APPENDIX C

HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENT WORK PLAN

HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENT WORK PLAN

FINAL
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Prepared for:

P4 Production, LLC

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ACRONYMS AND ABBREVIATIONS

95% UCL	95 percent upper confidence level
μg	micrograms
A/T	Agencies and Tribes
ATSDR	Agency for Toxic Substances and Disease Registry
AVS	acid volatile sulfides
BCF	bioconcentration factor
BLM	Bureau of Land Management (United States)
bw	body weight
Ca	calcium
Cd	cadmium
CEC	cation exchange capacity
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CILCR	cumulative incremental lifetime cancer risk
cm^2	cubic centimeters
CSF	cancer slope factor
CSM	conceptual site model
CTE	central tendency exposure
Cu	copper
d	day
DOC	dissolved organic carbon
DPS	distinct population segment
EE/CA	engineering evaluations/cost analysis
EPI	estimation program interface
ERA	ecological risk assessment
ERED	Environmental Residue Effects Database
FS	feasibility study
FSP	field sampling plan
H^+	hydrogen ions
HEAST	Health Effects Assessment Summary Tables
HHERA	human health and ecological risk assessment
HHRA	human health risk assessment
HI	hazard index
HQ	hazard quotient
IAC	Idaho Administrative Code
IDEQ	Idaho Department of Environmental Quality
IRIS	Integrated Risk and Information System
kg	kilogram
L	liter
LOAEL	lowest observed adverse effects level
m	meter
m^3	cubic meters
MCL	maximum contaminant level

MDL	method detection limit
MF	modifying factor
Mg	magnesium
mg	milligram
Na	sodium
NRWQC	National Recommended Water Quality Criteria
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NOAEL	no observed adverse effects level
ODEQ	Oregon Department of Environmental Quality
ORNL	Oak Ridge National Laboratories
P4	P4 Production, LLC
Ph	- Log [hydrogen]
PPRTV	Provisional Peer Reviewed Toxicity Values
QA	quality assurance
QAPP	quality assurance project plan
QC	quality control
RAGS	Risk Assessment Guidance for Superfund
RAIS	Risk Assessment Information System
RBP	Rapid Bioassessment Protocol
REM	Risk Evaluation Manual
RfC	reference concentration
RfD	reference dose
RI/FS	remedial investigation/feasibility study
RME	reasonable maximum exposure
RSL	Regional Screening Levels
SARA	Superfund Amendments and Reauthorization Act
SAP	sampling and analysis plan
SEF	sediment evaluation framework
SEM	simultaneously extracted metals
SOP	standard operating procedures
UF	uncertainty factor
URF	unit risk factor
USACE	United States Army Corps of Engineers
USDA	United States Department of Agriculture
USDHS	United States Department of Health and Human Services
USDOI	United States Department of the Interior
USEPA	United States Environmental Protection Agency
USFS	United States Forest Service
USFWS	United States Fish and Wildlife Service
WDNR	Washington Department of Natural Resources
WP	Work Plan
wt	weight

1.0 INTRODUCTION

This human health and ecological risk assessment work plan (HHERA Work Plan) was prepared by MWH Americas, Inc. (MWH) on behalf of P4 Production, LLC (P4), in accordance with the requirements set forth in the Administrative Settlement Agreement and Order on Consent/ Consent Order for Remedial Investigation/Feasibility Study (2009 CO/AOC; USEPA, 2009a). The 2009 CO/AOC is a voluntary agreement between P4 and the United States Environmental Protection Agency (USEPA), the Idaho Department of Environmental Quality (IDEQ), the United States Department of Agriculture (USDA), United States Forest Service (USFS), the U.S. Department of the Interior (USDOI), Bureau of Land Management (BLM), the Shoshone-Bannock Tribes (Tribes). This group of stakeholders is collectively referred to as the "Agencies and Tribes" or A/T. The HHERA Work Plan is part of the RI/FS Work Plan that supports the comprehensive mine-specific RI/FS that will be conducted at P4's three historic phosphate mines namely Ballard, Henry and Enoch Valley Mines (collectively known as the "Sites") located in southeast (SE) Idaho.

1.1 Objectives and Scope

The purpose of this HHERA Work Plan is to document the methods and procedures for evaluating potential human health and ecological risks associated with media of concern at the Sites that will meet A/Ts approval before conducting the HHERA at the Sites. While the HHERA for the Sites will be patterned after similar investigations in SE Idaho, the proposed approach for the Site's HHERA will incorporate changes in the current regulatory setting, the state of risk assessment science and site-specific conditions.

1.2 Scope of Risk Assessment

The scope of this HHERA Work Plan is to describe the methods and assumptions to be used in conducting the HHERA for the Sites. The methods proposed herein will include the following:

- Establishment of requirements for selection of data to be used in the HHERA.
- Identification of criteria for the selection of chemicals of potential concern (COPCs) and chemicals of potential ecological concern (COPECs).
- Determination of habitat types and potential beneficial/multiple uses at the Site.
- Creation of conceptual site models (CSMs) which identify complete exposure pathways for human and ecological receptors.
- Presentation of generalized exposure equations for quantifying exposure doses.
- Establishment of sources and procedures for the human health and ecological toxicity assessment.

- Development of procedures for the characterization of human health and ecological risks.
- Presentation of the process for the identification of any major uncertainties in the risk assessment process.

The HHERA will be part of the RI/FS process for the Sites. The goal of characterizing risks for the Sites is to determine which areas, if any, will require further evaluation, or implementation of remedial measures. The HHERA will begin with generalized descriptions of exposure assumptions and all potentially complete and significant exposure pathways for human and ecological receptors, followed by methods to be used in the toxicity assessments and characterization of risks to human health and the environment. A tiered approach will be used during the evaluation of risks to human and ecological receptors for the Sites in which Tier I uses maximum concentrations of site contaminants and default exposure assumptions, and subsequent tiers (i.e., Tiers II and III) are based on upper-bound average estimates of contaminant concentrations and more reasonable assumptions relative to exposure as described in Sections 3.0 and 4.0 of this HHERA Work Plan.

1.3 Process and Organization

The HHERA Appendix is organized into the following sections:

- Section 1 – Introduction to Risk Assessment Appendix
- Section 2 – Data Evaluation and Summary
- Section 3 – Human Health Risk Assessment
- Section 4 – Ecological Risk Assessment
- Section 5 – Uncertainties
- Section 6 – References

2.0 DATA EVALUATION AND SUMMARY

This section describes procedures for evaluating and selecting the data that will be used in the P4 HHERA. Media to be used in the HHERA include soil (upland and riparian), surface water, groundwater, surface expressions of groundwater (SEGW), sediment and vegetation data collected between 2004 and 2010. In addition, pre-2004 cattle tissue, elk tissue, bird egg tissue, fish tissue, benthic and terrestrial macroinvertebrates, and small mammal tissue data may be proposed for use in the HHERA, as described in the *DQUR/DAR*. The data evaluation process is presented in Section 5.5 and Appendix B of the RI/FS WP.

2.1 Site Data Selection

For an analytical result to be usable for assessing risk, the sample collection, preparation, and analytical methods should appropriately identify the chemical form or species, and the specified sample detection limit should be at or below a concentration that is associated with toxicologically relevant levels (e.g., published risk-based screening levels or action levels). The significance of analytical detection limits greater than such criteria will be evaluated on a case-by-case basis and will be described in the uncertainty analysis section of the HHERA Report. According to USEPA (USEPA, 1989), only field investigation analytical data that meet specific requirements are appropriate for use in a quantitative human health risk assessment (HHRA). Only data collected and analyzed at a quality control (QC) level equivalent to USEPA Level III or higher (USEPA, 1988), meets appropriate usability criteria for evaluation in a quantitative HHRA. USEPA Level III data provide the following:

- Low detection limits
- A wide range of calibrated analyses
- Matrix recovery information
- Laboratory process control information
- Known precision and accuracy

The abiotic media and vegetation sampling data was consistent with USEPA level III and is suitable for risk assessment purposes. Data collected for biota other than vegetation are being evaluated as described in the *DQUR/DAR*, and will be used in the quantitative HHRA with A/T concurrence.

Data that meet USEPA Contract Laboratory Program (CLP) Level III or Level IV (or functionally equivalent) data validation criteria are not required for data used in quantitative ecological risk assessments. In some cases, Level II data may be used in quantitative ecological risk assessment, if the uncertainty in the data is known and is deemed to be acceptable.

USEPA's Guidance for Data Usability in Risk Assessment (Part A) – Final (USEPA, 1992), further states:

- Data are almost always useable in the risk assessment process, as long as the uncertainty in the data and its impact on the risk assessment are thoroughly explained.
- The analytical data objective for baseline risk assessments is that uncertainty is known and acceptable, not that uncertainty be reduced to a particular level.
- Uncertainties in toxicological measures and exposure assessment are often assumed to be greater than uncertainties in environmental analytical data; thus, they are assumed to have a more significant effect on the uncertainty of the risk assessment. For example, the fact the elk tissue data didn't include a digestion spike, or were analyzed by a non-CLP lab, is relatively minor compared to uncertainties in the exposure and toxicity assessment portions of the risk assessment.
- Sampling variability typically contributes much more to total error than analytical variability.
- Field methods can produce legally defensible data if appropriate method QC is available and if documentation is adequate.
- Qualified data can usually be used for quantitative risk assessment.
- Use data qualified as U or J for risk assessment purposes.
- The primary planning objective is that uncertainty levels are acceptable, known and quantifiable, not that uncertainty is eliminated.

All validated and A/T approved chemical data from the previous sampling investigations will be evaluated for chemical, exposure, spatial and temporal representativeness prior to inclusion in the risk assessment, as follows:

- Chemical representativeness — Identify whether analyses were conducted for constituents expected to be present, on the basis of an understanding of historical processes or practices and potential releases at the site.
- Exposure representativeness—Identify whether environmental media were evaluated where receptor exposure is most feasible (including potential hot spots).
- Spatial representativeness — Identify whether samples were collected with a sufficient density and areal coverage that the detected constituent concentrations represent a geographically-integrated exposure for the receptors of concern.
- Temporal representativeness — Identify whether samples were collected within a time frame such that detected constituent concentrations indicate current site conditions.

Data that are determined to be representative, based on the above parameters, and deemed appropriate for inclusion in the risk assessment will be further evaluated based on the following criteria:

- If a single, unqualified value is provided for a given sample/location/data, the value will be used "as-is."

- If a chemical is detected at least once in soil, the non-detects will be included in the database as well.
- Data qualified with "R" will be removed from the database, while other qualified data will be entered.
- Laboratory duplicates and quality control data will not be included in the HHRA data set.
- For field duplicates and their respective primary samples, the following selection process will be used:

    - If both results were reported as detected concentrations, the average concentration was calculated and used in all further data analysis steps.
    - If one result was reported as detected and the other result was reported as not detected, the detected result was used in all further data analysis steps.
    - If both results were reported as not detected, the higher detection limit of the two sample results was assigned to the sample and used in further data analysis steps.

- For field triplicates and their respective primary samples, the following selection process will be used:

    - If all three results were reported as detected concentrations, the average concentration was calculated and used in all further data analysis steps.
    - If any two of the three results were reported as detected and the other result was reported as not detected, the average concentration of the detected results was calculated and used in all further data analysis steps.
    - If any one of the three results was reported as detected and the other two results were both reported as not detected, the detected result was selected and use in all further data analysis steps.
    - If all three results were reported as not detected, the higher detection limit of the two sample results was assigned to the sample and used in further data analysis steps.
    - Data qualification flags were maintained when averaging; any J flags associated with detected values were carried through to the final result.

2.2 Site-Specific Background Data

Background data at the Sites are available for upland and riparian soil, sediment, upland and riparian vegetation, surface water, groundwater, fish tissues, benthic macroinvertebrate tissues, bird egg tissues, cattle tissues, and elk tissues. Background data that meet data usability criteria specified in Section 2.1, and for which the A/Ts concur, will be employed for purposes of calculating background cancer risks and noncancer hazards in comparison to site risks and hazards, and for the calculation of incremental cancer risks and noncancer hazards. Incremental cancer risks and noncancer hazards represent the differences between total site carcinogenic risks and noncancer hazards and those attributable to background.

3.0 HUMAN HEALTH RISK ASSESSMENT

The HHRA portion of the HHERA focuses on potential risks associated with human exposures to site-derived contaminants under current and potential future site conditions. Results of the HHRA will be used to evaluate whether concentrations of Site-derived COPCs in site-specific media (at each Site) pose any unacceptable carcinogenic risks or noncarcinogenic hazards to potential current and future human receptors. Results of this HHRA will be used to evaluate whether current concentrations of COPCs in Site media are protective of human health and may remain in place, or if remedial measures are required.

This section presents the methods and assumptions to be used in the HHRA for the Sites. Risks to public health will be evaluated in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA)) process, as amended by Superfund Amendments and Reauthorization Act (SARA). The HHRA will evaluate potential public health risks associated with inorganic chemicals released from historic mining sources at the Sites. Potential threats to ecological habitats and receptors will be evaluated as described in Section 4.0.

The HHRA for the Sites will be performed in accordance with, or in consideration of, the following USEPA and State of Idaho guidance documents and/or reference materials:

- Risk Assessment Guidance for Superfund (RAGS). Volume I: Human Health Evaluation Manual, Part A (USEPA, 1989a)
- RAGS. Volume I: Human Health Evaluation Manual, Part F - Supplemental Guidance for Inhalation Risk Assessment (USEPA, 2009b)
- Guidelines for Carcinogen Risk Assessment (USEPA, 2005)
- Child-Specific Exposure Factors Handbook - Final Report (USEPA, 2008)
- Human Health Evaluation Manual, Supplemental Guidance: Standard Default Exposure Factors (USEPA, 1991)
- Final Exposure Assessment Guidelines (USEPA, 1992)
- Health Effects Assessment Summary Tables (HEAST) (USEPA, 1997a)
- Exposure Factors Handbook, Volume I: General Factors (USEPA, 1997b)
- Exposure Factors Handbook, Volume III: Activity Factors (USEPA, 1997c)
- Risk Assessment Guidance for Superfund (RAGS), Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment) (USEPA, 2004)
- Risk Evaluation Manual (REM) (IDEQ, 2004a)
- Surface Water Quality Standards. IDAPA 58.01.02 (IDEQ, 2009a)
- Groundwater Quality Rule. IDAPA 58.01.11 (IDEQ, 2009b)

Site cleanup rules provided in the aforementioned documents establish administrative processes and standards to determine the necessity for, and/or degree of, cleanup required to protect human health, safety, and welfare, and the environment at a site where one or more hazardous substances are located.

Medium-specific COPCs for the P4 Mines have already been developed and approved by the A/Ts; these are the lists of analytes measured within each medium. The HHRA for the Sites will begin with the selection of refined COPCs followed by a three-tiered risk assessment approach. Refinement of COPCs will involve a comparison of chemical concentrations to published screening criteria, as described in Section 3.1, below. Chemicals having concentrations that exceed protective screening criteria will be identified as refined COPCs and evaluated further in successive Tier I, II, and III HHRAs, as needed.

Tier I will consist of reasonable maximum exposure (RME) assumptions and maximum detected concentrations. Chemicals posing an unacceptable risk or hazard using Tier I risk assessment methods will be carried forward into a more site-specific Tier II HHRA. The Tier II HHRA will calculate risks separately using central tendency (CTE) and RME exposures and an upper bound average concentration for the exposure point concentration (EPC). Risks also will be calculated for background concentrations and an incremental risk will be derived from the CTE and RME-based calculations. A Tier III HHRA will be implemented, as needed, based on the results of Tier II, and will include evaluations of spatial relevance in the data (e.g., identification of hot spots) or site-specific exposure assumptions and information (refer to Section 3.4).

3.1 Refined COPC Selection

The goal of the HHERA is to estimate the potential risks to human health and ecological receptors from site-related chemicals under reasonable exposure scenarios (USEPA, 1989). To ensure that the primary focus of the HHRA is on the site-related chemicals that will be of most concern, medium-specific COPCs will be screened against protective human health screening criteria in a COPC refinement step. COPC refinement will be based on a residential scenario to evaluate whether chemical concentrations meet unrestricted land use criteria.

Human health screening criteria include numeric criteria and standards published in Federal regulations, State of Idaho regulations, and other regional reports. Federal sources for numeric screening criteria include the regional screening levels (USEPA, 2010a), National Recommended Water Quality Criteria (USEPA, 2010a) and National Maximum Contaminant Levels (USEPA, 2011a). Idaho standards include Water Quality Standards published in IDAPA 58.01.02 (IAC, 2009a), Groundwater Quality Rule published in IDAPA 58.01.02 (IAC, 2009b) the Area-Wide Risk Management Plan (IDEQ, 2003), and Idaho Health Comparison Levels for Drinking Water (ATSDR, 2006).

Chemicals will be included as refined COPCs if Mine Site-specific maximum detected concentrations of a chemical exceed published medium-specific screening levels.

3.1.1 COPC Selection Criteria

Medium-specific human health screening criteria are available for soil, surface water, and groundwater (Tables C3-1, C3-2 and C3-3, respectively). These tables present preliminary, refined COPCs as well as refined COPC screening criteria. Because sediment does not represent a potentially significant exposure to human receptors through direct exposure pathways (Figure C3-1), exposures to this medium will be discussed qualitatively in the uncertainties section of the HHERA (refer also to Section 3.3.1.3.2).

Surface Soil:

Refined human health COPC screening for soil will be based on comparison of maximum concentrations of chemicals detected in surface soil (0 to 6 inches) to USEPA Regional Screening Levels (RSLs; USEPA, 2010b); for carcinogenic chemicals (equivalent to a one-in-one million risk) and one-tenth of the USEPA RSLs for non-carcinogens. The most recent version of the RSLs available at the time the HHRA is prepared will be used.

USEPA RSLs are chemical-specific, include both the direct contact and inhalation exposure pathways, and are available for residential and industrial scenarios. The RSLs based on a residential scenario will be used for COPC screening purposes. In this screening, maximum concentrations of chemicals detected in soil will be compared to RSLs for residential soil. The COPC screening benchmarks for soil are presented in Table C3-1. The most recent version of the RSLs available at the time the HHRA is prepared will be used. Chemicals exceeding the refined COPC screening benchmarks will be identified as refined human health COPCs for soil.

Surface Water:

Refined human health COPC screening for surface water will be based on comparison of maximum concentrations of chemicals detected in surface water to the following hierarchy of criteria:

1. State of Idaho Surface Water Quality for Domestic Water Supply Use (IDAPA 58.01.02) (IAC, 2009) which is applied to all potential domestic use surface waters in the State of Idaho. The lower of the human health criteria for drinking water and consumption of organisms within the water is applied.
2. National Recommended Water Quality Criteria (USEPA, 2010a) criteria presented for human health include the consumption of organisms within the surface water body and for a combination of consumed organisms and ingestion of water.
3. USEPA RSLs for tap water (USEPA, 2010b).
4. Idaho Health Comparison Levels for Drinking Water (ATSDR, 2006), presented in Public Health Assessment for Bannock, Bear Lake, Bingham, and Caribou Counties in Idaho.

5. USEPA primary and secondary Maximum Contaminant Levels (USEPA, 2011a), criteria represent the national primary drinking water standards.

The refined COPC screening benchmarks for surface water are listed in Table C3-2. The most recent version of the above criteria available at the time the HHRA is prepared will be used. Chemicals exceeding the selected water quality criteria will be identified as refined human health COPCs for surface water.

Groundwater:

Refined human health COPC screening for groundwater will be based on comparison of maximum concentrations of chemicals detected in groundwater to:

- USEPA RSLs for tap water (USEPA, 2010b).
- Remedial action and monitoring levels; Area-Wide Risk Management Plan (IDEQ, 2003).
- State of Idaho Ground Water Quality Rule (IDAPA 58.01.11).
- USEPA primary and secondary MCLs and National Primary Drinking Water Regulations (USEPA, 2011a)
- Idaho Health Comparison Levels for Drinking Water (ATSDR, 2006), presented in Public Health Assessment for Bannock, Bear Lake, Bingham, and Caribou Counties in Idaho.

