zinc) with the evaluation focused on cadmium, lead, and zinc, the three primary COECs. In order to maximize comparability and evaluation of results, soil/sediment samples will be sieved to clay (<4 µm), silt (4-63 µm), and sand (63-250 µm) size fractions and prepared using a 4-acid digestion. Details for sample collection, preparation, and analysis are presented in Section 5.

The soil and sediment-monitoring program is summarized in Table 4-2 and sampling locations are shown on Figure 4-2.

4.2.3 Biological Resources

The biological resources monitoring program is designed to evaluate two of the BEMP monitoring hypotheses discussed in Section 3.3.

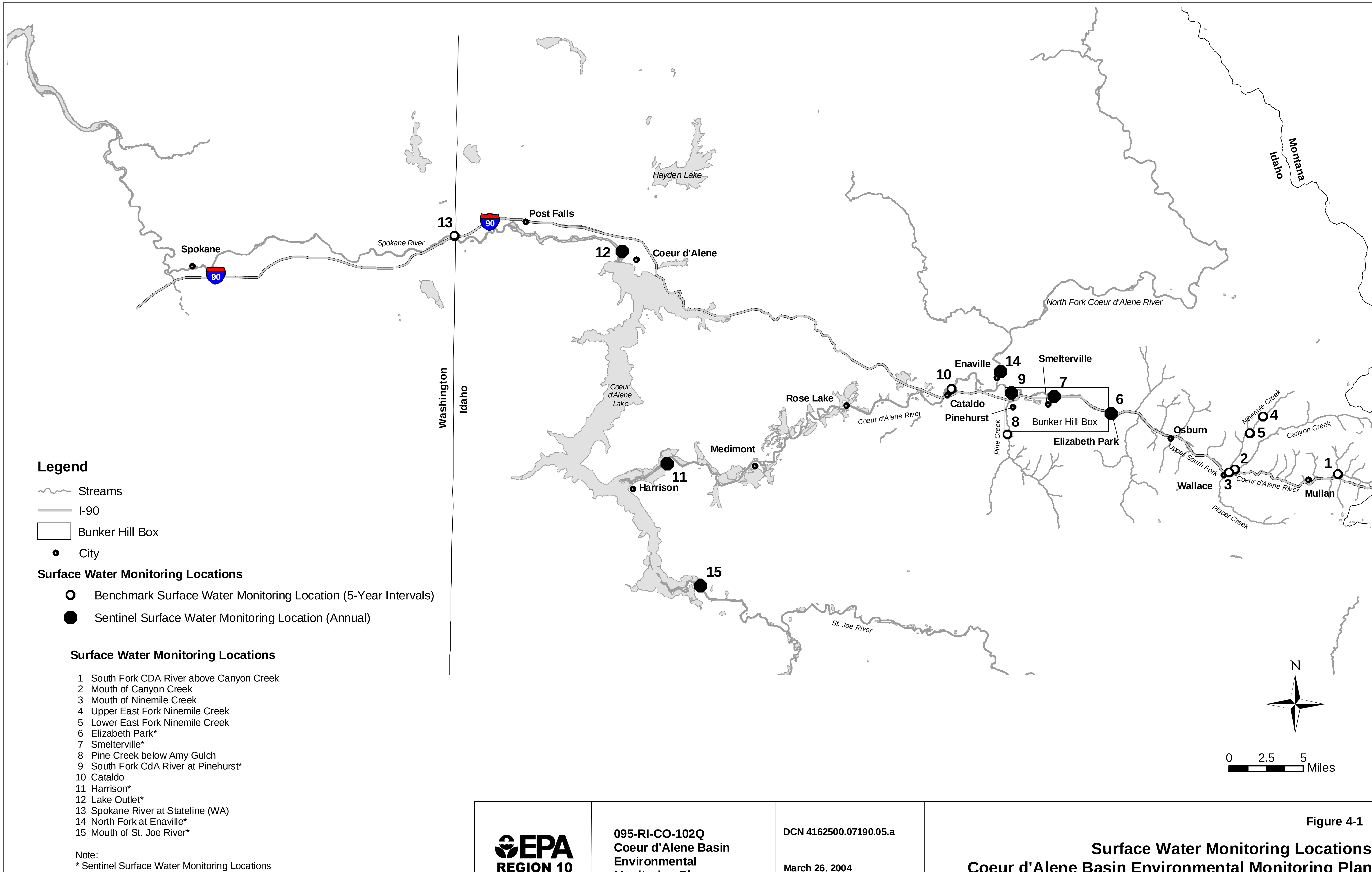
- **Monitoring Hypothesis 5.** There is an improvement in biotic benchmarks from the recent historic trend or pre-remediation condition.
- **Monitoring Hypothesis 8**. There has been progress toward achieving benchmarks of selected remedy.

Biotic benchmarks were established in the ROD (EPA 2002) and focus on indicators such as fish, songbirds, and waterfowl. Biological benchmark monitoring under the BEMP will evaluate improvements in biological resources on a habitat basis through the monitoring of habitat-specific indicators. The specific habitat indicators include:

- **Riverine habitat –** aquatic macroinvertebrates, fish, aquatic habitat assessment
- **Lacustrine / palustrine habitat –** waterfowl
- **Riparian habitat –** songbirds, terrestrial macroinvertebrates, riparian vegetation

Monitoring will be conducted at varying frequencies appropriate for the anticipated rate of change and variability of the specific biological indicators. Parameters anticipated to show considerable variation from year to year or sensitivity to changing ecological conditions (e.g. macroinvertebrate diversity/abundance, waterfowl population) are scheduled for monitoring at increased frequencies (e.g., twice or three times per five years). Most parameters are planned for monitoring at less frequent intervals (5-years). The frequencies are shown in the summary of the biological resources monitoring program presented in Table 4-3. The frequencies of monitoring for the different parameters allow for the biological monitoring to be distributed over time by staggering the schedules for the different parameters. The schedule for biological resources monitoring is presented in Table 4-5.

Monitoring of biological resource parameters will be conducted in accordance with Upper Columbia Fish and Wildlife Office (UCFWO) protocols designed for data continuity and comparability with existing studies. Data and sample collection methods are presented in Section 5. Results from the BEMP biological resources monitoring activities may be supplemented with results from remedial action-specific effectiveness and Box biological resources monitoring.



N:\envlmntr\maps\longtermmonitoring\longtermmonitoring_surfwatr_monitr.mxd

EPA REGION 10

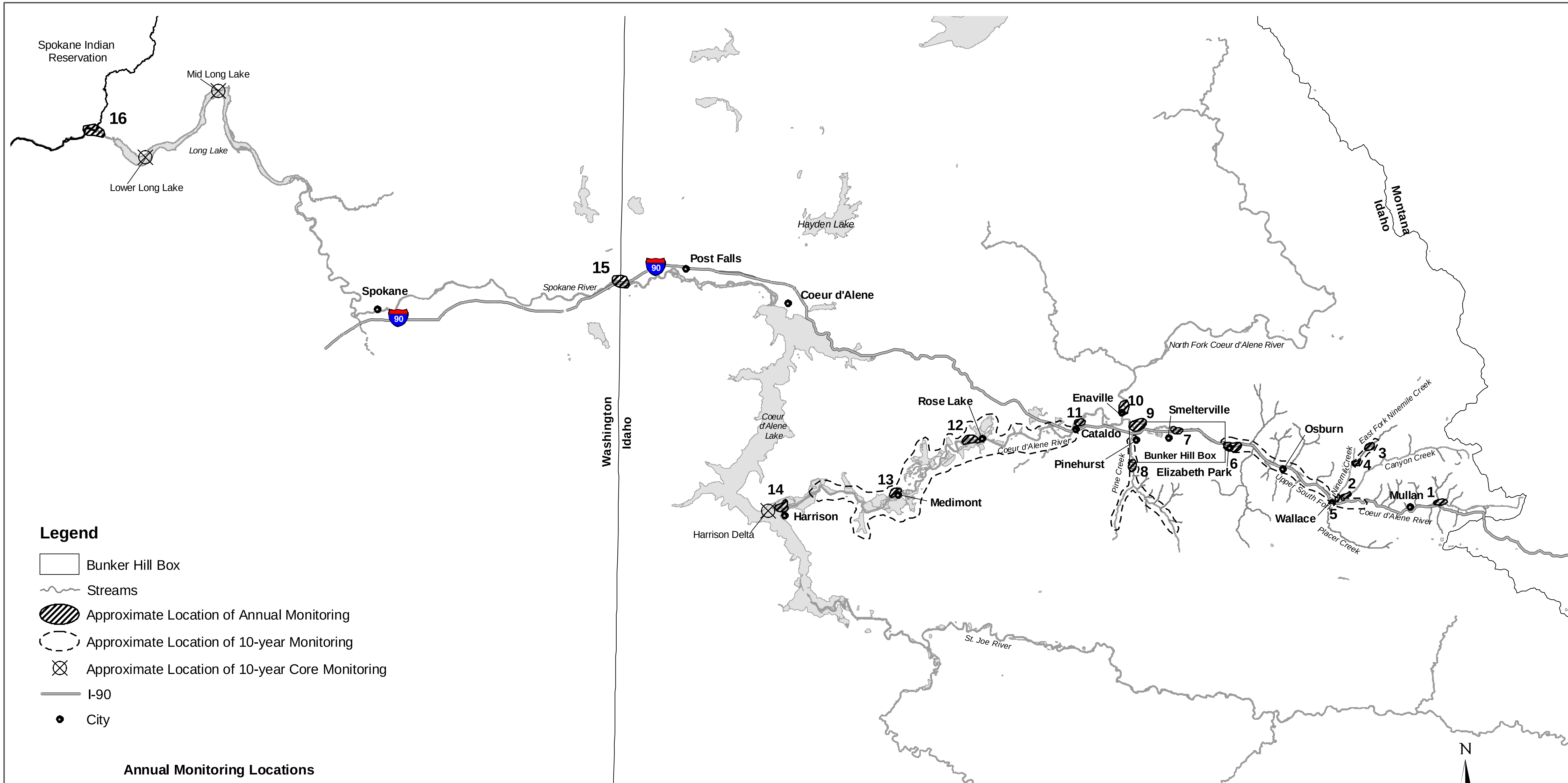
095-RI-CO-102Q
Coeur d'Alene Basin Environmental Monitoring Plan

DCN 4162500.07190.05.a

March 26, 2004

Figure 4-1

Surface Water Monitoring Locations
Coeur d'Alene Basin Environmental Monitoring Plan



Annual Monitoring Locations

1 South Fork above Canyon Creek
2 Mouth of Canyon Creek
3 Upper East Fork Ninemile Creek
4 Lower East Fork Ninemile Creek
5 Mouth of Ninemile Creek
6 Elizabeth Park
7 Smelterville
8 Pine Creek below Amy Gulch
9 Pinehurst
10 Enaville
11 Cataldo
12 Rose Lake
13 Medimont
14 Harrison
15 Stateline
16 Eastern Boundary of Spokane Indian Reservation at Spokane River

10-Year Monitoring Locations

South Fork Coeur d'Alene River
Ninemile Creek
Pine Creek
Lower Basin Floodplain
Harrison Delta (Core Sampling)
Mid Long Lake (Core Sampling)
Lower Long Lake (Core Sampling)

