FINAL

Baseline Ecological Risk Assessment for Non-Asbestos Contaminants

Operable Unit 3
Libby Asbestos Superfund Site
Libby, Montana

April 2013

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APPROVAL PAGE

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Operable Unit 3, Libby Asbestos Superfund Site, Libby, Montana
April 2013

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Acronyms and Abbreviations

°F	degrees Fahrenheit
%	percent
95UCL	95 percent upper confidence limit
ATSDR	Agency for Toxic Substances and Disease Registry
AUF	area use factor
BCS	biological condition score
BERA	baseline ecological risk assessment
BJC	Bechtel Jacobs Company, LLC
BW	body weight
C	concentration
CCME	Canadian Council of Ministers of the Environment
cfs	cubic feet per second
CSM	conceptual site model
COPC	chemical of potential concern
DF	dietary fraction
EC_{20}	effect concentration for 20% of exposed organisms
EcoSSL	Ecological Soil Screening Level
EFAW	Engineering Field Activity West
EMAP	Environmental Monitoring and Assessment Program
EPA	U.S. Environmental Protection Agency
EPC	exposure point concentration
GLWQI	Great Lakes Water Quality Initiative
HQ	hazard quotient
HQmax	maximum hazard quotient
HQS	habitat quality score
HSI	Habitat Suitability Index
IR	intake rate
KDC	Kootenai Development Corporation
LA	Libby amphibole
LCV	lowest chronic value
LOAEL	lowest observable adverse effect level
LRC	Lower Rainy Creek
MDEQ	Montana Department of Environmental Quality
MFWP	Montana Fish Wildlife and Parks
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
MLE	maximum likelihood estimate
mm	millimeter
MNHP	Montana National Heritage Program

MWH	MWH Americas, Inc.
NAWQC	National Ambient Water Quality Criteria
NOAEL	no observable adverse effect level
ORNL	Oak Ridge National Laboratory
OU	operable unit
OU3	Operable Unit 3
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
PEC	probable effect concentration
PQL	practical quantitation limit
P_{soil}	fraction of diet that is soil
RBA	relative bioavailability
RBP	Rapid Bioassessment Protocol
RI	remedial investigation
SAP	sampling and analysis plan
SAV	secondary acute value
SCV	secondary chronic value
SSD	species-sensitivity distribution
SVOC	semi-volatile organic compound
TEC	threshold effect concentration
TRV	toxicity reference value
μg/L	micrograms per liter
USDAFSR1	U.S. Department of Agriculture Forest Service Region 1
USFS	U.S. Forest Service
URC	Upper Rainy Creek
VOC	volatile organic compound
WQG	Water Quality Guidelines

Executive Summary

Introduction

This document is a baseline ecological risk assessment (BERA) for non-asbestos contaminants in Operable Unit 3 (OU3) of the Libby Asbestos Superfund Site, located near Libby, Montana. The purpose of this assessment is to describe the likelihood, nature, and extent of adverse effects on ecological receptors in OU3 that result from exposure to non-asbestos contaminants released to the environment as a result of past mining, milling, and processing activities at the site. This information will be used by risk managers to decide whether remedial actions are needed to protect ecological receptors in OU3 from site-related non-asbestos contamination. Ecological risks from exposures to asbestos will be addressed in a separate document.

Site Characterization

Libby is a community in northwestern Montana that is located near a large open-pit vermiculite mine. The mine location is shown in **Figure ES-1**. Vermiculite from the mine contains a form of asbestos referred to as Libby amphibole (LA). Based primarily on concerns about asbestos exposures, the U.S. Environmental Protection Agency (EPA) listed the Libby Asbestos Superfund Site on the National Priorities List in October 2002. OU3 includes the property in and around the former vermiculite mine and the geographic area surrounding the mine that has been impacted by releases and subsequent migration of contaminants (including both asbestos and non-asbestos contaminants) from the mine. A preliminary study area boundary for OU3 is shown by the red line in **Figure ES-1**. This study area encompasses the forested area surrounding the mine, and includes all of the major surface water features in OU3, including Rainy Creek, which is the principal drainage for the site.

Aside from asbestos, the principal contaminants of concern at OU3 are metals that occur in the ore body. In addition, various chemical reagents were used to facilitate the separation or vermiculite from waste rock, and oil may have been used for dust suppression on mine roads. Thus, a broad suite of non-asbestos contaminants, including both inorganic and organic contaminants, may be present at OU3.

The mined area is heavily disturbed by past mining activity and some areas remain largely devoid of vegetation. Outside the mined area, most of OU3 is forested, with Douglas fir and lodgepole pine being the predominant species. The mine is located within the Rainy Creek watershed, which includes several creeks and ponds, as well as the tailings impoundment. Various terrestrial and aquatic species are expected to occur at the OU3 site, including several federally-listed and state species of concern.

Problem Formulation

Problem formulation is the systematic planning step for ecological risk assessment that identifies the major concerns and issues to be considered and describes the basic approaches that will be used to characterize ecological risks.

A conceptual site model (CSM) is a schematic summary of what is known about the nature of source materials at a site, the pathways by which contaminants may migrate through the environment, and the scenarios by which receptors may be exposed to site-related contaminants. **Figure ES-2** presents the CSM for exposure of each general ecological receptor group (fish, aquatic invertebrates, amphibians, terrestrial plants, soil invertebrates, birds, mammals) to mining-related non-asbestos contaminants at OU3. As shown, the following exposure pathways were evaluated quantitatively in this BERA:

- *Aquatic Receptors (fish, aquatic invertebrates, amphibians)* – Direct contact exposures with sediment and/or surface water.

- *Terrestrial Plants and Soil Invertebrates* – Direct contact exposures with soil and mine waste materials.

- *Wildlife Receptors (birds and mammals)* – Exposures by three primary pathways: 1) ingestion of contaminants in or on dietary items; 2) incidental ingestion of soil and/or sediment while feeding; and 3) ingestion of contaminated water.

Basic Risk Assessment Approach

Three basic risk assessment evaluation strategies were used to evaluate risks for ecological receptors as OU3 – the hazard quotient (HQ) approach, site-specific community evaluations, and site-specific toxicity tests. Each of these risk assessment evaluation strategies has advantages and limitations. For this reason, conclusions based on only one method of evaluation may be misleading. Therefore, the best approach for reaching reliable conclusions is to combine the findings across all of the methods for which data are available, taking the relative strengths and weaknesses of each method into account in a weight of evidence evaluation.

Data Summary

Data needed to support the BERA for OU3 have been collected as part of several investigations. Sampling of environmental media for non-asbestos contaminants has focused on surface water, sediment, soils, and mine waste materials, since these are the media most likely to have been impacted by site-related releases. Most samples were analyzed for metals and metalloids, petroleum hydrocarbons, and various media quality parameters. In addition, selected samples were analyzed for a broad suite of other chemicals, including volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), cyanide, pesticides, polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAHs), and selected radionuclides.

Surface water and sediment samples collected from OU3 have been used to conduct site-specific toxicity tests for rainbow trout (*Oncorhynchus mykiss*) and aquatic invertebrates (*Hyalella azteca* and *Chironomus tentans*), respectively. In addition, direct observations of the fish and aquatic invertebrate communities and habitat quality were made at several locations in Rainy Creek.

Chemicals of Potential Concern

An initial HQ screen was completed as part of this BERA. The goal of the screen was to eliminate from further consideration any contaminants, media, or receptor groups for which the data indicate risks are clearly below a level of concern. Chemicals with concentrations above toxicity benchmarks were retained as chemicals of potential concern (COPCs) for further evaluation in the refined HQ evaluation. **Table ES-1** summarizes the list of COPCs identified in the initial HQ screen for each exposure medium and each receptor group.

Weight of Evidence Evaluation

In this BERA, three different lines of evidence are presented:

- Refined HQ Evaluations (Section 6)
- Habitat and Community Evaluations (Section 7)
- Site-Specific Toxicity Test Evaluations (Section 8)

Each of these lines of evidence has inherent advantages and limitations. Therefore, the BERA used a weight of evidence evaluation to develop risk conclusions, combining the findings across each line of evidence and taking the relative strengths and weaknesses of each line of evidence into account.

Table ES-2 summarizes the conclusions for each line of evidence, the confidence associated with each line of evidence, and the overall weight of evidence conclusion for each ecological receptor of interest at OU3. The risk conclusions for each ecological receptor group are discussed below.

For fish, the weight of evidence suggests that risks from non-asbestos contaminants in OU3 are likely to be minimal. However, the fish community evaluation showed that the density of large fish in Lower Rainy Creek is somewhat lower relative to reference and that smaller fish are absent. There are a number of habitat factors which might contribute to this reduction in fish density, but is not possible to determine the degree to which habitat factors are responsible, or if other factors (e.g., asbestos contamination) may also be contributing to this decline.

For aquatic invertebrates, the community evaluations in Rainy Creek showed that the aquatic invertebrate community ranked as unimpaired to slightly impaired and habitat quality may be a contributing factor to any observed effects. Although HQ values suggest that risks to aquatic invertebrates from chromium, manganese, and nickel in sediment were possible, the site-specific toxicity tests showed no adverse effects in exposed organisms. The weight of evidence suggests that risks from non-asbestos contaminants in OU3 are likely to be minimal.

For plants and terrestrial invertebrates, the single line of evidence available (HQ) indicated that the potential for risk from several metals (barium, cobalt, nickel, vanadium) in the mined area cannot be excluded. However, due to the conservative nature of the toxicity benchmarks used in deriving HQ values, results should not be interpreted as evidence that risk does exist.

For wildlife, the single line of evidence available (HQ) showed that risks to wildlife were either not expected or were likely to be minimal for nearly all COPCs for all receptors. The exception is potential risks to insectivorous wildlife from the ingestion of barium, manganese, and vanadium in aquatic invertebrates. However, due to conservative assumptions about bioaccumulation of these COPCs, the calculated HQ values are likely to be biased high and actual risks are lower. Thus, results should not be interpreted as evidence that risk does exist.

Uncertainty Assessment

There are a variety of sources of uncertainty in each line of evidence used in the BERA that need to be evaluated and considered when developing the weight of evidence and making risk management decisions. The uncertainty assessment discusses the uncertainties associated with the HQ evaluations (including uncertainties that impact the nature and extent evaluation, the exposure assessment, the toxicity assessment, and the risk characterization), the habitat and community evaluations, and the site-specific toxicity test evaluations for OU3.

The results and conclusions presented in this risk assessment should be viewed in light of these inherent uncertainties, and risk management decisions based on the risk assessment conclusions should be interpreted accordingly.

20-SEP-2007 S:\GIS\ARCPRJ2\0100-008-900-LIBBYMT\PLT\PHASE1_070920\FIG 2-1

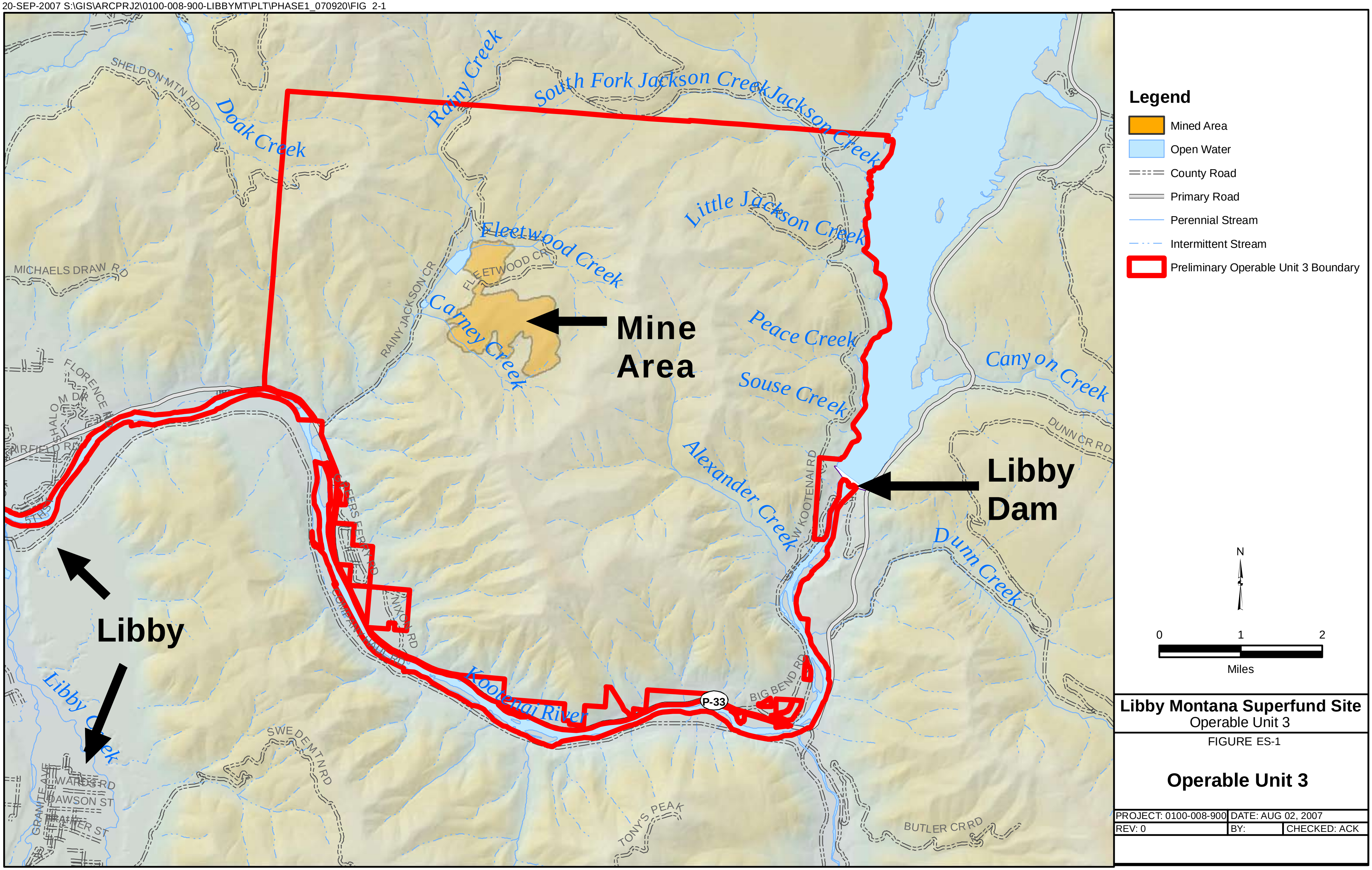
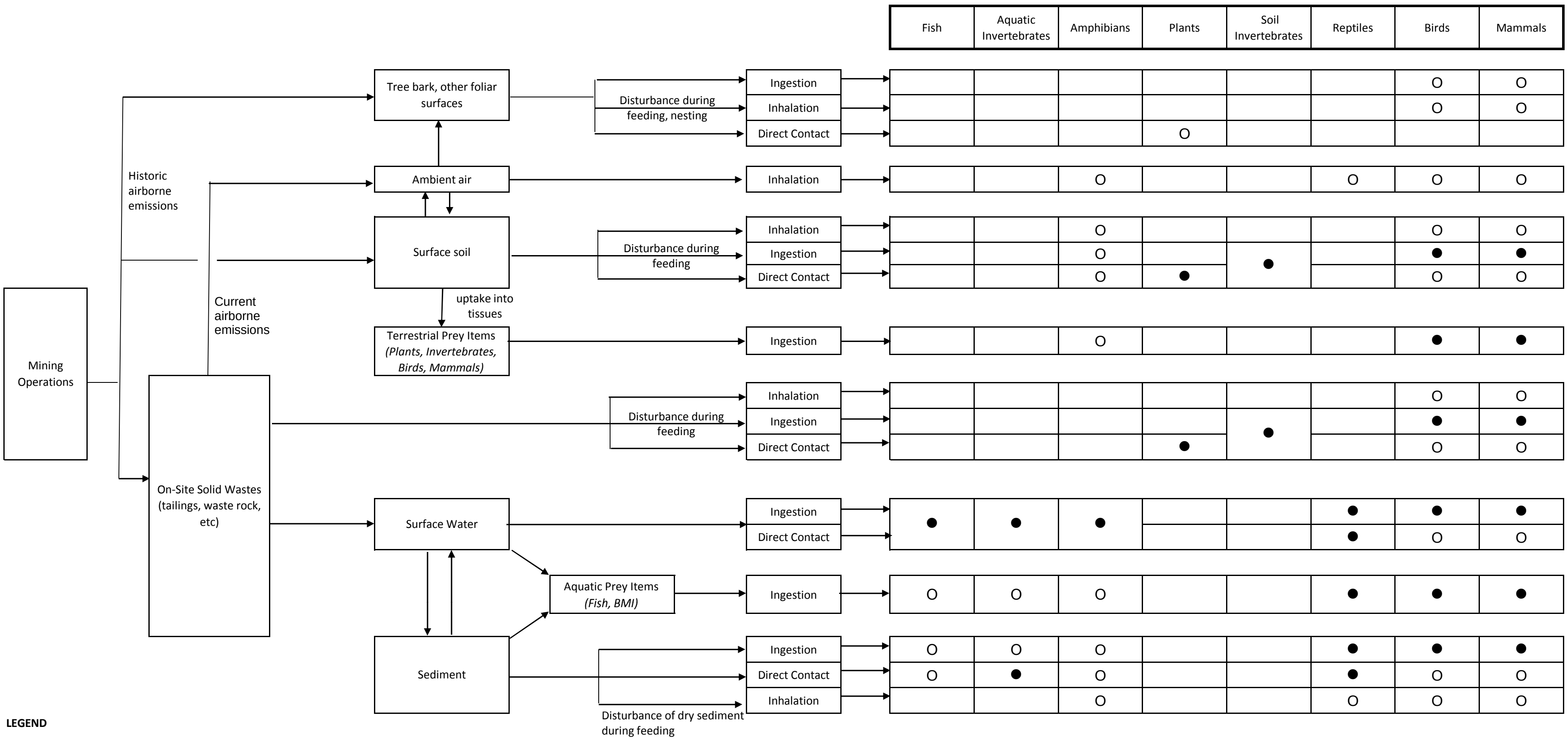


FIGURE ES-2. CONCEPTUAL SITE MODEL FOR EXPOSURE OF ECOLOGICAL RECEPTORS TO NON-ASBESTOS CONTAMINANTS AT OU3



LEGEND

● Pathway is believed to be complete and may be an important contribution to the total risk to the receptor.

O Pathway is believed to be complete but is unlikely to be a major contributor to the total risk to the receptor (in comparison to one or more other pathways that are evaluated).

Pathway is incomplete or believed to be negligible

TABLE ES-1. SUMMARY OF ALL COPCs IDENTIFIED IN THE INITIAL HQ SCREEN

Aquatic Receptors		Plants/Invertebrates	Wildlife		
Surface Water	**Sediment**	**Soil/Mine Waste**	**Soil/Mine Waste**	**Sediment**	**Surface Water**
Barium (diss.)	Aluminum	Barium	Antimony	Arsenic	Aluminum (tot.)
Manganese (diss.)	Cadmium	Chromium	Barium	Barium	
Fluoride	Chromium	Cobalt	Chromium	Chromium	
Nitrogen, Nitrite as N	Copper	Copper	Copper	Cobalt	
	Lead	Manganese	Lead	Copper	
	Manganese	Mercury	Mercury	Lead	
	Nickel	Nickel	Nickel	Manganese	
	Benzo(b)fluoranthene	Vanadium	Vanadium	Mercury	
	Benzo(k)fluoranthene		Zinc	Nickel	
	Naphthalene			Selenium	
				Vanadium	
				Zinc	

COPC = chemical of potential concern

diss. = dissolved fraction

HQ = hazard quotient

tot. = total recoverable fraction

TABLE ES-2. WEIGHT OF EVIDENCE EVALUATION AND CONCLUSIONS

Receptor Group	Exposure Location	Line of Evidence		Exposure Medium	Principal Findings	Confidence in Findings	WOE Conclusion
Fish	Creeks and Ponds	1	Refined HQ	Water	No risks (barium not evaluated)	Low-Moderate	Risks from non-asbestos COPCs are minimal
		2	Site specific toxicity test	Water	No adverse effects	Moderate	
		3	Community surveys	Water, Sediment, Diet	Lower density than expected; habitat and/or LA may contribute	High	
Aquatic Invertebrates	Creeks and Ponds	1a	Refined HQ	Water	Severe risk from barium	Low	Risks from non-asbestos COPCs are minimal
		1b	Refined HQ	Sediment	Moderate/severe risk from chromium, manganese, nickel	Low	
		2	Site-specific toxicity test	Sediment	No effects	Moderate	
		3	Community survey	Sediment, Water, Diet	Minimal impairment; habitat quality likely contributor	High	
Terrestrial Plants	Mined area	1	Refined HQ	Soil	Moderate/severe risk from barium, cobalt, nickel, vanadium (chromium not evaluated)	Low	Risks from non-asbestos COPCs cannot be excluded [a]
Terrestrial Invertebrates	Mined area	1	Refined HQ	Soil	High risk from barium (chromium not evaluated)	Low	
Wildlife (birds and mammals)	Terrestrial	1	Refined HQ	Soil, Diet	None/minimal risk	Low	Risks from non-asbestos COPCs are minimal
	Aquatic	1	Refined HQ	Water, Sediment, Diet	High risk from barium, manganese, vanadium from ingestion of aquatic invertebrates	Low	Risks from non-asbestos COPCs cannot be excluded [a]

[a] Refined HQ values above 1 should not be interpreted as evidence that risk does exist.

Section 1 – Introduction

1.1 Purpose of this Document

This document is a baseline ecological risk assessment (BERA) for non-asbestos contaminants for Operable Unit 3 (OU3) of the Libby Asbestos Superfund Site, located near Libby, Montana. The purpose of this assessment is to describe the likelihood, nature, and extent of adverse effects on ecological receptors in OU3 that result from exposure to non-asbestos contaminants released to the environment as a consequence of past mining, milling, and processing activities at the site. This information will be used by risk managers to decide whether remedial actions are needed to protect ecological receptors in OU3 from site-related non-asbestos contamination. Ecological risks from exposures to asbestos will be addressed in a separate document.

1.2 Overview of the Ecological Risk Assessment Process

This BERA was performed in general accordance with current U.S. Environmental Protection Agency (EPA) guidance for ecological risk assessments (EPA 1997; 1998).

Figure 1-1 outlines the eight-step process that EPA recommends for guiding ecological risk assessments at Superfund sites (EPA 1997). The first two steps are screening-level evaluations that are intentionally simplified and conservative, and usually tend to overestimate risks to minimize the potential for a false negative decision error (i.e., deciding that the site is not of concern, when, in fact, it is of concern). This allows for the elimination of chemical and exposure pathways that are not associated with significant ecological risk, ensuring subsequent efforts focus on chemicals and pathways that are of potential concern.

The remaining steps in the sequence are intended to support the development of the BERA. This includes the process of problem formulation (Step 3), collection of data needed to support the baseline assessment (Steps 4-6), evaluation and interpretation of the data in the risk characterization (Step 7), and use of the data to make risk management decisions (Step 8).

1.3 Document Organization

In addition to this introduction, this report is organized into the following sections:

- Section 2 – Site Characterization
- Section 3 – Problem Formulation
- Section 4 – Data Summary
- Section 5 – Initial Hazard Quotient Screening Evaluation
- Section 6 – Refined Hazard Quotient Evaluation
- Section 7 – Habitat and Community Evaluation

- Section 8 – Site-Specific Toxicity Testing Evaluation
- Section 9 – Uncertainty Assessment
- Section 10 – Weight of Evidence Evaluation
- Section 11 – References

All tables and figures cited in the text are provided at the end of the report. Appendices are provided electronically (e.g., in an attached compact disc or as an electronic file that can be downloaded).

Section 2 – Site Characterization

2.1 Overview

Libby is a community in northwestern Montana that is located near a large open-pit vermiculite mine. The mine location is shown in **Figure 2-1**. Vermiculite from the mine contains a form of asbestos referred to as Libby amphibole (LA). The Libby Asbestos Superfund Site is of concern to EPA primarily because historic mining, milling, and processing of vermiculite at the site are known to have caused releases of LA to the environment, and inhalation exposure to asbestos is known to increase the risk of cancer and non-cancer effects in humans (Agency for Toxic Substances and Disease Registry [ATSDR] 2001). Based primarily on these concerns, EPA listed the Libby Asbestos Superfund Site on the National Priorities List in October 2002.

Given the size and complexity of the Libby Asbestos Superfund Site, EPA divided the site into a series of operable units (OUs). This document focuses on OU3. OU3 includes the property in and around the former vermiculite mine and the geographic area surrounding the mine impacted by releases and subsequent migration of contaminants (including both asbestos and non-asbestos contaminants). A preliminary study area boundary for OU3 is shown by the red line in **Figure 2-1**. This study area encompasses the forested area surrounding the mine, and includes all of the major surface water features in OU3. EPA established this preliminary study area boundary for the purpose of planning and developing the initial scope of the remedial investigation (RI) for OU3. This preliminary boundary may be revised as data are acquired on the actual extent of environmental contamination associated with releases that may have occurred from the mine site.

2.2 Physical Setting

Land Use

The terrain in OU3 is mainly mountainous with dense forests and steep slopes. **Figure 2-2** shows the land ownership for areas within and surrounding OU3. Kootenai Development Corporation (KDC), a subsidiary of W.R. Grace & Co., owns the mine and land surrounding the mine (see **Figure 2-2**). The majority of the rest of the land in OU3 is owned by the United States government and is managed by the U.S. Forest Service (USFS), although some parcels are owned by the State of Montana and some are owned by Plum Creek Timberlands LP for commercial logging (see **Figure 2-2**).

Climate

Northern Montana has a climate characterized by relatively hot summers, cold winters, and low precipitation. **Table 2-1** presents climate data collected at the Libby Northeast Ranger Station, which is located just west of the town of Libby near the Kootenai River. Average summer high temperatures are in the upper 80s degrees Fahrenheit (°F), and average low temperatures are in the 40s °F. Average winter high temperatures are in the 30s °F, with average lows less than 20 °F.

The western mountain ranges cause Pacific storms to drop much of their moisture before they reach the area, resulting in relatively low precipitation, averaging about

18 inches per year. The most abundant rainfall occurs in late spring/early summer. In the winter months, snowfall averages 54 inches each year and snow cover typically remains on the ground from November through March. Data collected from the meteorological station at the mine site indicate that winds are predominantly to the northeast, and wind speeds are usually below 17 knots (about 20 miles per hour) (**Figure 2-3**).

Surface Water Features

The mine is located within the Rainy Creek watershed, an area of approximately 17.8 square miles. **Figure 2-4** shows the main surface water features in the Rainy Creek watershed, and **Figure 2-5** shows the relation of the surface water features to mine features at OU3. **Appendix A** provides photographs of the aquatic habitats within OU3. Primary surface water bodies include:

- Rainy Creek originates between Blue Mountain and the north fork of Jackson Creek at an elevation of about 5,000 feet, and falls to an elevation of 2,080 feet where it flows into the Kootenai River (Zinner 1982). Rainy Creek is perennial and supports a variety of fish and aquatic invertebrates throughout the extent of the creek. The average gradient for Rainy Creek is about 12 percent (%) (Parker and Hudson 1992) and the banks are well vegetated (MWH Americas, Inc. [MWH] 2007). As illustrated in **Figures 2-4 and 2-5**, Rainy Creek flows through a large tailings impoundment west of the mine site which was constructed within the Rainy Creek channel. For the purposes of this assessment, reaches of Rainy Creek above the impoundment are referred to as Upper Rainy Creek (URC), and reaches below the impoundment are referred to as Lower Rainy Creek (LRC).

- Fleetwood Creek originates from mountains on the east side of OU3 at an elevation of approximately 4,200 feet, flowing westward along the north edge of the mined area to the tailings impoundment at an elevation of approximately 2,800 feet (see **Figure 2-4**). The average stream gradient for Fleetwood Creek is about 11% (Parker and Hudson 1992). Fleetwood Creek is approximately 4-5 miles in length and, according to the local USFS fisheries biologist (Hooper 2011, pers. comm.), is perennial and provides habitat for fish and aquatic invertebrates in the reach above the mined area. The portion of Fleetwood Creek that flows through the tailings disposal area (see **Figure 2-5**) is a reach of approximately 0.5 miles, and is devoid of vegetation and habitat. A small ponded area at the edge of the tailings disposal area was identified along Fleetwood Creek during reconnaissance surveys by EPA in 2007.

- Carney Creek originates from the mountains on the southeast side of OU3 at an elevation of approximately 4,400 feet, flowing westward along the south edge of the mined area (see **Figure 2-4**) before joining Rainy Creek approximately 3,000 feet below the tailings impoundment at an elevation of approximately 2,800 feet. Carney Creek is approximately 2-3 miles in length. According to the local USFS Fisheries Biologist (Hooper 2011, pers. comm.), Carney Creek is perennial and provides fish and invertebrate habitat along the south side of the mined area. A small pond exists on Carney Creek that was formed when waste piles were deposited in the drainage and blocked and altered the flow of the creek. The pond is vegetated on one side and appears to support aquatic invertebrates and amphibians and is frequented by moose. Several small seeps are reported along Carney Creek (Zinner 1982) and were identified during reconnaissance surveys by EPA in 2007. However, these seeps are not considered viable aquatic habitat for the purposes of this ecological risk assessment.

- Tailings Impoundment. In 1972, W.R. Grace & Co. constructed a tailings impoundment in the channel of Rainy Creek that received the discharge of process waters that were previously discharged directly into Rainy Creek. The purpose of the impoundment was to provide for settlement of fine tailings produced by a new wet milling process and to recover water for reuse. The height of the dam is about 135 feet measured from the downstream toe. The impoundment occupies 70 acres and receives input from both Rainy Creek and Fleetwood Creek (see **Figure 2-5**). Under most conditions, the impoundment drains through a toe drain directly into Rainy Creek, but may also discharge to Rainy Creek via an overflow channel during high flow events (Parker and Hudson 1992).

- Mill Pond. A pond in the Rainy Creek channel downstream of the tailings impoundment was constructed to provide a water supply for mining operations. The pond discharges to Rainy Creek where it mixes with flow from Carney Creek and flows downstream to the Kootenai River. This reach has some seasonal gain in flow, most likely due to groundwater input (EPA 2007a).

- Kootenai River. The Kootenai River flows from southeast to northwest along the south side of the site. Flows in the Kootenai River are controlled by the Libby Dam, which was constructed in the late 1960s and early 1970s as part of the Columbia River development for flood control, power generation, and recreation. Daily water outflow plans[1] show lowest discharges typically occur in March and October at approximately 4,000 cubic feet per second (cfs) and maximum discharges occur in late May/early June at about 26,000 cfs.

Table 2-2 lists the Montana water-use classifications for Rainy Creek and the Kootenai River. As shown, both Rainy Creek and the Kootenai River have a use designation for the growth and propagation of salmonid fishes and associated aquatic life, waterfowl, and fur bearers.

2.3 History of Mining Activities at the Site

The vermiculite mine was operated from 1923 until 1990, mainly as an open pit, except for a short time in the early period of operations. As part of the mining process, rock was removed to allow access to the vermiculite or separated from the vermiculite

[1] Available from http://www.nwd-wc.usace.army.mil/ftppub/project_data/yearly/lib_wy_qr.txt

in the mine pits and dumped over the edge to form waste rock piles (see **Figure 2-5**). Ore was processed to separate out vermiculite product by crushing, screening or water floatation, with those operations generally occurring in the mill area. The mining process generated two types of waste material – coarse tailings, which were disposed in a pile to the north, and fine tailings, which were discharged to Rainy Creek (before 1971) or to the tailings impoundment (after 1971).

A review of historic information on mining operations at the site found that, in a typical year, about 5 million tons of rock was mined to generate 220,000 tons of vermiculite product. Primary waste materials were waste rock and tailings, with lesser amounts of oversize rock and screening plant concentrate wastes. As higher quality ores were depleted and lesser quality ores were mined, various reagents were used to facilitate the separation. Reported reagents included #2 Diesel Fuel, Armeen T (tallow alkyl amine), fluorosilicic acid, and lesser quantities of flocculants, defoamers, frothers and other reagents. In addition, the application of oil on mine roads as a dust control measure was also reported.

2.4 Ecological Setting

2.4.1 Terrestrial Habitats and Tree Species

The mined area is heavily disturbed by past mining activity and some areas remain largely devoid of vegetation. Outside the mined area, most of OU3 is forested, with only 4% of the land being classified as non-vegetated (U.S. Department of Agriculture Forest Service Region 1 [USDAFSR1] 2008). Data for the Kootenai National Forest indicate Douglas fir forest type is the most common, covering nearly 35% of the National Forest land area within OU3. Next in abundance are the lodgepole pine forest and spruce-fir forest types at 17% each, and the western larch forest type at 11%. Other tree species reported in the area are the Black Cottonwood (*Populus trichocarpa*), Quaking Aspen (*Populus tremuloides*), Western Paper Birch (*Betula papyrifera var. occidentalis*) and Pacific Yew (*Taxus brevifolia*) (USDAFSR1 2008).

Figure 2-6 presents a vegetative cover map based on remote sensing data developed by the Wildlife Spatial Analysis Lab at the University of Montana in Missoula (Fisher *et al.* 1998). Based on this mapping, the vegetative cover around the mine site is predominantly Douglas fir, lodgepole pine, and mixed mesic forest.

2.4.2 Aquatic Species

Rainy Creek Watershed

The Montana National Heritage Program (MNHP) lists 25 species of fish that are known or reasonably expected to occur in the area of OU3 (see **Appendix B**). Of these, 12 are considered to be possible inhabitants of waters in the Rainy Creek watershed. These species include brook trout (*Salvelinus fontinalis*), brown trout (*Salmo trutta*), Columbia River redband trout (*Oncorhynchus mykiss gairdneri*), fathead minnow (*Pimephales promelas*), largescale sucker (*Catostomus macrocheilus*), longnose dace (*Rhinichthys cataractae*), longnose sucker (*Catostomus catostomus*), mottled sculpin (*Cottus bairdi*), mountain whitefish (*Prosopium williamsoni*), rainbow trout

(*Oncorhynchus mykiss*), torrent sculpin (*Cottus rhotheus*), and westslope cutthroat trout (*Oncorhynchus clarkii lewisi*). The Montana Fish Wildlife and Parks (MFWP) reports that the westslope cutthroat trout is a year-round resident in both upstream Rainy Creek and upstream Carney Creek. Fish surveys performed as part of EPA's investigations at the site indicate that the most common species of fish captured by electroshocking in OU3 streams are western cutthroat trout, rainbow trout, "cutbow" trout (a rainbow/cutthroat hybrid), and brook trout (see Section 7.1 below).

It is expected that Rainy Creek is suitable habitat for a variety of aquatic invertebrate species, but survey data are limited. MNHP states that invertebrates known or reasonably anticipated to occur in OU3 include a freshwater sponge (*Heteromeyenia baileyi*), a stonefly (*Utacapnia columbiana*), and a caddisfly (*Agapetus montanus*). MNHP also notes seven types of amphibians, including chorus frogs (*Hylidae*), woodland and true salamanders (*Plethodontidae*), tailed frogs (*Ascaphidae*), true frogs (*Ranidae*), and true toads (*Bufonidae*) (see **Appendix B**). Aquatic invertebrate community surveys performed as part of EPA's investigations at the site indicate that the most common types of aquatic invertebrates observed in OU3 include mayflies (*Baetis, Cinygmula, Diphetor*), stoneflies (*Zapada, Capniidae*), caddisflies (*Cheumatopsyche, Hydropsyche*), true flies (*Simulium*), and beetle larvae (*Zaitzevia, Heterlimnius*) (see Section 7.2 below).

Kootenai River

The EPA Environmental Monitoring and Assessment Program (EMAP) collected aquatic community data at a station on the Kootenai River about 1 mile downstream of the confluence with Rainy Creek. This location was sampled in August 2002. Forty-four species of aquatic invertebrates were observed, including oligocheates, insects (diptera, ephemeroptera, trichoptera and hemiptera), colenterates (hydra), mollusks, and nematodes (**Table 2-3**). Eleven species of fish were observed (**Table 2-4**). Mountain whitefish were most commonly observed; along with several species of salmonids (rainbow trout, sockeye salmon, cutthroat trout, bull trout) and several species forage fish (dace, shiner, sculpin).

2.4.3 Wildlife Species On or Near the Libby OU3 Site

In order to identify wildlife species likely to occur in OU3, information available from the MNHP was consulted. First, using the MNHP Animal Tracker web page[2], all species known to occur within Lincoln County, Montana, were identified. Next, the MNHP and MFWP Animal Field Guide[3] were consulted to determine if a particular species was observed in the vicinity of OU3. Species not identified within the vicinity of OU3, and those not expected to occur at OU3 based on a consideration of available habitat, were removed. The species that remained are listed in **Appendix B**, along with information on general habitat requirements, habitat type for foraging and nesting, feeding guild, typical food, migration and hibernation, longevity, home range, and size. The year of the oldest and the most recent recorded sighting and the number of individuals identified are also indicated.

[2] http://nhp.nris.mt.gov/Tracker/
[3] http://fieldguide.mt.gov/

The species identified as residing all or part of the year within OU3 include 29 invertebrates (26 terrestrial and three aquatic), seven amphibians, seven reptiles, 175 birds, and 48 mammals (see **Appendix B**).

2.4.4 Federal and State Species of Special Concern

There are seven federally-listed protected species that may occur in Lincoln County, including 2 fish, 3 mammals, and 2 plants. These are listed in **Table 2-5**. Species of concern to the State of Montana that may occur in Lincoln County are listed in **Table 2-6**. This includes 3 amphibians, 2 reptiles, 17 birds, 8 mammals, 8 fish, 10 invertebrates, and 46 plants. However, not all of these species are equally likely to occur within OU3. Based on an evaluation of where the species was reported within Lincoln County, the following listed species are considered to be the most likely to occur in OU3:

- Bull Trout (*Salvelinus confluentus*)
- White Sturgeon (*Acipenser transmontanus*) (Kootenai River only)
- Torrent Sculpin (*Cottus rhotheus*)
- Westernslope Cutthroat Trout (*Oncorhynchus clarkii lewisi*)
- Grizzly Bear (*Ursus arctos horribilis*)
- Canada Lynx (*Lynx canadensis*)
- Flammulated Owl (*Otus flammeolus*)
- Northern Goshawk (*Accipiter gentilis*)
- Coeur d'Alene Salamander (*Plethodon idahoensis*)
- Boreal Toad, Green (also known as Western Toad) (*Bufo boreas*)
- Spalding’s Campion (*Silene spaldingii*)

Section 3 – Problem Formulation

Problem formulation is a systematic planning step that identifies the major concerns and issues to be considered in an ecological risk assessment, and describes the basic approaches that will be used to characterize ecological risks (EPA 1997). As discussed in EPA (1997), problem formulation is generally an iterative process, undergoing refinement as new information and findings become available.

The initial ecological risk assessment problem formulation was developed in 2008 (EPA 2008a). The following sections summarize the conceptual site model (CSM) and the management goals developed for the site, along with assessment techniques that were used at OU3 to evaluate potential ecological risks.

3.1 Conceptual Site Model

A CSM is a schematic summary of what is known about the nature of source materials at a site, the pathways by which contaminants may migrate through the environment, and the scenarios by which receptors may be exposed to site-related contaminants.

The property in and around the former vermiculite mine and the geographic area surrounding the mine, designated as OU3, may be impacted by releases and subsequent migration of asbestos and non-asbestos contaminants due to historical mining and milling activities. These areas provide habitat to a wide range of ecological receptors. **Figure 3-1** presents the CSM for exposure of each general ecological receptor group (fish, aquatic invertebrates, amphibians, terrestrial plants, soil invertebrates, birds, mammals) to mining-related non-asbestos contaminants. As seen, each receptor group may be exposed by several different pathways. However, not all pathways are equally likely to be important. In this CSM, pathways are divided into three main categories:

- A solid black circle (●) represents pathways that are believed to be complete, and which may provide an important contribution to the total risk to a receptor group.

- An open circle (○) represents an exposure pathway that is believed to be complete, but which is unlikely to be a major contributor to the total risk to a receptor group, at least in comparison to one or more other pathways that are evaluated.

- An open box represents an exposure pathway that is believed to be incomplete (now and in the future) and the pathway is not assessed in this ecological risk assessment.

The following sections provide a more detailed discussion of the main elements of the CSM.

3.1.1 Potential Sources of Contamination

As discussed in Section 2.3, the main sources of non-asbestos contamination at this site are the mine wastes generated by historic vermiculite mining and milling activities. This includes piles of waste rock and waste ore at on-site locations, as well as the coarse tailings pile and the fine tailings impoundment. In addition, some chemicals used at the mine site in the processing of vermiculite ore might also be present in on-site wastes, including diesel fuel, alkyl amines, fluorosilicic acid, and various other flocculants, defoamers, frothers, and other reagents. In addition, past use of the application of oil on mine roads as a dust control measure was also reported. Thus, a broad suite of non-asbestos contaminants, including both inorganic and organic contaminants, may be present at the mine site.

3.1.2 Migration Pathways

Air Transport. Contaminants in soil or mine waste may become suspended in air and transported from source areas *via* wind. Once airborne, contaminants may move with the air and then settle and become deposited onto surface soils.

Surface Transport. Contaminants may be carried in surface water runoff (e.g., from rain or snowmelt) from the mine, or other areas where soil is contaminated, and become deposited in soils or sediments at downstream locations. This pathway is known to have resulted in the transport of tailings and other mine wastes downstream in Rainy Creek waters and sediments.

Uptake into Living Organisms. Contaminants may be taken up from environmental media, such as water, sediment, or soil, into the tissues of aquatic or terrestrial organisms that may serve as forage or prey for other species higher on the food chain.

3.1.3 Receptors of Concern and Potential Exposure Pathways

As discussed in Section 2.4, there are a large number of ecological species that are known to occur or might reasonably be expected to occur in OU3 and that could be exposed to mine-related contaminants. However, it is generally not feasible or necessary to evaluate risks to each species individually. Rather, it is usually appropriate to group receptors with similar behaviors and exposure patterns and to evaluate the risks to each receptor group.

Aquatic Receptors

There are several categories of aquatic receptors that are known to occur at the site, including fish, aquatic invertebrates, and amphibians. For most aquatic receptors, the chief exposure pathway of concern is direct contact with surface water that is impacted by site releases. For aquatic invertebrates, another important exposure pathway is direct contact with sediment and sediment porewater.

Aquatic receptors may also be exposed to contaminants through the ingestion of aquatic prey items and from incidental ingestion of sediment. Ingestion exposures by aquatic receptors may be important for contaminants that bioaccumulate, but for contaminants that do not strongly accumulate, ingestion exposure *via* the food web is usually believed to be minor compared to exposures from direct contact pathways. In addition, toxicity information based on ingestion exposures in aquatic receptors is limited. Consequently, this pathway is not evaluated quantitatively in this assessment.

Likewise, some aquatic receptors (mainly amphibians) may be exposed by dermal contact with contaminated soils or sediments, but this pathway is suspected to be relatively minor compared to oral and/or direct contact with water exposures, and methods are not currently available to support reliable quantitative evaluation of the dermal contact pathway for aquatic receptors.

Plants and Soil Invertebrates

The structure and function of the terrestrial plant and invertebrate community is important because it provides a significant portion of the energy, organic matter, and nutrient inputs for terrestrial systems. Plant communities also provide habitat and forage for a variety of wildlife species. Terrestrial plants and soil organisms are good indicators of soil condition because they reside directly in the soil and are not mobile.

The primary exposure pathway for soil invertebrates is direct contact with contaminated soils. For terrestrial plants, the primary exposure pathway is direct contact of the roots with contaminants in soil. Contact may also occur *via* dust deposition on foliar (leaf) surfaces. However, because foliar surfaces have an insoluble waxy coating (cuticle) that limits chemical uptake, exposures due to foliar deposition are believed to be minor compared to root exposures.

Birds and Mammals

Birds and mammals may be exposed to site-related contaminants by three primary pathways: 1) ingestion of contaminants in or on prey items; 2) incidental ingestion of soil and/or sediment while feeding; and 3) ingestion of contaminated water. Direct contact (i.e., dermal exposure) of birds and mammals to water, sediment, and soil may occur in some cases, and inhalation exposure to non-asbestos contaminants in airborne dusts is possible for all birds and mammals, but these exposure pathways (i.e., dermal and inhalation) are usually considered to be minor in comparison to exposures from ingestion (EPA 2005a).

Reptiles

Several types of reptiles (turtles and snakes) have been observed in OU3 ponds. These organisms may be exposed to site-related contaminants by direct contact and ingestion of water or sediment, and by ingestion of prey items. However, methods for quantifying exposure and risk to snakes and turtles are not well developed, so a quantitative evaluation is not attempted for this group of receptors.

3.2 Management Goals and Evaluation Endpoints

3.2.1 Management Goals

Management goals are descriptions of the basic objectives that the risk manager and risk assessors wish to achieve. The overall management goal identified for ecological health at the OU3 site for non-asbestos contamination is:

> Ensure that non-asbestos contaminants from the mine do not cause unacceptable impacts on ecological receptors within OU3. An unacceptable impact is generally defined as environmental contamination that interferes with the ability of local communities of biota to maintain a healthy and self-sustaining population (EPA 1999).

To provide greater specificity regarding the overall management goal and to identify specific measurable ecological values to be protected, the following list of sub-goals was derived:

- Ensure that non-asbestos contaminants from the mine in surface water and sediment do not cause unacceptable impacts to aquatic communities in Rainy Creek, Fleetwood Creek, the tailings impoundment, the Mill Pond, the Carney Creek Pond, and Carney Creek.

- Ensure that non-asbestos contaminants in soils and mine waste materials within the mined area do not cause unacceptable impacts to terrestrial plant and soil invertebrate communities.

- Ensure that non-asbestos contaminants in biota and environmental media within the mined area and site drainages do not cause unacceptable impacts to bird and mammal populations.

3.2.2 Definition of Assessment Population

A "population" can be defined in multiple ways. To prevent miscommunication in risk assessment and risk management, use of the term "assessment population" is recommended (EPA 2003). For the OU3 site, the assessment populations are defined as the groups of organisms that reside in locations that have been impacted by mining-related releases. For exposure to non-asbestos contaminants in OU3, this is believed to be restricted to two groups:

- Receptors living in or about the mined area

- Receptors living in or along the drainages associated with the mined area

3.2.3 Assessment Endpoints

Assessment endpoints are explicit statements of the characteristics of the ecological system that are to be protected. Because the risk management goals are formulated in terms of the protection of populations and communities of ecological receptors, the assessment endpoints selected for use in this problem formulation focus on endpoints that are directly related to the management goals, such as mortality, growth, and reproduction.

3.2.4 Measurement Endpoints

Measurement endpoints are quantifiable environmental or ecological characteristics that can be measured, interpreted, and related to the valued ecological components chosen as the assessment endpoints (EPA 1997, 1998).

There are a number of different techniques available for measuring the impact of site releases on assessment endpoints and assessing whether or not risk management goals are achieved. These basic strategies were used to evaluate risks for ecological receptors as OU3. Each strategy is discussed in more detail below.

Hazard Quotient Approach

A hazard quotient (HQ) is the ratio of the estimated exposure of a receptor to a "benchmark" that is believed to be without significant risk of unacceptable adverse effect:

HQ = Exposure / Toxicity Benchmark

Exposure may be expressed in a variety of ways, including:

- Concentration of a contaminant in an environmental medium (water, sediment, diet, and soil)
- Concentration of a contaminant in tissue of an exposed receptor
- Amount of a contaminant that is ingested by an exposed receptor (dose)

In all cases, the site exposure and the toxicity benchmark must be expressed in the same units. For example, surface water concentrations expressed as milligrams per liter (mg/L) must be compared to benchmarks expressed as mg/L. Ideally, the benchmark is selected to represent the threshold for a toxicity endpoint that is relevant to population sustainability (e.g., mortality, growth, reproduction). **Appendix E** provides details on the toxicity benchmarks selected for use in this assessment.

If the value of an HQ is less than or equal to 1, then it is assumed that the risk of unacceptable adverse effects to the receptor is acceptable. If the HQ exceeds 1, the risk of adverse effects to the receptor may be of concern. It is further assumed that the probability and/or severity of adverse effects increase as the value of the HQ increases.

When interpreting HQ results for non-threatened or endangered receptors, it is important to remember that the assessment endpoint is based on the sustainability of exposed populations, and risks to some individuals in a population may be acceptable if the population is expected to remain healthy and stable. In these cases, population risk is characterized by quantifying the fraction of individual HQ values greater than 1, and by the magnitude of the exceedances. The fraction of the HQ values that must be less than 1 in order for the population to remain stable depends on the species being evaluated and toxicological endpoint underlying the toxicity benchmark. In addition, reliable characterization of the impact of a chemical stressor on an exposed population requires knowledge of population size, birth and death rates, as well as immigration and emigration rates. Because this type of detailed knowledge of population dynamics is generally not available on a site-specific basis, extrapolation from a distribution of individual HQ values to a characterization of population-level risks is generally uncertain. In this assessment, the distributions of HQ values are interpreted as follows:

- If all or nearly all of the individual HQ values are less than 1, it is unlikely that unacceptable population-level effects will occur in the exposed population.

- If all or nearly all of the individual HQ values are greater than 1, then it is likely that unacceptable population-level effects will occur in the exposed population, especially if the HQ values are large.

- If only a small portion of the individual HQ values are greater than 1, then some individuals may be impacted, but population-level effects are not expected to occur. As the fraction of individual HQ values greater than 1 increases, and as the magnitude of the exceedances increases, risk that a population-level effect will occur also increases. This concept is illustrated in **Figure 3-2**.

HQ values are predictions and are subject to the uncertainties that are inherent in both the estimates of exposure and the estimates of toxicity benchmarks. Therefore, HQ values above 1 should be interpreted as indicators of potential risk, rather than definitive evidence that adverse effects are occurring.

Site-Specific Toxicity Testing

Site-specific toxicity tests measure the response of receptors exposed to site media. Testing may be done in the field (*in situ*) or in the laboratory using media collected from the site. The primary advantage of direct toxicity testing is that it can account for site-specific conditions and mixtures of contaminants that can influence toxicity. The results of toxicity testing reflect the combined effect of the mixture of chemicals present in the site medium. A potential disadvantage is that, if toxic effects are observed, it may not be possible to specify which chemical or combination of chemicals is responsible for the effect. Also, it is often difficult to test the full range of environmental conditions which may occur across time and space, either in the field or in the laboratory, and the studies may not be adequate to identify the boundary between acceptable exposures and those that are not.

Population and Community Demographic Observations

A third approach for evaluating effects of environmental contamination on ecological receptors is to make direct observations on the receptors in the field. These studies seek to determine if any receptor population has unusual numbers of individuals (either lower or higher than expected), or whether the diversity (number of different species) of a particular category of receptors (e.g., plants, aquatic organisms, small mammals, birds) is different than expected. The primary advantage of this approach is that direct observations of demographics do not require making the numerous assumptions and estimates needed in the HQ approach. A limitation of this approach is that both the abundance of individuals and the diversity of communities depend on site-specific factors (e.g., habitat quality, availability of food, predator pressure, etc.). It is often difficult to know what the expected (non-impacted) abundance and diversity of an ecological population should be in a particular area. This problem is generally approached by seeking an appropriate "reference area" (either the site itself before the impact occurred, or some similar site that has not been impacted), and comparing the observed abundance and diversity in the reference area to that for the site. Sometimes, it is not possible to locate reference areas that are a good match for the important habitat variables. Thus, comparisons based on this approach do not always establish firm cause-and-effect conclusions. In addition, because populations in the wild fluctuate due to natural processes, population comparisons may require several years of data to make meaningful comparisons.

In-Situ Measures of Exposure and Effects

An additional approach for evaluating the possible adverse effects of environmental contamination on ecological receptors is to make direct observations of receptors in the field, seeking to identify if individuals have higher exposure (tissue) levels or a higher than expected frequency of observed lesions and/or deformities. This type of information is usually interpreted by comparing data from the site to data from one or more reference areas. If significant increases in tissue burden are observed, this is evidence of a site-related exposure. However, evidence of increased exposure does not necessarily imply that adverse effects are occurring. If increases in the frequency and/or severity of effects are observed in on-site receptors, then this is direct evidence for a site-related effect. Depending on the effects observed, it is sometimes difficult to establish a strong relationship between those effects and the assessment endpoints of survival, growth, and reproduction.

Weight of Evidence Approach

As noted above, each of the measurement endpoints has advantages and limitations. For this reason, conclusions based on only one method of evaluation may be misleading. Therefore, the best approach for reaching reliable conclusions is to combine the findings across all of the methods for which data are available, taking the relative strengths and weaknesses of each method into account. If the methods all yield similar conclusions, confidence in the conclusion is increased. If different methods yield different conclusions, then a careful review must be performed to identify the basis of the discrepancy (if possible), and to decide which approach provides the most reliable information. In this risk assessment, the weight of evidence evaluation is performed qualitatively, based primarily on a consideration of the amount, quality, and relevance of the data available for each line of evidence.

3.3 Overview of OU3 Assessment Approach

Figure 3-3 provides a flow diagram that illustrates the strategy that was followed for evaluating potential ecological risks from non-asbestos contaminants in OU3. The first step is to compile measurements of non-asbestos concentrations that have been collected for site media. Next, relevant toxicity benchmarks, or toxicity reference values (TRVs), are assembled for each chemical in each exposure medium for each ecological receptor group. Then, an initial HQ screen is performed (see Section 5). There are four possible outcomes of this initial HQ screen:

- For chemicals that were not detected in site media and for which no TRVs are available, these chemicals are evaluated qualitatively in the Uncertainty Assessment (see Section 9).

- For detected chemicals for which no TRVs are available, it is not possible to calculate an HQ value. However, it is possible to determine if a release of the chemical has occurred by comparing measured chemical concentrations in site media to levels in an appropriate reference area. If site concentrations are similar to levels in the reference area, then it is probable that a release of the chemical has not occurred and no further assessment is needed. However, if site concentrations are elevated relative to the reference area, a site-related release of the chemical may have occurred and this information can be evaluated as part of the Uncertainty Assessment (see Section 9).

- For chemicals that were not detected in site media for which TRVs are available, a detection limit adequacy assessment is performed. To assess adequacy, the method-specific practical quantitation limit (PQL) is compared to an appropriate screening-level TRV. If the PQL is less than the TRV, the analytical method would have reliably detect the chemical if it were present at a level of potential concern and, because results were non-detect, no further assessment is needed. If the PQL is greater than the TRV, the analytical method did not have adequate sensitivity to reliably detect the chemical if it were present at a level of potential concern. These chemicals are discussed further as part of the Uncertainty Assessment (see Section 9).

- For detected chemicals with appropriate TRVs, a conservative initial HQ screen is performed. In this screen, the maximum detected concentration for each chemical in each medium is compared to an appropriate screening-level toxicity benchmark, yielding the maximum HQ for that medium (HQmax). If the HQmax does not exceed 1, it is concluded that risks from that chemical in that medium are acceptable and that further assessment is not required. If the HQmax is greater than or equal to 1, a refined HQ evaluation is performed.

The refined HQ evaluation (see Section 6) uses refined estimates of the exposure concentration, exposure parameters, and toxicity values (when available). Estimated HQ values from the refined evaluation are interpreted by considering the frequency, magnitude, and spatial pattern of HQ exceedances. There are two possible outcomes of this refined HQ screen:

- If the results of the refined HQ evaluation indicate that the frequency and magnitude of HQ exceedances is low, and an evaluation of the spatial pattern does not indicate localized areas of elevated risk, it is concluded that risks from that chemical in that medium are acceptable and that further assessment is not required.

- If HQ exceedances indicate the potential for unacceptable risks, then a comparison of concentrations in site media to levels in the reference area is performed. If site concentrations are similar to levels in the reference area, then it is probable that no release of the chemical occurred and no further assessment is needed. If site concentrations are elevated relative to the reference area, additional lines of evidence (e.g., site-specific toxicity tests, population surveys) are evaluated to characterize potential ecological risks as part of the weight of evidence approach (see Section 10).

Section 4 – Data Summary

Data needed to support the ecological risk assessment for OU3 have been collected as part of the RI at OU3. The RI has been performed in a phased approach. Each phase of data collection is conducted in accordance with phase-specific sampling and analysis plans (SAPs). The respective SAPs for each sampling program provide the detailed data quality objectives and study designs for each data collection effort. Each of the sampling programs that collected data in support of the evaluation of potential risks from non-asbestos contaminants at OU3 are discussed briefly below.

Phase I of the RI was performed in the fall of 2007 in accordance with the *Phase I Sampling and Analysis Plan for Operable Unit 3* (EPA 2007a). The primary goal of the Phase I investigation was to obtain preliminary data on the levels and spatial distribution of asbestos and also other non-asbestos chemicals that might have been released to the environment in the past as a consequence of the mining and milling activities at the site.

Phase II of the RI was performed in the spring, summer, and fall of 2008. Part A of Phase II (EPA 2008b) focused on the collection of data non-asbestos chemicals in surface water and sediment, as well as site-specific toxicity testing of surface water using rainbow trout. Part C of Phase II (EPA 2008c) focused on the collection of site-specific sediment toxicity data, as well as the collection of community demographic data for both fish and aquatic invertebrates to support the ecological risk assessment at the site.

Phase III of the RI was performed in the spring, summer, and fall of 2009 in accordance with EPA (2009). Phase III included the collection of a variety of ecological community and habitat metrics for fish and aquatic invertebrates in support of the ecological risk assessment.

Phase IV (Part B) of the RI (EPA 2011) was performed in the summer of 2011, and included collection of data on stream flow, temperature, and other habitat characteristics of OU3 streams. No new data on the concentration of non-asbestos contaminants in water or sediment were obtained.

Phase V (Part B) of the RI (EPA 2012a) was performed in the spring and summer of 2012, and included performing several ecological investigations for fish and amphibians to support the asbestos ecological risk assessment. No new data on the concentration of non-asbestos contaminants in water or sediment were obtained.

The following sections summarize the non-asbestos chemical data for each environmental medium sampled, the habitat and community evaluations, and the site-specific toxicity tests for OU3. This includes all data that were available in September 2011 (the date that the ecological risk assessment for non-asbestos contaminants was initiated), as well as some more recent data, collected in 2012 to support the asbestos ecological risk assessment, that are considered to add meaningful additional information.

4.1 Chemical Data

Sampling of environmental media for non-asbestos chemicals focused on the collection of surface water, sediment, and mine wastes/soils, since these are the media most likely to have been impacted by site-related releases. **Appendix C** provides the analytical results for non-asbestos chemicals for the Phase I and Phase II samples.

4.1.1 Surface Water

Figure 4-1 identifies the on-site locations where samples of surface water and sediment were collected during the Phase I and Phase II sampling programs. In Phase I, surface water samples were collected in October 2007 at a total of 24 locations along Carney Creek, Fleetwood Creek, and Rainy Creek, including the ponds and impoundments on these streams, as well as nearby seeps.

In Phase II, surface water samples were collected at the same locations as Phase I, plus additional stations in upper Rainy Creek (URC-1A), Carney Creek pond (CC-Pond), and the upper tailings pond (UTP) as shown in **Figure 4-1** and in the off-site reference areas (Noisy Creek [NSY-R1] and Bobtail Creek [BTT-R1]), as shown in **Figure 4-2**. Surface water samples for non-asbestos chemicals were collected twice from each station, once in June 2008 and once in September 2008.

All surface water samples were analyzed for metals and metalloids, petroleum hydrocarbons, anions, nitrogen-containing compounds, and other water quality parameters. In addition, several selected surface water samples were analyzed for a broad suite of other chemicals, including volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), pesticides, polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAHs), and selected radionuclides.

Table 4-1 shows the non-asbestos analyses that were performed for surface water samples from each station. **Table 4-2** summarizes the analytical results for non-asbestos chemicals that were detected in surface water. Because seeps are usually intermittent and small, they are not considered to be viable habitat for aquatic receptors and are not likely to be an important drinking water source for wildlife receptors. Therefore, surface water samples from seeps were excluded from this assessment and are not included in the summary statistics presented in **Table 4-2**. However, surface water samples from locations that may be impacted by these seeps (i.e., Carney Creek) were included in this assessment.

4.1.2 Sediment

Sediment samples were collected from the same locations and at the same time as surface water samples during Phase I and Phase II (see **Figures 4-1 and 4-2**).The Phase II sediment sampling plan differed from Phase I for the tailings impoundment and each of the ponds (the Mill Pond and the ponds on Carney Creek and Fleetwood Creek) in that each was sampled by collecting a series of grab samples rather than 1-2 composite samples. A total of 17 samples grab samples were collected at the tailings impoundment and five grab samples were collected from each pond. This was done to investigate the degree of spatial variability in sediments.

All sediment samples were analyzed for metals/metalloids, petroleum hydrocarbons, anions, total organic carbon, and other sediment quality parameters. In addition, several selected sediments were analyzed for a broad suite of other chemicals, including VOCs, SVOCs, pesticides, PCBs, PAHs, and cyanide.

Table 4-3 shows the non-asbestos analyses that were performed for sediment samples from each station. **Table 4-4** summarizes the analytical results for non-asbestos chemicals that were detected in sediment. All values are expressed on a dry weight basis. Because sediments at seep locations are not viable habitat for aquatic receptors, sediment samples from seeps were excluded from this assessment and are not included in the summary statistics presented in **Table 4-4**. As noted above, sediment samples from locations that may be impacted by these seeps (i.e., Carney Creek) were included in this assessment.

4.1.3 Mine Waste Materials from the Mined Area

Figure 4-3 identifies the locations where samples of mine waste materials were collected during the Phase I sampling program. As shown, mine waste material samples were collected from a total of 38 locations. Samples were collected from each of the principal mine waste materials that have been identified at the site (mine waste rock, impounded fine tailings, and coarse tailings). Samples were also collected of soils in the former mill area and roadway materials used for construction of unpaved sections of Rainy Creek Road.

All mine waste samples were analyzed for metals/metalloids, anions, and other soil quality parameters. Mine waste rock, tailings, soil from the former mill area, and roadway materials were also analyzed for petroleum hydrocarbons and the three samples of Rainy Creek roadway materials were analyzed for PCBs and PAHs. Samples collected from the fine tailings impoundment were analyzed for a broad suite of other chemicals, including VOCs, SVOCs, pesticides, PCBs, and PAHs.

Table 4-5 shows the non-asbestos analyses that were performed for mine waste samples from each station. **Table 4-6** summarizes the analytical results for detected non-asbestos chemicals in mine wastes. Because materials collected from the unpaved section of Rainy Creek Road are not expected to be viable ecological habitat, these samples were excluded from this assessment and are not included in the summary statistics presented in **Table 4-6**.

4.1.4 Forest Soil

During the Phase I sampling program, 74 surface soil samples were collected from seven transects extending from the mine in each direction into the surrounding forested areas for analysis of asbestos. More recently, a subset of 12 forest soil samples from the distal ends of 3 downwind transects and 3 cross-wind/upwind transects (see **Figure 4-4**) were selected for the analysis of metals/metalloids to provide site-specific data on concentrations in soils that are likely to be representative of reference conditions (i.e., not impacted by mining activities).

Table 4-7 presents summary statistics for the samples from the downwind transects and the cross-wind/upwind transects. Statistical comparisons of these two datasets were made using the two-sample hypothesis testing approach for datasets with non-detects (Gehan test) provided in ProUCL v4.00.05 (EPA 2010a). There was no statistically significant difference between samples from the downwind transects and the cross-wind/upwind transects. Thus, the two datasets were combined (see **Table 4-8**) for the purposes of performing statistical comparisons of reference soil to on-site mine waste materials.

4.1.5 Chemical Data Validation

All data on the concentration of non-asbestos chemicals in site media were validated in accordance with EPA's National Functional Guidelines. Data validation reports are provided in **Appendix D**. The raw data provided in **Appendix C** include all assigned validation qualifiers. Any samples that were R-qualified (rejected) by the data validator were excluded from any risk calculations. All other data presented in this data summary were deemed valid and appropriate for use in the risk assessment.

4.1.6 Data Adequacy Evaluation

An evaluation of data adequacy is performed in two steps. The first step is to determine if the data are representative in space and time. This is usually a qualitative assessment. The second step is to determine if the data are statistically adequate. For data to be used for evaluation of risks to ecological receptors, statistical adequacy considers the magnitude of the uncertainty in the measured concentrations, the proximity of the exposure concentration to a decision threshold, and whether the uncertainty is too large to support confident decision-making.

The *Phase III Sampling and Analysis Plan for Operable Unit 3* (EPA 2009) included a detailed evaluation of the adequacy of available non-asbestos data for surface water, sediment, mine waste materials and soil at the OU3 site to determine if additional sampling was needed (as part of the Phase III investigation) to support risk management decision-making. In brief, available non-asbestos data from OU3 were found to be spatially and temporally representative, since multiple surface water and sediment samples were collected from each major segment of the OU3 watershed during three different times of year. Statistical adequacy was determined based on a review of the number of samples collected for each media in each exposure area and the coefficient of variation across measured concentration values (see EPA 2009 for detailed results). Surface water and sediment data were determined to be adequate to support the HQ line of evidence.

For mine waste materials, because the mined area continues to be disturbed by heavy machinery, and may undergo remedial actions due to potential concerns over LA releases, it was determined that collection of additional data on non-asbestos contaminants in mine waste materials was not necessary to support decision-making

(EPA 2009). Likewise, for forest soil, it was shown that impacts from non-asbestos contaminants to soils in the forested area surrounding the mine were likely to be minimal, and additional data were not needed for risk management decision-making (EPA 2009).

Thus, it was concluded that available data for non-asbestos contaminants in surface water, sediment, mine waste materials and soil were adequate to support risk management decision-making for ecological receptors and that no further non-asbestos contaminant sampling was needed in subsequent RI sampling programs (EPA 2009).

4.2 Habitat and Community Evaluations

During the 2008 and 2009 field seasons (Phase III sampling effort), direct observations of the fish and aquatic invertebrate communities were made at nine stream locations including two in Upper Rainy Creek (URC-1A and URC-2), four in Lower Rainy Creek (LRC-1, LRC-2, LRC-3, and LRC-5), one location downstream of the tailings impoundment (TP-TOE2) and at two off-site reference locations (BTT-R1 and NSY-R1) (see **Figures 4-1 and 4-2**).

Because variations in habitat can contribute to differences in aquatic populations between stations, a habitat assessment was also completed at each location during the Phase III sampling effort, using procedures from the EPA Rapid Bioassessment Protocol (RBP) (Plafkin *et al.* 1989; Barbour *et al.* 1999). Ten alternative measures of habitat quality were combined to yield a Habitat Assessment Score for each sampling location that reflects overall habitat quality. For each site sampling location, a relative score (as % of reference) was also calculated. This relative score indicates how closely site habitat quality was matched to the reference station.

In the summer and fall of 2011 (during the Phase IV Part B sampling effort), supplemental habitat information was collected that provided a clearer picture of habitat quality for fish. This investigation included the collection of data on the number and types of pools present in site streams, as well as temperature monitoring data for these pools. These data were collected to support an evaluation of habitat quality using the Habitat Suitability Index (HSI) model for rainbow trout.

The results of the habitat and community evaluations are presented in Section 7.

4.3 Site-Specific Toxicity Tests

4.3.1 Surface Water

As part of the Phase II sampling effort, water collected from the tailings impoundment (station TP) was used in a site-specific surface water toxicity test. The toxicity test design is detailed in the *Phase II Part A Sampling and Analysis Plan* (EPA 2008b). In brief, the test was conducted with newly hatched larval (sac fry) rainbow trout (*Oncorhynchus mykiss*) under static renewal conditions for an exposure duration of 6 weeks. Survival, behavior, and growth were observed during the exposure period, and the histopathology of the fish was examined at the end of the study.

The results of this site-specific surface water toxicity test are discussed in Section 8.1.

4.3.2 Sediment

As part of the Phase II sampling effort, two on-site locations (CC-1 and TP-TOE2) and two off-site reference locations (BTT-R1 and NSY-R1) were selected for site-specific sediment toxicity testing. The toxicity test design is detailed in the *Phase II Part C Sampling and Analysis Plan* (EPA 2008c). Selected sediment samples were tested for toxicity using the amphipod *Hyalella azteca* in a 42-day test (EPA Test Method 100.4) for measuring the effects of sediment associated contaminants on survival, growth, and reproduction (EPA 2000). Sediment samples were also tested for toxicity to the midge *Chironomus tentans* using the life-cycle test (EPA Test Method 100.5) for measuring effects on survival, growth, and reproduction (EPA 2000).

The results of these site-specific sediment toxicity tests are discussed in Section 8.2.

Section 5 – Initial Hazard Quotient Screening Evaluation

The ecological risk characterization process begins with a conservative initial HQ screen (see **Figure 3-3**). The goal of this screen is to eliminate from further consideration any contaminants, media, or receptor groups for which risks are clearly below a level of concern. Chemicals, media, and receptors that are not eliminated are then retained for further evaluation. Chemicals with concentrations above toxicity benchmarks are retained as chemicals of potential concern (COPCs) and are evaluated further in the refined HQ evaluation (Section 6). Chemicals that lack toxicity benchmarks are evaluated qualitatively in the Uncertainty Assessment (see Section 9).

5.1 Direct Contact of Aquatic Receptors with Surface Water

5.1.1 Exposure Assessment

For the initial HQ screen, exposure of aquatic receptors was based on the maximum detected concentration of each analyte in surface water (see **Table 4-2**). For metals in surface water, concentration values may be expressed either as total recoverable or as "dissolved" (that which passes through a fine-pore filter). There is general consensus that toxicity to aquatic receptors is dominated by the level of dissolved chemicals (Prothro 1993), since chemicals that are adsorbed onto particulate matter may be less toxic than the dissolved forms. Therefore, the initial HQ screen utilized the maximum detected dissolved metal concentrations.