The refined COPC screening benchmarks for groundwater are listed in Table C3-3. The most recent version of the above criteria available at the time the HHRA is prepared will be used. Chemicals exceeding the refined COPC screening benchmarks will be identified as refined human health COPCs for groundwater.
Refined COPCs for metals in soil, surface water and groundwater will also be compared to medium-specific background concentrations to be developed for the P4 Mines. Background concentrations will be derived as the 95 percent upper confidence limit about the 95th percentile (95/95 UTL). Refined COPCs for metals with maximum concentrations below medium-specific 95/95 UTLs will be considered for elimination from further quantitative evaluation in the HHRA. Potential uncertainties associated with the elimination of refined COPCs for metals from quantitative evaluation in the HHRA will be discussed in the Uncertainty Analysis portion of the HHRA. Metals that are retained for further evaluation in the quantitative HHRA will be included in the calculation of Site-related risk estimates, background risk estimates, and incremental risk estimates, as described in Section 3.3.5.

Additionally, chemicals detected in less than 5% of samples (if more than 20 samples are available) will be further evaluated with spatial context to determine whether they can be excluded as COPCs (USEPA, 1989). Professional judgment will be used to determine whether these analytes will be carried forward as COPCs. Chemicals removed from further risk analysis following this decision rule will be described in the uncertainty section of the HHERA.

3.2 Tier I HHRA

The Tier I HHRA, also referred to as a screening risk assessment, will be performed on those constituents carried forward as COPCs from the COPC screening step. The Tier I HHRA will quantitatively evaluate cancer risks and noncancer hazard estimates from COPCs in Site media, on a Site-specific basis consistent with the documents mentioned earlier in this section of the HHERA Work Plan. Each P4 Site-specific screening evaluation will be performed for Native American, residential and seasonal rancher scenarios, only, using default exposure assumptions and maximum detected concentrations of COPCs. These three exposure scenarios cover all relevant abiotic and biotic exposure pathways; therefore, cancer risk and noncancer hazard estimates for these receptors are anticipated to the highest of the six human receptors that will be evaluated in the HHRA (refer to Figure C3-1). The exposure assessment and general HHRA process will follow the Tier II baseline risk assessment steps as detailed in Section 3.3 below.

Sites for which Tier I cumulative carcinogenic risk and noncarcinogenic hazard estimates are below IDEQ's point of departure carcinogenic risk and noncarcinogenic hazard index (HI) equal to 1×10^{-5} and 1, respectively, will be not be evaluated further in the HHRA. Any individual Sites having Tier I carcinogenic risk or noncarcinogenic hazard estimates above IDEQ's point of departure criteria will be evaluated further in a Tier II HHRA.

3.3 Tier II HHRA

The Tier II HHRA will evaluate carcinogenic risks and noncarcinogenic hazards for all six human receptors identified in Figure C3-1. The Tier II HHRA will be equivalent to a baseline risk assessment, and will evaluate upper-bound average concentrations of EPCs and both RME and CTE exposure assumptions. The RME exposure assumptions for adult residents will be based on standard default values published in USEPA's *Exposure Factors Handbook* (USEPA, 1997a, b, and c) or other published sources (the most current version of risk assessment guidance documents, at the time the HHRA is prepared, will be used). The CTE exposure assumptions for adult residents will be based on average or 50th percentile values published in USEPA (1997a,b,c) other published sources, or site-specific information (e.g. local dietary surveys) as available. Exposure factors for child residents will be based upon USEPA's *Child-Specific Exposure Factors Handbook – Final Report* (USEPA, 2008). Results of the Tier II HHRA will provide a range of site-specific carcinogenic risk and noncarcinogenic hazard estimates for each of the Sites.

Using this same approach, the Tier II HHRA also will include calculation of site-specific background risks for the RME scenario. The difference between Site risks and Site-specific background risks for each COPC will be defined as the incremental risk.

The general framework for conducting a baseline HHRA is provided in *Risk Assessment Guidance for Superfund (RAGS), Volume I: Human Health Evaluation Manual, Part A* (USEPA, 1989a). Consistent with this guidance document, the HHRA consists of the following five steps:

1. Exposure assessment
2. Exposure quantification
3. Toxicity assessment
4. Risk characterization
5. Uncertainty analysis

The first four steps are described in the following sections, as they relate to the human health portion of the HHERA. Step 5 will be a combined human health and ecological uncertainty analysis for the Sites, and will be presented and discussed in the HHERA. A brief summary of the process for determining uncertainties is presented in Section 5.0.

3.3.1 Exposure Assessment

The following sections describe elements of the human health conceptual site model (CSM). A thorough description of the human health CSM was provided in Section 3.8 of the RI/FS WP, and is included here for convenience.

The exposure assessment portion of the HHRA includes the development of a site-specific CSM. The human health CSM identifies current and anticipated future land uses for the Sites, potential site-related receptors, and potentially complete exposure pathways between human receptors and site-related contaminants.

A graphical representation of the human health CSM for the Sites is presented in Figure C3-1. As described in Section 2.1 of the RI/FS work plan, the primary sources of trace mineral contaminants (i.e., primarily inorganic elements) associated with the Sites include reclaimed mine waste rock dumps and mine pits. A more detailed description of the mobilization and transport of trace minerals from native materials and waste rock is provided in Sections 3.6 and 3.7 of the RI/FS work plan. In general, physical (wind, precipitation, and ambient temperature changes) and chemical weathering processes at the Sites release trace minerals from waste rock in the mine dumps and other more minor sources. The dissolution of soluble minerals and the oxidation of the surface and, in some cases, the interior of the waste rock dumps and mine pits, are the primary chemical processes affecting the release of chemicals from these areas. Once the waste rock is broken down by physical and chemical processes, trace minerals may be leached into waste rock and soil pore water. Surface and subsurface soils (e.g., waste rock) may be considered secondary sources of contamination (refer to Figure C3-1). Secondary release mechanisms include wind erosion of exposed rock and surface soils, surface water runoff, and infiltration of surface water into soils followed by percolation of pore water into groundwater. Tertiary sources of contamination include the following abiotic exposure media: ambient air, surface and subsurface soils, sediment, surface water and groundwater (Figure C3-1).

Because the primary sources of trace mineral contaminants (i.e., mine pits and waste rock dumps) are present at each of the three Sites, similar fate and transport processes apply at all three Sites. In addition, at each Site similar human receptors and exposure pathways are potentially present. As a result, the following CSM discussion is generalized to all three of the Sites. During the preparation of the RI/FS report, the potential need to refine the human health CSM on a Site-specific basis will be evaluated, and Site-specific CSMs will be developed, if necessary.

Key elements of the human health CSM for the Sites, including land uses in and around the Sites, current and future human receptors relevant to the Sites, and potentially complete and incomplete exposure pathways between human receptors and contaminated media, are discussed in the following subsections.

3.3.1.1 Land Uses

The Sites are located in the SE Idaho Phosphate Resource Area and consist of former phosphate mines and ancillary facilities. The Sites are an amalgamation of ownership types including: lands privately held by P4, and lands leased or formerly leased from the BLM, State of Idaho, and USFS for the purpose of mining. The adjoining or neighboring lands include privately-held ranches, and public lands including BLM, State of Idaho and USFS lands.

Currently, the Sites are primarily reclaimed mine lands used for limited livestock grazing and some uses that support nearby active mining. However, neighboring lands may be used for recreation, and ranching, including grazing of livestock. While unlikely under P4's current operation, future changes could result in P4 current and former leases of public lands reverting to the government for unrestricted use.

3.3.1.2 Current and Future Receptors

At, and in the vicinity of, the Sites the most common land uses are phosphate mining and livestock grazing. Consequently, current and anticipated future human receptors in these areas include mine site workers and seasonal ranchers. However, mine site workers are protected by Mining Safety and Health Administration (MSHA) regulations and other health and safety rules. As a result, mine site workers will not be addressed further in the HHRA conducted for the Sites. The current and future seasonal rancher is present for a few months of the year while grazing cattle at, or in the vicinity of, the Sites.

State, USFS, BLM and private lands are present in the vicinity of the Sites and are potentially used by recreational receptors. Current and future recreational receptors include fisherman, hunters, campers and hikers. These receptors potentially come into contact with contaminated abiotic media (e.g., soil, surface water or sediment) and may consume tissues of harvested biota (e.g., fish or large game animals, including deer and elk). Additionally, according to the Bridger Treaty between the U.S. Government and Shoshone and Bannock Tribes, current and future Native American receptors have rights to hunt, fish, gather plants, and practice other traditional land uses on unoccupied federal lands. However, a review of this information indicates that only about 1% of inhabitants in the Western U.S. consume wild game, and less than 1% (i.e., 0.6%) of Native Americans consumes wild game. Furthermore, mean intake rates of wild game by Western U.S. residents and Native Americans are 0.012 grams per kilogram per day (g/kg-d) and 0.001 g/kg-d, respectively. In comparison, mean intake rates for 'total meats' by Western U.S. residents and Native Americans are 1.903 g/kg-d and 2.269 g/kg-d, respectively. As a result, wild game contributes only about 0.63% of the total meat consumed by Western U.S. residents and 0.044% of the meat consumed by Native Americans. Based on the above, the consumption of upland birds and small game harvested from the P4 Sites would contribute a negligible amount to total contaminant intake relative to other potential exposure pathways. Therefore, harvesting and consumption of small game by hunters will not be quantitatively evaluated in the HHRA.

Under a hypothetical future use scenario, there are several possible land uses including:

- Private lands within the Sites (their holdings) could be developed for residential use.
- Public lands within the Sites could be reopened as parks or open space for unrestricted public (primarily recreational) use.
- Seasonal ranchers also could convert their private property into rural residential land use if it was developed, zoned, and approved accordingly.

While future residential land use is unlikely for the majority of the Sites and vicinity, a residential receptor will be evaluated for purposes of evaluating potential risks under hypothetical future unrestricted land use, and to assist in the development of land use management plans.

Consistent with the current and future land uses discussed above, current and future human receptors appropriate for evaluation in the HHRA for the Sites include:

- Current/Future Recreational Hunter
- Current/Future Recreational Fisherman
- Current/Future Recreational Camper/Hiker
- Current/Future Native American
- Current/Future Seasonal Rancher
- Hypothetical Future Resident

In addition to the above receptors, potential future use of the Sites as parkland could result in potential exposures to future park employees. Given that a future park employee is anticipated to have exposures and risks at the low end of those that will be estimated for the above six receptors, risk estimates for these receptors are anticipated to be protective of a future park employee. Therefore, risks to future workers will be evaluated semi-quantitatively using risk estimates for other receptors and comparisons between exposure assumptions for future workers and such receptors.

It is also possible that some biota consumption pathways could be applicable to multiple receptors. For example, a recreational hunter could also fish; a recreational fisherman could also hunt; a recreational camper/hiker could hunt and/or fish. Such alternative exposure pathways will be evaluated qualitatively in the Uncertainty Analysis section of the HHERA.

3.3.1.3 Complete and Incomplete Exposure Pathways

The human receptors identified in Section 3.3.1.2 are potentially exposed to site-derived contaminants during various activities. Recreational hunters and Native Americans may use lands for harvesting wild game including upland birds, small game, and large game such as deer and elk. Recreational fisherman, Native Americans, and hypothetical future residents may use the Sites for fishing. However, only in those stream sections or ponds that contain water throughout the year and support game fish of sufficient size to be caught and consumed will this pathway be considered complete. Rapid bioassessment survey (RBS) stream surveys were implemented for flowing waters near the Sites to characterize the aquatic habitat quality. None of the stations evaluated at the Ballard Mine had, or were likely to have, fish present and had corroborating low RBS scores. RBS scores at the other two mines ranged both higher and lower than at Ballard, and both mines showed the presence or likely presence of fish at approximately half the stations evaluated. Native American receptors may also use the Sites while gathering culturally significant plants, which are used for traditional and cultural purposes. Hikers and campers may use the Sites for hiking and camping on short recreational trips. Longer-term activities include potential future residents and seasonal ranchers who live at, or in the vicinity of, the Sites. These receptors may use groundwater for potable uses, for washing or cooking purposes, or for irrigating fruits and vegetables that are subsequently consumed. Groundwater may also be used by seasonal ranchers for watering livestock.

Complete and incomplete exposure pathways for the above receptors are graphically illustrated in Figure C3-1, and described on a medium-specific basis in the following subsections.

Soil. Contaminants may be released to soil through weathering/leaching and dispersion of air-born particulates at overburden disposal areas (ODAs). Human receptors with a potential for exposure to soils at the Sites include seasonal ranchers, recreational hunters, recreational fisherman, recreational hikers/campers, Native Americans, and hypothetical future residents.

These receptors are potentially exposed to contaminants in soil through direct contact pathways including incidental ingestion and dermal absorption of soil, or inhalation of fugitive dust particles (e.g., generated from physical disturbance of the soil like from vehicle usage). Indirect exposure pathways include consumption of plants grown in contaminated soils, and consumption of livestock or game animals foraging on or around the Sites. Both Native Americans and recreational hunters have a complete exposure pathway through the consumption of game animals that may potentially bioaccumulate contaminants from soils at the Sites. This pathway is potentially complete but insignificant for hypothetical future residents. Native Americans also may collect, utilize or consume culturally significant plants that grow on or around the Sites. Hypothetical future residents may consume fruits and vegetables grown in contaminated soils. The seasonal rancher has potential exposure to soil-derived contaminants through consumption of beef which is harvested from cattle grazing on or around the Sites. This pathway is potentially complete but insignificant for hypothetical future residents.

As noted in Section 3.3.1.2, above, it is possible that some terrestrial biota consumption pathways could be applicable to receptors not specifically mentioned above. For example, a recreational fisherman or a recreational camper/hiker could also hunt. Such alternative exposure pathways will be evaluated qualitatively in the Uncertainty Analysis section of the HHERA.

Sediment. Contaminants may be released to sediments through weathering/leaching processes from mine dump materials, infiltration/percolation, and surface water runoff to on-Site ponds and on-Site/off-Site drainages. Direct exposure to contaminants in sediment is potentially complete but insignificant for the recreational fisherman, recreational camper/hiker, Native American, and hypothetical future resident.

While direct human exposure to sediments at the Sites is not likely to occur to any appreciable degree, indirect exposure pathways are potentially significant through the consumption of organisms that uptake contaminants from drainage sediments. [Note: On-Site ponds do not support populations of fish; therefore, human consumption of fish is limited to fish harvested from on-Site and off-Site drainages.] Recreational fisherman, Native Americans, and residential receptors may consume fish harvested from impacted drainages. Additionally, Native Americans may consume culturally significant plants (e.g. cattails) harvested from impacted ponds or drainages.

As noted in Section 3.3.1.2, above, it is possible that some aquatic biota consumption pathways could be applicable to receptors not specifically mentioned above. For example, a recreational hunter or a recreational camper/hiker could also fish. Such alternative exposure pathways will be evaluated qualitatively in the Uncertainty Analysis section of the HHERA.

Surface Water. Contaminants may be released to surface water through weathering/leaching of mine dump materials, infiltration/percolation, and surface water runoff to on-site ponds and on-site/off-site drainages. Human exposure to surface water at or in the vicinity of the Sites is considered potentially complete for recreational hunters, recreational fishermen, recreational hikers/campers, Native Americans, hypothetical future residents, and seasonal ranchers.

Complete surface water exposure pathways include both direct and indirect exposures to contaminants in surface water. Potentially complete direct exposure pathways include incidental ingestion and dermal contact with surface water. Direct exposure pathways for surface water are potentially complete for recreational fishermen, Native Americans and hypothetical future residents. It is unlikely that recreational swimming is a significant exposure pathway due to low surface water temperatures, remoteness of the Sites, and the limited size of surface water bodies in the vicinity of the Sites. Seasonal ranchers may have limited direct contact with surface water, but such exposures are unlikely to be significant. Inhalation of contaminants from surface water is considered to be an incomplete exposure pathway because trace metals are not volatile.

Indirect exposure pathways for surface water include the consumption of fish harvested from on-site/off-site drainages. As noted above, on-Site ponds do not support populations of fish; therefore, human consumption of fish is limited to fish harvested from on-Site and off-Site drainages. The fish consumption pathway is potentially complete for Native Americans, recreational fisherman and hypothetical future residents, who may harvest fish from on-Site/off-Site drainages. However, fish that could potentially be caught and harvested would only be present in those stream sections that contain water throughout the year and provide viable aquatic habitat. Contaminant uptake from surface water to wild game, including elk and moose, represents a potentially complete exposure pathway for Native Americans and recreational hunters. This exposure pathway is potentially complete but insignificant for hypothetical future residents. Consumption of culturally significant aquatic plants is also a potentially complete exposure pathway for Native Americans. Surface water may also be used for watering cattle and other livestock, which are subsequently consumed by seasonal ranchers. This exposure pathway is potentially complete but insignificant for hypothetical future residents.

As noted in Section 3.3.1.2, above, it is possible that some aquatic biota consumption pathways could be applicable to receptors not specifically mentioned above. For example, a recreational hunter or a recreational camper/hiker could also fish. Such alternative exposure pathways will be evaluated qualitatively in the Uncertainty Analysis section of the HHERA.

Groundwater. Contaminants may be released to groundwater through weathering/leaching of overburden material and infiltration/percolation of trace minerals through the vadose zone to subsurface water. Potentially complete human exposure pathways for groundwater at the Sites are limited to the seasonal rancher and the hypothetical future resident.

Complete groundwater exposure pathways include both direct and indirect exposures to contaminants in groundwater. Potentially complete direct exposure pathways result from the use of groundwater at, or in the vicinity of, the Sites as a potable water supply. Direct exposure pathways for seasonal ranchers and hypothetical future residents include ingestion of potable water, and dermal contact with potable water while bathing or showering.

Indirect exposure pathways are also potentially complete for the seasonal rancher and hypothetical future resident. The use of groundwater for watering livestock may result in contaminant uptake by livestock including beef cattle that are subsequently consumed by seasonal ranchers. Groundwater used to irrigate homegrown fruits and vegetables may result in contaminant uptake by plants that are harvested and consumed by hypothetical future residents.

Complete Exposure Pathways Summary. In summary, potentially complete and significant exposure pathways for human receptors are as follows:

- Recreational hunters have potentially complete and significant exposure pathways associated with direct soil contact (i.e., incidental soil ingestion, dermal contact with soil, and inhalation of fugitive dust), and from consumption of wild game that uptake contaminants from surface water and soil.
- Recreational fishermen have potentially complete and significant exposure pathways associated with direct soil contact (i.e., incidental soil ingestion, dermal contact with soil, and inhalation of fugitive dust), direct contact with surface water (i.e., incidental ingestion and dermal contact with surface water) and consumption of fish that uptake contaminants from surface water and sediments.
- Recreational campers/hikers have potentially complete and significant exposure pathways related to direct contact with contaminated soils.
- Native Americans have potentially complete and significant exposure pathways related to direct contact with soil; direct contact with surface water; and consumption of biota including fish, wild game, and culturally significant plants.
- Seasonal ranchers have potentially complete and significant exposure pathways related to direct contact with soil, direct contact with groundwater used as a potable water supply (i.e., inhalation, ingestion and dermal contact with groundwater) and consumption of beef cattle that uptake contaminants from groundwater and soil while grazing at the Sites.
- Hypothetical future residents have potentially complete and significant exposure pathways related to direct contact with soil, direct contact with groundwater used as a potable water supply, consumption of fish, and consumption of homegrown fruits and vegetables that uptake contaminants from groundwater and soil.

Note: Year-round exposure to contaminated media including soil and surface water at, and in the vicinity of, the Sites does not occur due to seasonal limitations (i.e., snowpack and ice for approximately six months of the year). As a result, direct exposure pathways between human receptors and these media are limited. Additionally, indirect exposure pathways associated with the harvesting and consumption of fish and wild game are limited by licenses and seasonal availability, along with State regulations regarding harvest quantities. These limitations will be addressed in the human health exposure assessment to be used in the evaluation of risks to public health, as further described in the following sections.

3.3.2 Exposure Quantification

The exposure quantification portion of the HHRA describes the methods for estimating exposure doses based on the exposure pathways identified in the exposure assessment (Section 3.2.1). This section presents the methods for calculating EPCs from site data, the exposure models for calculating pathway-specific exposures, and the methods for selecting the inputs and assumptions used in exposure modeling.

3.3.2.1 Exposure Point Concentrations

An EPC describes the level of a chemical in soil, sediment, water, or food to which a receptor is potentially exposed (USEPA, 1989a). As such, the EPC serves as the basis for quantifying pathway-specific exposure doses. Calculation of EPCs in site media will be based on both measured concentrations and non-detect results.