N:\envlmntr\maps\longtermmonitoring\lupbasin_annualsamps_ll.mxd

EPA REGION 10

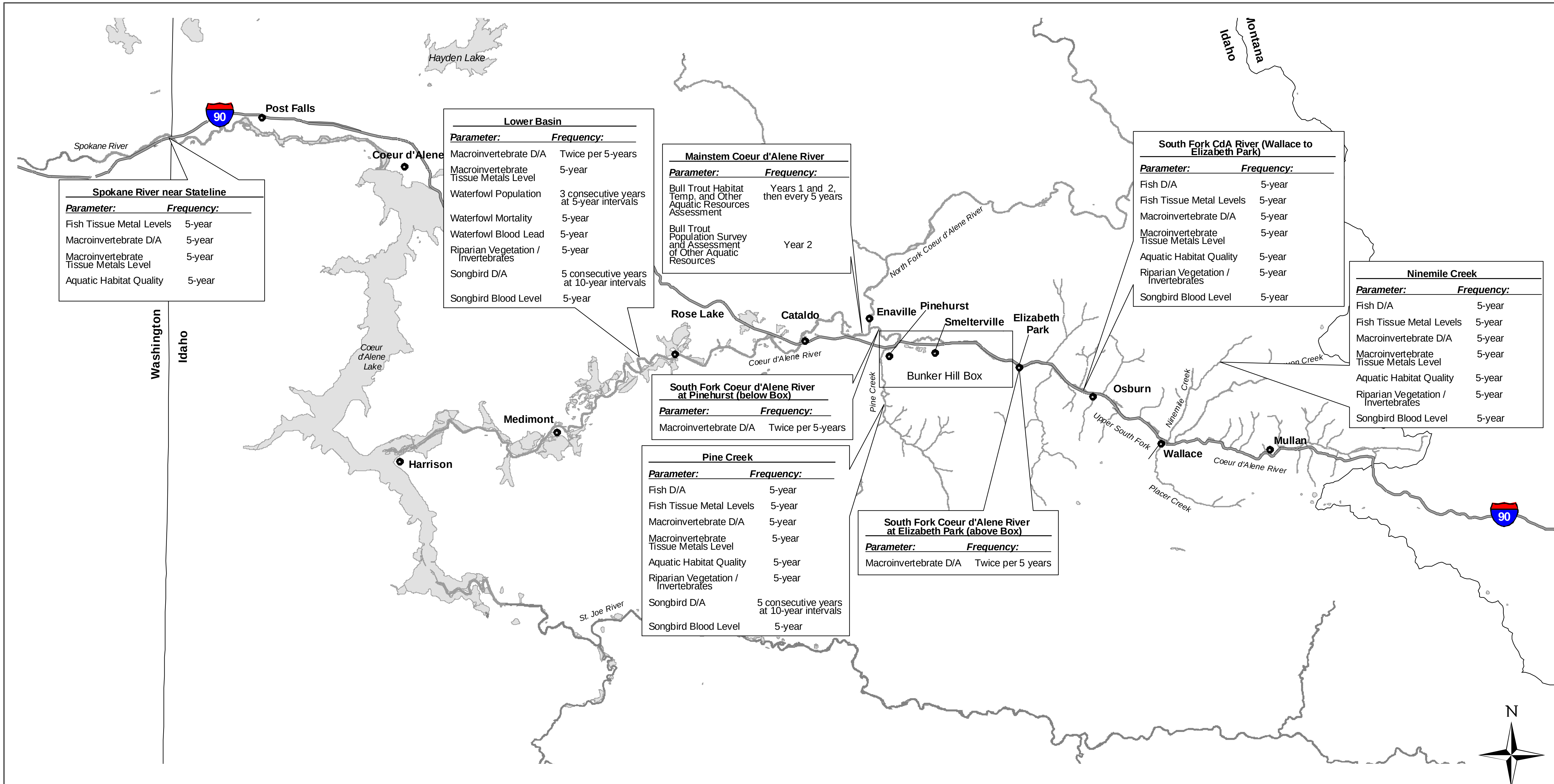
095-RI-CO-102Q
Coeur d'Alene Basin Environmental Monitoring Plan

DCN 4162500.07190.05.a

March 26, 2004

Figure 4-2

Soil / Sediment Monitoring Locations
Coeur d'Alene Basin Environmental Monitoring Plan



Spokane River near Stateline

Parameter:	Frequency:
Fish Tissue Metal Levels	5-year
Macroinvertebrate D/A	5-year
Macroinvertebrate Tissue Metals Level	5-year
Aquatic Habitat Quality	5-year

Lower Basin

Parameter:	Frequency:
Macroinvertebrate D/A	Twice per 5-years
Macroinvertebrate Tissue Metals Level	5-year
Waterfowl Population	3 consecutive years at 5-year intervals
Waterfowl Mortality	5-year
Waterfowl Blood Lead	5-year
Riparian Vegetation / Invertebrates	5-year
Songbird D/A	5 consecutive years at 10-year intervals
Songbird Blood Level	5-year

Mainstem Coeur d'Alene River

Parameter:	Frequency:
Bull Trout Habitat Temp. and Other Aquatic Resources Assessment	Years 1 and 2, then every 5 years
Bull Trout Population Survey and Assessment of Other Aquatic Resources	Year 2

South Fork CdA River (Wallace to Elizabeth Park)

Parameter:	Frequency:
Fish D/A	5-year
Fish Tissue Metal Levels	5-year
Macroinvertebrate D/A	5-year
Macroinvertebrate Tissue Metals Level	5-year
Aquatic Habitat Quality	5-year
Riparian Vegetation / Invertebrates	5-year
Songbird Blood Level	5-year

Ninemile Creek

Parameter:	Frequency:
Fish D/A	5-year
Fish Tissue Metal Levels	5-year
Macroinvertebrate D/A	5-year
Macroinvertebrate Tissue Metals Level	5-year
Aquatic Habitat Quality	5-year
Riparian Vegetation / Invertebrates	5-year
Songbird Blood Level	5-year

South Fork Coeur d'Alene River at Pinehurst (below Box)

Parameter:	Frequency:
Macroinvertebrate D/A	Twice per 5-years

Pine Creek

Parameter:	Frequency:
Fish D/A	5-year
Fish Tissue Metal Levels	5-year
Macroinvertebrate D/A	5-year
Macroinvertebrate Tissue Metals Level	5-year
Aquatic Habitat Quality	5-year
Riparian Vegetation / Invertebrates	5-year
Songbird D/A	5 consecutive years at 10-year intervals
Songbird Blood Level	5-year

South Fork Coeur d'Alene River at Elizabeth Park (above Box)

Parameter:	Frequency:
Macroinvertebrate D/A	Twice per 5 years

Legend

Streams
I-90
Bunker Hill Box
City

D/A Diversity and Abundance

Biological Resources Monitoring Locations

1 Ninemile Creek
2 South Fork Coeur d'Alene River (Wallace to Elizabeth Park)
3 South Fork Coeur d'Alene River at Elizabeth Park (above Box)
4 South Fork Coeur d'Alene River at Pinehurst (below Box)
5 Pine Creek
6 Mainstem Coeur d'Alene River
7 Lower Basin
8 Spokane River at Stateline

N:\envlmntr\maps\longtermmonitoring\longtermonitoring_biological_2004_inview.mxd

EPA REGION 10

095-RI-CO-102Q
Coeur d'Alene Basin Environmental Monitoring Plan

DCN 4162500.07190.05.a

March 26, 2004

Figure 4-3

Biological Resources Monitoring Locations
Coeur d'Alene Basin Environmental Monitoring Plan

Table 4-1
Surface Water Monitoring Program

Location	Station ID	USGS Station ID	IDEQ Station ID	Gaging Station Type	Sentinel Monitoring [a] (Annual)	ROD Benchmark Monitoring [a] (Every 5 years)	Fall Baseflow Monitoring [b] (Every Oct.)	Rationale
SFCDA above Canyon Creek (near Mullan at Deadman Gulch)	SF-208	12413040	None	Misc.	--	X	X	Supports ROD Benchmark Evaluation
Mouth of Canyon Creek	CC-287/ CC-288	12413125	CC-1	Standard	--	X	X	Supports ROD Benchmark Evaluation
Mouth of Ninemile Creek	NM-305	12413130	NM-1	Standard	--	X	X	Supports ROD Benchmark Evaluation
Upper E Fork Ninemile Creek (above Success Mine)	NM-295	124131265	ENM-3	Misc.	--	X	X	Supports ROD Benchmark Evaluation
Lower E Fork Ninemile Creek	NM-298	12413127	ENM-1	Misc.	--	X	X	Supports ROD Benchmark Evaluation
Elizabeth Park [c]	SF-268	12413210	SF-3	Standard	X	--	X	Sentinel Station, Load from SFCDR above Bunker Hill Box, Supports ROD Benchmark Evaluation
Smelterville [c]	SF-270	12413300	SF-2	Misc.	X	--	X	Sentinel Station, Load from SFCDR below CIA & Govt. Gulch
Pine Creek Below Amy Gulch	PC-339	12413445	None	Standard	--	X	X	Supports ROD Benchmark Evaluation
South Fork at Pinehurst [c]	SF-271	12413470	SF-1	Real-time	X	--	X	Sentinel Station, Load from SFCDR below Bunker Hill Box, supports ROD Benchmark Evaluation
Cataldo	LC-50	12413500	Cataldo	Real-time [e]	--	X	X	Upper Basin/Lower Basin River Character Transition
Harrison	L-C60	12413860	Harrison	Real-time (w/ suspended sediment)	X	--	X	Sentinel Station, Inflow to Lake
Spokane River at Outlet (See Note [d])	See Note [d]	See Note [d]	None	Misc. [e]	X	--	X	Sentinel Station, Outflow from Lake
Spokane River near Stateline	SR-55	12419500	None	Misc.	--	X	X	Required for WA State
NF CDR at Enaville	NF-50	12413000	None	Real-time	X	--	X	Sentinel Station, Load from North Fork CDR
St. Joe River at Mouth (Chatcolet)	SJ-60	12415130	None	Real-time (w/ suspended sediment)	X	--	X	Sentinel Station, Load from St. Joe River

Schedule for Sentinel (Annual) and Benchmark (Every 5 Years) Monitoring

Coeur d'Alene River, its Tributaries and St. Joe River

1. Fall Baseflow (early October)
2. Initial Flush after Baseflow (Fall)
3. Rain-on-snow (Winter or Early Spring)
4. Winter Baseflow (January - March)
5. Peak Snowmelt Runoff (late May. - Suspended sediment chemistry)
6. Hydrograph Recession 1 (mid-June)
7. Hydrograph Recession 2 (mid July)
8. Hydrograph Recession 3 (mid-August)

Spokane River

1. Mid-Fall Drawdown (mid-October)
2. Post-Fall Drawdown (late December)
3. Low Pool (mid-Winter)
4. Rain-on-snow (late Winter or early Spring)
5. Lake Filling (late April or early May)
6. Snowmelt Runoff Peak (late May)
7. Full Pool (mid July)
8. Full Pool, Maximum Productivity (late August)

Notes:

[a] Sentinel and benchmark station samples collected 8 times per year will be analyzed for total metals, dissolved metals, hardness, and nutrients. Metals analysis will include COECs (Cd, Pb, Zn; ROD Sect. 5.2.2). Nutrient analysis will include total and dissolved nitrogen and total and dissolved phosphorus. Samples collected during high flows (i.e. during peak snowmelt runoff in late May) will also be analyzed for suspended sediment grain size distribution metals.

[b] Benchmark stations sampled once a year will be analyzed for dissolved metals and hardness only. Metals analyses will include COECs (Cd, Pb, Zn; ROD Sect. 5.2.2).

[c] BEMP monitoirng within the Box will be coordinated with ongoing surface water / groundwater monitoring performed for the Box. Coordination of these programs (to the extent practical) will aid in the interpretation of monitoring results from the BEMP and the Box monitroinf programs.

[d] Discharge measurements to be taken at Post Falls gaging station (USGS Station No. 12419000); surface water sample to be collected at Lake Outlet. EPA Station ID for Lake Outlet is SR-5 and for Post Falls is SR-50.

[e] Funded by Idaho Water Resources

Table 4-2
Sediment Monitoring Program

Area	Sampling Description [a]
Sentinel Locations: Annual sampling to evaluate time-history trends (Fall)	
Upper Basin and Lower Basin : Surficial in-channel sediment from selected locations [b]	Composite surface samples
Spokane River : Near Stateline and near eastern boundary of Spokane Reservation	
Upper Basin, Lower Basin, and Spokane River: Water-suspended sediment sampling during high-flow conditions [c]	Filter residue from filtration of surface water samples collected during high flow events.
Basin-Wide Assessment ("Snapshot") Locations: Sampling every 10 years to evaluate aggregated, area-wide temporal averages (i.e. ratio analysis) (Fall)	
Upper Basin : Ninemile Creek, South Fork, Pine Creek	Composite surface sampling of in-channel and riparian sediment and soil.
Lower Basin : Floodplain and Harrison Delta [d]	Grid-based, composite surface sampling of riparian, lacustrine, and palustrine sediment deposits.
Spokane River: Mid and lower Long Lake [d]	Sediment core sampling

[a] Samples will be analyzed for grain size distributions of COEC metals (arsenic, cadmium, copper, lead, mercury, silver, and zinc). Sampling methods and analytical protocols for grain size distributions, sample digestion, and analysis are presented on BEMP Tables 5-1 and 5-2. (i.e. grain size distributions, sample digestion, and analytical methods). Suspended sediment monitoring locations and frequencies are presented on BEMP Table 4-1 (Surface Water Monitoring Program).

[b] In-channel (low water) locations include: 1) South Fork above Canyon Creek, 2) Mouth of Canyon Creek, 3) Upper East Fork Ninemile Creek, 4) Lower East Fork Ninemile Creek, 5) Mouth of Ninemile Creek, 6) Elizabeth Park, 7) Smelterville, 8) Pine Creek below Amy Gulch, 9) Pinehurst, 10) Enaville, 11) Cataldo, 12) Rose Lake, 13) Medimont, and 14) Harrison.

[c] Water-suspended sediment sampling locations and frequencies are presented on BEMP Table 4-1 (Surface Water Monitoring Program).

[d] Sampling at the Harrison delta and at Long Lake will be accomplished with a core sampler.