5.1.2 Toxicity Assessment

Toxicity benchmark values for the protection of aquatic receptors (including fish, aquatic invertebrates, and amphibians) from direct contact with chemicals in surface water are available from several sources. In general, two different types of aquatic toxicity benchmark are identified – acute and chronic. The acute toxicity benchmark is intended to protect against short-term (48-96 hour) lethality, while the chronic toxicity benchmark is intended to protect against long-term effects on growth, reproduction, and survival. In the initial HQ screen, HQ calculations utilized chronic toxicity benchmarks.

Each of the sources evaluated in the selection of surface water toxicity benchmarks is described in detail in **Appendix E**. In establishing the hierarchy for surface water benchmarks, greater weight was given to sources that utilized data from multiple studies across multiple aquatic species in the derivation of the toxicity value and sources that have undergone peer-review. Thus, the selection of the surface water chronic toxicity benchmarks for aquatic receptors was based on the following hierarchy:

- Chronic National Ambient Water Quality Criteria (NAWQC) for the protection of aquatic life in freshwater (EPA 2012b)

- Great Lakes Water Quality Initiative (GLWQI) Tier II secondary chronic values (Suter and Tsao 1996)
- EPA Region 4 chronic screening values (EPA 2001a)
- Canadian Council of Ministers of the Environment (CCME) Water Quality Guidelines (WQGs) (CCME 2012)
- Oak Ridge National Laboratory (ORNL) lowest chronic values (LCVs) and effect concentrations for 20% of exposed organisms (EC_{20}) values (Suter and Tsao 1996)

For many metals and metalloids, the NAWQC values are dependent upon the hardness of the water (i.e., the precise value of the chronic NAWQC is calculated from the water hardness). In the initial HQ screen, the toxicity benchmarks for metals that are hardness-dependant were calculated based on the lowest measured hardness (68 mg/L) in surface water samples from the site.

5.1.3 Initial HQ Screen Results

Table 5-1 presents the initial HQ screen for surface water for direct contact exposures by aquatic receptors. For each detected chemical in surface water, this table shows the maximum detected concentration, the selected chronic toxicity benchmark, and the calculated HQmax.

Two metals (dissolved barium and dissolved manganese), fluoride, and nitrite in surface water had HQmax values above 1 and were retained as COPCs for further evaluation in the refined HQ evaluation (see Section 6).

5.2 Direct Contact of Aquatic Invertebrates with Sediment

5.2.1 Exposure Assessment

For the initial HQ screen, direct contact exposure of aquatic invertebrates was based on the site-wide maximum detected concentration of each analyte in sediment (see **Table 4-4**).

5.2.2 Toxicity Assessment

Toxicity benchmark values for the protection of aquatic invertebrates from direct contact with sediment are available from several sources in the literature. Depending on the details of the toxicity study design, most sediment-based benchmarks also include oral exposure due to ingestion of food present in the sediments, thus the resulting toxicity values account for both direct contact and oral exposure pathways.

Often two types of toxicity benchmarks are derived – a threshold effect concentration (TEC) and a probable effect concentration (PEC). Sediment toxicity should be observed only rarely below the TEC and should be frequently observed above the

PEC. If sediment concentrations are between the TEC and PEC, then risks are possible, but would generally be expected to be of limited severity. For the purposes of the initial HQ screen, the TEC-based toxicity benchmark was used. All sediment benchmarks are expressed on a dry weight basis.

Each of the sources evaluated in the selection of sediment toxicity benchmarks is described in detail in **Appendix E**. In establishing the hierarchy for sediment benchmarks, several sources were excluded from use due to inadequate documentation of derivation methodology, use of site-specific assumptions, use of marine or estuarine sediments, use of inappropriate receptors, or errors in benchmark derivation. Of the remaining sources, greater weight was given to sources that utilized data from multiple studies across multiple aquatic species in the derivation of the toxicity value and sources that have undergone peer-review. A benchmark selection hierarchy was established for each chemical class of compounds analyzed in sediment. The selection hierarchy is shown in **Figure 5-1**.

5.2.3 Initial HQ Screen Results

Table 5-2 presents the initial HQ screen for sediment for direct contact exposures by aquatic invertebrates. For each detected chemical in sediment, this table shows the maximum detected concentration, the selected TEC-based toxicity benchmark, and the calculated HQmax.

Seven metals (aluminum, cadmium, chromium, copper, lead, manganese, and nickel) and three PAHs (benzo(b)fluoranthene, benzo(k)fluoranthene, and naphthalene) in sediment had HQmax values above 1 and were retained as COPCs for further evaluation in the refined HQ evaluation (see Section 6).

5.3 Direct Contact of Plants and Terrestrial Invertebrates with Soils and Mine Waste Materials

5.3.1 Exposure Assessment

For the initial HQ screen, direct contact exposure of terrestrial plants and invertebrates was based on the site-wide maximum detected concentration of each analyte in soils and mine waste materials (see **Table 4-6**). All soil and mine waste concentrations are expressed on a dry weight basis. It is assumed that concentrations of site-related contaminants in soils outside the mined area are not higher than in mine wastes present at the mine site.

5.3.2 Toxicity Assessment

Screening-level toxicity benchmarks for the protection of terrestrial plants and invertebrates from exposure to contaminants in surface soils are available from several sources. Each of the sources evaluated in deriving soil toxicity benchmarks is described briefly in **Appendix E**. In establishing the hierarchy for soil toxicity benchmarks, several sources were excluded from use due to inadequate documentation of derivation methodology (i.e., the basis of the derived value was not clearly specified) or because they were not primary sources. Of the remaining sources, greater weight was given to the Ecological Soil Screening Levels[4] (EcoSSLs) because they utilized data from multiple studies in the derivation of the toxicity benchmark value and because these values have undergone review. Thus, the selection of the soil toxicity benchmarks for plants and terrestrial invertebrates was based on the following hierarchy:

- EcoSSLs for plants and soil invertebrates
- ORNL screening benchmarks for plants and soil organisms (Efroymson *et al.* 1997a,b)
- Dutch target values for soil (Swartjes 1999)

For the purposes of the initial HQ screen, the lowest soil toxicity benchmark (across benchmarks for plants and terrestrial invertebrates) was used. All soil benchmarks are expressed on a dry weight basis.

5.3.3 Initial HQ Screen Results

Table 5-3 presents the initial HQ screen for soil and mine waste materials for plants and terrestrial invertebrates. For each detected chemical in mine waste materials, this table shows the maximum detected concentration, the lowest soil toxicity benchmark, and the calculated HQmax.

Eight metals (barium, chromium, cobalt, copper, manganese, mercury, nickel, and vanadium) in mine waste materials had HQmax values above 1 and were retained as COPCs for further evaluation in the refined HQ evaluation (see Section 6).

5.4 Wildlife Ingestion of Soils and Mine Waste Materials

5.4.1 Exposure Assessment

For the initial HQ screen, ingestion exposure of wildlife to mine waste materials was based on the maximum detected concentration of each analyte in mine waste (see **Table 4-6**).

5.4.2 Toxicity Assessment

Soil-based toxicity benchmarks for wildlife are available in the literature for some chemicals. Each of the sources evaluated in deriving soil-based toxicity benchmarks is described briefly in **Appendix E**. In brief, EcoSSLs for birds and wildlife were preferentially selected for use because they are derived from toxicity data drawn from multiple studies across multiple species and because these values have undergone review. For chemicals where an EcoSSL was not available, the following approach was used:

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[4] Individual documents for each metal and organic chemical evaluated as part of the EcoSSL program are provided at: http://www.epa.gov/ecotox/ecossl/

- If dose-based TRVs were available from Engineering Field Activity West (EFAW) (EFAW 1998), soil-based toxicity benchmarks for wildlife were back-calculated from the dose-based TRVs using assumed ingestion rates and uptake factors for terrestrial prey items in accordance with the EcoSSL methodology (EPA 2005a). Details on the derivation of soil-based toxicity benchmarks for wildlife are provided in **Appendix E**.

- If dose-based TRVs were not available from EFAW (1998) but a food-based concentration screening value was derived in Sample *et al.* (1996), this value was used as a conservative screening value for soil.

- If dose-based TRVs were available in the primary literature, soil-based toxicity benchmarks for wildlife were back-calculated from the dose-based TRVs using assumed ingestion rates and uptake factors for terrestrial prey items in accordance with the EcoSSL methodology (EPA 2005a). Details on the derivation of soil-based toxicity benchmarks for wildlife are provided in **Appendix E**.

In the initial HQ screen, the lowest soil value across mammals and birds was selected as the screening value.

5.4.3 Initial HQ Screen Results

Table 5-4 presents the initial HQ screen for soil and mine waste materials for wildlife exposures. For each detected chemical in mine waste materials, this table shows the maximum detected concentration, the selected soil-based toxicity benchmark for wildlife, and the calculated HQmax.

Nine metals (antimony, barium, chromium, copper, lead, mercury, nickel, vanadium, and zinc) in soil and mine waste materials had HQmax values above 1 and were retained as COPCs for further evaluation in the refined HQ evaluation (see Section 6).

5.5 Wildlife Ingestion of Sediment

5.5.1 Exposure Assessment

For the initial HQ screen, ingestion exposure of wildlife to sediment was based on the site-wide maximum detected concentration of each analyte in sediment (see **Table 4-4**).

5.5.2 Toxicity Assessment

Sediment-based toxicity benchmarks for wildlife were back-calculated from available dose-based TRVs using assumed ingestion rates and uptake factors for two surrogate aquatic invertivore receptors – the American dipper and the big brown bat. Details on the derivation of sediment-based toxicity benchmarks for wildlife are provided in **Appendix E**. In brief, sediment screening values were derived for each receptor based on receptor-specific exposure parameters (i.e., intake rates, body weight, dietary composition), assuming a target HQ of 1, and using 90th percentile sediment-to-aquatic invertebrate accumulation factors, as provided in *Biota Sediment Accumulation Factors for Invertebrates: Review and Recommendations for the Oak Ridge Reservation* (Bechtel Jacobs Company, LLC [BJC] 1998). In the initial HQ screen, the lowest sediment value (across wildlife receptors) was selected as the screening value.

5.5.3 Initial HQ Screen Results

Table 5-5 presents the initial HQ screen for sediment for ingestion exposures by wildlife. For each detected chemical in sediment, this table shows the maximum detected concentration, the selected sediment-based toxicity benchmark for wildlife, and the calculated HQmax.

As shown, twelve metals (arsenic, barium, chromium, cobalt, copper, lead, manganese, mercury, nickel, selenium, vanadium, and zinc) in sediment had HQmax values above 1 and were retained as COPCs for further evaluation in the refined HQ evaluation (see Section 6).

5.6 Wildlife Ingestion of Surface Water

5.6.1 Exposure Assessment

For the initial HQ screen, ingestion exposure of wildlife to surface water was based on the site-wide maximum detected concentration of each analyte in surface water (see **Table 4-2**). For ingestion of water by wildlife, concentration values of metals in surface water are based on the total recoverable fraction, since all metal forms (both dissolved and bound to particulates) are ingested during drinking.

5.6.2 Toxicity Assessment

Sample *et al.* (1996) provides water-based screening values for wildlife. These water values were back-calculated for a variety of wildlife receptors and are protective of piscivorous wildlife (i.e., the back-calculation included exposures from fish ingestion). For the purposes of the initial HQ screen, the lowest toxicity benchmark (across mammalian and avian wildlife species) was used.

5.6.3 Initial HQ Screen Results

Table 5-6 presents the initial HQ screen for surface water for ingestion exposures by wildlife receptors. For each detected chemical in surface water, this table shows the maximum detected concentration, the selected water-based toxicity benchmark for wildlife, and the calculated HQmax.

One metal in surface water (total recoverable aluminum) had an HQmax value above 1 and was retained as a COPC for further evaluation in the refined HQ evaluation (see Section 6).

5.7 Summary

Table 5-7 summarizes the list of COPCs identified from the initial HQ screen for each exposure medium and each receptor group. These COPCs were retained for further evaluation in the refined HQ evaluation (see Section 6).

Section 6 – Refined Hazard Quotient Evaluation

In the refined HQ evaluation, attention is focused only on those chemicals, exposure pathways, and receptors that were identified for further evaluation during the initial HQ screening process (i.e., the COPCs) (see Section 5). In the refined HQ evaluation, the HQ is calculated using somewhat more realistic (but still conservative) exposure assumptions than those of the initial HQ screen.

Table 6-1 summarizes the differences between the initial HQ screen and the refined HQ evaluation with respect to the parameters selected and methods used in the exposure assessment, effects (toxicity) assessment, and risk characterization. The results of the refined HQ evaluation are intended to provide additional information on the likelihood that a particular ecological risk exists and to identify those chemicals and exposure pathways associated with potential risks. Results of the refined HQ evaluation are combined with other lines of evidence in the weight of evidence evaluation to determine if risks are acceptable.

The refined HQ evaluations for each receptor group from each exposure pathway are presented below.

6.1 Direct Contact of Aquatic Receptors with Surface Water

6.1.1 Exposure Assessment

As shown in **Table 5-7**, dissolved barium, dissolved manganese, fluoride, and nitrite were identified as COPCs for exposures to aquatic receptors from direct contact with surface water.

In the refined HQ evaluation, each sample of surface water is viewed as representing an environmental exposure location in which one or more aquatic organisms may be exposed. Thus, HQ values were calculated for each surface water sample. For the purposes of this assessment, non-detects (U-qualified) were evaluated at one-half the reported value.

6.1.2 Toxicity Assessment

In the refined HQ evaluation, risks to aquatic receptors are evaluated both for short-term (acute) and long-term (chronic) exposure conditions. There are no NAWQC for any COPCs for the protection of freshwater aquatic life. A report by ORNL (Suter and Tsao 2006) provides GLWQI Tier II secondary acute values (SAVs) and secondary chronic values (SCVs) for barium and manganese.

For barium, the GLWQI Tier II toxicity values are based on four studies conducted between 1972 and 1990 for four aquatic invertebrate species; a freshwater flea (*Daphnia magna*), two amphipod species (*Echinogammarus berilloni* and *Gammarus pulex*), and the New Zealand mud snail (*Potamopyrgus jenkinsi*). Although these species may not be representative of invertebrate species in OU3, this value was used to evaluate risks to aquatic invertebrates. Because no fish species were evaluated, the GLWQI Tier II toxicity values for barium cannot be used to assess potential risks to fish.

For manganese, the GLWQI Tier II toxicity values are based on two studies for four species, including three aquatic invertebrate species (*Asellus spp.*, *Crongonyx spp.*, and *Daphnia spp.*) and one fish species (*Pimephales spp.*). Although these species may not be representative of aquatic invertebrate and fish species occurring in OU3, the toxicity values were used to estimate HQ values.

The CCME has derived WQGs for fluoride and nitrite; these values are screening levels that are intended to be protective of freshwater aquatic life (CCME 2012). No information as to the supporting toxicity dataset for the CCME WQG for nitrite was located (CCME 2012).

For fluoride, the derivation of the CCME WQG included an evaluation of acute and chronic toxicity for a variety of aquatic species. The interim guideline was derived from the lowest acceptable adverse effect level reported, which was a lethal concentration for 50% of exposed individuals (LC50) value for the caddisfly (*Hydropsyche*). Because this was an acute value derived from an endpoint of lethality, a safety factor of 100 was applied in deriving the interim WQG (CCME 2002). The CCME WQG derivation guidelines acknowledge that the selected safety factors are arbitrary and may be too conservative for many substances (CCME 2007). For the purposes of this refined HQ evaluation, and based on a review of the available toxicity data, the fluoride toxicity value identified by CCME WQG was modified to reflect a safety factor of 10, resulting in a modified toxicity value of 1,200 micrograms per liter (µg/L). This modified toxicity value is below the acute and chronic effects data for fluoride presented in CCME (2002) and is similar to the EC_{20} value for aquatic populations reported in Suter and Tsao (1996).

Table 6-2 summarizes the surface water toxicity values for COPCs used in the calculation of refined HQ values.

6.1.3 Refined HQ Evaluation Results

Figures 6-1 to 6-4 present the surface water HQ values, grouped by reach, for each COPC, respectively. In these scatter plots, several different reaches are shown, including URC, the upper portion of the tailings impoundment (UTP), Fleetwood Creek, the tailings impoundment (TP), the toe of the tailings impoundment (TP-TOE), the Mill Pond, LRC, Carney Creek, and the two off-site reference areas. The Fleetwood Creek and Carney Creek drainages are displayed in the relative locations where they enter Rainy Creek.

The data in these figures are interpreted as discussed in Section 3.2.4, considering the frequency and magnitude of HQ values above 1:

- For barium, HQ values for aquatic invertebrates in Rainy Creek downstream of Fleetwood Creek tend to be higher than HQ values in Upper Rainy Creek or the off-site reference areas. The highest HQ values are seen in Carney Creek. Chronic HQ values for all surface water samples and acute HQ values for most samples are above 1, with chronic HQ values up to 250 and acute HQ values up to 9. Because the frequency and magnitude of HQ exceedances is high, these results suggest that concentrations of barium in surface water may be adversely impacting aquatic invertebrates and that effects could be severe. However, chronic and acute HQ values for surface water samples from the off-site reference locations and Upper Rainy Creek also have a high frequency and magnitude of HQ exceedances. Because HQ values above 1 are not generally expected in reference areas, this suggests that the selected SAV and SCV for barium may be too conservative and site HQ values for aquatic invertebrates may be overestimated.

- For manganese and nitrite, with the exception of one sample, acute and chronic HQ values are below 1 in all reaches. For manganese, concentrations in one sample from the toe of the tailings impoundment slightly exceeded the SCV (HQ of 1.2). For nitrite, concentrations in one sample from the tailings pond exceeded the WQG (HQ of 1.3); nitrite concentrations in most water samples were non-detect. Because the frequency and magnitude of HQ exceedances is low, these results indicate that surface water concentrations of manganese and nitrite are not adversely impacting aquatic receptors at the OU3 site.

- For fluoride, HQ values are below 1 for all samples. These results indicate that surface water concentrations of fluoride are not adversely impacting aquatic receptors at the OU3 site.

Based on the distribution of HQ values, the risk to aquatic receptors as estimated by the refined HQ approach is as follows:

COPC	Risk Based on HQ Distribution	
	Based on Chronic	Based on Acute
Barium	Severe*	Severe*
Manganese	Minimal	None
Fluoride	None	--
Nitrite	Minimal	--

-- = no benchmark; HQ values were not derived

* HQ values > 1 in reference areas

6.1.4 Statistical Comparison to Reference

Statistical comparisons to reference were performed using the procedures recommended in EPA's *Guidance for Comparing Background and Chemical Concentrations in Soil for CERCLA Sites* (EPA 2002a). Statistical comparisons were made using the two-sample hypothesis testing approach for datasets with non-detects (Gehan test) provided in ProUCL v4.00.05 (EPA 2010a). Reference evaluations for surface water (see **Table 6-3**) were performed based on a comparison of concentrations from on-site sampling stations to off-site reference stations (i.e., Noisy Creek [NSY-R1], Bobtail Creek [BTT-R1]) and Upper Rainy Creek [URC] stations.

This analysis indicated that dissolved barium and fluoride concentrations (and hence HQ values) were elevated in site surface water relative to reference (i.e., dissolved manganese and nitrite concentrations in site surface water were not statistically different from reference). Thus, it is considered unlikely that the concentrations of manganese or nitrite are elevated due to releases from the mine, and that any risks that may exist to aquatic receptors are not site-related. However, any risks that may exist from barium or fluoride may be attributable to site releases.

6.1.5 Conclusion

Dissolved barium, dissolved manganese, fluoride, and nitrite were identified as COPCs for exposures to aquatic receptors from direct contact with surface water. Comparisons of COPC concentrations in site surface water to reference stations indicated that elevated levels of barium and fluoride in surface water are likely site-related. Refined HQ calculations showed that risks to aquatic receptors from barium in surface water had the potential to be severe and widespread. However, there is low confidence in the HQ values for barium because risks were also predicted in reference areas. In addition, the underlying data used to develop the barium toxicity value were limited (i.e., no toxicity data for fish species).

6.2 Direct Contact of Aquatic Invertebrates with Sediment

6.2.1 Exposure Assessment

As shown in **Table 5-7**, seven metals (aluminum, cadmium, chromium, copper, lead, manganese, and nickel) and three PAHs (benzo(b)fluoranthene, benzo(k)fluoranthene, and naphthalene) were identified as COPCs for aquatic invertebrate exposure to sediment.

Although concentrations of chemicals in sediment are usually not as time-variable as concentrations in surface water, sediment concentrations do fluctuate as contaminated material is added or removed by surface water flow. In addition, there may be significant small-scale variability in sediment concentrations at any specific sampling station. Therefore, exposure of aquatic invertebrates to sediments is usually best characterized as a distribution of individual values at a specific location.

In the refined HQ evaluation, each sample of sediment is viewed as representing an environmental exposure location in which aquatic invertebrates may be exposed. Thus, HQ values were calculated for each sediment sample. For the purposes of this assessment, non-detects (U-qualified) were evaluated at one-half the reported value. All concentration values in sediment are on a dry weight basis.

6.2.2 Toxicity Assessment

In the refined HQ evaluation, risks to aquatic invertebrates are evaluated based on both the TEC and PEC sediment benchmarks. As noted previously, sediment toxicity is not expected to be significant at concentrations below the TEC, but may be significant at concentrations above the PEC. If sediment concentrations are between the TEC and PEC, then risks are possible, but would generally be expected to be of lesser severity. **Appendix E** presents each of the sources evaluated in deriving sediment toxicity benchmarks. A benchmark selection hierarchy was established for each chemical class of compounds analyzed in sediment. The selection hierarchy is shown in **Figure 5-1**.

Table 6-4 provides the selected TEC and PEC toxicity benchmark values for COPCs for aquatic invertebrates for direct contact with sediment used in the refined HQ evaluation. As shown, most toxicity benchmarks are based on the consensus-based TEC and PEC values provided by MacDonald *et al.* (2000). Toxicity benchmarks for aluminum, manganese, benzo(b)fluoranthene, and benzo(k)fluoranthene are based on threshold effect levels and probable effect levels for *Hyalella* reported by Ingersoll *et al.* (1996). All sediment benchmarks are expressed on a dry weight basis.

6.2.3 Refined HQ Evaluation Results

Figures 6-5 to 6-14 present the sediment HQ values for each COPC grouped by reach, respectively. In these scatter plots, several different reaches are shown, including Upper Rainy Creek (URC), the upper portion of the tailings impoundment (UTP), Fleetwood Creek, the tailings impoundment (TP), the toe of the tailings impoundment (TP-TOE), the Mill Pond, Lower Rainy Creek (LRC), Carney Creek, and the two off-site reference areas. The Fleetwood Creek and Carney Creek drainages are displayed in the relative locations where they enter Rainy Creek.

The data in these figures are interpreted as discussed in Section 3.2.4, considering the frequency and magnitude of HQ values above 1:

- For aluminum, copper, and lead, HQ values based on the TEC benchmark are frequently above 1 for site creeks and ponds, but with the exception of copper, none of the HQ values based on the PEC benchmark were above 1. For copper, concentrations in one sample from the Mill Pond and two samples in Carney Creek pond were slightly above the PEC benchmark (maximum HQ of 1.2). In general, HQ values based on the TEC benchmark tend to be below 1 for the reference areas and Upper Rainy Creek. These HQ values indicate that sediment concentrations of aluminum, copper, and lead in some areas of the OU3 site are at levels where adverse impacts to aquatic invertebrates may occur. Based on the magnitude of the HQ exceedances based on the PEC benchmark, any impacts from these metals are likely to be minimal.

- For chromium, manganese, and nickel, HQ values based on the PEC benchmark are frequently above 1 at site locations. For chromium and nickel, HQ values tend to be highest for sediment samples collected from the tailings impoundment, the

Mill Pond, and in Carney Creek. For manganese, HQ values tend to be highest for sediment samples collected from toe of the tailings impoundment. In general, HQ values based on the TEC benchmark tend to be below 1 for the reference areas and Upper Rainy Creek. These HQ values indicate that sediment concentrations of chromium, nickel, and manganese in some areas of the OU3 site are above levels where adverse impacts to aquatic invertebrates are expected. Based on the magnitude of the HQ exceedances, these impacts have the potential to be moderate to severe.

- For cadmium, HQ values based on the TEC benchmark are less than or equal to 1 for all sediment samples. HQ values based on the PEC benchmark are all well below 1. These HQ values indicate that sediment concentrations of cadmium are not adversely impacting aquatic invertebrates at the OU3 site.

- For benzo(b)fluoranthene and benzo(k)fluoranthene, detected concentrations of these chemicals were only reported in 1-2 sediment samples (<3% of all samples). However, the PQL achieved for most samples was above the TEC benchmark but below the PEC benchmark. Given that the detection frequency was low and the achieved PQLs were adequate with respect to the PEC benchmark, it is unlikely that these PAHs are adversely impacting aquatic invertebrates at the OU3 site.

- For naphthalene, only 2 sediment samples (both from the tailings impoundment) reported detected concentrations. The HQ values based on the PEC benchmark for both samples were above 1, with HQ values up to 5. The PQL achieved for all non-detect samples was below the PEC benchmark. Given that the detection frequency was low in the tailings impoundment (only 2 of 35 samples were detect), the achieved PQLs were adequate with respect to the PEC benchmark, and naphthalene was not detected in any other samples, it is unlikely that naphthalene is adversely impacting aquatic invertebrates at the OU3 site.

Based on the distribution of HQ values, the risk to aquatic invertebrates as estimated by the refined HQ approach is as follows:

COPC	Risk Based on HQ Distribution	
	Based on TEC	Based on PEC
Aluminum	Minimal-Moderate	None
Cadmium	None	None
Chromium	High-Severe	Moderate-High
Copper	Moderate-High*	Minimal
Lead	Moderate	None
Manganese	Moderate-Severe*	Minimal-Severe*
Nickel	Moderate-High	Moderate
Benzo(b)fluoranthene	[a]	--
Benzo(k)fluoranthene	[a]	--
Naphthalene	None-Minimal [a]	None-Minimal

-- = no benchmark; HQ values were not derived

[a] Non-detect HQ values > 1
* HQ values > 1 in reference areas

6.2.4 Statistical Comparison to Reference

Statistical comparisons of COPC concentrations in site sediments to reference were performed using the statistical procedures recommended in EPA (2002a) using the two-sample hypothesis testing approach for datasets with non-detects (Gehan test) provided in ProUCL v4.00.05 (EPA 2010a). Reference evaluations for sediment (see **Table 6-5**) were performed based on a comparison of concentrations from on-site stations to reference stations (i.e., Noisy Creek [NSY-R1], Bobtail Creek [BTT-R1]) and Upper Rainy Creek [URC] stations.

This analysis indicated that the distribution of concentration values (and hence HQ values) at on-site sampling stations were not statistically different from reference stations for cadmium and the three PAHs. Consequently, it is considered unlikely that the concentrations of these COPCs are elevated due to releases from the mine, and that any risks that may exist to aquatic invertebrates from these COPCs are not site-related. However, concentrations of aluminum, chromium, copper, lead, manganese, and nickel were statistically higher than reference, so risks associated with these COPCs may be attributable to site releases.

6.2.5 Conclusion

Seven metals (aluminum, cadmium, chromium, copper, lead, manganese, and nickel) and three PAHs (benzo(b)fluoranthene, benzo(k)fluoranthene, and naphthalene) were identified as COPCs for aquatic invertebrate exposure to sediment. Comparisons of COPC concentrations in site sediment to reference stations indicated that elevated levels of aluminum, chromium, copper, lead, manganese, and nickel in sediment are likely site-related. Refined HQ calculations showed that risks to aquatic invertebrates from chromium, manganese, and nickel in sediment had the potential to be moderate to severe depending upon the sampling location, with the OU3 ponds tending to have higher predicted risks than the creeks.

6.3 Direct Contact of Plants and Terrestrial Invertebrates to Soils and Mine Waste Materials

6.3.1 Exposure Assessment

As shown in **Table 5-7**, eight metals (barium, chromium, cobalt, copper, manganese, mercury, nickel, and vanadium) in site mine waste materials were identified as COPCs for plants and terrestrial invertebrates.

For the purposes of the refined HQ evaluation, each sampling location is evaluated as a potential exposure point and the HQ values are characterized as a distribution of individual values, stratified according to the type of soil or mine waste material – coarse tailings, cover soil, rock from outcrops in the mined area, fine tailings from exposed (not inundated) areas of the impoundment, and waste rock. For the purposes of this assessment, non-detects (U-qualified) were evaluated at one-half the reported value.

6.3.2 Toxicity Assessment

In the refined HQ evaluation, risks to plants and terrestrial invertebrates were evaluated separately. **Appendix E** presents each of the sources evaluated in deriving soil toxicity benchmarks for plants and terrestrial invertebrates. **Table 6-6** presents the soil toxicity benchmark values for COPCs for plants and terrestrial invertebrates used in the refined HQ evaluation. As shown, toxicity benchmarks for barium (invertebrates only), cobalt (plants only), copper, manganese, and nickel are based on the EcoSSLs. Toxicity benchmarks for barium (plants only), mercury, and vanadium (plants only) are based on the screening levels provided by ORNL (Efroymson *et al.* 1997a,b).

For chromium, toxicity benchmarks are available for exposures to hexavalent chromium, but not trivalent chromium. Because most chromium in soil tends to be the trivalent form (ATSDR 2008), and because hexavalent chromium is generally thought to be more toxic than trivalent chromium (Efroymson *et al.* 1997a), it was concluded that use of the benchmarks for hexavalent chromium would inappropriately overestimate risk, so no HQ values were derived for chromium.

Toxicity benchmarks for terrestrial invertebrates were not available for cobalt or vanadium.

6.3.3 Refined HQ Evaluation Results

Figures 6-15 to 6-21 present refined HQ values for plants (Panel A) and terrestrial invertebrates (Panel B) for each COPC, respectively, grouped by the type of mine waste material sampled (coarse tailings, cover soil, outcrop, tailings impoundment, and waste rock). In addition, these figures also present HQ values for the 12 reference soil samples collected from the forested area surrounding OU3.

The data in these figures are interpreted as discussed in Section 3.2.4, considering the frequency and magnitude of HQ values above 1. Inspection of Panel A in these figures reveals the following for plants:

- For barium, cobalt, manganese, and nickel, HQ values are frequently above 1 for on-site mine waste materials, with HQ values ranging up to about 5. These data support the conclusion that elevated concentrations of these metals in mine waste materials at the OU3 site may be adversely impacting plants, with potential effects ranging from moderate to high. However, HQ values for cobalt, manganese, and nickel were also at or above 1 for reference soils, which indicates that the toxicity benchmarks for these COPCs may be too low and HQ values may be overestimated.

- For copper and mercury, HQ values for onsite materials are at or below 1. These data support the conclusion that concentrations of these COPCs in on-site mine waste materials at the OU3 site are not of significant concern to plants.

- For vanadium, HQ values are above 1 for all samples, including both on-site mine waste materials and reference soils, with HQ values ranging from 3 to 60. These data support the conclusion that adverse impacts to plants from vanadium have the potential to be severe. However, because HQ values are well above 1 for reference soils, this suggests that on-site HQ values may be overestimated.

Inspection of Panel B in these figures reveals the following for terrestrial invertebrates:

- For copper and nickel, HQ values for on-site mine waste materials are at or below 1. These data support the conclusion that concentrations of these COPCs in mine waste material at the OU3 site are not of significant concern to terrestrial invertebrates.

- For manganese, HQ values for a few samples are above 1 for on-site mine waste materials, with HQ values ranging up to about 2-3. These data support the conclusion that manganese concentrations in mine waste materials at the OU3 site may have minimal impacts on terrestrial invertebrates. However, HQ values were also at or above 1 for several reference soil samples, which indicates that the manganese toxicity benchmarks for terrestrial invertebrates may be too low and HQ values may be overestimated.

- For mercury, only one sample had an HQ value above 1 for on-site mine waste materials (HQ value of 3). All other samples were non-detect. These data support the conclusion that mercury concentrations in mine waste materials at the OU3 site are likely to have minimal impacts on terrestrial invertebrates.

- For barium, HQ values are frequently above 1 for on-site mine waste materials, with HQ values ranging up to about 10. HQ values were below 1 for the reference soils. These data support the conclusion that elevated concentrations of barium in mine waste materials at the OU3 site may be adversely impacting terrestrial invertebrates, with potential effects being high.

Based on the distribution of HQ values, the risk to plants and terrestrial invertebrates as estimated by the refined HQ approach is as follows:

COPC	Risk Based on HQ Distribution	
	Plants	Invertebrates
Barium	Moderate	High
Chromium	--	--
Cobalt	High*	--
Copper	Minimal	None

COPC	Risk Based on HQ Distribution	
	Plants	Invertebrates
Manganese	Moderate*	Minimal*
Mercury	None	None-Minimal
Nickel	Moderate	None
Vanadium	Severe*	--

-- = no benchmark; HQ values were not derived
* HQ values > 1 in reference areas

6.3.4 Statistical Comparison to Reference

Statistical comparisons of metal concentrations in on-site mine waste materials to concentrations in reference soils from the forested areas surrounding OU3 (see **Table 6-7**) were performed using the statistical procedures recommended in EPA (2002a) using the two-sample hypothesis testing approach for datasets with non-detects (Gehan test) provided in ProUCL v4.00.05 (EPA 2010a).

This analysis indicated that the distribution of concentration values (and hence HQ values) at site locations are not statistically different from reference soil for copper, manganese, and mercury. Consequently, it is considered unlikely that the concentrations of these metals are elevated due to releases from the mine, and that any risks associated with these metals are not site-related. However, concentrations of barium, chromium, cobalt, nickel, and vanadium were statistically higher than reference, so risks associated with these COPCs may be attributable to site releases.

6.3.5 Conclusion

Eight metals (barium, chromium, cobalt, copper, manganese, mercury, nickel, and vanadium) in site mine waste materials were identified as COPCs for plants and terrestrial invertebrates. Comparisons of COPC concentrations in site mine waste materials to reference soil indicated that elevated levels of barium, chromium, cobalt, nickel, and vanadium in mine waste materials are likely site-related. Refined HQ calculations showed that risks to plants from barium, cobalt, nickel, and vanadium had the potential to be moderate to severe, and risks to terrestrial invertebrates from barium could be high. Refined HQ calculations for chromium could not be performed due to the lack of toxicity benchmarks for trivalent chromium.

6.4 Wildlife Ingestion Exposures

6.4.1 COPCs

Table 5-7 presents the COPCs that were identified for wildlife (i.e., birds and mammals). The only COPC identified in the initial HQ screen for wildlife exposures from ingestion of surface water and fish was aluminum (based on total recoverable concentrations).

Twelve metals (arsenic, barium, chromium, cobalt, copper, lead, manganese, mercury, nickel, selenium, vanadium, and zinc) were retained as COPCs for wildlife for exposure from incidental ingestion of sediment and ingestion of aquatic invertebrates.

Nine metals (antimony, barium, chromium, copper, lead, mercury, nickel, vanadium, and zinc) were retained as COPCs for wildlife for exposure from incidental ingestion of mine waste materials and ingestion of terrestrial prey items (e.g., plants, terrestrial invertebrates, small mammals).

6.4.2 Exposure Assessment

Basic Equation

The basic equation used for calculation of exposure of a wildlife receptor to a chemical by ingestion of an environmental medium is:

$$Daily\ \ Intake_{i,j,r} = C_{i,j} \times IR_{j,r} \times DF_{j,r} \times AUF_{r}$$

where:

Daily $\text{Intake}_{i,j,r}$ = average daily ingested dose of chemical "i" in medium "j" by receptor "r"

$C_{i,j}$ = Concentration of chemical "i" in medium "j" (e.g., milligrams per kilogram, dry weight [mg/kg dw])

$IR_{j,r}$ = Intake rate of medium "j" by receptor "r" (e.g., kilograms, dry weight of medium per kilogram body weight [BW] per day [kg dw/kg BW/d])

$DF_{j,r}$ = Dietary fraction of medium "j" by receptor "r" derived from site

AUF_r = Area use factor by receptor “r”

Surrogate Wildlife Receptors

It is not feasible to evaluate exposures and risks for every bird and mammal species potentially present at the site. For this reason, surrogate species were selected to serve as representatives of several different avian and mammalian feeding guilds. For wildlife groups that ingest terrestrial prey items, the surrogate species selected for evaluation in the EcoSSL guidance (EPA 2005a) were also used in this assessment, including:

- Avian herbivore – Mourning Dove (*Zenaida macroura*)
- Avian insectivore – American Woodcock (*Scolopax minor*)
- Avian carnivore – Red-tailed Hawk (*Buteo jamaicensis*)

- Mammalian herbivore – Meadow Vole (*Microtus pennsylvanicus*)
- Mammalian insectivore – Short-tailed Shrew (*Blarina spp.*)
- Mammalian carnivore – Long-tailed Weasel (*Mustela frenata*)

For wildlife groups that ingest aquatic invertebrates and/or emerging insects, one avian and one mammalian insectivore were selected:

- Avian insectivore – American Dipper (C*inclus mexicanus*)
- Mammalian insectivore – Big Brown Bat (*Eptesicus fuscus*)

For wildlife groups that ingest fish, one avian and one mammalian piscivore were selected:

- Avian piscivore – Belted Kingfisher (*Ceryle alcyon*)
- Mammalian piscivore – Mink (*Mustela vison*)

Wildlife Exposure Factors

For wildlife groups that ingest terrestrial prey items, exposure parameters and dietary intake factors were based values provided in EcoSSL Attachment 4-1, *Exposure Factors and Bioaccumulation Models for Derivation of Wildlife Eco-SSLs* (EPA 2007b). Food ingestion rates were calculated from the mean food intake rates presented in Table 1 of EcoSSL Attachment 4-1. Soil ingestion rates were calculated from the mean values of the fraction of diet that is soil (P_{soil}) provided in Table 3 of EcoSSL Attachment 4-1. Water ingestion rates for terrestrial wildlife were based on values provided in Sample *et al.* (1996).

For wildlife groups that ingest aquatic invertebrates and/or emerging insects or fish, exposure parameters and dietary intake were derived from the *Wildlife Exposure Factors Handbook* (EPA 1993), as well as a variety of other literature sources. In general, wildlife exposure factors were selected to represent average year-round adult exposures. In some cases, no quantitative data could be located, so professional judgment was used in selecting exposure parameters. Detailed information on the available exposure data for these wildlife receptors is provided in **Appendix E** (see Table E-6).

Table 6-8 summarizes the exposure parameters selected for each representative wildlife receptor.

Selecting Exposure Areas

For the purposes of estimating risks to wildlife receptors from incidental ingestion of soil and mine waste materials and ingestion of terrestrial prey items, two different approaches were evaluated to account for differences in wildlife home range sizes.

For wildlife with large home ranges, the entire mine site was evaluated a single exposure area. Exposures were assumed to occur entirely within OU3 (i.e., the area use factor [AUF] is assumed to be 1.0). For wildlife with smaller home range sizes, each sampling location was evaluated as an exposure area.

For the purposes of estimating risks to wildlife receptors from ingestion of surface water, incidental ingestion of sediment, and ingestion of aquatic invertebrates, each drainage reach was evaluated as a separate exposure area.

Exposure Point Concentrations (EPCs)

Large Home Range Receptors

Wildlife receptors are likely to move at random across an exposure area. Therefore, exposure is best characterized as the arithmetic mean concentration across the exposure area. Since the true arithmetic mean concentration cannot be calculated with certainty from a limited number of measurements, EPA recommends that the 95% upper confidence limit (95UCL) of the arithmetic mean for each exposure area be used as the exposure point concentration (EPC) when calculating exposure and risk (EPA 1992).

The mathematical approach that is most appropriate for computing the 95UCL of a data set depends on a number of factors, including the number of data points available, the shape of the distribution of the values, and the degree of censoring (EPA 2002b). Because of the complexity of this process, the EPA Technical Support Center has developed a software application called ProUCL (EPA 2010a) to assist in the estimation of 95UCL values. ProUCL calculates 95UCLs for a data set using several different strategies and recommends which 95UCL is considered preferable based on the properties of the data set. In the calculation of the 95UCL, all results ranked as non-detect were evaluated in ProUCL using Regression on Order Statistics. A minimum of five samples with two or more detected values is required to calculate 95UCLs in ProUCL. If the minimum data requirements for ProUCL are not met, the EPC was set equal to the maximum detected value. If ProUCL provided more than one "recommended" 95UCL to use (e.g., Chebeshev or Bootstrap), the highest recommended value was used as the EPC.

Small Home Range Receptors

In the case where the exposure area is equal to a sampling location (i.e., small home range receptors), exposures are calculated based on the measured concentration for each sample. In this specific evaluation, non-detects (U-qualified) were evaluated at one-half the reported value.

Estimating Dietary Tissue Concentrations

Measured data on concentrations in terrestrial and aquatic dietary items are not available for the site. Therefore, dietary concentrations were estimated using uptake factors and/or bioaccumulation models from the literature. For terrestrial dietary items (i.e., plants, invertebrates, small mammals), tissue concentrations were estimated from soil using the same uptake model sources as those used in the development of the EcoSSLs (EPA 2007b).

For aquatic invertebrates, tissue concentrations were estimated from sediment using median sediment-to-aquatic invertebrate accumulation factors derived by BJC (1998). For COPCs where sediment-to-aquatic invertebrate accumulation factors were not available, an accumulation factor of 1.0 was assumed.

For fish, tissue concentrations were estimated from surface water using bioconcentration factors provided in Sample *et al.* (1996).

Table 6-9 summarizes the uptake equations for each COPC in each type of food item evaluated in the calculation of refined HQ values.

6.4.3 Toxicity Assessment

Dose-based Toxicity Reference Values

For wildlife, two types of dose-based TRVs are often identified in the literature. The first TRV is an estimate of the dose (in units of mg of chemical per kg of body weight per day [mg/kg BW/day]) that is not associated with any adverse effects, and is referred to as the no observed adverse effect level (NOAEL) TRV. The second TRV is an estimation of the dose that causes an observable adverse effect, and is referred to as the lowest observed adverse effect level (LOAEL) TRV.

The true threshold for adverse effects lies between the NOAEL and LOAEL TRVs. It is expected that the adverse effect threshold will vary from species to species within any particular wildlife group. If data are available for the effects thresholds for many different species in a particular group, the data may be rank-ordered to define a species-sensitivity distribution (SSD) for that group. In order to ensure that the HQ values calculated for each representative species are protective of most species within the group, a TRV which represents the lower end of the SSD is preferred. Ideally, toxicity data would be sufficient to define the SSD and support derivation of a TRV for each unique wildlife group selected for evaluation (e.g., avian insectivores, mammalian herbivores, etc.). Unfortunately, available toxicity data for birds and mammals are generally not robust enough to develop SSDs for each group, so a single bird TRV and a single mammal TRV are used to represent all bird and mammal species, respectively.

Because the purpose of this assessment was to evaluate wildlife exposures from ingestion of contaminated media at the OU3 site over the lifetime of the receptor, TRVs derived from studies in which the exposure route was oral (e.g., *via* ingestion in diet or water or *via* gavage) and dosing occurred over a long period of time (chronic exposure) or during a critical life stage period were given preference. In addition, to the extent feasible, wildlife TRVs were selected to represent relevant toxicity endpoints for population sustainability (e.g., growth, reproduction, mortality).

Dose-based TRVs for wildlife were mainly compiled from secondary literature sources. **Appendix E** presents detailed information for each of the sources evaluated in the derivation of wildlife dose-based TRVs. In brief, the following hierarchy was used to select wildlife TRVs:

- EcoSSLs for NOAEL TRVs; TechLaw (2008) for LOAEL TRVs
- EFAW (1998)
- Sample *et al.* (1996)
- Other primary literature sources

Table 6-10 shows the selected dose-based NOAEL and LOAEL TRVs for wildlife used in the refined HQ evaluation.

Relative Bioavailability

Dose-based TRVs from literature studies are generally expressed in units of ingested dose (mg/kg BW/day). However, the toxicity of an ingested dose depends on how much of the ingested dose is actually absorbed, which in turn depends on the properties of both the chemical and the exposure medium. Ideally, toxicity studies would be available that establish empiric TRVs for all site media of concern (water, food, soil, sediment). However, most laboratory tests use either food or water as the exposure medium, and essentially no studies use soil or sediment. Therefore, in cases where a TRV is based on a study in which the oral absorption fraction is different than what would be expected for a site medium, it is desirable to adjust the TRV to account for the difference in absorption whenever data permit.

The ratio of absorption from the study medium compared to absorption from site medium is referred to as the relative bioavailability (RBA). The RBA is used to adjust the TRV as follows:

TRV(adjusted) = TRV(literature) / RBA

For the purposes of this assessment, the RBA for all chemicals in all site media was assumed to be equal to 1.0 (100%). This approach is likely to be realistic for contaminants in water and most food items, but may tend to overestimate exposure and risk from incidental ingestion of soil or sediment. However, no site-specific information on RBA was available which would provide a basis to modify this assumption.

6.4.4 Refined HQ Evaluation Results

Basic Equation

The basic equation for calculating refined HQ values for wildlife receptors is:

$$HQ_{i,j,r} = \frac{Daily\ Intake_{i,j,r}}{TRV_{i,r}}$$

Because all wildlife receptors are exposed to more than one environmental medium, the total HQ to a receptor from a specific chemical is calculated as the sum of HQ values across all media:

$$\text{Total } HQ_{i,r} = \sum HQ_{i,j,r}$$

If the total HQ is less than or equal to one, risk is considered to be acceptable. If the total HQ exceeds one, risk of adverse effects in the exposed organisms may be of potential concern.

Ingestion of Terrestrial Dietary Items and Mine Waste Materials

Appendix H.1 presents the detailed HQ calculations for wildlife receptors that ingest terrestrial prey items, soil and mine waste materials from the OU3 mine area. This appendix provides the EPCs, intake rates, calculated doses, TRVs, and resulting HQ values for each type of wildlife receptor for each COPC.

<u>Small Home Range Receptors</u>

Figure 6-22 shows the total HQ values for small home range wildlife receptors for each COPC. In this figure, each panel represents a different COPC, while the different wildlife receptors are stratified along the x-axis of each graph. In each graph, HQ values are shown for each sampling location, to show the distribution of potential risks to each receptor population. For the purposes of comparison, the distribution of HQ values for the 12 reference soil samples collected from the forested area surrounding OU3 are also shown.

Inspection of these graphs reveals the following:

- For antimony, copper, and zinc, total HQ values based on NOAEL and LOAEL TRVs are below 1 for the mine site for all wildlife receptor groups. These HQ values support the conclusion that levels of these COPCs in mine waste materials are not adversely impacting wildlife receptors.

- For mercury, nickel, and vanadium, total HQ values based on NOAEL TRVs were above 1 for the mine site, with HQ values ranging from 2 to 5. However, reference HQ values based on NOAEL TRVs were also above 1, with HQ values equal to or higher than those for the mine site. Total HQ values based on LOAEL TRVs for the mine site were below 1 for these COPCs. Therefore, these HQ values support the conclusion that concentrations of these COPCs in mine waste materials are not likely to be adversely impacting wildlife receptors.

- For chromium and lead, total HQ values based on NOAEL TRVs are frequently above 1 for insectivores and/or herbivores, with HQ values ranging from 2 to 5. With the exception of insectivorous wildlife, total HQ values based on NOAEL TRVs are not above 1 for other wildlife receptor groups or in reference areas. Total HQ values based on LOAEL TRVs are below 1 for all wildlife receptor groups. These results indicate that, while concentrations of chromium and lead in mine waste materials have the potential to adversely impact herbivorous and insectivorous wildlife receptors, it is unlikely that any adverse effects are occurring.

- For barium, total HQ values based on both NOAEL and LOAEL TRVs are above 1 for avian herbivores and avian insectivores for the mine site. Total HQ values are not above 1 for other wildlife receptor groups or in reference areas. However, for HQ values based on the LOAEL TRV, the frequency and magnitude of HQ exceedances was low (only 4 of 35 HQ values above 1; highest HQ of 2). A review of the study utilized as the basis of the barium TRVs shows that barium exposures ten times higher than the selected NOAEL TRV did not result in any effects in exposed organisms (Sample *et al.* 1996). Therefore, while concentrations of barium in mine waste materials have the potential to adversely impact wildlife receptors, any effects are likely to be minimal.

The data in **Figure 6-22** are interpreted as discussed in Section 3.2.4, considering the frequency and magnitude of HQ values above 1. Based on the distribution of HQ values, the risk to small home range wildlife receptors as estimated by the refined HQ approach is as follows:

COPC	Risk Based on HQ Distribution
Antimony	None
Barium	Minimal
Chromium	None
Copper	None
Lead	None
Mercury	None
Nickel	None
Vanadium	None
Zinc	None

Large Home Range Receptors

Table 6-11 summarizes HQ values based on the EPC for the entire exposure area (i.e., the entire mine site), to show potential exposures to large home range receptors. For the purposes of comparison, HQ values based on the EPC for the reference soil samples collected from the forested area surrounding OU3 are also shown. In general, the discussion presented above for small home range receptors is consistent with the results for large home range receptors (i.e., adverse effects are not expected or likely to be minimal for all COPCs).

Ingestion of Fish and/or Surface Water

Appendix H.2 presents the detailed HQ calculations for wildlife receptors that ingest fish and/or surface water from site drainages. This appendix provides the EPCs for each exposure reach, intake rates, calculated doses, TRVs, and resulting HQ values for each type of wildlife receptor for aluminum.

Table 6-12 summarizes the total HQ values for each exposure reach for each type of wildlife receptor from ingestion of aluminum in fish and/or surface water. For the purposes of comparison, this table also presents HQ values for Upper Rainy Creek and the off-site reference areas. As shown, with one exception, total HQ values are below 1 in all exposure reaches for all wildlife receptors. For piscivorous birds feeding in Fleetwood Creek/Ponds, the total HQ value based on the NOAEL TRV was 4, but the total HQ value based on the LOAEL TRV was less than 1. These results indicate that, while concentrations of aluminum in water have the potential to adversely impact piscivorous birds feeding in Fleetwood Creek/Ponds, it is unlikely that any adverse effects are occurring.

Ingestion of Aquatic Invertebrates and Sediment

Appendix H.3 presents the detailed HQ calculations for wildlife receptors that ingest aquatic (and emerging) invertebrates and sediment from site drainages. This appendix provides the EPCs for each exposure reach, intake rates, calculated doses, TRVs, and resulting total HQ values for each type of wildlife receptor for each COPC. These tables also present total HQ values for Upper Rainy Creek and the off-site reference areas. **Table 6-13** summarizes the total HQ values for each exposure reach for each type of wildlife receptor from ingestion of aquatic invertebrates and sediment.

Inspection of this table reveals the following:

- For arsenic, cobalt, lead, mercury, and zinc, total HQ values based on NOAEL and LOAEL TRVs for all wildlife receptors were less than 1 for all exposure areas. These HQ values support the conclusion that levels of these COPCs in sediment are not likely to be adversely impacting wildlife at the OU3 site.

- For chromium, copper, nickel, and selenium, total HQ values based on NOAEL TRVs were above 1 for one or more site exposure areas (HQ values of 2-3), but total HQ values based on LOAEL TRVs were below 1. These results indicate that concentrations of these COPCs in sediment at the OU3 site have the potential to adversely impact wildlife, but any effects are likely to be minimal.

- For barium, manganese, and vanadium, total HQ values based on LOAEL TRVs were frequently above 1 for most site exposure areas, with HQ values ranging from 2-7. However, information was not available on the uptake of these COPCs from sediment into aquatic invertebrates, thus it was conservatively assumed that the sediment-to-invertebrate accumulation factor was 1.0. Based on a review of available accumulation factors for other COPCs (see **Table 6-9**), with the exception of mercury (which is known to be bioaccumulative), accumulation factors are all less than 1.0. Therefore, it is likely that the estimated HQ values for barium, manganese, and vanadium are biased high and actual risks are lower.

6.4.6 Statistical Comparison to Reference

Statistical comparisons of COPC concentrations in site media to concentrations in reference areas were performed using the statistical procedures recommended in EPA (2002a) using the two-sample hypothesis testing approach for datasets with non-detects (Gehan test) provided in ProUCL v4.00.05 (EPA 2010a). Evaluations for site soils and mine waste materials were performed based on a comparison to concentrations in reference soils from the forested area surrounding OU3. Evaluations for surface water and sediment were performed based on a comparison of concentrations from on-site stations to reference stations (i.e., Noisy Creek [NSY-R1], Bobtail Creek [BTT-R1]) and Upper Rainy Creek [URC] stations.

The following summarizes the wildlife COPCs that were determined to be elevated in site media relative to reference:

- Soil and Mine Waste Materials – barium, chromium, nickel, and vanadium (see **Table 6-14**)
- Surface Water – none (see **Table 6-15**)
- Sediment – barium, chromium, cobalt, copper, lead, manganese, mercury, nickel, selenium, vanadium, and zinc (see **Table 6-16**)

Because concentrations of these COPCs are statistically higher than reference, any risks associated with these COPCs are likely attributable, at least in part, to site releases. For all other COPCs, it is considered unlikely that environmental concentrations of these metals have been elevated due to releases from the mine, and any risks to wildlife are not likely to be site-related.

6.4.6 Conclusion

Several metals (aluminum, antimony, arsenic, barium, chromium, cobalt, copper, lead, manganese, mercury, nickel, selenium, vanadium, and zinc) were identified as COPCs for wildlife receptors in one or more environmental media. Refined HQ calculations showed that risks to wildlife were not expected or likely to be minimal for nearly all receptors and exposure pathways. The exception is potential risks from the ingestion of barium, manganese, and vanadium in aquatic invertebrates. However, due to conservative assumptions about the uptake of these COPCs from sediment into aquatic invertebrate tissues, the calculated HQ values are likely to be biased high and actual risks are lower.

Section 7 – Habitat and Community Evaluation

7.1 Fish Community Surveys

Surveys of fish density and diversity were performed in October 2008 and September 2009. **Figures 4-1 and 4-2** show the locations of the site and reference sampling stations, respectively. In 2008, fish were collected using electroshocking equipment. Multiple passes of electroshocking were performed at each sampling location. In 2009, minnow traps were used in addition to the electroshocking passes in an effort to increase the effectiveness of capturing smaller fish. Length, weight, and species type were recorded for each fish collected. Detailed information on the fish community sampling efforts is provided in Parametrix (2009a; 2010).

Table 7-1 summarizes the results from these sampling efforts (detailed data are provided in **Appendix G**). After a review of the data for fish caught in the minnow traps, it was determined that the openings on these minnow traps may have been too large (~25 millimeters [mm] in diameter) to effectively capture smaller fish (Parametrix 2010). Therefore, fish from the minnow traps were not included in fish community metrics. **Figure 7-1** summarizes the number of fish caught per acre by species at each sampling station during the first and second electroshocking passes[5]. In this figure, larger fish (length > 65 mm) are summarized in Panel A and smaller fish (length ≤ 65 mm) are summarized in Panel B.

Based on the species identification of the larger fish, Lower Rainy Creek stations are populated mainly by rainbow trout, though cutthroat trout were present at station LRC-5 in 2009. Cutthroat trout and cutbow trout (cutthroat/rainbow hybrids) tend to be predominant in Upper Rainy Creek and Noisy Creek. Bobtail Creek tended to be populated with a mixture of brook trout and rainbow trout.

As shown in Panel B of **Figure 7-1**, Lower Rainy Creek stations had no fish ≤ 65 mm in length. This observation suggests that young-of-the-year are not present in Lower Rainy Creek. However, because Lower Rainy Creek is isolated from upward migration of fish from the Kootenai River by a hanging culvert and from downward migration of fish from Upper Rainy Creek by the tailings impoundment (Parametrix 2010), it is apparent that the population in Lower Rainy Creek must be self-sustaining and that young-of-the-year must be present. It is not clear why young-of-the-year fish were not captured in Lower Rainy Creek as part of the 2008 and 2009 sampling efforts. As noted above, the absence of small fish may have been due to sampling issues (e.g., minnow trap openings were too large); however, the presence of fish ≤ 65 mm at other stations suggests that electroshocking was effective in capturing smaller fish in other reaches. It is also possible that the areas selected for electroshocking in

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[5] Because a 3rd electroshocking pass was not performed at all stations, for comparability, this figure presents the total number of fish per acre based on 1st and 2nd pass electroshocking data only.

Lower Rainy Creek were not characteristic of locations where young-of-the-year would be present (i.e., stream channel *vs.* deeper pools) (Parametrix 2010).

Subsequent fish sampling efforts performed in 2012 did result in the collection of fish ≤ 65 mm in length from stations in Lower Rainy Creek. Of the 25 fish collected from the Lower Rainy Creek stations, 11 fish were ≤ 65 mm. One potential reason for the success in observing fish ≤ 65 mm in 2012 but not in 2008/2009 is that young-of-the-year may tend to grow beyond the 65 mm size range by late September (the time frame sampled in the initial studies), whereas sampling occurred in early August in 2012.

7.1.1 Population Modeling

The fish caught during electroshocking represent only a subset of the total population present in the sampling reach. The total fish population was estimated using a mathematical model available in an application referred to as "Microfish" (version 3.0) using a maximum likelihood estimate (MLE) method (Van Deventer and Platts 1989). In this model, when more fish are caught on the second pass than the first pass (this occurred at some sampling locations in both 2008 and 2009, see **Table 7-1**), the population estimate is set equal to 1.5 times the total catch across all electroshocking passes (Van Deventer 2011, pers. comm.).

The Microfish-based MLE population size estimates were used to calculate an estimated fish population density for each sampling station. **Figure 7-2** provides fish density estimates (number of fish per acre) for 2008 and 2009. In this figure, larger fish (length > 65 mm) are summarized in Panel A and smaller fish (length ≤ 65 mm) are summarized in Panel B. Data on fish population density are interpreted by comparing the values for Lower Rainy Creek [LRC] stations to one or more of the reference stations. The Bobtail Creek reference station [BTT-R1] is considered the closest match to Lower Rainy Creek in terms of gradient and elevation. Upper Rainy Creek [URC] stations are also a potentially relevant reference for Lower Rainy Creek. The Noisy Creek reference station [NSY-R1] is considered the closest match to Upper Rainy Creek. As seen, the density of larger fish at Lower Rainy Creek stations tended to be lower than both the off-site reference stations and the Upper Rainy Creek stations.

Other methods for estimating fish population density were also evaluated, including the MLE method with the minnow trap data included (as presented in Parametrix 2010) and the CapPost (v1.0) estimation method developed by Peterson and Zhu (2004). Regardless of the estimation method utilized, the overall conclusions are the same (i.e., the population density of large fish in Lower Rainy Creek is lower).

Figure 7-3 provides the cumulative distribution frequency of fish length across sampling years for Upper Rainy Creek [URC] locations, Lower Rainy Creek [LRC] locations, the toe of the tailings impoundment [TP-TOE], and the two off-site reference locations (Bobtail Creek [BTT] and Noisy Creek [NSY]). In this figure, only those fish captured during the first and second electroshocking passes are included. As shown, the size distributions of fish in Lower Rainy Creek were right-shifted (larger) from the reference areas and had no fish ≤ 65 mm in length. However, as noted previously, this lack of smaller fish may be a consequence of sampling deficiencies.

7.1.2 Potential Effects of Habitat

One possible explanation for the differences in fish density in Lower Rainy Creek is differences in habitat. An evaluation of potential impacts of habitat on site fish populations was performed using the HSI model for rainbow trout. This model was developed by the U.S. Fish and Wildlife Service to aid in identifying important habitat variables by utilizing species-habitat relationships (Raleigh *et al.* 1984). The species-habitat relationships were developed based on information obtained from research literature and expert reviews. Because the program that was originally created to support the HSI calculations was not able to be used, the figures in the supporting documentation (Raleigh *et al.* 1984) were re-created in Microsoft Excel®. Formulas representing the species-habitat relationship were derived by fitting a line through data points that were selected from the figures in the supporting documentation.

Four life stages (embryo, fry, juvenile, adult) and one "other"[6] component are evaluated in the HSI model by utilizing data for individual habitat metrics and translating it into indices. Indices range from 0 to 1.0, with 0 indicating unsuitable conditions and 1.0 indicating optimal conditions. The life stage-specific HSI components are then combined to achieve one total HSI score for the species.

For OU3, data were only available to compute an HSI score for the fry, juvenile, and adult life stages (i.e., data were insufficient to compute HSI scores for the embryo life stage and "other" component). Hence, a total HSI score for the species could not be computed. Because a total HSI score could not be computed for the species, scores for individual life stages were computed and site HSI scores were compared to reference scores.

Figure 7-4 presents HSI scores for each life stage at each station. In these graphs, the average of the 2008 and 2009 MLE fish population density estimate for large fish (>65 mm) is also shown. As seen, there is no apparent correlation between the estimated population density and the HSI score for the individual life stages.

Note that a limitation of the HSI model is exhibited for the juvenile life stage where the score for all stations is 0.3. This is because, if the minimum score for any metric is less than or equal to 0.3 for this life stage, then the minimum score is the HSI score for the life stage.

Because the HSI scores were not informative, the potential influence of habitat on fish populations was evaluated based on a comparison of individual habitat parameters to estimated fish density and biomass. **Table 7-2** summarizes the basic stream and habitat parameters measured at OU3 and their optimal ranges for rainbow and

[6] The "other" component contains model variables for two sub-components – water quality and food supply – that affect all life stages.

cutthroat trout sustainability. **Figure 7-5** provides a comparison of the average of the 2008 and 2009 MLE fish population density and biomass estimates for large fish (>65 mm) to various habitat metrics measured at OU3. As seen, as evidenced by the correlation coefficients and p values, most habitat parameters appear to be associated (directly or inversely) with the MLE fish population density and biomass. For Lower Rainy Creek, the elevated water temperatures, higher amounts of fine sediments, and the lack of spawning gravel, woody debris, and stream pools, may be contributing to the lower fish population density. Whether habitat is the primary reason for the decline or only a minor factor is not clear.

7.2 Aquatic Invertebrate Community Surveys

Surveys of aquatic invertebrate density and diversity were performed in 2008 and 2009 at the same site and reference sampling stations where fish surveys were conducted (see **Figures 4-1 and 4-2**). At each location, aquatic invertebrate samples were collected using two different protocols. One sample was collected according to the EPA RBP method (Plafkin *et al.* 1989; Barbour *et al.* 1999), and one sample was collected using the USFS Surber method (Barbour *et al.* 1999). For each sample, invertebrates were identified to the genus level and the relative abundance of each taxon was determined. Numerous measures of aquatic invertebrate habitat suitability were also collected at each station. Detailed information on the aquatic invertebrate sampling efforts is provided in Parametrix (2009a; 2010). Results from these sampling efforts are summarized below.

7.2.1 Evaluation of RBP Samples

As illustrated in **Figure 7-6**, the data collected in accordance with the RBP method are interpreted by combining a number of alternative metrics of aquatic invertebrate community status to yield a biological condition score (BCS). In addition, for each station, measures of habitat quality are combined to yield a habitat quality score (HQS). The BCS values from site stations are compared to BCS values for appropriate reference stations and a biological condition category is assigned for each sampling location, using the strategy shown in **Figure 7-6**. If a station is found to be impaired, the HQS values are evaluated to determine if habitat is the likely explanation for observed aquatic invertebrate community differences. As noted above, the Bobtail Creek reference station [BTT-R1] is considered the closest match to Lower Rainy Creek stations in terms of gradient and elevation. The Noisy Creek reference station [NSY-R1] is considered the closest match to Upper Rainy Creek stations.

Tables 7-3 and 7-4 present the calculated aquatic invertebrate community metrics, the BCS, and assigned biological condition category for each sampling location for 2008 and 2009, respectively. As seen, in 2008, all Lower Rainy Creek stations were ranked as slightly impaired and all Upper Rainy Creek stations were ranked as unimpaired relative to the off-site reference areas. In 2009, with the exception of LRC-1 and LRC-2, all Upper and Lower Rainy Creek stations were ranked as slightly impaired relative to the off-site reference areas. LRC-1 and LRC-2 were ranked as unimpaired.

Tables 7-5 and 7-6 present the HQS values for each metric, the overall HQS, and assigned habitat ranking for each sampling location for 2008 and 2009, respectively. As seen, habitat quality at site stations was ranked as suboptimal to optimal, with HQS values tending to be fairly similar across the sampling locations (HQS values ranged from 120 to 169). Station LRC-1 had the lowest HQS values in both 2008 and 2009. LRC-1 is located just below the Mill Pond in Rainy Creek, and scored lower than other stations for available cover, depth, and channel integrity.

Figure 7-7 presents the habitat quality and biological condition relative to the respective reference areas for each sampling location in 2008 (shown as diamonds) and in 2009 (shown as squares). As seen, the biological conditions at the Rainy Creek stations tend to be within 60-90% of the respective reference stations. This indicates that aquatic invertebrate population density and diversity are generally comparable to the reference areas. With the exception of station LRC-1, habitat quality for Rainy Creek stations tends to be within about 85-95% of the respective reference areas. This indicates that aquatic invertebrate habitat quality in Rainy Creek is generally comparable to the reference areas.

Overall, these results indicate that habitat quality and biological conditions are similar across all Rainy Creek stations and that comparability of these metrics to the reference areas is good.

7.2.2 Evaluation of USFS Surber Samples

The USFS (Vinson 2007) has utilized the Surber sampling method to collect aquatic invertebrates from several locations in the Kootenai National Forest over a several year period (1998-2006). In order to utilize these USFS data as a frame of reference for OU3, aquatic invertebrate community samples were collected at each OU3 sampling station using the same method as used by the USFS (i.e., the Surber method). As illustrated in **Table 7-7**, the Surber samples are interpreted by calculating a total score from a number of aquatic invertebrate community metrics using a set of scoring criteria established by the Montana Department of Environmental Quality (MDEQ 2005). **Tables 7-8 and 7-9** present the aquatic invertebrate community metrics and the total score for each OU3 sampling location for 2008 and 2009, respectively.

Table 7-10 presents the total scores for eight streams located in the Kootenai National Forest near OU3. **Figure 7-8** presents a comparison of the total scores for the OU3 sampling locations to the Kootenai National Forest reference stations. In general, total scores for the OU3 sampling locations tended to be within the range of scores for the Kootenai National Forest stations. However, Lower Rainy Creek sampling locations consistently had scores at or slightly below the low end of the scoring range. As seen, the total score for one sample[7] in Upper Rainy Creek and from Bobtail Creek appears to be quite low relative to the other samples. The reason for these low scores is not certain but may be due to the "patchiness" of the aquatic invertebrate communities at these stations. Unlike the RBP method, the Surber sampling method does not work

[7] The 2008 sample from URC-1A.

well at locations where the community patch dynamics are such that the number of invertebrates in the samples is low (Parametrix 2009a).

These results suggest that the aquatic invertebrate community in Lower Rainy Creek may be slightly impaired relative to streams within the Kootenai National Forest. These impairments could be due to habitat quality, as suboptimal habitat conditions were noted in Rainy Creek (see **Tables 7-5 and 7-6**), but could also be due to other stressors.

Section 8 – Site-Specific Toxicity Testing Evaluation

8.1 Exposure of Trout to Site Surface Water

Surface water testing was conducted to determine the toxicity of OU3 surface water to fish. A detailed summary of the surface water toxicity test study design and results is provided in Parametrix (2009b). In brief, the test was conducted with newly hatched larval (sac fry) rainbow trout (*Oncorhynchus mykiss*) under static renewal conditions for an exposure duration of 6 weeks. Behavioral response, survival, weight, length, and condition factor were observed during the exposure period, and the histopathology of the fish was examined at the end of the study.

The water sample selected for site-specific toxicity testing was collected from the tailings impoundment (station TP) on May 8, 2008. No significant effects on mortality, growth, or frequency of histological lesions were detected in exposed fish. These results suggest that exposure to concentrations of non-asbestos contaminants in surface water does not adversely impact fish.

However, this conclusion is limited because only one surface water sample was tested, and this sample may not be representative of other water samples from the site. Toxicity test water was analyzed for metals (total recoverable and dissolved) and asbestos prior to use in the toxicity test. **Table 8-1** summarizes the dissolved metal concentrations measured in the test water with concentrations in other surface water samples at OU3. The respective acute and chronic toxicity benchmarks are also shown for reference.

As discussed previously in the refined HQ evaluation for surface water (see Section 6.1.3), with the exception of barium, risks to aquatic receptors from COPCs in water were expected to be minimal and/or similar to levels in reference areas. Refined HQs for fish could not be calculated for barium, because the available toxicity data did not provide toxicity information for any fish species. The barium concentration in the toxicity test water were similar to concentrations measured in reference areas and lower than concentrations measured in most site water (see **Figure 8-1**). Therefore, it is not possible to draw firm conclusions from the results of the surface water toxicity test about potential fish toxicity from barium at OU3. However, because concentrations in site samples are within a factor of 2-3 of levels tested (see **Figure 8-1**) and no adverse effects were noted in the toxicity tests, it is expected that any adverse effects on fish, if they were occurring, would probably be minimal.

8.2 Exposure of Aquatic Invertebrates to Site Sediment

As part of the Phase II Part C sampling effort, sediments were collected from two site sampling locations (CC-1 and TP-TOE2) for sediment toxicity testing. Sediments were also collected for testing from the two reference sites (BTT-R1 and NSY-R1).