Abiotic media sampling results for the Sites are based on site investigation activities conducted between 2004 and 2010. When data are insufficient to calculate a 95 percent upper confidence limit (95% UCL) on the mean concentration (e.g. less than 5 samples), or data are deemed to be of inadequate quality (e.g., due to elevated sample quantitation limits), maximum concentrations of site COPCs will be used to quantify exposure doses and risk estimates.

For COPCs with sufficient quantity and quality of data, EPCs will be estimated as either the 95% UCL on the arithmetic mean concentration, or the maximum detected contaminant concentration. If the calculated 95% UCL is greater than the maximum value, then the maximum value will be used as the EPC.

The 95% UCL will be calculated using USEPA's ProUCL software version 4.00.05 (USEPA, 2010c). Recommendations for appropriate distributions and 95% UCLs provided by the program will be utilized. If a data set contains non-detect results, these results will be handled as recommended by the program. If the software recommends more than one 95% UCL, the first in the list will be used. Additionally, if a higher confidence than 95% is recommended by ProUCL, the recommended UCL will be utilized.

EPCs for media where data are unavailable (e.g., aquatic culturally significant plants and tea ingestion) will be modeled using bioaccumulation factors.

3.3.2.2 Calculating Exposure Doses

This section describes HHRA methods for quantifying exposure doses for human receptors. As described in Section 3.2.1, complete and potentially significant exposure pathways between human receptors and site-related COPCs include direct contact pathways (i.e., incidental ingestion, dermal contact, and inhalation of particulates) and indirect pathways (i.e., consumption of tissues from plants, livestock and game). Potential exposures and risks related to other pathways and media will be qualitatively evaluated in the HHRA. The dose equations to be used in the quantification of direct exposure pathways are consistent with USEPA guidance for conducting exposure assessments (USEPA, 1989; 2009d). Indirect exposure pathways will be calculated in accordance with regional screening levels guidance (USEPA, 2009) and the Risk Assessment Information System (RAIS) (RAIS, 2010). Equation 1 is a generalized dose equation:

(1) $$\textbf{General Dose}\ \left(\frac{mg}{kg \times d}\right) = \frac{C \times IR \times CF \times EF \times ED}{BW \times AT}$$

where:

C	=	Concentration of contaminant in a media(milligrams per kilogram [mg/Kg], milligrams per liter [mg/L], or milligrams per cubic meter [mg/m^3])
IR	=	Intake rate (milligrams [mg] /day)
CF	=	Conversion factor (10^{-6} kilogram [kg]/mg)
EF	=	Exposure frequency (days/year)
ED	=	Exposure duration (years)
BW	=	Body weight (kg)
AT	=	Averaging time (period over which exposure is averaged – days)

The inputs and assumptions for exposure models will be based on IDEQ's Risk Evaluation Manual (IDEQ, 2004). Additional exposure factors and fate and transport information not provided by IDEQ will be derived from USEPA guidance (USEPA, 1991; USEPA 1997b; and USEPA 1997c). Numeric exposure assumptions will be provided to the A/Ts for review prior to conducting the Draft HHRA.

Soil. Equations for quantifying potential exposures of human receptors to COPCs in P4 Site soils through direct exposure pathways are presented below.

Soil Ingestion Pathway:

(2) $$\text{Incidental Ingestion Dose}\ \left(\frac{mg}{kg \times d}\right) = \frac{C_S \times IR_S \times CF \times EF \times ED}{BW \times AT}$$

where:

C_s	=	Concentration in soil (mg/kg)
IR_s	=	Soil ingestion rate (mg/day)
CF	=	Conversion factor (10^{-6} kg/mg)
EF	=	Exposure frequency (days/year)
ED	=	Exposure duration (years)
BW	=	Body weight (kg)
AT	=	Averaging time (days)

For hypothetical future residential receptors an age-adjusted factor is used to combine child and adult receptors in Equation 2, above, for carcinogenic chemicals. This factor incorporates age-specific factors including body weight, ingestion rate and exposure duration.

Inhalation of Fugitive Dust Pathway:

$$(3) \qquad \text{Inhalation of Fugitive Dust Concentration}\ (\frac{\mu g}{m^3}) = \frac{C_s \times (\frac{1}{PEF}) \times ET \times EF \times ED}{AT}$$

where:

- C_s = Concentration in soil (mg/kg)
- CF = Conversion factor (10^3 µg/mg)
- PEF = Particulate emission factor (cubic meters [m^3]/kg)
- ET = Exposure time (fraction of day)
- EF = Exposure frequency (days/year)
- ED = Exposure duration (years)
- AT = Averaging time (days)

For hypothetical future residential receptors an age-adjusted factor is used to combine child and adult receptors in Equation 3, above, for carcinogenic chemicals. This factor incorporates age-specific factors such as body weight, inhalation rate and exposure duration. All inhalation exposure estimates will be quantified consistent with RAGS Part F, Supplemental Guidance for Inhalation Risk Assessment (USEPA, 2009d).

Dermal Absorption Pathway:

$$(4) \qquad \text{Dermally Absorbed Dose}\ (\frac{mg}{kg \times d}) = \frac{C_s \times AF \times ABS \times SA \times CF \times EF \times ED}{BW \times AT}$$

where:

- C_s = Concentration in soil (mg/kg)
- AF = Soil adherence factor (mg/(square centimeters [cm^2]-day))
- ABS = Skin absorption factor (unitless)
- SA = Skin surface area (cubic centimeters [cm^3])
- CF = Conversion factor (10^{-6} kg/mg)
- EF = Exposure frequency (days/year)
- ED = Exposure duration (years)
- BW = Body weight (kg)
- AT = Averaging time (days)

For hypothetical future residential receptors an age-adjusted factor is used to combine child and adult receptors in Equation 4, above, for carcinogenic chemicals. This factor incorporates age-specific factors such as body weight, skin surface area, soil adherence factor, and exposure duration.

Surface Water. Equations for quantifying potential exposures of human receptors to COPCs in P4 Site surface water through direct exposure pathways are presented below.

Incidental Ingestion:

$$(5)\qquad \text{Incidental Ingestion Dose } \left(\frac{mg}{kg \times d}\right) = \frac{C_{sw} \times IR_{sw} \times EF \times ED}{BW \times AT}$$

where:

- C_{sw} = Concentration in groundwater (milligrams per liter [mg/L])
- IR_{sw} = Ingestion rate (liters water/day)
- EF = Exposure frequency (days/year)
- ED = Exposure duration (years)
- BW = Body weight (kg)
- AT = Averaging time (period over which exposure is averaged – days).

For hypothetical future residential receptors an age-adjusted factor is used to combine child and adult receptors in Equation 5, above, for carcinogenic chemicals. This factor incorporates age-specific factors such as body weight, water ingestion rate, and exposure duration.

Dermal Contact:

$$(6)\qquad \text{Dermally Absorbed Dose } \left(\frac{mg}{kg \times d}\right) = \frac{C_{sw} \times CF \times SA \times DA_e \times EF \times ED}{BW \times AT}$$

where:

- C_{sw} = Concentration in surface water (mg/L)
- CF = Conversion factor (10^{-3} L/cm^3)
- SA = Skin surface area exposed while wading (cm^2)
- DA_e = Dermal permeability constant (cm/event)
- EF = Exposure frequency (days/year)
- ED = Exposure duration (years)
- BW = Body weight (kg)
- AT = Averaging time (period over which exposure is averaged – days)

For hypothetical future residential receptors an age-adjusted factor is used to combine child and adult receptors in Equation 6, above, for carcinogenic chemicals. This factor incorporates age-specific factors such as body weight, skin surface area, dermal permeability constant and exposure duration.

Groundwater. Equations for quantifying potential exposures of human receptors to COPCs in P4 Site groundwater through direct exposure pathways are presented below.

Ingestion:

$$(7)\qquad \text{Incidental Ingestion Dose}\ (\frac{mg}{kg \times d}) = \frac{C_{gw} \times IR_{gw} \times EF \times ED}{BW \times AT}$$

where:

C_{gw} = Concentration in groundwater (milligrams per liter [mg/L])
IR_{gw} = Ingestion rate (liters water/day)
EF = Exposure frequency (days/year)
ED = Exposure duration (years)
BW = Body weight (kg)
AT = Averaging time (period over which exposure is averaged – days).

For hypothetical future residential receptors an age-adjusted factor is used to combine child and adult receptors in Equation 7, above, for carcinogenic chemicals. This factor incorporates age-specific factors such as body weight, water ingestion rate, and exposure duration.

Dermal Contact:

$$(8)\qquad \text{Dermally Absorbed Dose}\ (\frac{mg}{kg \times d}) = \frac{C_{gw} \times CF \times SA \times DA_e \times EF \times ED}{BW \times AT}$$

where:

C_{gw} = Concentration in surface water (mg/L)
CF = Conversion factor (10^{-3} L/cm^3)
SA = Skin surface area exposed while wading (cm^2)
DA_e = Dermal permeability constant (cm/event)
EF = Exposure frequency (days/year)
ED = Exposure duration (years)
BW = Body weight (kg)
AT = Averaging time (period over which exposure is averaged – days)

For hypothetical future residential receptors an age-adjusted factor is used to combine child and adult receptors in Equation 8, above, for carcinogenic chemicals. This factor incorporates age-specific factors such as body weight, skin surface area, dermal permeability constant and exposure duration.

Vegetation. Equations for quantifying potential exposures of human receptors to COPCs in P4 Site vegetation (i.e., homegrown produce and culturally significant plants) are presented below.

$$(9)\qquad \text{Ingestion of plant matter}\ (\frac{mg}{kg \times d}) = \frac{C_p \times (IR_p \times EF \times ED \times FI)}{BW \times AT}$$

where:

C_p = Concentration of contaminant in homegrown produce or culturally significant plant (mg/kg).
IR_p = Intake rate (milligrams [mg] /day)
CF = Conversion factor (10^{-6} kilogram [kg]/mg)
EF = Exposure frequency (days/year)
ED = Exposure duration (years)
BW = Body weight (kg)
FI = Fraction ingested that is Site-related (unitless)
AT = Averaging time (period over which exposure is averaged – days)

Where site-specific plant tissue data are incomplete or unavailable, plant tissue concentrations will be modeled based on uptake from primary media (i.e., soil or sediment) as described in Equation 10, below, and as further discussed in Section 4.2.2.1.

(10)
$$C_p = C_s \times BCF_{s-p}$$

where:

C_p = Total COPEC concentration in plant tissue (mg COPEC/kg dry tissue).
C_S = Concentration of COPEC in soil or sediment (mg COPEC/kg dry soil or sediment)
BCF_{s-i} = Bioconcentration factor from soil or sediment to plant tissue (kg dry plant tissue/kg dry soil or sediment).

Fish. Equations for quantifying potential exposures of human receptors to COPCs in P4 Site fish tissues are presented below.

(11)
$$\text{Ingestion of fish tissues } \left(\frac{mg}{kg \times d}\right) = \frac{C_f \times IR_f \times EF \times ED \times FI}{BW \times AT}$$

where:

C_f = Concentration of contaminant in fish (mg/kg)
IR_f = Fish ingestion rate (mg day)
CF = Conversion factor (10^{-6} kg/mg)
EF = Exposure frequency (days/year)
ED = Exposure duration (years)
FI = Fraction ingested that is Site-related (unitless)
BW = Body weight (kg)
AT = Averaging time (period over which exposure is averaged – days)

Where site-specific fish tissue data are incomplete or unavailable, COPC concentrations in fish tissues (C_f) will be modeled based on uptake from surface water as described in Equation 12, below, and as further discussed in Sections 4.2.2.1 and 4.2.2.2.

(12) $$C_f = C_w \times BCF_{w-f}$$

where:

C_f = COPC concentration in fish tissue (mg/kg dry tissue)
C_w = COPC concentration in water (mg COPC/liter of water)
BCF_{w-f} = Bioconcentration factor from water to fish tissue (liter of water/kg of dry tissue).

Beef and Elk. The equation for quantifying potential exposures of human receptors to COPCs in P4 Site beef and elk tissues is presented in Equation 13, below.

(13) $$\text{Ingestion of beef and elk tissue } \left(\frac{mg}{kg \times d}\right) = \frac{C_{lm} \times IR_{lm} \times CF \times EF \times ED \times IF}{BW \times AT}$$

where:

C_{lm} = Concentration of contaminant in large mammal tissues (mg/kg)
IR_{lm} = Ingestion rate of large mammal tissue (mg/day)
CF = Conversion factor (10^{-6} kg/mg)
EF = Exposure frequency (days/year)
ED = Exposure duration (years)
IF = Fraction ingested that is Site-related (unitless)
BW = Body weight (kg)
AT = Averaging time (period over which exposure is averaged – days)

3.3.3 Toxicity Assessment

This section describes the toxicity assessment methodology to be used in the evaluation of human health risks for the Sites. Human health toxicity assessment methods were developed in accordance with USEPA guidance (USEPA, 1989).

The human health toxicity assessment involves a critical review and interpretation of toxicology data from epidemiological, clinical, animal, and in vitro studies. A review of toxicology data ideally determines both the nature of health effects associated with a particular chemical and the probability that a given dose of a chemical could result in an adverse health effect. In accordance with the USEPA's 2003 Directive (USEPA, 2003), the following hierarchy of sources of toxicity values will be used in the baseline HHRA for the Sites:

1. Integrated Risk Information System (IRIS) Database (USEPA, 2011b).
2. Provisional Peer Reviewed Toxicity Values (PPRTVs) (USEPA, 2011c).
3. *Health Effects Assessment Summary Tables* (HEAST) (USEPA, 1997a).
4. Agency for Toxic Substances and Disease Registry (ATSDR) Minimal Risk Levels (ATSDR, 2008).

The most recent version of the above sources of toxicity criteria available at the time the HHRA is prepared will be used.

Toxicology information important for quantitative risk assessment of long-term health effects is generally divided into the following two categories:

- Potential for carcinogenic health effects
- Potential for chronic noncarcinogenic, adverse health effects

3.3.3.1 Carcinogenic Effects of COPCs

The cancer slope factor (CSF) is the toxicity value used to quantitatively express the carcinogenic potential of cancer-causing constituents following oral or dermal exposure. The slope factor is expressed in units of $mg/kg\text{-}day^{-1}$ and represents the cancer risk per unit daily intake of a carcinogenic chemical. The carcinogenic potential of cancer-causing constituents following inhalation exposure is quantified by a unit risk factor (URF). The URF has units of the inverse of micrograms per cubic meter $(\mu g/m^3)^{-1}$ and represents the cancer risk for a specified air concentration of a carcinogenic chemical. The CSF and URF represent the upper 95 percent confidence interval of the slope of the dose response curve. The 95 percent upper confidence interval assures a safety factor to protect the most sensitive receptors.

All carcinogenic toxicity assessments will be performed consistent with RAGS Part F, Supplemental Guidance for Inhalation Risk Assessment (USEPA, 2009b).

3.3.3.2 Noncarcinogenic Effects of COPCs

The reference dose (RfD) is the toxicity value used to quantitatively express the potential for a chemical to produce chronic, noncarcinogenic effects following oral or dermal exposure. The RfD is expressed in units of mg/kg-day and represents a daily intake of contaminant per kg of body weight that is not sufficient to cause the threshold effect of concern for the contaminant. The potential for a noncarcinogenic chemical to produce chronic effects following inhalation exposure is quantified by a reference concentration (RfC), in units of milligrams per cubic meter (mg/m^3). The RfC represents the air concentration of a noncarciogenic chemical that is not sufficient to cause effects. Exposures that are above the RfD or RfC could potentially cause adverse health effects. Confidence in the RfD or RfC is subjective, based on USEPA review groups and the quality of the supporting database. Chemical-specific RfD and RfCs do not account for the potential effects of chemical mixtures.

RfD and RfCs are generally based on no observable adverse effect levels (NOAELs) derived from animal studies. When NOAEL values are unavailable, a lowest observable adverse effect level (LOAEL) is generally used. An uncertainty factor (UF) is typically incorporated into the RfD or RfC to reduce the numerical value, resulting in a more conservative toxicity value.

In addition to UFs, modifying factors (MFs) are often used in calculating RfD and RfCs. A MF ranging from 0 to 10 can be included to reflect a qualitative, professional assessment of additional uncertainties in critical studies and available databases.

All noncarcinogenic toxicity assessments will be performed consistent with RAGS Part F, Supplemental Guidance for Inhalation Risk Assessment (USEPA, 2009b).

3.3.4 Risk Characterization

The Tier II baseline human health risk characterization for the Sites will integrate results of the exposure and toxicity assessments described in Sections 3.2 and 3.3, respectively, to derive a quantitative and qualitative evaluation of potential risks to current and potential future human receptors. Methods to be used in the characterization of Tier II baseline human health risks are described below.

Calculated exposure doses for each COPC identified for a particular media will be used to estimate chemical-specific and cumulative cancer risks; and non-cancer hazard quotients (HQs) and hazard indices (HIs).

The pathway specific risk of developing cancer from exposure to a carcinogenic chemical is estimated by multiplying the CSF by the exposure dose, or the URF by the concentration (USEPA, 1989):

(14) $$\mathrm{ILCR(unitless)} = \mathrm{CSF\ (or\ URF)} \times \mathrm{Dose\ (or\ Concentration)}$$

where:

ILCR = Incremental lifetime cancer risk (unitless)
CSF = Cancer slope factor $(mg/Kg\text{-}day)^{-1}$
URF = Unit risk factor $(\mu g/m^3)^{-1}$
Concentration = Exposure concentration ($\mu g/m^3$)
Dose = Exposure dose (mg/Kg-day)

Pathway specific cancer risks for individual chemicals are summed to derive a chemical specific risk. Cancer risks from multiple COPCs identified for a site medium are assumed to be additive and will be summed to estimate a cumulative ILCR for all carcinogenic site contaminants in that medium. Additionally, cancer risks calculated for various site media will be summed, as appropriate, to estimate cumulative ILCRs for each receptor.

The HQ describes the potential for site COPCs to produce noncarcinogenic effects. The pathway specific HQ is defined as the ratio of the exposure dose to the RfD, or the concentration to the RfC (USEPA, 1989a):

$$\text{HQ (unitless)} = \frac{\text{Dose (or Concentration)}}{\text{RfD (or RfC)}} \qquad (15)$$

where:

HQ	=	Hazard quotient (unitless)
Concentration	=	Exposure concentration (mg/m^3)
Dose	=	Exposure dose (mg/Kg-day)
RfC	=	Reference concentration (mg/m^3)
RfD	=	Reference dose (mg/Kg-day)

A chemical-specific HQ is derived by summing the pathway specific hazards. An HQ greater than 1 indicates that the estimated exposure dose for that COPC may not be protective of noncarcinogenic health effects. An HQ of less than 1 suggests that noncarcinogenic health effects should not occur. Individual HQs for site COPCs will be summed to produce a cumulative hazard estimate, termed the HI. In cases where the cumulative HI exceeds 1, the HI will be re-evaluated based on target organ effects and a maximum target organ-specific HI will be reported. This procedure is consistent with USEPA risk assessment guidance (USEPA, 1989).

USEPA currently considers sites with a cumulative cancer risk estimate between 1×10^{-6} and 1×10^{-4}, and a noncancer HI of less than 1, to be appropriate for conditional closure (USEPA, 1991). IDEQ considers a cumulative cancer risk of 1×10^{-5} and noncancer HI of 1 as the point of departure for making risk management decisions concerning a site (IDEQ, 2004a). A single value rather than a range was selected by IDEQ to facilitate risk management decisions. Sites associated with cumulative cancer risk and noncancer HI estimates that exceed these criteria will be proposed for (1) additional data collection to revise the conceptual exposure model and provide more realistic exposure and risk estimates, or (2) evaluation of remedial alternatives. In addition, conditional closure will be considered following an evaluation of site-specific issues related to future land uses, the technical feasibility of remediation, and related considerations.

3.3.5 Background Risk Calculations

Site-specific background data for metals are available for various biotic and abiotic media including, but not limited to, soil, surface water, groundwater and terrestrial vegetation. Methods and procedures to be used in the derivation of background statistics for background data sets will be presented in a forthcoming technical memorandum. Background data will be used to calculate Site-related risks and background risks for metals that are retained as refined COPCs using the same process as described in the proceeding sections. Background risks will be calculated both for the Tier I screening HHRA and the Tier II baseline HHRA. Background risk estimates for the Tier I HHRA will be calculated using Site-specific maximum detected concentrations and default exposure assumptions. Tier I screening background cancer risk and noncancer hazard estimates will be used in a qualitative comparison to total site cancer risk and noncancer hazard estimates.