Table 4-3
Biological Resources Monitoring Program

Parameter	Representative Scale	Frequency	Location(s)
Riverine Habitat			
Fish diversity/ abundance	Representative habitats at segment level (or weir counts of migratory fish)	5-year	Ninemile Creek
			Pine Creek
			South Fork (Wallace to Elizabeth Park)
Fish Tissue Metal Levels (Upper Basin and Spokane River)	TBD	5-year	Ninemile Creek
			Pine Creek
			South Fork (Wallace to Elizabeth Park)
			Spokane River near Stnearline
Bull Trout Habitat/ Temp. and Other Aquatic Resources Assessment	TBD	Years 1 and 2, then every 5 years	Mainstem CdA River
Bull Trout Population Survey and Assessment of Other Aquatic Resources	TBD	Year 2 only	Areas of cold refuge (bull trout) and representative habitats in Mainstem CdA River (other aquatic resources)
Macroinvertebrate diversity/abundance	Quadrants in representative habitats	Twice per 5-years	Elizabeth Park (above Box)
			SFCdA at Pinehurst (below Box)
			Lower Basin
		5- year	Ninemile Creek
			Pine Creek
			South Fork (Wallace to Elizabeth Park)
			Spokane River near Stnearline
Macroinvertebrate tissue metal levels	Quadrants in representative habitats	5-year	Ninemile Creek
			Pine Creek
			South Fork (Wallace to Elizabeth Park)
			Spokane River near Stnearline
Aquatic habitat quality	Parameter dependent scale, representative habitats	5-year	Ninemile Creek
			Pine Creek
			South Fork (Wallace to Elizabeth Park)
			Spokane River near Stnearline
Lacustrine / Palustrine Habitat			
Waterfowl population	Wetland/lake units	3 Consecutive years @ 5 year intervals	Lower Basin
Waterfowl mortality	Mortality rate per unit effort (High use habitats)	5-year	Lower Basin
Waterfowl blood lead	Representative stations, Harrison Slough (sentinel area)	5-year	4 Stations (including Harrison Slough)
Riparian Habitat			
Riparian vegetation / invertebrates	Transects in representative locations	5-year	Ninemile Creek
			Pine Creek
			South Fork (Wallace to Elizabeth Park)
			Lower Basin
Songbird diversity/abundance	Point survey technique	5 Consecutive years @ 10-year intervals	Monitoring Avian Productivity & Survivability survey routes (MAPS) in Pine Creek and Lower Basin
Songbird blood lead	Representative stations	5-year	Ninemile Creek
			South Fork (Wallace to Elizabeth Park)
			Pine Creek
			Lower Basin (2 stations)

Table 4-4
Monitoring Program Summary

Location	Station Type	USGS Gaging Station Type	Surface Water			Sediment				Biological Resources													
										Riverine								Lacustrine/Palustrine			Riparian		
										Fish				Macroinvertebrates			Habitat	Waterfowl			Habitat	Songbirds	
			Sentinel Monitoring	Benchmark Monitoring	Low Flow	Surfical in-channel Sampling	In-channel, lacustrine, palustrine& riparain	Water-suspended Sediment at high flows (part of SW sampling)		Diversity/ Abundance	Tissue Metals Levels	Bull Trout Habitat Assessment [c] and Other Aquatic Resources	Bull Trout Pop. Survey [c]	Diversity/ Abundance	Diversity/ Abundance	Tissue Metals Levels	Aquatic Habitat Quality Assessment	Population Survey	Mortality Survey	Blood Lead	Riparian Veg. + Inverts	Diversity/ Abundance	Blood Lead
	Monitoring Frequency		Annual	5 Years	Annual	Annual	10 Years	Annual	5 Years	5 Years	5 Years	Years 1 & 2, then every 5 years	Year 2 only	2 per 5 years	5 Years	5 Years	5 Years	3 consec. yrs. every 5 yrs.	5 Years	5 Years	5 Years	5 consec. yrs. every 10 yrs.	5 Years
SFCDA above Canyon Creek	Benchmark	Misc.		X	X	X			X														
Mouth of Canyon Creek	Benchmark	Std.		X	X	X			X														
Ninemile Drainage							X			X	X				X	X	X				X		X
Mouth of Ninemile Creek	Benchmark	Std.		X	X	X			X														
Upper E. Fork Ninemile Creek	Benchmark	Misc.		X	X	X			X														
Lower E. Fork Ninemile Creek	Benchmark	Misc.		X	X	X			X														
SFCDA Drainage (Wallace-Elizabeth Park)							X			X	X				X	X	X				X		X
Elizabeth Park (above Box)	Sentinel/ Benchmark	Std.	X		X	X		X						X									
Smelterville	Sentinel	Misc.	X		X	X		X															
Pine Creek Drainage							X			X	X				X	X	X				X	X	X
Pine Creek below Amy Gulch	Benchmark	Real-time		X	X	X			X														
SFCDA at Pinehurst (below Box)	Sentinel/ Benchmark	Real-time	X		X	X		X						X									
NFCDA at Enaville	Sentinel	Real-time	X		X	X		X															
Lower Basin							X					X	X	X				X	X	X	X	X	X
Cataldo		Real-time [a]		X	X	X			X														
Rose Lake		NA				X																	
Medimont		NA				X																	
Harrison	Sentinel/ Benchmark	Real-time/SS	X		X	X	X [b]	X															
Spokane River at Outlet	Sentinel	Misc.	X		X			X															
Spokane River at Post Falls		Std. [a]																					
Spokane River near Stateline		Misc.		X	X	X			X		X				X	X	X						
Mid and lower Long Lake		NA					X [b]																
Near Eastern Boundary of Spokane Reservation		NA				X																	
St. Joe River at Mouth near Chatcolet	Sentinel	Real-time/SS	X		X			X															

[a] Funded by Idaho Water Resources
[b] Surface sediment sampling of Harrison delta and mid and lower Long Lake using a core sampler
[c] Bull trout habitat assessemnet to be performed years 1 and 2, then every 5 years. Surveying (electroshocking) locations will be identified based on habitat assessment (i.e. areas of cold refuge).

Notes:
Surface water samples to be analyzed for total and dissolved metals (Cd, Pb, Zn), suspended sediment, and nutrients.
Gaging station types:
Standard - recording equipment that needs the data to be physically downloaded
Real-time - satellite transmission of recording data
Real-time/SS - satellite transmission of recording data plus suspended sediment data
Miscellaneous - no actual gaging station but can measure instantaneous flow and estimate hourly flow

Table 4-5
Monitoring Schedule

Media/Organism	Activity	Location Year	2004	2005*	2006	2007	2008	2009	2010*	2011	2012	2013	2014	2015*	2016	2017	2018
			Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8	Y9	Y10	Y11	Y12	Y13	Y14	Y15
SURFACE WATER																	
Sentinel stations + annual low flow sampling		7 stations / 15 stations	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Benchmark stations		8 stations					X					X					X
SEDIMENT																	
Surfical sediment sampling + suspended sediment		16 areas	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Broader sediment sampling + coring		7 areas						X									
BIOLOGICAL RESOURCES																	
Waterfowl	Population survey	Lower Basin		X	X	X			X	X	X			X	X	X	
Waterfowl	Mortality Survey	Lower Basin				X					X					X	
Waterfowl	Blood Lead	4 stations					X					X					X
Songbird	Blood Lead	5 stations							X				X				X
Songbird	Population survey	2 MAPs	X	X	X	X	X						X	X	X	X	X
Riparian spp.	Riparian habitat	5 stations			X					X					X		
Aquatic Invertebrate	Diversity/adundance	3 locations	X	X				X	X				X	X			
Aquatic Invertebrate	Diversity/adundance	4 additional locations		X					X					X			
Aquatic Invertebrate	Tissue residues	4 locations		X					X					X			
Fish and invertebrate	Habitat assessment	3 locations		X			X					X					X
Fish	Diversity/abundance	3 locations			X					X					X		
Fish	Tissue residues	4 locations			X					X					X		
Bull trout	Habitat/temperature assessment	S.F.CdA and Mainstem	X	X					X					X			
Bull trout	Population survey	Areas of cold refuge		X													
REPORTING																	
Annual data report/assessment			X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Tech memo to support Five-Year Review report preparation									X					X			

Notes:
* Indicates the year that five-year reviews will need to be completed.

Table 4-5 (Continued)
Monitoring Schedule

		Year	2019	2020*	2021	2022	2023	2024	2025*	2026	2027	2028	2029	2030*	2031	2032	2033
Media/Organism	**Activity**	**Location**	Y16	Y17	Y18	Y19	Y20	Y21	Y22	Y23	Y24	Y25	Y26	Y27	Y28	Y29	Y30
SURFACE WATER																	
Sentinel stations + annual low flow sampling		7 stations / 15 stations	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Benchmark stations		8 stations					X					X					X
SEDIMENT																	
Surfical sediment sampling + suspended sediment		16 areas	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Broader sediment sampling + coring		7 areas	X										X				
BIOLOGICAL RESOURCES																	
Waterfowl	Population survey	Lower Basin		X	X	X			X	X	X			X	X	X	
Waterfowl	Mortality Survey	Lower Basin				X					X					X	
Waterfowl	Blood Lead	4 stations					X					X					X
Songbird	Blood Lead	5 stations						X					X				
Songbird	Population survey	2 MAPs						X	X	X	X	X					
Riparian spp.	Riparian habitat	5 stations			X					X					X		
Aquatic Invertebrate	Diversity/adundance	3 locations	X	X				X	X				X	X			
Aquatic Invertebrate	Diversity/adundance	4 additional locations		X					X					X			
Aquatic Invertebrate	Tissue residues	4 locations		X					X					X			
Fish and invertebrate	Habitat assessment	3 locations					X					X					X
Fish	Diversity/abundance	4 locations			X					X					X		
Fish	Tissue residues	4 locations			X					X					X		
Bull trout	Habitat/temperature assessment	S.F.CdA and Mainstem		X					X					X			
Bull trout	Population survey	Areas of cold refuge															
REPORTING																	
Annual data report/assessment			X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Tech memo to support Five-Year Review report preparation				X					X					X			

Notes:
* Indicates the year that five-year reviews will need to be completed.

5.0 DATA COLLECTION METHODS

This section describes the standard procedures to be used during sample collection, field data generation, and laboratory analysis of samples collected under the monitoring programs described in Section 4 of this document. The methods described in this section were selected for the specific monitoring parameters to provide representative, reproducible data for environmental conditions in the Basin. The sample collection and analytical procedures were chosen to provide data that is comparable to previous (baseline) data. USFWS and USGS personnel will performed field data and sample collection. Table 5.1 describes the agencies responsible for sampling or monitoring each media or parameter.

Field and laboratory methods are included in Appendix E. The field data and sample collection methods identified herein are current as of the date that this document was developed. Given the 30-year time frame over which this monitoring program will be implemented, it is likely that the referenced methods will be updated or superceded. In the event that updated or new methods are recommended for implementation, the revised/new methods will be compared with methods described herein to ensure the appropriateness of the new method and comparability of results. Revisions to sampling or analytical methods will be reviewed by EPA, USGS, and USFWS, and will be documented via the corrective action form included with the Quality Assurance Project Plan (Appendix B). A review of sampling and analytical methods will be performed during the CERCLA-required 5-year reviews.

The following sections describe sample and field data collection procedures, laboratory analytical methods and data quality objectives for each monitoring parameter.

5.1 SURFACE WATER

This section describes the field and analytical methods identified for use during surface water sample collection, the agency responsible for performing the sampling, and the analytical methods and laboratories.

5.1.1 Surface Water Sample Collection

Surface water samples will be collected at the gauging stations identified in Section 4. The USGS will perform sampling in accordance with their standard procedures for sample collection, as described in the National Field Manual for the Collection of Water-Quality Data: U.S. Geological Survey Techniques of Water-Resources Investigations (TWRI), book 9, chaps. A1-A6 (USGS, variously dated). The TWRI manual describes the procedures for:

- Preparation for water sampling (Chapter A1)
- Selection of equipment for water sampling (Chapter A2)

- Cleaning of equipment for water sampling (Chapter A3)
- Collection of water samples (Chapter A4)
- Processing of water samples (Chapter A5)
- Field measurements (Chapter A6)

Appendix E includes TWRI chapters A1-A6. Additional details are provided in the Quality Assurance Project Plan (Appendix B). The recommended container sizes, container types, sample preservation, and holding times for each analysis are summarized on Table 5.1. Surface water samples will be collected using a depth-integrating sampler, as described in TWRI. Surface water samples collected for analysis of dissolved metals and dissolved nutrients will be field-filtered through a 0.45-µm filter prior to sample preservation.

During high-flow sampling events (such as rain-on-snow or peak spring runoff) when the suspended concentrations are elevated, water samples will be collected for analysis of total metals in the suspended sediment. Bulk (1-liter) water samples will be collected and processed through a 0.45-µm filter. The total metals analysis will be performed on the filter residue and requires one gram of sediment. If suspended sediment concentrations in surface water during high flows are found to be insufficient for the collection of one gram of sediment from 10 liters of water, then total metals analysis of suspended sediment will not be performed.