A detailed summary of the sediment toxicity test study design and results is provided in Parametrix (2009c, 2009d). In brief, sediment samples were tested using the amphipod *Hyalella azteca* in a 42-day test (EPA Test Method 100.4) and the midge *Chironomus tentans* using the life-cycle test (EPA Test Method 100.5) (EPA 2000). Measurement endpoints included survival, growth, and reproduction.

Neither test organism (*Hyalella* or *Chironomid*) exhibited any statistically significant differences in survival, growth, or reproduction when compared to both laboratory control sediments and field-collected reference sediments (Parametrix 2009c, 2009d). These results suggest that exposure to non-asbestos contaminants, at the levels present in the on-site test sediments, does not adversely impact aquatic invertebrates.

However, this conclusion is limited because sediment samples evaluated in the toxicity tests were not representative of the full range of concentrations observed in other site sediments. **Table 8-2** summarizes the metal concentrations in the test sediments, as well as concentrations measured in other sediment samples at OU3. The respective TEC and PEC toxicity benchmarks are also shown for reference. In this table, the COPCs identified for sediment based on direct contact exposures to aquatic invertebrates are shaded in grey.

As discussed previously in the refined HQ evaluation for sediment (see Section 6.2.3), risks to aquatic invertebrates were predicted to be moderate to severe due to elevated concentrations of chromium, manganese, and nickel in sediment relative to the PEC toxicity benchmark. As shown in **Table 8-2**, concentrations of these metals in TP-TOE2 were above the PEC, yet no adverse effects to either exposed test organism were reported in the toxicity tests. This suggests that the PECs for these metals are too conservative and/or that environmental conditions in site sediments are reducing the toxicity of these metals. Site-specific sediment characteristics, such as pH and levels of organic matter, hydroxides, sulfide, carbonates and sulfates in the sediment, can alter the degree of toxicity.

Figure 8-2 presents a graphical comparison of measured COPC concentrations in the sediment toxicity test samples to other OU3 sediment samples. In these graphs, the samples evaluated in the sediment toxicity tests are circled. As shown, concentrations in the toxicity test samples usually reflected the mid- to upper range of potential concentrations that are present in most OU3 creeks and ponds, but were below maximum measured concentrations. Thus, it is not possible to draw firm conclusions from the results of these tests about potential aquatic invertebrate toxicity in locations with sediment concentration values above those that were tested. However, because concentrations in site sediments are usually within a factor of 2-5 of levels tested, and no adverse effects were noted in the toxicity tests, it is expected that any adverse effects on aquatic invertebrates, if they were occurring, would likely be minimal.

Section 9 – Uncertainty Assessment

There are a variety of sources of uncertainty in each line of evidence used in the risk assessment that need to be evaluated and considered when developing the weight of evidence and making risk management decisions. This section discusses the uncertainties associated with the refined HQ evaluation (Section 6), the habitat and community evaluation (Section 7), and the site-specific toxicity test evaluation (Section 8) for OU3.

9.1 Refined HQ Evaluation

This section provides a detailed discussion of the main sources of uncertainty in the HQ-based evaluation, along with a qualitative estimate of the direction and magnitude of the likely errors attributable to the uncertainty. Because of these uncertainties, the refined HQ values calculated and presented in this risk assessment should be viewed as having substantial uncertainty. In addition, because of the inherent conservatism in the derivation of many of the exposure estimates and toxicity benchmarks, refined HQ values presented in this risk assessment should generally be viewed as being more likely to be high than low, and conclusions should be interpreted accordingly.

9.1.1 Nature and Extent of Contamination

Representativeness of Sampling Data

<u>Surface Water.</u> Surface water data from OU3 are considered to provide good spatial representativeness, since multiple samples were collected from each major segment of the OU3 watershed and from locations that serve as reference areas. Although the number of samples is limited (usually three samples per station), the samples are representative of three different seasons within the year (fall, spring, summer), and at least one sample was collected during the spring run-off period, when concentrations are likely to be highest. Therefore, temporal representativeness is considered to be adequate.

<u>Sediment.</u> The sediment data from OU3 are considered to provide good spatial representativeness, since multiple samples were collected from each stream and pond in the OU3 watershed and from locations that serve as reference areas. Although concentrations of chemicals in sediment are usually not as time-variable as concentrations in surface water, concentrations may fluctuate as contaminated material is added or removed by surface water flow. Since sediment samples were collected from three different times of year (fall, spring, summer) at most stations, temporal representativeness is considered to be adequate.

<u>Soil and Mine Waste Materials.</u> The samples of on-site soil and mine waste materials were collected from multiple locations in the mined area. As such, these samples are likely to provide a good representation of the levels of contaminants in the mined area. Because non-asbestos contaminants were not measured in soils from locations in the forested area near the mine, concentrations in mine waste were used as a surrogate for what might be present in forest soils around the mine. Because it is

unlikely that non-asbestos contaminants were released in significant quantities to areas outside of the mined area and the site drainages, this is likely to be a conservative approach (i.e., is more likely to overestimate than underestimate actual exposures).

Accuracy of Analytical Measurements

Laboratory analysis of environmental samples is subject to a number of technical difficulties, and values reported by the laboratory may not always be exactly correct. The magnitude of analytical error is usually small compared to other sources of uncertainty, although the relative uncertainty increases for results that are near the method detection limit.

9.1.2 Exposure Assessment

Exposure Pathways not Evaluated

Exposure pathways selected for quantitative evaluation in this assessment do not include all potential exposure pathways for all ecological receptors. **Figure 3-1** identifies those exposure pathways that were not evaluated quantitatively in this assessment. Omission of these pathways will tend to lead to an underestimation of total risk to the exposed receptors. As discussed previously, many of these exposure pathways (i.e., dermal exposures of wildlife) are likely to be minor compared to other pathways that were evaluated, and the magnitude of the underestimation is not likely to be significant in most cases.

Chemicals not Detected

Although the analyte list for samples collected at the OU3 site was extensive, most chemicals were not detected in most media. Any chemical that was not detected in a site medium was not included in the initial HQ screens. Omission of these chemicals is not likely to result in an underestimation of risk, provided that the data were collected using an analytical method that would have detected the chemical if it were present at a level of concern. For example, if the toxicity benchmark for some chemical in sediment were 1 mg/kg, and all of the analytical results were obtained using a method with a PQL of 5 mg/kg, then it would not be certain that the chemical was below a level of concern, even if all of the values were non-detect.

Appendix F presents a comparison of the mean PQL of all non-detect and infrequently detected (<5%) chemicals for each medium to respective toxicity benchmarks. As shown, in some instances, the PQL was too high to determine if the chemical may have been present above a level of concern (but below the PQL). Although this is a source of uncertainty and might lead to an underestimate of risk, it is important to note that there is little reason to suppose that these chemicals are actually present in site media. Consequently, the absence of data from a method with an adequate PQL is not likely to be a significant limitation.

Wildlife Exposure Parameters

The intake (ingestion) rates for food, soil, and sediment used to estimate exposure of wildlife at the site are subject to uncertainty from multiple sources. Most intake rates are derived from literature reports of intake rates, body weights, and dietary compositions in receptors at other locations or from measurements of laboratory-raised organisms. These values may or may not serve as appropriate models for site-specific intake rates of typical wild receptors at this site. Moreover, the actual dietary composition of an organism will vary daily and seasonally. In addition, some wildlife receptor-specific intake rates are estimated by extrapolation from data on a closely related species or by use of allometric scaling equations (scaling of intake rates based on body weights). This introduces further uncertainty into the exposure and risk estimates. These uncertainties could either under- or overestimate the actual exposures of wildlife to chemicals in soil, sediment, and diet.

For this assessment, it was assumed that wildlife exposures were continuous and that receptor home ranges were located entirely within the OU3 site exposure areas (i.e., the entire total dietary intake was from the site). In the case of resident receptors with small home ranges, this assumption is likely to be fairly realistic. However, this assumption may tend to overestimate exposures for receptors that have larger home ranges and/or migratory species that may not be exposed on-site most of the time.

Concentrations in Tissues of Dietary Items

Measured data on concentrations in dietary items are not available for the OU3 site. Therefore, for the purposes of estimating exposures to wildlife, dietary tissue concentrations were estimated using uptake factors and/or bioaccumulation models from the literature. These uptake models may not account for site-specific factors that may influence accumulation into biota. In cases where no uptake factors were available for estimating COPC concentrations in aquatic invertebrate tissues, a factor of 1.0 was assumed. Based on a review of available uptake factors, this assumption is likely to overestimate actual tissue concentrations. Therefore, predictions of wildlife risk based on estimated tissue concentrations are considered to be uncertain and are likely to overestimate the actual exposures of wildlife to chemicals in dietary items.

9.1.3 Toxicity Assessment

Receptors Evaluated

Risks to wildlife were assessed for a selected subset of species that were representative of several feeding guilds likely to be present at the OU3 site. Although the wildlife receptors evaluated in the risk assessment were selected to represent a range of feeding guilds, these species may not represent the full range of sensitivities present. The species selected may be either more or less sensitive to chemical exposure than typical species located within the area.

Selected Toxicity Values

In the initial HQ screen and the refined HQ evaluation, HQ values were calculated using TRVs compiled from the literature (i.e., not site-specific toxicity values). There are several sources of uncertainty associated with the selected toxicity values that are discussed in more detail below. In general, because the resulting HQ values are more likely to be overestimated than underestimated, if HQ values are below 1, it is possible to draw meaningful conclusions regarding potential risks despite the uncertainties in the selected toxicity values. However, if HQ values are above 1, the uncertainties in the selected toxicity values should be carefully considered in making risk management decisions.

Surface Water TRVs for Aquatic Receptors

TRVs used to predict risk to aquatic receptors in the refined HQ evaluation were based on GLWQI Tier II toxicity values (Suter and Tsao 1996) or CCME WQG values (CCME 2012). These TRVs are based on multiple toxicity studies and are intended to be protective of most aquatic species for which reliable toxicity data are available. However, the set of organisms for which there are data include many that are not likely to reside in the site waters, and data may be lacking for some organisms that are likely to be present in the site and reference waters.

For example, the barium SCV and SAV used in the refined HQ evaluation for surface water were based on three studies for four invertebrate species, several of which are not expected to occur in OU3. Consequently, the relevance of this value to aquatic receptors, especially fish (since no fish species were evaluated), in OU3 creeks and ponds is uncertain. As noted previously, HQ values for barium for nearly all OU3 surface water samples, including samples from the off-site reference locations and Upper Rainy Creek, were above 1. Because HQ values above 1 are not generally expected in reference streams, this suggests that the barium TRVs used in the refined HQ evaluation are too conservative and HQ values are likely overestimated.

In addition, these TRVs are based on studies performed in laboratory waters, and may not account for site-specific factors that influence toxicity of metals. Because of these potential limitations in the TRVs, risk predictions based on these TRVs may either overestimate or underestimate risks to site species.

Sediment TRVs for Aquatic Invertebrates

Sediment toxicity benchmarks for aquatic invertebrates used in HQ calculations are based on studies in which multiple contaminants were present and it was assumed all of the observed toxicity was due to the contaminant of interest, even though other contaminants in the sediment could have been associated with observed toxicity. In addition, there may be a wide variety of differences between sediments from the OU3 site and those used to establish the toxicity benchmarks, which could influence the relative toxicity of chemicals in the sediments. Site-specific sediment characteristics (e.g., pH, organic carbon, sulfide, carbonates and sulfates levels in the sediment) can alter the degree of toxicity. Therefore, there is uncertainty that exceedances of the PEC benchmarks for a particular chemical will actually cause toxicity in aquatic invertebrates.

The site-specific sediment toxicity tests conducted at OU3 support this conclusion. Concentrations of several metals in the test sediment exceeded bulk sediment PECs, yet no adverse effects were observed in the exposed organisms.

Because of these limitations in bulk sediment benchmarks, HQ values based on the benchmarks should be considered uncertain. Based on the site-specific toxicity tests, the bulk sediment toxicity benchmarks for metals are more likely to overestimate than underestimate risks.

Soil TRVs for Terrestrial Plants and Invertebrates

The toxicity benchmarks used in HQ calculations for terrestrial plants and invertebrates are usually based on laboratory studies in which soluble forms of test metals are added to test soils. Thus, these values do not account for occurrence of metals in mineral forms in soil that are largely insoluble and do not contribute as much toxicity as soluble forms. For example, the available chromium toxicity benchmarks for plants (and terrestrial invertebrates) were based on hexavalent chromium, which is more soluble and more phytotoxic than trivalent chromium (Smith *et al.* 1989). Although the valence state of chromium is not known for the site, it is likely to be in a trivalent form (ATSDR 2008). Thus, HQ values were not calculated in the refined HQ evaluation for plants or terrestrial invertebrates.

Another limitation of the toxicity benchmarks is that the values do not account for variations in environmental factors such as pH and total organic carbon content, which may influence the toxicity of metals in soils. In addition, the laboratory tests may not utilize test species that are likely to occur in or on-site soils.

Based on these considerations, confidence in the TRVs and hence in the refined HQ values is low. This conclusion is supported by the relatively high frequency of refined HQ values above 1 in soils which are thought to represent reference conditions.

TRVs for Wildlife

The concentration-based benchmarks used in the initial HQ screen for the evaluation of wildlife exposures to contaminants in soil and mine waste materials were derived based on a back-calculation from dose-based TRVs (see **Appendix E** for details). This back-calculation is subject to a number of uncertainties, including:

- Uptake of contaminants from soil into dietary food items was calculated using tissue uptake factors established in the literature. These models are usually based on limited datasets, and are generally intended to be conservative. In addition, these models do not account for site-specific conditions that could influence uptake of contaminants into dietary items. Hence, calculated dietary tissue concentration values are uncertain, and are likely to be higher than actual.

- Data on incidental ingestion of soil and sediment by wildlife species are generally limited; therefore, the intake rates for soil and sediment used in these calculations are uncertain, and actual values might be either higher or lower than assumed.

- Concentration-based benchmarks were derived assuming that the RBA of all COPCs in site soils, mine waste materials, and sediments was 100%. However, for some metals, it is considered likely that absorption may not be as high as from food or water, so this approach is likely to overestimate risks from incidental ingestion of soil and sediment.

- The dose-based TRVs used to back-calculate concentration-based benchmarks do not account for site-specific environmental attributes that may influence uptake and toxicity.

As noted above, these uncertainties in wildlife TRVs limit the reliability of both the initial HQ screen and the refined HQ calculations for wildlife, and calculated HQ values are more likely to overestimate than underestimate actual risk.

Extrapolation from Laboratory to Field Conditions

Available toxicity data are usually generated under laboratory conditions, and extrapolation of those data to free-living receptors in the field is uncertain. One factor is that laboratory organisms are more homogeneous that wild populations. For example, laboratory test populations are usually all the same genetic strain, age, and gender, and all are usually healthy. In contrast, wild populations are genetically diverse, consist of individuals of different ages and genders, and health status may vary widely between individuals. In addition, laboratory animals are generally free from the stresses experienced by a wild population. Because of these factors, extrapolation of dose-response data and toxicity factors from laboratory species to wild populations is uncertain. The magnitude and direction of error introduced by this extrapolation is unknown.

Absence of Toxicity Data

Evaluation of risks from chemicals using the HQ approach requires the availability of reliable TRVs. When no reliable TRV is available, it is not possible to calculate HQ values, thus precluding this approach as a potential line of evidence in drawing risk conclusions. **Tables 5-1 to 5-6** identify the detected chemicals in each medium for which no reliable TRV was available.

The absence of toxicity data is usually not a source of significant uncertainty in cases where the concentration of chemical in site media is similar to the concentration observed in appropriate reference area. This is because any risks that may be present are not expected to be attributable to site releases. **Table 9-1** presents summary statistics for site and reference areas for detected chemicals where no TRVs were available to calculate HQ values. When data were adequate (number of samples > 4, site detection frequency > 5%), site concentrations were compared to reference concentrations using the statistical procedures recommended in EPA (2002a) using the two-sample hypothesis testing approach for datasets with non-detects (Gehan test) provided in ProUCL v4.00.05 (EPA 2010a).

- For surface water, the available data do not indicate that site concentrations are higher than reference areas. This suggests that levels of these chemicals in surface water are not elevated as a consequence of site-related activities. Thus, the lack of toxicity values for these chemicals is not likely to be an important source of uncertainty.

- For sediment, the site concentrations of several detected metals are statistically higher than in reference streams. In addition, concentrations of several detected organics may also be elevated in site sediments (but data are not adequate to perform a statistical evaluation). This suggests that levels of these chemicals may be elevated as a consequence of site-related activities.

- For mine waste materials, the reference soil data set only provides information on metals (i.e., concentrations of organic chemicals are not available). Concentrations of iron in mine waste materials were statistically higher than concentrations in reference soil.

For chemicals without a TRV, the potential for toxicity from chemicals that are higher than reference is a source of uncertainty, and the inability to quantify risks from these chemicals could result in an underestimation of total risk. However, it is suspected that the magnitude of any underestimation of risk is likely to be low, at least in comparison to chemicals where toxicity values exist. This is based on the assumption that absence of laboratory studies to establish a toxicity value reflects a relatively low level of concern for the chemical. To the extent that this assumption is true, risks from detected chemicals without toxicity benchmark values are likely not to contribute risks of the same magnitude as those predicted for detected chemicals that do have a toxicity benchmark value.

9.1.4 Risk Characterization

Interactions Among Chemicals

Most toxicity benchmark values are derived from studies of the adverse effects of a single contaminant. However, exposures to ecological receptors usually involve multiple contaminants, raising the possibility that synergistic or antagonistic interactions might occur. Generally, data are not adequate to permit any quantitative adjustment in toxicity values or risk calculations based on inter-chemical interactions. In accordance with EPA guidance, effects from different chemicals are not added unless reliable data are available to indicate that the two (or more) chemicals act on the same target tissue by the same mode of action. At this site, refined HQ values for each chemical were not added across different COPCs. If any of the COPCs at the site act by a similar mode of action, total risks could be higher than estimated. Conversely, if the COPCs at the site act antagonistically, total risks could be lower than estimated.

Estimation of Population-Level Impacts

Assessment endpoints for the receptors at this site are based on the sustainability of exposed populations (i.e., the ability of a population to maintain normal levels of diversity and density), and risks to some individuals in a population may be acceptable if the population is expected to remain healthy and stable. However, even if it is possible to accurately characterize the distribution of risks or effects across the members of the exposed population, estimating the impact of those effects on the population is generally difficult and uncertain.

Figure 3-2 illustrates the general approach that was used in the interpretation of refined HQ values to estimate potential population-level impacts. The relationship between adverse effects on individuals and effects on the population is complex and depends on the demographic and life history characteristics of the receptor being considered, as well as the nature, magnitude, and frequency of the chemical stresses and associated adverse effects. Thus, the actual risks that will lead to population-level adverse effects will vary from receptor to receptor.

9.2 Habitat and Community Survey Evaluation

The chief advantage of the use of direct observations of community status is that it does not require making the numerous assumptions and estimates needed in the HQ approach. However, there are also important uncertainties that need to be considered in interpreting community survey results.

The diversity and density of any ecological populations will depend on many site-specific factors (e.g., habitat suitability, availability of food, predator pressure, natural population cycles, meteorological conditions, etc.). Thus, it is difficult to know what the "expected" ecological population should be in any particular area. While this issue is addressed by selecting an appropriate reference area, it can be difficult to locate reference areas that are truly a good match for all of the important habitat variables at the site. Therefore, it is difficult to establish firm cause-and-effect conclusions regarding the impact of environmental contamination on a given population. At OU3, two different types of reference areas were identified – areas located upstream of the site (Upper Rainy Creek) and areas located in streams that were off-site (Bobtail Creek and Noisy Creek). Although each reference area was selected to represent conditions that were as similar to the site as possible (absent any potential contamination), the selected reference stations are not exactly matched in every environmental condition to the site stations.

The organisms caught during a community survey represent only a subset of the total population present in the sampling reach. For fish, population density estimates were derived using a mathematical model that is based on the assumption that the number of fish captured is a constant proportion of the fish that are present. However, this assumption may not be valid for all species and size classes, so population predictions based on any model are uncertain. Because several different models all yielded similar results, this is not likely to be a substantial source of uncertainty in this assessment.

In addition, because populations in the wild fluctuate due to natural processes, population comparisons usually require many years of collected data to make meaningful comparisons. At OU3, habitat and community surveys were conducted in 2008 and 2009. Hence, characterizations based on only two years of data might not be entirely representative of true long-term population conditions.

9.3 Site-Specific Toxicity Test Evaluation

The chief advantage of the use of site-specific toxicity tests is that they account for the site-specific conditions that can influence toxicity.

One limitation of the use of toxicity tests is that the sensitivity of the organisms used in the laboratory tests (rainbow trout, *Hyalella azteca*, *Chironomus tentans*) may not be identical to the sensitivity of other species of organisms residing in site waters.

Another limitation of both the surface water and the sediment toxicity tests conducted at OU3 was that the samples tested did not include concentration levels of non-asbestos chemicals that were representative of maximum exposure conditions. Thus, the observation that no adverse effects were noted in either the surface water or sediment toxicity tests can only be applied to site locations with similar or lower levels of contamination. However, because maximum concentrations at the site were usually within a factor 2-5 of the levels evaluated in the toxicity tests, this is not thought to be a large source of uncertainty.

Section 10 – Weight of Evidence Evaluation

There are a number of different techniques available to ecological risk assessors for evaluating the impact of site releases on assessment endpoints and assessing whether or not risk management goals are achieved. In this BERA, three different lines of evidence are presented:

- Refined HQ Evaluations (Section 6)
- Habitat and Community Evaluations (Section 7)
- Site-Specific Toxicity Test Evaluations (Section 8)

As discussed in Section 3.2.4 and in the Uncertainty Assessment (Section 9), each of these lines of evidence has inherent advantages and limitations. Therefore, the best approach for deriving reliable conclusions is to combine the findings across all of the methods for which data are available to develop a weight of evidence conclusion, taking the relative strengths and weaknesses of each line of evidence into account.

Table 10-1 summarizes the conclusions for each line of evidence, the confidence associated with each line of evidence, and the overall weight of evidence conclusion for each ecological receptor of interest at OU3. The following sections provide detailed information for the weight of evidence evaluation.

10.1 Risks to Fish

Three lines of evidence are available to assess risks to fish from site-related non-asbestos contaminants: 1) refined HQ values based on measured concentrations of contaminants in site surface water; 2) site-specific surface water toxicity tests; and 3) site-specific fish community surveys. The assessment of each of these lines of evidence is discussed below.

It was not possible to utilize barium HQ values to draw conclusions about potential impacts to fish, because the underlying data used to develop the surface water TRV did not include any fish species. The refined HQ values for all other non-asbestos contaminants show that risks to fish from direct contact with surface water are not above a level of concern. This conclusion is supported by the results of the site-specific surface water toxicity test, which showed no adverse effects in exposed trout. However, the fish community evaluation showed that the density of large fish in Lower Rainy Creek is somewhat lower relative to reference and that smaller fish are absent. There are a number of habitat factors which might contribute to this reduction in fish density, but is not possible to determine the degree to which habitat factors are responsible, or if other factors (e.g., LA contamination) may also be contributing to this decline. Taken together, the weight of evidence suggests that risks to fish from non-asbestos contaminants in OU3 are likely to be minimal.

10.2 Risks to Aquatic Invertebrates

Three lines of evidence are available to assess risks to aquatic invertebrates from site-related non-asbestos contaminants: 1) refined HQ values based on measured concentrations of contaminants in site surface water and sediment; 2) site-specific sediment toxicity tests; and 3) site-specific aquatic invertebrate community surveys. The assessment of each of these lines of evidence is discussed below.

The refined HQ values for surface water suggest that, with the exception of barium, risks to aquatic invertebrates from non-asbestos contaminants in surface water are acceptable. Risks to aquatic invertebrates from barium in surface water were predicted to be severe and widespread, but there is low confidence in this conclusion because of uncertainties in the barium surface water TRV. The refined HQ values for sediment suggest that risks to aquatic invertebrates from chromium, manganese, and nickel in sediment have the potential to be moderate to severe. However, risk predictions for aquatic invertebrates based on HQ values are not supported by the aquatic invertebrate community results, which showed the aquatic invertebrate community in Rainy Creek as unimpaired to slightly impaired and that habitat quality may be a contributing factor to any observed effects. The aquatic invertebrate community results are supported by the site-specific sediment toxicity tests, which showed no adverse impacts to exposed aquatic invertebrates. While toxicity tests did not include maximum concentrations of COPCs in measured in sediments, concentrations in site sediment are within a factor of 2-5 of levels tested. Consequently, it is expected that any adverse effects on aquatic invertebrates, if they were occurring, would likely be minimal. In this weight of evidence evaluation, the aquatic invertebrate community evaluation and toxicity test conclusions are given more weight than the conclusions based on the refined HQ values. Thus, it is concluded that risks to aquatic invertebrates from non-asbestos contaminants in OU3 are likely to be minimal.

10.3 Risks to Plants and Terrestrial Invertebrates

Only one line of evidence (the refined HQ approach) is available to evaluate risks to terrestrial plants and invertebrates from non-asbestos contaminants in site soils and mine waste materials. The refined HQ evaluation suggests that several metals (barium, cobalt, nickel, vanadium) exist in soils and mine waste materials at OU3 at levels that are potentially toxic to terrestrial invertebrates and/or plants.

Based on the HQ line of evidence, the potential for risk to plants and soil invertebrates from these metals in the mined area cannot be excluded. However, HQ values above 1 should not be interpreted as evidence that risk does exist. For example, laboratory-based toxicity studies and field surveys at other mining sites (EPA 2001b; 2005b; 2010b) have shown that elevated HQ values alone are usually not sufficient evidence to conclude that metals in soil are toxic to plants or invertebrates. This is because the toxicity benchmarks (i.e., EcoSSLs; Efroymson *et al.* 1997a,b) that are utilized to derive

HQ values are intended to be conservative screening-level values. That is, if concentrations are below the screening level, toxicity will not occur, but if concentrations are above the screening level, this does not necessarily indicate that adverse impacts are occurring. The conservative nature of these toxicity benchmarks is evidenced by the observation that measured concentrations of several metals in reference soil samples are above the screening-level toxicity benchmark. Thus, there is low confidence in any risk conclusions based solely on HQ values.

10.4 Risks to Wildlife

Only one line of evidence is available (the refined HQ approach) to evaluate risks wildlife from non-asbestos contaminants in site media.

Several metals were identified as COPCs for wildlife receptors in one or more environmental media. Refined HQ calculations showed that risks to wildlife were either not expected or were likely to be minimal for nearly all COPCs for all receptors (including both terrestrial and aquatic wildlife). The exception is potential risks to insectivorous wildlife from the ingestion of barium, manganese, and vanadium in aquatic invertebrates. However, due to conservative assumptions about bioaccumulation of these COPCs, the calculated HQ values are likely to be biased high and actual risks are lower. Thus, while potential risks cannot be excluded, there is low confidence in any risk conclusions based solely on HQ values, and results should not be interpreted as evidence that risk does exist.

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Figures

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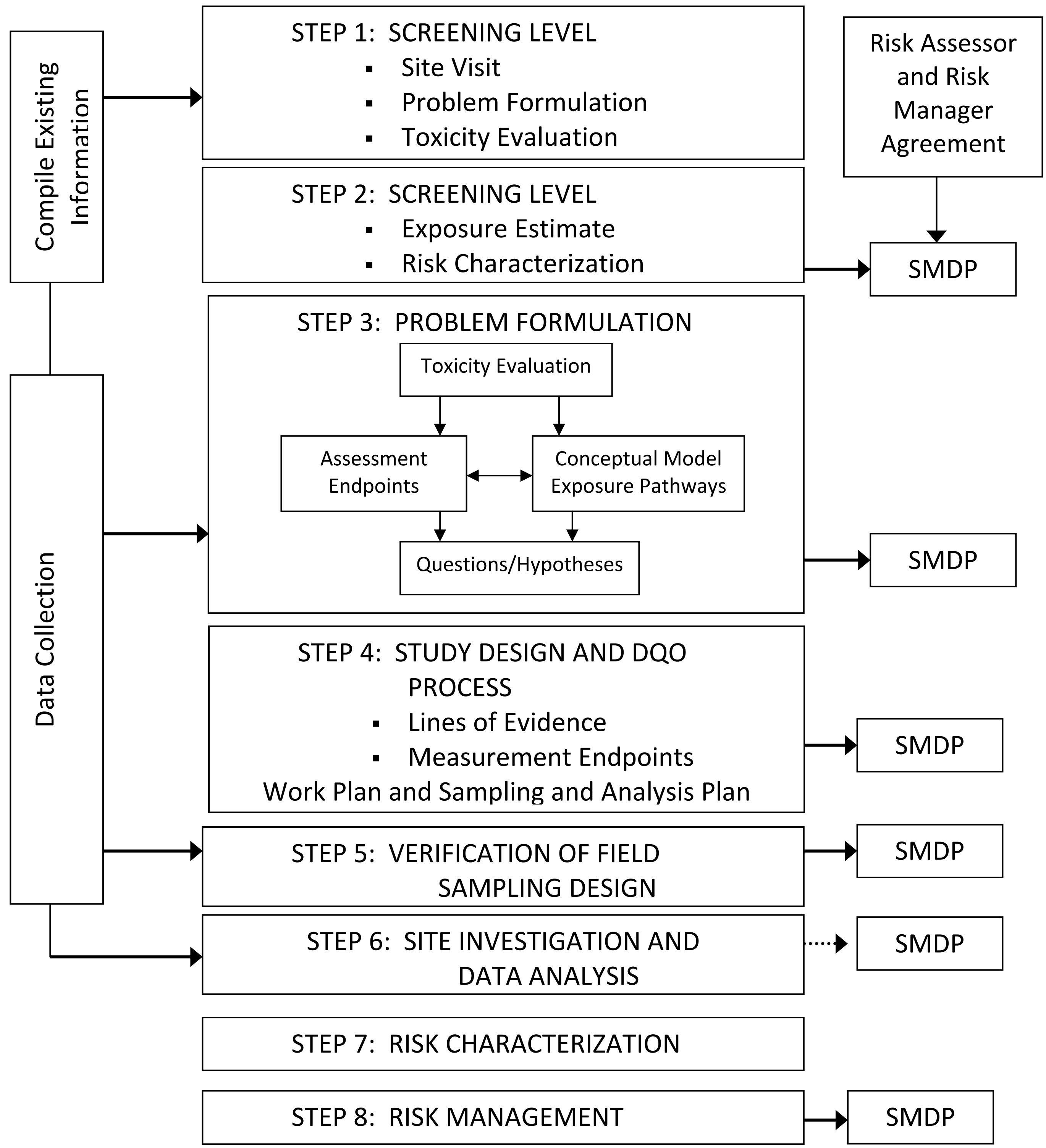
FIGURE 1-1. EIGHT STEP PROCESS RECOMMENDED IN ECOLOGICAL RISK ASSESSMENT GUIDANCE FOR SUPERFUND (ERAGS)

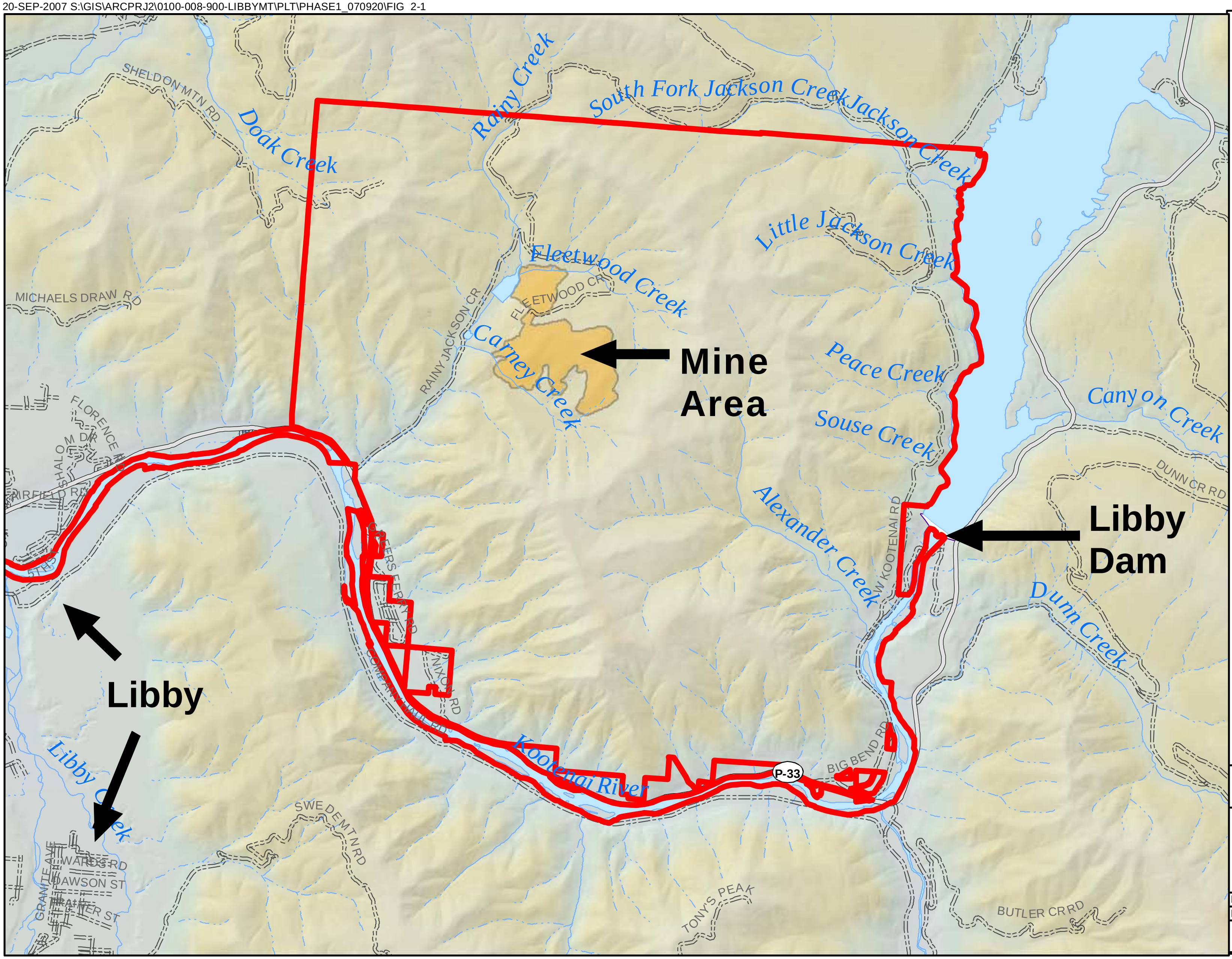


Steps 1 & 2 – Tier 1 (Screening-Level Assessment)
Steps 3 to 7 – Tier 2 (Baseline Assessment)

SMDP = Scientific/Management Decision Point

Source: EPA 1997

20-SEP-2007 S:\GIS\ARCPRJ2\0100-008-900-LIBBYMT\PLT\PHASE1_070920\FIG 2-1



Legend

- Mined Area
- Open Water
- County Road
- Primary Road
- Perennial Stream
- Intermittent Stream
- Preliminary Operable Unit 3 Boundary

N

0 1 2

Miles

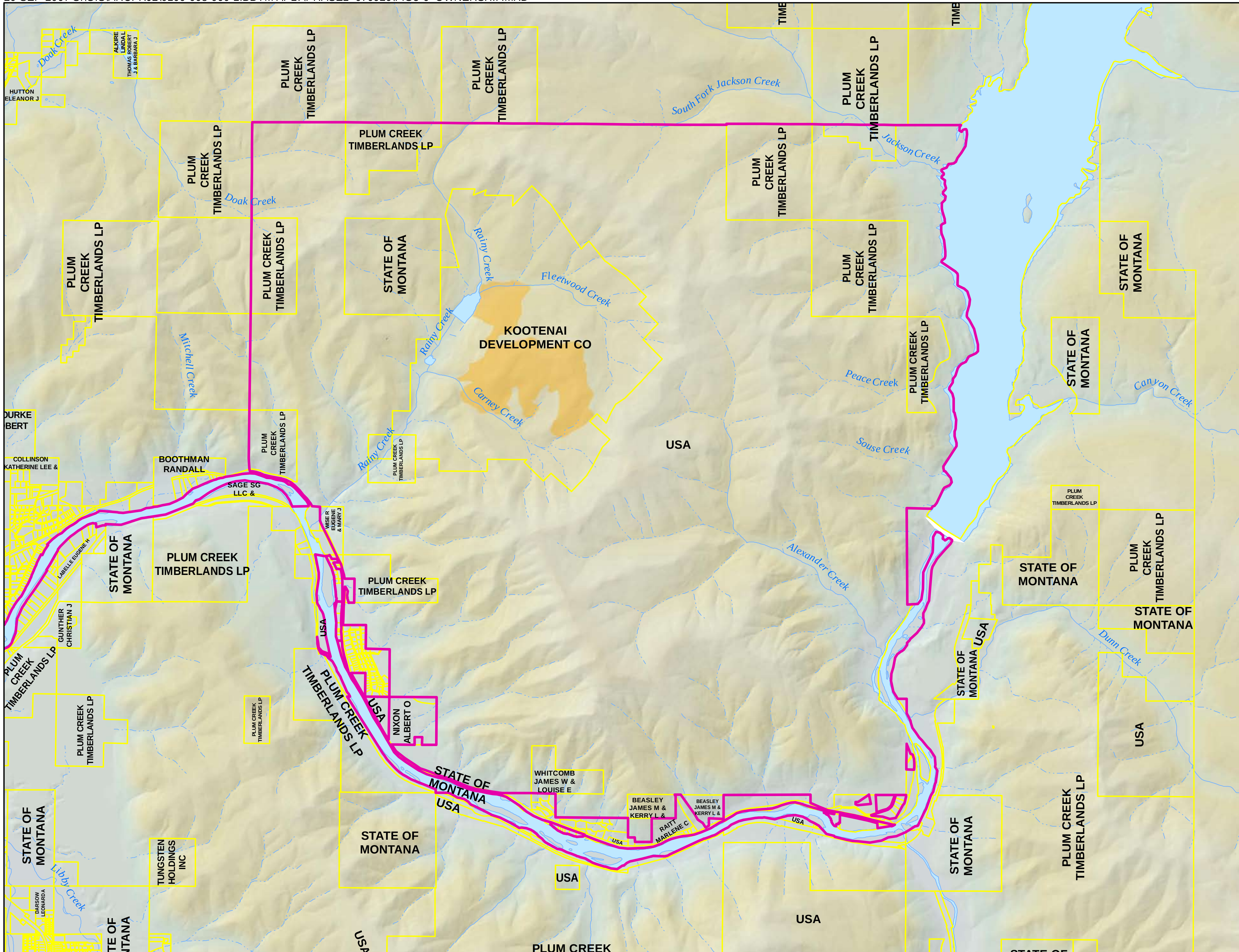
Libby Montana Superfund Site
Operable Unit 3

FIGURE 2-1

Operable Unit 3

PROJECT: 0100-008-900	DATE: AUG 02, 2007	
REV: 0	BY:	CHECKED: ACK

20-SEP-2007 S:\GIS\ARCPRJ2\0100-008-900-LIBBYMT\PLT\PHASE1_070920\FIG5-6_OWNERSHIP.MXD



Legend

- Preliminary Operable Unit 3 Boundary
- Property Ownership Boundary
- Open Water
- Perennial Stream
- Intermittent Stream
- Mined Area

N

0 1 2

Miles

LIBBY MONTANA SUPERFUND SITE

OPERABLE UNIT 3

FIGURE 2-2

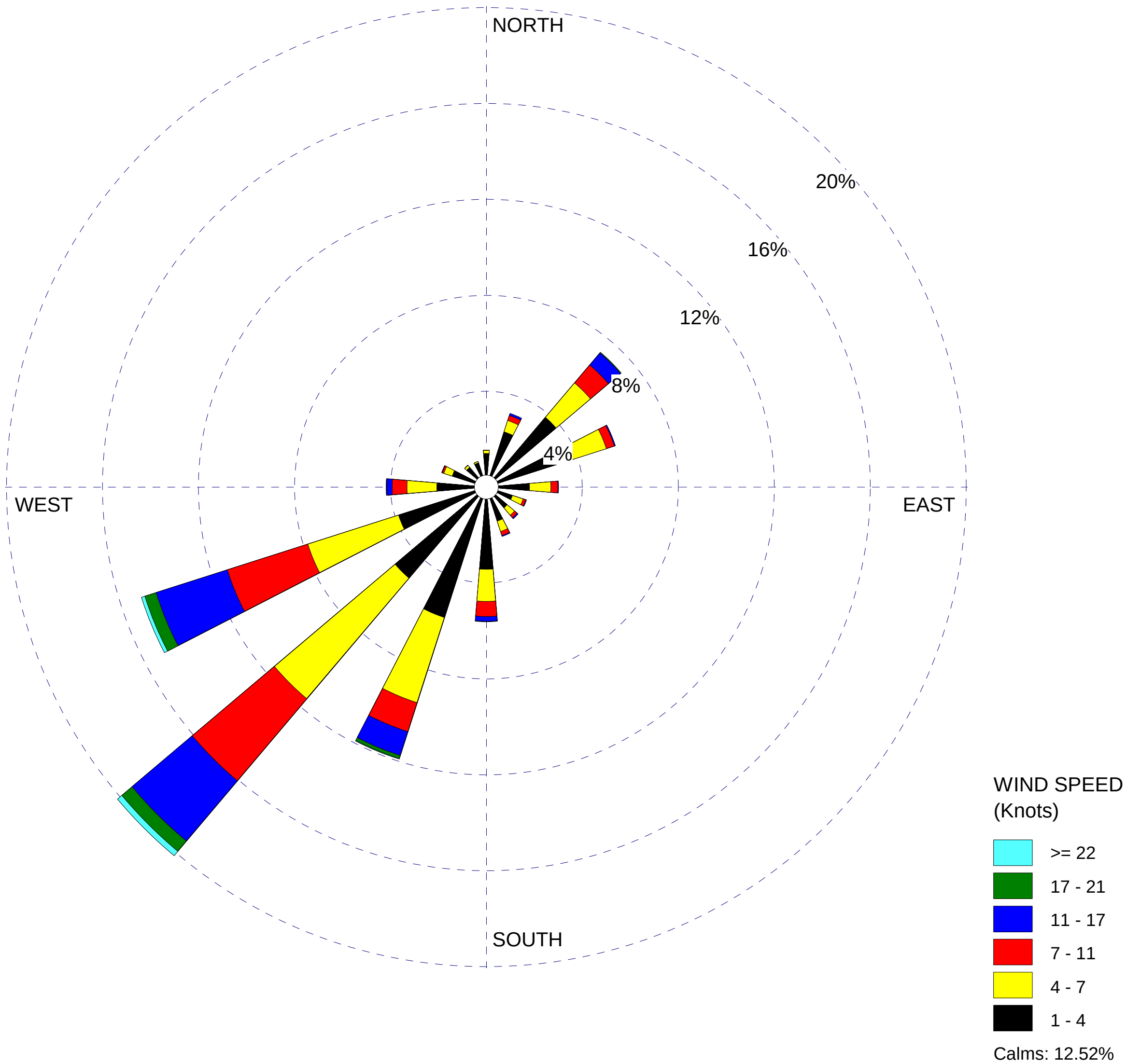
LAND OWNERSHIP

PROJECT: 0100-008-900	DATE: AUG 07, 2007
REV: 0	BY: CRL / CHECKED: ACK

NEWFIELDS

FIGURE 2-3
WindRose for Zonolite Mountain, Libby, MT

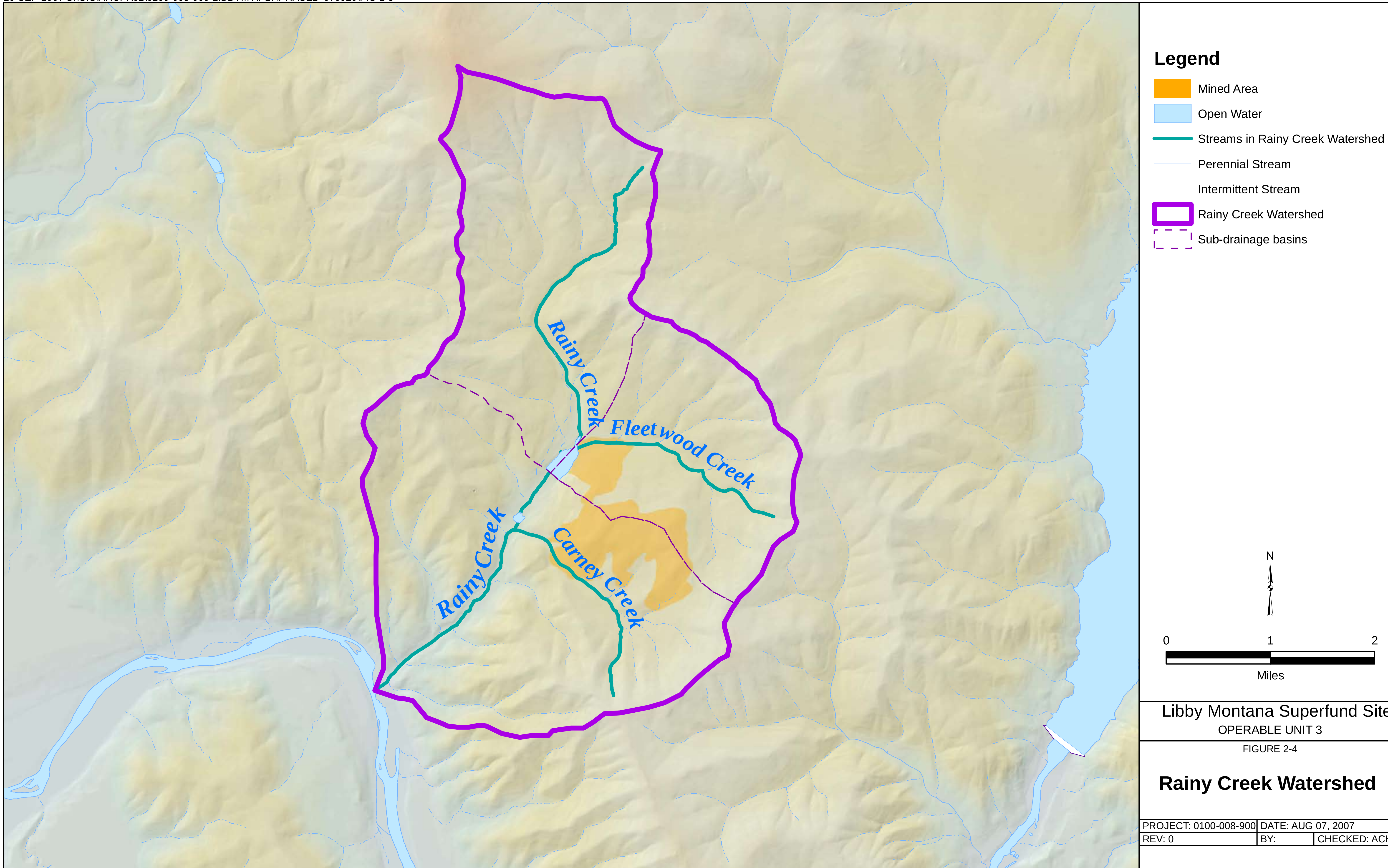
DISPLAY:
Wind Speed
Direction (blowing from)



COMMENTS:	DATA PERIOD:	COMPANY NAME:	
	2006-2009 **Jan 1 - Dec 31** **00:00 - 23:00**	**W.R. Grace**	
		MODELER: **MWH Global**	MWH BUILDING A BETTER WORLD
	CALM WINDS: **12.52%**	TOTAL COUNT: **26272 hrs.**	
	AVG. WIND SPEED: **4.93 Knots**	DATE: **2/26/2010**	PROJECT NO.:

WRPLOT View - Lakes Environmental Software

20-SEP-2007 S:\GIS\ARCPRJ2\0100-008-900-LIBBYMT\PLT\PHASE1_070920\FIG 2-5



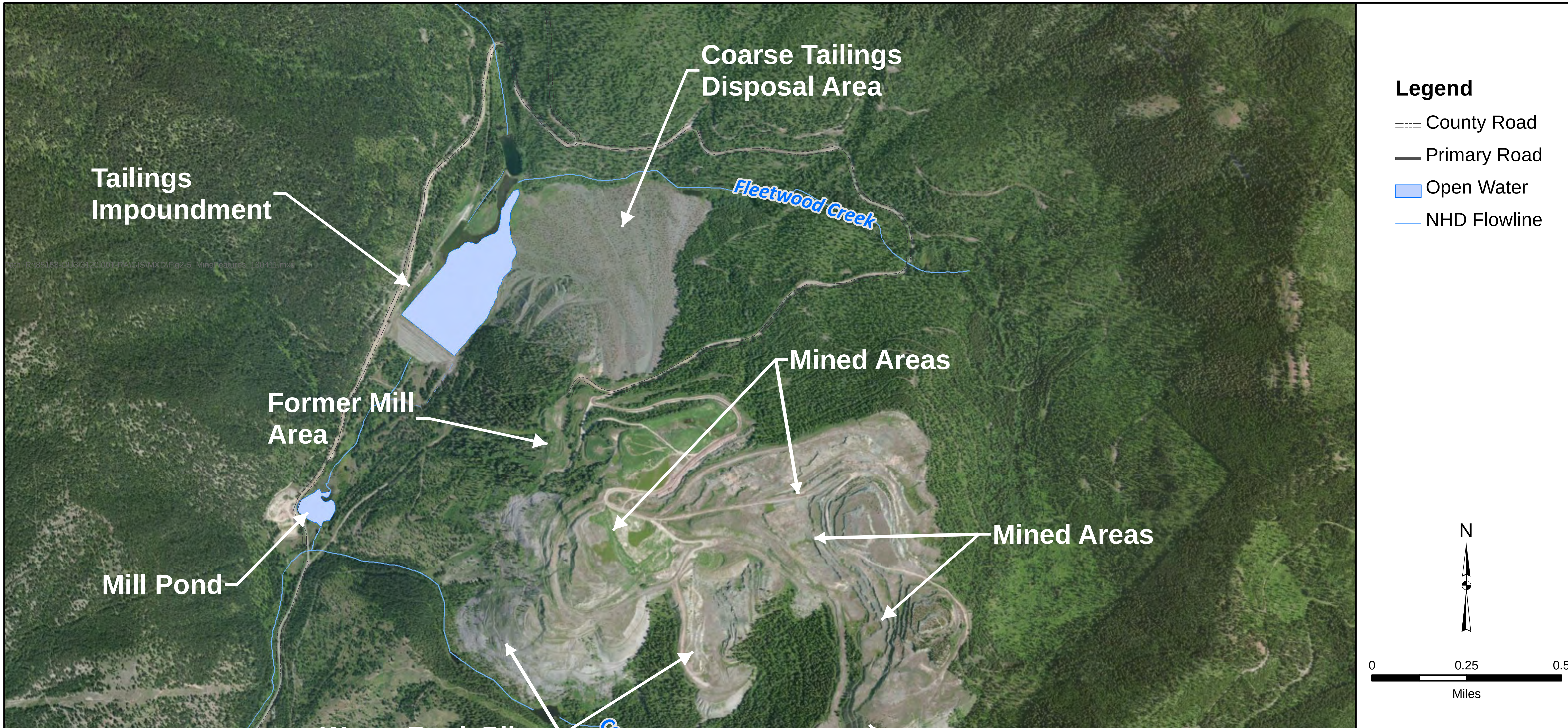
Libby Montana Superfund Site

OPERABLE UNIT 3

FIGURE 2-4

Rainy Creek Watershed

PROJECT: 0100-008-900	DATE: AUG 07, 2007	
REV: 0	BY:	CHECKED: ACK



LIBBY, MONTANA SUPERFUND SITE
Operable Unit 3

Figure 2-5

Mined Area Features

PROJECT: 0100-008-900	DATE: AUGUST 7, 2007
REV:0	CHECKED: ACK

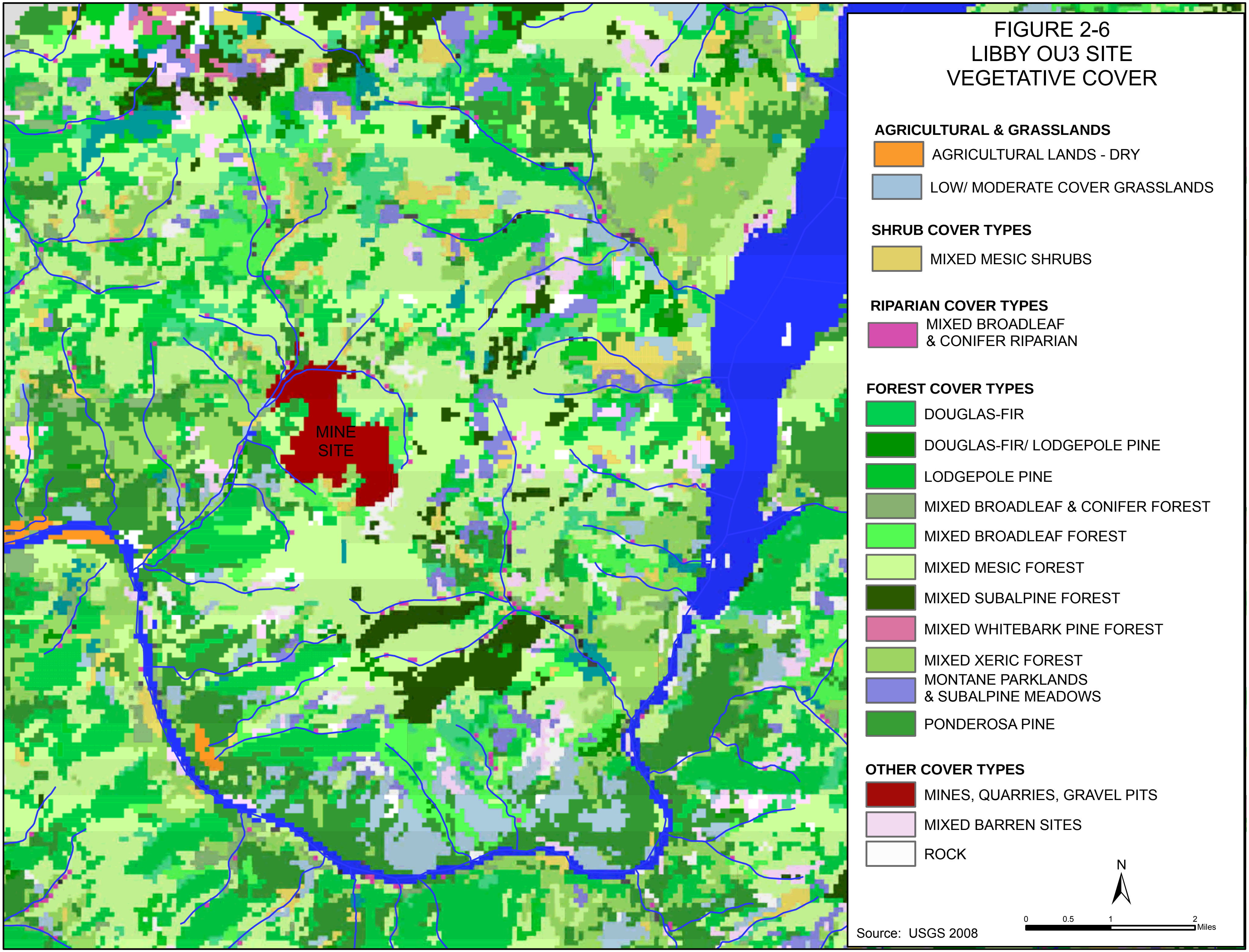
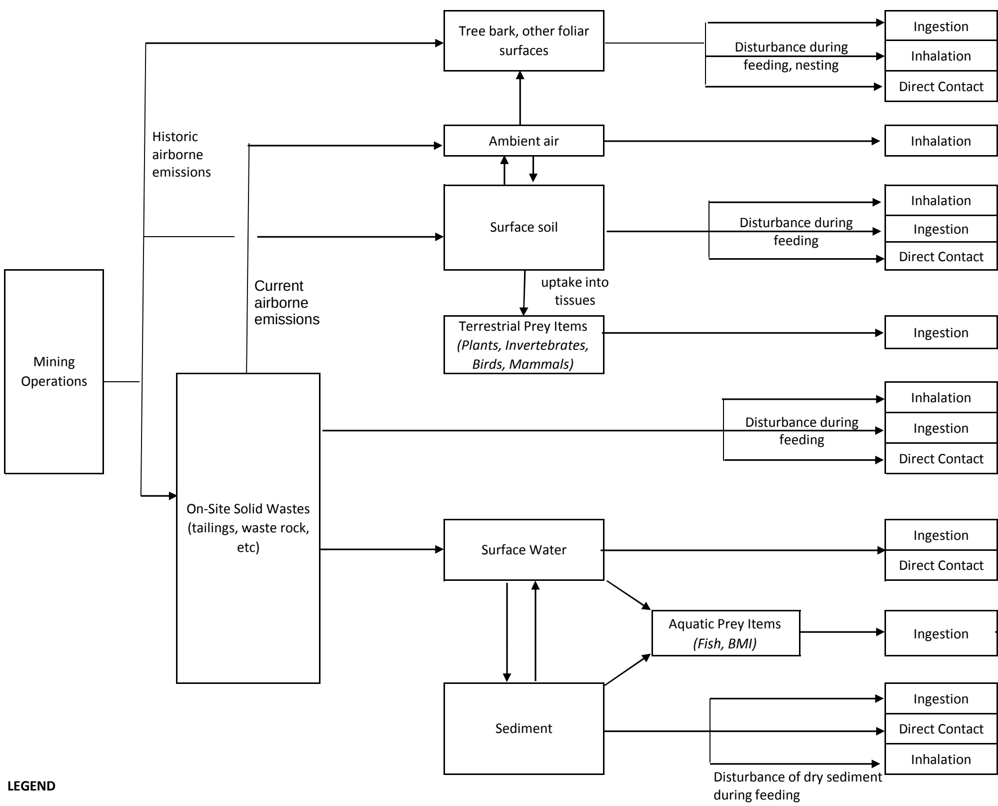


FIGURE 2-6
LIBBY OU3 SITE
VEGETATIVE COVER
AGRICULTURAL & GRASSLANDS
AGRICULTURAL LANDS - DRY
LOW/ MODERATE COVER GRASSLANDS
SHRUB COVER TYPES
MIXED MESIC SHRUBS
RIPARIAN COVER TYPES
MIXED BROADLEAF & CONIFER RIPARIAN
FOREST COVER TYPES
DOUGLAS-FIR
DOUGLAS-FIR/ LODGEPOLE PINE
LODGEPOLE PINE
MIXED BROADLEAF & CONIFER FOREST
MIXED BROADLEAF FOREST
MIXED MESIC FOREST
MIXED SUBALPINE FOREST
MIXED WHITEBARK PINE FOREST
MIXED XERIC FOREST
MONTANE PARKLANDS & SUBALPINE MEADOWS
PONDEROSA PINE
OTHER COVER TYPES
MINES, QUARRIES, GRAVEL PITS
MIXED BARREN SITES
ROCK
MINE SITE
N
0
0.5
1
2
Miles
Source: USGS 2008

FIGURE 3-1. CONCEPTUAL SITE MODEL FOR EXPOSURE OF ECOLOGICAL RECEPTORS TO NON-ASBESTOS CONTAMINANTS AT OU3

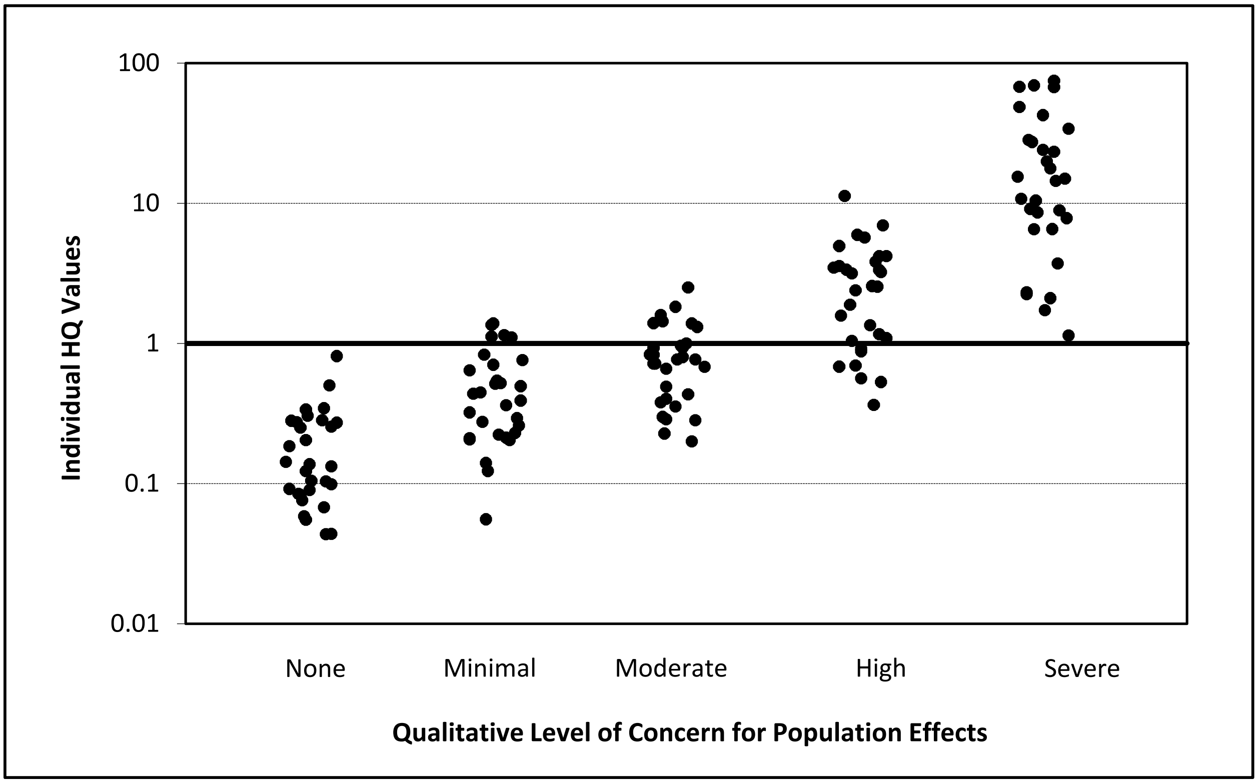


		Fish	Aquatic Invertebrates	Amphibians	Plants	Soil Invertebrates	Reptiles	Birds	Mammals
Tree bark, other foliar surfaces	Ingestion							O	O
	Inhalation							O	O
	Direct Contact				O				
Ambient air	Inhalation			O			O	O	O
Surface soil	Inhalation			O				O	O
	Ingestion			O		●		●	●
	Direct Contact			O	●			O	O
Terrestrial Prey Items	Ingestion			O				●	●
On-Site Solid Wastes	Inhalation							O	O
	Ingestion					●		●	●
	Direct Contact				●			O	O
Surface Water	Ingestion	●	●	●			●	●	●
	Direct Contact						●	O	O
Aquatic Prey Items	Ingestion	O	O	O			●	●	●
Sediment	Ingestion	O	O	O			●	●	●
	Direct Contact	O	●	O			●	O	O
	Inhalation			O			O	O	O

LEGEND

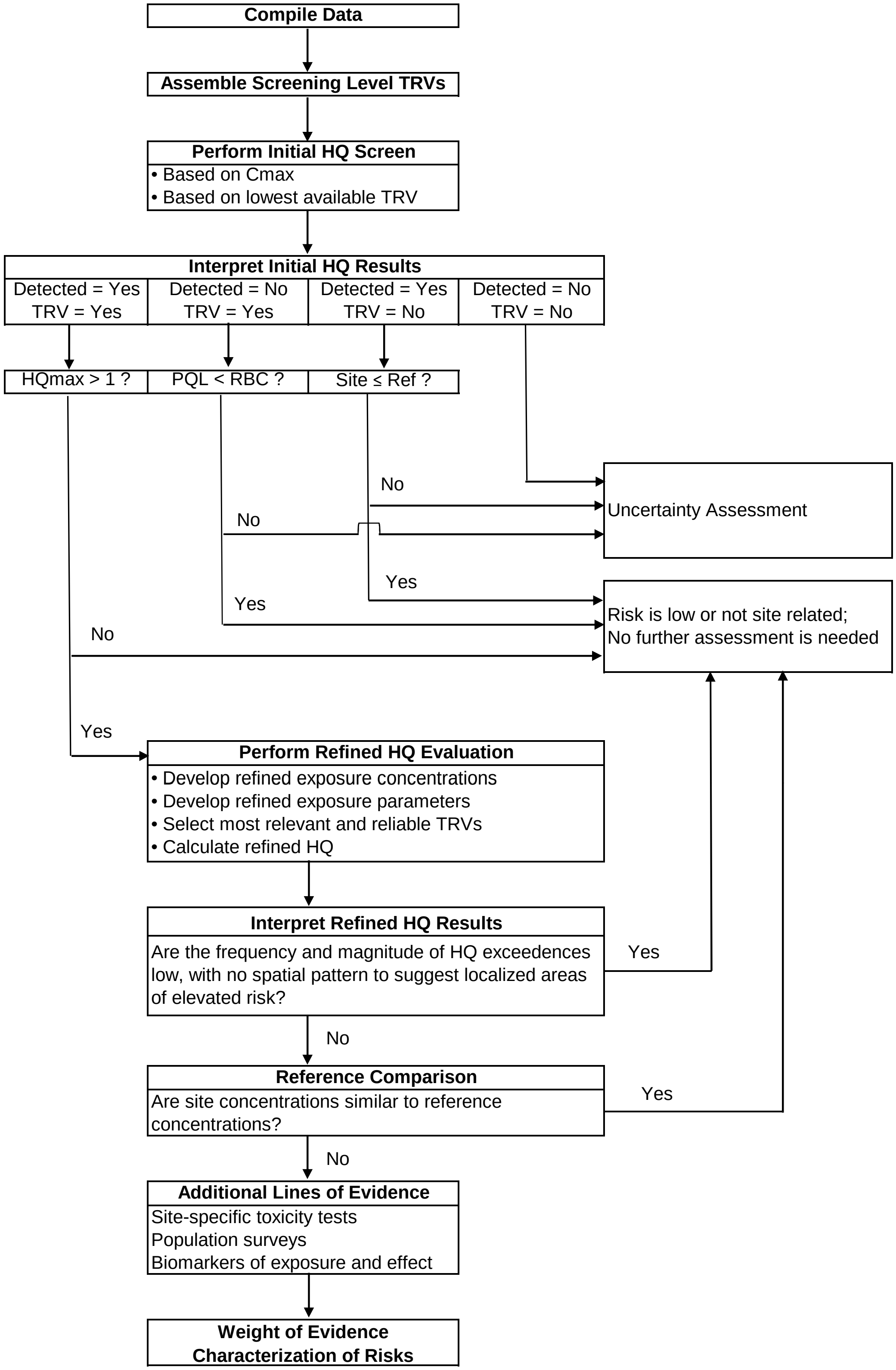
●	Pathway is believed to be complete and may be an important contribution to the total risk to the receptor.
O	Pathway is believed to be complete but is unlikely to be a major contributor to the total risk to the receptor (in comparison to one or more other pathways that are evaluated).
	Pathway is incomplete or believed to be negligible

Figure 3-2
Conceptual Approach for Characterizing Population-Level Risks



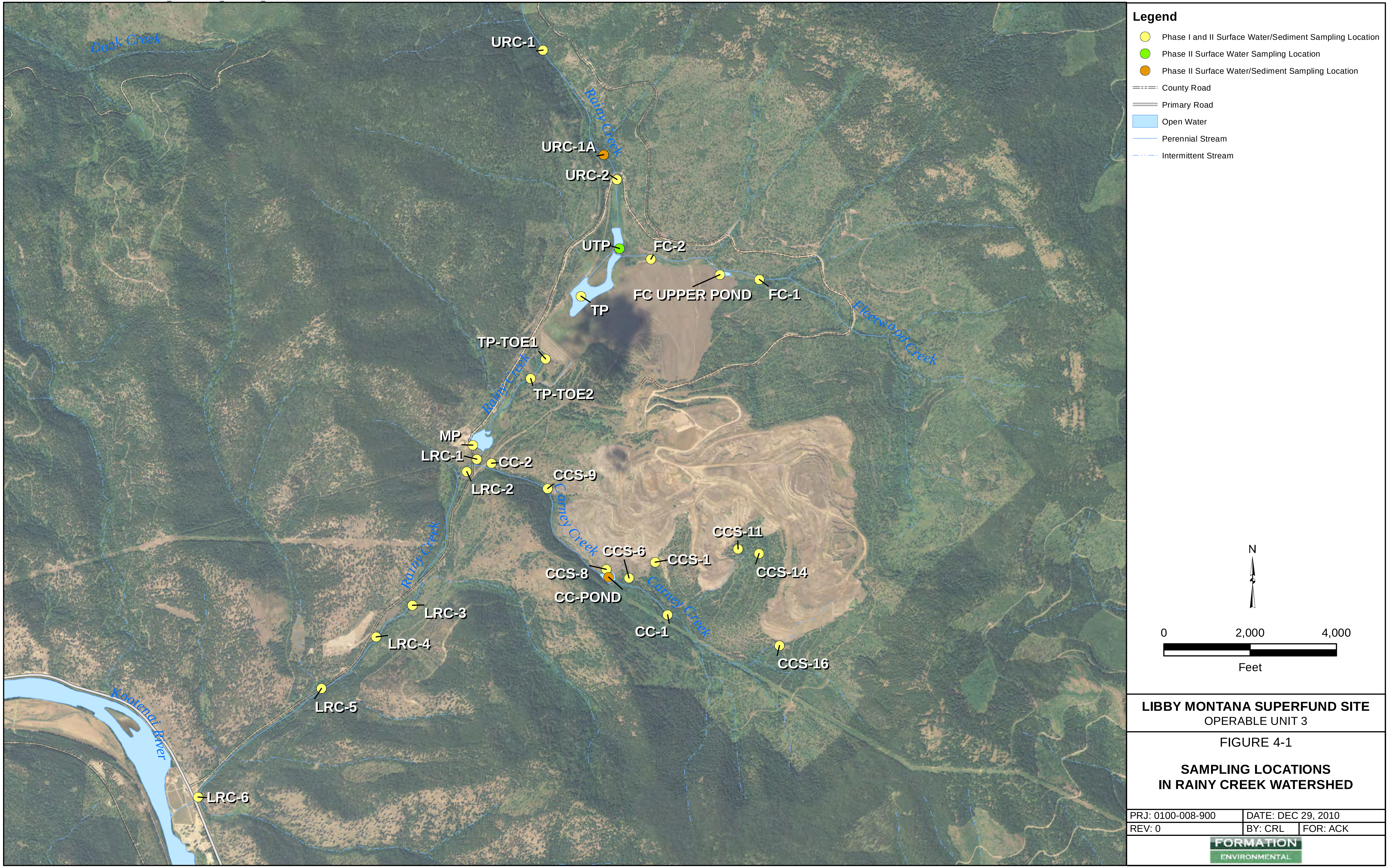
HQ = hazard quotient

FIGURE 3-3. STRATEGY FOR EVALUATION OF ECOLOGICAL RISKS FROM NON-ASBESTOS CONTAMINANTS



TRV = toxicity reference value
HQ = hazard quotient
HQmax = maximum hazard quotient
PQL = practical quantitation limit