Tier II baseline HHRA background cancer risk and noncancer hazard estimates will be calculated based on upper-bound average EPCs and RME exposure assumptions. Background data will be used to calculate Site-related risks and background risks for metals that are retained as refined COPCs using the same process as described in the proceeding sections. In addition, incremental risk estimates will be calculated for each Site by subtracting ambient cancer risk and noncancer estimates from total cancer risk and noncancer hazards for each receptor and COPC combination. Incremental risk estimates for carcinogenic COPCs and noncarcinogenic COPCs will be presented separately. The underlying rationale for calculating incremental risk estimates for metals in environmental media is that some fraction of the concentration of a metal is naturally occurring. Therefore, an incremental risk estimate represents that portion of the total risk (i.e., Site-related and ambient risk) that is above natural, baseline conditions.

Incremental risk estimates for all carcinogenic COPCs will be summed to calculate the cumulative, incremental carcinogenic risk for each receptor. Cumulative, incremental carcinogenic risk estimates for the Sites will be compared to USEPA's risk management range of 1×10^{-6} to 1×10^{-4} for carcinogenic risk (USEPA, 1991), and IDEQ point-of-departure cancer risk criterion of 1×10^{-5}, when making risk management recommendations. Sites with a cumulative, incremental carcinogenic risk estimate above these criteria will be proposed for further evaluation in a Tier III HHRA, as described in Section 3.4 below, or for evaluation of remedial alternatives in the FS portion of the RI/FS.

Incremental noncancer HQ estimates for all noncarcinogenic COPCs will be summed to calculate the cumulative, incremental noncancer HI for each receptor. Cumulative, incremental noncancer HIs will be compared to USEPA's non-cancer HI criterion of 1. In the event that the total cumulative, incremental noncancer HI estimate summed across all noncarcinogenic COPCs exceeds 1, target organ-specific incremental HI estimates will be calculated. Target organ-specific incremental HI estimates for each receptor will be compared to USEPA's non-cancer HI criterion of 1. Sites with a cumulative, target organ-specific incremental non-cancer HI estimate greater than 1 will be proposed for further evaluation in a Tier III HHRA, as described in Section 3.4 below, or for evaluation of remedial alternatives in the FS portion of the RI/FS.

3.4 Tier III HHRA

As described in Sections 3.2 and 3.3, the Tier I and II HHRAs will be performed for each Site so the risks for each can be evaluated independently. Depending on results of the Tier II HHRA, further risk evaluations for specific receptors and COPCs may be conducted to determine the degree to which areas with adverse risk are localized, and to refine risk estimates based on site-specific exposure assumptions and information (e.g., local dietary surveys), as available. Tier III HHRA procedures may be implemented if unacceptable carcinogenic risks and noncancer hazard estimates for human receptors are identified in the Tier II assessment, or if the associated uncertainties in these risk estimates are high. Tier III HHRA procedures are intended to assist with remedy selection, if warranted, and will be used in the FS to refine areas requiring remediation. Specific procedures for Tier III will be determined through discussion with the A/Ts following review and discussion of the Tier II HHRA results.

4.0 ECOLOGICAL RISK ASSESSMENT

The process defined here for ecological risk assessment (ERA) is consistent with procedures defined for the HHRA using USEPA (1997) and IDEQ (2004a) guidance, and with prior regional risk assessments that were conducted for the Sites. As further described in this section, the ERA will be structured in a tiered manner with each tier presenting further refinements to the exposure and effects characterization steps used in the preceding tier. The Tier I ERA will consist of a conservative, screening-level ERA to identify COPECs, media of concern, and receptors of concern for each of the Sites. Tier II will consist of a baseline ERA that will be implemented on a Site-specific basis and use refined exposure and effects characterization methods. Tier III will be implemented, as needed, based on the results of Tier II, and will consist of further refinements to evaluate ecological exposures to specific sources areas within each Site, and/or to consider Site-specific exposure information.

The ERA methods, assumptions and screening criteria described below are applicable to the preparation of a baseline ERA that evaluates effects of chronic exposures of Site contaminants on wildlife and livestock. Because cases of livestock illness or death following acute exposures to selenium are well documented within the Southeast Idaho Phosphate Resource Area, acute exposures of livestock to selenium will also be evaluated, as described in Sections 4.2.3 and 4.2.4.

4.1 COPEC Screening

The COPEC screening is intended to focus the risk assessment on COPECs primarily through a comparison of Site chemical concentrations to media-specific (soil, surface water, and sediment) screening levels. The Site concentrations to which these screening levels will be compared are maximum concentrations, determined for each of the Sites, based on data determined to be of adequate quality for risk assessment purposes (Section 3). These screening levels as well as other tools used to refine COPECs are discussed in this section.

4.1.1 Screening Levels

Selected screening levels, or benchmarks, representing the lowest medium-specific screening criteria available from sources reviewed, are presented in Tables C4-1 (soil), C4-2 (surface water), and C4-3 (sediment). These screening benchmarks are intended to represent concentrations below which there are no ecological concerns.

4.1.1.1 Soil

The selected soil screening benchmark presented in Table C4-1 represents the lowest value of the screening criteria evaluated for each COPEC. Soil screening benchmarks for mammalian and avian indicator receptors were selected from available benchmarks based on the following preferred hierarchy:

1. USEPA EcoSSLs (USEPA, various dates)
2. ORNL (ORNL, 1996b)
3. Primary literature

Medium-based benchmarks for lower trophic level receptors were selected from available benchmarks based on the following preferred hierarchy:

1. USEPA EcoSSLs (USEPA, various dates)
2. ORNL (ORNL, 1996a, 1996b, 1997a, 1997b, 1997c)
3. Environmental Residue Effects Database (ERED) – maintained by USACE and USEPA and available at: http://el.erdc.usace.army.mil/ered/ (USACE, 2010)
4. USEPA Ecotox Database available at http://cfpub.epa.gov/ecotox/help.cfm?sub=aboutEPA
5. Aquatox available at http://www.epa.gov/waterscience/models/aquatox/

4.1.1.2 Surface Water

Surface water screening benchmarks presented in Table C4-2 were selected from available benchmarks based on the following preferred hierarchy:

1. State of Idaho surface water quality criteria (IDAPA 58.01.02)
2. USEPA National Recommended Water Quality Criteria (USEPA, 2010a)
3. ORNL toxicological benchmarks for aquatic biota (ORNL, 1996a)

4.1.1.3 Sediment

Sediment screening benchmarks presented in Table C4-3 were selected from available benchmarks based on the following preferred hierarchy:

1. Sediment Evaluation Framework (SEF) recently prepared by IDEQ and others for the Pacific Northwest (USACE et al., 2009)
2. Selenium specific value from Van Derveer and Canton (1997)
3. National Oceanic and Atmospheric Administration (NOAA) Screening Quick Reference Tables (SQuiRTs; Buchman, 2008)

4.1.2 Other COPEC Screening Tools

Other tools used to determine whether a chemical will be retained as a COPEC for evaluation in the tiered-ERA are:

- Is the chemical considered to be an essential nutrient in which case screening levels may not be available? Essential nutrients will not be evaluated in the tiered-ERA.
- Is the chemical detected at a frequency of five percent or less[1]? Those chemicals that are infrequently detected in sub areas of the Sites are not considered to significantly contribute to risk or remedy decision making at the Sites. For those chemicals considered for removal from the list of COPECs, they will not be removed until the concentration magnitude and the spatial distribution of these detections are evaluated and determined to be of little concern, so that chemical "hot spots" are not inadvertently missed. Not more than five percent of the detected concentrations may exceed screening levels.
- Are site concentrations of COPECs less than or equal to background concentrations? Given the understanding that some inorganic chemical concentrations are or may be naturally elevated in the region, it is important to focus the risk characterization on those COPECs where mine practices are considered to have elevated concentrations above those that are naturally occurring.
- Is the chemical potentially bioaccumulative and toxic to upper trophic level wildlife? Even if a chemical is screened out based on comparison to screening levels, generally intended for the protection of lower trophic level producers and consumers, if these chemicals may be transferred up the food chain through ingestion and potentially toxic, these chemicals will be retained for evaluation in Tier II.

A COPEC chemical will be retained for further evaluation in Tier II even if it was not identified as of concern in all media evaluated.

4.2 Tier I and II ERA

Tier I and II ERA procedures described by USEPA under CERCLA (USEPA, 1997) will be used to quantitatively evaluate ecological risks to identified assessment endpoints for each mine so the risks for each Site can be evaluated independently. Similar to the HHRA, risk estimates from the Tier I ERA are termed screening level risk estimates and those from the Tier II ERA are termed baseline risks. The tiered process is intended to further focus and refine the risk evaluation by potentially eliminating both COPECs or specific exposure pathways and by reducing inherent uncertainties. Both Tier I and Tier II with use the same methods, but the assumptions regarding the potential for exposures and adverse effects to occur will be skewed in the Tier I screening to represent the upper bounds of potential exposure and the lower bounds of potential for adverse effects. Thus, any COPECs, or exposure pathways/receptors that may be eliminated in Tier I are done so with a high degree of certainty that adverse effects will not

[1] This approach is used by EPA in human health risk assessment and is routinely adopted as a screening tool in ecological risk assessments. See Section 5.9.3 of Part A of the Risk Assessment Guidance for Superfund (RAGS)(EPA1989).

occur. The specific differences in assumptions between these two Tiers are discussed in further detail in Section 4.2.2 (Exposure Analysis) and Section 4.2.3 (Effects Analysis).

The COPECs and exposure pathways may differ between individual Sites based on the COPEC screening results and based on differences in ecological habitats and, therefore, receptors present. The process framework consists of three phases: the problem formulation phase, the analysis phase, and the risk characterization phase (Figure C4-1). The problem formulation is the first phase of the process where the problem, the purpose of the assessment, and plan for analyzing and characterizing risk are defined. Discussion and planning among risk managers and risk assessors are important components of this phase of the ERA (Figure C4-1) and thus, are important to clarify during the work plan stage of the RI/FS process. The second step of the process is the analysis phase in which potential ecological exposures to environmental stressors are quantified as are the potential adverse ecological effects from these environmental stressors. During the third phase of the process, risk characterization, the exposure and effects analyses are integrated. In this phase the likelihood of adverse ecological effects occurring is estimated. Major uncertainties, assumptions, and strengths and limitations of the assessment are also summarized in the risk characterization. The methods proposed to execute each of these phases of the ERA are defined below.

4.2.1 Problem Formulation

Problem formulation is a formal process for generating and evaluating preliminary hypotheses about the potential for adverse ecological effects to have occurred. The primary components of problem formulation are:

- Identification of the ecosystem at risk
- Identification of stressor characteristics
- Identification of known effects
- Selection of assessment endpoints
- Construction of a CSM

These components are discussed in the sections below.

4.2.1.1 Ecosystem at Risk

An ecosystem is composed of biological, physical, and chemical elements that function together in a complex, inter-dependent manner. Ecosystems are dynamic and change with alterations in one or more of their elements. The objective of this section is to describe the ecological setting from which more narrowly defined specific assessment and measurement endpoints (Section 3.2.3) can be selected and can be linked together in a CSM. The simplification of complex ecosystem attributes into a select few is necessary for the risk assessment process to be implemented. Our objective in this section is to transparently describe how this complex information will be reduced to specific endpoints for the assessment of risk.

Disregarding the influence of environmental contaminants, the abundance and diversity of wildlife in an area is directly dependent on habitat characteristics such as type, quality and quantity. Primary resources used to describe the habitats that occur in the Sites and the species that use these habitats include site-specific surveys and previous investigations of the Southeast Idaho phosphate resource area region including the *Regional Investigation Report* (MW, 1999) and the regional *Area-wide Human health and Ecological Risk Assessment* (Tetra Tech, 2002). This section is organized into two categories: (1) habitat characteristics and (2) species potentially found at the Sites that use these habitats.

Habitat Characteristics. The Sites exist in a transitional ecosystem between the Great Basin vegetation to the south and the Rocky Mountain vegetation to the north and east. Land within the area is managed by the state of Idaho, the USFS, and the BLM. There is also private land ownership, and parts of the area are developed and used for agriculture or grazing.

Terrestrial - There are several plant communities present at the Sites as a result of variations in elevation, moisture, temperature, soil type, slope and aspect. Plant communities include mixed conifer/aspen forest, sagebrush/grassland, aspen forest, and riparian/wetlands. The mixed aspen and conifer forests are characterized by occasional dense stands of aspen surrounded by open stands of aspens or conifers. Dominant conifer species within the vicinity of the Sites include lodgepole pine, Douglas fir, and subalpine fir with understory plants including snowberry, serviceberry, chokecherry, and various grasses and forbs. The sagebrush communities occur mainly on dry soils or rocky outcrops. Dominant species include big sagebrush, mountain snowberry, yellow rabbitbrush, antelope bitterbrush and various forbs such as alfalfa, lupine, scorpion weed, white sage, sticky geranium, and mule's ears, as well as various grass species. Riparian and wetland vegetation is similar in composition to other vegetation communities, with willow, cattail, rush and sedge species often present. Stream habitats within the vicinity of the Sites have been sampled for periphyton, plankton, macrophytes and benthic invertebrates, and a variety of these species are present. Several streams within the vicinity of the Sites are fish-bearing and fish samples have been collected. Fish species sampled included the Utah chub, sculpin, cutthroat trout, rainbow trout and brook trout (MW, 1999).

The habitats described above support a variety of animal and avian species. The conifer-aspen communities support black bear, snowshoe hare, yellow pine chipmunk, great horned owl, downy woodpecker and western bluebird. The sagebrush-grass communities support coyote, deer mouse, prairie falcon, sage grouse and mourning dove. Riparian and marsh communities support moose, beaver, muskrat, belted kingfisher, mallard duck, great blue heron, sandhill crane and common snipe (MW 1999).

A 2009 vegetation survey and sampling event at the Sites identified dominant species that were sampled for each area. Most of the areas sampled were sagebrush/grassland communities, as well as some aspen/conifer communities (SV Tech Memo).

- Ballard Mine common species include: *Pascopyrum smithii* (western wheatgrass); *Dactylis glomerata* (orchardgrass); *Bromus tectorum* (cheatgrass); *Bromus inermis* (smooth brome); *Medicago sativa* (alfalfa); *Achillea millefolium* (western yarrow); *Geranium viscosissimum* (sticky geranium); *Lappula occidentalis* (flatspine stickseed); *Amelanchier alnifolia* (serviceberry); *Artemesia tridentate* (big sagebrush); and *Populus* tremuloides (quaking aspen).

- Henry Mine common species include: *Bromus inermis* (smooth brome); *Bromus marginatus*: (mountain brome); *Dactylis glomerata* (orchardgrass); *Pascopyrum smithii* (western wheatgrass); *Medicago sativa (*alfalfa); *Artemesia ludoviciana* (white sage); *Collomia linearis* (slenderleaf collomia); and *Artemesia tridentate* (big sagebrush).

- Enoch Valley Mine common species include: *Bromus inermis* (smooth brome); *Bromus marginatus* (mountain brome); *Dactylis glomerata* (orchardgrass); *Pascopyrum smithii* (western wheatgrass); *Achillea millefolium* (western yarrow); *Geranium viscosissimum* (sticky geranium); *Linum lewisii* (Lewis flax); *Wyethis amplexicaulis* (mule's ears); *Amelanchier alnifolia* (serviceberry); *Artemesia tridentate* (big sagebrush); and *Populus tremuloides* (quaking aspen).

Aquatic. Several perennial creeks and numerous drainages that contain intermittent streams occur in the vicinity of the Sites; the largest of which are the Little Blackfoot and Blackfoot rivers. These relatively small rivers contain aquatic habitat suitable to support some fish species. There are also eighteen identified ponds of varying habitat quality (IDEQ, 2004b) and several streams and drainages with surrounding riparian vegetation within the Sites.

An aquatic functional use survey of ponds (non-regulated surface water features) at the Sites was conducted in June 2004 (IDEQ, 2004b). This review categorized all ponds into one of three tiers as follows:

- Tier 1 – surface water features that appeared to provide adequate open water, emergent vegetation, protective cover, and food sources to support a local resident migratory bird population during typical nesting/breeding seasons.
- Tier 2 – surface water features within grazing allotments, those exhibiting evidence of livestock use, or ponds with a reasonable potential for future livestock use as drinking water.
- Tier 3 – surface water features used as an occasional drinking water source by transitory terrestrial wildlife.

The results of this survey by Site are summarized in Table C4-4. None of the ponds at Ballard Mine (n=5) are Tier 1, two of the four ponds at Henry Mine are Tier 1, and four of the eight mines at Enoch Valley Mine are Tier 1. In addition, RBS stream surveys were implemented to characterize the habitat quality of flowing waters at the Sites, the results of which are presented in Table C4-5. None of the stations evaluated at the Ballard Mine had or were likely to have fish present, and had corroborating low RBS scores. RBS scores at the other two mines ranged both higher and lower than at Ballard, and both mines showed the presence or likely presence of fish at approximately half the stations evaluated.

Species. As previously indicated, prior regional studies have documented species occurrence (MW, 1998, Tetra Tech, 2002). Additionally, many Site-specific studies have been conducted and are sources of information on species that are specifically known to occur on the Sites or in relevant background areas (Table C4-6). Below, specific invertebrates, reptiles and amphibians, fish, birds, mammals, and threatened and endangered species are presented that have been identified at or near the Sites.

Invertebrates - Invertebrates such as worms, insects, crustaceans and spiders, are primary consumers in the food web. Sampling has occurred of both benthic and terrestrial invertebrates. These organisms are important prey for birds, reptiles, amphibians and small mammal and fish species. Several taxa of invertebrates have been sampled for analyses of tissue concentrations on the Sites including:

Ephemeroptera (mayflies), Odonata (dragonflies and damselflies), Plecoptera (stoneflies), Hemiptera (aphids, cicadas), Coleoptera (beetles), Megaloptera (alderflies, fishflies), Trichoptera (caddis flies), Diptera (mosquitoes), Lepidoptera (moths and butterflies), Erpobdelliformes (leeches), Rhynchobdellida (leeches), Hiridinea (leeches), Haplotaxida (worms), Lumbriculidae (freshwater oligochaetes), Oligochaeta (earthworms), Nematoda (roundworms), Veneroida (bivalve mollusks), Pulmonata (snails and slugs), Mesogastropoda (snails), Gastropoda (mollusks), Ctenobranchiata (mollusks), Amphipoda (crustaceans), Ostracoda (crustaceans), Turbellaria (flatworms), Tricladida (flatworms), and Hydroida (cnidarians).

Reptiles and Amphibians - Reptiles and amphibians have not been surveyed or sampled in the vicinity of the Sites, but several species are known to occur, as noted in the Regional Investigation Report (MW, 1999). Amphibians in the area include the tiger salamander, the western toad, the leopard frog and the western chorus frog. Reptiles within the area include the sagebrush lizard, the gopher snake, the western and common garter snake, the racer and the western skink. These organisms are secondary consumers and may be prey for higher trophic level species.

Fish - A total of 24 fish species have been documented in the region, half of which have been collected and analyzed for tissue levels of contaminants (Table C4-7). Rivers and streams within the vicinity of the Sites are host to populations of forage fish (minnows) as well as benthic fish (suckers and sculpins), and higher trophic level salmonid species (trout) that are important ecologically and as game fish. Benthic fish are most closely in contact with sediment and are most likely to consume sediment during their foraging for benthic invertebrates, algae, detritus, plants and small fish. Forage fish inhabit benthopelagic areas, from near the sediment surface to mid- waters, and may feed at the water surface. Forage fish consume a varied diet of zooplankton, benthic invertebrates, terrestrial invertebrates, and small fish. In turn, forage fish are prey to larger fish and wildlife. The salmonid species occupy the highest trophic level of fish observed and are generally considered pelagic species that occupy the water column and maintain a diet of benthic invertebrates, terrestrial invertebrates, and fish. Salmonids may be prey for wildlife.

Birds - Birds in the vicinity of the Sites exist in all trophic levels (Table C4-8). Species like the house finch, the mourning dove and the trumpeter swan are all herbivores. Most species such as the robin, the crow and nuthatch, sparrow and warbler species consume both invertebrates and plant materials. There are also several species that are primarily carnivorous, including the great blue heron, which consume a diet dominantly composed of fish (i.e., piscivorous), and hawks such as the red-tailed hawk, the northern harrier, the Cooper's hawk and several owl species all of which eat mostly small mammals such as mice and voles. Bird eggs from various species have been sampled in the vicinity of the Sites.