5.1.2 Surface Water Sample Analysis

Surface water samples will be analyzed at the USGS National Water Quality Laboratory (NWQL) in Denver, Colorado in accordance with USGS analytical SOPs and/or EPA methods. Analytical methods for sample analyses are presented on Table 5-2. Surface water samples will be analyzed for:

- Dissolved metals (cadmium, lead, and zinc)
- Total metals (cadmium, lead, and zinc)
- Hardness
- Nutrients (total nitrogen, dissolved ammonia, dissolved nitrate/nitrite, total phosphorus, dissolved phosphorus)

Metals and hardness analyses will be performed by inductively-coupled plasma atomic emission spectrometry (ICP-AES) and inductively-coupled plasma mass spectrometry (ICP-MS) referencing USGS analytical SOPs. Nutrient analyses will be performed by conventional analyses, referencing USGS analytical SOPs and EPA methods presented on Table 5-2. Suspended sediment samples collected during high flows as part of the surface water monitoring program will be prepared and analyzed for total metals as described in Section 5.2.2. Suspended sediment samples will be prepared using a four-acid digestion capable of effecting nearly total digestion of most minerals. As the four-acid digestion is not appropriate for mercury analysis, a split of the suspended sediment sample will be prepared for mercury analysis referencing EPA Method 7471B.

Target reporting limits and quality control criteria (precision, accuracy, and completeness) are summarized for each analysis on Table 5-2.

5.2 SOIL AND SEDIMENT

USGS personnel will perform soil and sediment sampling, and samples will be analyzed at the NWQL in Denver, Colorado. The methods for sample collection and analysis are summarized on Tables 5-1 and 5-2.

5.2.1 Soil and Sediment Sample Collection

Soil and sediment samples will be collected at the locations and frequencies described in Section 4-2. The schedule for soil/sediment sample collection is summarized on Table 4-5. Samples will be collected in accordance with the USGS standard procedures for sample collection, as described in TWRI, book 9, chapter A8. TWRI chapter A8 describes the field procedures for collection of bottom-material samples.

Annual and 10-year sampling of depositional areas will be performed as described in USGS' TWRI chapter A8. However, the samples will be collected in the subaerial portion of the high water channel or floodplain rather than in the submerged channel. A plastic or Teflon scoop or spatula will be used to sample the upper 2 cm of sediment. Because of the variations in boulder/cobbles and the distribution of the finer sampled material (<250 μm) along the channel, sample collection details such as the number of subsamples to be composited per sampling location, the size of the sampling area, and the method of selecting subsample points (evenly spaced grid, random selection of grid points, quasi-random opportunistic sampling, etc.) are expected to vary by site. A sampling approach suitable for each specific sampling location will be documented during the first sampling event so that subsequent events are completed the same way.

5.2.2 Soil and Sediment Sample Analysis

Soil/sediment samples will be analyzed at the NWQL in Denver, Colorado. Soil/sediment samples will be analyzed for the COECs arsenic, cadmium, copper, lead, mercury, silver and zinc. Samples will be prepared using a four-acid digestion method capable of nearly digesting most minerals. The four-acid total digestion was selected to minimize variability associated with sample preparation method. Sample digestion methods such "total-extractable" microwave digestions introduce variability to analytical results by partially digesting the solid samples. A total digestion of soil/sediment samples will therefore promote comparable sample preparation results by reducing variability of the extent of extraction. Soil/sediment metals concentrations by the four-acid digestion method may or may not be higher than by the USEPA strong acid digestion procedures typically used for comparison of analytical results to risk-based screening or cleanup levels. As the four-acid digestion method is not appropriate for mercury analysis, a split of each sample will be prepared for mercury analysis referencing EPA Method 7471B.

Digested samples will be analyzed for total arsenic, cadmium, copper, lead, silver, and zinc by ICP-AES referencing USGS method OFR 02-223-G. Mercury analysis will be performed by cold vapor atomic absorption, referencing EPA Method 7471B. Analytical methods, target reporting limits, and quality control criteria (precision, accuracy, and completeness) are presented on Table 5-2.

5.3 BIOLOGICAL RESOURCES

USFWS personnel will perform biological resources monitoring. Biological resources monitoring program includes both analytical (e.g., blood lead levels) and observational data (e.g., waterfowl population). Sample and data collection methods for biological resource monitoring are shown on Table 5-1 and analytical methods, when applicable, are shown on Table 5-2.

Biological resources monitoring data will be collected in accordance with SOPs developed specifically for the Basin by the Upper Columbia Fish and Wildlife Office. Data collection will be performed and reviewed by USFWS personnel. Fish, macroinvertebrate, and blood samples collected for metals analysis will be prepared and analyzed by the EPA Region 10 laboratory at Manchester, Washington. Songbird blood analysis for δ-aminolevulinic acid dehydrates will be performed by the USGS laboratory at Patuxent, Maryland.

Table 5-1
Sample and Field Data Collection Methods

Monitoring Component	Responsible Agency	Data / Sample Collection Method [c]	Analysis	Container Size	Container Type	Preservation	Holding Time	Analytical Laboratory
Surface Water	USGS	USGS - TWRI, Book 9, 1998 [d] Chapters A1-A6	Ammonia, diss. [a]	125 mL	Polyethylene bottle	Cool to 4 C	28 days	USGS
			Total nitrogen	125 mL	Polyethylene bottle	H2SO4 to pH<2, cool to 4 C	28 days	
			Nitrate + nitrite, diss. [a]	125 mL	Polyethylene bottle	Cool to 4 C	28 days	
			Total phosphorus	125 mL	Polyethylene bottle	H2SO4 to pH<2, cool to 4 C	28 days	
			Phosphorus, diss. [a]	125 mL	Polyethylene bottle	H2SO4 to pH<2, cool to 4 C	28 days	
			Total metals	250 mL	Polyethylene bottle, acid rinsed	Nitric acid to pH<2	6 months	
			Dissolved metals [a]	250 mL	Polyethylene bottle, acid rinsed	Nitric acid to pH<2	6 months	
			Total metals in suspended sediment [b]	1 g	Polypropylene bottle	None	6 months (28 days for Hg)	
Surface Sediment	USGS	USGS - TWRI, Book 9, 1998 [d] Chapter A8	Total metals	40 g	Polypropylene bottle	None	6 months (28 days for Hg)	USGS
Sediment Coring	USGS	USGS - TWRI, Book 9, 1998 [d] Chapter A8	Total metals	40 g	Polypropylene bottle	None	6 months (28 days for Hg)	USGS
Fish diversity/ abundance	USFWS	UCFWO 1020.1001 (Procedures for sampling fish to determine diversity and abundance)	NA	NA	NA	NA	NA	NA
Fish Tissue Metal Levels (Upper Basin and Spokane River) Whole-body trout only.	USFWS	UCFWO 1020.1002 (Collection of individual fish samples for analysis of whole body metal residues)	Total metals	Field: Plastic bags; Lab: 4 ounce glass jars with Teflon-lined lids. Sufficient headspace must be left in jars such that expansion during freezing does not		Freeze	1 year	EPA Manchester
Bull Trout Habitat/ Temp. and Other Aquatic Resources Assessment	USFWS	UCFWO 1020.1003 (Bull trout habitat and water temperature)	NA	NA	NA	NA	NA	NA
Bull Trout Population Survey and Assessment of Other Aquatic Resources	USFWS	UCFWO 1020.1004 (Bull trout and native species survey in temperature refuge areas)	NA	NA	NA	NA	NA	NA
Macroinvertebrate diversity/abundance	USFWS	UCFWO 1020.1005 (Procedures for determining macroinvertebrate diversity and abundance)	NA	NA	NA	NA	NA	NA
Macroinvertebrate tissue metal levels	USFWS	UCFWO 1020.1006 (Procedures for the collection of benthic macroinvertebrate samples for the analysis of metal residues)	Total metals, percent solids	Field: Plastic bags or 4 ounce polypropylene jars; Lab: 4 ounce glass jars with Teflon-lined lids. Sufficient headspace must be left in jars such that		Freeze	1 year	EPA Manchester
Aquatic habitat quality	USFWS	UCFWO 1020.1007 (Procedures for assessing aquatic habitat quality)	NA	NA	NA	NA	NA	NA
Waterfowl population	USFWS	UCFWO 1020.1013 (Waterfowl Survey in the Coeur d'Alene River Basin)	NA	NA	NA	NA	NA	NA
Waterfowl mortality	USFWS	UCFWO 1020.1008 (Procedures for waterfowl mortality searches)	NA	NA	NA	NA	NA	NA
Waterfowl blood collection	USFWS	UCFWO 1019.3742 (Techniques for capturing mallards and redhead ducks); UCFWO 1020.1009 (Procedures for the collection of waterfowl blood samples for the analysis of blood-lead only)	Lead	5 ml	Cryogenic tube	Frozen	1-year	EPA Manchester
Riparian vegetation / invertebrates	USFWS	UCFWO 1020.1010 (Procedures for evaluating plant communities in riparian areas of the Coeur d'Alene River Basin); UCFWO 1020.1011 (Procedures for monitoring invertebrates in riparian areas of the Coeur d'Alene River Basin)	NA	NA	NA	NA	NA	NA
Songbird diversity/abundance	USFWS	UCFWO 1020.1012 (Procedures for conducting MAPS songbird studies)	NA	NA	NA	NA	NA	NA
Songbird blood collection	USFWS	UCFWO 1019.3757 (Use of mist nets for capturing passerines); UCFWO 1019.3765 (Collection and preservation of blood from small birds for laboratory analysis)	Lead	1-2 ml	Cryogenic tube	Frozen	1-year	EPA Manchester
			ALAD enzyme assay	1-2 ml	Cryogenic tube	Snap frozen in liquid nitrogen	1-year	USGS-Patuxent
			Hematocrit		Hematocrit tubes, sealed with hematocrit tube sealant	Heparin-treated fresh blood	8-hours	UCFWO field crew

(a) Samples will be field filtered through a 0.45 um filter.
(b) Suspended sediment analyses will be performed on residue from 0.45 um filtration of surface water collected during high-flow sampling events
(c) SOPs will be reviewed prior to sample/data collection. Modifications to SOPs will be reviewed and approved by USFWS or USGS and EPA prior to use.
(d) USGS, 1998, National Field Manual for Collection of Water-Quality Data, Techniques of Water-Resources Investigations, Book 9, numerous chapters.
Field measurements for pH, temperature, and specific conductivity will be collected at surface water sampling locations at the time of sampling.

Table 5-2
Analytical Methods and Data Quality Objectives (DQOs)