S:\GIS\ARCPRJ2\0100-008-900-LIBBYMT\PLT\RA_101222\FIG4-1_SAMPLING_LOCNS.MXD



LIBBY MONTANA SUPERFUND SITE
OPERABLE UNIT 3

FIGURE 4-1

SAMPLING LOCATIONS IN RAINY CREEK WATERSHED

PRJ: 0100-008-900	DATE: DEC 29, 2010	
REV: 0	BY: CRL	FOR: ACK

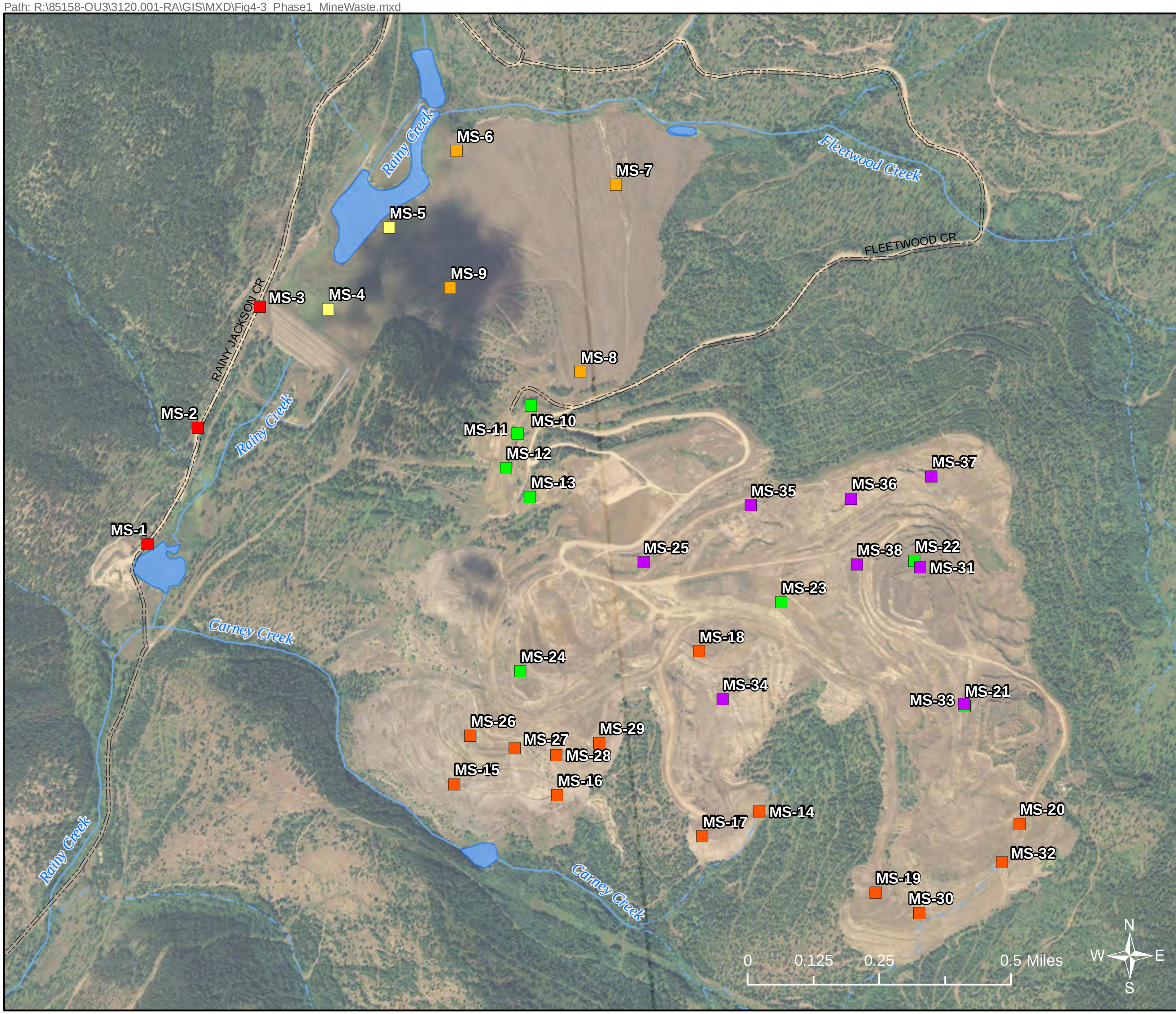
FORMATION ENVIRONMENTAL

CDM Smith

Aquatic Reference Location
Open Water
Perennial Stream
Intermittent Stream

Figure 4-2
Aquatic Reference Locations

Path: R:\85158-OU3\3120.001-RA\GIS\MXD\Fig4-3_Phase1_MineWaste.mxd



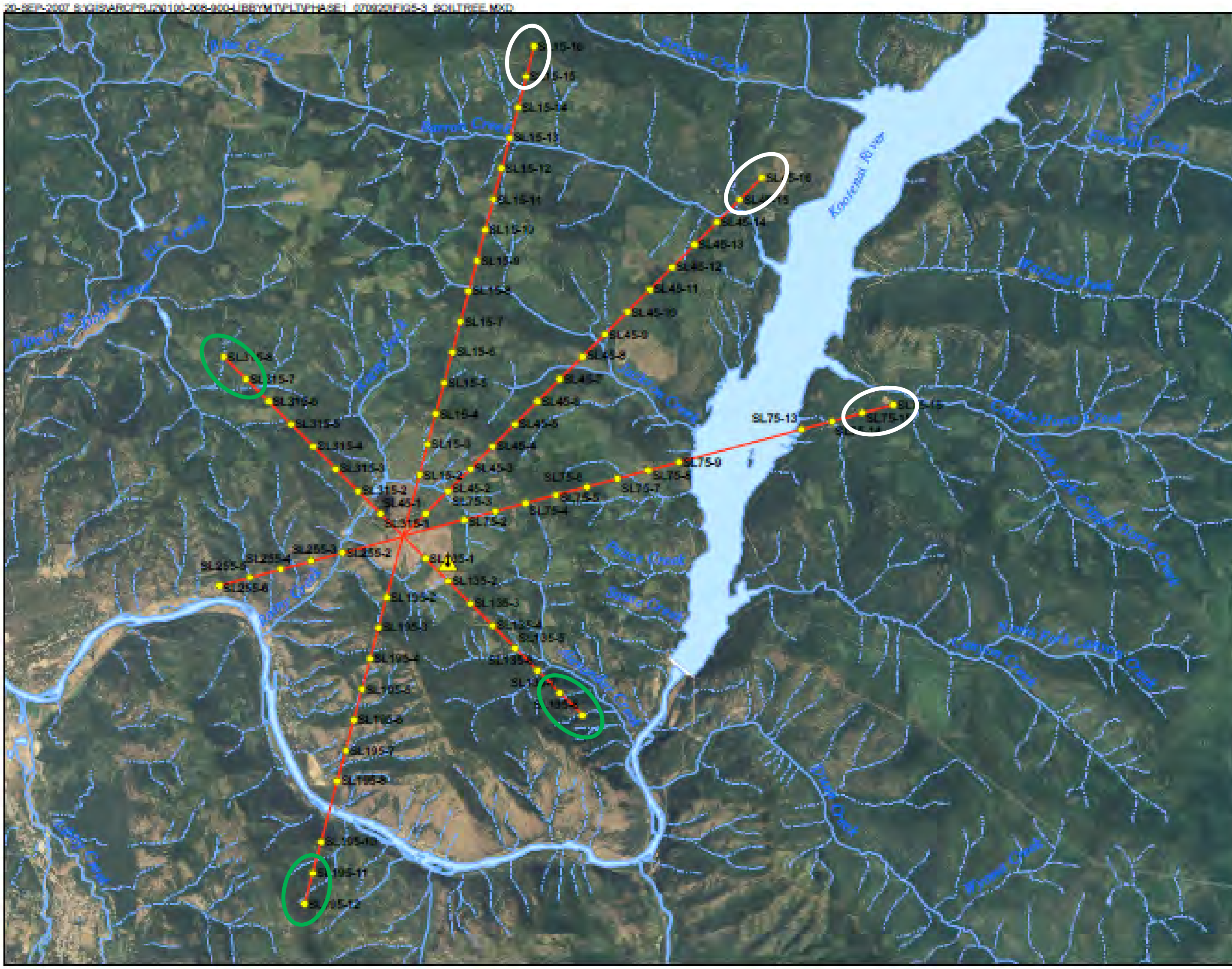
Mine Waste Sampling Location

- Waste Rock
- Cover Material
- Outcrop
- Coarse Tailings
- Tailings Impoundment
- Road
- County Road
- Primary Road
- Perennial Stream
- Intermittent Stream
- Open Water

Figure 4-3
Mine Waste Sampling Locations

CDM Smith

20-SEP-2007 S:\GIS\ARCPRJ\20100-008-900-LIBBYMT\PLT\PHASE1_070920\FIG5-3_SOILTREE.MXD



Legend

- Soil/Tree Bark Sampling Location
- Open Water
- Perennial Stream
- Intermittent Stream

Green circle = downwind samples

White circle = up/crosswind samples

N

0 1.5 3

Miles

LIBBY MONTANA SUPERFUND SITE

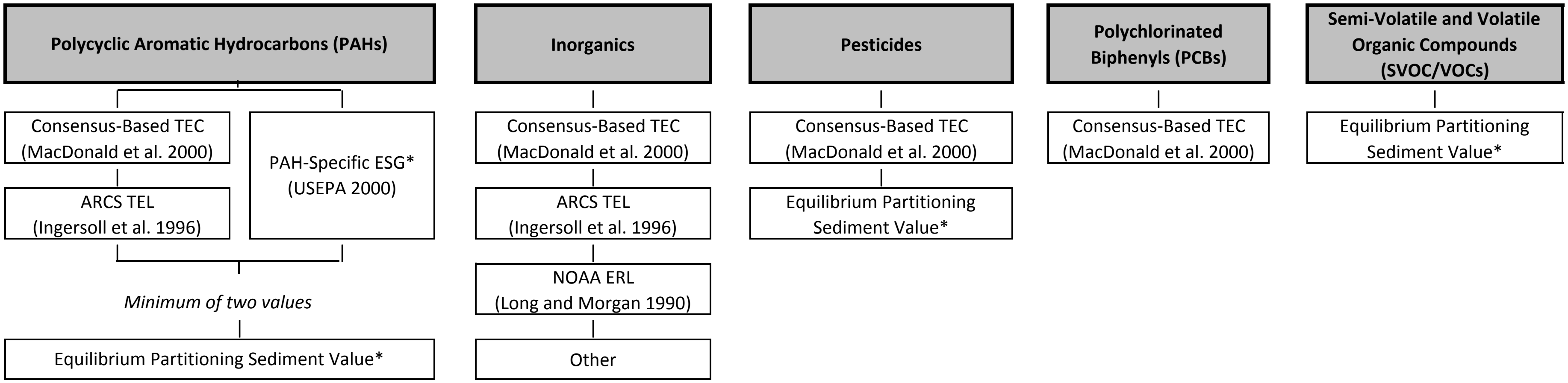
OPERABLE UNIT 3

FIGURE 4-4 FOREST SOIL SAMPLES SELECTED FOR METALS ANALYSIS

PROJECT: 0100-008-900	DATE: AUG 28, 2007
REV: 0	BY: CRL CHECKED: ACK

NEWFIELDS

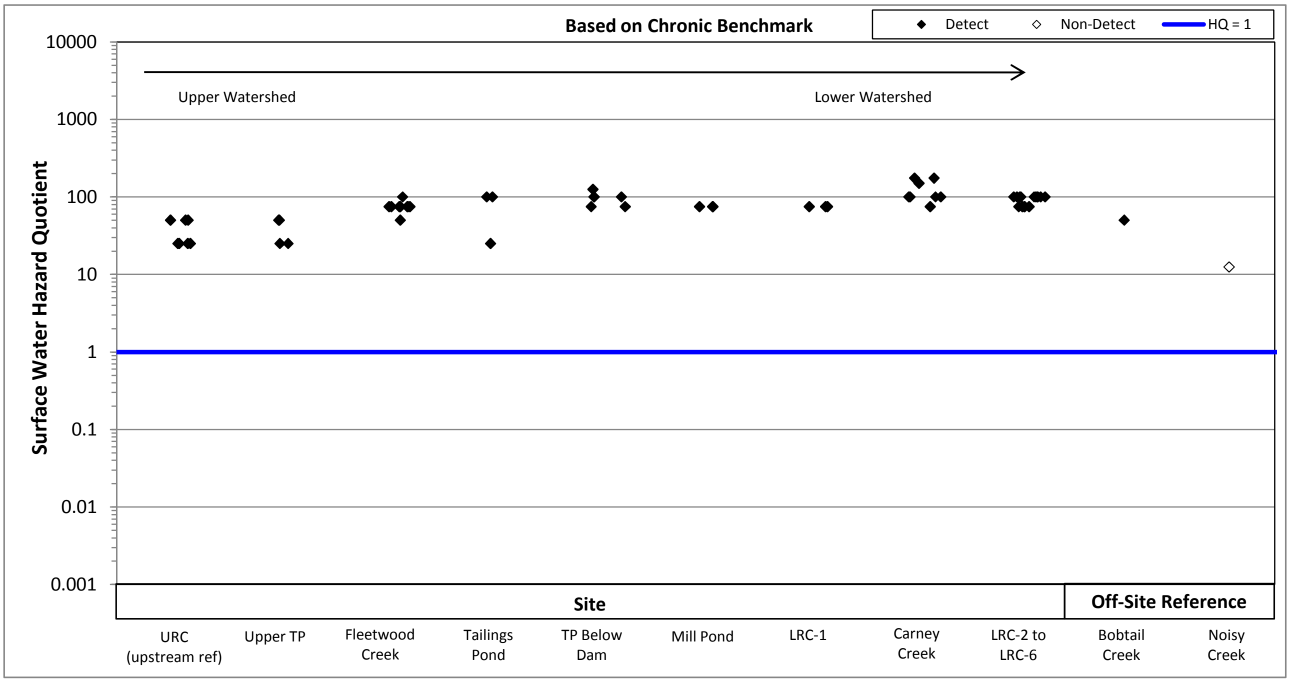
FIGURE 5-1. SUMMARY OF SELECTION HIERARCHY FOR SEDIMENT TOXICITY BENCHMARKS FOR AQUATIC RECEPTORS

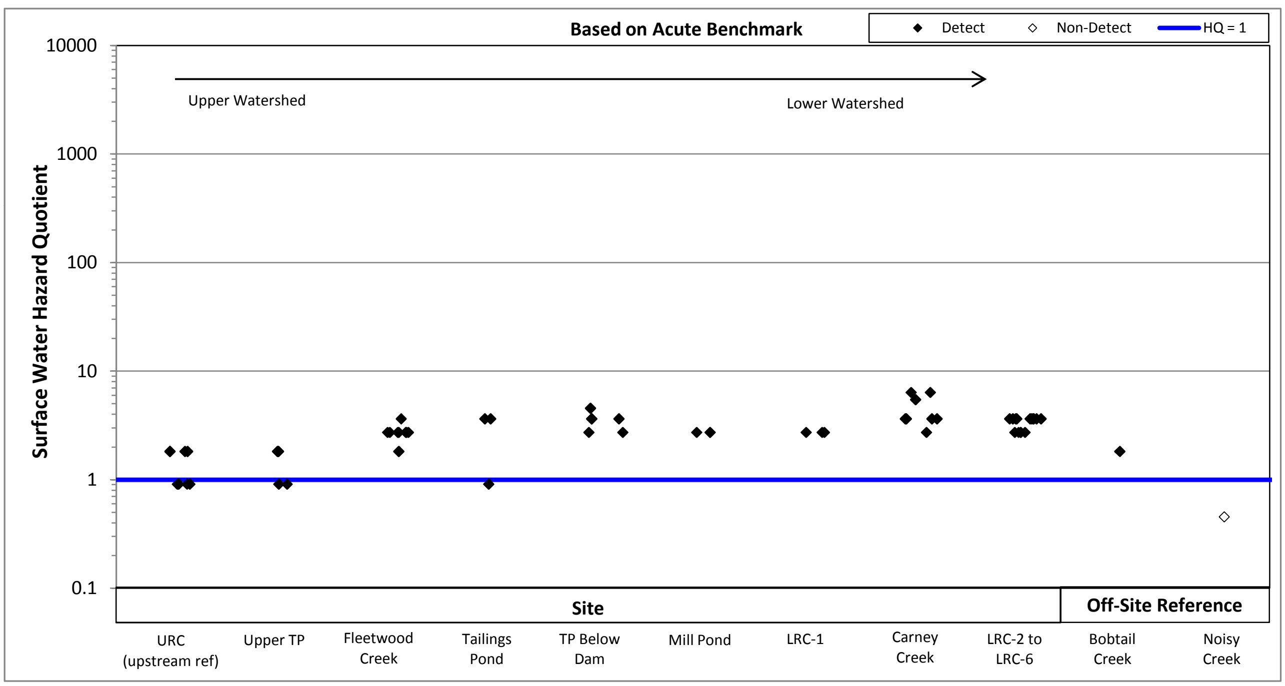


**Screening level benchmark based on a TOC of 1%*

ARCS = Assessment and Remediation of Contaminated Sediments
ERL = Effect Range Low
ESG = Equilibrium-partitioning sediment guidelines
NOAA = National Oceanic and Atmospheric Administration
TEC = threshold effect concencentration
TEL = threshold effect level
TOC = total organic carbon

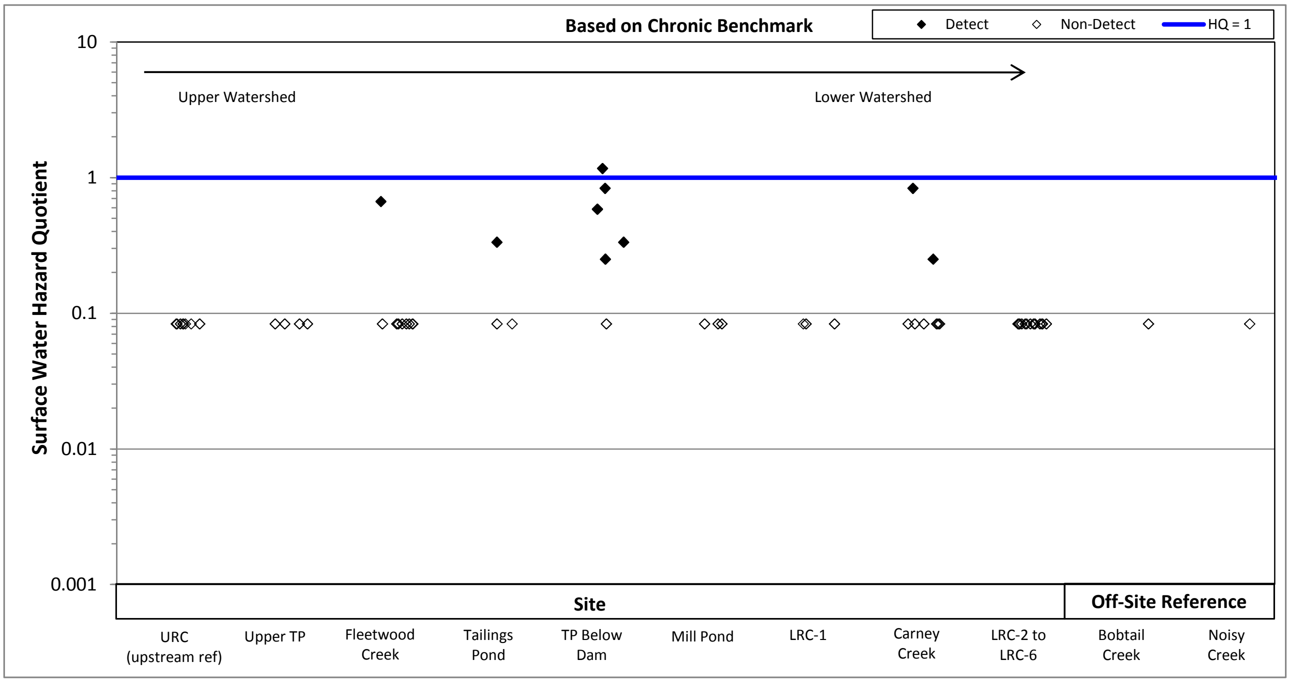
FIGURE 6-1. EVALUATION OF RISKS FROM BARIUM TO AQUATIC RECEPTORS FROM DIRECT CONTACT WITH SURFACE WATER

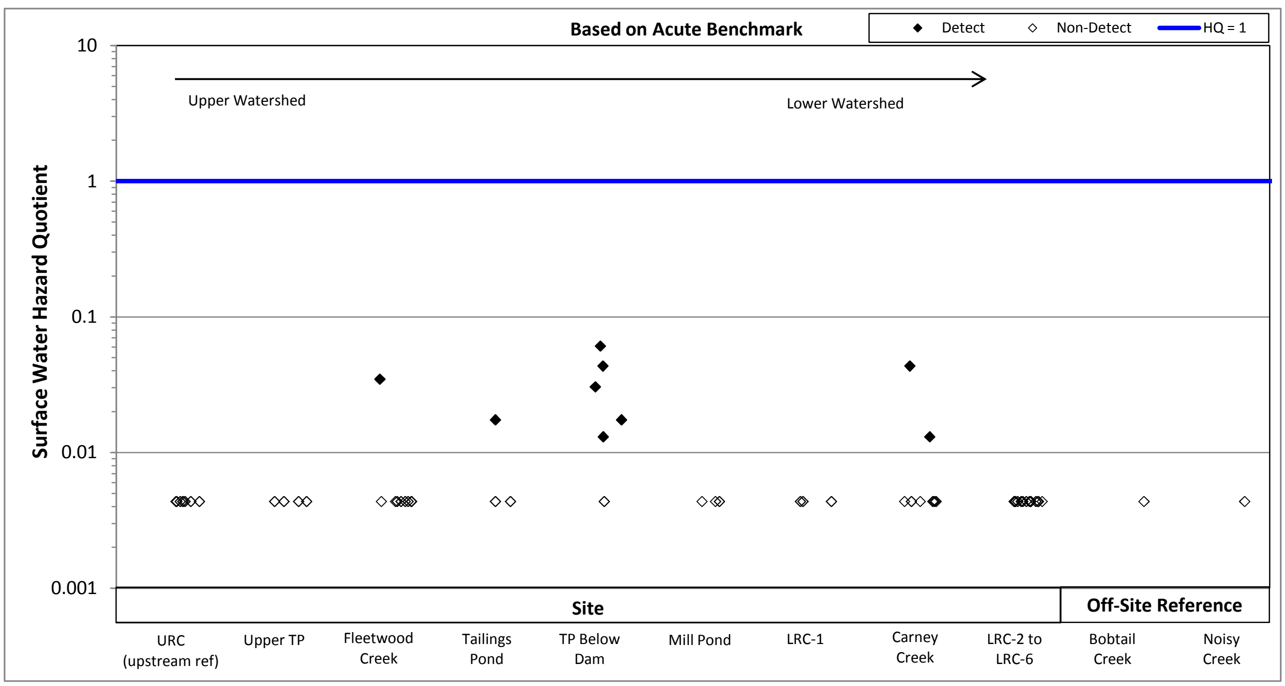




HQ = hazard quotient

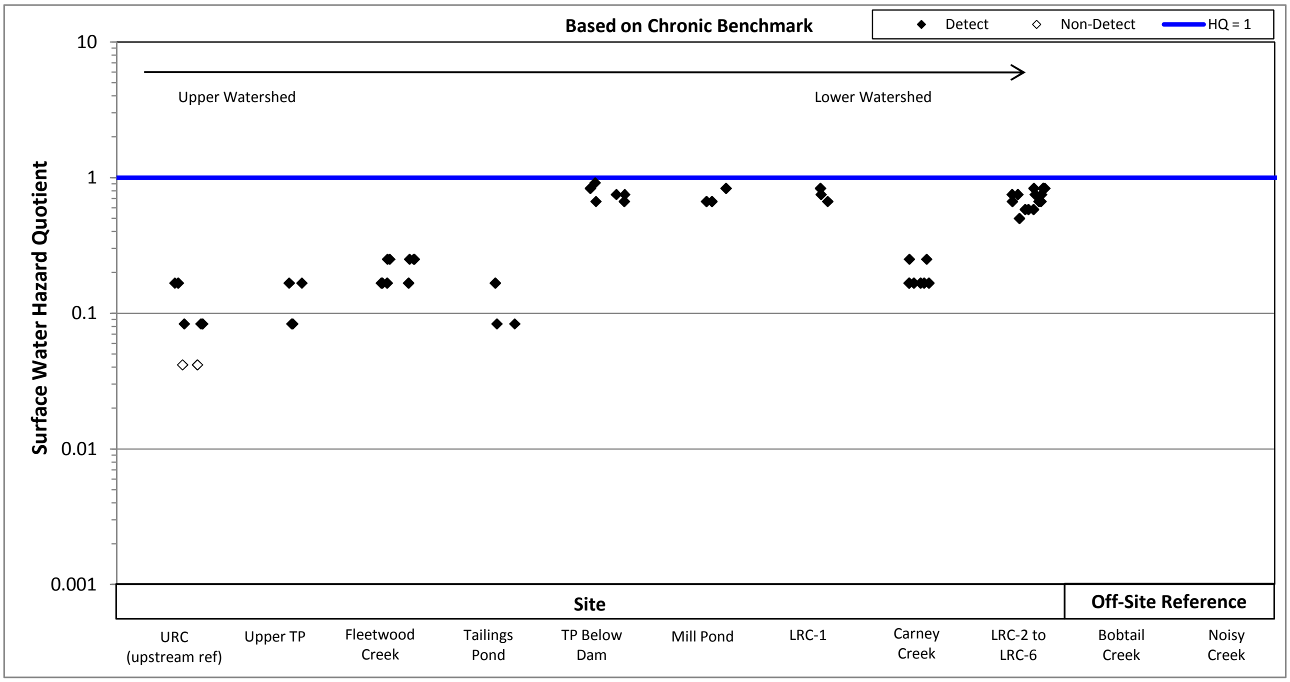
FIGURE 6-2. EVALUATION OF RISKS FROM MANGANESE TO AQUATIC RECEPTORS FROM DIRECT CONTACT WITH SURFACE WATER

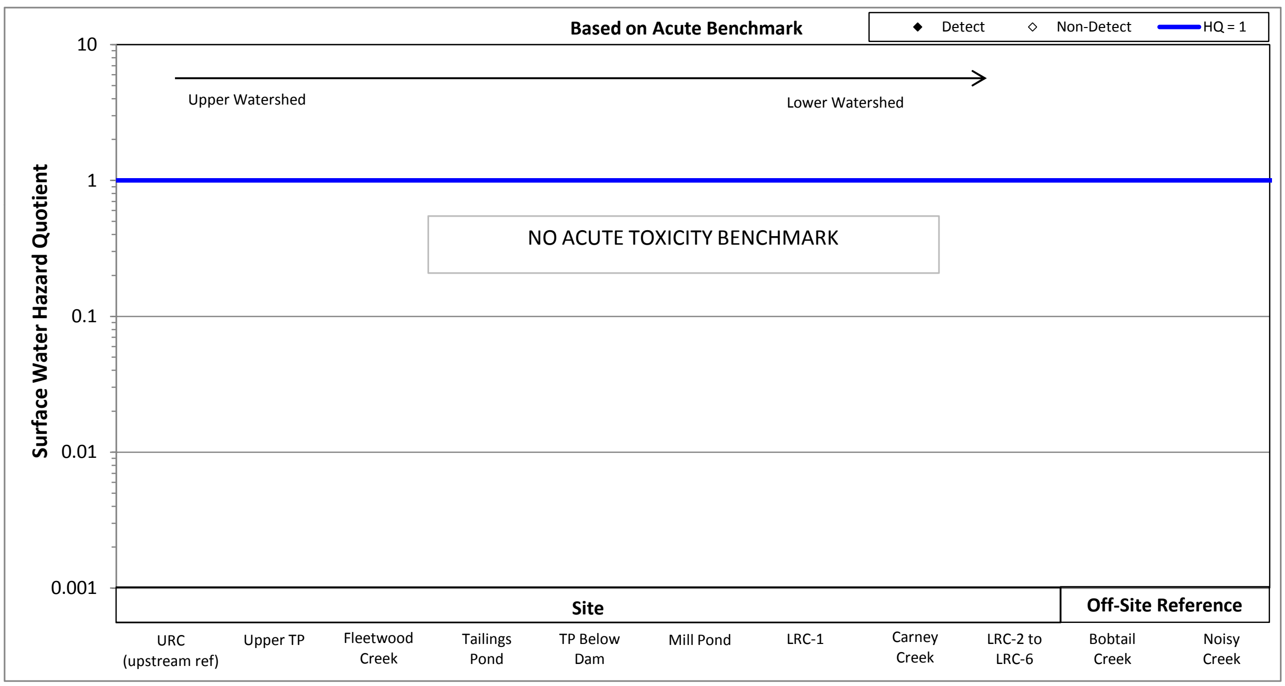




HQ = hazard quotient

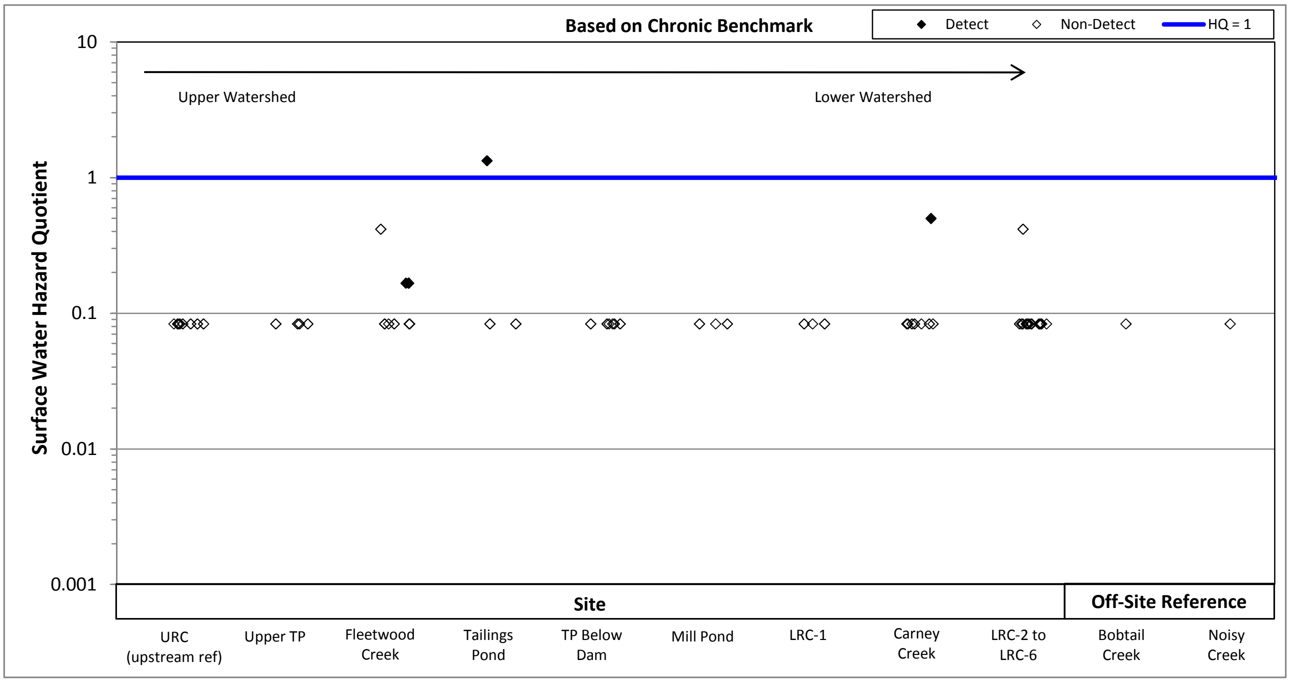
FIGURE 6-3. EVALUATION OF RISKS FROM FLUORIDE TO AQUATIC RECEPTORS FROM DIRECT CONTACT WITH SURFACE WATER

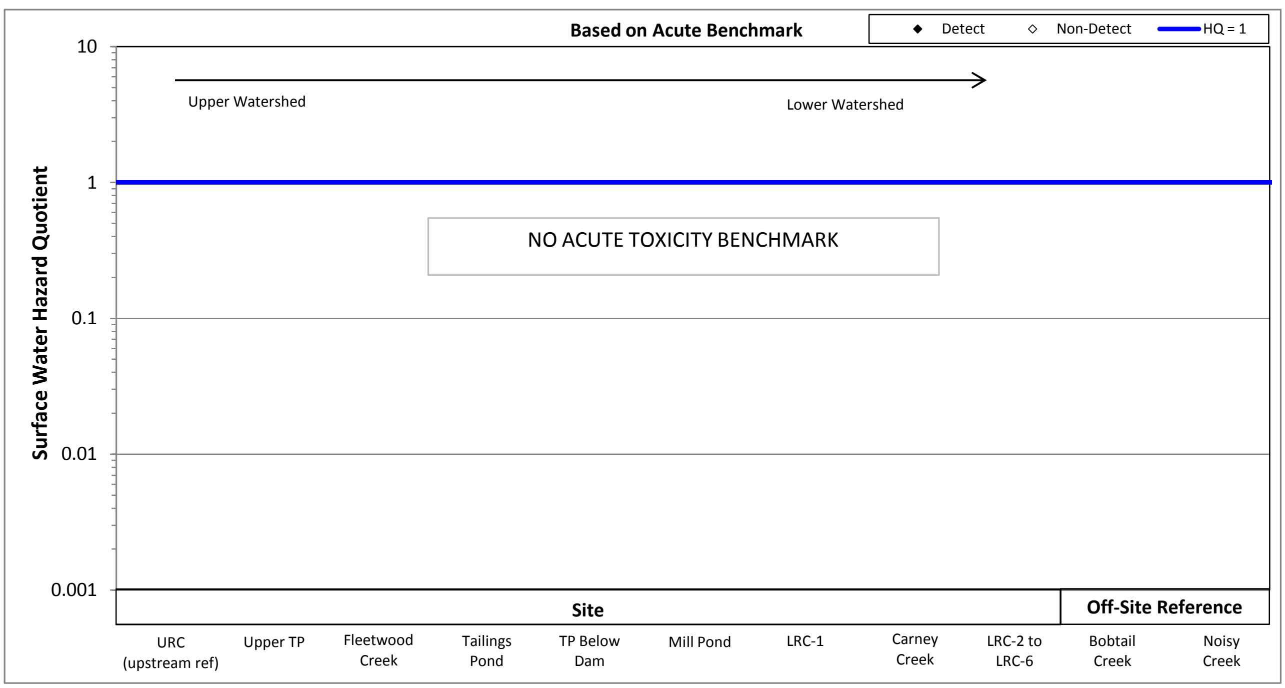




HQ = hazard quotient

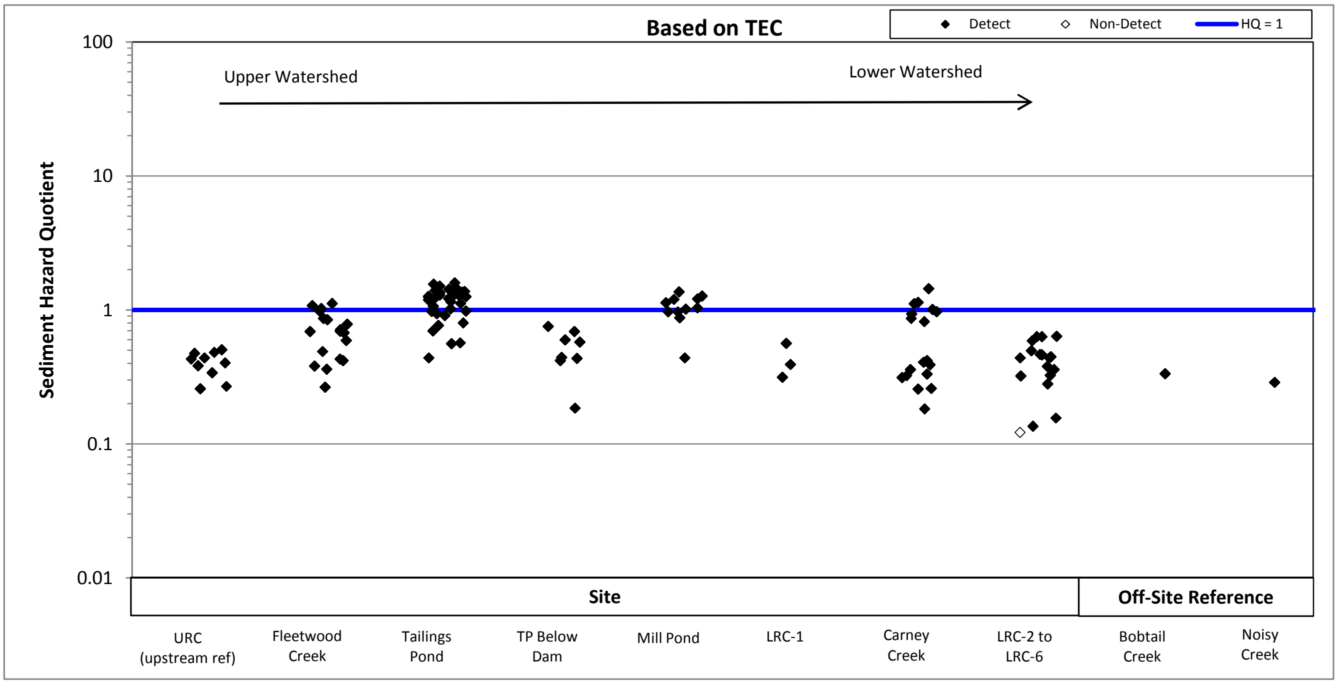
FIGURE 6-4. EVALUATION OF RISKS FROM NITROGEN, NITRITE AS N TO AQUATIC RECEPTORS FROM DIRECT CONTACT WITH SURFACE WATER

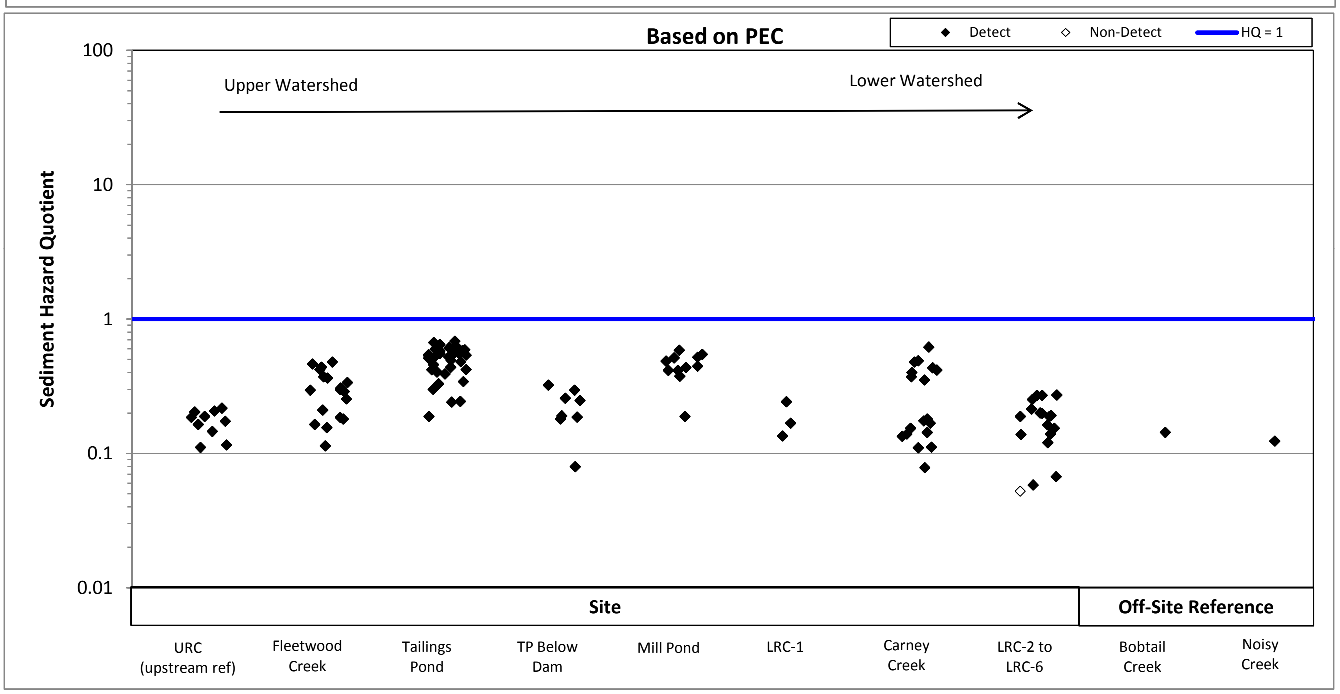




HQ = hazard quotient

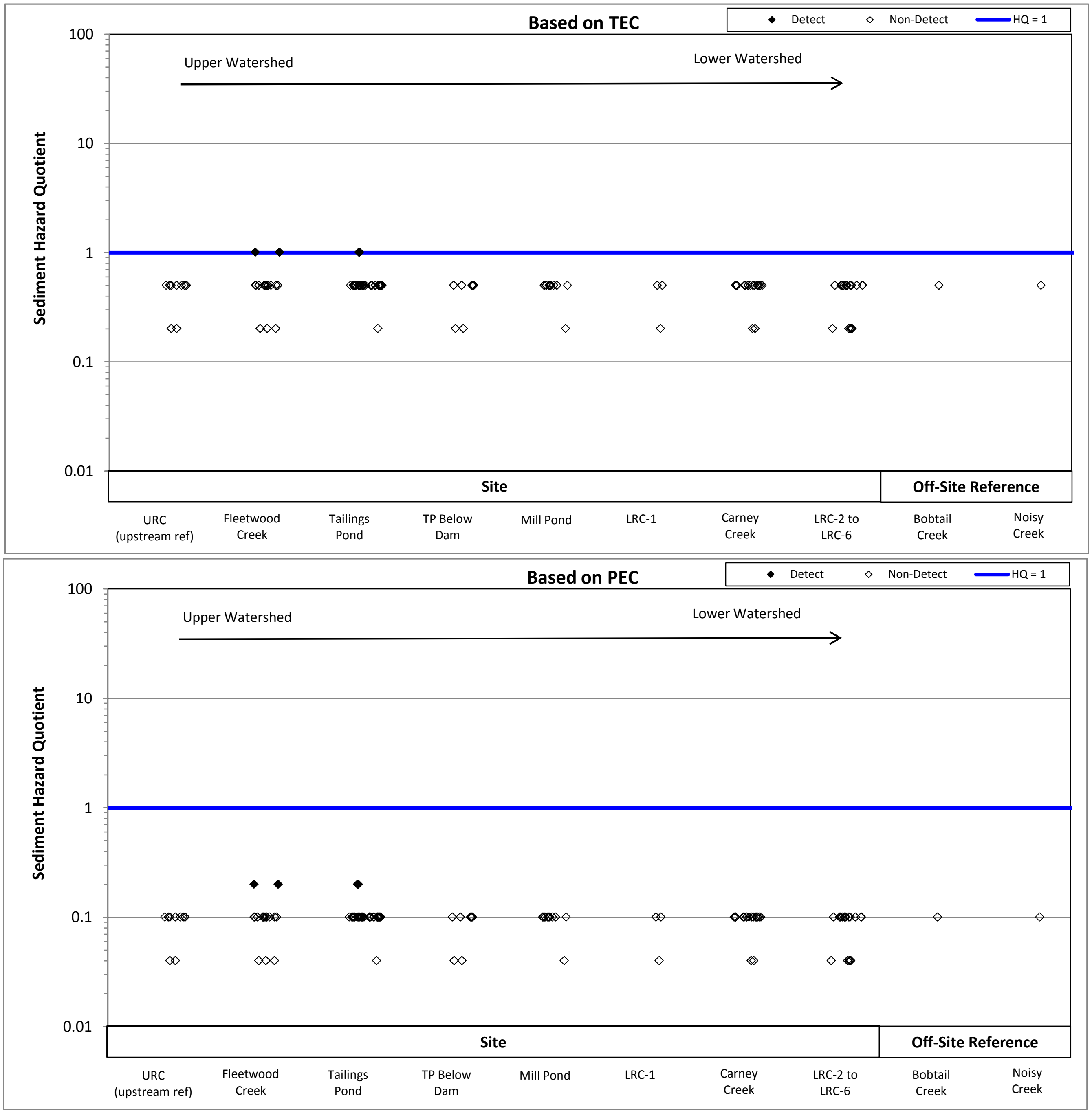
FIGURE 6-5. EVALUATION OF RISKS FROM ALUMINUM TO AQUATIC INVERTEBRATES FROM DIRECT CONTACT WITH SEDIMENT





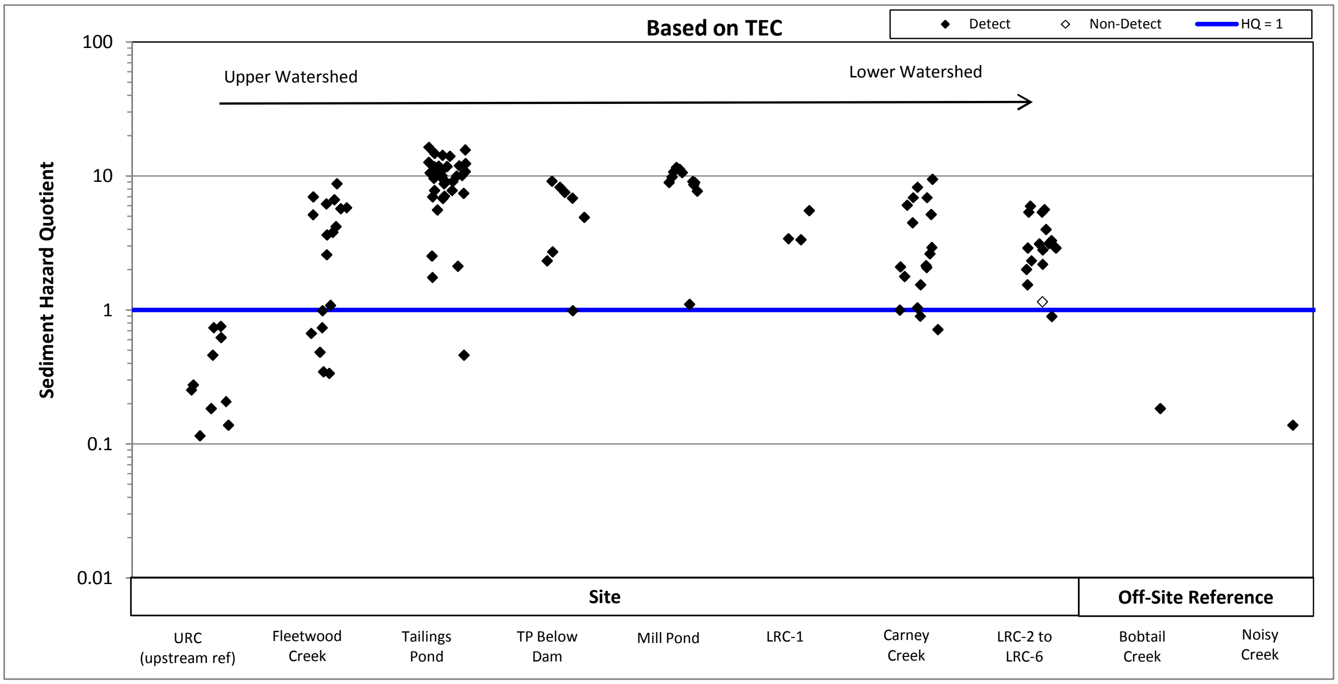
TEC = threshold effect concentration
PEC = probable effect concentration
HQ = hazard quotient

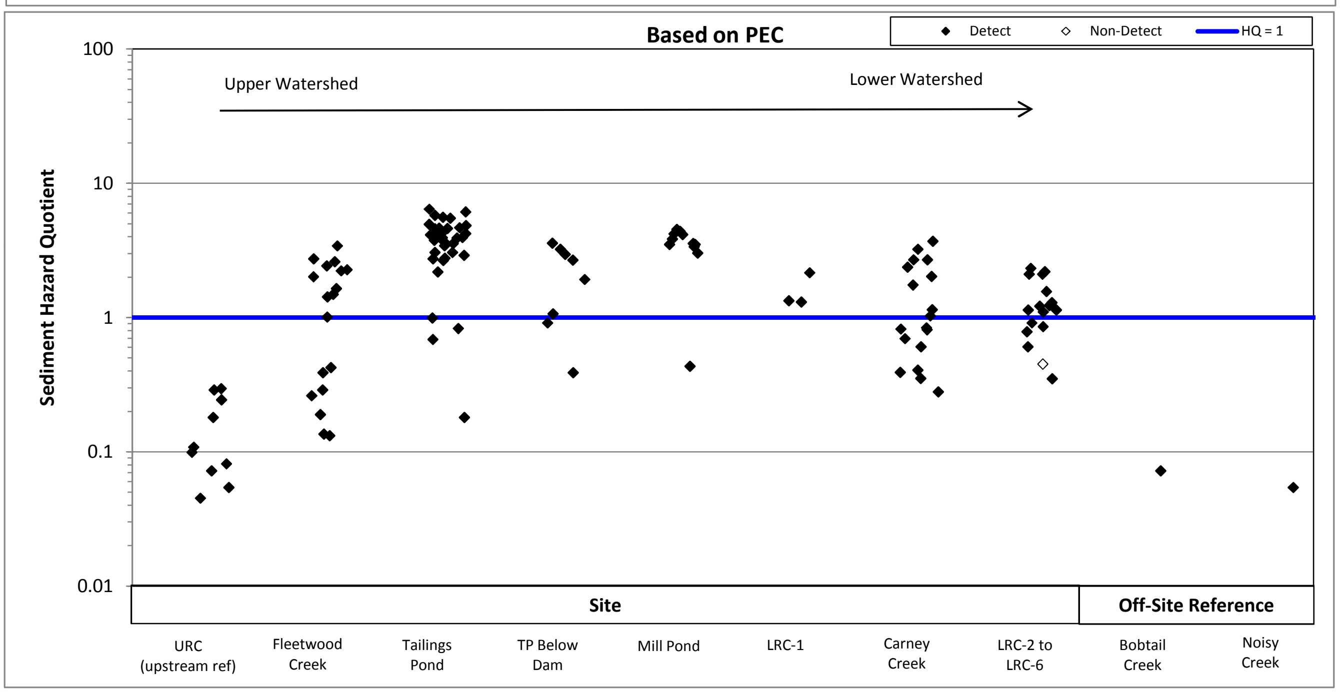
FIGURE 6-6. EVALUATION OF RISKS FROM CADMIUM TO AQUATIC INVERTEBRATES FROM DIRECT CONTACT WITH SEDIMENT



TEC = threshold effect concentration
PEC = probable effect concentration
HQ = hazard quotient

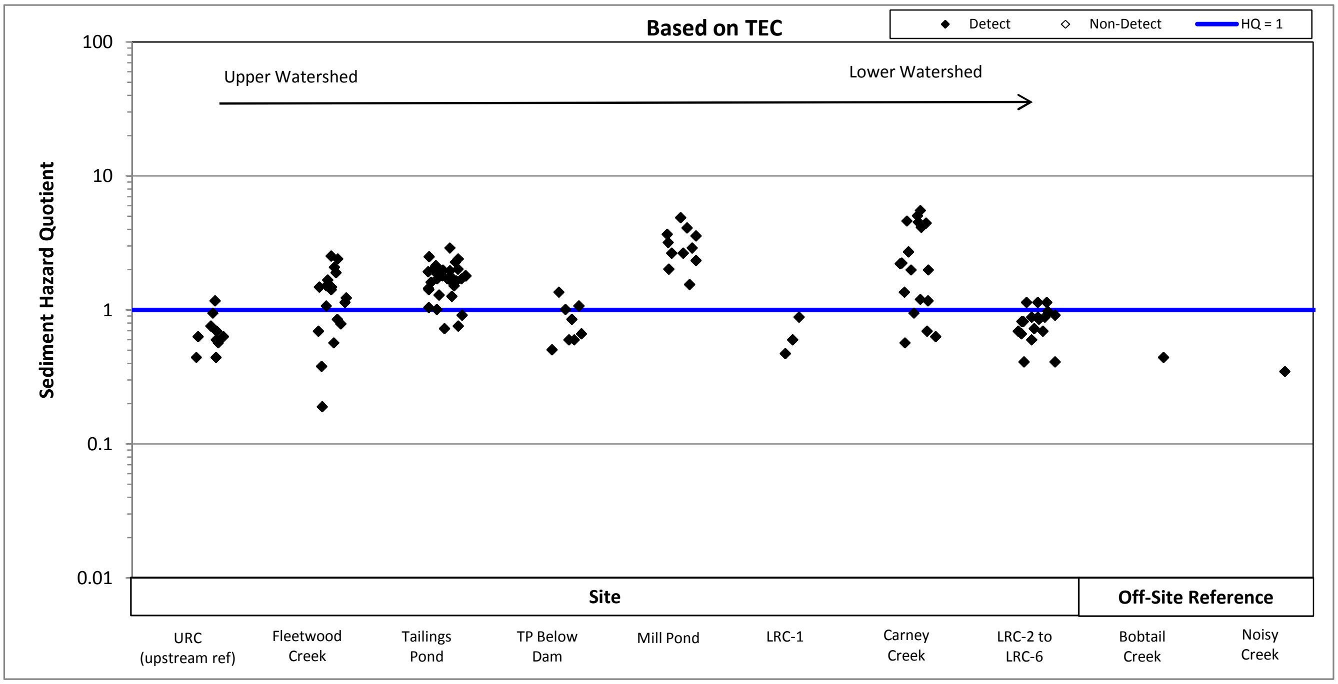
FIGURE 6-7. EVALUATION OF RISKS FROM CHROMIUM TO AQUATIC INVERTEBRATES FROM DIRECT CONTACT WITH SEDIMENT

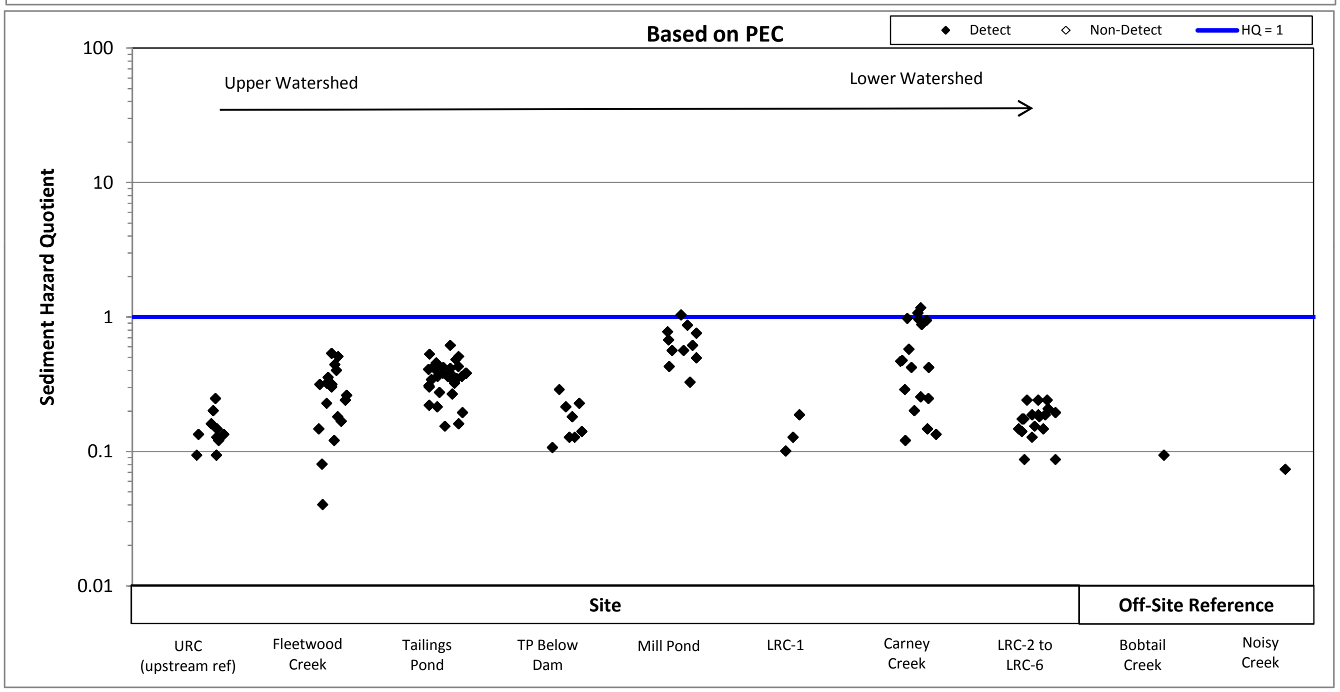




TEC = threshold effect concentration
PEC = probable effect concentration
HQ = hazard quotient

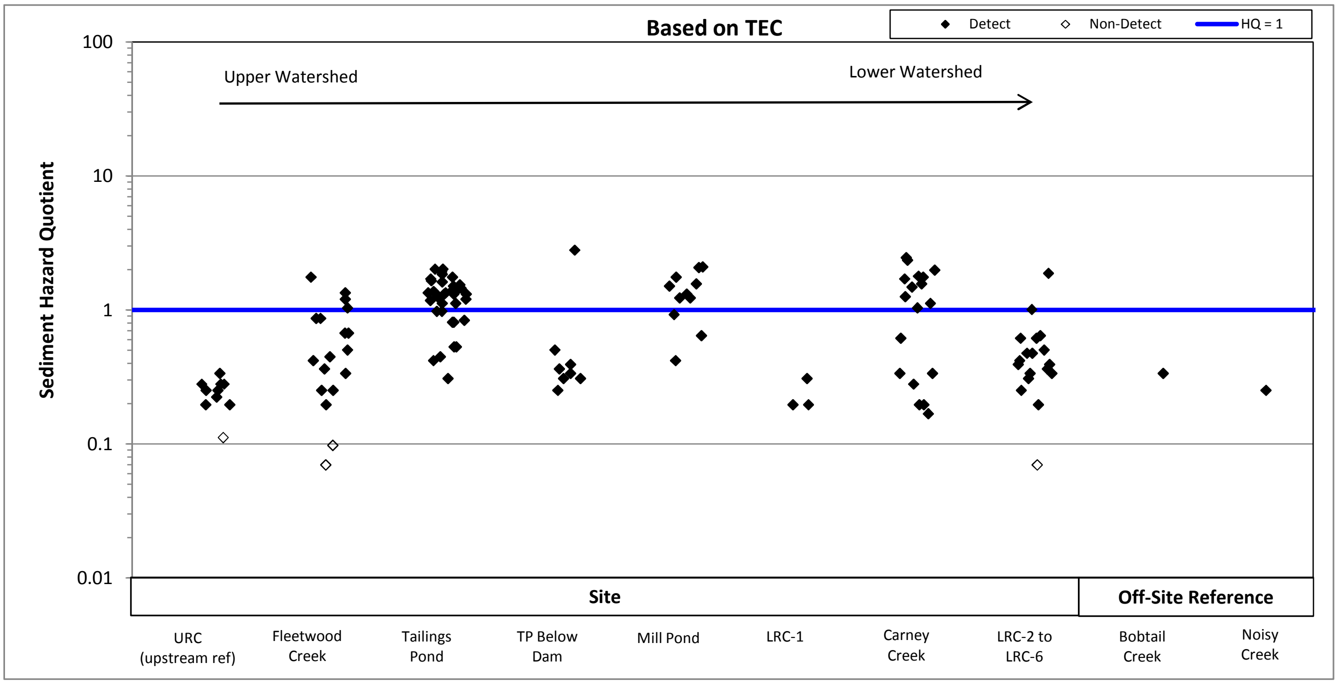
FIGURE 6-8. EVALUATION OF RISKS FROM COPPER TO AQUATIC INVERTEBRATES FROM DIRECT CONTACT WITH SEDIMENT

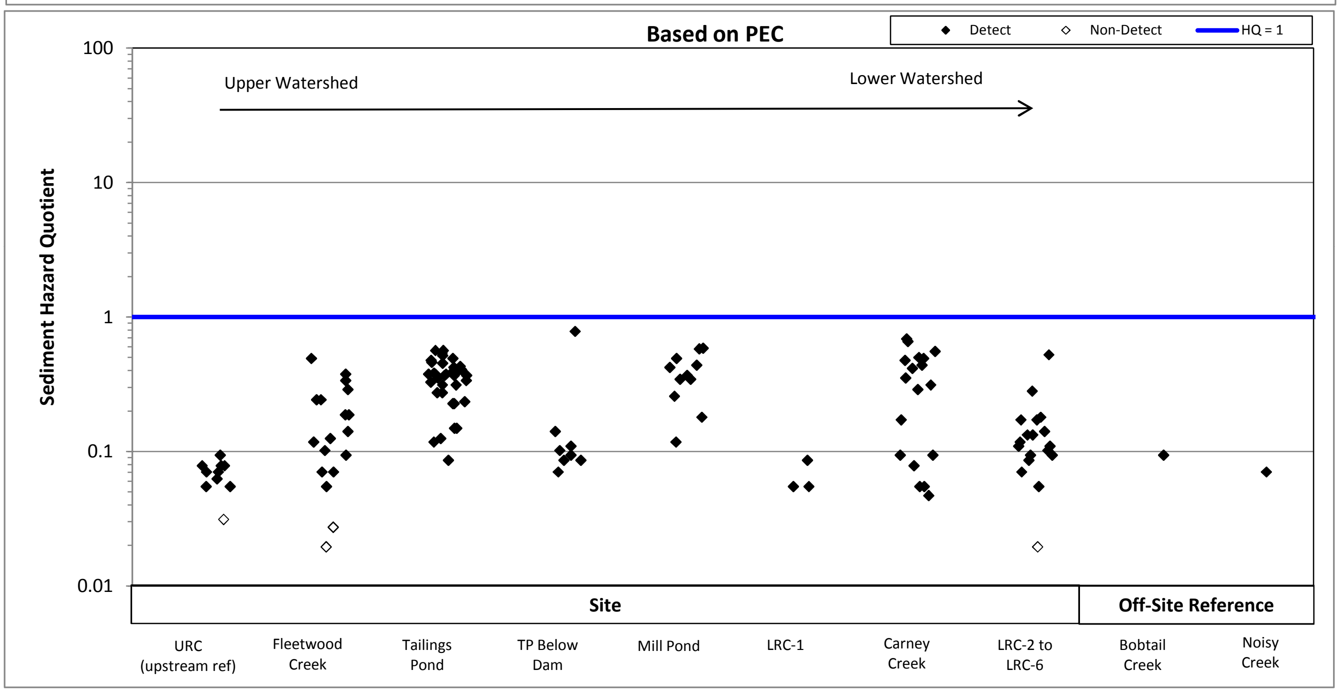




TEC = threshold effect concentration
PEC = probable effect concentration
HQ = hazard quotient

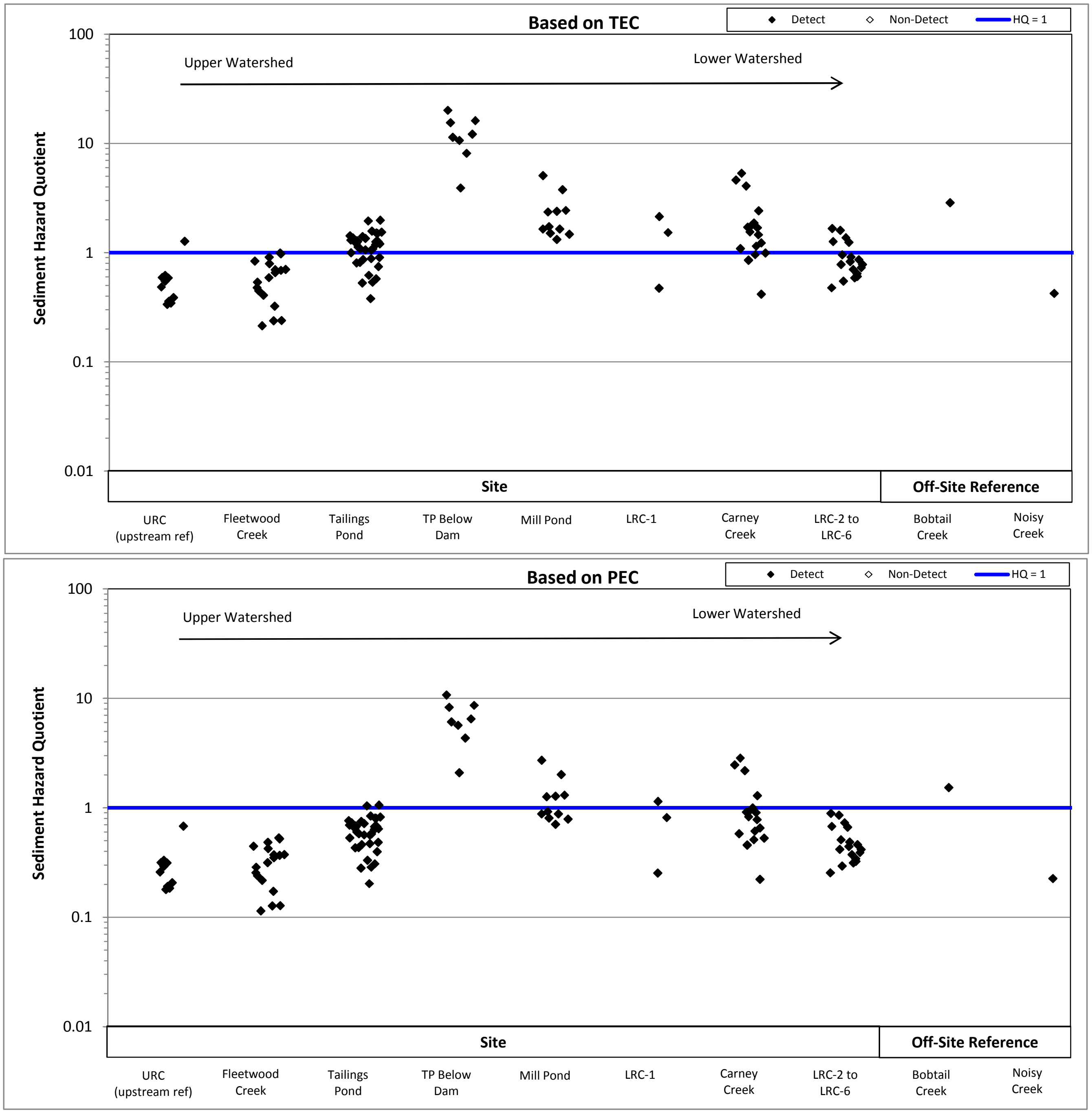
FIGURE 6-9. EVALUATION OF RISKS FROM LEAD TO AQUATIC INVERTEBRATES FROM DIRECT CONTACT WITH SEDIMENT