Mammals - Mammal species within the vicinity of the Sites include species at many trophic levels (Table C4-9). These species include primary consumers and omnivores such as the deer mouse, the long-tailed vole, the least chipmunk and the Uinta ground squirrel. These species are often prey items for tertiary consumers like the carnivorous coyote. The mink is also a high trophic level species potentially occurring in the vicinity of the Sites, which dominantly feeds on area fish. Elk are also present in the vicinity of the Sites as primary consumers. Other mammals potentially found in the vicinity of the Sites include bats, gophers, beavers, chipmunks, deer, raccoons, porcupines and hares. Mammals that have been sampled on the Sites or in the region include: small mammals (deer mouse, least chipmunk, and western harvest mouse), and elk tissue samples.

Threatened and Endangered Species - Information regarding the potential for listed Endangered Species Act (ESA) species to occur on the Sites was obtained from the USFWS and Lynx (*Lynx Canadensis*) was reported to be the only species. A distinct population segment (DPS) of gray wolves (*Canis lupus*) identified as the Northern Rocky Mountain Population, and which includes gray wolf populations in Idaho, were reinstated on August 5th, 2010 as Endangered except in areas south of Interstate Highway 90.

4.2.1.2 Stressor Bioavailability and Exposure Routes

For toxicity to occur in an ecological receptor, there must be clear indications of the quantity of chemical exposure and the degree to which the chemical exposure may include a bioavailable fraction that can cause toxicity directly or indirectly through food web transfer. This section describes factors that affect the bioavailability of metals in aquatic and terrestrial environments based on routes of exposure to ecological receptors. Drexler et al. (2003) provides a recent and detailed review of factors affecting metals bioavailability in aquatic and terrestrial systems.

An overriding condition of metals exposure is that metals are naturally occurring and some are essential nutrients, such that plants and animals have evolved intricate strategies to balance nutrient levels and thus modulate exposures to metals (Drexler et al., 2003). These strategies may include: inhibited uptake, detoxification, storage, and increased elimination (Drexler et al., 2003). The ecological risk assessment will not quantitatively examine the relative contribution of each of these strategies. However, measures of tissue concentrations, for example whole fish, provide our best quantitative measure of site-specific exposure concentrations.

Aquatic Environment. Freely dissolved levels of inorganic ions are the best indicator of aquatic toxicity to phytoplankton, zooplankton, other invertebrates, and fish as evidenced by the development of national ambient water quality criteria (NAWQC) for inorganics (USEPA, 2009). Water hardness (concentrations of the cations calcium (Ca), magnesium (Mg), manganese (Mn)) can also affect the degree of bioavailability of inorganics and has been specifically incorporated into the application of water quality criteria for cadmium (Cd), chromium III (Cr III), lead (Pb), nickel (Ni), silver (Ag) and zinc (Zn). With the 2009 NAWQC update, USEPA now requires that the biotic ligand model be used to determine the bioavailability and toxicity for copper. The biotic ligand model is based on the hypothesis that toxicity is not simply related to total aqueous metal concentration, but that both metal-ligand complexation (organic and inorganic) and metal interaction with competing cations at the site of action of toxicity need to be considered. For fish, the biotic ligand appears to correspond to sites on the surface membrane of the gill responsible for regulating sodium ion uptake. Mortality occurs when the concentration of metal bound to the biotic ligand exceeds a threshold concentration. Dissolved organic (DOC) matter is known to be an important ligand for most metals in most natural waters and is an input variable in the biotic ligand model (USEPA, 2007). Biotic ligand models for other metals (aluminum (Al), cadmium, lead, nickel, silver, and zinc) are in the development stage, but have not been through review and acceptance by USEPA[2].

Water pH is another factor that influences the degree of metal complexation, and therefore, bioavailability and toxicity. Metal ions generally become more available as pH decreases since as pH decreases, there is a corresponding increase in H+ ions that compete with metal ions for complexation with DOC.

With regard to compensatory mechanisms in animals, rainbow trout have been shown to actively control whole body and tissue concentrations of copper and zinc (essential nutrients) such that concentrations in the fish were not well correlated with exposure concentrations, while concentrations of cadmium (non-essential) were correlated with exposure concentrations (Drexler et al., 2003). Mechanisms of this control of metals concentrations in trout have been shown to include uptake inhibition, detoxification and storage using matalothionine, and increased elimination (Drexler et al., 2003).

Water ingestion is also a contaminant exposure route for wildlife as is further described in Section 4.2.2.

Terrestrial Environment. Plants as sessile organisms have developed several means of managing toxic levels of metals: 1) excluding them at the root zone from biological uptake, 2)

[2] See Hydroqual's web site at: http://www.hydroqual.com/wr_blm.html as referenced on EPAs water quality web site (http://www.epa.gov/waterscience/criteria/copper/2007/index.htm)

sequester the metal in a non-toxic form once accumulated (Grill et al., 1985), and 3) adaptation. As evidence for adaptation, metal tolerant plants were historically used by those in the mining industry to determine where mineral concentrations were (Baker et al., 1988). Plants may exhibit a wide range of sensitivity to metals and in general, bulk soil concentrations have been found to be poor predictors of the bioavailable fraction of metals to plants (Lasat, 2000). The same issues of a broad range of sensitivities in species and a poor correlation between toxicity and bulk soil concentrations exists for terrestrial invertebrates too. Terrestrial invertebrates are exposed to contaminants in soil by direct contact and through ingestion. Alan (2002) has proposed the development of terrestrial biotic ligand models (tBLMs) to determine the bioavailable fraction of metals available to plants, invertebrates, and microbes and thus the potential for toxicity, but tBLMs have yet to be evaluated by USEPA. Bioavailable forms of metals for uptake include free metal ions and soluble metal complexes. Metal forms that are not bioavailable include: adsorbed to inorganic soil, bound to soil organic matter, precipitated as oxides, hydroxides and carbonates, and embedded in the structure of silicate minerals. Factors known to affect metals bioavailability include: cation exchange capacity (CEC), organic carbon levels, pH, and amorphous Al/Fe (Barnett and Hawkins, 2008).

Soil ingestion by birds and mammals may occur incidentally during foraging and may occur indirectly through prey consumption where the prey species (e.g., earthworms) have consumed soil which still resides in their gut and then are ingested by the predator species. Soil ingestion as a contaminant exposure route for wildlife is further described in Section 4.2.2.

Sediment. Benthic invertebrates, or invertebrates that live in the sediments found in streams and ponds in the vicinity of the Sites, are exposed to contaminants in sediment by direct contact and through ingestion. Sediment pore water has been identified as a major route of exposure of infaunal and epibenthic organisms to sediment contaminants (Adams et al., 2001). Factors that influence the bioavailable concentration of metals in pore water include those identified for surface waters and described above. The bioavailability of several metals (divalent metals, including copper, cadmium, nickel, lead, and zinc) is also dependent on the amount of sulfide in the sediment (McGrath et al., 2002). Under anoxic sediment conditions, sulfide is produced by sulfate reducing bacteria. Sulfide can bind with free metal ions to produce insoluble complexes that cause the metal to not be bioavailable. AVS is a very good measure of the portion of the solid phase sulfide that reacts with free metal. Predictions of metal bioavailability can be made based on measured concentrations of AVS and simultaneously extracted metal (SEM). SEM analyses are performed on the same extract used to determine AVS and measure how much of a reactive form of metal is present. If AVS concentrations are present in excess of SEM concentrations then it is likely that little reactive metal is available. If, however, AVS concentrations are lower than sum total SEM concentrations, than there may be excess and bioavailable metals.

Sediment ingestion by fish, birds, and mammals may occur incidentally during foraging and may occur indirectly through prey consumption where the prey species (e.g., chironomids) have consumed sediment which still resides in their gut and then are ingested by the predator species.

Sediment ingestion as a contaminant exposure route for wildlife is further described in Section 4.2.2.

Food. Transfer of contaminants to higher level predators in the food chain is a primary means by which animals are exposed to contaminants and has been an integral part of risk assessment modeling practices as developed by USEPA (USEPA, 1993, Drexler et al., 2003) and discussed in Section 4.2.2. Despite the occurrence of trophic transfer as an important and primary exposure route for animals, there are very few instances where metals have been found to biomagnify (i.e., increase in concentration with increasing trophic level) (Drexler et al., 2003). Assimilation efficiency of metals from the gut of the predator is dependent on the form of the metal that is found in the prey. For example, it has been shown for aquatic herbivores that consume algae, it is only the metals that are inside the algal cell that are assimilated, the metals bound to the exterior of the algal cell wall are eliminated through feces (Drexler et al., 2003). With regard to selenium, a particular metal of concern in the region, it can be both rapidly accumulated and rapidly excreted (approximately 70 to 80 percent) such that tissue body burdens may change within days and adverse effects from toxicity may be reversed if the adverse effects did not include developmental deformities (USDOI, 1998).

4.2.1.3 Known Effects

High levels of selenium, unique from other metals, have been documented as toxic to livestock since the 19th century. In the SE Idaho phosphate mining region, several instances of selenium toxicity have been documented:

- December 1996 – six horses grazing on private land located downstream from the former South Maybe Canyon phosphate mine were diagnosed with chronic selenosis (selemium poisoning) and five of these horses had to be destroyed.
- Summer 1997 – two horses pastured on the former Conda Phosphate Mine were diagnosed with selenosis and both animals had to be destroyed. 176 sheep were found dead in the Conda Mine area. The cause of death was not confirmed, but selenium poisoning was a possibility. Since then, other occurrences of sheep deaths have been reported at the Conda and Wooley Valley Phosphate Mines. Forensic examination of samples taken in every case showed elevated selenium concentrations in tissue and rumen although definitive conclusions as to the actual cause of the deaths were not made. Myocardial necrosis, a symptom of toxic selenosis, was found in the Wooley Valley sheep (Buck and Jones, 2004).
- August 5, 2009 – eighteen cattle died of likely selenium poisoning near defunct Lanes Creek Mine in the Idaho Phosphate mining region (Miller, 2009).

Efforts to understand the cause of these incidents were undertaken, and management practices have been implemented to prevent future occurrences of similar incidents.

4.2.1.4 Endpoint Receptor Selection

Endpoints define the focus of the ecological risk assessment and this section will identify both assessment and measurement endpoints. Assessment endpoints are explicit statements about what aspects of the ecological system (conditions or processes) are valued and intended for protection. Each assessment endpoint is evaluated for risk, which may not be directly quantifiable. Generally, assessment endpoints are populations or communities of ecological receptors (USEPA, 1997). Measurement endpoints are the various means by which the assessment endpoints are evaluated. Measurement endpoints are quantifiable indicators of the state of the valued conditions or processes through laboratory or field experimentation that are related to the characteristic chosen as the assessment endpoint.

The assessment and measurement endpoints for this ERA are shown in Table C4-10. Assessment endpoints include the survival and reproductive success of fish, birds and mammals. Baseline risk evaluations for plants, aquatic invertebrates, terrestrial invertebrates, and reptiles were not selected for detailed risk evaluations as is consistent with prior risk evaluations in the region (Tetra Tech, 2002) and IDEQ's intent to focus resources, minimize future site-specific risk assessment needs, and make decisions about Site-specific risk management using a process consistent with their regional perspective (IDEQ, 2004a).

Measurement endpoints for upper trophic level wildlife are evaluated based on an evaluation of risk to specific target receptors since it is neither possible nor practical to evaluate the risk posed to every potentially exposed species. Selection of indicator receptors focuses the ecological risk assessment on those ecological features or resources that have substantial aesthetic, social, or economic value or are important in the biological function or biodiversity of the system. Additionally, receptors provide a clear, logical connection between regulatory policy goals and anticipated ecotoxicological investigations. The selected indicator receptors are representative species from the feeding guilds identified for habitats in the Sites. A feeding guild represents a group of species which exploit the same ecosystem resources in the same way, and therefore could be expected have the same exposure to environmental contaminants. Feeding guilds for the Sites are described below:

A systematic approach was used to identify representative wildlife species (receptors) on which to base the ecological risk assessment for the Sites. The criteria used to select the representative species were as follows:

- *Species occurrence*. Species known to occur in the vicinity of the Sites (e.g., deer mouse) had priority for the evaluation over species that are transient or do not occur in the area (e.g., lynx) because they are likely to have much greater exposure to stressors from the site (discussed in Appendix C, Section 4.2.2.1.2).
- *Exposure frequency*. Receptors that are likely to have the highest exposures were selected over receptors with lower potential exposure. Exposure frequency was evaluated based on the organism's home range. Species with large home ranges (e.g., elk) will have lower

exposure frequency to chemicals at a site than nonmigratory animals with small home ranges (e.g. meadow vole) (discussed in detail for selected receptors in Appendix C Section 4.2.2 Exposure Analysis).

- *Foraging habits/Feeding guilds.* Foraging habits were evaluated to determine the pathways by which wildlife would become exposed. Both terrestrial and aquatic based foraging habits were evaluated. Species that forage on prey in the sediment will be exposed to contaminants through the incidental ingestion of sediments at higher rates than species that forage in the water column. Wildlife that forages on invertebrates that live in the sediment are also likely to be exposed to higher concentrations of chemicals because their prey has greater exposure to the sediment. The same analogy can be applied to soil based exposure pathways. Additionally, position in the food chain level (i.e., trophic level status) is an indicator of the likelihood of exposure to bioaccumulative chemicals, where wildlife in upper trophic levels are more highly exposed. For example we expect a seed eating migratory bird such as the American goldfinch to be less exposed to Site contaminants than a cutthroat trout that is in greater contact with potentially contaminated media and has a higher trophic position in the food web (see Appendix C Tables C4-7 through C4-9).
- *Ingestion rates.* Intake rates of sediment and food were evaluated because they help determine the potential level of exposure. Within similar feeding guilds, smaller species within a feeding guild will tend to have greater exposure to contaminants because they have higher rates of food consumption relative to their body weight per day (discussed in detail for selected receptors in Appendix C Section 4.2.2 Exposure Analysis).

Selection of receptors was based on the factors described above, prior precedence of receptor selection for the region (MW, 1999, Tetra Tech, 2002), and species occurrence described in Appendix C Section 4.2.1.1.2. Wildlife species (receptors) that were selected to represent of each assessment endpoint are presented in Table C4-10.

It should be noted that the elk was selected as the indicator receptor for the evaluation of large herbivorous mammals, based on the following. As described in *An Evaluation of the Effects of Selenium on Elk, Mule Deer, and Moose in Southeastern Idaho* (Kuck, 2003a) and *The Management of Big Game Populations, Their Habitat, and Selenium in Southeast Idaho* (Kuck, 2003b), the total population of elk within the Phosphate Resource Area has increased from approximately 230 animals in 1952 to 3,690 animals in 2002, while the population of mule deer have declined from approximately 6,000 animals in 1950 to <3,000 animals in 2002. It is hypothesized that because of decreased summer range quality caused by a succession from aspen to conifer types, and the mule deer's dependence on forbs and other high-quality forage in their diet, the Phosphate Resource Area is no longer able to sustain historic populations of this species (Kuck, 2003b). In contrast, the rapid increase in the elk population in this area probably reflects this specie's broad diet and habitat requirements, and the ability of elk to exploit the changing habitat effectively (Kuck, 2003b). According to Kuck (2003a, b), the population of mule deer within the Phosphate Resource Area is likely to continue to decline, unless fire suppression and other resource management practices are changed. It should also be noted that the elk is a more popular large game animal for hunters within the Phosphate Resource Area than is the mule deer. From the standpoint of representativeness, and economic and recreational value, P4 believes that the elk is a more appropriate indicator receptor for large herbivorous mammals than is the mule deer. In regard to home range and exposure potential, although mule deer have a smaller summer home range than the elk, mule deer have a larger total (i.e., summer and winter) home range because they tend to winter in lower elevation areas farther from the waste rock dumps (Kuck, 2003a). As a result, most mule deer do not consume any seleniferous forage in the winter, and they depurate selenium from their bodies by spring (Kuck, 2003b). In contrast, elk do not migrate significantly and they tend to summer and winter in the same areas (Kuck, 2003a). As a result, elk are believed to have a higher exposure potential than mule deer.

4.2.1.5 Conceptual Site Model

The culmination of a problem formulation is the development of a CSM. The CSM for the Sites identifies the primary contaminant sources, release mechanisms, transport mechanisms, secondary contaminant sources, potential pathways, and exposure routes for the selected receptors. The migration of potential contaminants from primary sources to secondary sources occurs through various transport processes that were described in detail in Section 3.7 and 3.8. The ecological portion of the conceptual model identifies where contaminant interactions with biota can occur, describes the uptake of site contaminants into the biological system, and diagrams key receptor contaminant exposure pathways. Receptors are exposed to metals through direct contact with contaminated media and through food web transfer. Figure C4-2 depicts the ecological CSM and includes the sources, transport pathways, the ecological receptors, and the potentially contaminated media to which receptors are most likely exposed. Figure C4-3 depicts the food web relationships for selected ecological receptors at the Sites and illustrates energy and contaminant transfer in the ecosystem which constitutes complete exposure pathways.

4.2.2 Exposure Analysis

The exposure analyses will be performed separately for all three of the Sites as independent Sites along with a separate exposure assessment for background at each of these Sites for those COPECs retained in the screening analyses. Exposure concentrations determined for Site and background areas will, as previously mentioned, differ between the Tier I and Tier II assessments. In Tier I, exposure concentrations will be based on maximum detected concentrations. In Tier II, exposure concentrations will be the 95% UCL on the mean or the maximum concentration, whichever is lower. The 95% UCL of average concentrations will be calculated using USEPA's ProUCL software version 4.00.05 (USEPA, 2010c). This software calculates the 95% UCL of average concentrations based on the underlying distribution of the data. If a higher confidence than 95% is recommended by ProUCL, the recommended UCL will be utilized. Exposure analyses will be conducted for each of the receptors identified in Table C4-10.

4.2.2.1 Amphibian Exposure

Amphibian exposures will be estimated based on measured concentrations of COPECs in surface water. Potential effects of COPECs on the aquatic life stage of amphibians will be evaluated through comparison of surface water concentrations to NRWQC (USEPA, 2009b).

4.2.2.2 Benthic and Terrestrial Invertebrate Exposure

Benthic and terrestrial invertebrate exposures will be determined from available site-specific tissue data. Where exposure data are lacking either spatially or for COPCs where analyte concentrations in tissues are not available, concentrations will be estimated either based on regional-specific bioconcentration factors (BCFs) from the following sources:

- Primary literature
- Database sources:
    - Environmental Residue Effects Database (ERED) – maintained by USACE and USEPA and available at: http://el.erdc.usace.army.mil/ered/ (USACE, 2010)
    - USEPA Aquatox available at http://www.epa.gov/waterscience/models/aquatox/
    - USEPA Estimation Program Interface (EPI) Suite available at http://www.epa.gov/oppt/exposure/pubs/episuite.htm
    - USEPA Ecotox Database available at http://cfpub.epa.gov/ecotox/help.cfm?sub=about
- Screening Level Ecological Risk Assessment Protocol for Hazardous Waste Combustion Facilities (USEPA, 1999)
- USEPA EcoSSL tools available at http://www.epa.gov/ecotox/ecossl/pdf/ecossl_attachment_4-1.pdf
- USEPA EPI Suite available at http://www.epa.gov/oppt/exposure/pubs/episuite.htm
- Development and Validation of Bioaccumulation Models for Small Mammals (Sample et al., 1998).
- Preliminary Remediation Goals for Ecological Endpoints (ORNL, 1997c).
- RAIS (http://risk.lsd.ornl.gov/tox/tox_values.shtml), 2009.

COPEC concentrations in invertebrate tissues (C_i) are modeled based on the following equation (Equation 16):

$$C_i = C_s \times BCF_{s-i} \qquad (16)$$

where:

C_i = Total COPEC concentration in invertebrate tissue (mg COPEC/kg dry tissue).

C_S = Concentration of COPEC in soil or sediment (mg COPEC/kg dry soil or sediment)

BCF_{s-i} = Bioconcentration factor from soil or sediment to invertebrate tissue (kg dry soil or sediment/kg dry invertebrate tissue).

4.2.2.3 Fish and Small Mammal Exposure

The same approach and source references used to determine exposure concentrations in invertebrates will be used for fish and small mammals where site-specific data may be incomplete or unavailable (e.g., Ballard Mine where fish were not found).