Analysis	Matrix	Laboratory	Prep Method	Analytical Method	Target Reporting Limit	Sample Container Size	Sample Container Type	Sample Preservation	Holding Time	Precision	Accuracy	Completeness
Conventionals												
Total nitrogen	Water	USGS	NA	USGS I-4650-03	0.03 mg/L	125 mL	Polyethylene bottle	H2SO4 to pH<2, cool to 4 C	28 days	+/- 25%	+/- 25%	95%
Nitrate + nitrite, diss. [a]			NA	USGS I-2546-91	0.016 mg/L	125 mL	Polyethylene bottle	Cool to 4 C	28 days			
Ammonia, diss. [a]			NA	USGS I-4515-91	0.01 mg/L	125 mL	Polyethylene bottle	Cool to 4 C	28 days			
Phosphorus, total			NA	EPA 365.1 USGS I-2525-89	0.004 mg/L	125 mL	Polyethylene bottle	H2SO4 to pH<2, cool to 4 C	28 days			
Phosphorus, diss. [a]			NA	EPA 365.1	0.004 mg/L	125 mL	Polyethylene bottle	H2SO4 to pH<2, cool to 4 C	28 days			
Total metals												
Cadmium	Water	USGS	USGS I-3486-95 USGS I-4471-97	USGS I-4471-97	0.00004 mg/L	250 mL	Polyethylene bottle, acid rinsed	Nitric acid to pH<2	6 months	+/- 25%	+/- 25%	95%
Lead					0.00006 mg/L							
Zinc					0.002 mg/L							
Dissolved metals [a]												
Cadmium	Water	USGS	USGS I-3486-95 USGS I-4471-97	USGS I-2477-92	0.00004 mg/L	250 mL	Polyethylene bottle, acid rinsed	Nitric acid to pH<2	6 months	+/- 25%	+/- 25%	95%
Lead					0.00008 mg/L							
Zinc					0.00006 mg/L							
Calcium				USGS I-1472-87	0.01 mg/L							
Magnesium					0.008 mg/L							
Total metals (suspended sediment) [b]												
Cadmium	Soil / Sediment	USGS	NAWQA Size Fractionation Sieving Protocol; USGS OFR 02-223-G	USGS OFR 02-223-G	2 mg/kg	1 L	Polypropylene bottle	Cool to 4 C	6 months	+/- 35%	+/- 25%	95%
Copper					2 mg/kg							
Silver					2 mg/kg							
Zinc					2 mg/kg							
Arsenic					10 mg/kg							
Lead					4 mg/kg							
Mercury			USEPA 7471B	USEPA 7471B	0.1 mg/kg				28 days			
Total metals (soil / sediment)												
Cadmium	Soil / Sediment	USGS	NAWQA Size Fractionation Sieving Protocol; USGS OFR 02-223-G	USGS OFR 02-223-G	2 mg/kg	40 g	Polypropylene bottle	Cool to 4 C	6 months	+/- 35%	+/- 25%	95%
Copper					2 mg/kg							
Silver					2 mg/kg							
Zinc					2 mg/kg							
Arsenic					10 mg/kg							
Lead					4 mg/kg							
Mercury			USEPA 7471B	USEPA 7471B	0.1 mg/kg				28 days			
Fish Tissue Metal Levels												
Arsenic	Tissue	EPA Manchester	Manchester SOP INOR-006	EPA 206.2	0.25 mg/kg	Field: Plastic bags; Lab: 4 ounce glass jars with Teflon-lined lids. Sufficient headspace must be left in jars such that expansion during freezing does not cause the jar to break.		Freeze	1 year	+/- 20%	+/- 25%	95%
Cadmium				EPA 200.7/200.8	0.05 mg/kg							
Lead					0.05 mg/kg							
Zinc					1.0 mg/kg							
Macroinvertebrate Tissue Metal Levels												
Arsenic	Tissue	EPA Manchester	Manchester SOP INOR-006	EPA 206.2	0.25 mg/kg	Field: Plastic bags or 4-ounce polypropylene jars; Lab: 4 ounce glass jars with Teflon-lined lids. Sufficient headspace must be left in jars such that expansion during freezing does not cause the jar to break.		Freeze	1 year	+/- 20%	+/- 25%	95%
Cadmium				EPA 200.8/200.9	0.05 mg/kg							
Lead					0.05 mg/kg							
Zinc					1.0 mg/kg							
Waterfowl / Songbird Blood Lead (ALAD and Hematocrit on songbird only)												
Lead (songbird)	Blood	EPA Manchester	Manchester SOP INOR-006	EPA 200.9	0.1 mg/kg	1-2 mL	Cryogenic tube	Frozen	1 year	+/- 20%	+/- 25%	95%
Lead (waterfowl)		EPA Manchester	Manchester SOP INOR-006	EPA 200.9	0.05 mg/kg	5 mL						
ALAD enzyme assay (songbird only)		USGS-Patuxent	Inclusive of UCFWO 1019.3801	UCFWO 1019.3801 (ALAD determination)	Per method	1-2 mL	Cryogenic tube	Snap frozen in liquid nitrogen	1 year	Per method		95%
Hematocrit (songbird only)		UCFWO field personnel	NA	Hematocrit procedures in UCFWO 1019.3765 (Collection and Preservation of Blood form Small Birds for Laboratory Analysis)	5 %		Hematocrit tubes sealed with hematocrit tube sealant	Fresh blood pre-treated with sodium heparin	8 hours	NA	NA	95%

[a] Samples will be field filtered through a 0.45 um for dissolved analyses.
[b] Suspended sediment analyses will be performed on residue from 0.45 um filtration of surface water collected during high-flow sampling events.

6.0 ANALYSIS AND ASSESSMENT OF SAMPLING DATA

Sampling data will be analyzed with analysis results interpreted and evaluated consistent with the purpose, goals, and objectives of the BEMP to assess Basin environmental conditions and trends and document progress toward and attainment of the ecological benchmarks identified in the ROD. As discussed in preceding sections, sampling data represent measurements at selected monitoring locations and times of monitoring parameters that include chemical concentrations in surface waters, sediments, and biota; chemical loading and AWQC ratios in surface water; and other ecologically relevant parameters. In particular, Section 4 identified by media the monitoring parameters and sampling schedules.

This section provides a general discussion of the analysis and assessment of the sampling data. Section 6.1 covers data analysis, with an emphasis on statistical hypothesis testing consistent with the discussion of Section 3. Section 6.2 discusses the follow on assessment (interpretation and evaluation) of the data analysis results. Assessment will be framed within the purpose, goals, and objectives of the BEMP using an adaptive management strategy that supports the 5-year remedy reviews required by CERCLA.

The BEMP assumes that extensive analysis of accumulated monitoring data will be conducted at 5-year intervals timed to precede the 5-year remedy reviews required by CERCLA. These 5-year data analyses will follow the approach discussed in Section 6.1 and also include the assessment of results discussed in Section 6.2. Analyses and assessments will be documented in BEMP Technical Memoranda, which will be used to support the 5-year remedy reviews.

Limited-scope data summary reports will be issued yearly. The yearly data summary reports will include tabular and graphical summaries of the monitoring data, with analysis limited to computation of standard sample statistics. The yearly reports will identify any potentially significant "anomalies" that may require early attention.

Also, it is anticipated that as they become available, monitoring data will accessible on the web for inspection by the interested public. Data management is discussed in Section 7.

6.1 DATA ANALYSIS

This section provides a conceptual basis for a general understanding of how sampling data resulting from the sampling identified in Section 4 will be analyzed to statistically test the hypotheses discussed in Section 3. Supplementary and complementary analyses for probabilistic characterization of monitoring parameters – including confidence levels and intervals, probability distributions, and statistical power analyses – are also discussed here. While the discussions generally apply to all the media and monitoring parameters identified in

Section 4, application to specific media may evolve as needed for each medium over the implementation period of the BEMP. The discussions are thus intended as adaptable guidelines.

The sample data represent time-specific measurements of monitoring parameters at Basin sampling locations for surface water, sediments, and biota. Because monitoring parameters reflect naturally variable temporal and spatial averages, the sampling data are analyzed as time-varying aggregate averages applicable to their specific monitoring locations.

The focus is on statistically analyzing the sampling data in a framework that considers the hypothesis testing discussed in Section 3 under conditions of uncertainty. The sampling data are analyzed as aggregated averages and associated time-history trends. The conceptual overview of this section is extended in the forthcoming BEMP Technical Memorandum to include a more detailed technical discussion and quantitative development, as described in Appendix D.

The statistical analyses deal with the uncertainty inherent in the sampling data in a scientifically defensible manner. Yet scientifically defensible means neither perfect nor uniquely objective. The statistical analyses, like all analyses, require professional judgment, and results must be fairly interpreted in proper context(s) using professional knowledge and insight. It is also expected that the analyses will be supplemented and complemented with applicable information available from other sources, including the results from remedy effectiveness monitoring. Interpretation and evaluation of the statistical analysis results are discussed in Section 6.2.

6.1.1 Natural Variability, Uncertainty and Statistical Analyses

The sampling data will be limited in number and accuracy and subject to inherent natural variability and statistical fluctuations—common effects in all complex natural systems like the Basin. Coupled with the uncertainty of natural variability is the statistical uncertainty of limited sampling measurements having imperfect accuracy (i.e., random measurement "error"). The net effect is that exact true values of monitoring parameters cannot be known with certainty, but must be estimated from statistical analysis of the available sampling data.

Because true values are uncertain, measuring progress toward benchmarks and improvements in environmental conditions requires statistical analyses of the sampling data. Statistical analysis quantitatively characterizes the uncertainty in the true values reflected in the sampling data. Statistical estimates thus represent *potential* true values inherent in the sampling data. The statistical analyses characterize the sampling data in terms of probabilities and associated terminology of hypothesis testing, as discussed next.

6.1.2 Measuring Remedy Progress and Attainment of Benchmarks

Measurable progress toward ecological improvements and benchmarks means that there are acceptable *probabilities* or "confidence levels" that the true values of measured monitoring parameters have generally improved over time. Systematic changes over time are represented by a time-history trend (trend) at a given monitoring location. It may be concluded that there is a true trend if the sampling data for the given monitoring location indicate a trend at an acceptable confidence level.

Concluding that a quantified benchmark associated with a given monitoring parameter (e.g., AWQC ratio) has been met uses the same approach as used for trends: there must be an acceptable confidence level or probability that the inherently uncertain true value (e.g., AWQC ratio) has actually met the benchmark. It may be concluded that the benchmark has been met if the sampling data meet the benchmark at an acceptable confidence level.

The BEMP is designed to support quantification of both the trends over time of the monitoring parameters and the probability (confidence) that the parameters meet applicable benchmarks. Data from the monitoring program will be analyzed using common statistical techniques to estimate the true values and trend over time.

Measuring remedy progress and attainment of benchmarks is based in large part on statistical hypothesis testing discussed in Section 3. The burden of proof used to test the hypotheses is quantified by the an acceptable confidence level, approximated as "1–alpha" where alpha is the "significance level." Numerical examples of confidence levels include 0.95, 0.90, or 0.51 with corresponding alphas of 0.05, 0.10, and 0.49. Effective hypothesis testing also includes estimating "statistical power," which measures the ability of the sampling data to detect specified magnitudes of change in the monitoring parameters. For a given parameter, location, and sample design, statistical power increases with sample size, the number of independent measurements in the sample, and symbolized as "N." Hypothesis testing, including confidence levels and statistical power, will be discussed further in the following sections.

The hypothesis testing will be supplemented and complemented by estimating statistical confidence intervals and limits on the true parameter averages and true slopes of the trend lines, based on the sampling data. This approach is consistent with standard scientific and statistical principles.

6.1.3 Hypotheses Testing and Decision Criteria

Statistical testing will compare each monitoring hypothesis (the alternative hypothesis) against its corresponding null hypothesis. The null hypothesis is a presumption that is accepted (but not "proven") unless statistically "falsified," and hence rejected in favor of adopting the alternative hypothesis. This approach places the burden of proof on rejecting the null hypothesis or, equivalently, on accepting the alternative hypothesis.

As in any complex natural system like the Basin, natural variability and statistical fluctuations in monitoring parameters (and sampling limitations, including random measurement error) means that statistical hypothesis testing suffers from potential error. Error rates or probabilities associated with hypothesis testing are characterized as Type I and Type II errors, measured by alpha and "beta."

- Rejecting a true null hypothesis is a Type I error, measured by alpha, the significance level of the statistical test. Recall that the complement of alpha (1 – alpha) is the confidence level of the test. Assume, as a simple example, that there is *in fact* no zinc reduction (zero change) at a particular monitoring location and that statistical testing used an alpha of 0.05. In this case, falsely rejecting a null hypothesis that there is no zinc reduction would be expected to occur on average in 5 out of 100 measurements, or in 5 percent of repeated measurements (alpha = 0.05). Correctly accepting the null hypothesis would be expected in 95 percent of repeated measurements, on average (1 – alpha = 0.95).
- Accepting a false null hypothesis is a Type II error, measured by beta, the probability of accepting a false negative hypothesis. The complement of beta (1 – beta) is the statistical power of the test: the ability to detect a specified magnitude of change in the monitoring parameters. Assume, as a simple example, that there is *in fact* a zinc reduction (of a certain magnitude) at a particular monitoring location and that statistical testing used a beta of 0.20 (for that magnitude). In this example, falsely accepting a null hypothesis that there is no zinc reduction would be expected to occur on average in 20 out of 100 measurements, or in 20 percent of repeated measurements (beta = 0.20). Correctly rejecting the null hypothesis would be expected in 80 percent of repeated measurements, on average (1 – beta = 0.80).

Equivalently, erroneously accepting a false alternative hypothesis is a Type I error and erroneously rejecting a true alternative hypothesis is a Type II error. Type I and Type II errors (i.e., alpha and beta) are related by a statistical power analysis (see Appendix D). These potential statistical testing errors are consistent with the scientific fact that hypotheses cannot be "proven" true or false, except in the inductive statistical sense—by the weight of evidence inherent in the representative data.

6.1.3.1 *Null Hypotheses*

It is important to be clear that null hypotheses are presumptions. In more precise statistical terms, accepting a null hypothesis means "failing to reject" that null hypothesis. Accepting a null hypothesis is thus not a test of truth. A false null hypothesis may go undetected because of limited data having inadequate statistical power to reject, at an acceptable confidence level, false null hypothesis. This type II error (beta) illustrates why, ideally, there should be adequate statistical power to "test" the validity of the null hypothesis.

To reiterate, accepting a null hypothesis does not statistically "prove" or validate that null hypothesis. Accepting a null hypothesis absent compelling contrary information is a policy decision. A false null hypothesis may thus be accepted by presumptive default. This argues for why null hypotheses should represent a protective policy position, a conservative position (often the status quo) that if false results, on balance, in less aggregate expected cost (loss and risk) than if it were true but assumed false.

The null hypothesis acts as the hurdle or burden of proof that must be met by the available monitoring data to accept the alternative hypothesis. If the available data fails the burden-of-proof test, thus failing to reject the null hypothesis, the null hypothesis -- whether true or false -- is accepted. If the available data clears the burden-of-proof test, the null hypothesis is considered false and the alternative hypothesis is accepted as true.

The status quo for active Superfund sites represents conditions that are not protective and thus require cleanup to effect a change to being protective. Null hypotheses for Superfund sites are, therefore, typically formulated as "not-protective" or, equivalently, "no-change" from the status quo. The not-protective or no-change presumption stands until "proven" false by the data. Setting the null hypotheses as "not-protective" or "no-change" is a conservative position from the point of view of environmental protection.