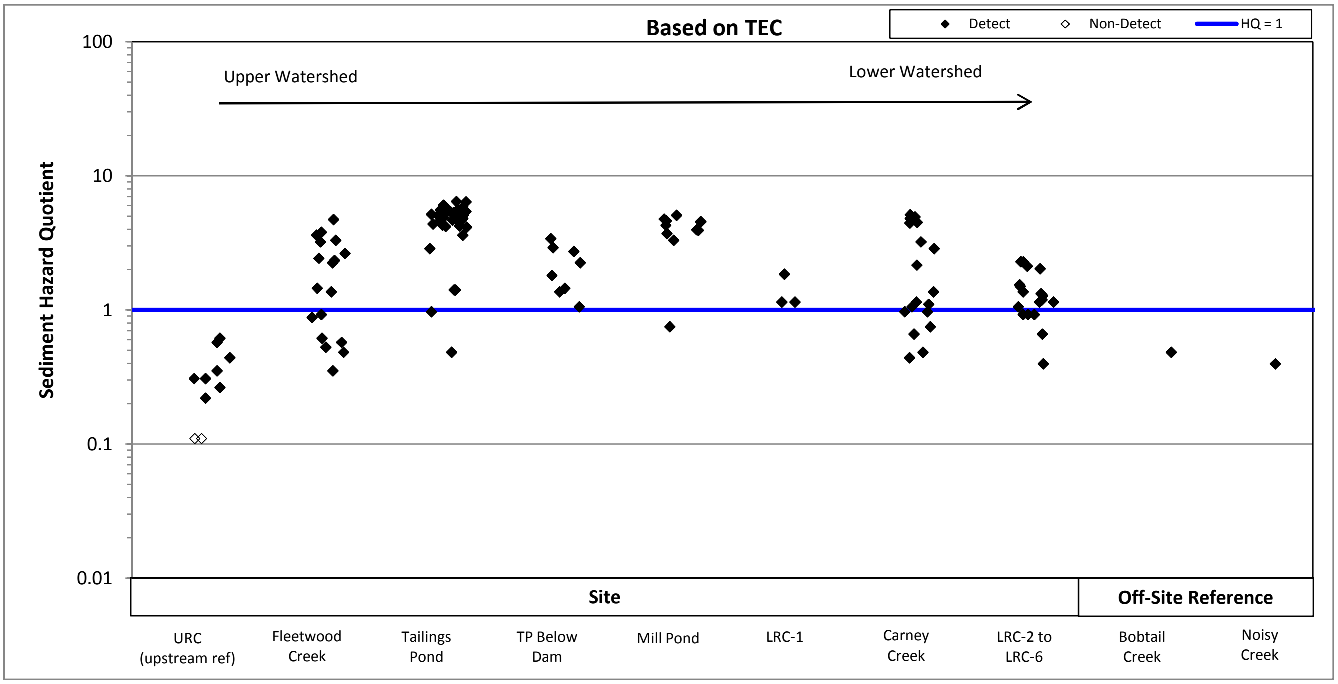
TEC = threshold effect concentration
PEC = probable effect concentration
HQ = hazard quotient

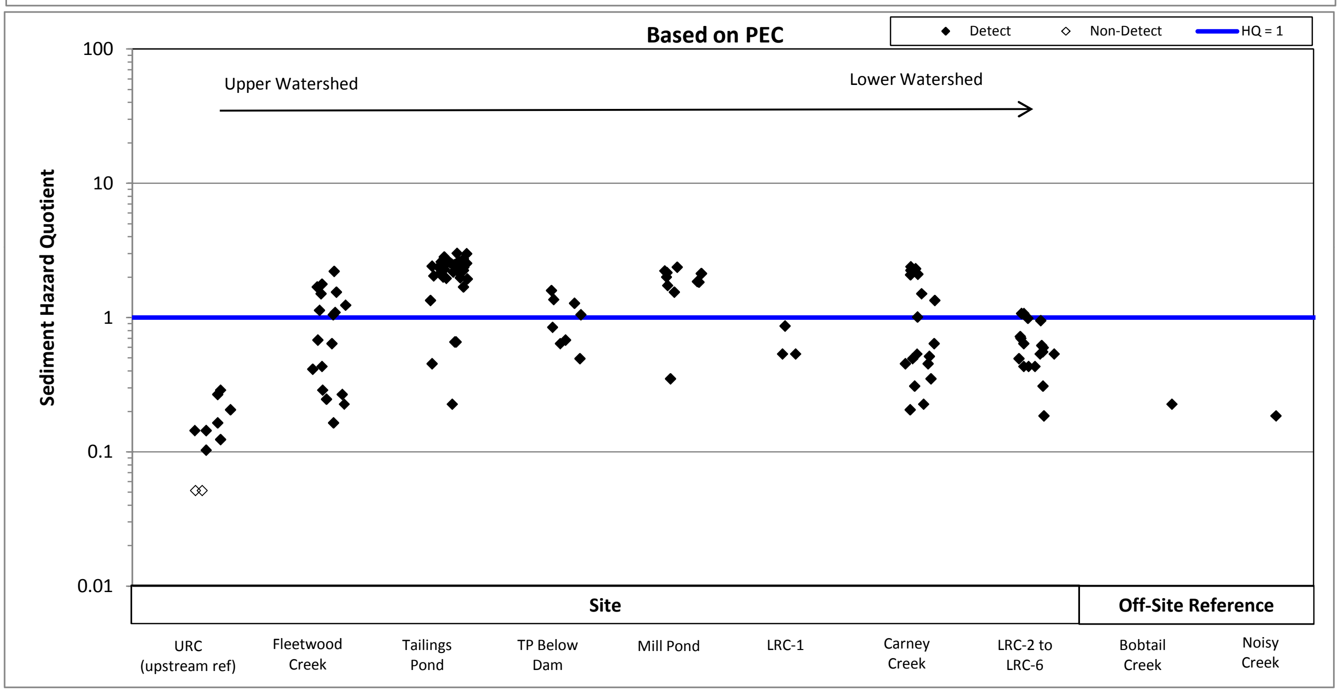
FIGURE 6-10. EVALUATION OF RISKS FROM MANGANESE TO AQUATIC INVERTEBRATES FROM DIRECT CONTACT WITH SEDIMENT



TEC = threshold effect concentration
PEC = probable effect concentration
HQ = hazard quotient

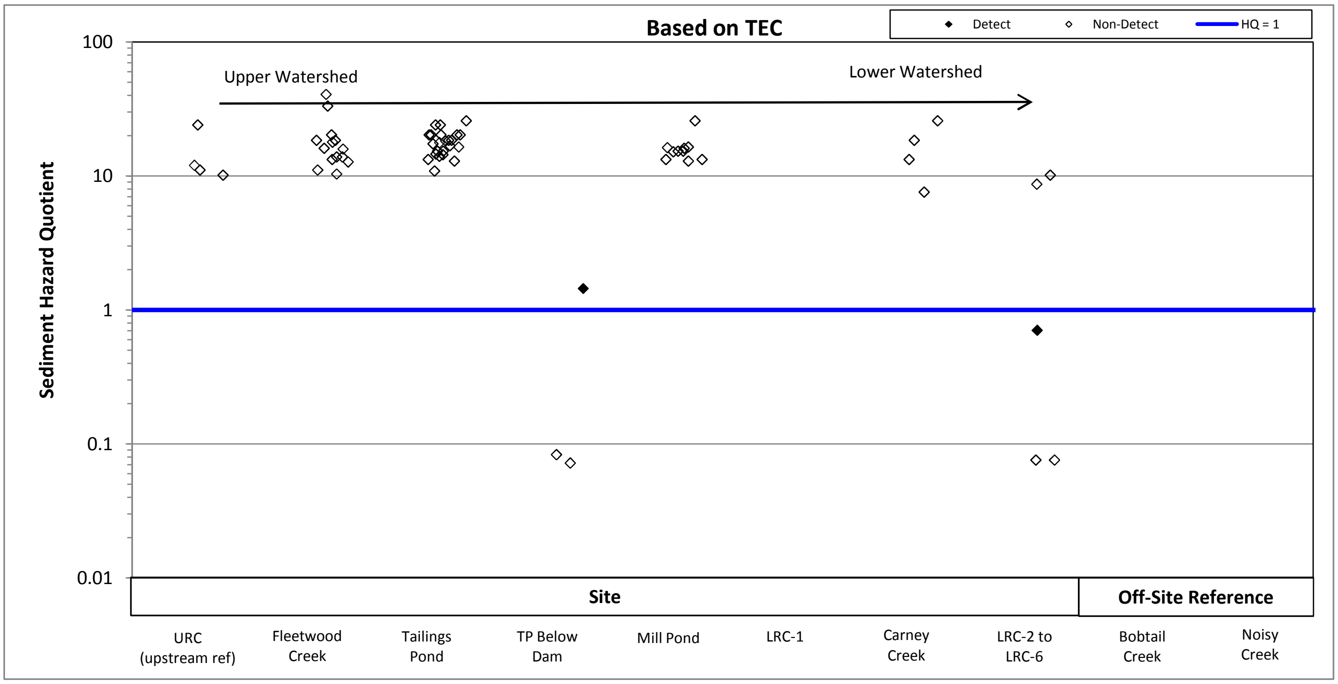
FIGURE 6-11. EVALUATION OF RISKS FROM NICKEL TO AQUATIC INVERTEBRATES FROM DIRECT CONTACT WITH SEDIMENT

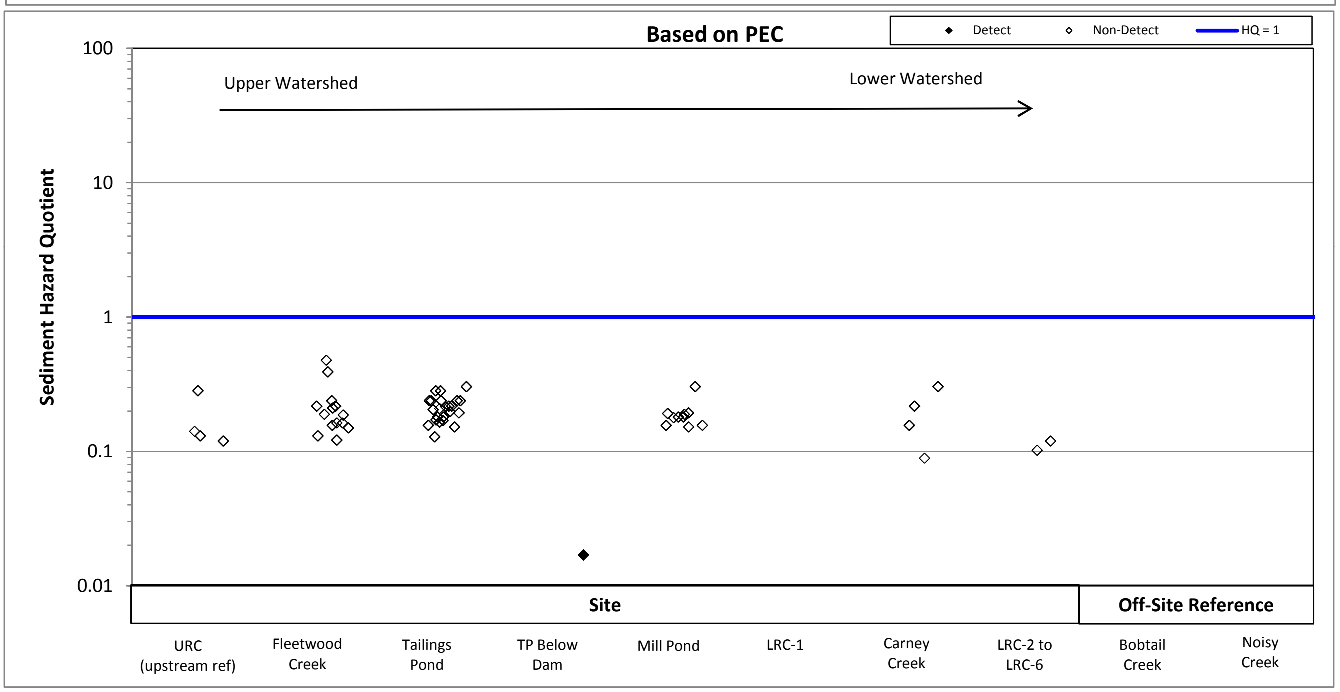




TEC = threshold effect concentration
PEC = probable effect concentration
HQ = hazard quotient

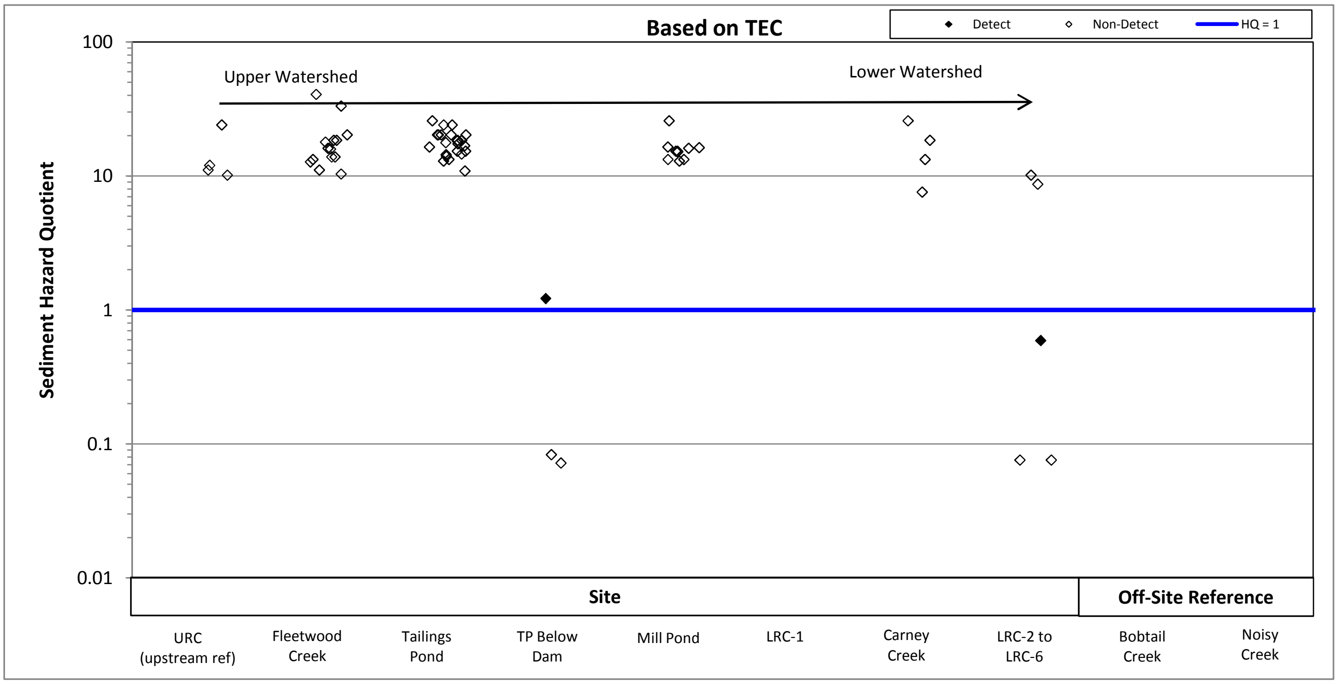
FIGURE 6-12. EVALUATION OF RISKS FROM BENZO(B)FLUORANTHENE TO AQUATIC INVERTEBRATES FROM DIRECT CONTACT WITH SEDIMENT

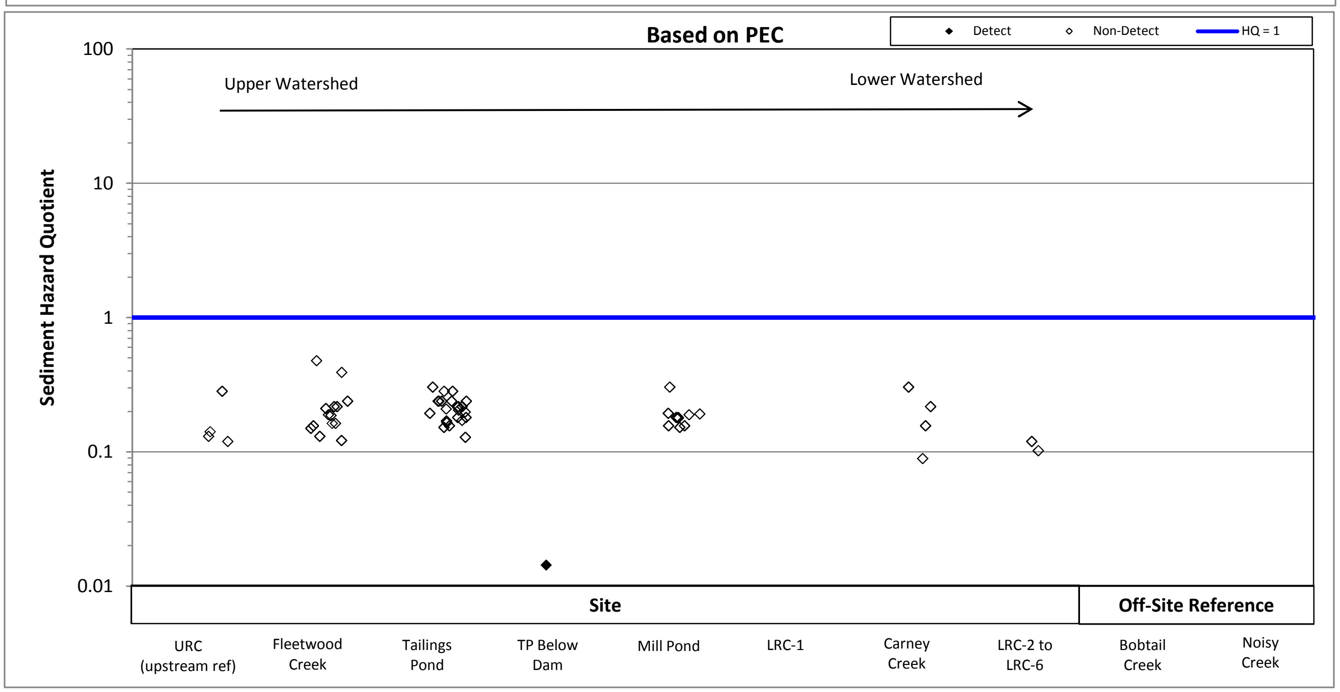




TEC = threshold effect concentration
PEC = probable effect concentration
HQ = hazard quotient

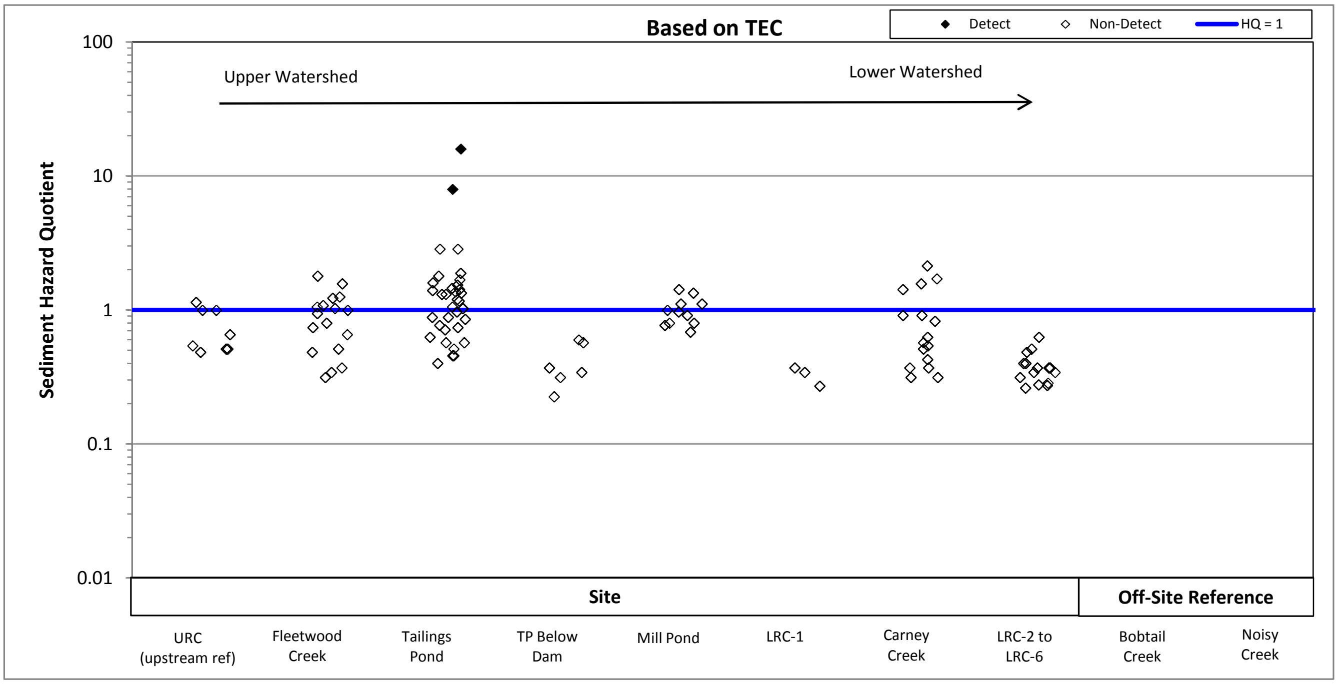
FIGURE 6-13. EVALUATION OF RISKS FROM BENZO(K)FLUORANTHENE TO AQUATIC INVERTEBRATES FROM DIRECT CONTACT WITH SEDIMENT

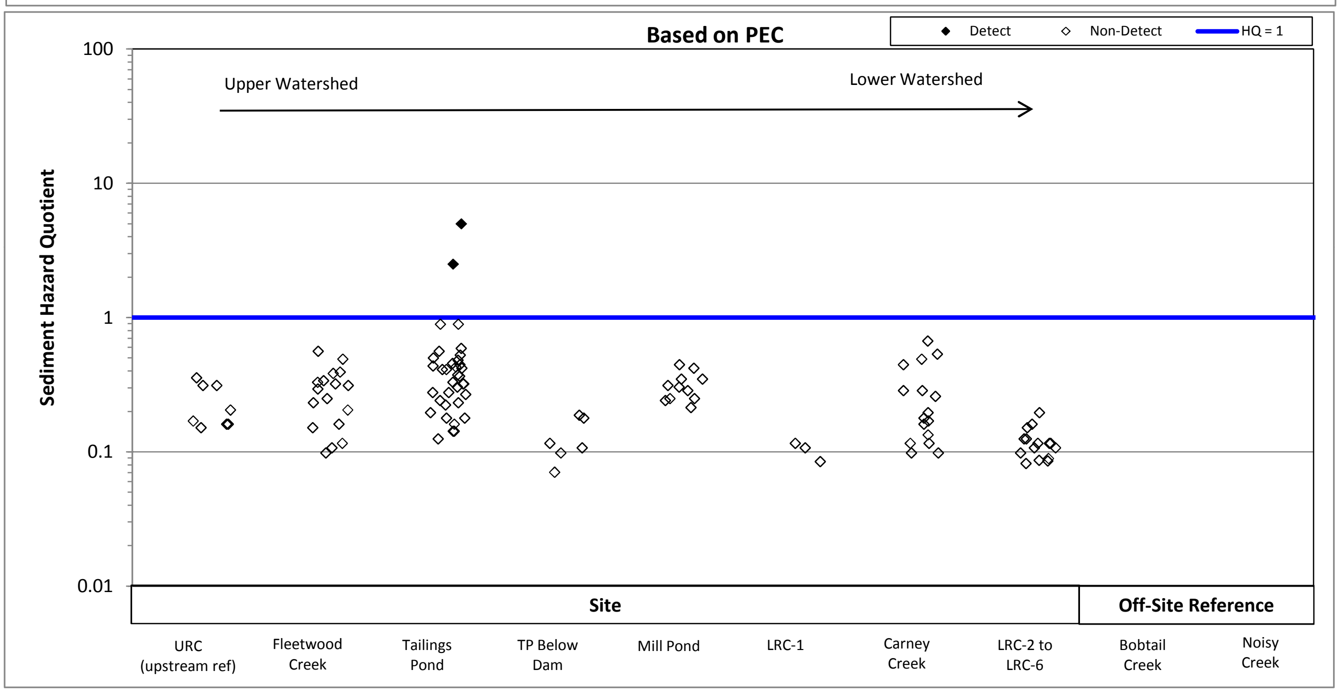




TEC = threshold effect concentration
PEC = probable effect concentration
HQ = hazard quotient

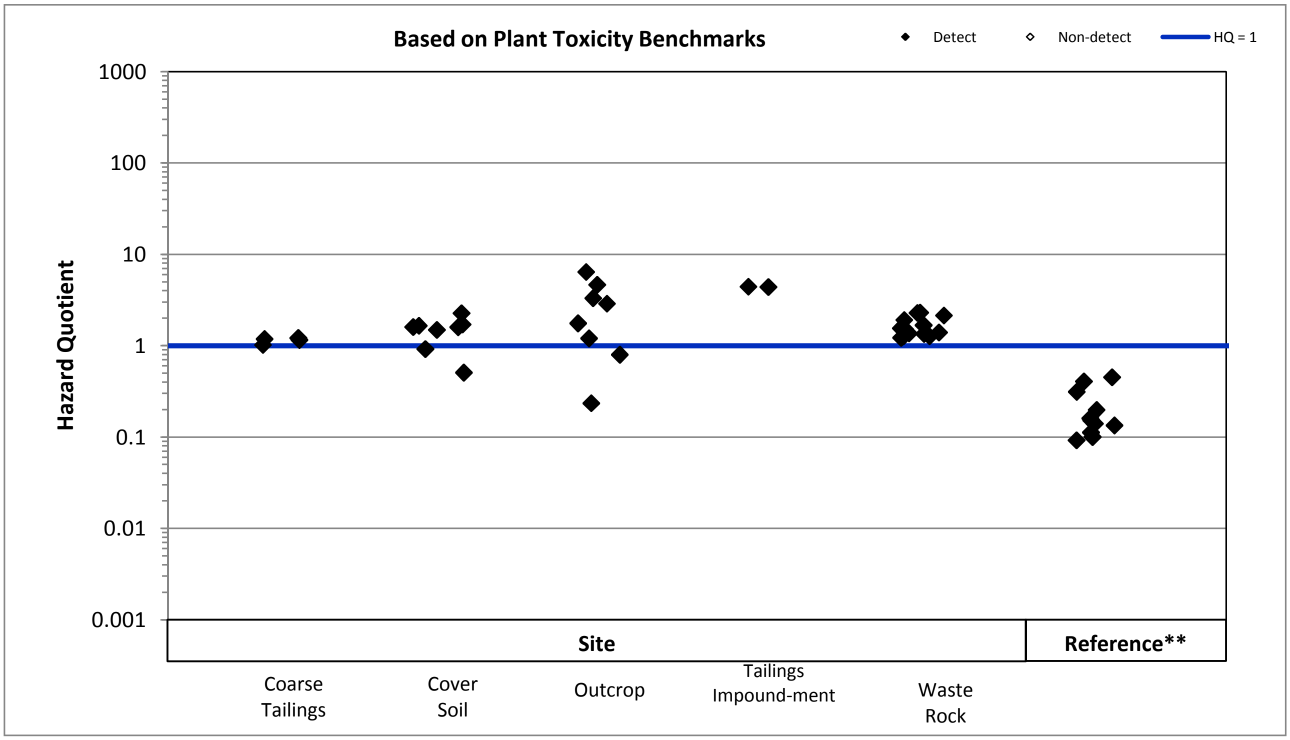
FIGURE 6-14. EVALUATION OF RISKS FROM NAPHTHALENE TO AQUATIC INVERTEBRATES FROM DIRECT CONTACT WITH SEDIMENT

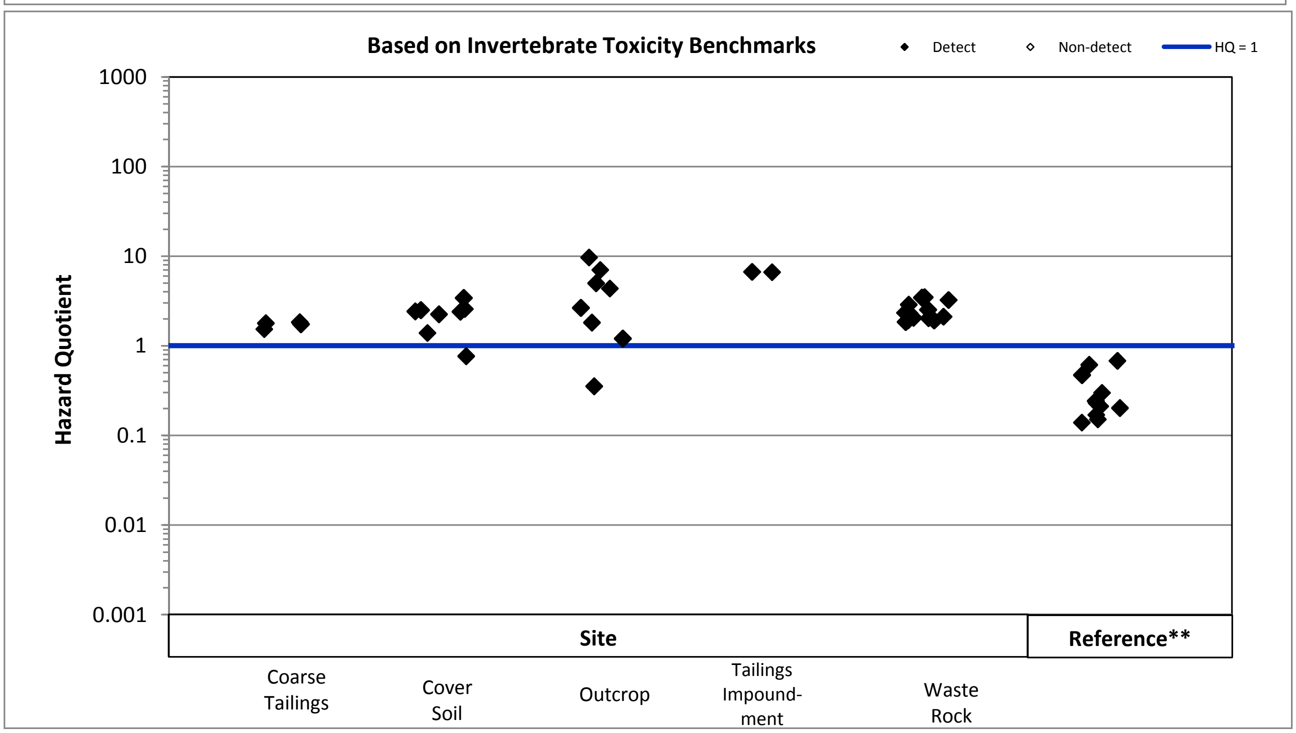




TEC = threshold effect concentration
PEC = probable effect concentration
HQ = hazard quotient

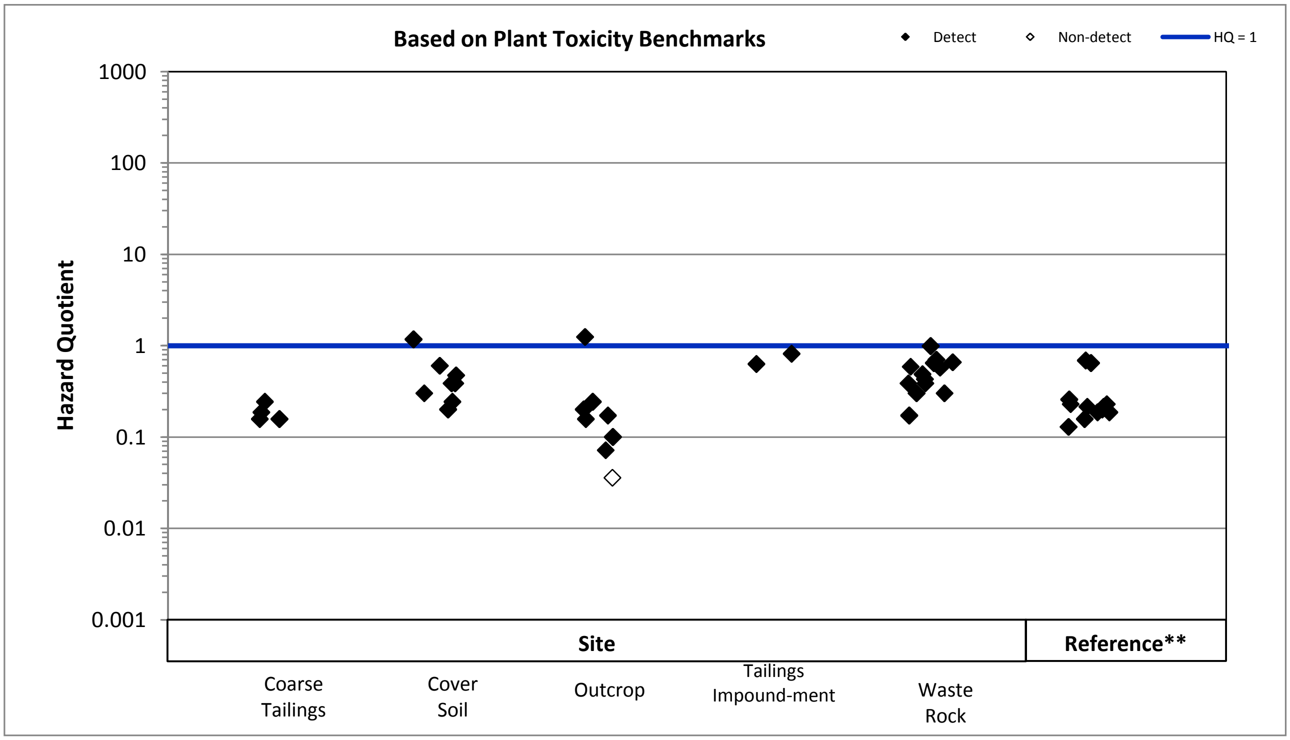
FIGURE 6-15
EVALUATION OF RISKS FROM BARIUM TO TERRESTRIAL PLANTS AND INVERTEBRATES FROM DIRECT CONTACT WITH SOIL AND MINE WASTE MATERIALS

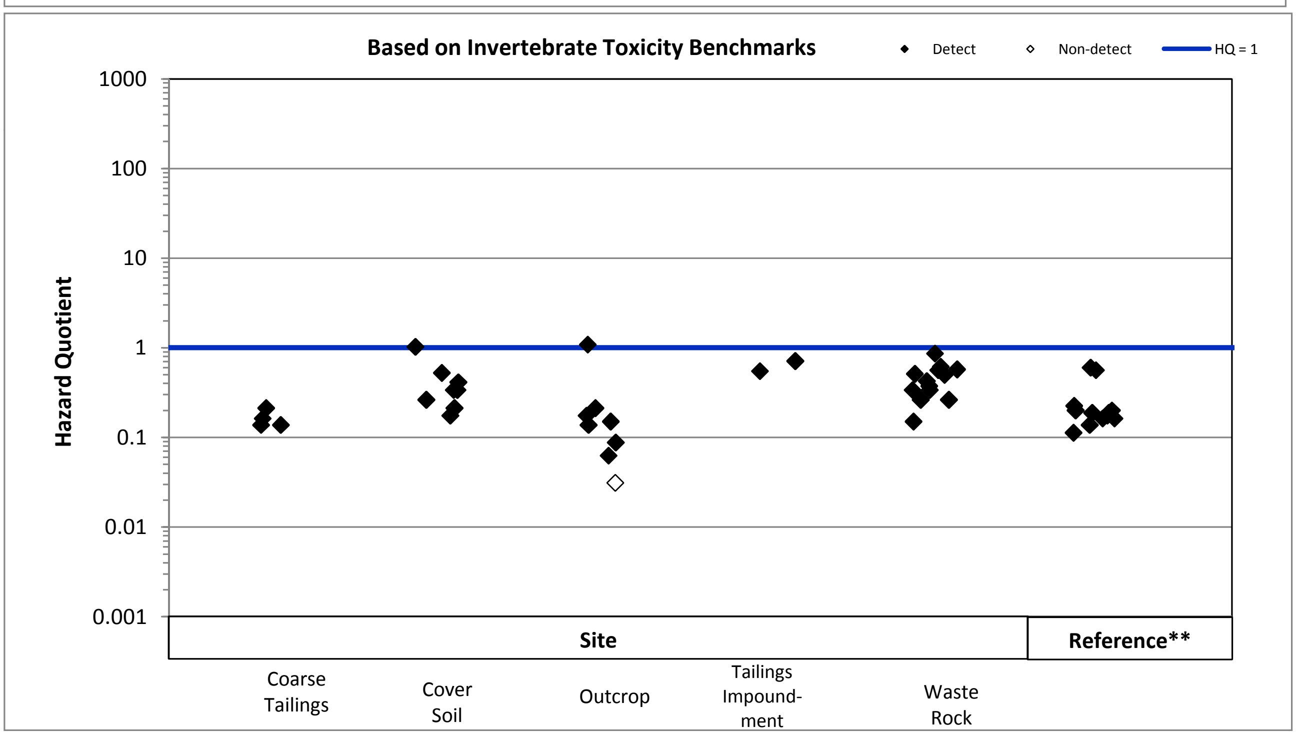




HQ = hazard quotient
**Reference soil from distal ends of forested area transects

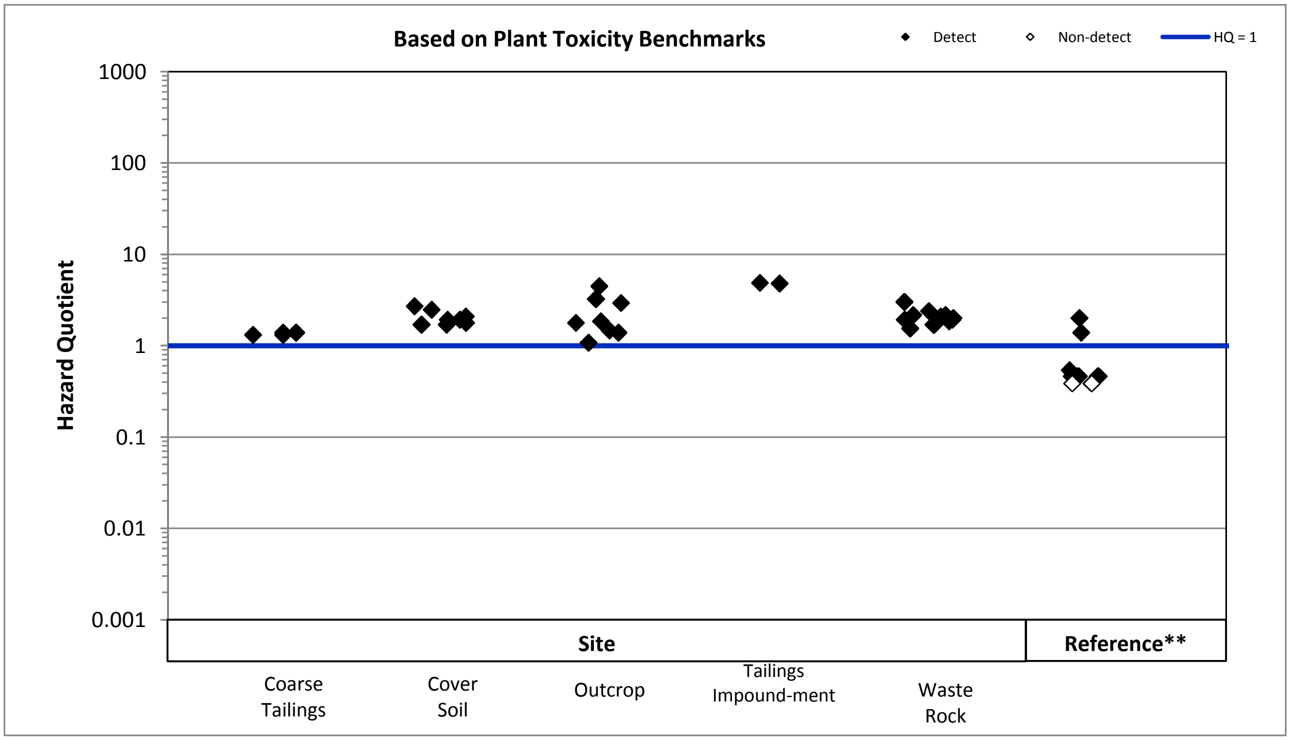
FIGURE 6-17
EVALUATION OF RISKS FROM COPPER TO TERRESTRIAL PLANTS AND INVERTEBRATES FROM DIRECT CONTACT WITH SOIL AND MINE WASTE MATERIALS

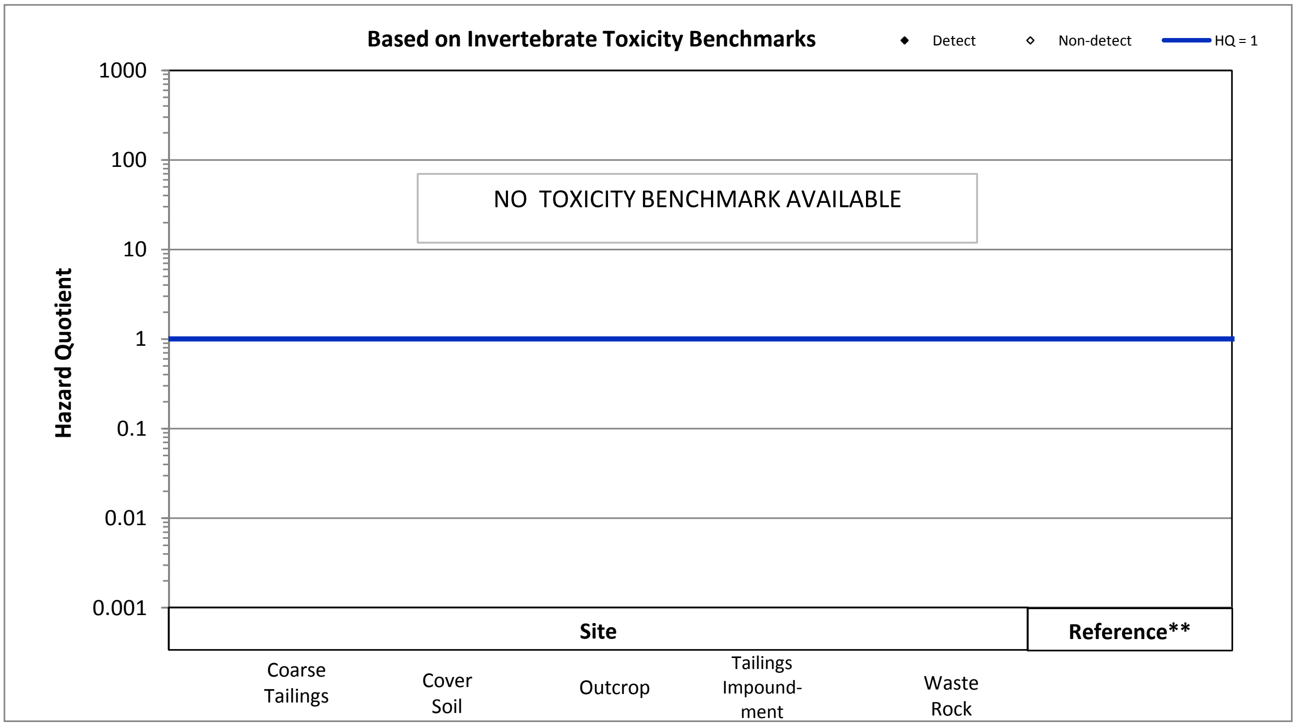




HQ = hazard quotient
**Reference soil from distal ends of forested area transects

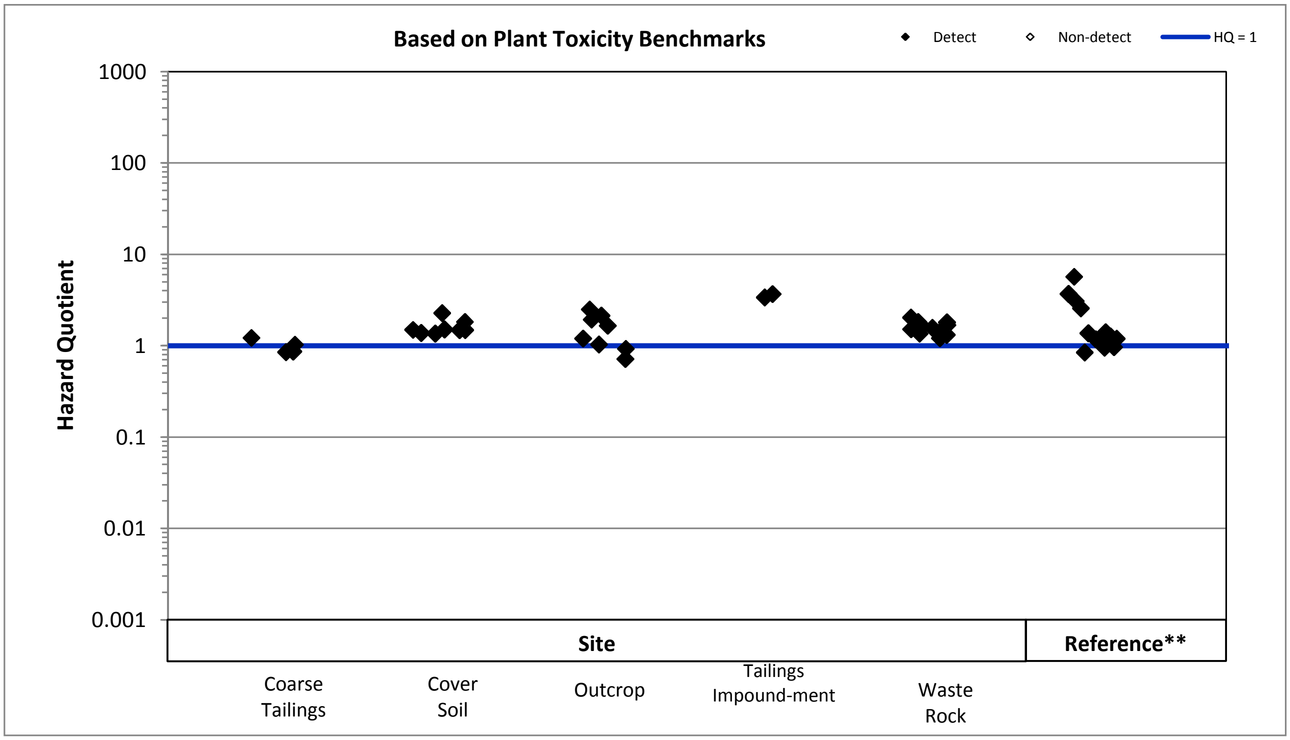
FIGURE 6-16
EVALUATION OF RISKS FROM COBALT TO TERRESTRIAL PLANTS AND INVERTEBRATES FROM DIRECT CONTACT WITH SOIL AND MINE WASTE MATERIALS

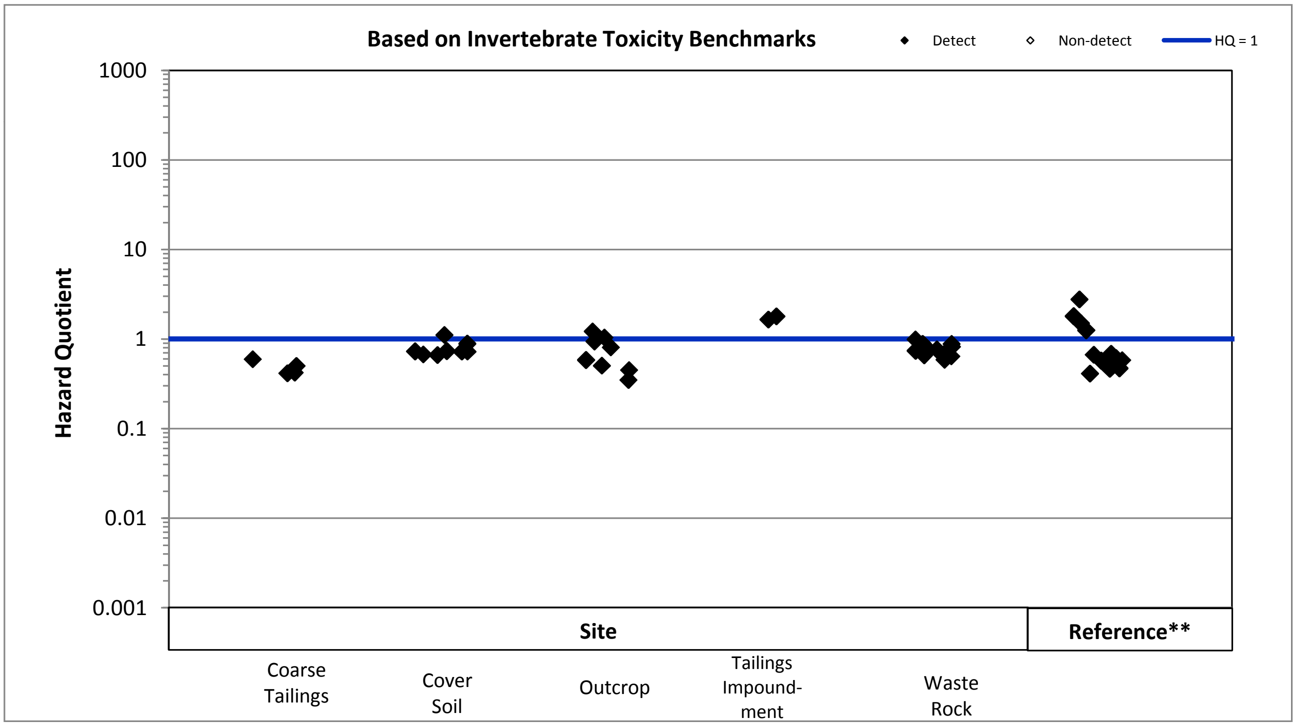




HQ = hazard quotient
**Reference soil from distal ends of forested area transects

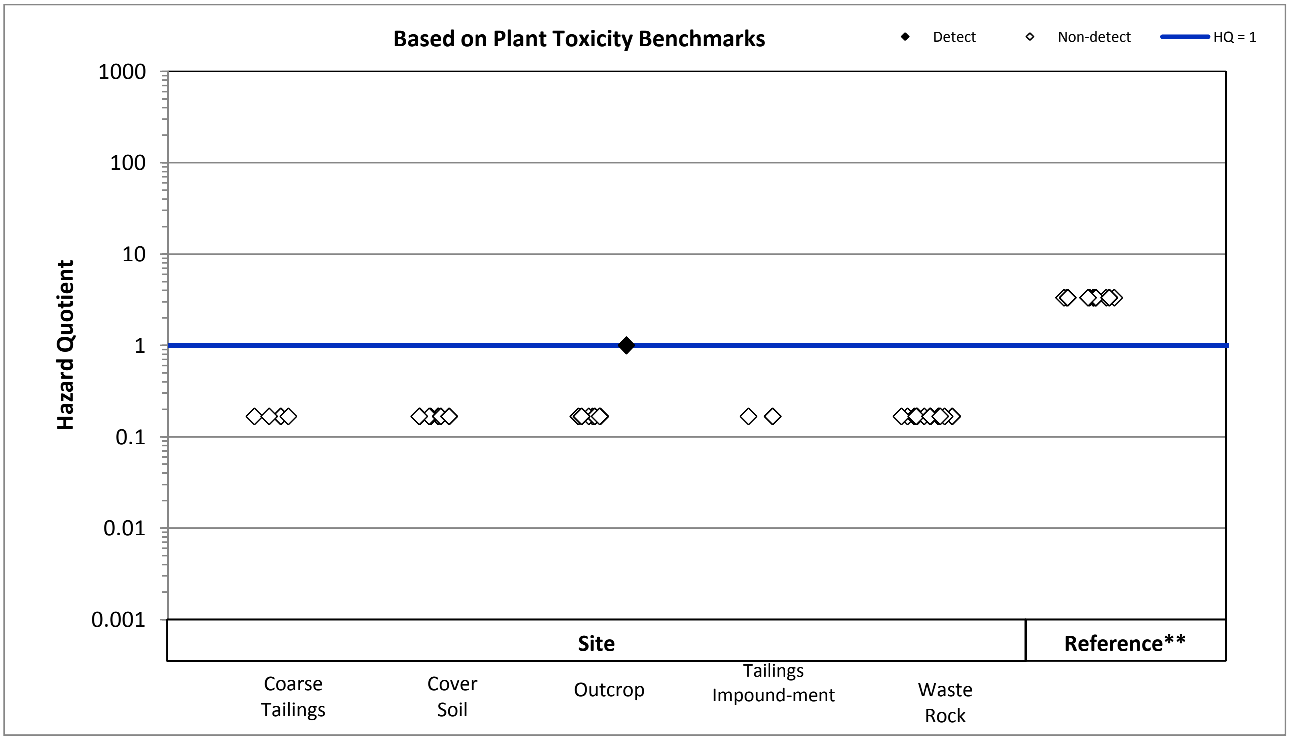
FIGURE 6-18
EVALUATION OF RISKS FROM MANGANESE TO TERRESTRIAL PLANTS AND INVERTEBRATES FROM DIRECT CONTACT WITH SOIL AND MINE WASTE MATERIALS

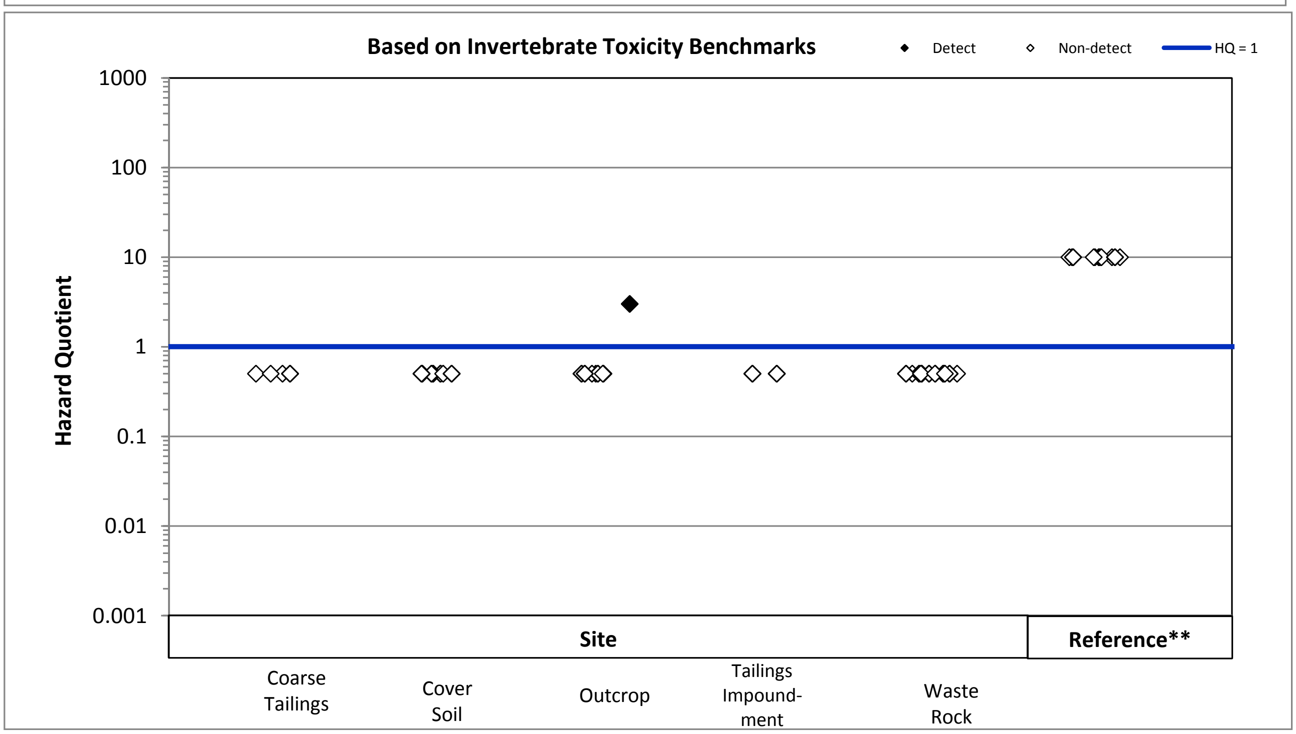




HQ = hazard quotient
**Reference soil from distal ends of forested area transects

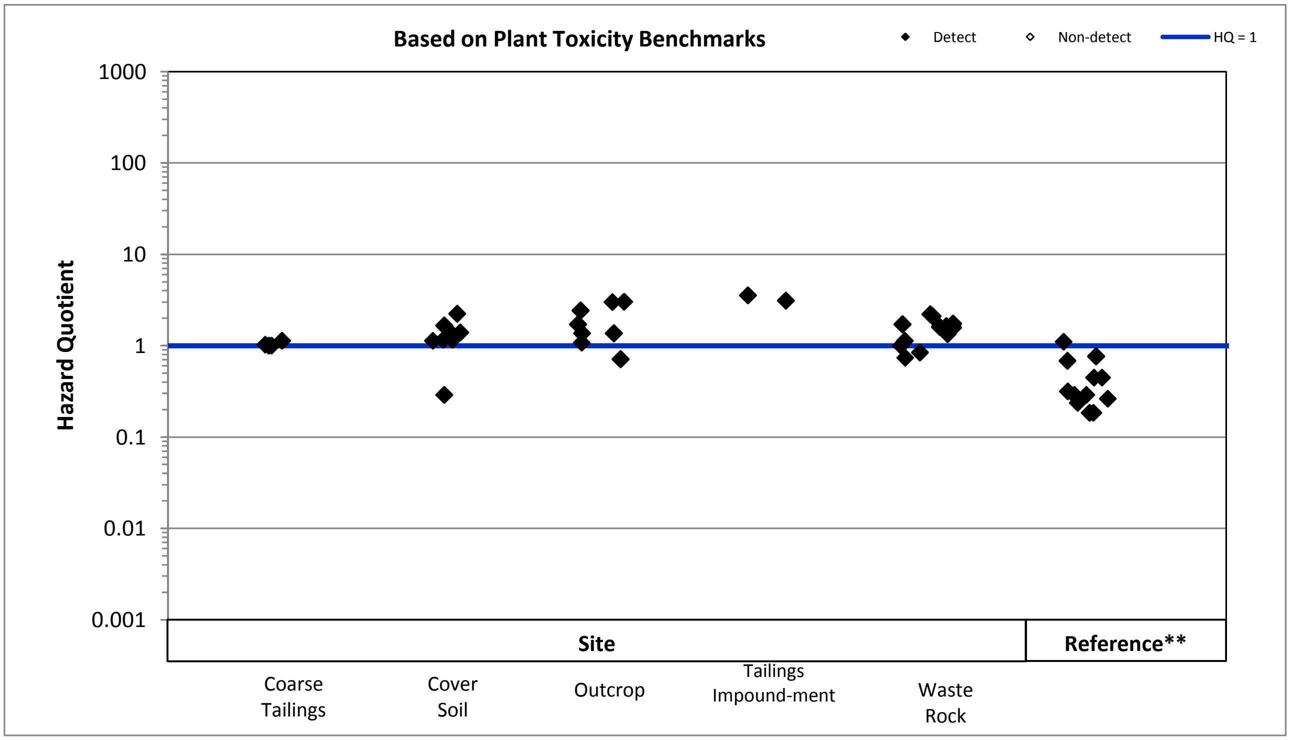
FIGURE 6-19
EVALUATION OF RISKS FROM MERCURY TO TERRESTRIAL PLANTS AND INVERTEBRATES FROM DIRECT CONTACT WITH SOIL AND MINE WASTE MATERIALS

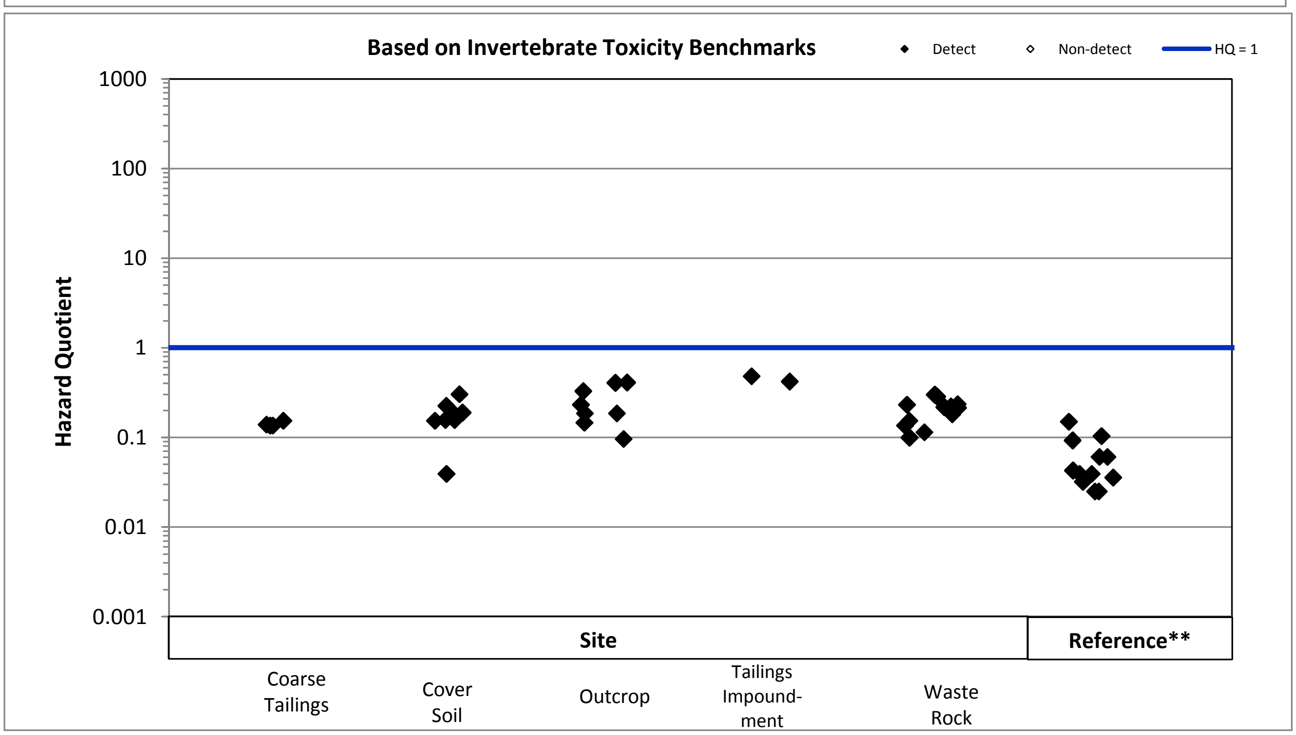




HQ = hazard quotient
**Reference soil from distal ends of forested area transects

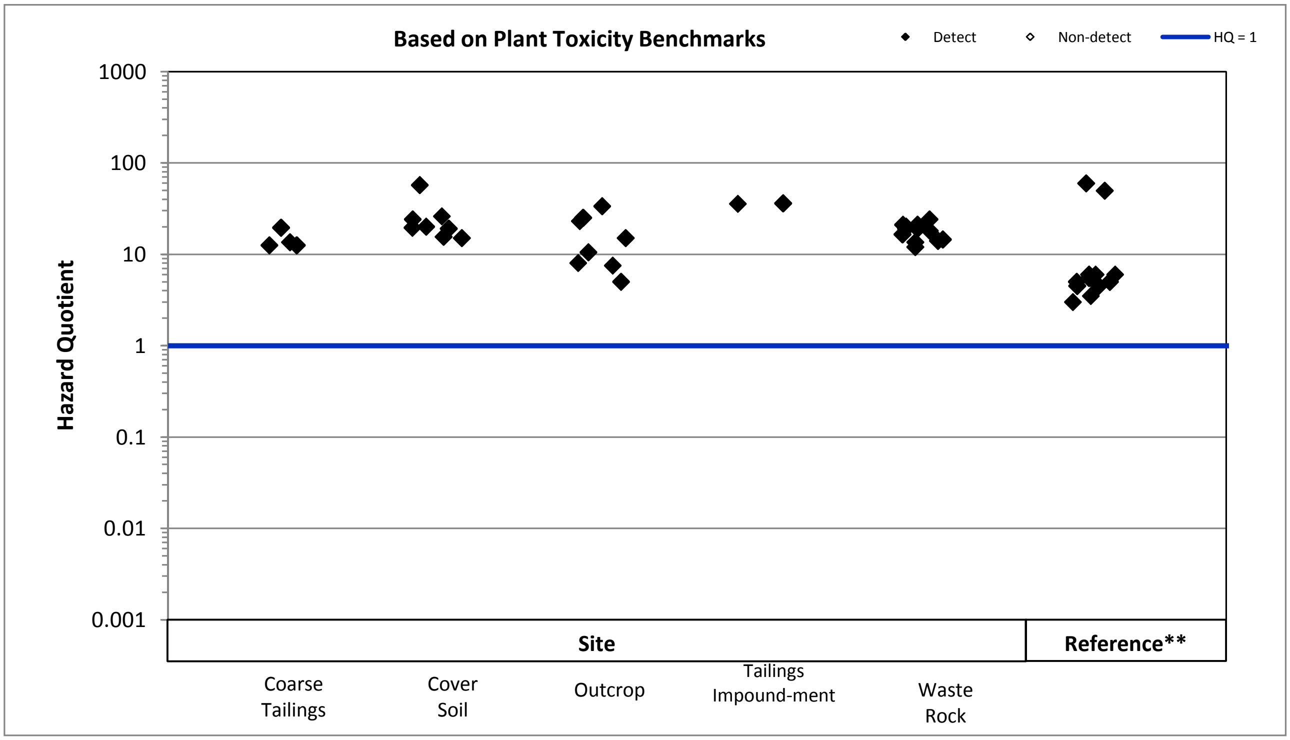
FIGURE 6-20
EVALUATION OF RISKS FROM NICKEL TO TERRESTRIAL PLANTS AND INVERTEBRATES FROM DIRECT CONTACT WITH SOIL AND MINE WASTE MATERIALS

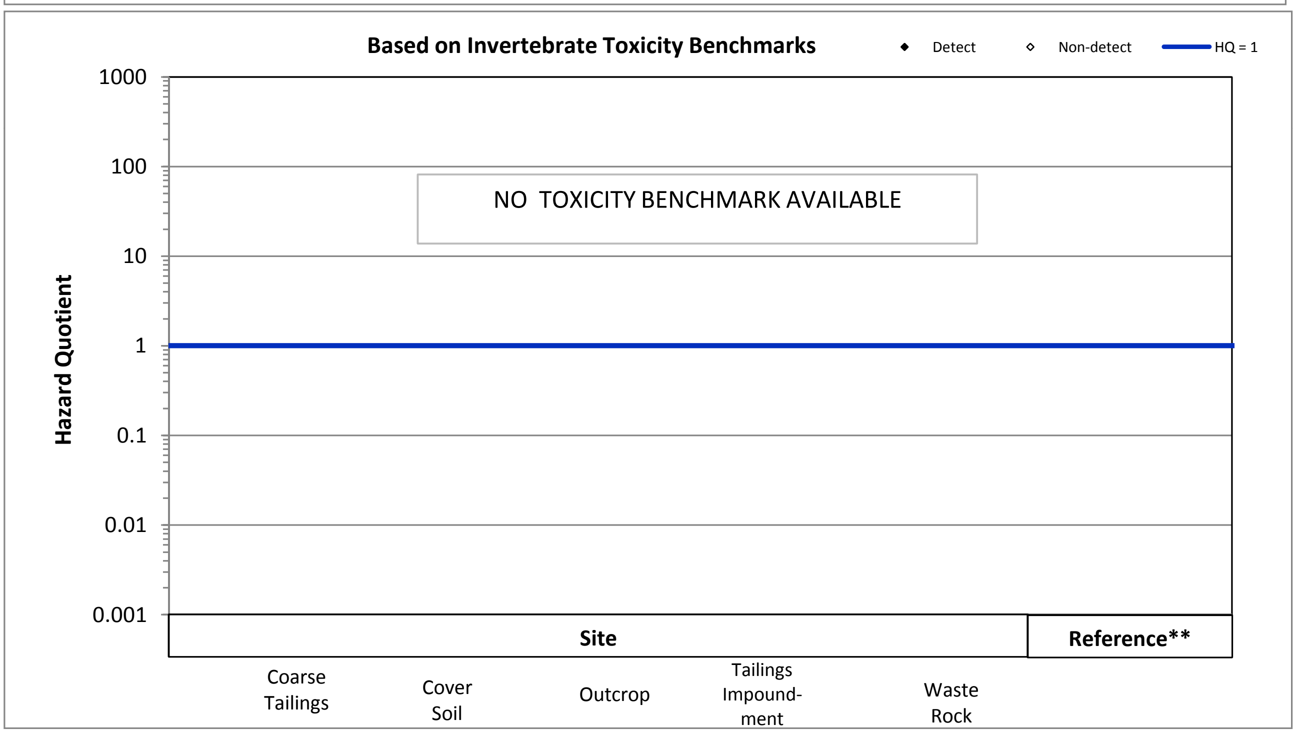




HQ = hazard quotient
**Reference soil from distal ends of forested area transects

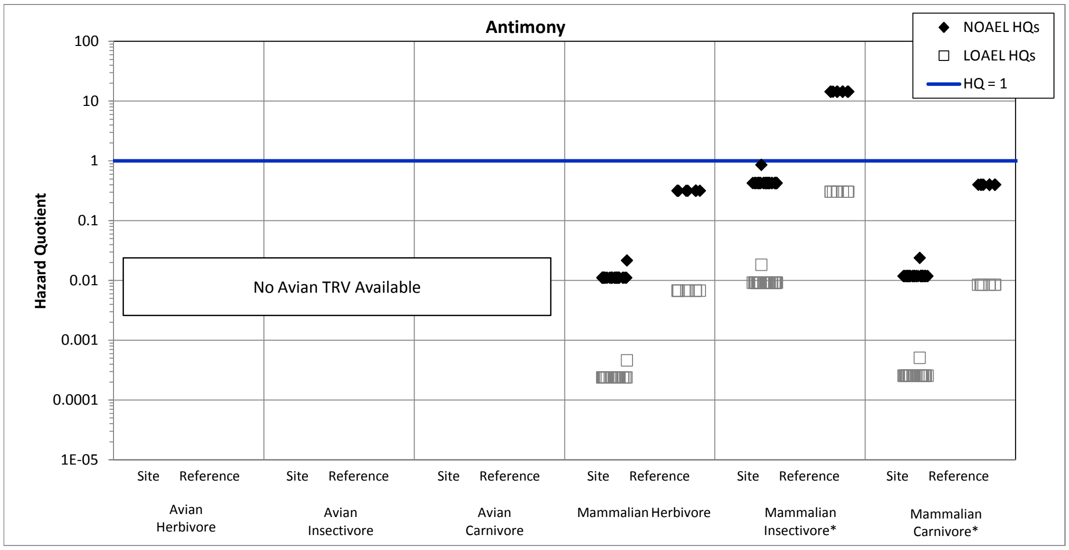
FIGURE 6-21
EVALUATION OF RISKS FROM VANADIUM TO TERRESTRIAL PLANTS AND INVERTEBRATES FROM DIRECT CONTACT WITH SOIL AND MINE WASTE MATERIALS