COPEC concentrations in fish prey tissues (C_f) are modeled based on the following equation (Equation 17):

$$C_f = C_w \times BCF_{w-f} \quad (17)$$

where:

C_f = COPEC concentration in fish prey tissue (mg COPEC/kg dry tissue)

C_w = COPEC concentration in water (mg COPEC/liter of water)

BCF_{w-f} = Bioconcentration factor from water to fish tissue (liter of water/kg of dry fish tissue).

COPEC concentrations in mammalian prey tissues (C_m) are modeled based on the following equation (Equation 18):

$$C_m = C_s \times BCF_{s-m} \quad (18)$$

where:

C_m = COPEC concentration in mammalian prey tissue (mg/kg dry tissue)

C_s = COPEC concentration in soil (mg/kg dry soil)

BCF_{s-m} = Bioconcentration factor between soil and mammal tissue (kg dry soil/kg dry mammal tissue).

4.2.2.4 Bird and Mammal Exposure

Dietary exposure modeling using EPAs oral dose approach (USEPA 1993) will be used to estimate exposure concentrations to bird and mammal receptors identified in Table C4-10. Wildlife exposure models are used to evaluate the potential for contaminants to move through the food chain and impact organisms occupying higher trophic levels. Characterizing risks to larger vertebrates from specific pollutants often requires the use of exposure modeling because:

(1) it is often infeasible to collect sufficient numbers of these organisms to achieve valid sample sizes, (2) it is often infeasible to replicate the highest plausible exposure, (3) the larger home ranges characteristic of predators make it difficult to relate any chemical concentrations found in the bodies of the organisms to the site being evaluated, and (4) behavioral changes such as those influenced by changes in diet and reproductive status, and physiological changes can cause substantial variation in chemical accumulation and exposure making temporarily non-replicated measurements inconclusive. Models also have the advantage of allowing the risk assessor to make reasonable estimates of the highest plausible exposure to a specific organism. These exposures can then be related to the effects that have been measured elsewhere for evaluation. This results in an estimate of potential baseline risk that likely overestimates the risk and thus errs on the side of protecting the receptors.

The exposure assessment model quantifies the dose (otherwise defined as the amount of chemical contacted by a receptor) of the chemical potentially received by each of the receptors. Uptake of contaminants is typically via three routes: ingestion, dermal absorption, and inhalation. For wildlife, dermal absorption is of secondary importance due to the protection provided by fur, feathers, and for some species, scaly skin. Furthermore, chemicals that are present on the exterior of an organism are often consumed during routine cleaning or, for aquatic organisms, simply washed away. For mammals and birds, exposure to chemicals from inhalation is also deemed to be of secondary importance, since chemicals that have the tendency to volatilize are also typically highly soluble. Based on this rationale, risk assessment to vertebrate wildlife has focused on ingestion exposure pathways which may include the ingestion of food, water, or soils/sediments. Food ingestion is the pathway by which most of the exposure occurs particularly for bioaccumulative chemicals. The daily exposure of a wildlife receptor (e.g., mammal or bird) to a chemical can be expressed as the sum of the amount of chemical consumed during the ingestion of food. The daily exposure of a wildlife receptor (e.g., mammal or bird) to a chemical can be expressed as the sum of the amount of chemical consumed during the ingestion of food, water and sediment/soil. The dose is typically quantified in mg of chemical ingested per kg body weight of the organism per day (mg/kg-bw/d) as described by the equation below (Equation 19).

$$(19) \qquad \text{Wildlife Dose} = \frac{\left[\left(\sum f_{prey} \times \left(IR_{prey} \times C_{prey}\right) + \left(IR_{sed} \times C_{sed}\right)\right) \times BW\right]}{SUF}$$

where:

Wildlife Dose	= Dose of chemical ingested (mg/kg-bw/day)
f_{prey}	= fraction of prey item in diet (%)
IR_{prey}	= ingestion rate of prey item (kg/day)
C_{prey}	= concentration in prey item (mg/kg)
f_{sed}	= fraction of sediment/soil in diet (%)
IR_{sed}	= ingestion rate of sediment/soil (kg/day) = IR_{prey} x f_{sed}
C_{sed}	= concentration in sediment/soil (mg/kg)

SUF	= home range (HR) of the receptor divided by the area (A) being evaluated.
BW	= body weight of wildlife receptor (kg)

The remainder of this section describes the values selected for each of the variables noted above which are summarized in Table C4-11.

Fraction of Prey Items in Diet (F_{prey}):

Predator foraging strategies can vary from generalists to specialists. Generalists tend to feed on a variety of prey items and the selection of prey items is predominantly influenced by the abundance and availability of the prey species in the area inhabited. Specialists tend to focus on a specific prey item and have often evolved to exploit specific types of prey. The variable noted as f_{prey} in Equation C4-4 represents the percent of the diet each prey item would represent in the receptor's diet given the habitat, ecosystem, and prey availability known to exist at the Sites, and the known foraging behavior of the receptor. The general fraction of prey items in the diet of each receptor and the sources of these data are summarized in Table C4-11. While it is understood that prey consumption will vary seasonally and that predators consume a variety of prey, the final selected dietary prey items that will be used in the risk assessment will be determined based on prey items known to occur on the Sites and preferably those prey for which site-specific data are available, and to clearly differentiate receptor prey items and thereby differentiate how focused feeding strategies may impact a receptors exposure. The final selected fraction of prey items in the diet will be detailed in the risk assessment.

Ingestion Rate of Prey (IR_{prey}):

Ingestion of prey items is the primary means by which receptors are exposed to chemicals. The preferred source of receptor prey ingestion rates were species specific feeding studies reported in the literature and from these available studies, ingestion rates for free ranging wildlife were preferred over captive wildlife. If literature values for the ingestion rate of a receptor were not found, the ingestion rate was calculated using allometric equations provided in the USEPA *Wildlife Exposure Factors Handbook* (Nagy, 1987; USEPA, 1993) or more recently updated allometric equations (Nagy, 2001).

An allometric relationship is the relationship between an organism's body size and metabolic rate relative to some other biological parameter of the organism. The discussion of allometric equations in this ERA for the purpose of deriving receptor-specific ingestion rates is limited to equations that describe the relationship of an organism's body size to its free-living metabolic rate (FMR). Because body size is the only variable in an allometric equation, multiple allometric equations have been developed separately for birds and mammals although they are not species specific. Selected food ingestion rate equations for receptors are summarized below:

American Goldfinch (Equation 37 for passerines [Nagy, 2001]):

(20) $$\mathrm{FIR}\left(\frac{\mathrm{g\ dry\ wt}}{\mathrm{day}}\right) = (0.630 \times \mathrm{Wt(g)})^{0.683}$$

where:

FIR = food ingestion rate (g dry wt/day)
g = grams
dry wt = dry weight
Wt = average weight of indicator receptor

American Robin and Mallard Duck (Equation 61 for avian omnivore [Nagy, 2001]):

(21) $$\mathrm{FIR}\left(\frac{\mathrm{g\ dry\ wt}}{\mathrm{day}}\right) = (0.670 \times \mathrm{Wt(g)})^{0.627}$$

where:

FIR = food ingestion rate (g dry wt/day)
g = grams
dry wt = dry weight
Wt = average weight of indicator receptor

Great Blue Heron and Northern Harrier (Equation 63 for avian carnivore [Nagy, 2001]):

(22) $$\mathrm{FIR}\left(\frac{\mathrm{g\ dry\ wt}}{\mathrm{day}}\right) = (0.849 \times \mathrm{Wt(g)})^{0.663}$$

where:

FIR = food ingestion rate (g dry wt/day)
g = grams
dry wt = dry weight
Wt = average weight of indicator receptor

Elk and Cattle (Equation 29 for mammalian herbivore [Nagy, 2001]):

(23) $$\mathrm{FIR}\left(\frac{\mathrm{g\ dry\ wt}}{\mathrm{day}}\right) = (0.859 \times \mathrm{Wt(g)})^{0.628}$$

where:

FIR = food ingestion rate (g dry wt/day)
g = grams
dry wt = dry weight

Wt = average weight of indicator receptor

Raccoon (Equation 33 for mammalian omnivore [Nagy, 2001]):

(24) $$\text{FIR}\left(\frac{\text{g dry wt}}{\text{day}}\right) = (0.432 \times \text{Wt(g)})^{0.678}$$

where:

FIR = food ingestion rate (g dry wt/day)
g = grams
dry wt = dry weight
Wt = average weight of indicator receptor

Mink and Coyote (Equation 25 for mammalian carnivore [Nagy, 2001]):

(25) $$\text{FIR}\left(\frac{\text{g dry wt}}{\text{day}}\right) = (0.153 \times \text{Wt(g)})^{0.834}$$

where:

FIR = food ingestion rate (g dry wt/day)
g = grams
dry wt = dry weight
Wt = average weight of indicator receptor

Food ingestion rates for the long-tailed vole and deer mouse were based on values given in Table 1 of Nagy (2001) for those species.

Concentration in Prey Item (C_{prey}):

Food items for indicator receptors include terrestrial and aquatic plants, terrestrial and aquatic invertebrates, fish, and small mammals. Concentrations in prey will be determined from available site-specific data or will be estimated using the tools and sources described in Section 4.2.2.2 and Section 4.2.2.3. Site-specific vegetation data are sufficient for the estimation of exposure concentrations, but concentrations in other prey items, such as invertebrates, fish, and small mammals may need to be modeled to robustly support the estimation of exposure. Even in the event that prey item concentrations are estimated, what is known about these concentrations from the Sites and regional data available will be used as a second line of evidence in supporting prey concentration estimates.

Soil or Sediment Ingestion Rate Calculations:

The fraction of soil or sediment in the diet will be obtained from USEPA (1993) or from primary literature sources. The ingestion rate of soil or sediment is calculated using the equation below (Equation 26):

$$IR_{sed} = IR_{prey} \times f_{sed} \quad (26)$$

where:

IR_{sed} = ingestion rate of sediment or soil (kg/day dry wt)
IR_{prey} = ingestion rate of prey item (kg/day dry wt)
f_{sed} = fraction of sediment or soil in diet (% dry wt)

Water Ingestion Rate Calculations

The water ingestion (WI) rate is used to estimate exposure intake of COPECs through consumption of surface water. Water ingestion rates were calculated based on equations described in *Wildlife Exposure Factors Handbook* (USEPA, 1993), as follows.

All mammals (USEPA Equation 3-17):

$$WI \left(\frac{L}{day}\right) = 0.099 \times Wt^{0.90}(kg) \quad (27)$$

where:

WI = water ingestion rate
L/day = liters per day
kg = kilograms
Wt = average weight of indicator receptor

All birds (USEPA Equation 3-15):

$$WI\ (L/day) = 0.059 \text{ x } Wt^{0.67}\ (kg) \quad (28)$$

where:

WI = water ingestion rate
L/day = liters per day
kg = kilograms
Wt = average weight of indicator receptor

Area Represented by Concentration Data:

The area represented by concentration data used as inputs to the exposure model can be compared to the receptor wildlife home range to approximate the likely proportion of time spent foraging at the Sites.

Receptor Home Range:

Wildlife receptor home ranges will be obtained from primary literature sources or from the USEPA *Wildlife Exposure Factors Handbook* (USEPA, 1993). The selected home range will represent the low end of the range of values reported, as appropriate depending upon the range of values and representativeness of the values. The intent of using the low end of literature-derived home range values is to not underestimate exposure.

Receptor Body Weight:

Wildlife receptor body weight will be obtained from primary literature sources or from the USEPA *Wildlife Exposure Factors Handbook* (USEPA, 1993). The selected body weight will represent the mean adult body weight of males and females.

4.2.3 Ecological Effects Analysis

The effects evaluation documents and quantifies the relationship between exposures to a stressor in the environment (for this risk assessment, metals) and the harmful effects resulting from that exposure. The quantitative results of this evaluation are termed toxicity reference values (TRVs). TRVs for fish and small mammals are reported on a whole body burden basis to correspond to the exposure unit basis which wildlife TRVs are determined – the daily dose of the chemical. Two TRVs will be determined for each receptor evaluated: (1) the TRV_{noael} is defined as the highest dose at which adverse effects are unlikely to occur; and (2) TRV_{loael} is defined at the lowest dose where a specific biological effect is expected to occur. Exposure concentrations below the TRV_{loael} are unlikely to result in adverse effects and exposure concentrations below the TRV_{noael} with a high degree of certainty will not result in adverse effects. Only the TRV_{noael} will be used in the Tier I screening evaluation and both the TRV_{loael} and the TRV_{noael} will be used to characterize the potential for adverse effects in the Tier II evaluation.

Ecological TRVs for evaluating potential impacts of COPECs on mammalian and avian indicator receptors will be obtained from the following hierarchy of sources:

1. USEPA EcoSSLs (USEPA, various dates)
2. ORNL (ORNL, 1996b)
3. Primary literature

Sources of medium-based ecological benchmarks for evaluating potential effects of COPECs on lower trophic level organisms include, but are not limited to, the following database sources:

1. USEPA EcoSSLs (USEPA, various dates)
2. ORNL (ORNL, 1996a, 1996b, 1997a, 1997b, 1997c)
3. Environmental Residue Effects Database (ERED) – maintained by USACE and USEPA and available at: http://el.erdc.usace.army.mil/ered/
4. USEPA Ecotox Database available at http://cfpub.epa.gov/ecotox/help.cfm?sub=aboutEPA
5. Aquatox available at http://www.epa.gov/waterscience/models/aquatox/

The above effects analysis sources are applicable to the evaluation of chronic or sub-chronic exposures of wildlife to general contaminants. As noted in Section 4.0, cases of livestock illness or death following acute exposures of livestock to selenium are well documented within the Southeast Idaho Phosphate Resource Area. Appropriate effects analysis criteria for the evaluation of acute exposures of livestock to selenium will be developed in cooperation with the A/Ts.

4.2.4 Risk Characterization

Risk characterization is the final phase of risk assessment in which the likelihood of adverse effects is evaluated by combining the analyses of exposure and effects. Risk characterization consists of estimating and describing risk, including the assumptions and level of uncertainty associated with the risk estimate. The assessment endpoints evaluated and each evaluation method is a line of evidence. In this risk assessment report, the analyses and risk characterization phases are reported for each assessment endpoint.

The risk characterization for amphibians compares measured COPEC concentrations in surface water to the appropriate water quality criteria to calculate a HQ as described by Equation 29.

(29)
$$HQ = \frac{Exposure}{AWQC}$$

where:

HQ	= hazard quotient
Exposure	= measured surface water concentration (mg/L)
AWQC	= ambient water quality criteria (mg/L)

The risk characterization for fish compares measured COPEC concentrations in whole fish tissues to the selected TRVs to calculate a HQ as described by Equation 30.

(30)
$$HQ = \frac{Exposure}{TRV}$$

where:

HQ	= hazard quotient
Exposure	= measured whole body concentration (mg/kg)
TRV	= toxicity reference value (mg/kg)

The risk characterization for wildlife is a process of integrating the modeled dietary receptor exposures and chemical toxicity information discussed in the analysis section. Wildlife exposure and toxicity data are integrated using Equation 31 to calculate an HQ.

$$\text{HQ} = \frac{\text{Dose}}{\text{TRV}} \quad (31)$$

where:

HQ	= hazard quotient
Dose	= total ingested daily dose of a chemical (mg/kg-d)
TRV	= toxicity reference value (mg/kg-d)

For all receptors, the HQ will be interpreted as follows:

- An $HQ_{noael} < 1.0$ indicates that toxicological effects and potential risk are likely not occurring.
- An $HQ_{noael} > 1.0$ and an $HQ_{loael} < 1.0$ generally indicates that toxicological effects and potential risk are unlikely to occur.
- An $HQ_{loael} > 1.0$ indicates that toxicological effects and potential risk may occur.

The most that can be concluded from a calculated HQ in excess of one is that there is an increased potential that an adverse effect may occur in at least one individual. While this potential increases as the magnitude of the HQ increases, the level of concern does not increase linearly with increases in HQ. This lack of linearity is based on the fact that typical dose response curves for chemicals are not linear, but rather sigmoidal.

In those cases where $HQ_{noael} > 1.0$ and an $HQ_{loael} < 1.0$, the HQs will be evaluated in the context of the representativeness of the chemical data sets and the quality of the available exposure and toxicity information.

In addition, ecological HQs for COPECs with similar mechanisms of action will be summed to HIs for each medium for a given receptor. Ecological HIs for a given receptor will also be summed across media (e.g., soil, surface water), as applicable.

As noted in Sections 4.0 and 4.2.3, potential risks to livestock associated with acute exposures to selenium will also be evaluated in the ERA for the Mine Sites. Methods for evaluating acute exposures of livestock to selenium will be developed in cooperation with the A/Ts.

A discussion of uncertainty is an important component of risk characterization since they have the potential to bias (high or low) risk estimates. Sources of uncertainty associated with wildlife exposure include:

- Sites' use
- Exposure concentration
- Receptors selected as surrogate species for all mammalian and avian species that are potentially exposed at the site
- Assumptions regarding dietary preferences
- Chemical bioavailability
- Chemical toxicity

4.3 Tier III ERA

Currently, the Tier I and II ERAs are Site-specific and specific to sub-area use of the Sites by wildlife receptors based on preferred prey items, where these prey likely occur, and the home range of the receptor. Depending on the results of the Tier II risk estimates, further risk evaluations for specific receptors may be warranted to determine the degree to which areas with adverse risk may be localized, and to refine risk estimates based on site-specific exposure assumptions and information (e.g., tissue sampling results). Tier III ERA procedures may be implemented if unacceptable adverse risks to ecological receptors is identified in the Tier II assessment, or if uncertainties on these risk estimates are too high. Tier III ERA procedures are intended to assist with remedy selection, if warranted, and will be used in the FS. Specific procedures for Tier III will be determined through discussion with the A/Ts following review and discussion of the Tier II ERA results.

5.0 UNCERTAINTIES

As recommended by USEPA (1989a, 1992), an assessment of uncertainties in the risk characterization estimates will be presented in the HHERA. Oftentimes, risk estimates are based on conservative risk assessment methodologies and assumptions (applied to both the toxicity assessment and exposure assessment), and are designed to be protective in nature. Accordingly, it is critical that uncertainties associated with risk modeling practices employed, as well as those associated with known or potential data gaps, be thoroughly addressed such that the numerical estimates are placed in the proper perspective by risk managers. Following the deterministic nature of the human health risk assessment methodology included herein, uncertainties will be evaluated in a qualitative fashion. If future probabilistic risk assessment practices and sensitivity analyses are employed following the results of the Tier II HHERA, uncertainties may be presented in a quantitative fashion.

6.0 REFERENCES

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TABLES

TABLE C3-1

Preliminary COPC Screening for Soil

Sampling Parameter	Maximum Detected Concentration (mg/kg)	Number of Results	Number of Detected Results	Number of Detected Results Exceeding Screening Criteria: Residential	Number of Detected Results Exceeding Screening Criteria: Industrial	USEPA Regional Screening Levels for Soil[1]: Residential (mg/kg)	USEPA Regional Screening Levels for Soil[1]: Industrial (mg/kg)	Preliminary COPC based on Residential Screening Level	Preliminary COPC based on Industrial Screening Level
Antimony	10.9	268	219	0	0	31 [a]	410 [a]	No	No
Arsenic	45.5	268	268	268	268	0.39 [b]	1.6 [b]	**Yes**	**Yes**
Boron	60.9	268	228	0	0	16,000 [c]	200,000 [c]	No	No
Cadmium	167	268	268	16	0	70 [d]	800 [d]	**Yes**	No
Chromium [e]	627	268	268	0	0	120,000	1,500,000 [f]	No	No
Cobalt	25.6	268	268	1	0	23	300	**Yes**	No
Copper	229	268	268	0	0	3,100	41,000	No	No
Manganese	5,180	268	268	23	0	1,800 [g]	23,000 [g]	**Yes**	No
Mercury [h]	0.892	268	267	0	0	4.3 [i]	24 [i]	No	No
Molybdenum	48.7	268	222	0	0	390	5,100	No	No
Nickel	635	268	268	0	0	1,500 [j]	20,000 [j]	No	No
Selenium	318	268	268	0	0	390	5,100	No	No
Silver	14.4	268	257	0	0	390	5,100	No	No
Thallium	3.68	268	268	0	0	5.1 [j]	66 [j]	No	No
Uranium	151	268	263	0	0	230 [j]	3100 [j]	No	No
Vanadium	1,370	268	268	23	0	390 [k]	5,200 [k]	**Yes**	No
Zinc	1,810	268	268	0	0	23,000 [a]	310,000 [a]	No	No

Notes:

[1] The most current version of the screening levels and toxicity information at the time the HHRA is performed will be used.