This Superfund approach is used in the BEMP, where the null hypotheses represent "no-change" and the alternative hypotheses represent positive "change" in terms of improving conditions toward cleanup. As detailed in Section 3, the monitoring hypotheses are alternative hypotheses (positive change), evaluated against the null hypothesis of no change. Hypothesis testing for potentially degrading conditions (negative change) is discussed further in Section 6.1.4.

6.1.3.2 *Choosing Decision Criteria*

Clearly, the hypothesis testing requires specifying appropriate decision criteria for acceptable Type I and Type II error probabilities, as represented by alpha and beta. *Selecting values for alpha and beta are subjective risk management decisions*, as there are no uniquely correct values. Ideally, alpha and beta appropriately reflect the risk and cost associated with potential decision errors. The following discussion provides additional background for selecting alphas and betas.

- A maximum acceptable Type I error probability, or alpha, represents the acceptable burden of proof to reject the null hypothesis, and thus accept the alternative hypothesis. The burden of proof increases with decreasing alpha. Quantity 1–alpha, the confidence level associated with rejecting the null hypothesis, increases as alpha decreases. The confidence level increases with the burden of proof.
- Admissible Type I errors cannot exceed 0.50, which means that admissible alpha cannot exceed 0.50. Alpha equal to 0.50 is a limiting condition corresponding to no null hypothesis. Practically, the maximum admissible alpha is 0.49 (theoretically 0.4999…). Alpha greater than 0.50 is equivalent to exchanging the null and alternative hypotheses, effectively bringing alpha back to less than 0.50.

Alpha should be situation-dependent, and rationally consistent with the expected cost of falsely rejecting a true null hypothesis. Following historic convention, alpha has commonly been set at 0.05 in scientific studies and EPA's CERCLA regulatory-guidance documents. Notably, however, alpha values between 0.20 and 0.05 are recommended in EPA's recent *Guidance for Comparing Background and Chemical Concentration in Soil for CERCLA Sites* (EPA 540-R-01-003, September 2002). It remains useful to recognize that alpha may, in noncritical cases, be as high as 0.49, which represents a burden of proof corresponding to "more probable than not." While low alpha values are appropriate for helping assure adequate protectiveness and conservative decision-making, the BEMP reserves the flexibility to use higher alpha values, if appropriate, for what are essentially non-decision situations. Again, there is no single correct value of alpha applicable in all situations. After a short discussion of beta, the concluding paragraphs of this section introduce a tiered-approach to choosing alpha and beta in the context of adaptive management.

An acceptable beta depends on the required or desired statistical power, 1–beta, to detect a true alternative hypothesis, and thus reject the (false) null hypothesis. Whereas alpha may be a single-valued decision criterion, beta and statistical power are more complex. Statistical power increases with increasing alpha. Power also depends on the variability of the data, the sampling design and sample size, and the minimum "effect size" – the magnitude of the effect – to be detected. The effect size is the magnitude of the difference between the null hypothesis and the true value. Statistical power is estimated by analysis, as detailed in Appendix D.

As with alpha, there is no single correct value of beta or power. As with alpha, beta should be situation-dependent and consistent with the expected cost of failing to accept a true alternative hypothesis.

While uniquely correct values do not exist, alpha and beta, as risk management decision criteria, should be realistic and balanced to minimize expected costs (risks). A general aim is to maximize cost-effectiveness while maintaining acceptable protectiveness. Appropriate values are therefore likely to vary over time and between monitoring parameters and media. Particularly in the context of adaptive management, a "tiered approach" related to the severity of real or potential decision consequences (expected costs) may be useful for choosing alpha and beta values:

- A low-consequence tier with alpha potentially as high as 0.49 could be used for testing trends of monitoring parameters that do no relate to a specific quantitative benchmark or result in significant costs of actions or inaction. Similarly, low power could be acceptable where uncovering a false null hypothesis has minor consequences—e.g., where maintaining the status quo, consistent with maintaining the null hypothesis, is not costly.
- Conversely, a high-consequence tier with alpha of 0.05 would be used where the costs of falsely rejecting a null hypothesis are considered high—e.g., declaring that a

quantitative benchmark has been achieved where it has not. High power could be needed to uncover a false null hypothesis that maintains a costly status quo or blocks acceptance of improved understanding or management practices.

Although specifics have not been developed at this time, the BEMP assumes that a tiered approach to choosing alpha and beta will be used in the adaptive management framework outlined in Section 6.2. Thus, for a given monitoring parameter (e.g., zinc concentrations) there may be multiple tiers of alpha and beta for different effect magnitudes of interest, which may evolve over the course of implementing the remedy, including the BEMP. Clearly, the real constraints of available funding must be considered, particularly where large number of samples would be needed to for small values of alpha and beta.

A tiered approach is consistent both with principles of adaptive management and EPA's "ideal approach to hypothesis testing," as stated in their data quality assessment guidance (EPA 2000, p5-12,13). EPA 2000 *Guidance for Data Quality Assessment*, QA/G-9, Final July 2000. Characteristics of EPA's ideal approach include the following. It sets up the null hypothesis to protect the environment. It controls the false rejection error (alpha). It encourages quality in term of high precision and accuracy, and thus statistical power. Yet the ideal also seeks to minimize expenditures in situations where decisions are relatively easy—e.g., all measurement observations are far from decision thresholds or levels of serious interest.

6.1.4 Hypothesis Testing for Potentially Degrading Conditions

Recall from Section 3 that the monitoring hypotheses, which represent alternative hypotheses, have been generally formulated as improvements in monitoring parameters. The resulting hypothesis tests are thus "improvement vs. no-improvement," consistent with the remedy intent to improve ecological conditions.

Detecting potentially degrading conditions is also important. Although the null hypotheses explicitly represent no-change (as no-improvement), they *implicitly* include degradation in the monitoring parameters being analyzed. However, to explicitly account for potentially degrading conditions, complementary hypotheses of the form "degradation vs. no-degradation" will also be tested. These complementary 1-tailed tests are considered superior to single 2-tailed tests (using a significance level of ½ alpha) because the direction of the change (improvement or degradation) is explicit. In a classical 2-tailed test, direction is not explicit.

6.1.5 Limitations of Hypothesis Testing

By itself, classical hypothesis testing is an inadequate basis for interpreting actual conditions from sampling results of monitoring programs. In particular, significance or confidence levels may suggest a simple "yes-no" answer to the validity of monitoring hypotheses. Without explicit consideration of the probabilities associated with the range of potential values of the true (but uncertain) monitoring parameter, this "yes-no" interpretation can lead to apparent dilemmas.

For example, a monitoring hypothesis may be rejected at significance level alpha of 5% (95% confidence level) yet accepted at alpha of 10% (90% confidence level). This example illustrates that the choice of alpha, or confidence level, is not a fundamentally scientific issue. Rather, the choice of alpha is always a risk management decision, determined by policy or cost-consequence evaluation. Decisions will vary with circumstances and contexts, which will generally vary over time.

Therefore, as part of data analysis and interpretation, hypothesis testing will be supplemented with explicit estimates of the uncertainty in the monitoring parameters, as characterized by probability curves. This approach leads to a more general form of hypothesis testing related to confidence intervals and limits associated with the true values.

6.1.6 Confidence Intervals and Limits

Confidence intervals and limits will be estimated to provide a more complete characterization of the sampling data and their implications to actual conditions in the Basin. Confidence intervals and limits will be estimated both for the true average of each monitoring parameter for each sampling event and the associated trend over time. Estimates will be used to quantify the uncertainty in the true values and support a generalized approach to hypothesis testing. Uncertainty is quantified as cumulative probabilities.

6.1.7 Cumulative Probability Curve Application to Hypothesis Testing

Cumulative probability curves can be used to determine the maximum alpha level, or minimum confidence level, at which a given null hypothesis would be rejected. The maximum alpha level is the "critical alpha"; the minimum confidence level is the "critical confidence level." For given sampling data, the critical alpha is the maximum alpha that would result in rejecting the null hypothesis. The critical confidence level is the minimum confidence level, consistent with the critical alpha.

Whether formally established or hypothetical, the given null hypothesis being evaluated for a critical alpha can be any potential *value of interest* of the true value (average or trend) of the monitoring parameter. The values of interest may be any "target value," or benchmark, including ROD ecological benchmarks.

The monitoring hypotheses of Section 3 use a null hypothesis of no (zero) trend; in these cases, the target value is zero. More comprehensive analysis and interpretation of BEMP sampling data will assess ranges of possible target values, and thus use corresponding ranges of hypothetical null hypotheses.

This generalized approach to hypothesis testing allows entire ranges of target values (null hypotheses) and potential true values to be analyzed in a systematic, practical and rapid way. Results can be assessed against benchmarks in terms of sensitivity to target values and critical alpha values. This capability may be particularly useful to risk management decision making and adaptive management.

6.1.8 Post-Sampling Statistical Power Analyses

During development of the BEMP, pre-sampling statistical power analyses were used to analyze the effectiveness and efficiency of proposed and alternative sampling designs for hypothesis testing and characterizing uncertainty in true values. These analyses and associated supporting discussions are included in Appendix D. Analysis results were evaluated during development of the BEMP within the overall context determined by the ROD, basin conditions, the data quality objectives (DQO) process, and various practical tradeoffs and limitations, including constraints imposed by the projected availability of funds. The BEMP sampling designs identified in Section 4 reflect the result of this overall evaluation.

The pre-sampling power analyses formally considered currently available quantitative baseline data for surface water and sediments, as summarized in Section 2.3. However, because statistical analyses of baseline biological data were not available, formal power analyses were not specifically conducted for biological-sampling designs. Biological sampling designs were developed using professional judgment and suspected acceptable power, subject to practical constraints, and interpretation of power analysis results for surface water and sediments.

For all media (surface water, sediments, and biological), power analyses will be used in the post-sampling analysis of the actual, realized sampling data that will be obtained as the BEMP is implemented. Post-sampling analyses are similar to pre-sampling analyses except actual (post) sampling data is analyzed in the former. Post-sampling power analyses allow quantitative evaluation of the evidential support provided by the sampling data for both null hypotheses and monitoring (alternative) hypotheses.

Post-sampling power analyses also estimate probabilities of accepting or rejecting null hypotheses (target values) and alternative hypotheses conditional on assumed true values. While true values are always uncertain to the extent there is natural variability and sampling limitations, hypothetical true values may be *assumed* and statistically analyzed for implications. These analyses use the actual sampling design and realized data, which reflect the extent uncertainty affecting estimates. Post-sampling power analyses are thus "what if" analyses that complement the generalized approach to hypothesis testing discussed in the previous section.

The post-sampling power analyses, conducted after the sampling data are available, provide the most accurate estimates of the actual sampling design "performance." Since post-sampling analysis results are not available now, the adaptive management strategy allows appropriate modification of the BEMP (within practical constraints) should statistical power prove inadequate in the future.

6.1.9 Methods of Analysis

The BEMP will appropriately use or adapt common graphical and mathematical statistical methods appropriate for exploring, characterizing, or analyzing data from observational studies, consistent with the discussions in this document. These methods generally include time-history graphs, summary statistics, distribution analyses, various quantitative statistical tests, power analyses, and regression methods. Appendix D and the forthcoming BEMP Technical Memorandum provide a more detailed background discussion including pertinent mathematical details. The methods assumed in this section are partially predicated on results and experience gained from analyzing currently available Basin environmental (background) data in the context of conducting the RI/FS and developing the ROD, as well as supplementary exploratory analyses done in support of the BEMP.

The BEMP recognizes that results from statistical analyses of complex, real-world monitoring data represent probabilistic estimates of uncertain true field values and that explicit probability levels represent approximate statements of knowledge that are always conditional on available information and its interpretation. That theoretical statistical models are never perfectly consistent with real world data is also recognized. Furthermore, the BEMP data may be statistically "messy" because of the dynamic and complex nature of the Basin along with the practicalities and contingencies associated with multiple sampling and analysis programs conducted over many years.

In general, the selection and use of statistical methods should adequately consider the tradeoffs between method benefits and limitations. Potential limitations include effects of deviations between the observational data and model assumptions (e.g., data or parameter correlations, potentially mixed populations or outliers, distribution forms of parameters or populations, gaps in the sampling record, and so on). While there are no hard and fast rules, in certain cases, multiple analysis methods and interpretations may be appropriate. It is also likely that data analysis needs will evolve over time.

In practical terms, these considerations argue for the BEMP assuming a flexible viewpoint that maintains appropriate scientific rigor and rationality while avoiding unnecessary restrictions or complications imposed by rigid interpretations of academic fine-points or unobtainable expectations of objectivity or precision. In support of this practical viewpoint, generalized Bayesian concepts (including weight-of-evidence arguments using formal or informal information "updating") may be used. It bears emphasis that appropriate analysis, interpretation and evaluation requires sound professional judgment exercised in the context of the purpose, goals, and objectives of the BEMP, with adequate understanding of relevant Basin processes. Formalized methods and criteria cannot eliminate the fundamental need for professional judgment exercised in real time.