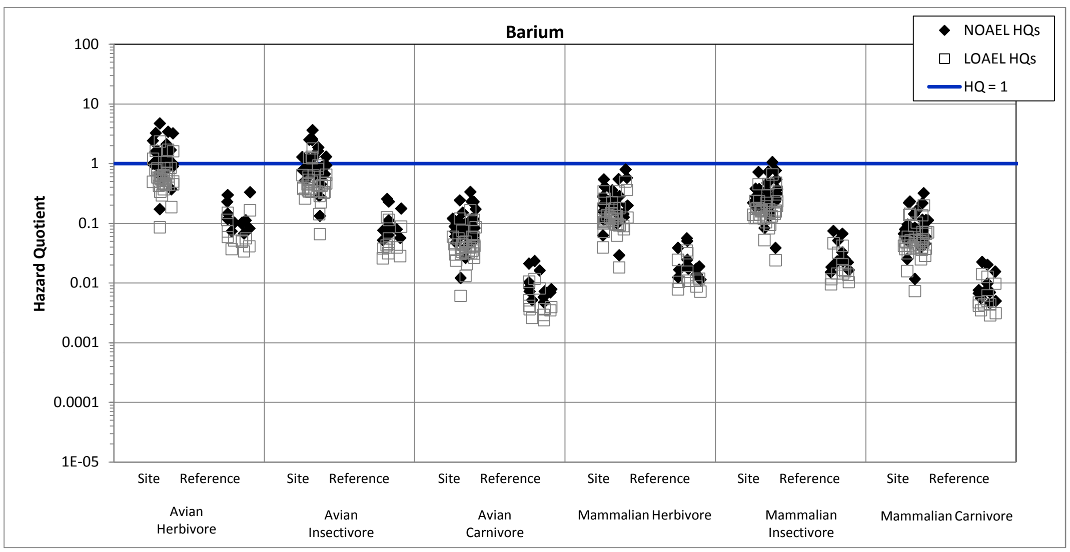


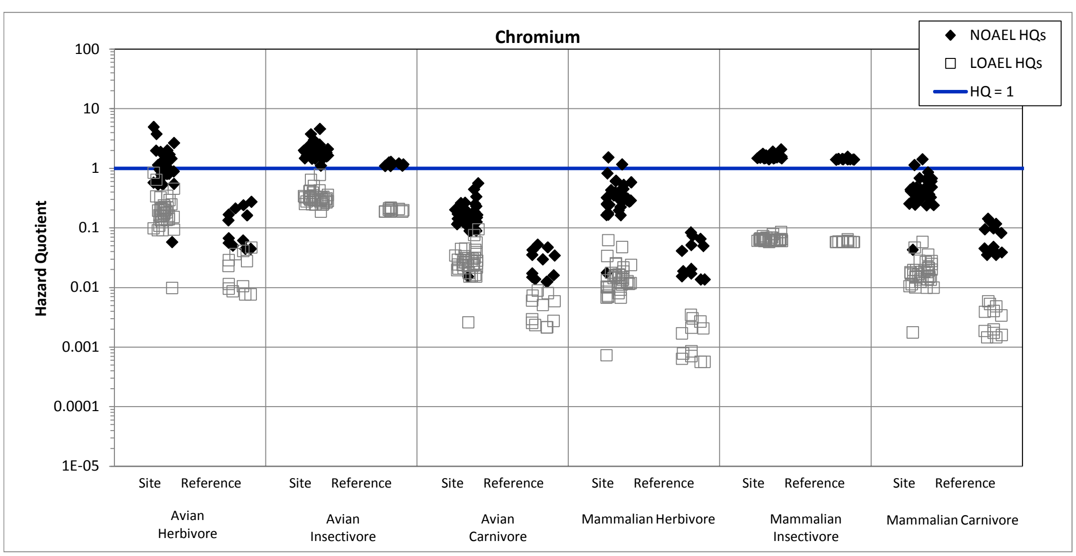


HQ = hazard quotient
**Reference soil from distal ends of forested area transects

FIGURE 6-22. EVALUATION OF RISKS TO SMALL HOME RANGE WILDLIFE RECEPTORS FROM DIRECT CONTACT WITH SOIL AND MINE WASTE MATERIALS



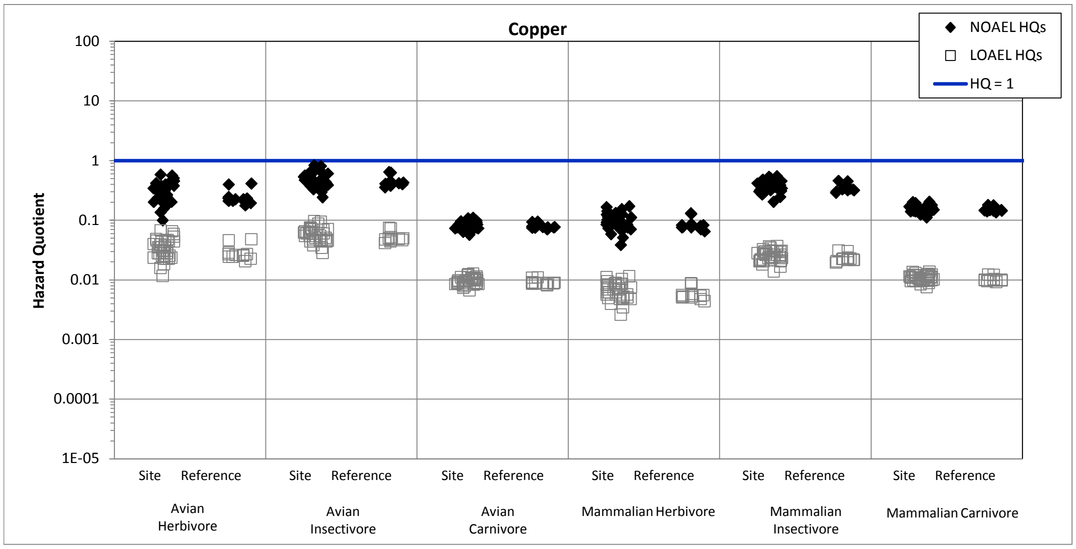


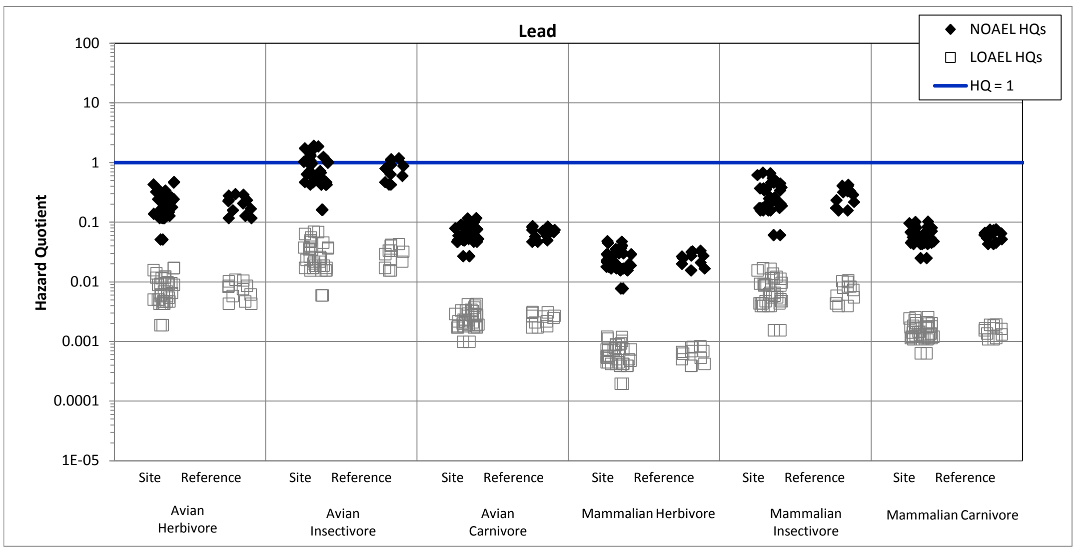


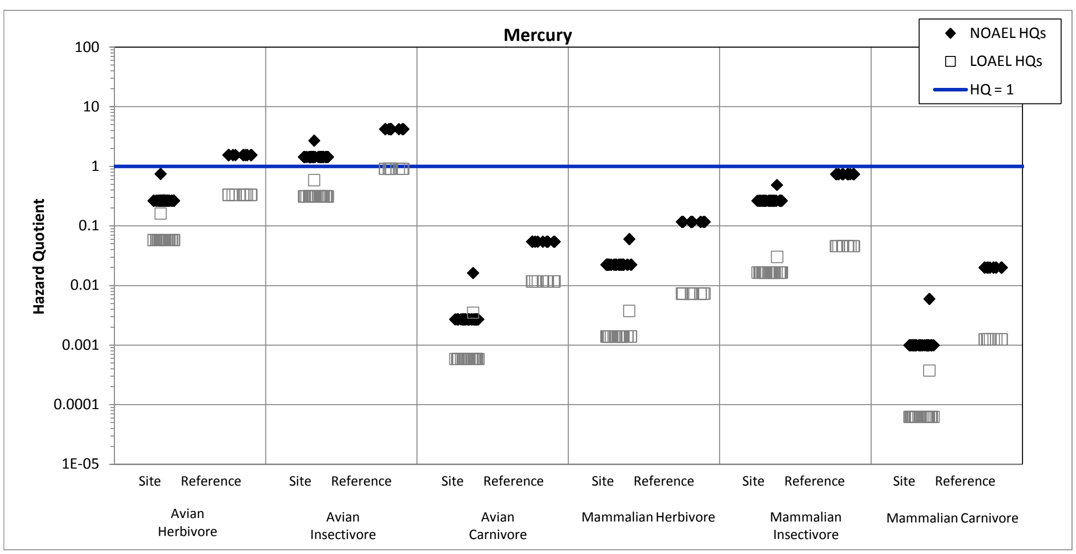
**Reference soil from distal ends of forested area transects

HQ = hazard quotient
NOAEL = no observed adverse effect level
LOAEL = low observed adverse effect level

FIGURE 6-22. EVALUATION OF RISKS TO SMALL HOME RANGE WILDLIFE RECEPTORS FROM DIRECT CONTACT WITH SOIL AND MINE WASTE MATERIALS (cont.)



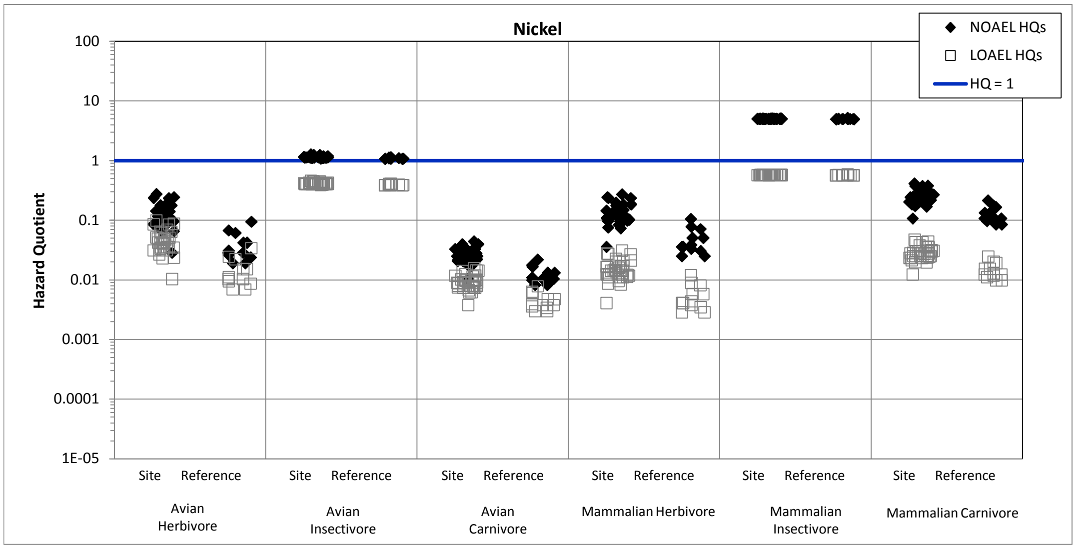


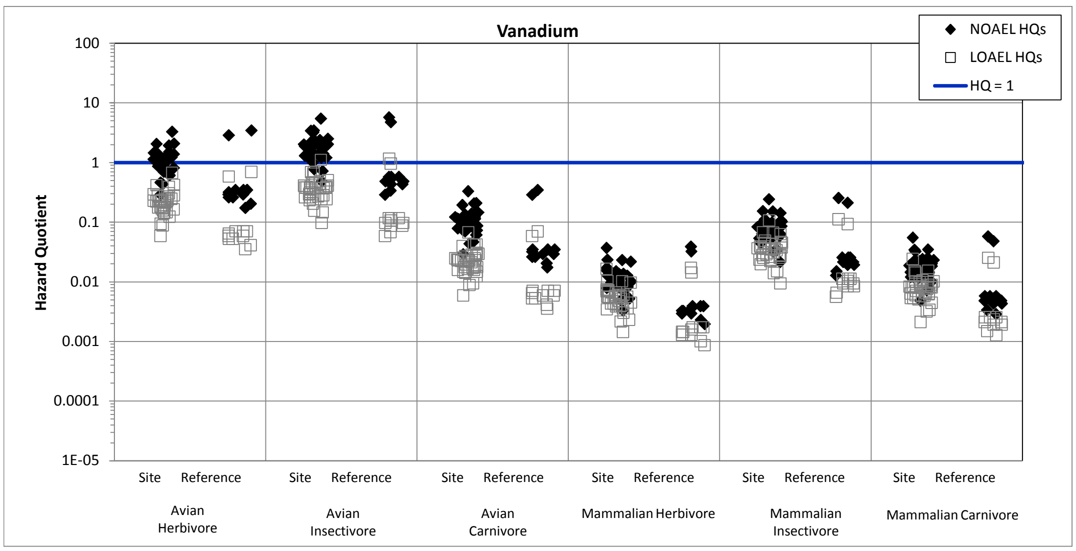


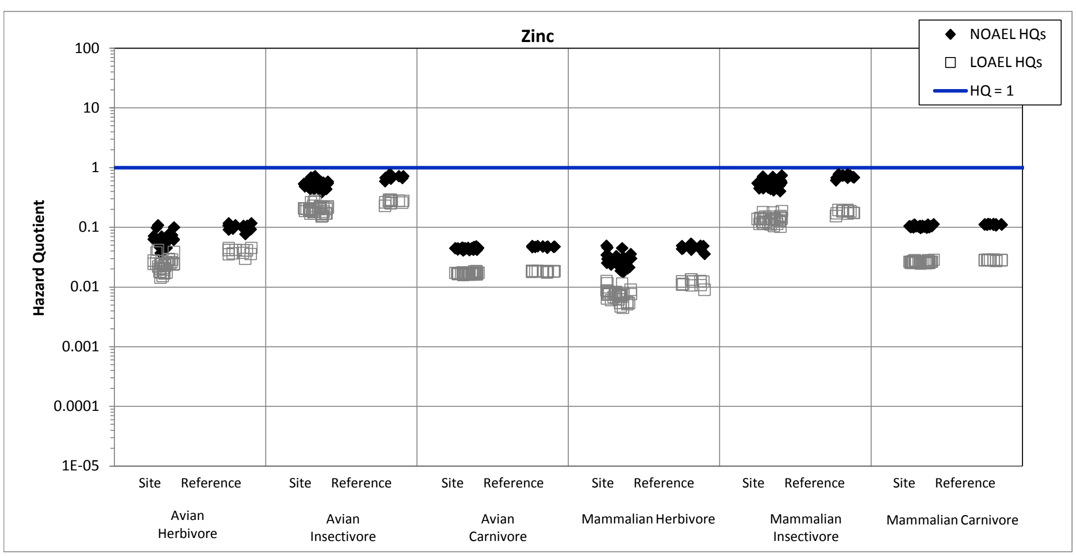
**Reference soil from distal ends of forested area transects

HQ = hazard quotient
NOAEL = no observed adverse effect level
LOAEL = low observed adverse effect level

FIGURE 6-22. EVALUATION OF RISKS TO SMALL HOME RANGE WILDLIFE RECEPTORS FROM DIRECT CONTACT WITH SOIL AND MINE WASTE MATERIALS (cont.)





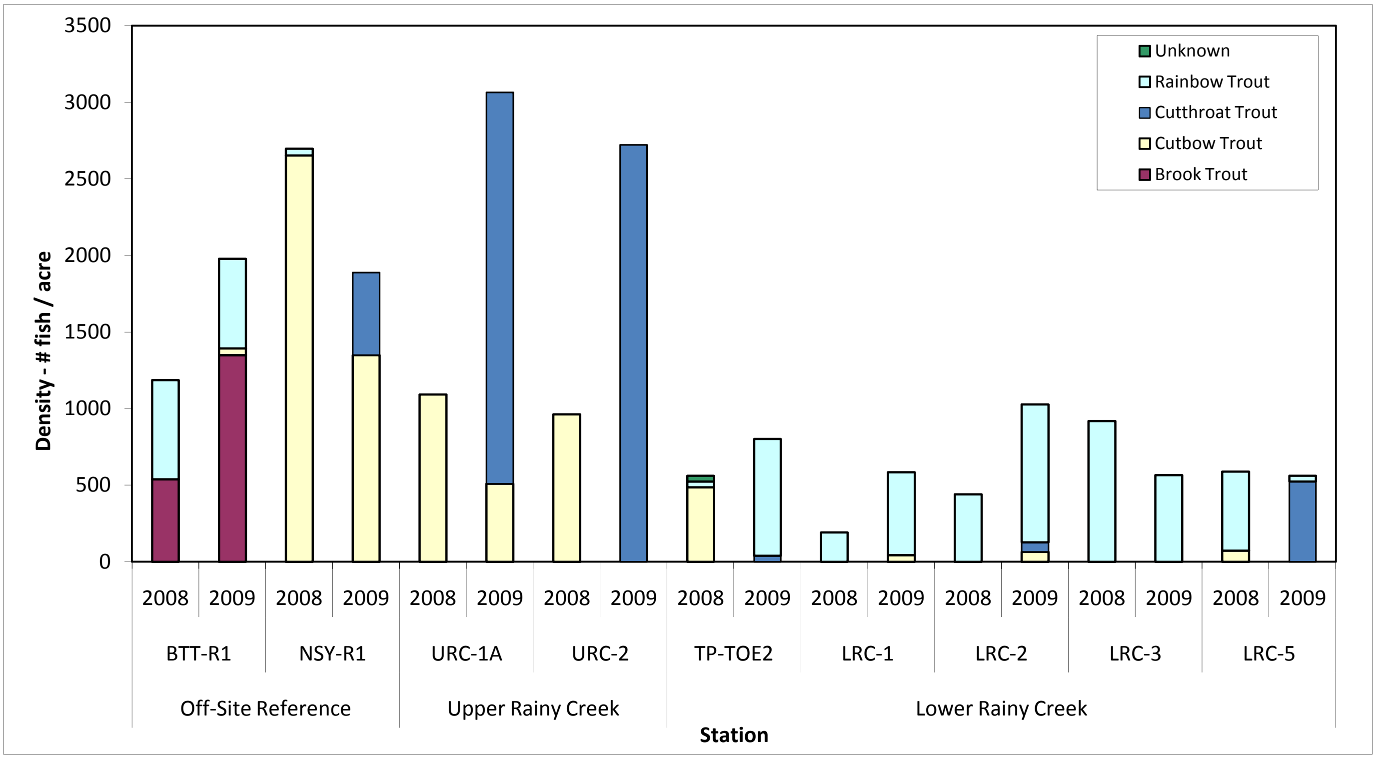


**Reference soil from distal ends of forested area transects

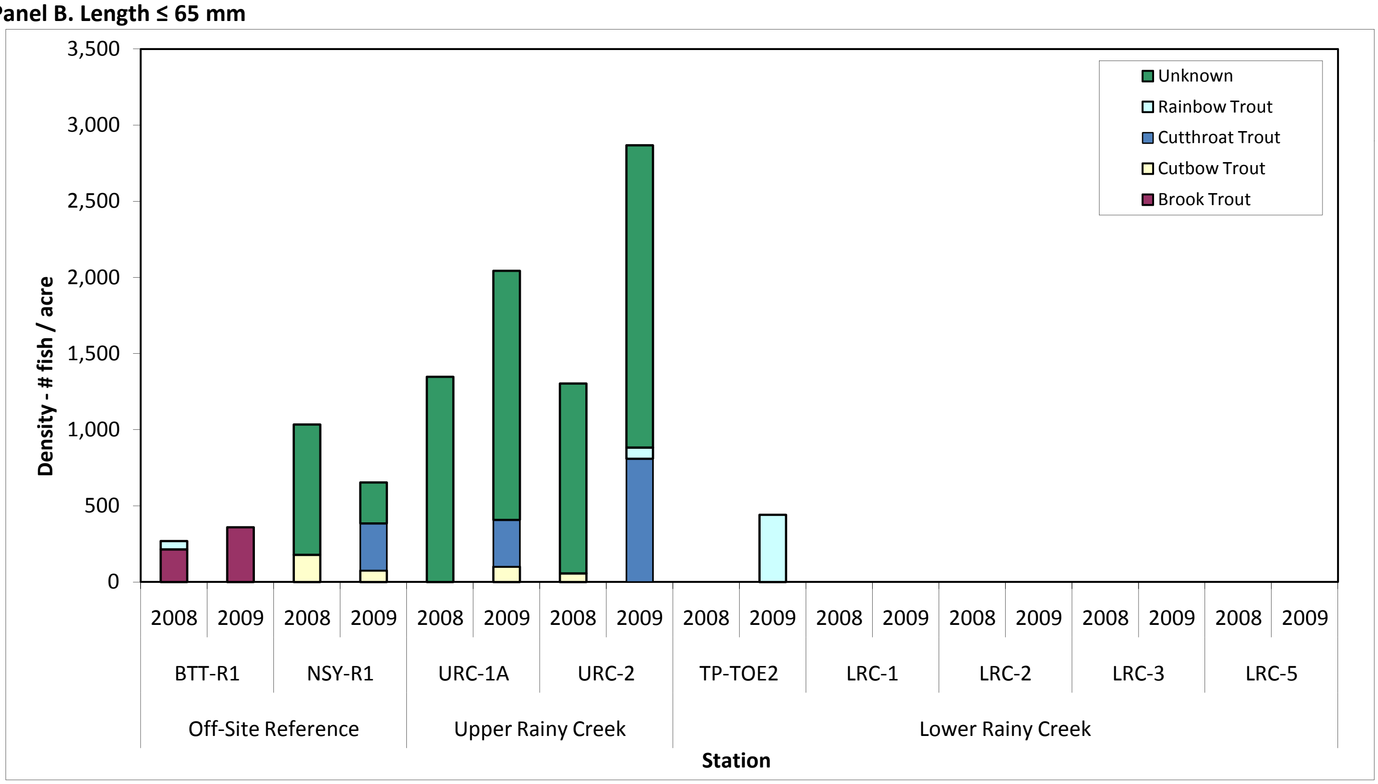
HQ = hazard quotient
NOAEL = no observed adverse effect level
LOAEL = low observed adverse effect level

FIGURE 7-1 FISH DENSITY FOR FIRST AND SECOND PASS ELECTROSHOCKING

Panel A. Length > 65 mm



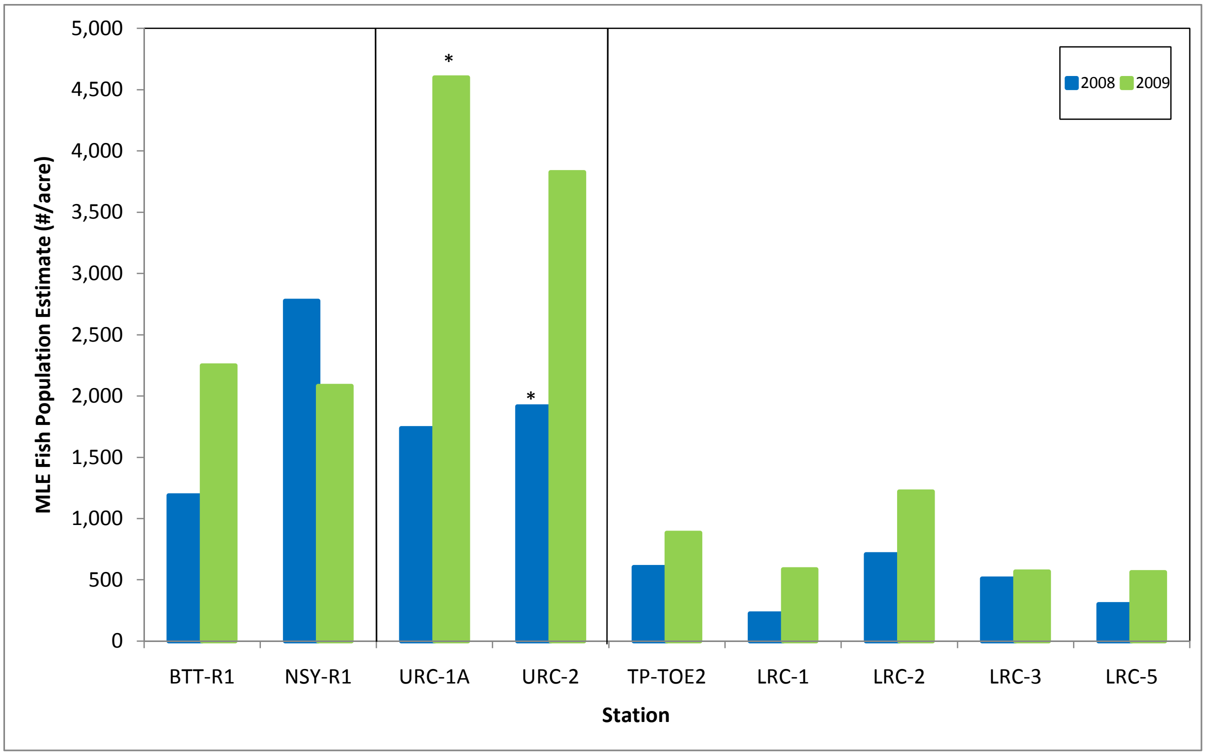
Panel B. Length ≤ 65 mm



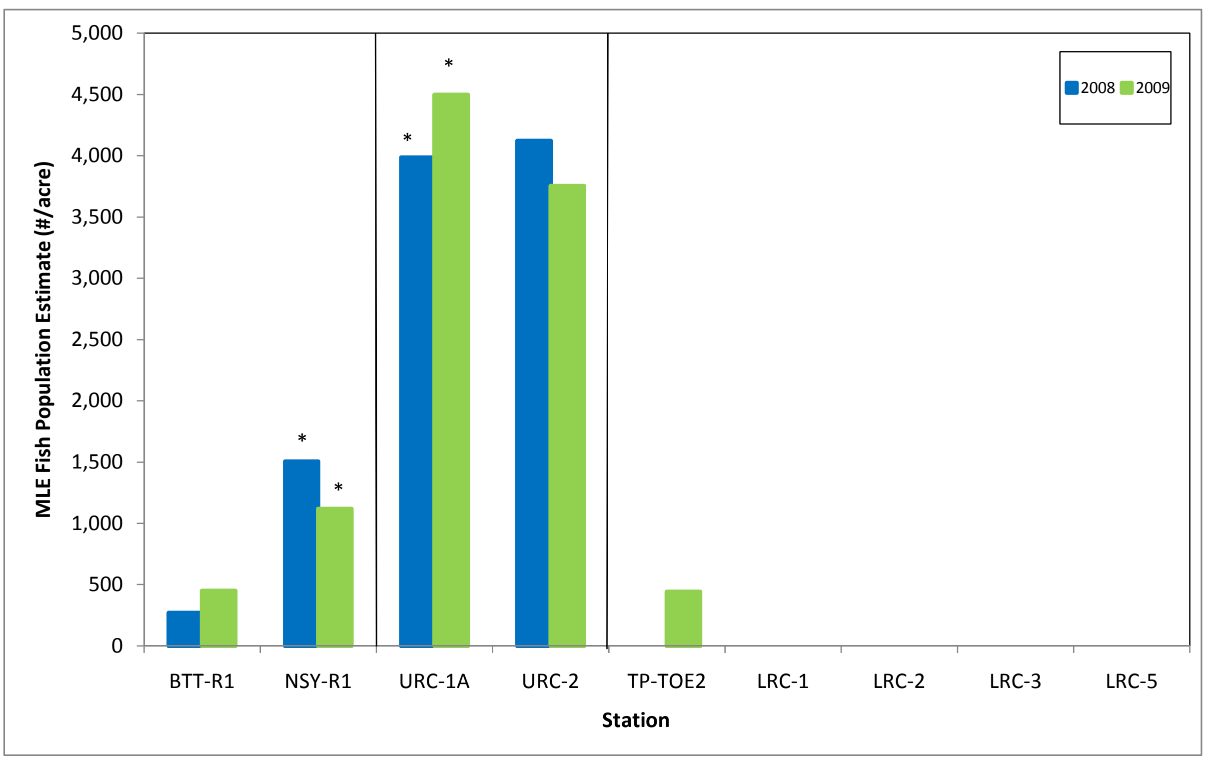
> = greater than
≤ = less than or equal to
mm = millimeter

FIGURE 7-2 MLE FISH POPULATION ESTIMATES (NUMBER PER ACRE)

Panel A: Length > 65 mm



Panel B: Length ≤ 65 mm



* = 2nd pass greater than 1st pass; population estimate is based on 1.5 * the total catch rather than MLE.

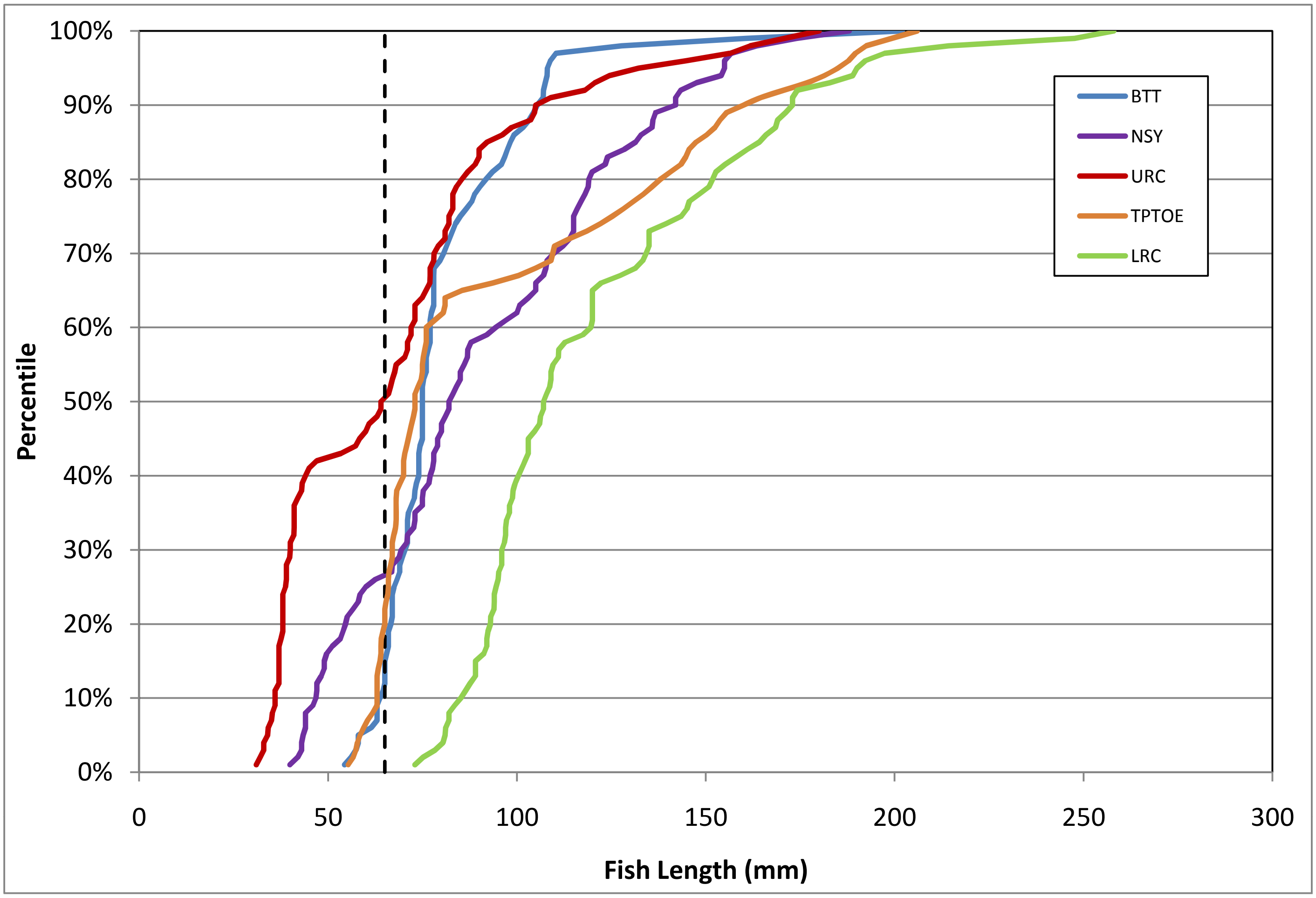
> = greater than

≤ = less than or equal to

MLE = maximum likelihood estimate

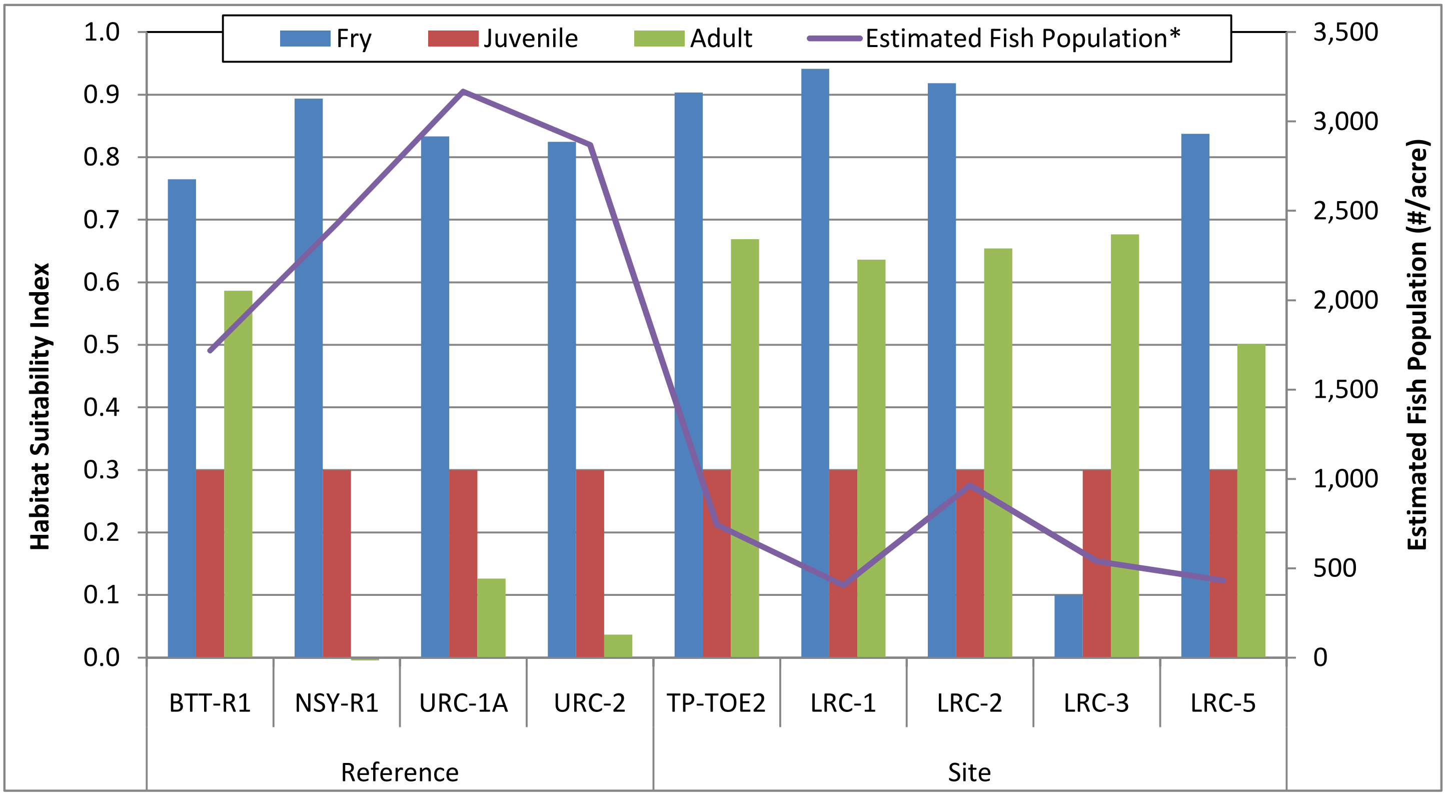
mm = millimeter

FIGURE 7-3 CUMULATIVE DISTRIBUTION FREQUENCY OF FISH LENGTH BY LOCATION



Note: ≤ 65 mm = young-of-the-year
mm = millimeters
≤ = less than or equal to

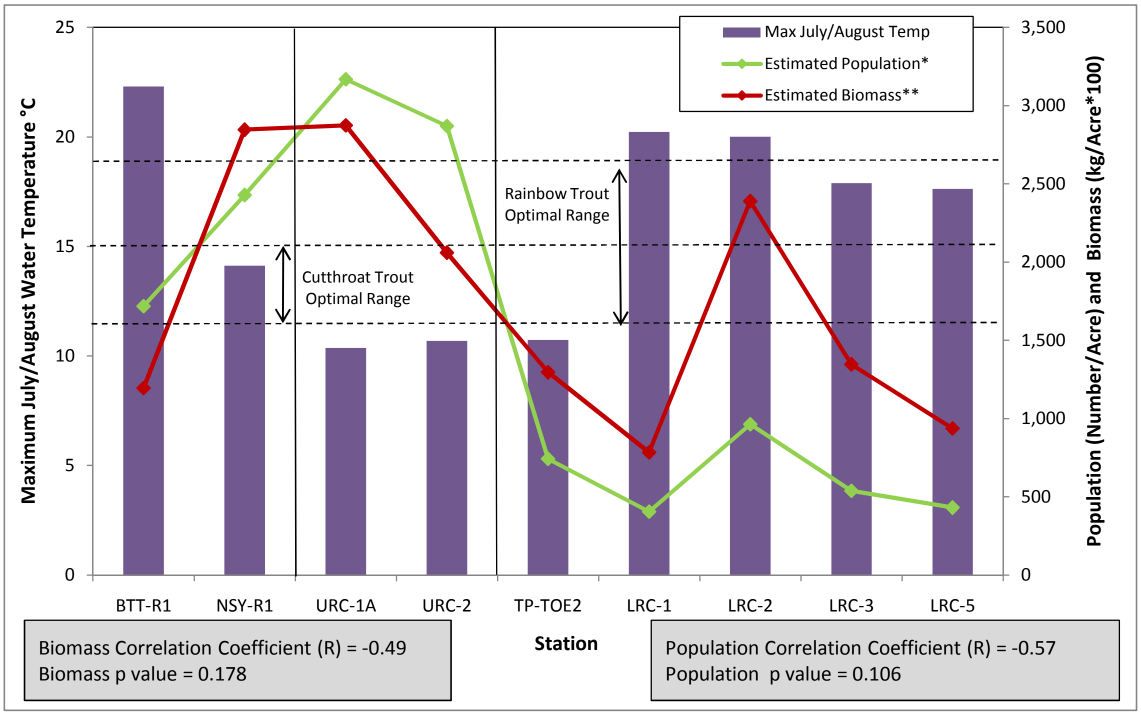
FIGURE 7-4. HABITAT SUITABILITY INDEX FOR FRY, JUVENILE, AND ADULT LIFE STAGES



*Estimate is based on the average 2008 and 2009 MLE population estimate for fish greater than 65 mm.

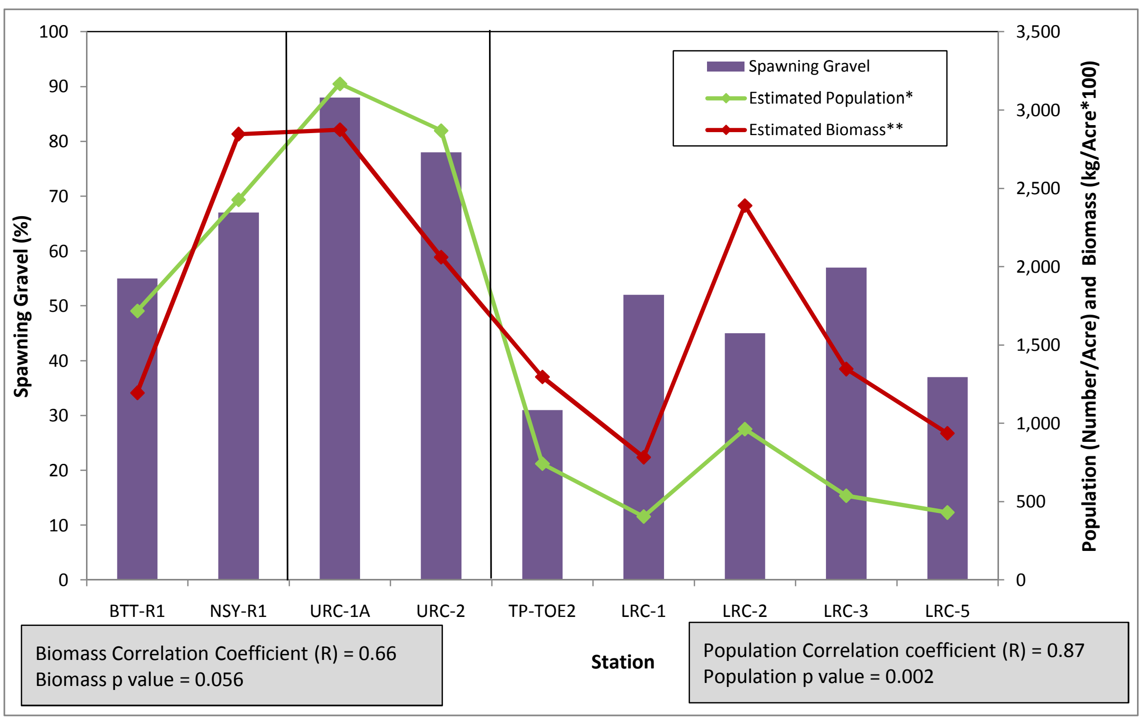
FIGURE 7-5. COMPARISON OF FISH POPULATION ESTIMATES AND BIOMASS TO MEASURED HABITAT METRICS

Panel A: Maximum July/August Water Temperature



Optimal maximum July-August temperature for rainbow trout is 12 - 18 °C and for cutthroat trout is 12 - 15 °C.

Panel B: Percent Spawning Gravel (2 - 64 mm)



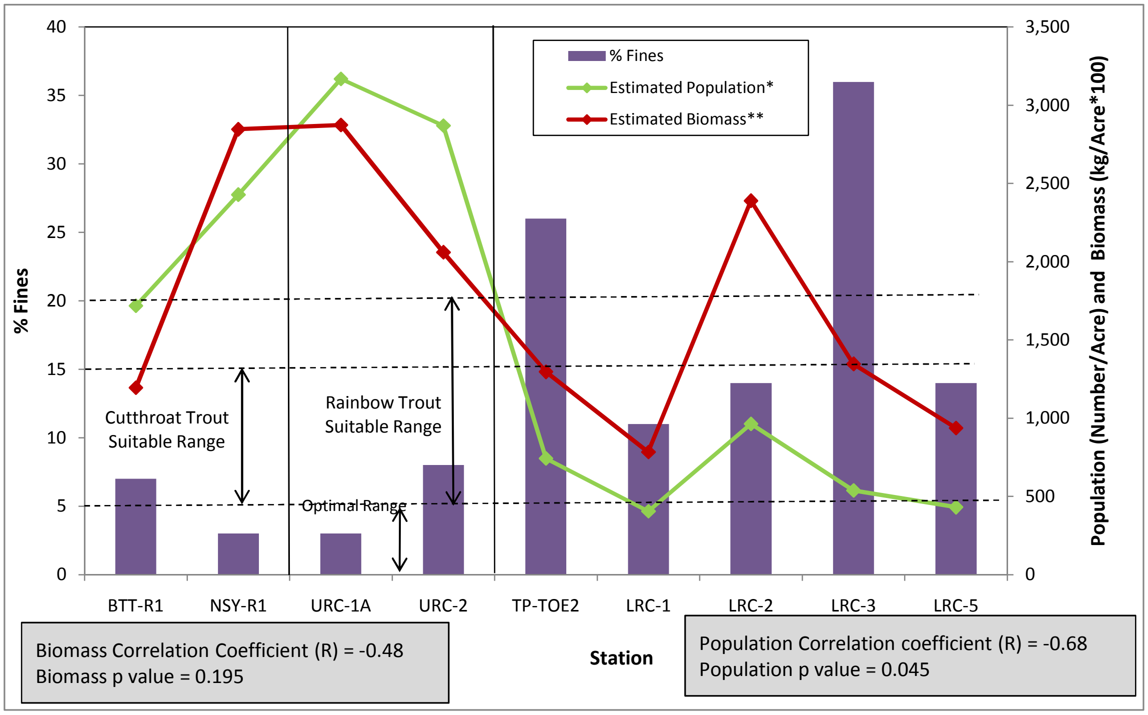
*Average of 2008 and 2009 MLE population estimate for fish greater than 65 mm.

**Average of fish biomass by station for 2008 and 2009. Fish biomass = average fish weight * estimated number of fish/acre. Fish biomass was multiplied by a factor of 100 for plotting purposes.

MLE = maximum likelihood estimate	< = less than	≥ = greater than or equal to	°C = degrees Celsius
% = percent	> = greater than	mm = millimeter	kg = kilogram

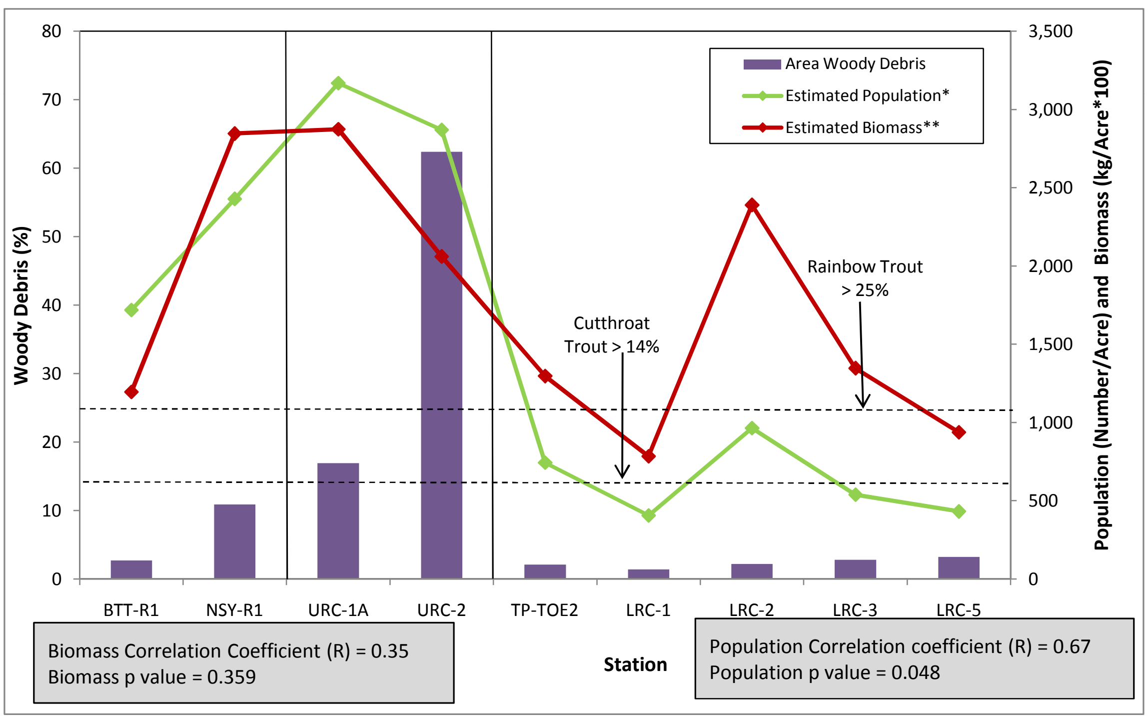
FIGURE 7-5. COMPARISON OF FISH POPULATION ESTIMATES AND BIOMASS TO MEASURED HABITAT METRICS

Panel C: Percent Fines (< 2 mm)



Optimal < 5%; suitable range up to 15% for cutthroat trout and 20% for rainbow trout.

Panel D: Percent Woody Debris



Optimal of ≥ 25% for rainbow trout and 14% to ≥ 22% for cutthroat trout.

*Average of 2008 and 2009 MLE population estimate for fish greater than 65 mm.

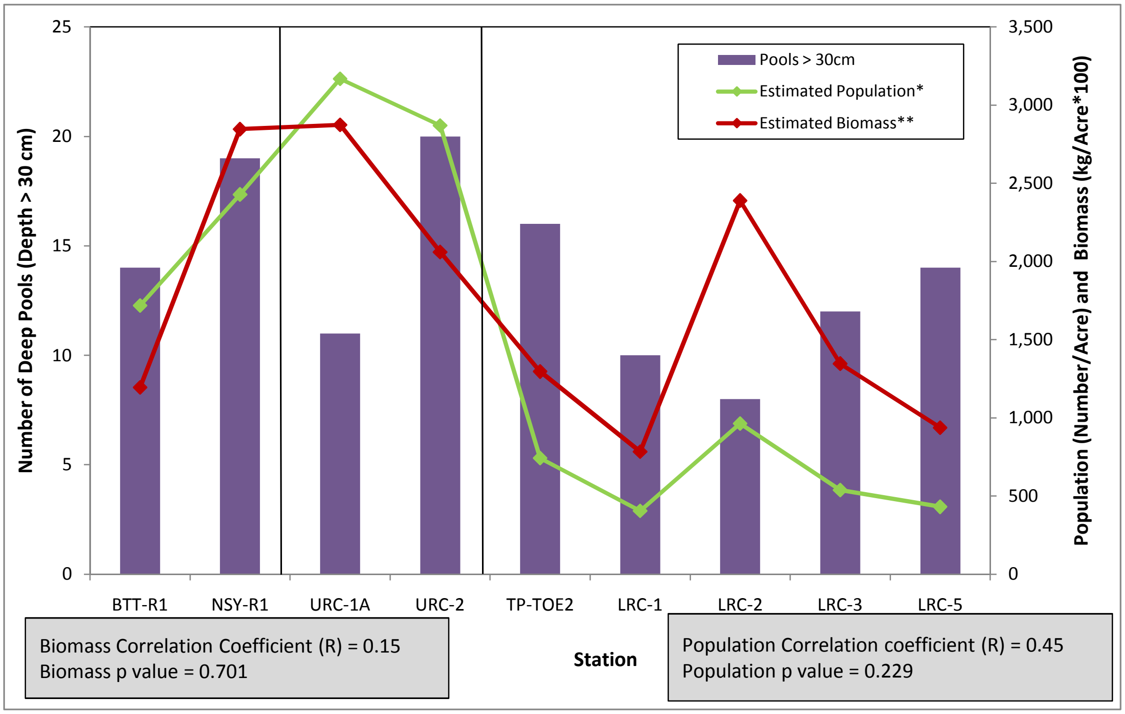
**Average of fish biomass by station for 2008 and 2009. Fish biomass = average fish weight * estimated number of fish/acre. Fish Biomass was multiplied by a factor of 100 for plotting purposes.

MLE = maximum likelihood estimate | < = less than | ≥ = greater than or equal to | °C = degrees Celsius

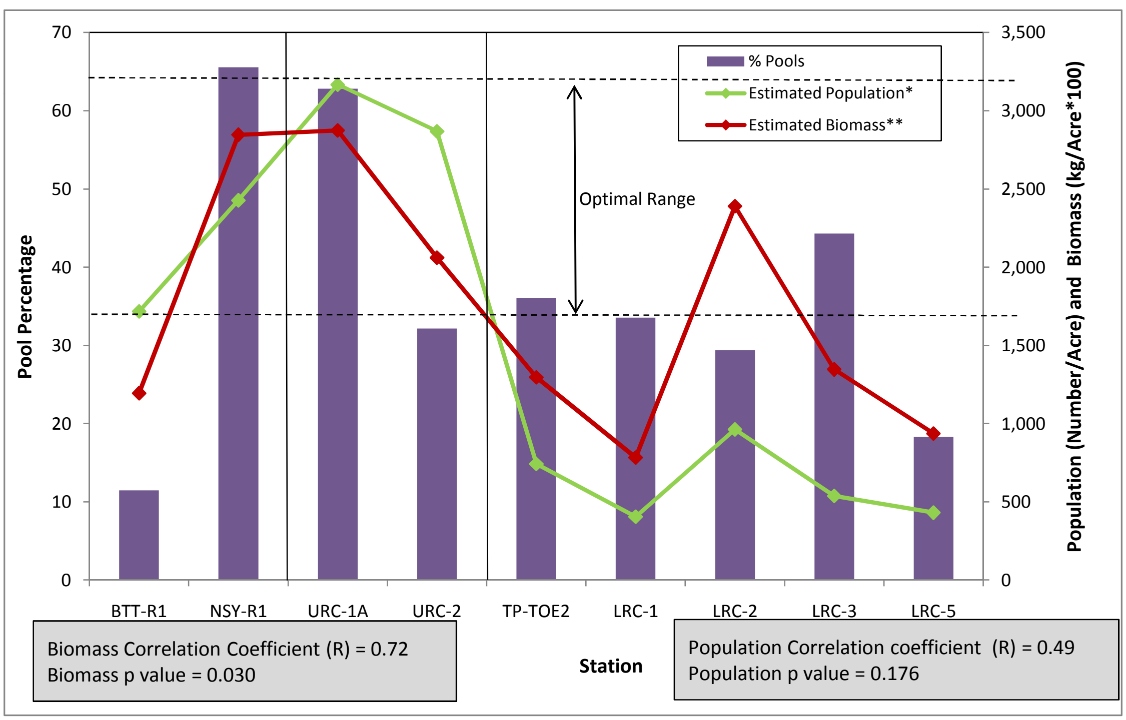
% = percent | > = greater than | mm = millimeter | kg = kilogram

FIGURE 7-5. COMPARISON OF FISH POPULATION ESTIMATES AND BIOMASS TO MEASURED HABITAT METRICS

Panel E: Number of Deep Pools (Depth > 30 cm)



Panel F: Pool Percentage



Optimal % pools for rainbow and cutthroat trout in late growing season (35% - 65%).

*Average of 2008 and 2009 MLE population estimate for fish greater than 65 mm.

**Average of fish biomass by station for 2008 and 2009. Fish biomass = average fish weight * estimated number of fish/acre. Fish Biomass was multiplied by a factor of 100 for plotting purposes.

MLE = maximum likelihood estimate	< = less than	≥ = greater than or equal to	^{o}C = degrees Celsius
% = percent	> = greater than	mm = millimeter	kg = kilogram

FIGURE 7-6 FLOWCHART OF APPROACH FOR RAPID BIOASSESSMENT PROTOCOL (RBP)

Site-Specific Study

Sampling and Analysis

Metric	Biological Condition Scoring Criteria			
	6	4	2	0
1. Taxa Richness (site / reference)	>80%	60-80%	40-60%	<40%
2. Total Density (site / reference)	>80%	60-80%	40-60%	<40%
3. EPT Index (site / reference)	>90%	80-90%	70-80%	<70%
4. Shannon –Weaver Diversity (site / reference)	>85%	70-85%	50-70%	<50%
5. % Ephemeroptera (site / reference)	>50%	35-50%	20-35%	<20%
6. % Tolerant organisms (reference / site)	>80%	60-80%	40-60%	<40%
7. % Contribution of Dominant Taxon	<20%	20-30%	30-40%	>40%
8. % Scrapers (site / reference)	>50%	35-50%	20-35%	<20%
9. % Clingers (site / reference)	>50%	35-50%	20-35%	<20%

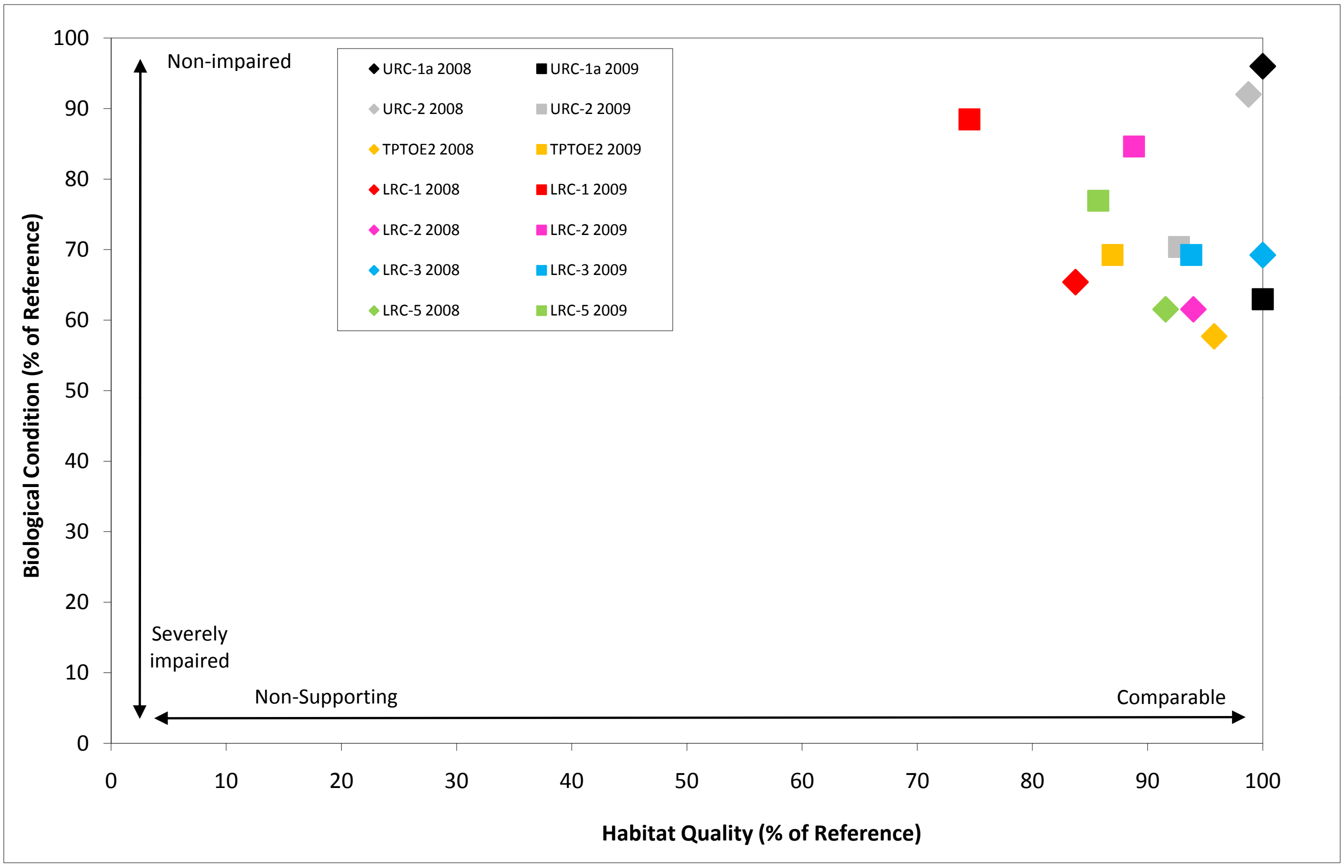
BIOASSESSMENT

% Comparison to Reference Score	Biological Condition Category	Attributes
>80%	Not impaired	Balanced trophic structure. Optimum community composition and dominance for stream size and habitat quality.
50-79%	Slightly impaired	Community structure less than expected. Composition (species richness) lower than expected due to loss of some intolerant forms. Percent contribution of tolerant forms increases.
20-49%	Moderately impaired	Fewer species due to loss of most sensitive forms. Reduction in EPT index.
<20%	Severely impaired	Few Species present. If high densities of organisms, then dominated by one or two taxa.

% = percent
< = less than
> = greater than
EPT = Ephemeroptera, Plecoptera, Trichoptera

Source: USEPA (1989, 1999)

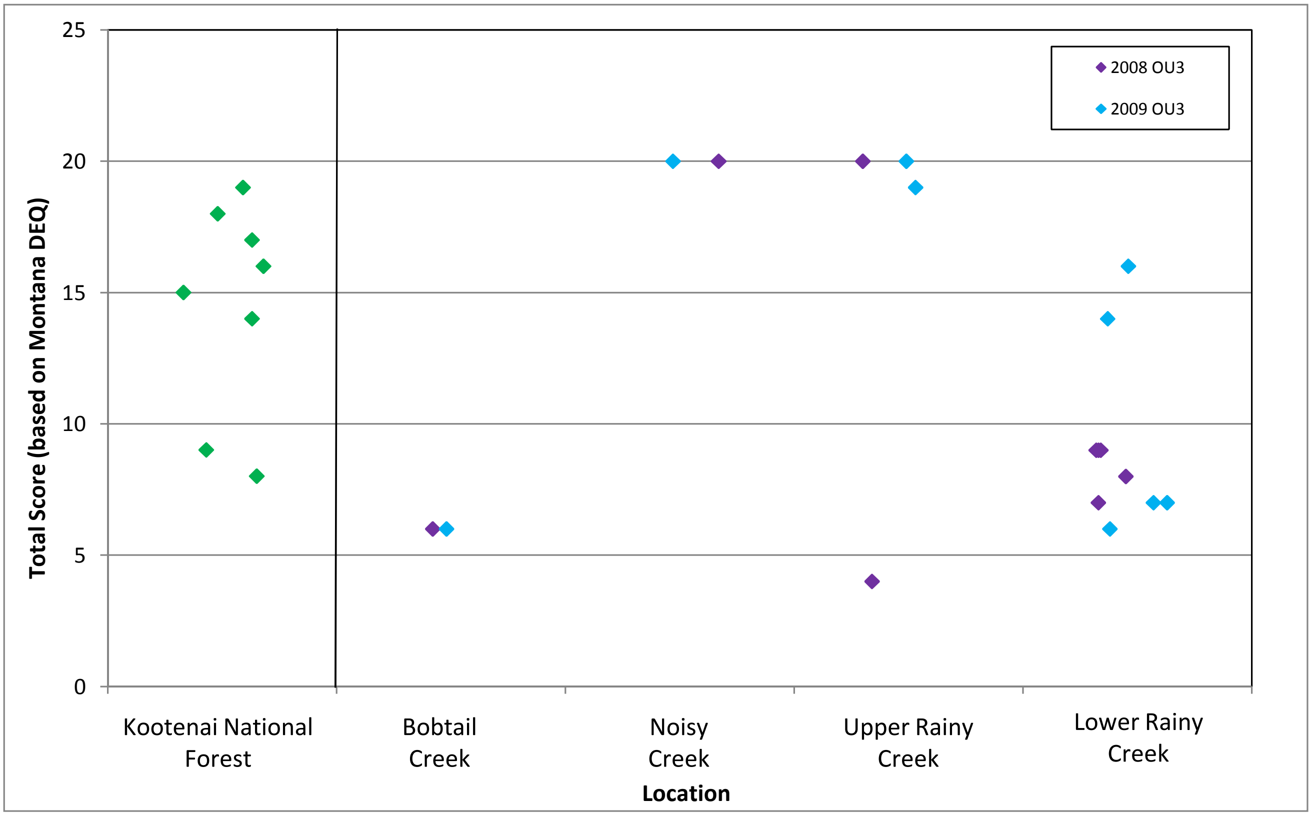
FIGURE 7-7. BIOLOGICAL CONDITION OF AQUATIC INVERTEBRATE COMMUNITIES AND HABITAT QUALITY FOR STATIONS IN OU3 VS. REFERENCE STATIONS



For graphing purposes, values greater than 100% of reference are shown as 100%.
NSY is the reference stream for URC and BTT is the reference stream for TP-TOE2 and LRC.