[a] Screening value for metallic compound.
[b] Screening value for inorganic form of arsenic.
[c] Screening value for boron and borates only.
[d] Screening value is based on toxicity information from dietary cadmium.
[e] Measured as total chromium; however, because chromium VI was not detected in soil samples, total chromium is assumed to be represented by chromium III.
[f] Insoluble salts. Although the correct screening level is listed, 1,500,000 mg/kg is not possible because there are 1,000,000 milligrams in a kilogram.
[g] Screening value is based on toxicity information for manganese in drinking water.
[h] Classified as persistent, bioaccumulative and toxic (PBT) by the USEPA (USEPA, 2010d).
[i] Screening value is for elemental mercury.
[j] Screening value is for soluble salts.
[k] Screening value for vanadium and compounds.

COPC - chemical of potential concern
mg/kg - milligrams per kilogram
USEPA - United States Environmental Protection Agency

TABLE C3-2

Preliminary COPC SCreening for Surface Water

Monitoring Parameter [1]	Maximum Detected Concentration (mg/l)	Number of Samples	Number of Detected Results	State of Idaho Standards Surface Water [2, 3] (mg/l)	National Standards Aquatic Life [2, 4] Organism Consumption		USEPA Regional SL [2, 5] Tap Water (mg/l)	Health Comparison Values of Drinking Water [2, 6]		USEPA MCL [2, 7]		Proposed COPC Screening Criteria [8] (mg/l)	Preliminary COPC (Yes/No)
					W+O (mg/l)	O Only (mg/l)		Child (mg/l)	Adult (mg/l)	Primary (mg/l)	Secondary (mg/l)		
Aluminum	2.39	105	88	- -	- -	- -	37	- -	- -	- -	- -	37	No
Aluminum, dissolved	0.844	35	2	- -	- -	- -	37	- -	- -	- -	- -	37	No
Cadmium	0.00231	169	13	- -	- -	- -	0.018	- -	- -	- -	- -	0.018	No
Calcium	349	169	169	- -	- -	- -	- -	- -	- -	- -	- -	- -	No
Chromium	0.00393	140	35	- -	- -	- -	55/0.11 [a]	0.1	0.1	0.1	- -	0.11	No
Iron	0.827	64	30	- -	0.3	- -	26	- -	- -	- -	- -	0.3	**Yes**
Magnesium	78.5	169	169	- -	- -	- -	- -	- -	- -	- -	- -	- -	No
Manganese	0.374	35	35	- -	- -	- -	0.88	- -	- -	- -	- -	0.88	No
Nickel	0.0101	140	140	0.61	0.61	4.6	0.73	- -	- -	- -	- -	0.61	No
Potassium	16.8	140	138	- -	- -	- -	- -	- -	- -	- -	- -	- -	No
Selenium	1.2	169	117	0.17	0.17	4.2	0.18	- -	- -	- -	- -	0.17	**Yes**
Sodium	67.4	140	140	- -	- -	- -	- -	- -	- -	- -	- -	- -	No
Uranium	0.0024	105	83	- -	- -	- -	0.26	- -	- -	- -	- -	0.26	No
Vanadium	0.0885	169	83	- -	- -	- -	0.11	0.03 [b]	0.03 [b]	0.03 [b]	- -	0.11	No
Zinc	0.062	140	84	7.4	7.4	26	11	- -	- -	- -	- -	7.4	No

Notes:

[1] Monitoring parameters included in 2009 Surface Water Monitoring Sampling and Analysis Plan (MWH, 2009). Concentrations for all parameters are dissolved unless otherwise noted.

[2] The most current version of the screening levels and toxicity information at the time the HHRA is performed will be used.

[3] State of Idaho Surface Water Quality for Domestic Water Supply Use (IDAPA 58.01.02).

[4] National Recommended Water Quality Criteria (USEPA, 2010a); Criteria for Human Health for Organism Consumption of Water + Organism (W+O) and Organism Only (O Only).

[5] USEPA Regional Screening Levels (RSLs) for Chemical Contaminants at Superfund Sites (http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/index.htm, November, 2010).

6 Public Health Assessment: Southeast Idaho Phosphate Mining Resource Area: Bannock, Bear Lake, Bingham, and Caribou Counties, Idaho EPA Facility ID: IDN001002245 (U.S. Department of Health and Human Services, Public Health Services, Agency for Toxic Substances and Disease Registry, 2006).

[7] USEPA primary and secondary Maximum Contaminant Level (MCL), National Primary Drinking Water Regulations (http://www.epa.gov/safewater/contaminants/index.html#rads, January 11, 2011a).

[8] Proposed COPC screening criteria is based on the following hierarchy:
1) State of Idaho Surface Water Quality for Domestic Water Supply Use (IDAPA 58.01.02).
2) National Recommended Water Quality Criteria (USEPA, 2010a); Criteria for Human Health for Organism Consumption of Water + Organism (W+O) and Organism Only (O Only).
3) USEPA RSLs for Chemical Contaminants at Superfund Sites (November, 2010).
4) Public Health Assessment: Southeast Idaho Phosphate Mining Resource Area (ATSDR, 2006).
5) USEPA primary and secondary MCLs, National Primary Drinking Water Regulations (USEPA, 2011a).

[a] Values specified are for chromium III/VI. If data are screened against these standards, then the total chromium results will be compared to the chromium VI standard.

[b] Reporting limit (RL) is greater than screening value, but the method detection limit (MDL) is less than the screening value.

ATSDR - Agency for Toxic Substances and Disease Registry
COPC - chemicals of potential concern
IDAPA Idaho Administrative Procedures Act
mg/L - milligrams per liter
USEPA - United States Environmental Protection Agency

TABLE C3-3

Preliminary COPC Screening for Groundwater

				Applicable Screening Levels									
					IDEQ Area-Wide RMP [2, 4] Groundwater Levels		State of Idaho Standards	USEPA MCL [2, 8]		Health Comparison Values of Drinking Water [2, 9]		Proposed COPC Screening	
Monitoring Parameter [1]	**Maximum Detected Concentration (mg/l)**	**Number of Samples**	**Number of Detected Results**	**USEPA Regional SL [2, 3] Tap Water (mg/l)**	**Remedial A[5] (mg/l)**	**Monitoring [6] (mg/l)**	**Ground Water [2, 7] (mg/l)**	**Primary (mg/l)**	**Secondary[a] (mg/l)**	**Child (mg/l)**	**Adult (mg/l)**	**Criteria [10] (mg/l)**	**Preliminary COPC (Yes/No)**
Aluminum	14.4	203	115	37	- -	- -	0.2[a]	- -	0.2	- -	- -	37	No
Aluminum, dissolved	0.905	142	25	37	- -	- -	0.2[a]	- -	0.2	- -	- -	37	No
Antimony	0.00269	63	16	0.015	- -	- -	0.006	0.006	- -	- -	- -	0.015	No
Antimony, dissolved	0.0014	52	17	0.015	- -	- -	0.006	0.006	- -	- -	- -	0.015	No
Arsenic	0.0398	63	58	0.000045	- -	- -	0.05	0.01	- -	- -	- -	0.000045	**Yes**
Arsenic, dissolved	0.0362	52	44	0.000045	- -	- -	0.05	0.01	- -	- -	- -	0.000045	**Yes**
Barium	0.195	63	63	7.3	- -	- -	2	2	- -	- -	- -	7.3	No
Barium, dissolved	0.18	52	51	7.3	- -	- -	2	2	- -	- -	- -	7.3	No
Beryllium	0	63	0	0.073	- -	- -	0.004	0.004	- -	- -	- -	0.073	No
Beryllium, dissolved	0	52	0	0.073	- -	- -	0.004	0.004	- -	- -	- -	0.073	No
Boron	0.22	52	47	7.3	- -	- -	- -	- -	- -	- -	- -	7.3	No
Boron, dissolved	0.21	52	38	7.3	- -	- -	- -	- -	- -	- -	- -	7.3	No
Cadmium	0.085	175	72	0.018	0.005[b]	0.001[c]	0.005[b]	0.005	- -	- -	- -	0.018	**Yes**
Cadmium, dissolved	0.0714	200	61	0.018	0.005[b]	0.001[c]	0.005[b]	0.005	- -	- -	- -	0.018	**Yes**
Calcium	383	79	79	- -	- -	- -	- -	- -	- -	- -	- -	- -	No
Calcium, dissolved	475	222	222	- -	- -	- -	- -	- -	- -	- -	- -	- -	No
Chromium	0.265	133	116	55/0.11 [d]	0.1[b]	0.025[e]	0.1[b]	0.1	- -	0.1	0.1	0.11	**Yes**
Chromium, dissolved	0.0157	158	95	55/0.11 [d]	0.1[b]	0.025[e]	0.1[b]	0.1	- -	0.1	0.1	0.11	No
Cobalt	0.000954	63	6	0.011	- -	- -	- -	- -	- -	- -	- -	0.011	No
Cobalt, dissolved	0	52	0	0.011	- -	- -	- -	- -	- -	- -	- -	0.011	No
Copper	0.02	63	15	1.5	1.3[b]	0.011	1.3	1.3	1	- -	- -	1.5	No
Copper, dissolved	0.03	52	2	1.5	1.3[b]	0.011	1.3	1.3	1	- -	- -	1.5	No
Iron	17.5	160	127	26	- -	- -	0.3[b]	- -	0.3	- -	- -	26	No
Iron, dissolved	4.37	165	63	26	- -	- -	0.3[b]	- -	0.3	- -	- -	26	No
Lead [f]	0.0286	63	32	- -	- -	- -	0.015	0.015		- -	- -	0.015	**Yes**
Lead, dissolved [f]	0.0003	52	5	- -	- -	- -	0.015	0.015		- -	- -	0.015	No
Magnesium	115	79	79	- -	- -	- -	- -	- -	- -	- -	- -	- -	No
Magnesium, dissolved	123	222	222	- -	- -	- -	- -	- -	- -	- -	- -	- -	No
Manganese	2.18	160	154	0.88	- -	- -	0.05[b]	- -	0.05	- -	- -	0.88	**Yes**
Manganese, dissolved	2.01	142	132	0.88	- -	- -	0.05[b]	- -	0.05	- -	- -	0.88	**Yes**
Molybdenum	0.15	63	10	0.18	- -	- -	- -	- -	- -	- -	- -	0.18	No
Molybdenum, dissolved	0.15	52	20	0.18	- -	- -	- -	- -	- -	- -	- -	0.18	No
Nickel	1.37	160	156	0.73	0.73[g]	0.160	- -	- -	- -	- -	- -	0.73	**Yes**
Nickel, dissolved	1.78	185	179	0.73	0.73[g]	0.160	- -	- -	- -	- -	- -	0.73	**Yes**
Potassium	6	79	79	- -	- -	- -	- -	- -	- -	- -	- -	- -	No
Potassium, dissolved	6.5	222	222	- -	- -	- -	- -	- -	- -	- -	- -	- -	No
Selenium	1.67	236	209	0.18	0.05[b]	0.0050	0.05[b]	0.05	- -	- -	- -	0.18	**Yes**
Selenium, dissolved	1.19	169	136	0.18	0.05[b]	0.0050	0.05[b]	0.05	- -	- -	- -	0.18	**Yes**
Silver	0	63	0	0.18	- -	- -	0.1[b]	- -	0.1	- -	- -	0.18	No
Silver, dissolved	0.01	52	1	0.18	- -	- -	0.1[b]	- -	0.1	- -	- -	0.18	No
Sodium	37.6	52	52	- -	- -	- -	- -	- -	- -	- -	- -	- -	No
Sodium, dissolved	103	222	222	- -	- -	- -	- -	- -	- -	- -	- -	- -	No
Thallium	0.0008	63	30	0.0024	- -	- -	0.002	- -	- -	- -	- -	0.0024	No

TABLE C3-3

Preliminary COPC Screening for Groundwater

Monitoring Parameter [1]	Maximum Detected Concentration (mg/l)	Number of Samples	Number of Detected Results	Applicable Screening Levels: USEPA Regional SL [2, 3] Tap Water (mg/l)	IDEQ Area-Wide RMP [2, 4] Groundwater Levels: Remedial A[5] (mg/l)	IDEQ Area-Wide RMP [2, 4] Groundwater Levels: Monitoring [6] (mg/l)	State of Idaho Standards Ground Water [2, 7] (mg/l)	USEPA MCL [2, 8]: Primary (mg/l)	USEPA MCL [2, 8]: Secondary[a] (mg/l)	Health Comparison Values of Drinking Water [2, 9]: Child (mg/l)	Health Comparison Values of Drinking Water [2, 9]: Adult (mg/l)	Proposed COPC Screening Criteria [10] (mg/l)	Preliminary COPC (Yes/No)
Thallium, dissolved	0.0009	52	11	0.0024	- -	- -	0.002	- -	- -	- -	- -	0.0024	No
Uranium	0.0444	63	63	0.11	- -	- -	- -	0.03 [a]	- -	0.03 [b]	0.03 [b]	0.11	No
Uranium, dissolved	0.0601	95	94	0.11	- -	- -	- -	0.03 [a]	- -	0.03 [b]	0.03 [b]	0.11	No
Vanadium	0.106	175	83	0.26	0.26[g]	0.02[h]	- -	- -	- -	- -	- -	0.26	No
Vanadium, dissolved	0.113	185	107	0.26	0.26[g]	0.02[h]	- -	- -	- -	- -	- -	0.26	No
Zinc	5.99	160	126	11	5[b]	0.100	5[a]	- -	5	- -	- -	11	No
Zinc, dissolved	5.94	185	128	11	5[b]	0.100	5[a]	- -	5	- -	- -	11	No

Notes:

[1] Monitoring parameters included in 2009 Goundwater Monitoring Sampling and Analysis Plan (MWH, 2009).
[2] The most current version of the screening levels and toxicity information at the time the HHRA is performed will be used.
[3] USEPA Regional Screening Levels (RSLs) for Chemical Contaminants at Superfund Sites (http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/index.htm, November, 2010).
[4] Remedial action and monitoring levels; Area-Wide Risk Management Plan (RMP; IDEQ, 2003).
[5] Remedial action levels for total recoverable groundwater (RMP; IDEQ, 2003).
[6] Remedial action levels for semi-annual monitoring (RMP; IDEQ, 2003).
[7] State of Idaho Ground Water Quality Rule (IDAPA 58.01.11).
[8] USEPA primary and secondary Maximum Contaminant Level (MCL), National Primary Drinking Water Regulations, EPA (http://www.epa.gov/safewater/contaminants/index.html#rads, January 11, 2011a).
9 Public Health Assessment: Southeast Idaho Phosphate Mining Resource Area: Bannock, Bear Lake, Bingham, and Caribou Counties, Idaho EPA Facility ID: IDN001002245 (U.S. Department of Health and Human Services (USDHHS), Public Health Services (PHS), Agency for Toxic Substances and Disease Registry, 2006).
[10] Proposed COPC screening criteria is based on the following hierarchy:
1) USEPA RSLs for Chemical Contaminants at Superfund Sites (USEPA, 2010b)
2) Remedial action and monitoring levels; Area-Wide Risk Management Plan (RMP; IDEQ, 2003).
3) State of Idaho Ground Water Quality Rule (IDAPA 58.01.11).
4) USEPA primary and secondary MCLs and National Primary Drinking Water Regulations (USEPA, 2011a)
5) Public Health Assessment: Southeast Idaho Phosphate Mining Resource Area (ATSDR, 2006).

[a] Value is secondary standard based on taste/color/smell (USEPA, 2011a).
[b] Value reported is based on the USEPA MCL.
[c] Value reported is based on the USEPA National Recommended Water Quality Criteria.
[d] Values specified are for chromium III/VI. If data are screened against these standards then the total chromium results will be compared to the chromium VI standard.
[e] Value is 1/4 the groundwater MCL (IDEQ, 2003).
[f] Classified as persistent, bioaccumulative and toxic (PBT) by the USEPA (USEPA, 2010d).
[g] Value reported is based on the USEPA RSL tap water screening values (IDEQ, 2003).
[h] Value reported is based on Tier II Secondary Chronic Benchmarks (IDEQ, 2003).

ATSDR - Agency for Toxic Substances and Disease Registry
COPC - chemicals of potential concern
IDAPA Idaho Administrative Procedures Act
mg/L - milligrams per liter
USEPA - United States Environmental Protection Agency

Table C4-1

Ecological Soil Screening Levels[a]

Analyte	Lowest Soil Screening Level (mg/kg)	Eco-SSL[b] (mg/kg)				ORNL Ecological Benchmark[c] (mg/kg)		
		Plants	Soil Invertebrates	Avian	Mammalian	Plants	Soil Microbes	Soil Invertebrates
Antimony	0.27	- -	78	- -	0.27	5	- -	- -
Arsenic	18	18	- -	43	46	10	100	60
Boron	0.5	- -	- -	- -	- -	0.5	20	- -
Cadmium	0.36	32	140	0.77	0.36	4	20	20
Chromium[d]	0.4	- -	- -	26	34	1	10	0.4
Cobalt	13	13	- -	120	230	20	1,000	- -
Copper	28	70	80	28	49	100	100	50
Manganese	220	220	450	4,300	4,000	500	100	- -
Mercury	0.1	- -	- -	- -	- -	0.3	30	0.1[e]
Molybdenum	2	- -	- -	- -	- -	2	200	- -
Nickel	38	38	280	210	130	30	90	200
Selenium	0.52	0.52	4.1	1.2	0.63	1.00	100	70
Silver	2	560	- -	4.2	14	2	50	- -
Thallium	1	- -	- -	- -	- -	1	- -	- -
Uranium	5	- -	- -	- -	- -	5	- -	- -
Vanadium	2	- -	- -	7.8	280	2	20	- -
Zinc	46	160	120	46	79	50	100	200

Notes:

[a] Hierarchy of toxicity criteria used during selection of ecological soil screening levels for mammalian and avian indicator receptors:
1. USEPA Eco-SSLs (USEPA, various dates).
2. ORNL (ORNL, 1996b)
3. Primary literature.

Sources of medium-based benchmarks for evaluating potential effects of COPECs on lower trophic-level organisms include:
1. USEPA Eco-SSLs (USEPA, various dates).
2. ORNL (ORNL, 1996a, 1996b, 1997a, 1997b, 1997c).
3. Environmental Residue Effects Database (ERED) (USACE, 2010).
4. USEPA Ecotox Database.
5. Aquatox.

[b] USEPA ecological soil screening levels (SSL); units are mg/kg, dry weight.

[c] Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Terrestrial Plants (ORNL, 1997a); Toxicological Benchmarks for Contaminants of Potential Concern for Effects on Soil and Litter Invertebrates and Heterotrophic Process (ORNL, 1997b).

[d] Measured as total chromium; however, because chromium VI was not detected in soil samples, total chromium is assumed to be represented by chromium III.

[e] Based on a LOEC of 0.5 mg/kg for reduction in soil invertebrate survival cocoon production with an applied safety factor of 5.

"- -" - not available
LOEC - lowest observed effects concentation
mg/kg - milligrams per kilogram
ORNL - Oak Ridge National Laboratory
SSL - soil screening level
USEPA - United States Environmental Protection Agency

Table C4-2

Ecological Surface Water Screening Levels

Analyte[1]	Proposed COPEC Screening Criteria (mg/l)	State of Idaho Standards [2] Aquatic Life Chronic (mg/l)	National Standards Aquatic Life [3] Chronic (mg/l)	ORNL Toxicological Benchmarks Lowest Chronic Value [4] (mg/l)	Tier II SCV [5] (mg/l)	Lowest Population EC20 [6] (mg/l)
Aluminum, Total	0.087	--	0.087	0.46	--	--
Aluminum	0.087	--	0.087	0.46	--	--
Cadmium	0.0006	0.0006 [a]	0.00025 [b,c]	0.00015	--	0.0043
Calcium	116	--	--	116	--	--
Chromium	0.011	0.074/0.011 [a,d]	0.074/0.011 [b,d]	<0.044	--	0.13
Copper	0.011	0.011 [a]	BLM [e]	0.00023	--	0.00
Iron	0.158	--	--	0.158	--	--
Magnesium	82	--	--	82	--	--
Manganese	0.112	--	--	<1.1	0.12	0.112
Nickel	0.052	0.052 [a]	0.052 [b]	<0.005	--	0.215
Potassium	53	--	--	53	--	--
Selenium	0.005	0.005 [f]	0.0050 [g]	0.088	--	--
Sodium	680	--	--	680	--	--
Uranium	0.142	--	--	0.142	0.0026	0.027
Vanadium	0.02	--	--	0.08	0.02	0.32
Zinc	0.12	0.12 [a]	0.12 [b]	0.03	--	0.08

Notes:

[1] Monitoring parameters included in 2009 Surface Water Monitoring Sampling and Analysis Plan (MWH, 2009). Concentrations for all parameters are dissolved unless otherwise noted.