Clearly, because the BEMP is expected to evolve over its 30-year implementation period, this current version of the BEMP does not limit future beneficial use of other applicable methods that may become appropriate during implementation. The concepts and methods discussed here may be appropriately updated and modified as evolving conditions may dictate. This evolutionary approach is consistent with the adaptive management strategy inherent in the BEMP, as discussed in the next section.

6.2 ASSESSMENT AND ADAPTIVE MANAGEMENT

Following the analysis of sampling data generally discussed in Section 6.1, the analysis results will be interpreted and evaluated consistent with the relevant context discussed in Sections 1 through 3 and the purpose of the BEMP to periodically monitor, quantify, and document overall remedy performance. As discussed in Section 3, remedy performance is defined in terms of meeting or progressing toward the ecological benchmarks identified in the ROD. Those benchmarks represent the ecological "performance expectations," the goals and objectives, of the remedy that will be measured and assessed by the BEMP.

The integrative assessment of data analysis, interpretation, and evaluation provides the information needed for periodic evaluation of evolving remedy performance against the ROD benchmarks, the expectations of remedy performance. Potentially, these evaluations may help identify and guide "course corrections" to remedy implementation that improve remedy performance, including cost-effectiveness. Specific efforts include detecting trends or major trend discontinuities, which may signal a need to update critical assumptions or change management practices, potentially including the BEMP or the remedy itself.

The integrated assessment used in the BEMP will be conducted within an adaptive management framework, as called for in the ROD. In general terms, adaptive management is a systematic strategy for continually learning from the ongoing monitoring results to cost-effectively improve future remediation and monitoring. It provides a purposeful feedback loop to assess evolving conditions and identify useful changes to the remedy, including long-term monitoring, as identified in the BEMP. Adaptive management is a key strategic component inherent in the BEMP.

6.2.1 Adaptive Management Framework

Assessment of the evolving Basin ecological conditions against the expectations of remedy performance, as discussed in preceding sections, provides a basis for responsive adaptive management. The adaptive management framework will be integrated with the CERCLA five-year review process to provide the regulatory basis for implementing practical adaptive management changes that may be appropriate to improve the remedy, including the BEMP, as it is being implemented. Because there are numerous site-specific remedies planned under the ROD over the next 30 years, the adaptive management framework will consider information gathered from the BEMP and the effectiveness monitoring programs, as well as relevant information available from the LEMP (Lake Environmental Monitoring Program) or any other pertinent monitoring. The following 3-step assessment strategy will be implemented as an adaptive management framework:

1. Analyze BEMP sampling data consistent with Sections 3 through 6 and supporting appendices. Consider, as appropriate, other applicable and available data, including effectiveness monitoring and LEMP results.

2. Interpret and evaluate results, update understanding of Basin ecological conditions, and compare results against ROD benchmarks and the status of remedy implementation.

3. Decide what improvements, if any, are appropriate to modify the BEMP, effectiveness monitoring, or remedy design and implementation.

Within the integrated 3-step strategy, the following related questions will be answered. First and foremost, "is the remedy functioning as intended by the ROD?" Focused answers will provide interpretation and evaluation of the results of the statistical analyses of the cumulative monitoring data in terms of the monitoring hypotheses identified in Section 3. The intent is to document the magnitude and geographic extent of remedy performance in terms of the ROD benchmarks. To reiterate from Section 3, ecological benchmarks include:

- Decreases in dissolved zinc and cadmium concentrations in surface water.

Decreases in particulate lead concentrations in the flood plain soils/sediment, levees, and riverbed sediments.

- Decreases in particulate lead loads and concentrations in surface water.
- Decreases in zinc AWQC ratios
- Improvements in biotic benchmarks
- Improvements in metals retention in CDA Lake
- Identification of any "unwanted" impacts from remedy implementation
- Clear indications of progress toward achieving benchmarks

As discussed in Section 6.1, statistical analyses will include quantification of trends over time of monitoring parameters and the probability (confidence) that the parameters meet applicable benchmarks. Quantitative results will be complemented and supplemented by narrative that considers the broader context of Basin conditions and the state (relevant history) of remedy implementation at the time of the assessment.

A second question that will be answered is "does interpretation and evaluation of available data from the BEMP and other monitoring programs (LEMP, site-specific remedial actions, other pertinent programs or data sources) suggest new or refined understanding of Basin processes that are relevant to the remedy?" Focused answers to this broad question will be provided in narrative form that is integrated with answers to the question of remedy function, as discussed in the preceding paragraph.

Answers to a third set of questions will focus on identification of any warranted revisions or modifications to the BEMP or site-specific remedial action monitoring. The intent is to improve the technical performance or cost-effectiveness of the monitoring, including changes that may be needed to meet budget or other practical considerations. Related questions aimed at the BEMP, which will be answered in narrative form, include:

- Which monitoring efforts (if any) can be reduced or eliminated?
- Are there monitoring elements that should be added?
- Are the monitoring stations still appropriate, considering remedial action plans and other factors?
- Are there new monitoring techniques that should be considered?
- What changes (if any) should be considered to the statistical analysis techniques used to measure and identify progress?

Although not explicitly part of the BEMP, other adaptive management questions that will be addressed as part of the five-year review include (but are not limited to) the following. Are the exposure assumptions, toxicity data, cleanup levels, and remedial action objectives used at the time of remedy selection still valid? Has any other information come to light that could call into question the protectiveness of the remedy?

6.2.2 Reporting of BEMP Results

Major assessments that include the Section 6.1 analyses with interpretation and evaluation of results using the adaptive management framework will be conducted at 5-year intervals timed to support the 5-year remedy reviews required by CERCLA. Documentation of these efforts will be formalized in BEMP Technical Memoranda.

For years where BEMP Technical Memoranda are not developed, data summary reports will be issued. The yearly reports will include tabular and graphical summaries of the monitoring data, including updated time histories. Analysis in the yearly reports will be limited to computation of standard sample statistics. Interpretation and evaluation in the yearly reports will be limited to identification of any potentially significant "anomalies" or concerns that may require early attention, before consideration in the 5-year reports.

7.0 DATA MANAGEMENT AND REPORTING

Given the expected 30-year time frame of BEMP implementation, the variety of data to be collected, and the anticipated synthesis of BEMP data with remedial action effectiveness monitoring data, it is critical that the data generated under the BEMP be disseminated to interested parties on a routine basis and archived in a standardized, high-quality format. The routine release of data reports and convenient access to available data will allow interested stakeholders to review and assess the data in support of Basin environmental decision processes. The BEMP data will be reported, managed, and made available electronically by several mechanisms:

- The STORET web-based data management system
- Annual data summary reports
- Five-year data analysis and assessment reports

The following sections discuss the web-based data management system for the BEMP and the scopes of annual and five-year reports.

7.1 DATA MANAGEMENT

Data collected under the BEMP will be managed in a centralized database repository with a web-based portal for accessing and updating Basin environmental data. As the BEMP data will represent the institutional memory of many diverse users and data sets collected over many years, a non-proprietary software solution has been selected so that the project team is not locked into technologies or procedures accessible to only a select few. In addition, an "enterprise-level" database system is required to manage the data due to the large volume of historic and future project data and the anticipated large number of concurrent users. The EPA STOrage and RETrieval (STORET) data base application has been identified as the BEMP data management system.

The STORET server model is a distributed database application that runs on the Oracle platform. STORET is a repository for water quality, biological, and physical data and is currently used by state environmental agencies, EPA and other federal agencies, universities, private citizens, and others. STORET is a national EPA standard that has been in use since the 1970s, which has evolved to the current Version 2.0 (modernized STORET) of the data structure. The publicly accessible STORET website includes open-source code for the database, free data management applications, a widespread user community, and technical support from EPA into the foreseeable future. Since EPA has adapted STORET as the national environmental database, there is additional technical support and financial resources from EPA Headquarters and other EPA Regions which enhance the practicality and affordability of STORET for the Coeur d'Alene

Basin project. STORET satisfies the primary data management requirements for BEMP monitoring data and has room for growth.

The data management system includes open-source STORET tools such as the STORET Interface Module (SIM) data loader and web-based geographical information system (GIS) mapping applications developed by EPA Region 10 technical staff. These applications are integrated into a web-based project team portal hosted in EPA Region 10 and accessible to all project team members (Figure 7-1). The SIM tool will be implemented on the web so that agencies collecting BEMP data can directly upload their data to the repository and take ownership of their data management efforts. Data extractions/query tools and spatial data (basin maps) viewing capabilities will be incorporated into the portal so that data users and providers can access public data online shortly after it has undergone QA and been loaded to the STORET repository. Existing and historical GIS maps and environmental data already produced as part of the RI/FS will be incorporated into the portal, so that useful information is available as soon as the portal is brought online for public access.

The key underpinning of the BEMP data management system is a standardized electronic data deliverable (EDD) specification that defines the types of data and submission formats required for the STORET repository. The BEMP EDD is the predominant method by which data is exchanged and uploaded to a centralized repository for the Coeur d'Alene Basin and will be reviewed and modified in conjunction with the implementation of the BEMP. This EDD incorporates sampling and analytical SOPs and has been developed with supporting documentation that can be easily updated, as necessary, to address revised data management requirements identified over the time frame of BEMP monitoring activities.

The customized BEMP EDD format has been developed collaboratively with Coeur d'Alene stakeholders to addresses anticipated project team data requirements including location/station data, sampling events, analytical results, biological surveys, and field measurements. The EDD contains detailed specifications for data types (date, number, alphanumeric), field sizes and precision, required data elements and content, and format required for upload to the STORET repository via the SIM data loader. Agencies performing BEMP monitoring will be responsible for providing data to EPA in the BEMP EDD format for uploading to STORET by EPA or their contractor. It is anticipated that entities conducting the monitoring will eventually be able to load the monitoring data to STORET independently.

7.2 REPORTING

In addition to continually updated data available via STORET, data collected under the BEMP will be summarized annually. Data reports released annually will be limited-scope annual "data transmittals" with minimal data analyses. Every five years, more comprehensive, five-year reports summarizing the current understanding of environmental status and trends in the Basin as pertinent to the CERCLA-required five-year process.

7.2.1 Annual Data Summary Reports

Data collected under the BEMP will be summarized and reported annually. The annual data summary reports will include tables and figures showing the monitoring data, including updated time histories. Analysis in the yearly reports will be limited to computation of standard sample statistics. Interpretation and evaluation in the annual reports will be limited to identification of any potentially significant "anomalies" or concerns that may require early attention, before consideration in the more comprehensive 5-year reports. Limited-scope, annual data summary reports will be available on the EPA and Basin Commission websites. Annual summary reports will be completed by the end of January of the following year. This reporting schedule will allow for the incorporation of the previous field season's sampling and monitoring activities and the October baseflow surface water sampling event. In the event that analytical results have not been received and/or reviewed by the end of a calendar year, the annual summary report will identify what sampling was performed and the expected time frame for receipt of analytical results.

7.2.2 Five-year Data Analysis and Assessment Reports

The BEMP assumes that extensive analysis of accumulated monitoring data will be conducted at five-year intervals timed to support the 5-year remedy reviews required by CERCLA (Section 1.6). These five-year data analyses will follow the approach discussed in Section 6.1 and also include the assessment of results discussed in Section 6.2. In addition to data collected under the BEMP, the five-year data analyses may incorporate data collected as part of remedial action-specific monitoring or other monitoring programs in the Basin (i.e. Lake Environmental Monitoring Plan data). The five-year analyses and assessments will be documented in BEMP Technical Memoranda, which will be used to support the five-year remedy reviews. The BEMP Technical Memoranda will be completed by the end of February to allow for review by EPA and incorporation into the five-year review preparation activities.

The ROD calls for an adaptive management framework for remedy implementation. The environmental monitoring under the BEMP is anticipated to evolve over the 30-year interim remedy implementation time frame. The BEMP is expected to evolve to reflect a better understanding of Basin processes, changes in monitoring tools and techniques. The five-year data analysis and assessment reports will be a key component of the adaptive management review of the progress made under the OU-3 ROD. Specific components include detecting trends or major trend discontinuities, which may signal a need to update critical assumptions or change management practices or the BEMP itself. These evaluations and the experience gained from remedy implementation may help identify and guide "course corrections" that improve remedy performance or cost-effectiveness.