% = percent

FIGURE 7-8. COMPARISON OF TOTAL SCORES (BASED ON MONTANA DEQ) FOR OU3 SAMPLING LOCATIONS TO KOOTENAI NATIONAL FOREST STATIONS



DEQ = Department of Environmental Quality

FIGURE 8-1. COMPARISON OF MEASURED BARIUM CONCENTRATIONS IN THE TOXICITY TEST TO OTHER OU3 SITE SAMPLES

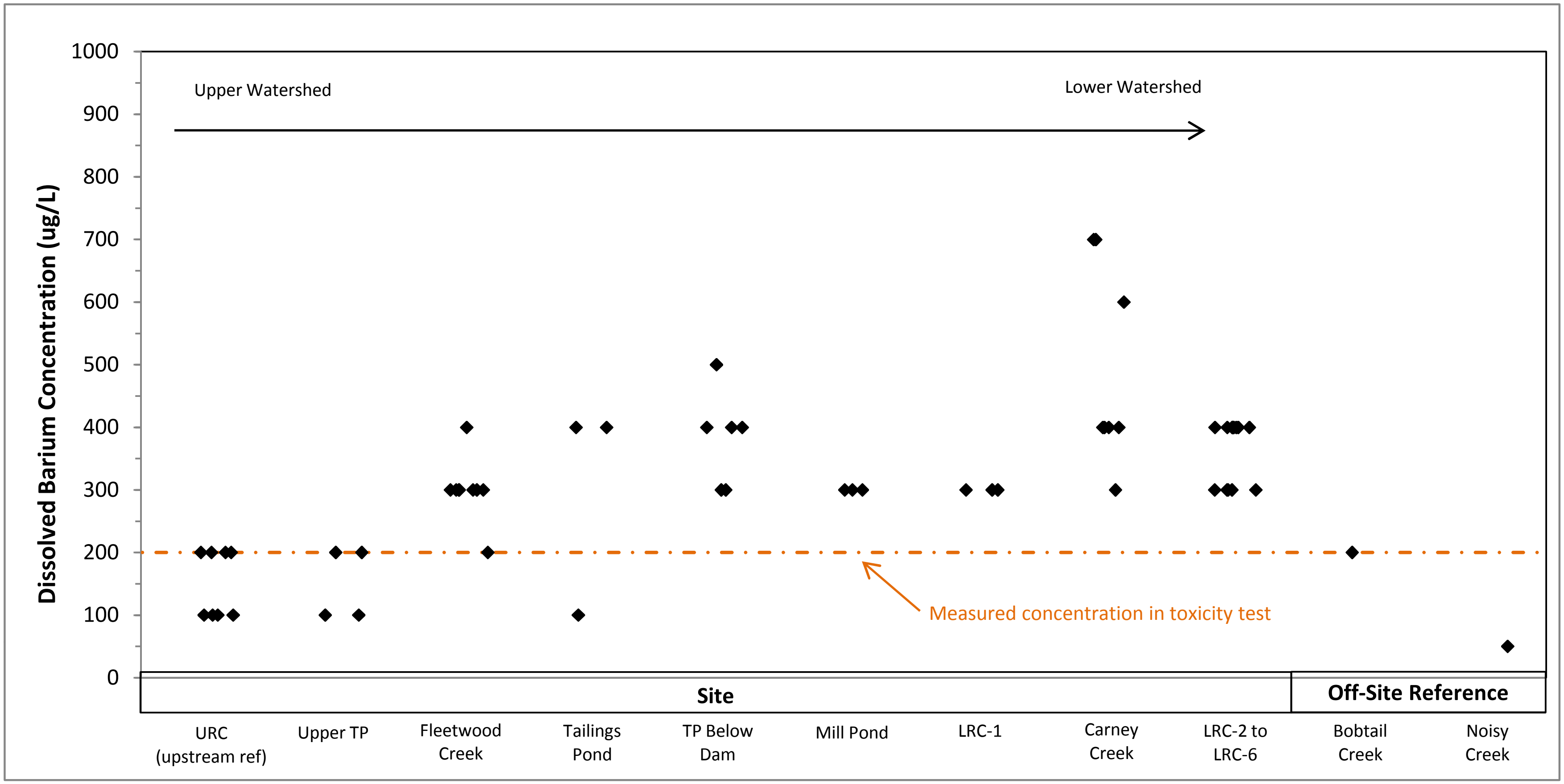
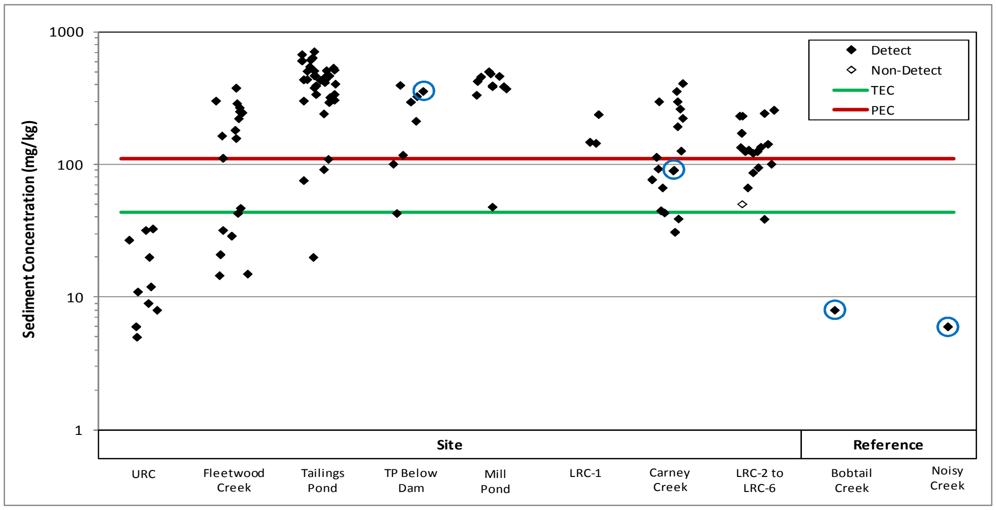
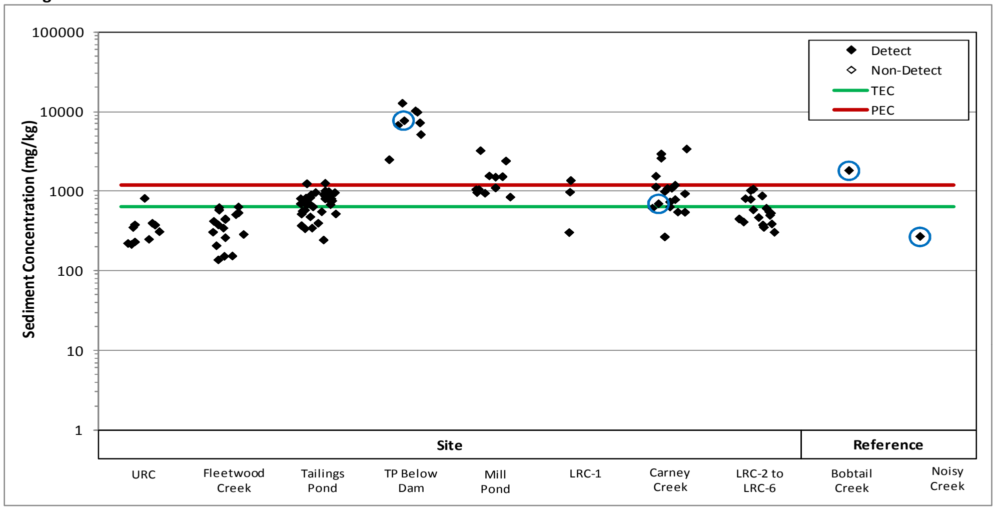


FIGURE 8-2. COMPARISON OF MEASURED SEDIMENT CONCENTRATIONS IN TOXICITY TEST SAMPLES TO OTHER OU3 SITE LOCATIONS

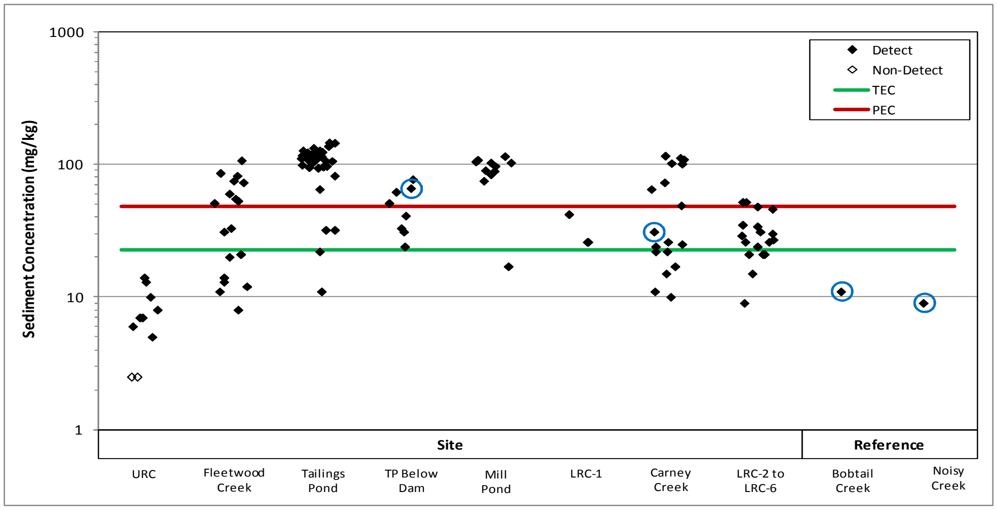
Chromium



Manganese



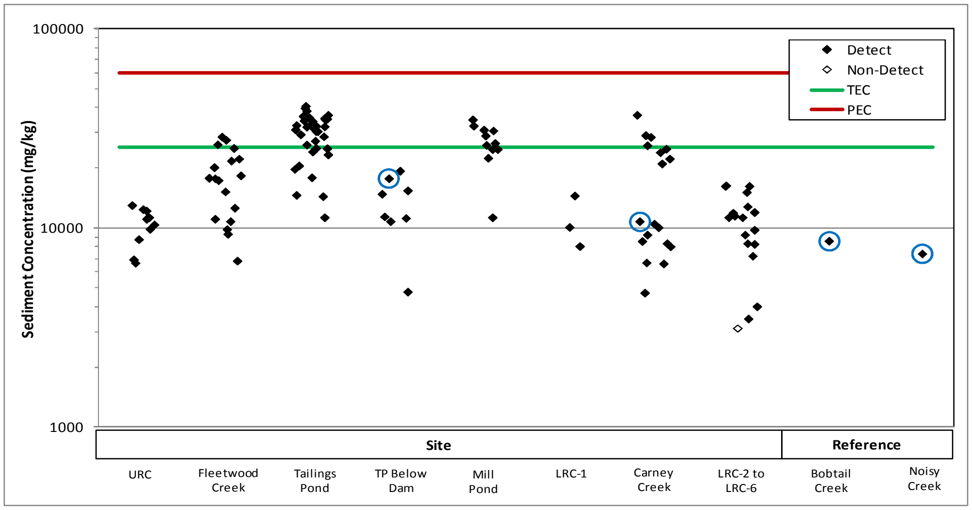
Nickel



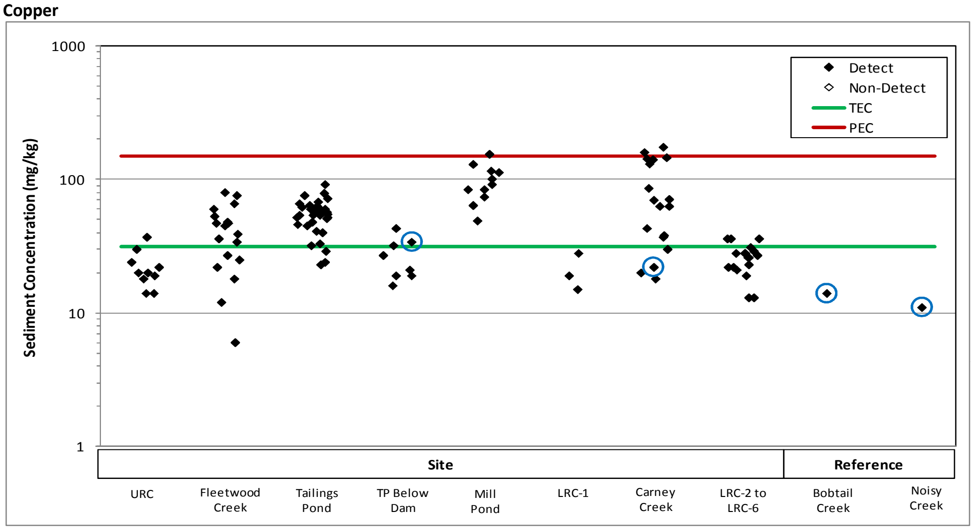
Sediment samples evaluated in the toxicity tests are circled.
mg/kg = milligram per kilogram
PEC = probably effect concentration
TEC = threshold effect concentration

FIGURE 8-2. COMPARISON OF MEASURED SEDIMENT CONCENTRATIONS IN TOXICITY TEST SAMPLES TO OTHER OU3 SITE LOCATIONS (cont.)

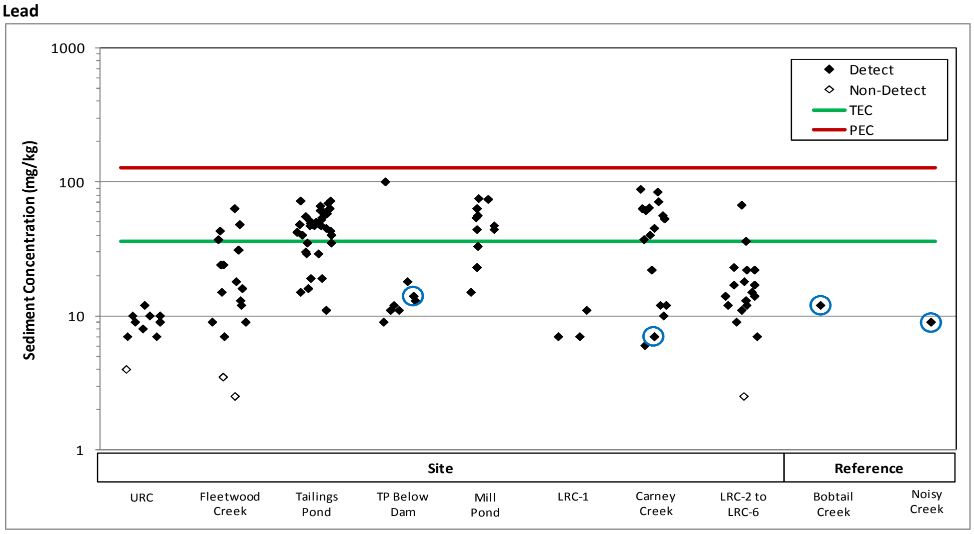
Aluminum



Copper



Lead



Sediment samples evaluated in the toxicity tests are circled.
mg/kg = milligram per kilogram
PEC = probably effect concentration
TEC = threshold effect concentration

Tables

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TABLE 2-1. CLIMATE DATA FOR LIBBY NE RANGER STATION (245015)

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Average Maximum Temperature (°F)	31.6	40.1	50.1	61.7	71.1	78.4	87.9	86.8	75	59	40.5	32.1	59.5
Average Minimum Temperature (°F)	15.7	19.1	24.4	30.2	36.9	43.3	46.2	44.5	38.4	32.3	25.5	18.9	31.3
Average Total Precipitation (in.)	2.03	1.39	1.31	1.01	1.39	1.59	0.87	0.94	1.18	1.56	2.26	2.3	17.84
Average Total Snow Fall (in.)	17.4	7.6	3.9	0.3	0	0	0	0	0	0.5	6.5	17.8	54
Average Snow Depth (in.)	9	9	4	0	0	0	0	0	0	0	2	5	2

Source: http://www.wrcc.dri.edu/cgi-bin/cliMAIN.pl?mtlibb
Period of Record : 6/9/1895 to 12/31/2005

°F = degrees fahrenheit
in = inches
NE = northeast

TABLE 2-2. STREAM USE CLASSIFICATIONS

Stream/Segment	Classification/Uses
Rainy Creek drainage upstream of the W.R. Grace Company water supply intake	**A-1.** Suitable for drinking, culinary and food processing purposes after conventional treatment for removal of naturally present impurities; bathing, swimming and recreation; growth and propagation of salmonid fishes and associated aquatic life, waterfowl and fur bearers; and agricultural and industrial water supply.
Rainy Creek (mainstem) from the W.R. Grace Company water supply intake to the Kootenai River	**C-1.** Suitable for bathing, swimming, and recreation; growth and propagation of salmonid fishes and associated aquatic life, waterfowl and furbearers; and agricultural and industrial water supply.
Kootenai River	**B-1.** Suitable for drinking, culinary and food processing purposes; propagation of salmonid fishes and associated aquatic life, waterfowl and fur bearers; and agricultural and industrial and industrial water supply.

Source: Administrative Rules of Montana (ARM), Department of Environemental Quality (Title 17), Water Quality (Chapter 30), Water Quality Standards and Procedures (Sub-Chapter 6), Water Use Classifications -- Kootenai River (Rule 17.30.609)
http://www.mtrules.org/gateway/RuleNo.asp?RN=17%2E30%2E609

TABLE 2-3. AQUATIC INVERTEBRATE SPECIES COLLECTED FROM EMAP SAMPLING LOCATIONS IN KOOTENAI RIVER (AUGUST 2002)

Phylum	Class	Order	Family	Genus	Species	Abundance
ANNELIDA	HIRUDINEA	RHYNCHOBDELLIDA	PISCICOLIDAE	NA	NA	1
	OLIGOCHAETA	NA	NA	NA	NA	59
ARTHROPODA	ARACHNIDA	TROMBIDIFORMES	HYGROBATIDAE	*HYGROBATES*	NA	1
			TORRENTICOLIDAE	*TORRENTICOLA*	NA	3
COELENTERATA	INSECTA	DIPTERA	CHIRONOMIDAE	NA	NA	8
				CRICOTOPUS	*BICINCTUS*	20
				CRICOTOPUS	NA	17
				CRYPTOCHIRONOMUS	NA	1
				DICROTENDIPES	NA	3
				EUKIEFFERIELLA	NA	8
				MICROPSECTRA	NA	16
				NA	NA	85
				PAGASTIA	NA	10
				PARACHIRONOMUS	NA	7
				PARAKIEFFERIELLA	NA	4
				NA	NA	1
				PHAENOPSECTRA	NA	57
				POTTHASTIA	*GAEDII*	2
				POTTHASTIA	*LONGIMANA*	7
				PROCLADIUS	NA	1
				PSECTROCLADIUS	NA	1
				SYNORTHOCLADIUS	NA	7
				TANYTARSUS	NA	73
				THIENEMANNIMYIA	NA	7
				TVETENIA	*DISCOLORIPES*	17
			TIPULIDAE	*TIPULA*	NA	1
		EPHEMEROPTERA	BAETIDAE	*BAETIS*	NA	10
				BAETIS	*TRICAUDATUS*	17
			EPHEMERELLIDAE	*DRUNELLA*	*GRANDIS*	1
				EPHEMERELLA	NA	13
				SERRATELLA	*TIBIALIS*	2
			SIPHLONURIDAE	NA	NA	1
		HEMIPTERA	CORIXIDAE	NA	NA	18
		TRICHOPTERA	HYDROPTILIDAE	*HYDROPTILA*	NA	3
			LEPTOCERIDAE	*MYSTACIDES*	*ALAFIMBRIATA*	1
				OECETIS	NA	1
			LIMNEPHILIDAE	NA	NA	1
				PSYCHOGLYPHA	NA	1
	OSTRACODA	NA	NA	NA	NA	1
	HYDROZOA	HYDROIDA	HYDRIDAE	*HYDRA*	NA	12
MOLLUSCA	GASTROPODA	BASOMMATOPHORA	LYMNAEIDAE	NA	NA	1
			LYMNAEIDAE	*STAGNICOLA*	NA	2
			PHYSIDAE	*PHYSA*	NA	7
NEMATODA	NA	NA	NA	NA	NA	2

EMAP = Environmental Monitoring and Assessment Program
NA = not available

TABLE 2-4. FISH SPECIES COLLECTED FROM EMAP SAMPLING LOCATIONS IN KOOTENAI RIVER (AUGUST 2002)

Common Name	Genus	Species	Abundance
Longnose Dace	*Catostomus*	*catostomus*	24
Largescale Sucker	*Catostomus*	*macrocheilus*	21
Slimy Sculpin	*Cottus*	*cognatus*	1
Torrent Sculpin	*Cottus*	*rhotheus*	2
Cutthroat trout	*Oncorhynchus*	*clarki*	4
Rainbow trout	*Oncorhynchus*	*mykiss*	39
Sockeye Salmon	*Oncorhynchus*	*nerka*	17
Mountain Whitefish	*Prosopium*	*williamsoni*	587
Longnose Dace	*Rhinichthys*	*cataractae*	1
Redside Shiner	*Richardsonius*	*balteatus*	9
Bull Trout	*Salvelinus*	*confluentus*	1

EMAP = Environmental Monitoring and Assessment Program

TABLE 2-5. FEDERALLY-LISTED SPECIES THAT MAY OCCUR IN LINCOLN COUNTY

Group	Common Name (*Genus species*)	Rank
Fish	White Sturgeon (*Acipenser transmontanus*) (Kootenai River Pop.)	LE
	Bull Trout (*Salvelinus confluentus*)	LT,CH
Mammals	Grizzly Bear (*Ursus arctos horribilis*)	LT
	Wolverine (*Gulo gulo luscus*)	C
	Canada Lynx (*Lynx canadensis*)	LT, CH
Plants	Spalding's Campion (*Silene spaldingii*)	LT
	Whitebark Pine (*Pinus albicaulis*)	C

LE = Listed endangered - Any species in danger of extinction throughout all or a significant portion of its range (16 U.S.C. 1532(6)).
LT = Listed threatened - Any species likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range (16 U.S.C. 1532(20)).
CH = Critical Habitat - The specific areas (i) within the geographic area occupied by a species, at the time it is listed, on which are found those physical or biological features (I) essential to conserve the species and (II) that may require special management considerations or protection; and (ii) specific areas outside the geographic area occupied by the species at the time it is listed upon determination that such areas are essential to conserve the species.
C = Candidate - Those taxa for which sufficient information on biological status and threats exist to propose to list them as threatened or endangered.

Source: USDOI. 2012. Endangered, Threatened, Proposed and Candidate species - Montana Counties. U.S. Department of the Interior, Fish and Wildlife Service, Ecological Services, Montana Field Office, Helena, MT. November 2012.
http://www.fws.gov/montanafieldoffice/Endangered_Species/Listed_Species/countylist.pdf

TABLE 2-6. STATE OF MONTANA SPECIES OF CONCERN THAT MAY OCCUR IN LINCOLN COUNTY

Group	Common Name	Genus species	State Rank
Mammals	Townsend's Big-eared Bat	*Corynorhinus townsendii*	S2
	Wolverine	*Gulo gulo*	S3
	Hoary Bat	*Lasiurus cinereus*	S3
	Canada Lynx	*Lynx canadensis*	S3
	Fisher	*Martes pennanti*	S3
	Fringed Myotis	*Myotis thysanodes*	S3
	Northern Bog Lemming	*Synaptomys borealis*	S2
	Grizzly Bear	*Ursus arctos*	S2S3
Birds	Northern Goshawk	*Accipiter gentilis*	S3
	Great Blue Heron	*Ardea herodias*	S3
	Veery	*Catharus fuscescens*	S3B
	Brown Creeper	*Certhia americana*	S3
	Pileated Woodpecker	*Dryocopus pileatus*	S3
	Peregrine Falcon	*Falco peregrinus*	S3
	Common Loon	*Gavia immer*	S3B
	Cassin's Finch	*Haemorhous cassinii*	S3
	Harlequin Duck	*Histrionicus histrionicus*	S2B
	Lewis's Woodpecker	*Melanerpes lewis*	S2B
	Clark's Nutcracker	*Nucifraga columbiana*	S3
	Flammulated Owl	*Otus flammeolus*	S3B
	Black-backed Woodpecker	*Picoides arcticus*	S3
	Boreal Chickadee	*Poecile hudsonicus*	S3
	Brewer's Sparrow	*Spizella breweri*	S3B
	Great Gray Owl	*Strix nebulosa*	S3
	Pacific Wren	*Troglodytes pacificus*	S3
Reptiles	Northern Alligator Lizard	*Elgaria coerulea*	S3
	Western Skink	*Eumeces skiltonianus*	S3
Amphibians	Western Toad	*Anaxyrus boreas*	S2
	Northern Leopard Frog	*Lithobates pipiens*	S1,S4
	Coeur d'Alene Salamander	*Plethodon idahoensis*	S2
Fish	White Sturgeon	*Acipenser transmontanus*	S1
	Torrent Sculpin	*Cottus rhotheus*	S3
	Westslope Cutthroat Trout	*Oncorhynchus clarkii lewisi*	S2
	Columbia River Redband Trout	*Oncorhynchus mykiss gairdneri*	S1
	Pygmy Whitefish	*Prosopium coulteri*	S3
	Bull Trout	*Salvelinus confluentus*	S2
	Lake Trout	*Salvelinus namaycush*	S2
	Arctic Grayling	*Thymallus arcticus*	S1
Invertebrates	Striate Disc	*Discus shimekii*	S1
	Robust Lancetooth	*Haplotrema vancouverense*	S1S2
	Pale Jumping-slug	*Hemphillia camelus*	S1S2
	Pygmy Slug	*Kootenaia burkei*	S1S2
	Magnum Mantleslug	*Magnipelta mycophaga*	S2S3
	Western Pearlshell	*Margaritifera falcata*	S2
	Shiny Tightcoil	*Pristiloma wascoense*	S1S3
	Smoky Taildropper	*Prophysaon humile*	S2S3
	Sheathed Slug	*Zacoleus idahoensis*	S2S3
	A Millipede	*Taiyutyla curvata*	S1S3

TABLE 2-6. STATE OF MONTANA SPECIES OF CONCERN THAT MAY OCCUR IN LINCOLN COUNTY

Group	Common Name	Genus species	State Rank
Plants (Ferns)	Moonworts	*Botrychium sp. (SOC)*	S1S3
	Crested Shieldfern	*Dryopteris cristata*	S3
	Treelike Clubmoss	*Lycopodium dendroideum*	S2
	Running-pine	*Lycopodium lagopus*	S2
	Adder's Tongue	*Ophioglossum pusillum*	S3
	Northern Beechfern	*Phegopteris connectilis*	S2S3
Flowering Plants - Dicots	Red Alder	*Alnus rubra*	S2S3
	Beck Water-marigold	*Bidens beckii*	S2
	Watershield	*Brasenia schreberi*	S1S2
	Diamond Clarkia	*Clarkia rhomboidea*	S3
	Pale Corydalis	*Corydalis sempervirens*	S2
	English Sundew	*Drosera anglica*	S3
	Western Pearl-flower	*Heterocodon rariflorum*	S2
	Latah Tule Pea	*Lathyrus bijugatus*	S2S3
	Geyer's Biscuitroot	*Lomatium geyeri*	S2
	Stalk-leaved Monkeyflower	*Mimulus ampliatus*	S3
	Short-flowered Monkeyflower	*Mimulus breviflorus*	S1S2
	Douglas Bladderpod	*Physaria douglasii*	S2
	Trailing Black Currant	*Ribes laxiflorum*	S2?
	Elmer's Ragwort	*Senecio elmeri*	S2
	Spalding's Catchfly	*Silene spaldingii*	S2
	Flatleaf Bladderwort	*Utricularia intermedia*	S2
	Great-spurred Violet	*Viola selkirkii*	S2
Flowering Plants - Monocots	Round-leaved Orchis	*Amerorchis rotundifolia*	S3
	Creeping Sedge	*Carex chordorrhiza*	S3
	Prairie Sedge	*Carex prairea*	S3
	Glaucus Beaked Sedge	*Carex rostrata*	S2S3
	Many-headed Sedge	*Carex sychnocephala*	S1S2
	Sheathed Sedge	*Carex vaginata*	S2?
	Sparrow's-egg Lady's-slipper	*Cypripedium passerinum*	S2S3
	Beaked Spikerush	*Eleocharis rostellata*	S3
	Slender Cottongrass	*Eriophorum gracile*	S3
	Pod Grass	*Scheuchzeria palustris*	S3
	Water Bulrush	*Schoenoplectus subterminalis*	S3
	Tufted Club-rush	*Trichophorum cespitosum*	S2
Plants (Bryophytes)	Aloina moss	*Aloina brevirostris*	S1
	Black golf club moss	*Catoscopium nigritum*	S1
	Leucolepis umbrella moss	*Leucolepis acanthoneuron*	S1
	Meesia moss	*Meesia triquetra*	S2
	Meesia moss	*Meesia uliginosa*	S1S2
	Platyhypnidium moss	*Platyhypnidium riparioides*	S1
	Scorpidium moss	*Scorpidium scorpioides*	S2
Plants (Lichens)	A Lichen	*Cladonia botrytes*	S1
	A Lichen	*Lobaria hallii*	S2
	A Lichen	*Nodobryoria subdivergens*	S1S2
	Collared Glass Whiskers Lichen	*Sclerophora amabilis*	S1

TABLE 2-6. STATE OF MONTANA SPECIES OF CONCERN THAT MAY OCCUR IN LINCOLN COUNTY

State Rank	Definition
S1	At high risk because of **extremely limited** and/or **rapidly declining** population numbers, range and/or habitat, making it highly vulnerable to global extinction or extirpation in the state.
S2	At risk because of **very limited** and/or **potentially declining** population numbers, range and/or habitat, making it vulnerable to global extinction or extirpation in the state.
S3	Potentially at risk because of **limited** and/or **declining** numbers, range and/or habitat, even though it may be abundant in some areas.
S4	Apparently secure, though it may be quite rare in parts of its range, and/or suspected to be declining.

Source: Query of Montana Fish, Wildlife, and Parks database of Montana Species of Concern. Queried on: 2/5/2013
(Species list last updated 1/4/2013 according to download output.)
http://fwp.mt.gov/fishAndWildlife/species/speciesOfConcern/

TABLE 4-1. LIST OF SURFACE WATER STATIONS AND ANALYSES

Reach	Station	Cations			Pesticides			PCBs	VOCs	SVOCs	PAHs	Pertroleum Hydrocarbons			Nitrogen Compunds				Radionuclides				Anions			Water quality parameters		
		TAL Metals		Mercury								Extractable HC		Volatile HC	NH4	Total N	N02+NO3	NO2	Gross α	Ra226	Ra228	Ra226+228	Cl, F, SO4	PO4	CN	HCO3,CO3	TDS	DOC
		SW6020	SW6010B	SW7470A	SW8081A	SW8151A	8141A	SW8082	SW8260B	SW8270C	SW8270C	MA-EPH	SW8015M	MA-VPH	E350.1	E351.2	E353.2	E353.2	E900.0	E903.0	RA-05	A7500-RA	E300.0	E365.1	Kelada	A2320 B	A2540C,D	A5310 C
Upper Rainy Creek	URC-1	X	X	X									X	X	X	X	X	X					X	X		X	X	X
	URC-1A†	X	X	X									X	X	X	X	X	X					X	X		X	X	X
	URC-2	X	X	X									X	X	X	X	X	X					X	X		X	X	X
Tailings Impoundment	TP	X	X	X									X	X	X	X	X	X					X	X		X	X	X
	TP-TOE1	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
	TP-TOE2	X	X	X									X	X	X	X	X	X					X	X		X	X	X
	UTP†	X	X	X									X	X	X	X	X	X					X	X		X	X	X
Mill pond	MP	X	X	X									X	X	X	X	X	X					X	X		X	X	X
Lower Rainy Creek	LRC-1	X	X	X									X	X	X	X	X	X					X	X		X	X	X
	LRC-2	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
	LRC-3	X	X	X									X	X	X	X	X	X					X	X		X	X	X
	LRC-4	X	X	X									X	X	X	X	X	X					X	X		X	X	X
	LRC-5	X	X	X									X	X	X	X	X	X					X	X		X	X	X
	LRC-6	X	X	X									X	X	X	X	X	X					X	X		X	X	X
Fleetwood Creek	FC-1	X	X	X									X	X	X	X	X	X					X	X		X	X	X
	FC-Pond	X	X	X							X	X	X	X	X	X	X	X					X	X		X	X	X
	FC-2	X	X	X									X	X	X	X	X	X					X	X		X	X	X
Carney Creek	CC-1	X	X	X									X	X	X	X	X	X					X	X		X	X	X
	CC-2	X	X	X									X	X	X	X	X	X					X	X		X	X	X
	CC-Pond†	X	X	X									X	X	X	X	X	X					X	X		X	X	X

X= Sample analyzed
† = Location sampled and analysed in Phase II only.

DOC = dissolved organic carbon
HC = hydrocarbons
PAHs = polycyclic aromatic hydrocarbons
PCBs = polychlorinated biphenyl
SVOCs = semi volatile organic compunds
TAL = target analyte list
TDS = total dissolved solids
VOCs = volatile organic compunds

TABLE 4-2. NON-ASBESTOS RESULTS FOR DETECTED ANALYTES IN SURFACE WATER

Category	Detected Analytes[3]	Detection Frequency		Concentration[1]	
				Mean[2]	Maximum Detected
Metals (Dissolved Fraction)	Barium	59 / 59	100%	320	700
	Calcium	59 / 59	100%	68,186	107,000
	Copper	1 / 59	2%	1.1	4.0
	Iron	1 / 59	2%	15	30
	Magnesium	59 / 59	100%	16,763	30,000
	Manganese	9 / 59	15%	19	140
	Potassium	59 / 59	100%	8,932	17,000
	Sodium	59 / 59	100%	5,610	10,000
Metals (Total Recoverable Fraction)	Aluminum	11 / 59	19%	82	1,080
	Barium	59 / 59	100%	317	700
	Calcium	59 / 59	100%	67,390	105,000
	Chromium	1 / 59	2%	4.4	10
	Copper	4 / 59	7%	1.4	16
	Iron	30 / 59	51%	94	1,760
	Lead	3 / 59	5%	0.42	5.1
	Magnesium	59 / 59	100%	16,627	29,000
	Manganese	24 / 59	41%	36	210
	Potassium	59 / 59	100%	9,136	18,000
	Sodium	59 / 59	100%	6,153	12,000
Extractable Hydrocarbons	TEH (SW8015M)	1 / 60	2%	155	470
Radionuclides	Gross Alpha	6 / 6	100%	1.8	2.6
	Gross Beta	4 / 4	100%	6.6	9.0
Nitrogen Compounds	Nitrogen, Kjeldahl, Total as N	7 / 56	13%	367	3,100
	Nitrogen, Nitrate as N	22 / 56	39%	40	440
	Nitrogen, Nitrate+Nitrite as N	24 / 56	43%	42	440
	Nitrogen, Nitrite as N	4 / 59	7%	7.5	80
Anions	Chloride	48 / 59	81%	3,432	10,000
	Fluoride	57 / 59	97%	500	1,100
	Phosphorus, Orthophosphate as P	59 / 59	100%	135	456
	Sulfate	59 / 59	100%	10,695	24,000
Water Quality Parameters	Alkalinity, Total as CaCO3	59 / 59	100%	240,136	376,000
	Bicarbonate as HCO3	59 / 59	100%	290,136	459,000
	Carbonate as CO3	8 / 59	14%	2,847	17,000
	Hardness as CaCO3	56 / 56	100%	240,625	385,000
	Organic Carbon, Dissolved (DOC)	58 / 58	100%	3,809	15,400
	Solids, Total Dissolved TDS @ 180 C	59 / 59	100%	289,153	454,000
	Solids, Total Suspended TSS @ 105 C	4 / 59	7%	6,186	36,000

TEH = Total Extractable Hydrocarbons

[1] All values reported in units of micrograms per liter (µg/L) except radionuclides (picocuries per liter [pCi/L]).

[2] Mean calculated assuming 1/2 reported value for non-detects.

[3] Samples from seeps and off-site reference stations are excluded from this table.

TABLE 4-3 LIST OF SEDIMENT STATIONS AND ANALYSES

Reach	Station	Cations			Cyanide	Pesticides			PCBs	VOCs	SVOCs	PAHs	Pertroleum Hydrocarbons			Anions		Sediment quality parameters		
		TAL Metals		Mercury									Extractable HC		Volatile HC	Fluoride	Phosphorus	pH	Moisture	OC
		SW6020	SW6010B	SW7471A	SW9012	SW8081A	SW8151A	8141A	SW8082	SW8260B	SW8270C	SW8270C	MA-EPH	SW8015M	MA-VPH	E300.0	E365.1	ASAM10-3.2	SW3550A	Leco
Upper Rainy Creek	URC-1	X	X	X								X	X	X	X	X	X	X	X	X
	URC-1A†	X	X	X									X	X	X	X	X	X	X	X
	URC-2	X	X	X								X	X	X	X	X	X	X	X	X
Tailings Impoundment	TP	X	X	X								X	X	X	X	X	X	X	X	X
	TP-TOE1	X	X	X										X	X	X	X	X	X	X
	TP-TOE2	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Mill pond	MP	X	X	X								X	X	X	X	X	X	X	X	X
Lower Rainy Creek	LRC-1	X	X	X		X	X		X					X	X	X	X	X	X	X
	LRC-2	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
	LRC-3	X	X	X		X	X		X			X	X	X	X	X	X	X	X	X
	LRC-4	X	X	X		X	X		X					X	X	X	X	X	X	X
	LRC-5	X	X	X		X	X		X					X	X	X	X	X	X	X
	LRC-6	X	X	X		X	X		X			X	X	X	X	X	X	X	X	X
Fleetwood Creek	FC-1	X	X	X								X	X	X	X	X	X	X	X	X
	FC-Pond	X	X	X								X	X	X	X	X	X	X	X	X
	FC-2	X	X	X								X	X	X	X	X	X	X	X	X
Carney Creek	CC-1	X	X	X								X	X	X	X	X	X	X	X	X
	CC-Pond†	X	X	X								X	X	X	X	X	X	X	X	X
	CC-2	X	X	X										X	X	X	X	X	X	X

X = Sample analyzed
† = Location sampled and analyzed in Phase II only.

HC = hydrocarbons
OC = organic carbon
PAHs = polycyclic aromatic hydrocarbons
PCBs = polychlorinated biphenyl
SVOCs = semi volatile organic compunds
TAL = target analyte list
VOCs = volatile organic compunds

TABLE 4-4. NON-ASBESTOS RESULTS FOR DETECTED ANALYTES FOR SEDIMENT

Category	Detected Analytes[2]	Detection Frequency		Concentration (mg/kg)	
				Mean[1]	Maximum Detcted
Metals	Aluminum	120 / 121	99%	19,474	40,700
	Arsenic	44 / 121	36%	1.8	7.0
	Barium	120 / 121	99%	1,113	2,970
	Boron	8 / 121	7%	2.8	11
	Cadmium	4 / 121	3%	0.47	1.0
	Chromium	120 / 121	99%	243	712
	Cobalt	113 / 121	93%	30	75
	Copper	121 / 121	100%	50	175
	Iron	121 / 121	100%	29,980	62,900
	Lead	117 / 121	97%	32	100
	Manganese	121 / 121	100%	1,221	12,700
	Mercury	2 / 111	2%	0.09	0.10
	Nickel	119 / 121	98%	61	146
	Selenium	3 / 115	3%	2.2	1.2
	Thallium	42 / 121	35%	0.49	1.2
	Vanadium	120 / 121	99%	50	98
	Zinc	120 / 121	99%	42	94
Polycyclic Aromatic Hydrocarbons (PAHs)	2-Methylnaphthalene	1 / 63	2%	0.42	0.020
	Benzo(a)anthracene	1 / 63	2%	0.42	0.018
	Benzo(a)pyrene	1 / 63	2%	0.42	0.012
	Benzo(b)fluoranthene	2 / 63	3%	0.42	0.039
	Benzo(k)fluoranthene	2 / 63	3%	0.42	0.033
	Dibenzo(a,h)anthracene	1 / 63	2%	0.42	0.0056
	Fluoranthene	1 / 63	2%	0.42	0.010
	Indeno(1,2,3-cd)pyrene	1 / 63	2%	0.42	0.010
	Pyrene	2 / 63	3%	0.39	0.012
Volatile Organic Compounds (VOCs)	Methyl acetate	4 / 6	67%	0.46	1.4
Extractable Hydrocarbons	C11 to C22 Aromatics	47 / 57	82%	104	507
	C19 to C36 Aliphatics	49 / 57	86%	164	739
	C9 to C18 Aliphatics	33 / 57	58%	100	590
	Total Extractable Hydrocarbons	156 / 168	93%	396	2,360
Volatile Hydrocarbons	C9 to C10 Aromatics	12 / 111	11%	5.1	63
	C9 to C12 Aliphatics	17 / 111	15%	6.2	58
	Naphthalene	2 / 174	1%	0.27	2.8
	Total Purgeable Hydrocarbons	29 / 111	26%	17	276
Anions	Fluoride	57 / 111	51%	1.7	18
	Phosphorus, Total	111 / 111	100%	2,465	8,390
Sediment Quality Parameters	Carbon, Organic	120 / 121	99%	1.3	15.4
	Moisture	122 / 122	100%	47	85
	pH, sat. paste	120 / 121	99%	7.1	8.3
	Solids, Total	103 / 104	99%	51	92

[1] Mean calculated assuming 1/2 reported value for non-detects.

[2] Samples from seeps and off-site reference stations are excluded from this table.

mg/kg = milligrams per kilogram

TABLE 4-5. LIST OF MINE WASTE AND SOIL STATIONS AND ANALYSES

		Cations			Pesticides			PCBs	VOCs	SVOCs	PAHs	Petroleum Hydrocarbons		
		TAL Metals		Mercury								Extractable HC		Volatile HC
Description	Station	SW6020	SW6010B	SW7471A	SW8081A	SW8151A	8141A	SW8082	SW8260B	SW8270C	SW8270C	MA-EPH	SW8015M	MA-VPH
Tailings Impoundment	MS-4	X	X	X	X	X	X	X	X	X	X	X	X	X
	MS-5	X	X	X	X	X	X	X	X	X	X	X	X	X
Coarse Tailings Disposal Area	MS-6	X	X	X									X	X
	MS-7	X	X	X									X	X
	MS-8	X	X	X									X	X
	MS-9	X	X	X									X	X
Cover Material	MS-10	X	X	X									X	X
	MS-11	X	X	X									X	X
	MS-12	X	X	X									X	X
	MS-13	X	X	X									X	X
	MS-21	X	X	X									X	X
	MS-22	X	X	X									X	X
	MS-23	X	X	X									X	X
	MS-24	X	X	X									X	X
Waste Rock Pile (central)	MS-14	X	X	X									X	X
	MS-17	X	X	X									X	X
	MS-18	X	X	X									X	X
Waste Rock Pile (west)	MS-15	X	X	X									X	X
	MS-16	X	X	X									X	X
	MS-26	X	X	X									X	X
	MS-27	X	X	X									X	X
	MS-28	X	X	X									X	X
	MS-29	X	X	X									X	X
Waste Rock Pile (east)	MS-19	X	X	X									X	X
	MS-20	X	X	X						X	X	X	X	X
	MS-30	X	X	X									X	X
	MS-32	X	X	X									X	X
Outcrop	MS-25	X	X	X										
	MS-31	X	X	X										
	MS-33	X	X	X										
	MS-34	X	X	X										
	MS-35	X	X	X										
	MS-36	X	X	X										
	MS-37	X	X	X										
	MS-38	X	X	X										

X = Sample analyzed

HC = hydrocarbons
PAHs = polycyclic aromatic hydrocarbons
PCBs = polychlorinated biphenyl
SVOCs = semi volatile organic compunds
TAL = target analyte list
VOCs = volatile organic compunds

TABLE 4-6. NON-ASBESTOS RESULTS FOR DETECTED ANALYTES MINE WASTE AND SOIL

Category	Detected Analytes[2]	Detection Frequency		Concentration (mg/kg)	
				Mean[1]	Maximum Detected
Metals	Aluminum	35 / 35	100%	18,101	50,900
	Antimony	1 / 35	3%	0.15	0.30
	Arsenic	1 / 35	3%	1.0	2.0
	Barium	35 / 35	100%	964	3,200
	Chromium	35 / 35	100%	231	881
	Cobalt	35 / 35	100%	28	63
	Copper	34 / 35	97%	30	87
	Iron	35 / 35	100%	25,137	51,900
	Lead	33 / 35	94%	18	48
	Manganese	35 / 35	100%	356	808
	Mercury	1 / 35	3%	0.057	0.30
	Nickel	35 / 35	100%	60	135
	Thallium	3 / 35	9%	0.34	0.90
	Vanadium	35 / 35	100%	39	114
	Zinc	35 / 35	100%	26	63
Polycyclic Aromatic Hydrocarbons (PAHs)	Benzo(a)anthracene	2 / 3	67%	0.068	0.021
	Benzo(a)pyrene	1 / 3	33%	0.066	0.019
	Benzo(b)fluoranthene	1 / 3	33%	0.069	0.030
	Benzo(g,h,i)perylene	1 / 3	33%	0.065	0.016
	Benzo(k)fluoranthene	1 / 3	33%	0.062	0.010
	Chrysene	2 / 3	67%	0.063	0.007
	Indeno(1,2,3-cd)pyrene	1 / 3	33%	0.072	0.038
	Pyrene	2 / 3	67%	0.075	0.029
Pesticide	Pentachlorophenol	1 / 4	25%	0.13	0.039
Volatile Organic Compounds (VOCs)	Methyl acetate	2 / 2	100%	1.1	1.7
Extractable Hydrocarbons	C11 to C22 Aromatics	2 / 3	67%	35	78
	C19 to C36 Aliphatics	3 / 3	100%	103	154
	C9 to C18 Aliphatics	2 / 3	67%	29	53
	TEH (MA-EPH)	3 / 3	100%	220	365
	TEH (SW8015M)	19 / 27	70%	46	474
Volatile Hydrocarbons	Toluene (MA-VPH)	1 / 29	3%	0.022	0.066
	C5 to C8 Aliphatics	1 / 27	4%	0.85	1.4
	C9 to C10 Aromatics	1 / 27	4%	1.4	16
	Total Purgeable Hydrocarbons	3 / 27	11%	1.6	17
Anions	Fluoride	2 / 35	6%	0.75	5.3
	Total Phosphorus	35 / 35	100%	2,724	11,700
Soil Quality Parameters	Carbon, Organic	35 / 35	100%	0.55	2.9
	Moisture	35 / 35	100%	8.5	33
	pH, sat. paste	35 / 35	100%	7.8	8.5

[1] Mean calculated assuming 1/2 reported value for non-detects.
[2] Samples from Rainy Creek Road are excluded from this table.

mg/kg = milligrams per kilogram
TEH = Total Extractable Hydrocarbons

TABLE 4-7
COMPARISON OF FOREST SOIL CONCENTRATIONS FROM DOWNWIND AND UPWIND/CROSS-WIND TRANSECTS

Metal	Dataset 1: Downwind Transects					Dataset 2: Upwind/Cross-wind Transects					Gehan Test p value	Comparison Conclusion
	N	% NDs	Mean (detects)	Min (detects)	Max (detects)	N	% NDs	Mean (detects)	Min (detects)	Max (detects)		
Aluminum	6	0.00%	9627	4560	26100	6	0.00%	8302	5280	17300	0.564	Do Not Reject H0, Conclude Dataset 1 <= Dataset 2
Antimony	6	100.00%	N/A	N/A	N/A	6	100.00%	N/A	N/A	N/A	N/A	All non-detect; Conclude Dataset 1 = Dataset 2
Arsenic	6	66.67%	6	6	6	6	33.33%	6.25	6	7	0.956	Do Not Reject H0, Conclude Dataset 1 <= Dataset 2
Barium	6	0.00%	94.33	46	225	6	0.00%	105.3	56	203	0.685	Do Not Reject H0, Conclude Dataset 1 <= Dataset 2
Beryllium	6	100.00%	N/A	N/A	N/A	6	100.00%	N/A	N/A	N/A	N/A	All non-detect; Conclude Dataset 1 = Dataset 2
Boron	6	83.33%	5	5	5	6	83.33%	5	5	5	0.549	Do Not Reject H0, Conclude Dataset 1 <= Dataset 2
Cadmium	6	100.00%	N/A	N/A	N/A	6	83.33%	1	1	1	0.841	Do Not Reject H0, Conclude Dataset 1 <= Dataset 2
Chromium	6	0.00%	23.83	8	49	6	0.00%	21.33	8	43	0.564	Do Not Reject H0, Conclude Dataset 1 <= Dataset 2
Cobalt	6	33.33%	11	6	26	6	16.67%	8.6	6	18	0.901	Do Not Reject H0, Conclude Dataset 1 <= Dataset 2
Copper	6	0.00%	19	9	48	6	0.00%	19.83	11	45	0.788	Do Not Reject H0, Conclude Dataset 1 <= Dataset 2
Iron	6	0.00%	17150	11100	30700	6	0.00%	16633	12800	24100	0.685	Do Not Reject H0, Conclude Dataset 1 <= Dataset 2
Lead	6	0.00%	16	8	27	6	0.00%	18	8	26	0.626	Do Not Reject H0, Conclude Dataset 1 <= Dataset 2
Manganese	6	0.00%	384.3	185	810	6	0.00%	501.2	209	1250	0.788	Do Not Reject H0, Conclude Dataset 1 <= Dataset 2
Mercury	6	100.00%	N/A	N/A	N/A	6	100.00%	N/A	N/A	N/A	N/A	All non-detect; Conclude Dataset 1 = Dataset 2
Nickel	6	0.00%	18.17	7	42	6	0.00%	14.83	9	29	0.626	Do Not Reject H0, Conclude Dataset 1 <= Dataset 2
Selenium	6	100.00%	N/A	N/A	N/A	6	100.00%	N/A	N/A	N/A	N/A	All non-detect; Conclude Dataset 1 = Dataset 2
Silver	6	100.00%	N/A	N/A	N/A	6	100.00%	N/A	N/A	N/A	N/A	All non-detect; Conclude Dataset 1 = Dataset 2
Thallium	6	100.00%	N/A	N/A	N/A	6	100.00%	N/A	N/A	N/A	N/A	All non-detect; Conclude Dataset 1 = Dataset 2
Vanadium	6	0.00%	27.83	6	119	6	0.00%	24.83	7	99	0.626	Do Not Reject H0, Conclude Dataset 1 <= Dataset 2
Zinc	6	0.00%	57	35	71	6	0.00%	56.83	47	71	0.436	Do Not Reject H0, Conclude Dataset 1 <= Dataset 2

Concentrations are reported as milligrams per kilogram (mg/kg).

N/A = not applicable
%ND = % of samples that are non-detect
Stdev = standard deviation

TABLE 4-8
FOREST SOIL SUMMARY STATISTICS

Metal	Detection Frequency	Soil Concentration (mg/kg)		
		Average*	Minimum	Maximum
Aluminum	12/12	8,964	4,560	26,100
Antimony	0/12	5 U	--	--
Arsenic	6/12	4.3	5 U	7.0
Barium	12/12	100	46	225
Beryllium	0/12	5 U	--	--
Boron	2/12	2.9	5 U	5.0
Cadmium	1/12	0.54	1 U	1.0
Chromium	12/12	23	8.0	49
Cobalt	9/12	7.9	5 U	26
Copper	12/12	19	9.0	48
Iron	12/12	16,892	11,100	30,700
Lead	12/12	17	8.0	27
Manganese	12/12	443	185	1,250
Mercury	0/12	1 U	--	--
Nickel	12/12	17	7.0	42
Selenium	0/12	5 U	--	--
Silver	0/12	5 U	--	--
Thallium	0/12	5 U	--	--
Vanadium	12/12	26	6.0	119
Zinc	12/12	57	35	71

*Non-detects evaluated at 1/2 the detection limit.

mg/kg = milligrams per kilogram
U = non-detect qualifier

TABLE 5-1. INITIAL HQ SCREEN FOR AQUATIC RECEPTORS FOR CHEMICALS DETECTED IN SURFACE WATER

Detected Analyte [a]	Maximum Detected Value (µg/L)	Chronic Benchmark (µg/L)		HQmax	Recommendation
Barium	700	4	B	1.8E+02	Retain as COPC
Fluoride	1,100	120	C	9.2E+00	
Nitrogen, Nitrite as N	80	60	C	1.3E+00	
Manganese	140	120	B	1.2E+00	
Copper	4.0	6.4 [b]	A	6.2E-01	Exclude from further evaluation
Nitrogen, Nitrate as N	440	13,000	C	3.4E-02	
Iron	30	1,000	A	3.0E-02	
Gross Alpha	2.6	no benchmark		NC	Qualitative evaluation in Uncertainty Assessment (see Section 9.1.3)
Gross Beta	9	no benchmark		NC	
Total Extractable Hydrocarbons	470	no benchmark		NC	
Nitrogen, Nitrate+Nitrite as N	440	no benchmark [c]		NC	
Calcium	107,000			--	Water quality parameters; not evaluated quantitatively as toxicants.
Magnesium	30,000			--	
Potassium	17,000			--	
Chloride	10,000			--	
Sodium	10,000			--	
Nitrogen, Kjeldahl, Total as N	3,100			--	
Phosphorus, Orthophosphate as P	456			--	
Sulfate	24,000			--	
Alkalinity, Total as $CaCO_3$	376,000			--	
Bicarbonate as HCO_3	459,000			--	
Carbonate as CO_3	17,000			--	
Hardness as $CaCO_3$	385,000			--	
Organic Carbon, Dissolved (DOC)	15,400			--	
Solids, Total Dissolved TDS @ 180 C	454,000			--	
Solids, Total Suspended TSS @ 105 C	36,000			--	

[a] Metal concentrations based on dissolved fraction.
[b] Chronic benchmark calculated using lowest measured hardness (68 mg/L) at site.
[c] Evaluated based on nitrate and nitrite-specific benchmarks.

Chronic Benchmark Source:
A - National Ambient Water Quality Criteria (EPA 2009)
B - Great Lake Water Quality Initiative Tier II Value (Suter and Tsao 1996)
C - Canadian Water Quality Guideline (CCME 2012)

µg/L = micograms per liter
COPC = chemical of potential concern
HQ = hazard quotient
HQmax = maximum hazard quotient
NC = not calculated; no benchmark available

TABLE 5-2. INITIAL HQ SCREEN FOR AQUATIC INVERTEBRATES FOR CHEMICALS DETECTED IN SEDIMENT

Detected Analyte	Maximum Detected Value [a]	TEC-based Benchmark (mg/kg dw)		HQmax	Recommendation
Aluminum	40,700	26,000	B	1.6E+00	Retain as COPC
Cadmium	1.0	0.99	A	1.0E+00	
Chromium	712	43	A	1.6E+01	
Copper	175	32	A	5.5E+00	
Lead	100	36	A	2.8E+00	
Manganese	12,700	630	B	2.0E+01	
Nickel	146	23	A	6.4E+00	
Benzo(b)fluoranthene	0.039	0.027	B	1.4E+00	
Benzo(k)fluoranthene	0.033	0.027	B	1.2E+00	
Naphthalene	2.8	0.18	A	1.6E+01	
Arsenic	7.00	9.8	A	7.2E-01	Exclude from further evaluation
Mercury	0.10	0.18	A	5.6E-01	
Iron	62,900	190,000	B	3.3E-01	
Zinc	94	121	A	7.8E-01	
2-Methylnaphthalene	0.020	4.5	C	4.5E-03	
Benzo(a)anthracene	0.018	0.11	A	1.7E-01	
Benzo(a)pyrene	0.012	0.15	A	8.0E-02	
Dibenzo(a,h)anthracene	0.0056	0.033	A	1.7E-01	
Fluoranthene	0.010	0.42	A	2.4E-02	
Indeno(1,2,3-cd)pyrene	0.010	0.017	B	5.9E-01	
Pyrene	0.012	0.20	A	6.2E-02	
Barium	2,970	no benchmark		NC	Qualitative evaluation in Uncertainty Assessment (see Section 9.1.3)
Boron	11	no benchmark		NC	
Cobalt	75	no benchmark		NC	
Selenium	1.2	no benchmark		NC	
Thallium	1.2	no benchmark		NC	
Vanadium	98	no benchmark		NC	
C11 to C22 Aromatics	507	no benchmark		NC	
C19 to C36 Aliphatics	739	no benchmark		NC	
C9 to C18 Aliphatics	590	no benchmark		NC	
C9 to C10 Aromatics	63	no benchmark		NC	
C9 to C12 Aliphatics	58	no benchmark		NC	
Total Extractable Hydrocarbons	2,360	no benchmark		NC	
Total Purgeable Hydrocarbons	276	no benchmark		NC	
Methyl acetate	1.4	no benchmark		NC	
Fluoride	18	no benchmark		NC	
Phosphorus, Total	8,390	no benchmark		NC	
Carbon, Organic (as percent)	15.4			--	Sediment quality parameters; not evaluated quantitatively as toxicants.
Moisture (as percent)	84.6			--	
pH, sat. paste (as s.u.)	8.3			--	
Solids, Total (as percent)	92.2			--	

[a] Units are mg/kg dw, unless specified otherwise.

TEC Benchmark Source:
A - Consensus-Based TEC (MacDonald et al. 2000)
B - ARCS TEL (Ingersoll et al. 1996)
C - Equilibrium-partitioning sediment guidelines (EPA 2000)

ARCS = Assessment and Remediation of Contaminated Sediments
COPC = chemical of potential concern
HQ = hazard quotient
HQmax = maximum hazard quotient
mg/kg dw = milligrams per kilogram (dry weight)
NC = not calculated; no benchmark available
TEC = threshold effect concentration
TEL = threshold effect level

TABLE 5-3. INITIAL HQ SCREEN FOR PLANTS AND TERRESTRIAL INVERTEBRATES FOR CHEMICALS DETECTED IN MINE WASTE AND SOIL

Detected Analyte	Maximum Detected Value[a]	Lowest Benchmark[b] (mg/kg dw)		HQmax	Recommendation
Barium	3,200	330	A	9.7E+00	Retain as COPC
Chromium	881	0.40	B	2.2E+03	
Cobalt	63	13	A	4.8E+00	
Copper	87	70	A	1.2E+00	
Manganese	808	220	A	3.7E+00	
Mercury	0.30	0.10	B	3.0E+00	
Nickel	135	38	A	3.6E+00	
Vanadium	114	2.0	B	5.7E+01	
Aluminum	50,900	no benchmark[c]	A	NC	Exclude from further evaluation
Antimony	0.30	5.0	B	6.0E-02	
Arsenic	2.0	18	A	1.1E-01	
Lead	48	120	A	4.0E-01	
Thallium	0.90	1.0	B	9.0E-01	
Zinc	63	120	A	5.3E-01	
Fluoride	5.3	30		1.8E-01	
Benzo(a)anthracene	0.021	18	A	1.2E-03	
Benzo(a)pyrene	0.019	18	A	1.1E-03	
Benzo(b)fluoranthene	0.03	18	A	1.7E-03	
Benzo(g,h,i)perylene	0.016	18	A	8.9E-04	
Benzo(k)fluoranthene	0.0096	18	A	5.3E-04	
Chrysene	0.0074	18	A	4.1E-04	
Indeno(1,2,3-cd)pyrene	0.038	18	A	2.1E-03	
Pentachlorophenol	0.039	5.0	A	7.8E-03	
Pyrene	0.029	18	A	1.6E-03	
Toluene (MA-VPH)	0.066	200	B	3.3E-04	
C11 to C22 Aromatics	78	no benchmark		NC	Qualitative evaluation in Uncertainty Assessment (see Section 9.1.3)
C19 to C36 Aliphatics	154	no benchmark		NC	
C9 to C18 Aliphatics	53	no benchmark		NC	
C5 to C8 Aliphatics	1.4	no benchmark		NC	
C9 to C10 Aromatics	16	no benchmark		NC	
TEH (MA-EPH)	365	no benchmark		NC	
TEH (SW8015M)	474	no benchmark		NC	
Total Purgeable Hydrocarbons	17	no benchmark		NC	
Iron	51,900	no benchmark[d]		NC	
Methyl acetate	1.7	no benchmark		NC	
Total Phosphorus	11700	no benchmark		NC	
Carbon, Organic (as percent)	2.86			--	Soil quality parameters; not evaluated quantitatively as toxicants.
Moisture (as percent)	33			--	
pH, sat. paste (as s.u.)	8.5			--	

[a] Units are mg/kg dw, unless specified otherwise.

[b] Lowest benchmark across plants and soil invertebrates (see Appendix E).

[c] Aluminum is not of potential concern unless soil pH is less than 5.5 (measured pH at site ranges from 6.3-8.5).

[d] A numeric Eco-SSL for iron was not derived. The potential toxicity of iron in soils is dependant on soil pH and Eh.

Soil Benchmark Source:
A - Ecological Soil Screening Level (EcoSSL)
B - Oak Ridge National Laboratory Screening Value (Efroymson et al. 1997a,b)

COPC = chemical of potential concern
HQ = hazard quotient
HQmax = maximum hazard quotient
mg/kg dw = milligrams per kilogram (dry weight)
NC = not calculated; no benchmark available

TABLE 5-4. INITIAL HQ SCREEN FOR WILDLIFE FOR CHEMICALS DETECTED IN MINE WASTE AND SOIL

Detected Analyte	Maximum Detected Value[a]	Wildlife Soil-Based Benchmark (mg/kg dw)		HQmax	Recommendation
Antimony	0.30	0.27	A	1.1E+00	Retain as COPC
Barium	3,200	17	C	1.9E+02	
Chromium	881	26	A	3.4E+01	
Copper	87	28	A	3.1E+00	
Lead	48	11	A	4.4E+00	
Mercury	0.30	0.005	B	6.0E+01	
Nickel	135	130	A	1.0E+00	
Vanadium	114	7.8	A	1.5E+01	
Zinc	63	46	A	1.4E+00	
Aluminum	50,900	no benchmark[b]	A	NC	Exclude from further evaluation
Iron	51,900	no benchmark[c]	A	NC	
Arsenic	2.0	43	A	4.7E-02	
Fluoride	5.3	6.5		8.2E-01	
Thallium	0.90	1.4	D	6.4E-01	
Cobalt	63	120	A	5.3E-01	
Manganese	808	4,000	A	2.0E-01	
Indeno(1,2,3-cd)pyrene	0.038	1.1	A	3.5E-02	
Benzo(b)fluoranthene	0.030	1.1	A	2.7E-02	
Pyrene	0.029	1.1	A	2.6E-02	
Benzo(a)anthracene	0.021	1.1	A	1.9E-02	
Pentachlorophenol	0.039	2.1	A	1.9E-02	
Benzo(a)pyrene	0.019	1.1	A	1.7E-02	
Benzo(g,h,i)perylene	0.016	1.1	A	1.5E-02	
Benzo(k)fluoranthene	0.0096	1.1	A	8.7E-03	
Chrysene	0.0074	1.1	A	6.7E-03	
Toluene	0.066	52	C	1.3E-03	
C11 to C22 Aromatics	78	no benchmark		NC	Qualitative evaluation in Uncertainty Assessment (see Section 9.1.3)
C19 to C36 Aliphatics	154	no benchmark		NC	
C9 to C18 Aliphatics	53	no benchmark		NC	
C5 to C8 Aliphatics	1.4	no benchmark		NC	
C9 to C10 Aromatics	16	no benchmark		NC	
Total Extractable Hydrocarbons	474	no benchmark		NC	
Total Purgeable Hydrocarbons	17	no benchmark		NC	
Methyl acetate	1.7	no benchmark		NC	
Total Phosphorus	11,700	no benchmark		NC	
Carbon, Organic (as percent)	2.86			--	Soil quality parameters; not evaluated quantitatively as toxicants.
Moisture (as percent)	33			--	
pH, sat. paste (as s.u.)	8.5			--	

[a] Units are mg/kg dw, unless specified otherwise.

[b] Aluminum is not of potential concern unless soil pH is less than 5.5 (measured pH at site ranges from 6.3-8.5).

[c] Iron is an essential nutrient for wildlife, and is not expected to be a primary contaminant of concern at most sites.

COPC = chemical of potential concern
HQ = hazard quotient
HQmax = maximum hazard quotient
mg/kg dw = milligrams per kilogram (dry weight)
NC = not calculated; no benchmark available
TRV = toxicity reference value

Soil Benchmark Source:
A - Ecological Soil Screening Level (EcoSSL)
B - Back-calculated soil value based on dose-based TRVs from Engineering Field Activity West (1998)
C - Sample et al. (1996) dietary screening value
D - Back-calculated soil value based on dose-based TRVs from primary literature

TABLE 5-5. INITIAL HQ SCREEN FOR WILDLIFE RECEPTORS FOR CHEMICALS DETECTED IN SEDIMENT

Detected Analyte	Maximum Detected Value[a]	Sediment-based Wildlife Benchmark[b] (mg/kg dw)	HQmax	Recommendation
Arsenic	7.0	1.4	5.1E+00	Retain as COPC
Barium	2970	130	2.3E+01	
Chromium	712	73	9.7E+00	
Cobalt	75	42	1.8E+00	
Copper	175	3.2	5.4E+01	
Lead	100	30	3.3E+00	
Manganese	12,700	292	4.3E+01	
Mercury	0.10	0.06	1.6E+00	
Nickel	146	45	3.2E+00	
Selenium	1.2	0.8	1.5E+00	
Vanadium	98	2.1	4.6E+01	
Zinc	94	88	1.1E+00	
Aluminum	40,700	no benchmark[c]	NC	Exclude from further evaluation
Boron	11	159	6.9E-02	
Cadmium	1.0	1.4	7.0E-01	
Thallium	1.2	2.2	5.5E-01	
Fluoride	18	49	3.7E-01	
2-Methylnaphthalene	0.020	3.5	5.7E-03	
Benzo(a)anthracene	0.018	3.5	5.2E-03	
Benzo(a)pyrene	0.012	3.5	3.4E-03	
Benzo(b)fluoranthene	0.039	3.5	1.1E-02	
Benzo(k)fluoranthene	0.033	3.5	9.4E-03	
Dibenzo(a,h)anthracene	0.0056	3.5	1.6E-03	
Fluoranthene	0.010	3.5	2.9E-03	
Indeno(1,2,3-cd)pyrene	0.010	3.5	2.9E-03	
Naphthalene	2.8	168	1.7E-02	
Pyrene	0.012	3.5	3.4E-03	
Iron	62,900	no benchmark[d]	NC	Qualitative evaluation in Uncertainty Assessment (see Section 9.1.3)
C11 to C22 Aromatics	507	no benchmark	NC	
C19 to C36 Aliphatics	739	no benchmark	NC	
C9 to C18 Aliphatics	590	no benchmark	NC	
C9 to C10 Aromatics	63	no benchmark	NC	
C9 to C12 Aliphatics	58	no benchmark	NC	
Total Extractable Hydrocarbons	2360	no benchmark	NC	
Total Purgeable Hydrocarbons	276	no benchmark	NC	
Methyl acetate	1.4	no benchmark	NC	
Phosphorus, Total	8390	no benchmark	NC	
Carbon, Organic (as percent)	15.4		--	Sediment quality parameters; not evaluated quantitatively as toxicants.
Moisture (as percent)	84.6		--	
pH, sat. paste (as s.u.)	8.3		--	
Solids, Total (as percent)	92.2		--	

[a] Units are mg/kg dw, unless specified otherwise.

[b] Back-calculated from dose-based TRVs based on assumed aquatic prey and sediment ingestion rates and default aquatic invertebrate uptake equations (see Appendix E for details).

[c] Aluminum is expected to be a contaminant of potential concern only when pH is below 5.5; pH values at the site range from 6.1 to 8.3.

[d] Iron is an essential nutrient for wildlife, and is not expected to be a primary contaminant of concern at most sites.

COPC = chemical of potential concern
HQ = hazard quotient
HQmax = maximum hazard quotient
mg/kg dw = milligrams per kilogram (dry weight)
NC = not calculated; no benchmark available
TRV = toxicity reference value

TABLE 5-6. INITIAL HQ SCREEN FOR WILDLIFE FOR CHEMICALS DETECTED IN SURFACE WATER

Detected Analyte [a]	Maximum Detected Value (µg/L)	Water-Based Wildlife Benchmark [b] (µg/L)	HQmax	Recommendation
Aluminum	1,080	18	6.0E+01	Retain as COPC
Barium	700	23,100	3.0E-02	Exclude from further evaluation
Fluoride	1,100	33,500	3.3E-02	
Chromium	10	3,593	2.8E-03	
Copper	16	213	7.5E-02	
Lead	5.1	49	1.0E-01	
Manganese	210	377,000	5.6E-04	
Nitrogen, Nitrate as N	440	2,719,000	1.6E-04	
Iron	1,760	no benchmark[c]	NC	Qualitative evaluation in Uncertainty Assessment (see Section 9.1.3)
Gross Alpha	2.6	no benchmark	NC	
Gross Beta	9.0	no benchmark	NC	
Total Extractable Hydrocarbons	470	no benchmark	NC	
Nitrogen, Nitrate+Nitrite as N	440	no benchmark	NC	
Nitrogen, Nitrite as N	80	no benchmark	NC	
Calcium	107,000		--	Water quality parameters; not evaluated quantitatively as toxicants.
Magnesium	30,000		--	
Potassium	17,000		--	
Chloride	10,000		--	
Sodium	10,000		--	
Nitrogen, Kjeldahl, Total as N	3,100		--	
Phosphorus, Orthophosphate as P	456		--	
Sulfate	24,000		--	
Alkalinity, Total as $CaCO_3$	376,000		--	
Bicarbonate as HCO_3	459,000		--	
Carbonate as CO_3	17,000		--	
Hardness as $CaCO_3$	385,000		--	
Organic Carbon, Dissolved (DOC)	15,400		--	
Solids, Total Dissolved TDS @ 180 C	454,000		--	
Solids, Total Suspended TSS @ 105 C	36,000		--	

[a] Metal concentrations based on total recoverable fraction.

[b] Water-based wildlife benchmarks are from Sample *et al.* (1996).

[c] Iron is an essential nutrient for wildlife, and is not expected to be a primary contaminant of concern at most sites.

µg/L = micrograms per liter
COPC = chemical of potential concern
HQ = hazard quotient
HQmax = maximum hazard quotient
NC = not calculated; no benchmark available

TABLE 5-7. SUMMARY OF ALL COPCs IDENTIFIED IN THE INITIAL HQ SCREEN

Aquatic Receptors		Plants/Invertebrates	Wildlife		
Surface Water	**Sediment**	**Soil/Mine Waste**	**Soil/Mine Waste**	**Sediment**	**Surface Water**
Barium (diss.)	Aluminum	Barium	Antimony	Arsenic	Aluminum (tot.)
Manganese (diss.)	Cadmium	Chromium	Barium	Barium	
Fluoride	Chromium	Cobalt	Chromium	Chromium	
Nitrogen, Nitrite as N	Copper	Copper	Copper	Cobalt	
	Lead	Manganese	Lead	Copper	
	Manganese	Mercury	Mercury	Lead	
	Nickel	Nickel	Nickel	Manganese	
	Benzo(b)fluoranthene	Vanadium	Vanadium	Mercury	
	Benzo(k)fluoranthene		Zinc	Nickel	
	Naphthalene			Selenium	
				Vanadium	
				Zinc	

COPC = chemical of potential concern

diss. = dissolved fraction

HQ = hazard quotient

tot. = total recoverable fraction

TABLE 6-1. SUMMARY OF INITIAL HQ SCREEN AND REFINED HQ EVALUATION PARAMETERS

Panel A. Exposure of Aquatic Receptors

Parameter	Initial HQ Screen	Refined HQ Evaluation
Concentration (Media: Surface water, Sediment)	Maximum value	Distribution of values
TRVs for Surface water	Chronic values (a)	Acute & Chronic values (b)
TRVs for Sediment	TEC	TEC and PEC

(a) Hardness-dependant metals calculated using lowest measured hardness.
(b) Hardness-dependant metals calculated using sample-specific hardness.

Panel B. Exposure of Terrestrial Plants and Invertebrates

Parameter	Initial HQ Screen	Refined HQ Evaluation
Concentration (Media: Soil/Mine Waste)	Maximum value	Distribution of values
TRVs for Soil	EcoSSL, ORNL Screening Value, or Dutch Target	EcoSSL, ORNL Screening Value, or Dutch Target

Panel C. Exposure of Birds and Mammals

Parameter	Initial HQ Screen	Refined HQ Evaluation
Concentration (Media: Soil/Mine Waste)	Maximum value	Large HR: 95UCL
		Small HR: Distribution of values
Concentration (Media: Surface water, Sediment)	Maximum value	95UCL
Concentration (Media: Food items)	Food item-specific models (conservative methods)	Food item-specific models (best-estimate methods)
Intake Factors	High-end maximum intake (across guilds)	Mean intake (guild-specific)
TRVs	Concentration-based toxicity benchmarks derived from NOAEL TRVs	Dose-based NOAEL & LOAEL TRVs
Relative Bioavailability (RBA)	1.0	1.0
Area Use Factor (AUF)	1.0	1.0

95UCL = 95% upper confidence limit on the mean
EcoSSL = Ecological Soil Screening Level
HQ = hazard quotient
HR = home range
LOAEL = lowest observed adverse effect level
NOAEL = no observed adverse effect level
ORNL = Oak Rdge National Laboratory
PEC = probable effect concentration
TEC = threshold effect concentration
TRV = toxicity reference value

TABLE 6-2. SURFACE WATER ACUTE AND CHRONIC TOXICITY VALUES FOR AQUATIC RECEPTORS

Analyte	Chronic Toxicity Value (µg/L)	Source	Acute Toxicity Value (µg/L)	Source
Barium	4	a	110	a
Manganese	120	a	2,300	a
Fluoride	1,200	b,c	no benchmark	b
Nitrogen, Nitrite as N	60	b	no benchmark	b

Sources:

a -- Great Lakes Water Quality Initiative Tier II values (Suter and Tsao 2006)
b -- Canadian Council of Ministers of the Environment Water Quality Guidelines (CCME 2012)
c -- In the refined HQ evalution, a modified safety factor of 10 was applied (see Section 6.1.2 for details).