33754181-44

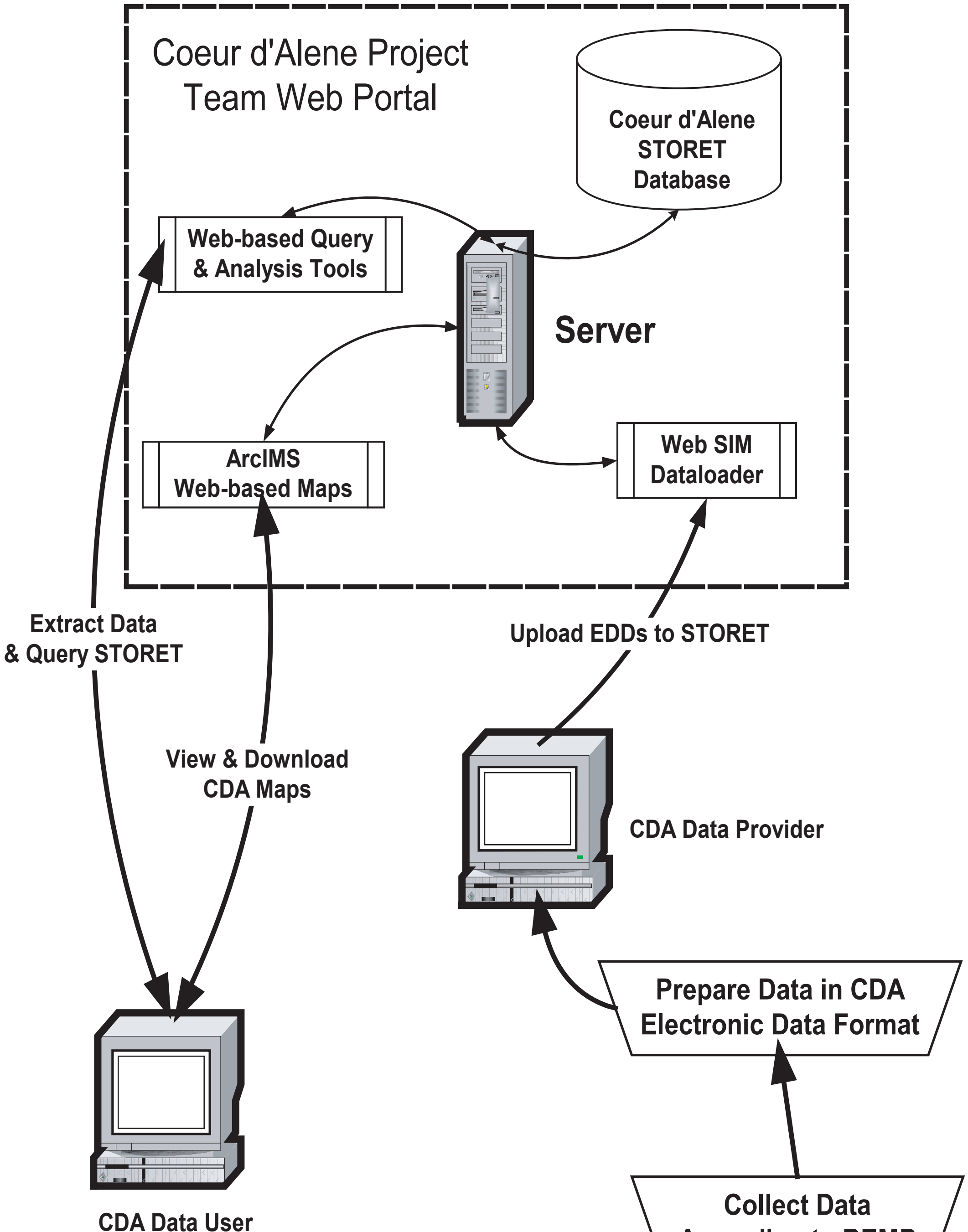


Figure 7-1
Data Management

8.0 REFERENCES

Audet, D.J., L.H. Creekmore, L. Sileo, M.R. Snyder, J.C. Franson, M.R. Smith, J.K. Campbell, C.U. Meteyer, L.N. Locke, L.L. McDonald, T.L. McDonald, D. Strickland, and S. Deeds. 1999. Wildfowl Use and Mortality Investigation in the Coeur d'Alene Basin 1992-1997. U.S. Fish and Wildlife Service, Spokane, WA.

Beyer, W.N., D.J. Audet, G.H. Heinz, D.J. Hoffman, and D. Day. 2000. Relation of waterfowl poisoning to sediment lead concentrations in the Coeur d'Alene River Basin. *Ecotoxicology* 9:207-218.

Blus, L.J., C.J. Henny, D.J. Hoffman, and R.A. Grove. 1995. Accumulation in and effects of lead and cadmium on waterfowl and passerines in northern Idaho. *Environmental Pollution* 3:311-318.

Bookstrom, A., S. Box, R. Fousek, B. Jackson, and J. Wallis. 2002. *Rates of Sedimentation and Lead Deposition on the Floodplain of the Coeur d'Alene River, Idaho.* Draft.

Bowers, C.L., R.R. Caldwell, and D.M. Dutton. 2003. Water-Quality, Streambed-sediment, and Biological Data from the Clark Fork – Pend Oreille and Spokane River Basins, Montana, Idaho, and Washington, 1998 – 2001. U.S. Geological Survey Open-File Report 03-292. Helena, Montana.

Campbell, J.K., D.J. Audet, J.W. Kern, M. Reyes, and L.L. McDonald. 1999. Metal Contamination of Palustrine and Lacustrine Habitats in the CDA Basin, Idaho. U.S. Fish and Wildlife Service and Western Ecosystems Technology, Inc.

CH2M Hill. 2000. Draft Final Conceptual Site Model Summary and Update, Coeur d'Alene River Basin. CH2M Hill Document Control No. WKP0036, URSG Document Control No. 5162500.5858.01.w. August 31.

Coeur d'Alene Lake Coordination Council (CLCC), Coeur d'Alene Tribe, and Idaho Department of Environmental Quality. 1996. Coeur d'Alene Lake Management Plan.

EPA – see U.S. Environmental Protection Agency

Farag, A.M., D.F. Woodward, J.N. Goldstein, W. Brumbaugh, and J.S. Meyer. 1998. Concentrations of metals associated with mining waste in sediments, biofilm, benthic macroinvertebrates, and fish from the Coeur d'Alene River basin, Idaho. *Archives of Environmental Contamination and Toxicology* 34:119-127.

Farag, A.M., D.F. Woodward, W. Brumbaugh, J.N. Goldstein, E. MacConnell, C. Hogstrand, and F.T. Barrows. 1999. Dietary effects of metals-contaminated invertebrates from the Coeur d'Alene River, Idaho, on cutthroat trout. *Trans. American Fisheries Society* 128:578-592.

Grosbois, C.A., A.J. Horowitz, J.J. Smith and K.A. Elrick. 2001. The effect of mining and related activities on the sediment-trace element geochemistry of Lake Coeur d'Alene, Idaho, USA. Part III, Downstream effects; the Spokane River Basin. *Hydrological Processes* v. 15 no. 5. April 15.

Henny, C.J., L.J. Blus, D.J. Hoffman, L. Sileo, D.J. Audet, and M. Snyder. 1999. Field Evaluation of Lead Effects on Canada Geese and Mallards in Coeur d'Alene River Basin, Idaho. United States Geological Survey, Forest and Rangeland Ecosystem Science Center. Corvallis, OR.

Idaho Department of Environmental Quality (IDEQ). 1999. Beneficial Use Reconnaissance Project. Raw data sheets provided Geoff Harvey, Idaho Department of Fish and Game. April 1999.

Idaho Department of Environmental Quality and Coeur d'Alene Tribe (IDEQ and CdA Tribe). 2002. Draft Coeur d'Alene Lake Management Plan Addendum. December 23, 2002.

Johnson, G., D.J. Audet, J.W. Kern, L.J. LeCaptain, M.D. Strickland, D.J. Hoffman, and L.L. McDonald. 1999. Lead exposure in passerines inhabiting lead-contaminated floodplains in the Coeur d'Alene River Basin, Idaho, USA. *Environmental Toxicology and Chemistry* 18:1190-1194.

MacCoy, D.E. and T.R. Maret. 2003. Ecological Indicators of Water Quality in the Spokane River, Idaho and Washington, 1998 and 1999. U.S. Geological Survey Fact Sheet FS 067-03.

Maret, T.R. and D.M. Dutton. 1999. Summary of Information on Synthetic Organic Compounds and Trace Elements in Tissue of Aquatic Biota, Clark Fork-Pend Oreille and Spokane River Basins, Montana, Idaho, and Washington, 1974-96. U.S. Geological Survey *Water Resources Investigations Report* 98-425. Boise, Idaho.

Maret, T.R. and K.D. Skinner. 2000. Concentrations of Selected Trace Elements in Fish Tissue and Streambed Sediments in the Clark Fork-Pend Oreille and Spokane River Basins, Montana, Idaho, and Washington, 1998. U.S. Geological Survey *Water Resources Investigations Report* 00-4159. Boise, Idaho.

Maret T.R., D.E. MacCoy, K.D. Skinner, S.E. Moore, and I. O'Dell. 2001. Evaluation of macroinvertebrate assemblages in Idaho rivers using multimetric and multivariate techniques, 1996-1998. U.S. Geological Society *Water Resources Investigations Report* 01-4145. Boise, Idaho.

Maret, T. and D. MacCoy. 2002. Fish Assemblages and Environmental Variables Associated With Hard-Rock Mining in the Coeur d'Alene River Basin, Idaho. *Trans. American Fisheries Society* 131:865-884. Bethesda, Maryland.

Mebane, C.A., T.R. Maret, and R.M. Hughes. 2002. An Index of Biological Integrity (IBI) for Pacific Northwest Rivers. *Trans. American Fisheries Society* 132:239-261.

Stratus Consulting, Inc. 2000. Report of Injury Assessment: Coeur d'Alene Basin Natural Resource Damage Assessment. Prepared for the USFWS, Forest Service, and the Coeur d'Alene Tribe. July.

U.S. Environmental Protection Agency (EPA). 1994. Guidance for the Data Quality Objectives Process. EPA QA/G4. USEPA Quality Assurance Management Staff. Washington D.C. Final. September 1994.

———. 2000a. Bunker Hill Populated Areas Operable Unit First Five Year Review Report.

———. 2000b. Bunker Hill Non-Populated Areas First 5-Year Review.

———. 2000c. Data Quality Objectives Process for Hazardous Waste Site Investigation. EPA QA/G-4HW. Final. January.

———. 2001a. Coeur d'Alene Basin RI/FS, Remedial Investigation Report. Final. Prepared by URS Greiner and CH2M Hill EPA Region 10. October 2001.

———. 2001b. Coeur d'Alene Basin RI/FS, Feasibility Study Report. Final. Prepared by URS Greiner and CH2M Hill. October 2001.

———. 2001c. Coeur d'Alene Basin RI/FS, Basinwide Ecological Risk Assessment. Prepared by CH2M Hill and URS Greiner. May 2001.

———. 2001d. Comprehensive Five-Year Review Guidance. EPA 540-R-01-007. Office of Emergency and Remedial Response. June.

———. 2001e. Coeur d'Alene Basin RI/FS Technical Memorandum (Revision 1). Probabilistic Analysis of Post-Remediation Metal Loading. Prepared by URS Greiner and CH2M Hill. September 20, 2001.

———. 2001f. Interim Fisheries Benchmarks for the Initial Increment of Remediation in the Coeur d'Alene Basin. Final Technical Memorandum. Prepared by URS Greiner and CH2M Hill. September 2001.

———. 2002. Record of Decision. Bunker Hill Mining and Metallurgical Complex Operable Unit 3. September.

U.S. Environmental Protection Agency and Idaho Department of Environmental Quality (EPA and IDEQ). 2000. Final Coeur d'Alene Basin Total Maximum Daily Load (TMDL) Package. August 21.

U.S. Fish and Wildlife Service (USFWS). 2001. Work Plan for Biological Monitoring at the Bunker Hill Facility Non-Populated Areas. Prepared for U.S. EPA Region 10. March 2001.

———. 2002. Bunker Hill Facility Biological Monitoring Investigations – Quality Assurance Plan. Prepared for U.S. EPA Region 10. June 2002.

U.S. Geological Survey (USGS). 2001. Draft Summary of Fisheries, Water Chemistry, and Habitat Data for the South Fork Coeur d'Alene River and Reference Streams. Collected by Terry Maret, Summer 2000 National Ambient Water Quality Assessment Monitoring Program. Presentation. May 1.

———. Variously dated. National field manual for the collection of water-quality data: U.S. Geological Survey Techniques of Water-Resources Investigations, book 9, chaps. A1 – A9. Available online at http://pubs.water.usgs.gov/twri9A.

Woods, P. 2000a. Loads and Concentrations of Cadmium, Lead, Zinc, and Nutrients During the 1999 Water Year Within the Spokane River Basin, Idaho and Washington. Administrative Report prepared by the USGS for EPA.

———. 2000b. Concentrations and Loads of Cadmium, Lead, and Zinc Measured Near the Peak of the 1999 Snowmelt Runoff Hydrograph at 42 Stations. Administrative Report prepared by the USGS for EPA. January 2000.

Woodward, D.F., A. Farag, D. Reiser, and B. Brumbaugh. 1997. Metals Accumulation in the Food-Web of the Coeur d'Alene Basin, Idaho: Assessing Exposure and Injury to Wild Trout. Draft. December 1. Available from the Coeur d'Alene Tribe, Coeur d'Alene, ID.