TABLE 6-3. STATISTICAL COMPARISON OF CONCENTRATIONS IN SITE SURFACE WATER TO REFERENCE FOR AQUATIC COPCs

COPC	Site Surface Water						Reference Surface Water**						Gehan test p value	Test Outcome+
	% NDs	Statistics for Detected Samples					% NDs	Statistics for Detected Samples						
		Mean	Median	Stdev	Minimum	Maximum		Mean	Median	Stdev	Minimum	Maximum		
Barium, dissolved	**0.00%**	**347**	**300**	**117**	**100**	**700**	**10.00%**	**156**	**200**	**53**	**100**	**200**	**1.67E-05**	**Reject H0, site > bkg**
Fluoride++	**0.00%**	**464**	**300**	**329**	**100**	**1100**	**25.00%**	**133**	**100**	**52**	**100**	**200**	**4.77E-04**	**Reject H0, site > bkg**
Manganese, dissolved	82.35%	70	70	38.4	30	140	100.00%	N/A	N/A	N/A	N/A	N/A	7.77E-02	Accept H0, site <= bkg
Nitrogen, Nitrite as N	91.67%	25	10	28	10	80	100.00%	N/A	N/A	N/A	N/A	N/A	1.68E-01	Accept H0, site <= bkg

Concentrations reported as micrograms per liter (ug/L).

** Includes Upper Rainy Creek, Bobtail Creek, and Noisy Creek stations; unless specified otherwise.

+ H0: Site Mean/Median ≤ Background Mean/Median (Form 1, alpha = 0.05)

++ Reference dataset only includes samples from Upper Rainy Creek (no off-site reference stations were sampled for this analyte).

bkg = background
COPC = chemical of potential concern
N/A = not applicable; all samples were non-detect
% NDs = percent of samples that are non-detect
Stdev = standard deviation

TABLE 6-4. SEDIMENT THRESHOLD AND PROBABLE EFFECT TOXICITY BENCHMARKS FOR AQUATIC INVERTEBRATES

Analyte	TEC-based Benchmark (mg/kg)	PEC-based Benchmark (mg/kg)	Benchmark Source
Aluminum	26,000	60,000	B
Cadmium	1.0	5.0	A
Chromium	43	111	A
Copper	32	149	A
Lead	36	128	A
Manganese	630	1,184	B
Nickel	23	49	A
Benzo(b)fluoranthene	0.027	2.3	B [1]
Benzo(k)fluoranthene	0.027	2.3	B [1]
Naphthalene	0.18	0.56	A

Benchmark Source:
A - MacDonald et al. (2000); consensus-based threshold effect concentration (TEC) and probable effect concentration (PEC).

B - Ingersoll et al. (1996); Threshold Effect Level (TEL) and Probable Effect Level (PEL) for total extraction of sediment (BT) samples from *Hyalella azteca* 28-day (HA28) tests.

Notes:
[1] PAH-specific benchmark identified as unreliable in Ingersoll et al. (1996). Utilizes the PEL identified for high molecular weight PAHs.

mg/kg = milligrams per kilogram

TABLE 6-5. STATISTICAL COMPARISON OF CONCENTRATIONS IN SITE SEDIMENT TO REFERENCE FOR AQUATIC COPCs

COPC	Site Sediment						Reference Sediment**						Gehan test p value	Test Outcome+
	% NDs	Statistics for Detected Samples					% NDs	Statistics for Detected Samples						
		Mean	Median	Stdev	Minimum	Maximum		Mean	Median	Stdev	Minimum	Maximum		
Aluminum	**0.90%**	**20468**	**19800**	**10101**	**3460**	**40700**	**0.00%**	**9803**	**10045**	**2184**	**6600**	**12900**	**3.06E-04**	**Reject H0, site > bkg**
Cadmium	96.40%	1	1	0	1	1	100.00%	N/A	N/A	N/A	N/A	N/A	2.53E-01	Accept H0, site <= bkg
Chromium	**0.90%**	**265.5**	**249.5**	**176.7**	**14.6**	**712**	**0.00%**	**14.73**	**10**	**10.42**	**5**	**32.8**	**2.48E-08**	**Reject H0, site > bkg**
Copper	**0.00%**	**53.07**	**47**	**34.95**	**6**	**175**	**0.00%**	**20.25**	**19.5**	**7.399**	**11**	**37**	**1.78E-05**	**Reject H0, site > bkg**
Lead	**2.70%**	**34.89**	**32**	**22.57**	**6**	**100**	**8.33%**	**9.364**	**9**	**1.69**	**7**	**12**	**1.37E-05**	**Reject H0, site > bkg**
Manganese	**0.00%**	**1299**	**725**	**2049**	**135**	**12700**	**0.00%**	**464.3**	**326**	**452.8**	**212**	**1810**	**3.36E-04**	**Reject H0, site > bkg**
Nickel	**0.00%**	**66.15**	**62**	**41.26**	**8**	**146**	**16.67%**	**9**	**8.5**	**2.981**	**5**	**14**	**2.82E-08**	**Reject H0, site > bkg**
Benzo(b)fluoranthene	96.61%	0.029	0.029	0.0141	0.019	0.039	100.00%	N/A	N/A	N/A	N/A	N/A	5.00E-01	Accept H0, site <= bkg
Benzo(k)fluoranthene	96.61%	0.0245	0.0245	0.012	0.016	0.033	100.00%	N/A	N/A	N/A	N/A	N/A	5.00E-01	Accept H0, site <= bkg
Naphthalene	98.06%	2.1	2.1	0.99	1.4	2.8	100.00%	N/A	N/A	N/A	N/A	N/A	3.46E-01	Accept H0, site <= bkg

Concentrations are reported as milligrams per kilogram (mg/kg).

** Includes Upper Rainy Creek, Bobtail Creek, and Noisy Creek stations

+ H0: Site Mean/Median ≤ Background Mean/Median (Form 1, alpha = 0.05)

bkg = background

COPC = chemical of potential concern

N/A = not applicable

% NDs = percent of samples that are non-detect

Stdev = standard deviation

TABLE 6-6. SOIL TOXICITY BENCHMARK VALUES FOR PLANTS AND TERRESTRIAL INVERTEBRATES

Analyte	Plant Benchmark (mg/kg)	Source	Invertebrate Benchmark (mg/kg)	Source
Barium	500	B	330	A
Chromium	no benchmark[1]		no benchmark[1]	
Cobalt	13	A	no benchmark	
Copper	70	A	80	A
Manganese	220	A	450	A
Mercury	0.3	B	0.1	B
Nickel	38	A	280	A
Vanadium	2.0	B	no benchmark	

[1] Available values are based on hexavalent chromium (not trivalent).

Benchmark Source:
A - Ecological Soil Screening Level (EcoSSL)
B - Oak Ridge National Laboratory Screening Value (Efroymson et al. 1997a,b)

mg/kg = milligrams per kilogram

TABLE 6-7. STATISTICAL COMPARISON OF CONCENTRATIONS IN SITE MINE WASTE MATERIAL TO REFERENCE FOR PLANT AND TERRESTRIAL INVERTEBRATE COPCs

COPC	Site Soil/Mine Waste (N=35)						Reference Soil** (N=12)						Gehan test p value	Test Outcome+
	% NDs	Statistics for Detected Samples					% NDs	Statistics for Detected Samples						
		Mean	Median	Stdev	Minimum	Maximum		Mean	Median	Stdev	Minimum	Maximum		
Barium	**0.00%**	**964.3**	**773**	**643.3**	**117**	**3200**	**0.00%**	**99.83**	**73**	**60.74**	**46**	**225**	**2.21E-07**	**Reject H0, site > bkg**
Chromium	**0.00%**	**231.5**	**191**	**164.9**	**10.3**	**881**	**0.00%**	**22.58**	**18**	**14.97**	**8**	**49**	**4.15E-07**	**Reject H0, site > bkg**
Cobalt	**0.00%**	**28.17**	**25**	**12.03**	**14**	**63**	**25.00%**	**9.667**	**6**	**7.28**	**6**	**26**	**4.00E-06**	**Reject H0, site > bkg**
Copper	2.86%	30.32	27	20.67	5	87	0.00%	19.42	15	12.89	9	48	8.98E-02	Accept H0, site <= bkg
Manganese	0.00%	356.3	331	137.3	157	808	0.00%	442.8	289	325.1	185	1250	3.21E-01	Accept H0, site <= bkg
Mercury	97.14%	0.3	0.3	N/A	0.3	0.3	100.00%	N/A	N/A	N/A	N/A	N/A	5.00E-01	Accept H0, site <= bkg
Nickel	**0.00%**	**59.71**	**53**	**28.14**	**11**	**135**	**0.00%**	**16.5**	**11.5**	**10.69**	**7**	**42**	**1.40E-06**	**Reject H0, site > bkg**
Vanadium	**0.00%**	**39.14**	**38**	**19.34**	**10**	**114**	**0.00%**	**26.33**	**10.5**	**38.89**	**6**	**119**	**4.94E-04**	**Reject H0, site > bkg**

Concentrations are reported as milligrams per kilogram (mg/kg).

**Soil from distal ends of forest transects near OU3

+ H0: Site Mean/Median ≤ Background Mean/Median (Form 1, alpha = 0.05)

COPC = chemical of potential concern
N/A = not applicable
% NDs = percent of samples that are non-detect
Stdev = standard deviation

TABLE 6-8. EXPOSURE PARAMETERS FOR SURROGATE WILDLIFE SPECIES

Terrestrial

Wildlife Group	Feeding Guild	Surrogate Receptor	Exposure Parameters				
			Food Intake Rate (kg dw/kg BW/d)[a]	Dietary Composition	P_{soil}[b]	Soil Intake Rate (kg dw/kg BW/d)[c]	Water Intake Rate (L/kg BW/d)[d]
Avian	Herbivore	Dove	0.137	100% plants	0.068	0.009	0.138
	Terrestrial insectivore	Woodcock	0.142	100% terr. invertebrates	0.075	0.011	0.101
	Carnivore	Hawk	0.026	100% small mammals	0.026	0.0007	0.057
Mammalian	Herbivore	Vole	0.076	100% plants	0.013	0.0010	0.136
	Terrestrial insectivore	Shrew	0.167	100% terr. invertebrates	0.011	0.0018	0.220
	Carnivore	Weasel	0.071	100% small mammals	0.016	0.0011	0.099

[a] Mean value calculated from species-specific intake rates in EcoSSL Attachment 4-1, Table 1.

[b] Fraction of diet that is soil; based on the mean value reported in EcoSSL Attachment 4-1, Table 3.

[c] Calculated as P_{soil} * Food Intake Rate

[d] As provided by Sample et al. (1996), Table B.1

Aquatic/Semi-Aquatic

Wildlife Group	Feeding Guild	Surrogate Receptor	Exposure Parameters				
			Food Intake Rate (kg dw/kg BW/d)	Dietary Composition	$P_{sediment}$	Sediment Intake Rate (kg dw/kg BW/d)[e]	Water Intake Rate (L/kg BW/d)
Avian	Aquatic insectivore	Dipper	0.157	100% aq. invertebrates	0.02	0.0031	0.151
	Piscivore	Kingfisher	0.125	100% fish	0.03	0.0038	0.111
Mammalian	Aquatic insectivore[f]	Bat	0.176	100% aq. invertebrates	0	0	0.148
	Piscivore	Mink	0.034	100% fish	0.01	0.00034	0.101

[e] emerging insects

[f] Calculated as $P_{sediment}$ * Food Intake Rate

Source: see Appendix E (Tables E-7a through E-7d)

kg dw/kg BW/d = kilograms (on a dry weight basis) per kilograms of body weight per day
L/kg BW/d = liters per kilograms of body weight per day

TABLE 6-9
UPTAKE EQUATIONS USED TO PREDICT DIETARY TISSUE CONCENTRATIONS

Panel A: Soil into Terrestrial Food Items

COPC	Soil to Plants			Soil to Terrestrial Invertebrates			Soil to Small Mammals [b]		
	Equation	Source	Basis	Equation	Source	Basis	Equation	Source	Basis
Antimony	ln(Cp) = 0.938 * ln(Cs) - 3.233	1	Figure 1	Ci = 1 * Cs	1	Table 4a	Cm = 0.001 * 50 * (Cs * 1)	1	Table 4a
Barium	Cp = 0.156 * Cs	2	Table D-1; median UF	Ci = 0.091 * Cs	3	Table C-1; median UF	Cm = 0.0566 * Cs	4	Table 7; general, median UF
Chromium	Cp = 0.041 * Cs	2	Table D-1; median UF	*none* [a]	3	Appendix B	ln(Cm) = 0.7338 * ln(Cs) - 1.4599	4	Table 8; general
Copper	ln(Cp) = 0.394 * ln(Cs) + 0.669	2	Table 7	ln(Ci) = 0.264 * ln(Cs) + 1.675	3	Table 12	ln(Cm) = 0.1444 * ln(Cs) + 2.0420	4	Table 8; general
Lead	ln(Cp) = 0.561 * ln(Cs) - 1.328	2	Table 7	ln(Ci) = 0.807 * ln(Cs) - 0.218	3	Table 12	ln(Cm) = 0.4422 * ln(Cs) + 0.0761	4	Table 8; general
Mercury	ln(Cp) = 0.544 * ln(Cs) - 0.996	2	Table 7	ln(Ci) = 0.3369 * ln(Cs) + 0.0781	3	Table 4	Cm = 0.0543 * Cs	4	Table 7; general, median UF
Nickel	ln(Cp) = 0.748 * ln(Cs) - 2.224	2	Table 7	*none* [a]	3	Appendix B	ln(Cm) = 0.4658 * ln(Cs) - 0.2462	4	Table 8; general
Vanadium	Cp = 0.00485 * Cs	2	Table D-1; median UF	Ci = 0.042 * Cs	3	Table C-1; median UF	Cm = 0.0123 * Cs	4	Table C-1; general, median UF
Zinc	ln(Cp) = 0.555 * ln(Cs) + 1.575	2	Table 7	ln(Ci) = 0.328 * ln(Cs) + 4.449	3	Table 12	ln(Cm) = 0.0738 * ln(Cs) + 4.4713	4	Table 8; general

Cs = Soil concentration (mg/kg)
Ci = Terrestrial invertebrate (earthworm) concentration (mg/kg dw)
Cp = Plant concentration (mg/kg dw)
Cm = Small mammal concentration (mg/kg dw)
ln = natural logarithm
UF = uptake factor
COPC = chemical of potential concern

Panel B: Sediment into Aquatic Invertebrates

COPC	Sediment to Aquatic Invertebrates		
	Equation	Source	Basis [c]
Arsenic	Ci = 0.373 * Cs	5	Table 2; median
Barium	*no uptake data available; assumed Ci = Cs*		
Chromium	Ci = 0.083 * Cs	5	Table 2; median
Cobalt	*no uptake data available; assumed Ci = Cs*		
Copper	Ci = 0.661 * Cs	5	Table 2; median
Lead	Ci = 0.080 * Cs	5	Table 2; median
Manganese	*no uptake data available; assumed Ci = Cs*		
Mercury	Cib = 2.837 * Cs	5	Table 2; median
Nickel	Ci = 0.134 * Cs	5	Table 2; median
Selenium	*no uptake data available; assumed Ci = Cs*		
Vanadium	*no uptake data available; assumed Ci = Cs*		
Zinc	Ci = 0.840 * Cs	5	Table 2; median

Cs = Sediment concentration (mg/kg)
Ci = Aquatic invertebrate concentration (mg/kg dw)
ln = natural logarithm
UF = uptake factor
COPC = chemical of potential concern

Panel C: Surface Water into Fish

COPC	Surface Water to Fish		
	Equation	Source	Basis
Aluminum	Cf = 231 * Cw * 0.25	6	Table 3; BCF [d]

Cf = fish tissue concentration (mg/kg dw)
Cw = surface water concentration (mg/L)
BCF = bioconcentration factor

Uptake Equation Source Documents:

1 -- EcoSSL, Attachment 4-1 *(http://www.epa.gov/ecotox/ecossl/pdf/ecossl_attachment_4-1.pdf)*
2 -- BJC/OR-133 *(http://www.esd.ornl.gov/programs/ecorisk/documents/bjcor-133.pdf)*
3 -- ES/ER/TM-220 *(http://www.esd.ornl.gov/programs/ecorisk/documents/tm220.pdf)*
4 -- ES/ER/TM-219 *(http://www.esd.ornl.gov/programs/ecorisk/documents/tm219.pdf)*
5 -- BJC/OR-112 *(http://www.esd.ornl.gov/programs/ecorisk/documents/bjcor-112a1.pdf)*
6 -- Sample *et al.* 1996 *(http://www.esd.ornl.gov/programs/ecorisk/documents/tm86r3.pdf)*

[a] No uptake model accurately predicted tissue concentration; risk estimates are derived based on the average of the measured tissue concentrations reported in the uptake source report. For chromium this value is 20 mg/kg dw, and for nickel this value is 50 mg/kg dw.

[b] Uptake source report provides four types of uptake models - insectivore, herbivore, omnivore, and general (across trophic groups). Recommended models for general estimates (per Table 9) are utilizec

[c] All uptake factors are based on data for depurated organisms.

[d] Conversion from wet weight to dry weight assumes 25% solids (75% moisture content) in fish tissue

TABLE 6-10 DOSE-BASED TRVs FOR WILDLIFE RECEPTORS

COPC	NOAEL TRV (mg/kg BW/day)				LOAEL TRV (mg/kg BW/day)			
	Mammal		Bird		Mammal		Bird	
Aluminum	1.93	3	109.7	3	19.3	3	175	5
Antimony	0.059	1	no TRV	1	2.76	4	no TRV	4
Arsenic	1.04	1	2.24	1	4.55	4	4.51	4
Barium	51.8	1	20.8	3	82.7	4	41.7	3
Chromium	2.4	1[a]	2.66	1[a]	58.2	4[a]	15.6	4[a]
Cobalt	7.33	1	7.61	1	18.9	4	20.2	4
Copper	5.6	1	4.05	1	82.7	4	34.9	4
Lead	4.7	1	1.63	1	186	4	44.6	4
Manganese	51.5	1	179	1	146	4	377	4
Mercury	0.25	2[b]	0.039	2	4	2[b]	0.18	2
Nickel	1.7	1	6.71	1	14.8	4	18.6	4
Selenium	0.143	1	0.29	1	0.66	4	0.82	4
Vanadium	4.16	1	0.34	1	9.44	4	1.70	4
Zinc	75.4	1	66.1	1	298	4	171	4

Dose-Based TRV Source:

1 -- EcoSSL

2 -- Engineering Field Activity West (1998)

3 -- Sample *et al.* (1996)

4 -- TechLaw (2008)

5 -- Sparling (1990)

[a] TRV is based on trivalent chromium

[b] TRV is based on rodent data

COPC = chemical of potential concern

EcoSSL = Ecological Soil Screening Level

LOAEL = lowest observed adverse effect level

mg/kg BW/day = milligram per kilogram body weight per day

NOAEL = no observed adverse effect level

TRV = toxicity reference value

TABLE 6-11. RISKS TO LARGE HOME RANGE WILDLIFE RECEPTORS FROM COPCS IN TERRESTRIAL DIETARY ITEMS AND MINE WASTE MATERIALS

Exposure Area	Receptor Type	Total Hazard Quotient															
		Antimony		Barium		Chromium		Copper		Lead		Mercury		Nickel		Vanadium		Zinc	
		NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL
Mine Site	Avian Herbivore	n/c	n/c	**2E+00**	9E-01	**2E+00**	3E-01	4E-01	4E-02	3E-01	9E-03	7E-01	2E-01	1E-01	5E-02	1E+00	3E-01	7E-02	3E-02
	Avian Insectivore	n/c	n/c	1E+00	7E-01	**2E+00**	4E-01	6E-01	7E-02	1E+00	4E-02	**3E+00**	6E-01	1E+00	4E-01	**2E+00**	4E-01	6E-01	2E-01
	Avian Carnivore	n/c	n/c	1E-01	6E-02	3E-01	4E-02	9E-02	1E-02	8E-02	3E-03	2E-02	4E-03	3E-02	1E-02	1E-01	3E-02	4E-02	2E-02
	Mammalian Herbivore	2E-02	5E-04	3E-01	2E-01	6E-01	3E-02	1E-01	8E-03	3E-02	7E-04	6E-02	4E-03	2E-01	2E-02	1E-02	6E-03	3E-02	8E-03
	Mammalian Insectivore	9E-01	2E-02	4E-01	3E-01	**2E+00**	7E-02	4E-01	3E-02	4E-01	9E-03	5E-01	3E-02	**5E+00**	6E-01	1E-01	4E-02	6E-01	1E-01
	Mammalian Carnivore	2E-02	5E-04	1E-01	8E-02	7E-01	3E-02	2E-01	1E-02	7E-02	2E-03	6E-03	4E-04	3E-01	3E-02	2E-02	1E-02	1E-01	3E-02
Reference	Avian Herbivore	n/c	n/c	2E-01	1E-01	2E-01	3E-02	4E-01	4E-02	2E-01	9E-03	**2E+00**	3E-01	5E-02	2E-02	**2E+00**	4E-01	1E-01	4E-02
	Avian Insectivore	n/c	n/c	2E-01	8E-02	1E+00	2E-01	6E-01	7E-02	9E-01	3E-02	**4E+00**	9E-01	1E+00	4E-01	**4E+00**	7E-01	7E-01	3E-01
	Avian Carnivore	n/c	n/c	1E-02	7E-03	4E-02	6E-03	9E-02	1E-02	7E-02	3E-03	5E-02	1E-02	2E-02	6E-03	2E-01	4E-02	5E-02	2E-02
	Mammalian Herbivore	3E-01	7E-03	4E-02	2E-02	5E-02	2E-03	1E-01	8E-03	3E-02	7E-04	1E-01	7E-03	6E-02	7E-03	2E-02	1E-02	5E-02	1E-02
	Mammalian Insectivore	**1E+01**	3E-01	5E-02	3E-02	1E+00	6E-02	4E-01	3E-02	3E-01	9E-03	7E-01	5E-02	**5E+00**	6E-01	2E-01	7E-02	7E-01	2E-01
	Mammalian Carnivore	4E-01	8E-03	1E-02	9E-03	1E-01	4E-03	2E-01	1E-02	7E-02	2E-03	2E-02	1E-03	2E-01	2E-02	4E-02	2E-02	1E-01	3E-02

n/c = not calculated, no TRV available.

COPC = chemical of potential concern
LOAEL = low observed adverse affect level
NOAEL = no observed adverse affect level

TABLE 6-12. RISKS TO WILDLIFE RECEPTORS FROM ALUMINUM IN SURFACE WATER AND FISH

Receptor Type		Total Hazard Quotient									
		Fleetwood Creek/Ponds		Tailings Impoundment/ Mill Pond		Carney Creek/Ponds		Lower Rainy Creek		Upper Rainy Creek/Off-Site Reference	
		NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL
Terrestrial	Avian Herbivore	1E-03	8E-04	1E-04	8E-05	2E-04	1E-04	2E-04	1E-04	3E-04	2E-04
	Avian Insectivore	1E-03	6E-04	9E-05	6E-05	2E-04	1E-04	1E-04	8E-05	2E-04	2E-04
	Avian Carnivore	6E-04	4E-04	5E-05	3E-05	1E-04	6E-05	7E-05	4E-05	1E-04	8E-05
	Mammalian Herbivore	8E-02	8E-03	7E-03	7E-04	1E-02	1E-03	1E-02	1E-03	2E-02	2E-03
	Mammalian Insectivore	1E-01	1E-02	1E-02	1E-03	2E-02	2E-03	2E-02	2E-03	3E-02	3E-03
	Mammalian Carnivore	6E-02	6E-03	5E-03	5E-04	1E-02	1E-03	7E-03	7E-04	1E-02	1E-03
Aquatic	Avian Piscivore	**4E+00**	5E-02	6E-03	4E-03	1E-02	8E-03	9E-03	6E-03	2E-02	1E-02
	Mammalian Piscivore	1E+00	1E-01	1E-01	1E-02	2E-01	2E-02	1E-01	1E-02	3E-01	3E-02
	Avian Insectivore	1E-03	9E-04	1E-04	8E-05	3E-04	2E-04	2E-04	1E-04	4E-04	2E-04
	Mammalian Insectivore	8E-02	8E-03	7E-03	7E-04	1E-02	1E-03	1E-02	1E-03	2E-02	2E-03

n/c = not calculated; no TRV

LOAEL = lowest observed adverse effect level
NOAEL = no observed adverse effect level

TABLE 6-13. RISKS TO WILDLIFE RECEPTORS FROM COPCS IN SEDIMENT AND AQUATIC INVERTEBRATES

Exposure Area	Receptor Type	Total Hazard Quotient																							
		Arsenic		Barium*		Chromium		Cobalt*		Copper		Lead		Manganese*		Mercury		Nickel		Selenium*		Vanadium*		Zinc	
		NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL
Fleetwood Creek/Ponds	Avian Insectivore	6E-02	3E-02	**8E+00**	**4E+00**	1E+00	2E-01	6E-01	2E-01	1E+00	2E-01	3E-01	1E-02	4E-01	2E-01	1E+00	2E-01	2E-01	7E-02	4E-01	1E-01	**2E+01**	**5E+00**	9E-02	3E-02
	Mammalian Insectivore	1E-01	3E-02	**3E+00**	**2E+00**	1E+00	5E-02	7E-01	3E-01	1E+00	7E-02	9E-02	2E-03	**2E+00**	5E-01	2E-01	1E-02	8E-01	9E-02	9E-01	2E-01	**2E+00**	1E+00	8E-02	2E-02
Tailings Impoundment/ Mill Pond	Avian Insectivore	8E-02	4E-02	**1E+01**	**7E+00**	**3E+00**	4E-01	1E+00	4E-01	**2E+00**	2E-01	5E-01	2E-02	**3E+00**	**2E+00**	1E+00	2E-01	4E-01	1E-01	1E+00	5E-01	**3E+01**	**6E+00**	1E-01	4E-02
	Mammalian Insectivore	2E-01	4E-02	**6E+00**	**4E+00**	**3E+00**	1E-01	1E+00	5E-01	1E+00	9E-02	1E-01	4E-03	**1E+01**	**4E+00**	2E-01	1E-02	**2E+00**	2E-01	**3E+00**	7E-01	**3E+00**	1E+00	1E-01	3E-02
Carney Creek/Ponds	Avian Insectivore	7E-02	4E-02	**8E+00**	**4E+00**	1E+00	2E-01	8E-01	3E-01	**3E+00**	3E-01	5E-01	2E-02	1E+00	7E-01	1E+00	2E-01	3E-01	1E-01	1E+00	5E-01	**3E+01**	**6E+00**	1E-01	4E-02
	Mammalian Insectivore	2E-01	4E-02	**4E+00**	**2E+00**	1E+00	6E-02	9E-01	4E-01	**2E+00**	2E-01	2E-01	4E-03	**5E+00**	**2E+00**	2E-01	1E-02	1E+00	1E-01	**3E+00**	7E-01	**2E+00**	1E+00	1E-01	3E-02
Lower Rainy Creek	Avian Insectivore	3E-02	1E-02	**5E+00**	**3E+00**	1E+00	2E-01	4E-01	1E-01	7E-01	8E-02	2E-01	8E-03	7E-01	3E-01	1E+00	2E-01	1E-01	5E-02	1E+00	5E-01	**2E+01**	**5E+00**	7E-02	3E-02
	Mammalian Insectivore	6E-02	1E-02	**2E+00**	1E+00	1E+00	4E-02	4E-01	2E-01	6E-01	4E-02	7E-02	2E-03	**3E+00**	9E-01	2E-01	1E-02	5E-01	6E-02	**3E+00**	7E-01	**2E+00**	9E-01	7E-02	2E-02
Upper Rainy Creek/Off-Site Reference	Avian Insectivore	1E-01	6E-02	**2E+00**	1E+00	1E-01	2E-02	1E-01	5E-02	6E-01	7E-02	1E-01	4E-03	9E-01	4E-01	1E+00	2E-01	4E-02	1E-02	8E-01	3E-01	**1E+01**	**2E+00**	7E-02	3E-02
	Mammalian Insectivore	3E-01	6E-02	1E+00	7E-01	1E-01	5E-03	2E-01	6E-02	5E-01	3E-02	3E-02	8E-04	**4E+00**	1E+00	2E-01	1E-02	1E-01	2E-02	**2E+00**	4E-01	9E-01	4E-01	6E-02	2E-02

* No uptake information available to predict aquatic invertebrate tissue concentrations; sediment to invertebrate accumulation factor assumed to be 1.

COPC = chemical of potential concern
LOAEL = low observed adverse effect level
NOAEL = no observed adverse effect level
TRV = toxicity reference value

TABLE 6-14. STATISTICAL COMPARISON OF CONCENTRATIONS IN SITE MINE WASTE MATERIAL TO REFERENCE FOR WILDLIFE COPCs

COPC	Site Soil/Mine Waste (N=35)						Reference Soil** (N=12)						Gehan test p value	Test Outcome+
	% NDs	Statistics for Detected Samples					% NDs	Statistics for Detected Samples						
		Mean	Median	Stdev	Minimum	Maximum		Mean	Median	Stdev	Minimum	Maximum		
Antimony	97.14%	0.3	0.3	N/A	0.3	0.3	100.00%	N/A	N/A	N/A	N/A	N/A	5.00E-01	Accept H0, site <= bkg
Barium	**0.00%**	**964.3**	**773**	**643.3**	**117**	**3200**	**0.00%**	**99.83**	**73**	**60.74**	**46**	**225**	**2.21E-07**	**Reject H0, site > bkg**
Chromium	**0.00%**	**231.5**	**191**	**164.9**	**10.3**	**881**	**0.00%**	**22.58**	**18**	**14.97**	**8**	**49**	**4.15E-07**	**Reject H0, site > bkg**
Copper	2.86%	30.32	27	20.67	5	87	0.00%	19.42	15	12.89	9	48	8.98E-02	Accept H0, site <= bkg
Lead	5.71%	19.45	15	11.85	8	48	0.00%	17	18	6.967	8	27	5.58E-01	Accept H0, site <= bkg
Mercury	97.14%	0.3	0.3	N/A	0.3	0.3	100.00%	N/A	N/A	N/A	N/A	N/A	5.00E-01	Accept H0, site <= bkg
Nickel	**0.00%**	**59.71**	**53**	**28.14**	**11**	**135**	**0.00%**	**16.5**	**11.5**	**10.69**	**7**	**42**	**1.40E-06**	**Reject H0, site > bkg**
Vanadium	**0.00%**	**39.14**	**38**	**19.34**	**10**	**114**	**0.00%**	**26.33**	**10.5**	**38.89**	**6**	**119**	**4.94E-04**	**Reject H0, site > bkg**
Zinc	0.00%	25.6	25	11.72	10	63	0.00%	56.92	61	10.66	35	71	1.00E+00	Accept H0, site <= bkg

Concentrations are reported as milligrams per kilogram (mg/kg).

**Soil from distal ends of forest transects near OU3

+ H0: Site Mean/Median ≤ Background Mean/Median (Form 1, alpha = 0.05)

COPC = chemical of potential concern
N/A = not applicable
ND = non-detect
Stdev = standard deviation

TABLE 6-15. STATISTICAL COMPARISON OF CONCENTRATIONS IN SITE SURFACE WATER TO REFERENCE FOR WILDLIFE COPCs

COPC	Site Surface Water						Reference Surface Water**						Gehan test p value	Test Outcome+
	% NDs	Statistics for Detected Samples					% NDs	Statistics for Detected Samples						
		Mean	Median	Stdev	Minimum	Maximum		Mean	Median	Stdev	Minimum	Maximum		
Aluminum, total	73.61%	262	190	245	90	1080	90.00%	260	260	N/A	260	260	1.53E-01	Accept H0, site <= bkg

Concentrations reported as micrograms per liter (ug/L).

** Includes Upper Rainy Creek, Bobtail Creek, and Noisy Creek stations

+ H0: Site Mean/Median ≤ Background Mean/Median (Form 1, alpha = 0.05)

bkg = background
COPC = chemical of potential concern
N/A = not applicable; only one sample was detect
% NDs = percent of samples that are non-detect
Stdev = standard deviation

TABLE 6-16. STATISTICAL COMPARISON OF CONCENTRATIONS IN SITE SEDIMENT TO REFERENCE FOR WILDLIFE COPCs

COPC	Site Sediment						Reference Sediment**						Gehan test p value	Test Outcome+
	% NDs	Statistics for Detected Samples					% NDs	Statistics for Detected Samples						
		Mean	Median	Stdev	Minimum	Maximum		Mean	Median	Stdev	Minimum	Maximum		
Arsenic	68.47%	3.171	3	1.124	2	7	8.33%	3.273	3	1.009	2	5	1.00E+00	Accept H0, site <= bkg
Barium	**0.90%**	**1197**	**1090**	**711.3**	**166**	**2970**	**0.00%**	**257.5**	**253.5**	**93.44**	**53**	**414**	**2.55E-07**	**Reject H0, site > bkg**
Chromium	**0.90%**	**265.5**	**249.5**	**176.7**	**14.6**	**712**	**0.00%**	**14.73**	**10**	**10.42**	**5**	**32.8**	**2.48E-08**	**Reject H0, site > bkg**
Cobalt	**0.90%**	**32.7**	**30**	**19.38**	**5**	**75**	**58.33%**	**6.8**	**6**	**1.643**	**5**	**9**	**2.75E-08**	**Reject H0, site > bkg**
Copper	**0.00%**	**53.07**	**47**	**34.95**	**6**	**175**	**0.00%**	**20.25**	**19.5**	**7.399**	**11**	**37**	**1.78E-05**	**Reject H0, site > bkg**
Lead	**2.70%**	**34.89**	**32**	**22.57**	**6**	**100**	**8.33%**	**9.364**	**9**	**1.69**	**7**	**12**	**1.37E-05**	**Reject H0, site > bkg**
Manganese	**0.00%**	**1299**	**725**	**2049**	**135**	**12700**	**0.00%**	**464.3**	**326**	**452.8**	**212**	**1810**	**3.36E-04**	**Reject H0, site > bkg**
Mercury	99.03%	0.1	0.1	N/A	0.1	0.1	90.00%	0.1	0.1	N/A	0.1	0.1	9.85E-01	Accept H0, site <= bkg
Nickel	**0.00%**	**66.15**	**62**	**41.26**	**8**	**146**	**16.67%**	**9**	**8.5**	**2.981**	**5**	**14**	**2.82E-08**	**Reject H0, site > bkg**
Selenium	99.05%	0.7	0.7	N/A	0.7	0.7	83.33%	0.85	0.85	0.495	0.5	1.2	1.00E+00	Accept H0, site <= bkg
Vanadium	**0.90%**	**53.87**	**54**	**18.26**	**16**	**98**	**0.00%**	**14.58**	**12.5**	**9.51**	**5**	**39**	**5.70E-08**	**Reject H0, site > bkg**
Zinc	**0.90%**	**43.48**	**43**	**19.18**	**9**	**94**	**0.00%**	**28.42**	**27**	**7.728**	**15**	**42**	**7.53E-03**	**Reject H0, site > bkg**

Concentrations are reported as milligrams per kilogram (mg/kg).

** Includes Upper Rainy Creek, Bobtail Creek, and Noisy Creek stations

+ H0: Site Mean/Median ≤ Background Mean/Median (Form 1, alpha = 0.05)

bkg = background
COPC = chemical of potential concern
N/A = not applicable
% NDs = percent of samples that are non-detect
Stdev = standard deviation

TABLE 7-1 FISH SAMPLING SUMMARY AND MLE POPULATION ESTIMATES

Year	Station	Number of Fish											Sampling Reach Attributes			MLE Population Estimate (#/acre)	
		Minnow Trap Fish	Electroshocking Fish (> 65 mm)					Electroshocking Fish (≤ 65 mm)									
			1st Pass	2nd Pass	3rd Pass	Total	MLE Population Estimate	1st Pass	2nd Pass	3rd Pass	Total	MLE Population Estimate	Length (m)	Average Width (m)	Area (acres)	> 65 mm	≤ 65 mm
2008	BTT-R1	NC	14	8	0	22	22	4	1	0	5	5	50	1.5	0.019	1,187	270
	NSY-R1		47	13	9	69	72	10	13	3	26	39 *	70	1.5	0.026	2,775	1,503
	URC-1A		13	4	0	17	17	8	13	5	26	39 *	33	1.2	0.010	1,737	3,986
	URC-2		8	9	NC	17	26 *	12	11	NC	23	56	50	1.1	0.014	1,913	4,120
	TP-TOE2		13	2	NC	15	15	0	0	NC	0	0	72	1.4	0.025	602	0
	LRC-1		4	1	NC	5	5	0	0	NC	0	0	60	1.5	0.022	225	0
	LRC-2		10	1	NC	11	11	0	0	NC	0	0	45	1.4	0.016	707	0
	LRC-3		6	3	NC	9	9	0	0	NC	0	0	42	1.7	0.018	510	0
	LRC-5		6	2	NC	8	8	0	0	NC	0	0	60	1.8	0.027	300	0
2009	BTT-R1	1	31	13	4	48	50	7	1	2	10	10	60	1.5	0.022	2,248	450
	NSY-R1	2	42	7	5	54	54	8	9	2	19	29 *	70	1.5	0.026	2,081	1,118
	URC-1A	10	10	20	10	40	45 *	6	14	9	29	44 *	33	1.2	0.010	4,599	4,497
	URC-2	3	25	12	8	45	52	27	12	7	46	51	50	1.1	0.014	3,826	3,753
	TP-TOE2	2	14	6	2	22	22	9	2	0	11	11	72	1.4	0.025	883	442
	LRC-1	5	11	2	NC	13	13	0	0	NC	0	0	60	1.5	0.022	585	0
	LRC-2	0	10	6	2	18	19	0	0	0	0	0	45	1.4	0.016	1,220	0
	LRC-3	0	9	1	NC	10	10	0	0	NC	0	0	42	1.7	0.018	567	0
	LRC-5	1	11	4	NC	15	15	0	0	NC	0	0	60	1.8	0.027	562	0

* = 2nd pass > 1st pass; population estimate is based on 1.5 * the total catch rather than MLE.

> = greater than

≤ = less than or equal to

m = meter

MLE = maximum likelihood estimate

mm = millimeter

NC = not collected

TABLE 7-2 HABITAT METRICS FOR RAINBOW AND CUTTHROAT TROUT

Habitat Metric	Optimal Range				Measured Values								
	Rainbow Trout		Cutthroat Trout		Off-Site Reference		Upper Rainy Creek		Lower Rainy Creek				
	Range	Source	Range	Source	BTT-R1	NSY-R1	URC-1A	URC-2	TP-TOE2	LRC-1	LRC-2	LRC-3	LRC-5
Maximum July/August Water Temperature (^{0}C)	7 - 18	2	7 - 16	3	22	14	10	11	11	20	20	18	18
% Gravel (mm)	15-100	2	15 - 80	5	55	67	88	78	31	52	45	57	37
% Fines (< 2 mm)	5 - 20	2	5 - 15	3	7	3	3	8	26	11	14	36	14
Large Woody Debris (%)	≥ 25	2	14 to ≥ 22	3	3	11	17	62	2	1	2	3	3
Number of Deep Pools (> 30 cm)	30 - 100	1,2	30 - 100	1,2	14	19	11	20	16	10	8	12	14
% Pools (late growing season)	35 - 65	4	35 - 65	3	11	66	63	32	36	34	29	44	18

Sources
1 - Harig and Fausch, 2002
2 - Adams et al., 2008
3 - Hickman and Raleigh, 1982 (Habitat Suitability Index Model for Cutthroat Trout)
4 - Raleigh, 1984 (Habitat Suitability Index Model for Rainbow Trout)
5- Varley and Gresswell, 1988

Harig and Fausch 2002
1. Watersheds >14.7 km^2 have a >50% probability of supporting high numbers of cutthroat.
2. Critical Success Factors:
   a. Summer water temperature
   b. Pool width
   c. Deep pools

^{0}C = degrees Celsius
% = percent
cm = centimeters
cm/s = centimeter per second
mg/L = milligrams per liter
mm = millimeters
NA = data not available

TABLE 7-3. AQUATIC INVERTEBRATE COMMUNITY METRIC AND BIOLOGICAL CONDITION SCORES FOR LOCATIONS AT OU3 - RBP 2008

	Off-Site Reference		Upper Rainy Creek		Lower Rainy Creek				
Panel A: Calculated Metrics	**BTT-R1**	**NSY-R1**	**URC-1A**	**URC-2**	**TPTOE2**	**LRC-1**	**LRC-2**	**LRC-3**	**LRC-5**
1) Taxa Richness (Number of Taxa)	30	31	29	28	26	23	19	19	15
2) Total Density	2375	1065	1256	707	538	5610	2618	304	5221
3) EPT Index (number of taxa at station)	13	26	21	21	9	7	8	12	10
4) Shannon -Weaver Diversity	3	3	4	3	3	3	3	3	2
5) % Ephemeroptera	22	64	43	34	31	4	3	20	30
6) % Tolerant organisms	17	3	3	4	12	35	21	11	7
7) % Contribution Dominant Taxon	27	60	25	25	31	23	46	50	49
8) % Scrapers	31	61	27	26	0	41	59	12	3
9) % Clingers	64	74	58	61	35	90	89	24	59

	BTT-R1		NSY-R1		URC-1A		URC-2		TPTOE2		LRC-1		LRC-2		LRC-3		LRC-5	
Panel B: Biological Condition Score (BCS)*	**%**	**Score**	**%**	**Score**	**%**	**Score**	**%**	**Score**	**%**	**Score**	**%**	**Score**	**%**	**Score**	**%**	**Score**	**%**	**Score**
1. Taxa Richness (site / reference)	100%	6	100%	6	94%	6	90%	6	87%	6	77%	4	63%	4	63%	4	50%	2
2. Total Density (site / reference)	100%	6	100%	6	118%	6	66%	4	23%	0	236%	6	110%	6	13%	0	220%	6
3. EPT Index (site / reference)	100%	6	100%	6	81%	4	81%	4	69%	0	54%	0	62%	0	92%	6	77%	2
4. Shannon –Weaver Diversity (site / reference)	100%	6	100%	6	135%	6	130%	6	85%	4	90%	6	80%	4	74%	4	60%	2
5. % Ephemeroptera (site / reference)	100%	6	100%	6	67%	6	53%	6	142%	6	18%	0	14%	0	91%	6	136%	6
6. % tolerant organisms (reference / site)	100%	6	100%	6	94%	6	90%	6	144%	6	48%	2	79%	4	158%	6	250%	6
7. % Contribution of Dominant Taxon	27%	4	60%	2	25%	4	25%	4	31%	2	23%	4	46%	2	50%	2	49%	2
8. % scrapers (site / reference)	100%	6	100%	6	44%	4	42%	4	0%	0	132%	6	193%	6	40%	4	11%	0
9. % clingers (site / reference)	100%	6	100%	6	78%	6	82%	6	55%	6	141%	6	139%	6	38%	4	92%	6
Biological Condition Score		52		50		48		46		30		34		32		36		32
Biological Condition Score % Compared to Reference**					**96%**		**92%**		**58%**		**65%**		**62%**		**69%**		**62%**	
Biological Condition Category					**Not impaired**		**Not impaired**		**Slightly impaired**		**Slightly impaired**		**Slightly impaired**		**Slightly impaired**		**Slightly impaired**	

* Biological Condition Scoring Criteria listed in Figure 7-6.
** URC stations compared to NSY; LRC stations compared to BTT.

EPT = Ephemeroptera, Plecoptera, and Trichoptera
RBP = Rapid Bioassessment Protocol
% = percent

TABLE 7-4. AQUATIC INVERTEBRATE COMMUNITY METRIC AND BIOLOGICAL CONDITION SCORES FOR LOCATIONS AT OU3 - RBP 2009

	Off-Site Reference		Upper Rainy Creek		Lower Rainy Creek				
Panel A: Calculated Metrics	BTT-R1	NSY-R1	URC-1A	URC-2	TPTOE2	LRC-1	LRC-2	LRC-3	LRC-5
1) Taxa Richness (Number of Taxa)	23	52	26	31	26	22	22	30	24
2) Total Density	2548	4560	1833	276	2825	3782	5236	1745	1771
3) EPT Index (number of taxa at station)	12	26	19	20	8	7	8	12	9
4) Shannon -Weaver Diversity	3	5	3	4	3	3	3	3	3
5) % Ephemeroptera	15	25	44	29	21	11	14	11	16
6) % Tolerant organisms	17	6	4	3	15	18	18	10	13
7) % Contribution Dominant Taxon	26	11	35	16	41	24	46	55	43
8) % Scrapers	25	22	35	16	0	40	55	3	8
9) % Clingers	71	35	66	49	48	91	79	20	66

	Off-Site Reference		0		Upper Rainy Creek		0		Lower Rainy Creek		0		0		0		0	
Panel B: Biological Condition Score (BCS)*	%	Score	%	Score	%	Score	%	Score	%	Score	%	Score	%	Score	%	Score	%	Score
1. Taxa Richness (site / reference)	100%	6	100%	6	50%	2	60%	2	113%	6	96%	6	96%	6	130%	6	104%	6
2. Total Density (site / reference)	100%	6	100%	6	40%	2	6%	0	111%	6	148%	6	205%	6	68%	4	70%	4
3. EPT Index (site / reference)	100%	6	100%	6	73%	2	77%	2	67%	0	58%	0	67%	0	100%	6	75%	2
4. Shannon –Weaver Diversity (site / reference)	100%	6	100%	6	68%	2	84%	4	76%	4	92%	6	86%	6	83%	4	85%	6
5. % Ephemeroptera (site / reference)	100%	6	100%	6	176%	6	116%	6	140%	6	73%	6	93%	6	73%	6	107%	6
6. % tolerant organisms (reference / site)	100%	6	100%	6	150%	6	200%	6	113%	6	94%	6	94%	6	170%	6	131%	6
7. % Contribution of Dominant Taxon	26%	4	11%	6	35%	2	16%	6	41%	2	24%	4	46%	2	55%	2	43%	2
8. % scrapers (site / reference)	100%	6	100%	6	159%	6	73%	6	0%	0	160%	6	220%	6	12%	0	32%	2
9. % clingers (site / reference)	100%	6	100%	6	189%	6	140%	6	68%	6	128%	6	111%	6	28%	2	93%	6
Biological Condition Score		52		54		34		38		36		46		44		36		40
Biological Condition Score % Compared to Reference**					**63%**		**70%**		**69%**		**88%**		**85%**		**69%**		**77%**	
Biological Condition Category					**Slightly impaired**		**Slightly impaired**		**Slightly impaired**		**Not impaired**		**Not impaired**		**Slightly impaired**		**Slightly impaired**	

* Biological Condition Scoring Criteria listed in Figure 7-6.
** URC stations compared to NSY; LRC stations compared to BTT.

EPT = Ephemeroptera, Plecoptera, and Trichoptera
RBP = Rapid Bioassessment Protocol
% = percent

TABLE 7-5. HABITAT QUALITY SCORES AT THE REFERENCE AND OU3 SITES IN 2008

Habitat Parameter		Perfect Score	Off-Site Reference		Upper Rainy Creek		Lower Rainy Creek				
			BTT-R1	NSY-R1	URC-1A	URC-2	TP-TOE2	LRC-1	LRC-2	LRC-3	LRC-5
Epifaunal Substrate/ Available Cover		20	18	16	18	17	15	13	16	17	16
Embeddedness		20	17	19	17	16	15	16	17	18	16
Velocity/Depth Regime		20	12	12	14	12	13	10	10	17	11
Sediment Deposition		20	15	17	16	13	16	14	16	16	17
Channel Flow Status		20	18	13	18	17	17	17	18	18	17
Channel Alteration		20	18	18	17	16	16	14	14	17	14
Frequency of Riffles (or bends)		20	15	15	14	15	14	14	17	12	14
Bank Stability	Left Bank	10	9	8	9	9	9	7	9	9	9
	Right Bank	10	9	8	9	9	9	7	9	9	8
Vegetative Protection	Left Bank	10	9	9	9	9	9	8	8	9	9
	Right Bank	10	9	9	9	9	9	7	8	9	7
Riparian Vegetative Zone Width	Left Bank	10	8	9	9	9	8	6	7	9	5
	Right Bank	10	9	9	9	9	9	6	7	9	9
HABITAT QUALITY SCORE[a]		200	166	162	168	160	159	139	156	169	152
Percent of Reference[b]					104%	99%	96%	84%	94%	102%	92%
Ranking					optimal	optimal	suboptimal	suboptimal	suboptimal	optimal	suboptimal

% = percent

NA = Not applicable.

[a] Optimal: 160 – 200, Suboptimal: 110 – 159, Marginal: 60 – 109, Poor: less than 60.

[b] Reference for URC-1A and URC-2 is NSY-R1; reference for TP-TOE2, LRC-1, LRC-2,LRC-3, LRC-5 is BTT-R1.

TABLE 7-6. HABITAT QUALITY SCORES AT THE REFERENCE AND OU3 SITES IN 2009

Habitat Parameter		Perfect Score	Off-Site Reference		Upper Rainy Creek		Lower Rainy Creek				
			BTT-R1	NSY-R1	URC-1A	URC-2	TP-TOE2	LRC-1	LRC-2	LRC-3	LRC-5
Epifaunal Substrate/ Available Cover		20	15	18	18	16	13	11	14	15	15
Embeddedness		20	18	18	16	13	15	13	13	15	13
Velocity/Depth Regime		20	11	12	14	12	12	9	15	14	11
Sediment Deposition		20	15	18	16	12	16	12	15	13	16
Channel Flow Status		20	18	12	17	14	16	15	17	16	16
Channel Alteration		20	18	18	17	17	13	10	12	15	12
Frequency of Riffles (or bends)		20	16	15	14	15	13	14	17	11	14
Bank Stability	Left Bank	10	8	9	9	9	6	6	8	8	9
	Right Bank	10	8	9	9	9	7	6	8	8	7
Vegetative Protection	Left Bank	10	9	9	9	9	7	7	7	9	9
	Right Bank	10	9	9	9	9	8	7	7	9	6
Riparian Vegetative Zone Width	Left Bank	10	8	9	9	9	7	5	5	9	7
	Right Bank	10	8	9	9	9	7	5	5	9	3
HABITAT QUALITY SCORE[a]		200	161	165	166	153	140	120	143	151	138
Percent of Reference[b]					101%	93%	87%	75%	89%	94%	86%
Ranking					optimal	suboptimal	suboptimal	suboptimal	suboptimal	suboptimal	suboptimal

% = percent

NA = Not applicable.

[a] Optimal: 160 – 200, Suboptimal: 110 – 159, Marginal: 60 – 109, Poor: less than 60.

[b] Reference for URC-1A and URC-2 is NSY-R1; reference for TP-TOE2, LRC-1, LRC-2,LRC-3, LRC-5 is BTT-R1.

TABLE 7-7. SCORING METHOD FOR MONTANA DEQ APPROACH

Metric	Biological Condition Scoring Criteria			
	3	2	1	0
1. Taxa Richness (Number of Taxa)	>28	28-24	23-19	<19
2. EPT Index (Number of Taxa/Station)	>19	19-17	16-15	<15
3. HBI Score	<3	3-4	4.01-5	>5
4. % Contribution Dominant Taxa	<25	25-35	35.01-45	>45
5. Collecter/Gatherer (% Adundance)	<60	60-70	70.01-80	>80
6. EPT Abundance	>70	70-55.01	55-40	<40
7. Scraper/Shredder (% Adundance)	>55	55-40.01	40-25	<25

% = percent
< = less than
> = greater than
EPT = Ephemeroptera, Plecoptera, and Trichoptera
DEQ = Montana Department of Environmental Quality
HBI = Hilsenhoff Biotic Index

TABLE 7-8. AQUATIC INVERTEBRATE COMMUNITY METRICS AND MONTANA DEQ MONTANE TOTAL SCORES - 2008

Panel A: Metrics

	Off-Site Reference		Upper Rainy Creek		Lower Rainy Creek				
	BTT-R1	**NSY-R1**	**URC-1A**	**URC-2**	**TPTOE2**	**LRC-1**	**LRC-2**	**LRC-3**	**LRC-5**
1) Taxa Richness (Number of Taxa)	24	34	10	36	30	20	27	17	20
2) EPT Index (number of taxa at station)	9	26	6	22	11	6	10	10	12
3) HBI Score	4.86	1.30	2.46	1.45	4.51	5.30	5.44	4.07	3.42
4) % Contribution Dominant Taxon	54	27	69	22	35	24	40	34	57
5) Collecter Gatherer, % Abundance	11	16	72	21	37	3	10	25	61
6) EPT Abundance	32	91	26	80	44	35	26	59	92
7) Scraper and Shredder, % Abundance	18	64	5	51	15	37	29	35	29

Panel B: Montana DEQ Montane Total Scores

	Off-Site Reference		Upper Rainy Creek		Lower Rainy Creek				
	BTT-R1	**NSY-R1**	**URC-1A**	**URC-2**	**TPTOE2**	**LRC-1**	**LRC-2**	**LRC-3**	**LRC-5**
1) Taxa Richness (Number of Taxa)	2	3	0	3	3	1	2	0	1
2) EPT Index (number of taxa at station)	0	3	0	3	0	0	0	0	0
3) HBI Score	1	3	3	3	1	0	0	1	2
4) % Contribution Dominant Taxon	0	2	0	3	1	3	1	2	0
5) Collecter Gatherer, % Abundance	3	3	1	3	3	3	3	3	2
6) EPT Abundance	0	3	0	3	1	0	0	2	3
7) Scraper and Shredder, % Abundance	0	3	0	2	0	1	1	1	1
Total Score	6	20	4	20	9	8	7	9	9

*Montana DEQ Montane Total Scores Criterion listed in Table 7-7.

DEQ = Department of Environmental Quality
EPT = Ephemeroptera, Plecoptera, and Trichoptera
HBI = Hilsenhoff Biotic Index
% = percent

TABLE 7-9. AQUATIC INVERTEBRATE COMMUNITY METRICS AND MONTANA DEQ MONTANE TOTAL SCORES - 2009

Panel A: Metrics

	Off-Site Reference		Upper Rainy Creek		Lower Rainy Creek				
	BTT-R1	NSY-R1	URC-1A	URC-2	TPTOE2	LRC-1	LRC-2	LRC-3	LRC-5
1) Taxa Richness (Number of Taxa)	28	42	40	45	27	16	23	24	32
2) EPT Index (number of taxa at station)	9	29	18	18	10	5	8	13	16
3) HBI Score	4.8	1.8	2.0	1.7	4.5	5.6	5.5	3.6	3.4
4) % Contribution Dominant Taxon	55	26	21	22	62	30	34	45	24
5) Collecter Gatherer, % Abundance	8	15	36	22	21	5	10	12	51
6) EPT Abundance	23	83	74	78	32	16	26	83	88
7) Scraper and Shredder, % Abundance	12	57	49	59	13	50	37	57	40

Panel B: Montana DEQ Montane Total Scores

	Off-Site Reference		Upper Rainy Creek		Lower Rainy Creek				
	BTT-R1	NSY-R1	URC-1A	URC-2	TPTOE2	LRC-1	LRC-2	LRC-3	LRC-5
1) Taxa Richness (Number of Taxa)	2	3	3	3	2	0	1	2	3
2) EPT Index (number of taxa at station)	0	3	2	2	0	0	0	0	1
3) HBI Score	1	3	3	3	1	0	0	2	2
4) % Contribution Dominant Taxon	0	2	3	3	0	2	2	1	3
5) Collecter Gatherer, % Abundance	3	3	3	3	3	3	3	3	3
6) EPT Abundance	0	3	3	3	0	0	0	3	3
7) Scraper and Shredder, % Abundance	0	3	2	3	0	2	1	3	1
Total Score	6	20	19	20	6	7	7	14	16

*Montana DEQ Montane Total Scores Criterion listed in Table 7-7.

DEQ = Department of Environmental Quality
EPT = Ephemeroptera, Plecoptera, and Trichoptera
HBI = Hilsenhoff Biotic Index
% = percent

TABLE 7-10. AQUATIC INVERTEBRATE COMMUNITY MONTANA DEQ MONTANE TOTAL SCORES - KOOTENAI NATIONAL FOREST DATA

Montana DEQ Montane Total Scores	Pipe Creek at Timberline	Quartz Creek Above Confluence	Bobtail Creek	Bristow Creek	Pipe Creek Below Shafer	Barron Creek	Quartz Creek Below Confluence	West Fork Quartz Creek
1) Taxa Richness (Number of Taxa)	0	0	3	3	3	3	3	3
2) EPT Index (number of taxa at station)	0	0	2	3	3	3	3	3
3) HBI Score	3	2	1	2	2	2	2	3
4) % Contribution Dominant Taxon	1	1	3	3	3	3	3	3
5) Collecter Gatherer, % Abundance	3	2	3	3	3	3	3	3
6) EPT Abundance	0	3	2	1	2	2	3	3
7) Scraper and Shredder, % Abundance	1	1	0	0	0	1	1	1
Total Score	8	9	14	15	16	17	18	19

*Montana DEQ Montane Total Scores Criterion listed in Table 7-7.

DEQ = Department of Environmental Quality
EPT = Ephemeroptera, Plecoptera, and Trichoptera
HBI = Hilsenhoff Biotic Index
% = percent

TABLE 8-1. METAL CONCENTRATIONS IN SITE SURFACE WATER COMPARED TO SURFACE WATER TOXICITY TEST

Analyte	Surface Water Toxicity Value (µg/L)		Site Samples[1] Summary Statistics (µg/L)					SW Toxicity Test Concentration[3] (µg/L)
	Acute	Chronic	N Detects	N Samples	Mean[2]	Minimum	Maximum	Station TP
Aluminum	750	87	0	56	45	45	45	45 U
Antimony	180	30	0	56	2.5	2.5	2.5	2.5 U
Arsenic	340	150	0	56	2.5	2.5	2.5	2.5 U
Barium	110	4.0	56	56	321	100	700	200
Beryllium	35	0.66	0	56	0.25	0.25	0.25	0.25 U
Boron	29.7	1.6	0	56	9.5	5	15	--
Cadmium	1.38	0.19	0	56	0.05	0.05	0.05	0.05 U
Calcium	no benchmark	116,000	56	56	70,000	32,000	107,000	53,000
Chromium	15.7	10.6	0	56	5	5	5	5 U
Cobalt	1,500	23	0	56	5	5	5	5 U
Copper	9.3	6.4	1	56	1.05	1	4	1 U
Iron	no benchmark	1,000	1	56	15.3	15	30	15 U
Lead	42	1.65	0	56	0.25	0.25	0.25	0.25 U
Magnesium	no benchmark	82,000	56	56	17,107	7,000	30,000	11,000
Manganese	2300	120	8	56	19.1	10	140	10 U
Mercury	1.19	0.65	0	56	0.3	0.3	0.3	0.3 U
Nickel	338	37.5	0	56	2.5	2.5	2.5	2.5 U
Potassium	no benchmark	53,000	56	56	9,018	2,000	17,000	5,000
Selenium	19.3	5	0	56	2.5	2.5	2.5	2.5 U
Silver	1.78	0.18	0	56	0.5	0.5	0.5	0.5 U
Sodium	no benchmark	680,000	56	56	5,679	2,000	10,000	3,000
Thallium	110	12	0	56	50	50	50	50 U
Vanadium	280	20	0	56	5	5	5	5 U
Zinc	84.5	85.2	0	56	5	5	5	5 U

Data presented in this table are based on the dissolved fraction for metals.

[1] Excludes toxicity test station and samples from Carney Creek seeps.

[2] Mean calculated assuming 1/2 reported value for non-detects.

[3] Measured at the beginning of the study.

-- = not measured

SW = surface water

µg/L = micorgrams per liter

TABLE 8-2. METAL CONCENTRATIONS IN SITE SEDIMENT SAMPLES COMPARED TO SEDIMENT TOXICITY TEST

Analyte	Sediment Screening Benchmark (mg/kg)		Site Samples[1] Summary Statistics (mg/kg)			Sediment Toxicity Test Concentration (mg/kg)			
	TEC	PEC	Mean[2]	Minimum	Maximum	CC-1	TP-TOE2	BTT-R1	NSY-R1
Aluminum	25,519	59,572	18,852	1,120	40,700	10,700	17,600	8,540	7,350
Antimony	2.0	25	0.81	0.15	1.0	1.0	1.0	1.0	1.0
Arsenic	9.79	33	1.71	1.0	7.0	1.0	4.0	5.0	5.0
Barium	no benchmark	no benchmark	1,126	166	4930	430	1,160	263	53
Beryllium	no benchmark	no benchmark	2.50	2.5	2.5	2.5	2.5	2.5	2.5
Boron	no benchmark	no benchmark	2.92	2.5	11	2.5	2.5	2.5	2.5
Cadmium	0.99	4.98	0.47	0.2	1.0	0.5	0.5	0.5	0.5
Chromium	43.4	111	240	5.0	988	91	358	8.0	6.0
Cobalt	no benchmark	no benchmark	29.2	2.5	75	16	32	8.0	5.0
Copper	31.6	149	49.3	6.0	175	22	34	14	11
Iron	188,400	247,600	29,189	4,790	62,900	22,000	28,200	18,900	14,000
Lead	35.8	128	32.5	2.5	96	7.0	14	12	9.0
Manganese	631	1,184	983	116	12,700	687	7,670	1,810	267
Mercury	0.18	1.06	0.09	0.05	0.1	--	--	0.1	0.1
Nickel	22.7	48.6	60.4	2.5	226	31	66	11	9.0
Selenium	no benchmark	no benchmark	2.13	0.25	2.5	2.5	2.5	2.5	2.5
Silver	1.0	3.7	0.58	0.5	1.0	0.5	0.5	0.5	0.5
Thallium	no benchmark	no benchmark	0.52	0.3	4.3	0.3	0.3	0.3	0.3
Vanadium	no benchmark	no benchmark	49.6	5.0	105	39	64	9.0	6.0
Zinc	121	459	40.0	5.0	94	18	37	42	37

(shaded) identified as a COPC for aquatic invertebrate exposures to sediment

[1] Excludes toxicity test locations

[2] Mean calculated assuming 1/2 reported value for non-detects

-- = not analyzed

mg/kg = milligrams per kilogram

PEC = probable effect concentration

TEC = threshold effect concentration

TABLE 9-1. STATISTICS FOR DETECTED CHEMICALS WITHOUT TRVs

Panel A: Surface Water

Detected Analyte	Units	Site Statistics				Reference Statistics*				Comparison Conclusion
		N Detects	N Samples	Mean	Maximum	N Detects	N Samples	Mean	Maximum	
Iron (Total Recoverable)	µg/L	29	51	102	1760	2	10	49	250	ProUCL, Form 1: site ≤ bkg
Gross Alpha	pCi/L	6	6	1.8	2.6	*not analyzed*				[a]
Gross Beta	pCi/L	4	4	6.6	9.0	*not analyzed*				[a]
Total Extractable Hydrocarbons	µg/L	1	53	156	470	0	8	150	150	[b]
Nitrogen, Nitrate+Nitrite as N	µg/L	20	48	41	440	4	8	48	300	ProUCL, Form 1: site ≤ bkg
Nitrogen, Nitrite as N [e]	µg/L	4	51	7.9	80	0	10	5.0	5.0	ProUCL, Form 1: site ≤ bkg

Panel B: Sediment

Detected Analyte	Units	Site Statistics				Reference Statistics*				Comparison Conclusion
		N Detects	N Samples	Mean	Maximum	N Detects	N Samples	Mean	Maximum	
Barium [c]	mg/kg	110	111	1,188	2,970	12	12	258	414	ProUCL, Form 1: site > bkg
Boron [c]	mg/kg	8	111	2.9	11	0	12	2.6	4.0	ProUCL, Form 1: site ≤ bkg
Cobalt [c]	mg/kg	110	111	32	75	5	12	4.3	9	ProUCL, Form 1: site > bkg
Iron	mg/kg	111	111	31,810	62,900	12	12	10,796	18,900	ProUCL, Form 1: site > bkg
Selenium [c]	mg/kg	1	105	2.2	2.5	2	12	2.2	2.5	ProUCL, Form 1: site ≤ bkg
Thallium [c]	mg/kg	42	111	0.51	1.2	0	12	0.30	0.30	ProUCL, Form 1: site > bkg
Vanadium [c]	mg/kg	110	111	54	98	12	12	15	39	ProUCL, Form 1: site > bkg
Fluoride	mg/kg	29	45	1.9	18	0	3	0.5	0.5	[d]
Phosphorus, Total	mg/kg	103	103	2,614	8,390	8	8	543	1,350	ProUCL, Form 1: site > bkg
C11 to C22 Aromatics	mg/kg	44	53	107	507	3	4	69	96	[d]
C19 to C36 Aliphatics	mg/kg	46	53	171	739	3	4	69	124	[d]
C9 to C10 Aromatics	mg/kg	11	103	5.2	63	1	8	3.3	10	ProUCL, Form 1: site ≤ bkg
C9 to C12 Aliphatics	mg/kg	17	103	6.5	58	0	8	2.3	3.5	ProUCL, Form 1: site ≤ bkg
C9 to C18 Aliphatics	mg/kg	33	53	106	590	0	4	12	20	[d]
Total Extractable Hydrocarbons	mg/kg	147	156	409	2,360	9	12	227	612	ProUCL, Form 1: site ≤ bkg
Total Purgeable Hydrocarbons	mg/kg	28	103	18	276	1	8	3.6	12	ProUCL, Form 1: site ≤ bkg
Methyl acetate	mg/kg	4	6	0.46	1.4	*not analyzed*				[a]

Panel C: Soil and Mine Waste Materials

Detected Analyte	Units	Site Statistics				Reference Statistics**				Comparison Conclusion
		N Detects	N Samples	Mean	Maximum	N Detects	N Samples	Mean	Maximum	
Iron	mg/kg	35	35	25,137	51,900	12	12	16,892	30,700	ProUCL, Form 1: site > bkg
Phosphorus, Total	mg/kg	35	35	2,724	11,700	*not analyzed*				[a]
C11 to C22 Aromatics	mg/kg	2	3	35	78	*not analyzed*				[a]
C19 to C36 Aliphatics	mg/kg	3	3	103	154	*not analyzed*				[a]
C5 to C8 Aliphatics	mg/kg	1	27	1	1.4	*not analyzed*				[a]
C9 to C10 Aromatics	mg/kg	1	27	1	16	*not analyzed*				[a]
C9 to C18 Aliphatics	mg/kg	2	3	29	53	*not analyzed*				[a]
Total Extractable Hydrocarbons	mg/kg	19	27	46	474	*not analyzed*				[a]
Total Purgeable Hydrocarbons	mg/kg	3	27	2	17	*not analyzed*				[a]
Methyl acetate	mg/kg	2	2	1	1.7	*not analyzed*				[a]

* Reference stations include Noisy Creek, Bobtail Creek, and Upper Rainy Creek

** Reference soil from distal ends of transects in forested area surrounding OU3

Site concentrations > reference (shaded rows)

[a] Not analyzed in reference; no comparison can be made.

[b] Detection frequency in site samples <5%; no statistical evaluation performed,but site concentrations do not appear elevated relative to reference.

[c] No TRV for evaluation of aquatic invertebrate exposures to sediment; TRVs are available to evaluate wildlife exposures.

[d] Not enough samples for reference dataset to perform a statistical evaluation, but site concentrations appear elevated relative to reference.

[e] No TRV for evaluation of wildlife exposures; TRVs are available to evaluate aquatic receptor exposures.

TRV = toxicity reference value

µg/L = micrograms per liter

mg/kg = milligrams per kilogram

N = number

pCi/L = picocuries per liter

TABLE 10-1. WEIGHT OF EVIDENCE EVALUATION AND CONCLUSIONS

Receptor Group	Exposure Location	Line of Evidence		Exposure Medium	Principal Findings	Confidence in Findings	WOE Conclusion
Fish	Creeks and Ponds	1	Refined HQ	Water	No risks (barium not evaluated)	Low-Moderate	Risks from non-asbestos COPCs are minimal
		2	Site specific toxicity test	Water	No adverse effects	Moderate	
		3	Community surveys	Water, Sediment, Diet	Lower density than expected; habitat and/or LA may contribute	High	
Aquatic Invertebrates	Creeks and Ponds	1a	Refined HQ	Water	Severe risk from barium	Low	Risks from non-asbestos COPCs are minimal
		1b	Refined HQ	Sediment	Moderate/severe risk from chromium, manganese, nickel	Low	
		2	Site-specific toxicity test	Sediment	No effects	Moderate	
		3	Community survey	Sediment, Water, Diet	Minimal impairment; habitat quality likely contributor	High	
Terrestrial Plants	Mined area	1	Refined HQ	Soil	Moderate/severe risk from barium, cobalt, nickel, vanadium (chromium not evaluated)	Low	Risks from non-asbestos COPCs cannot be excluded [a]
Terrestrial Invertebrates	Mined area	1	Refined HQ	Soil	High risk from barium (chromium not evaluated)	Low	
Wildlife (birds and mammals)	Terrestrial	1	Refined HQ	Soil, Diet	None/minimal risk	Low	Risks from non-asbestos COPCs are minimal
	Aquatic	1	Refined HQ	Water, Sediment, Diet	High risk from barium, manganese, vanadium from ingestion of aquatic invertebrates	Low	Risks from non-asbestos COPCs cannot be excluded [a]

[a] Refined HQ values above 1 should not be interpreted as evidence that risk does exist.

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Appendices

Appendix A – Photos of Aquatic Habitat within OU3

Appendix B – Species Potentially Inhabiting the Libby OU3 Site Area

Appendix C – Libby OU3 Project Database

Appendix D – Non-Asbestos Data Validation Reports

Appendix E – Toxicity Screening Benchmarks – Non-Asbestos Contaminants

Appendix F – Evaluation of Analytical Method Adequacy

Appendix G – Raw Data for Fish Community Sampling

Appendix H – Detailed Risk Calculations for Wildlife