[2] State of Idaho Surface Water Quality for Aquatic Life (IDAPA 58.01.02); Acute Criteria (CMC) and Chronic Criteria (CCC).

[3] National Recommended Water Quality Criteria (USEPA, 2010a); Freshwater Standards for Acute Criteria (CMC) and Chronic Criteria (CCC).

[4] Lowest Chronic Value (LCV) observed in freshwater daphnids. Source: ORNL, 1996a.

[5] Tier II Secondary Chronic Value. Source: ORNL, 1996a.

[6] Lowest Population EC_{20}. Source: ORNL, 1996a.

[a] Aquatic life criteria for these metals are expressed as a function of total hardness (mg/L as calcium carbonate), the pollutant's water effect ratio (WER) as defined in Subsection 210.03.c.iii of IDAPA 58.01.02 and multiplied by an appropriate dissolved conversion factor as defined in Subsection 210.02. For comparative purposes only, the values displayed in this table are shown as dissolved metal and correspond to a total hardness of 100 mg/L and a WER of 1.0.

[b] The freshwater criterion for this metal is expressed as a function of hardness (mg/L) in the water column. The value given here corresponds to a hardness of 100 mg/L. Criteria values for other hardness may be calculated from the following: CMC (dissolved) = exp {mA[ln(hardness)]+bA} (CF), or CCC (dissolved) = exp {mC[ln(hardness)]+bC} (CF) and the parameters specified in Appendix B - Parameters for Calculating Freshwater Dissolved Metals Criteria That Are Hardness-Dependent.

[c] Reporting limit (RL) is greater than screening value, but method detection limit (MDL) is less than the screening value.

[d] Values specified are for chromium III/VI. If data are screened against these standards, then the total chromium results will be compared to the chromium VI standard.

[e] Freshwater criteria calculated using the BLM mm (USEPA, 2007).

[f] Criterion is expressed as total recoverable (unfiltered) concentration.

[g] The CMC = 1/[(f1/CMC1)+(f2/CMC2)] where f1 and f2 are the fractions of total selenium that are treated as selenite and selenate, respectively, and CMC1 and CMC2 are 0.1859 mg/L and 0.01282 mg/L, respectively.

"- -" - not available
CCC - Criterion Chronic Concentration
CMC - Chronic Maximum Concentration
COPEC - chemicals of potential ecological concern
CWA - Clean Water Act
IDAPA Idaho Administrative Procedures Act
IDEQ - Idaho Department of Environmental Quality
mg/L - milligrams per liter
ORNL - Oak Ridge National Laboratory
RL - reporting limit
RMP - Resource Management Plan
SCV - secondary chronic values
USEPA - United States Environmental Protection Agency

Table C4-3

Ecological Sediment Screening Levels

Analyte	**Pacific Northwest Regional SQG[1] (mg/kg)**
Aluminum	25500 [2]
Antimony	- -
Arsenic	20
Barium	- -
Beryllium	- -
Boron	- -
Cadmium	1.1
Chromium	95
Cobalt	50 [3]
Copper	80
Iron	20000 [3]
Lead	340
Manganese	460 [3]
Mercury	0.28
Molybdenum	- -
Nickel	60
Selenium	4 [4]
Silver	2.0
Thallium	- -
Uranium	- -
Vanadium	- -
Zinc	130

Notes:

[1] Source of values is the Sediment Evaluation Framework for the Pacific Northwest, May 2009. Prepared by USACE et al. unless otherwise noted.

[2] Great Lakes ARCS program TEL as cited in NOAA SQuiRT table (Buchman, 2008)

[3] Ontario MOE LEL as cited in NOAA SQuiRT table (Buchman, 2008)

[4] Screening value from Van Derveer and Canton (1997)

"- -" - not available
ARCS - assessment and remediation of contaminated sediments
LEL - lowest effects levels
mg/kg - milligrams per kilogram
MOE- Ministry of the Environment
NOAA - National Oceanic and Atmospheric Administration
SQG - sediment quality guidelines
TEL - threshold effects level
USACE - United States Army Corps of Engineers

Table C4-4

Functional Use of P4 Mine Ponds

Mine	Pond Name	Pond ID	Tier*
Ballard	Dredge Pond [#9]	SP010	2
	Upper Elk Pond [#20]	SP011	3
	Lower Elk Pond [#21]	SP012	3
	Northeast Pond [#10]	SP013	2
	Pit #4 Stock Pond [#22]	SP059	3
	Pit #6 Pond [#23]	SP062	3
Henry	Henry Pond [#1,2]	SP014	1
	Smith Pond [#11]	SP015	2
	Center Henry Pond [#3]	SP016	1
	South Pit Pond [#24]	SP055	3
Enoch Valley	South Pond [#4,5]	SP017	1
	Keyhole Pond [#6]	SP018	1
	Bat Cave Pond [#12]	SP019	2
	West Pond [#13,14]	SP020	2
	Stock Pond [#7]	SP021	1
	Tipple Pond Complex [#15,16,17,18]	SP022	2
	Haul Road (Office) Pond [#19]	SP023	2
	Shop Pond [#8]	SP031	1

Note:
* As reported in the functional use survey (IDEQ, 2004b)

Table C4-5

Stream Survey RBP Summary Results

Mine	Number of Stations Evaluated (including background)	RBP Score Range	Fish Presence		Percent of Stations with Confirmed or Likely Fish
			Observed	Likely	
Ballard	12	29-50	none	none	0
Henry	20	7-153	5 (RBP 52-151)	5 (RBP 31-143)	50
Enoch	15	3-139	6 (RBP 52-	2 (RBP 48 &	53

Note:
The highest RBP habitat score possible is 200.
RBP - Rapid Bioassessment Protocols

Table C4-6

Area- and Site-Specific Ecological Studies

Matrix Sampled	Year Sampled	Area Sampled	COPCs	Report
Fish	1999, 2000	Area-wide	Selenium, Cadmium	1999-2000 Regional Investigation Data Report for Surface Water, Sediment and Aquatic Biota Sampling Activities, May-June 2000. Appendix C (MW, 2001)
Benthic Invertebrates	1999, 2000	Area-wide	Selenium, Cadmium	1999-2000 Regional Investigation Data Report for Surface Water, Sediment and Aquatic Biota Sampling Activities, May-June 2000. Appendix C (MW, 2001)
Elk	1999, 2000	Area-wide	Selenium, Cadmium	1999 Interim Investigation Data Report, Appendices H, J (MW, 2000)
Bird Eggs	1999, 2000, 2001	Area-wide	Selenium, Cadmium	1999 Interim Investigation Data Report (MW, 2000)
Cutthroat Trout	1999	Area-wide	Selenium	1999 Interim Investigation Data Report (MW, 2000)
2001 Small Mammals	2001	Area-wide	Selenium, Aluminum, Vanadium, Zinc , Antimony, Arsenic, Barium, Beryllium, Boron, Cadmium, Chromium, Copper, Lead, Manganese, Mercury, Molybdenum, Nickel, Silver, Thallium, Uranium	Summer 2001 Area-Wide Investigation Data Summary, Appendices B-E (MWH, 2002)
Terrestrial Invertebrates	2001	Area-wide	Selenium, Aluminum, Vanadium, Zinc, Antimony, Arsenic, Barium, Beryllium, Boron, Cadmium, Chromium, Copper, Lead, Manganese, , Molybdenum, Nickel, Silver, Thallium, Uranium, Mercury	Summer 2001 Area-Wide Investigation Data Summary, Appendices B-E (MWH, 2002)
Fish	2004	Mine Specific	Selenium, Cadmium, Nickel, Vanadium, Zinc	Phase I Site Investigation Summary Report (MWH, 2007)
Benthic Invertebrates	2004	Mine Specific	Selenium	Phase I Site Investigation Summary Report (MWH, 2007)

Notes:

Alternate bird egg study reference:

Analysis of Selenium Levels in Bird Eggs and Assessment of the Effects of Selenium on Avian Reproduction in Southeast Idaho prepared by J.T. Ratti, A. Rocklage and E.O. Garton, University of Idaho, published in The Journal of Wildlife Management

Alternate cutthroat trout study reference:

Data presented in: Effects of dietary selenium on cutthroat trout (*Oncorhynchus clarki*) growth and reproductive performance. From Ron Hardy, University of Idaho (2005).

Table C4-7

Regional Fish

Common Name	Species Name	Sampled
Family Catostomidae (Suckers; trophic level 2-3; benthic)		
Longnose Sucker	Catostomus catostomus	y
Mountain Sucker	Catostomus platyrhynchus	y
White Sucker	Catostomus commersoni	y
Family Catostomidae (Sculpins; trophic level 2-3; benthic)		
Bear Lake sculpin	Cottus extensus	y
Family Cyprinidae (Minnows or carps; trophic level 2-3; benthopelagic)		
Leatherside chub	Gila copei	
Utah chub	Gila atraria	y
Common dace	Leuciscus leuciscus	y
Longnose dace	Rhinichthys cataractae	
Speckled dace	Rhinichthys osculus	
Red shiner	Notropis lutrensis	
Redside shiner	Richardsonius balteatus	y
Common carp	Cyprinus carpio	
Family Percidae (Perches; trophic level 3; benthopelagic)		
Yellow perch	Perca flavescens	y
Family Salmonidae (salmon; trophic level 3-4; benthopelagic - pelagic)		
Bear Lake whitefish	Prosopium abyssicola	
Bonneville whitefish	Prosopium spilonotus	
Mountain whitefish	Prosopium williamsoni	y
Bonneville cisco	Prosopium gemmifer	
Brook Trout	Salvelinus fontinalis	y
Brown Trout	Salmo trutta	
Rainbow Trout	Oncorhynchus mykiss	y
Bear Lake cutthroat trout	Oncorhynchus clarki pop 3	
Bonneville cutthroat trout	Oncorhynchus clarki Utah	
Snake River Fine-Spotted Cutthroat	Oncorhynchus clarki ssp2	
Yellowstone cutthroat trout	Oncorhynchus clarki Bouvieri	y

Notes:
Species list source: MW, 1999
Trophic level source: USEPA, 1995
Habitat source: Froese and Pauly, 2010

Tables C4-8

Regional Birds

Common Name	Species Name	Sampled	Trophic Level
<u>Seabirds, Heron-like Birds, and Kingfishers - piscivorous diet</u>			
Family Peicaniformes			
American White Pelican	Pelecanus erythrorhynchos		3
Double-Crested Cormorant	Phalacrocorax auritus		2
Family Podicipediformes			
Eared Grebe	Podiceps nigricollis	√	2
Pied-Billed Grebe	Podilymbus podiceps		2
Horned Grebe	Podiceps auritus		2
Western Grebe	Aechmophorus occidentalis	√	2
Family Ciconiformes			
American Bittern	Botaurus lentiginosus		2
Black-Crowned Night-Heron	Nycticorax nycticorax		2
Great Blue Heron	Ardea herodias		3
Green Heron	Butorides striatus		2
Cattle Egret	Bubulcus ibis		2
Snowy Egret	Egretta Thula		2
White-Faced Ibis	Plegadis chihi	√	2
Turkey Vulture	Cathartes aura		3
Family Alcedinidae			
Belted Kingfisher	Ceryl alcyon		2
<u>Gulls, Terns and Shorebirds - omnivorous diet</u>			
Family Charadriformes			
Black Tern	Chlidonias niger		2
Bonaparte’s Gull	Larus philadelphia		2
California Gull	Larus californicus	√	2
Caspian Tern	Sterna Caspia		2
Common Tern	Sterna hirundo		2
Forster’s Tern	Sterna forsteri		2
Franklin’s Gull	Larus pipixcan	√	2
Herring Gull	Larus argentatus		2
Ring-Billed Gull	Larus delawarensis	√	2
American Avocet	Recurvirostra americana		2
American Dipper	Cinclus mexicanus		2
Baird’s Sandpiper	Calidris bairdii		2
Black-Bellied Plover	Pluvialis squatarola		2
Black-Necked Stilt	Himantopus mexicanus		2
Common Snipe	Gallinago gallinago	√	2
Greater Yellowlegs	Tringa melanoleuca		2
Killdeer	Charadrius vociferus	√	2
Least Sandpiper	Calidris minutilla		2
Lesser Golden-Plover	Pluvialis dominica		2
Lesser Yellowlegs	Tringa flavipes		2
Long-Billed Curlew	Numenius americanus		2
Long-Billed Dowitcher	Limnodromus scolopaceus		2
Short-Billed Dowitcher	Limnodromus griseus		2
Solitary Sandpiper	Tringa solitaria		2
Spotted Sandpiper	Actitis macularia		2
Stilt Sandpiper	Micropalma himantopus		2
Upland Sandpiper	Bartramia longicauda		2
Western Sandpiper	Calidris mauri		2
Willett	Catoptrophorus semipalmatus	√	2

Regional Birds

Common Name	Species Name	Sampled	Trophic Level
Wilson's Phalarope	Phalaropus tricolor		2
Marbled Godwit	Limosa Fedoa		2
Marsh Birds - omnivorous diet			
Family Gruiformes			
Sora	Porzana carolina		2
Virginia Rail	Rallus limicola		2
Whooping Crane	Grus americana		2
Greater Sandhill Crane	Grus canadensis	√	2
American Coot	Fulica americana	√	2
Swans, Geese and Ducks - omnivorous diet			
Family Anseriformes			
American Wigeon	Anas americana		2
Barrow's Goldeneye	Bucephala islandica		2
Blue-Winged Teal	Anas discors		2
Canvasback	Aythya valisineria		2
Cinnamon Teal	Anas cyanoptera	√	2
Common Goldeneye	Bucephala clangula		2
Common Merganser	Mergus merganser		2
Gadwall	Anas strepera		2
Common Teal	Anas crecca		2
Green-Winged Teal	Anas carolinensis		2
Hooded Merganser	Lophodytes cucullatus		2
Canada Goose	Branta canadensis	√	2
Lesser Scaup	Aythya affinis		2
Mallard	Anas platyrhynchas	√	2
Northern Shoveler	Anas Clypeata		2
Red-Breasted Merganser	Mergus serrator		2
Redhead Duck	Aythya americana		2
Ruddy Duck	Oxyura jamaicensis		2
Trumpeter Swan	Cygnus buccinator		1
Tundra Swan	Cygnus columbianus		1
Northern Pintail	Anas acuta		2
Greater Scaup	Aythya marila		2
Bufflehead	Bucephala albeola		2

Tables C4-8

Regional Birds
(Page 3 of 6)

Common Name	Species Name	Sampled	Trophic Level
Hawks and Owls - carnivorous diet			
Family Falconiformes			
American Kestrel	Falco sparverius	√	3
Coopers Hawk	Accipiter cooperii		3
Ferruginour Hawk	Buteo regalis		3
Golden Eagle	Aquila chrysuetos		3
Marsh Hawk	Circus cyaneus		3
Northern Goshawk	Accipiter gentilis		3
Northern Harrier	Circus cyaneus		3
Peregrine Falcon	Peregrinus anatum		3
Prairie Falcon	Falco mexicanus		3
Red-Tailed Hawk	Buteo jamaicensis		3
Rough-Legged Hawk	Buteo lagopus		3
Sharp-Shinned Hawk	Accipiter striatus		3
Sparrow Hawk	Falco spariverius		3
Swainson's Hawk	Buteo swainsoni		3
Bald Eagle	Haliaeetus leucocephalus		3
Family Strigiformes			
Barn Owl	Tyto alba		3
Boreal Owl	Aegolius funereus		3
Burrowing Owl	Athene cunicularia		2
Common Nighthawk	Chordeiles minor		2
Common Poorwill	Phalaenoptilus nuttallii		2
Flammulated Owl	Otus flammeolus		2
Great Gray Owl	Strix nebulosa		3
Long-Eared Owl	Asio otus		3
Northern Pygmy-Owl	Glaucidium gnoma		3
Northern Saw-Whet Owl	Aegolius acadicus		3
Short-Eared Owl	Asio flammeus		3
Western Screech Owl	Otus kennicottii		3
Chicken-like Birds and Pigeons - herbivorous diet			
Family Galliformes			
Blue Grouse	Dendragapus obscuras		2
Columbian Sharp-Tailed Grouse	ympanchus phasianellus columbianus		2
Gray-Partridge	Perdix perdix		1
Hungarian Partridge	Perdix perdix		2
Ring-Necked Pheasant	Phasianus colchicus		2
Ruffed Grouse	Bonasa umbellus		2
Sage Grouse	Centrocercus urophasianus		2
Sharp-Tailed Grouse	Pedioecetes phasianellus		2
Family Columbidae			
Mourning Dove	Zenaida macroura		1
Rock Dove	Columa livia		1

Regional Birds

Common Name	Species Name	Sampled	Trophic Level
Hummingbirds - Nectar diet			
Family Trochilidae			
Black-Chinned Hummingbird	Archilochus alexandri		2
Broad-Tailed Hummingbird	Selasphorus platycercus		2
Calliope Hummingbird	Stellula calliope		2
Rufous Hummingbird	Selasphorus rufus		2
Woodpeckers - insectivore diet			
Family Picidae			
Black-Backed Woodpecker	Picoides villosus		2
Hairy Woodpecker	Picoides villosus		2
Northern Flicker	Colaptes auratus	√	2
Red-Naped Sapsucker	Sphyrapicus varius		2
Red-Shafted Flicker	Colaptes cafer		2
Williamson’s Sapsucker	Sphyrapicus thyroideus		2
Downy Woodpecker	Dendrocopos pubescens		2
Songbirds (omnivorous diet unless otherwise specified)			
Family Fringillidae - herbivore diet			
Pine Grosbeak	Pinicola enucleator		1
Evening Grosbeak	Hesperiphona vespertina		2
American Goldfinch	Carduelis tristis		1
Cassin’s Finch	Carpodacus cassinnii		1
Common Redpoll	Carduelis flammea		2
Gray-Crowned Rosy Finch	Leucosticte atrata		2
House Finch	Carpodacus mexicanus		1
Pine Siskin	Carduelis pinus		1
Red Crossbill	Loxia curvirostra		1
White-Winged Crossbill	Loxia leucoptera		1
Family Bombycillidae - fruit diet			
Bohemian Waxwing	Bambycilla garrula		2
Cedar Waxwing	Bombycilla cedrorum		2
Family Picidae - Insectivore diet			
Cassin’s Kingbird	Tyrannus vociferans		2
Dusky Flycatcher	Empidonax oberholseri		2
Eastern Kingbird	Tyrannus tyrannus		2
Gray Flycatcher	Empidonax wrightii		2
Hammond’s Flycatcher	Empidonax hammondii		2
Olive-Sided Flycatcher	Nuttallornis borealis		2
Say’s Phoebe	Sayornis saya		2
Western Kingbird	Tyrannus verticalis		2
Western Wood-Peewee	Contopus sordidulus		2
Willow Flycatcher	Empidonax traillii		2
Family Hirundinidae - Insectivore diet			
Bank Swallow	Riparia riparia	√	2
Barn Swallow	Hirundo rustica		2
Cliff Swallow	Hirundo pyrrhonota	√	2
Northern Rough-Winged Swallow	Stelgidopteryx ruficollis		2
Rough-Winged Swallow	Stelgidopteryx serrupennis		2
Tree Swallow	Iridoprocne bicolor	√	2
Violet-Green Swallow	Tachycineta thalassina		2
Family Regulidae - Insectivore diet			
Golden-Crowned Kinglet	Regulus satrapa		2
Ruby-Crowned Kinglet	Regulus calendula		2

Regional Birds

Common Name	Species Name	Sampled	Trophic Level
Family Sylviidae - Insectivore diet			
Blue-Gray Gnatcatcher	Polioptila caerulea		2
Family Cinclidae - Insectivore diet			
Dipper	Cinclus mexicanus		2
Family Troglodytidae - Insectivore diet			
House Wren	Troglodytes aedon	√	2
Marsh Wren	Cistothorus palustris	√	2
Rock Wren	Salpinctes obsoletus		2
Family Turdidae - Insectivore diet			
American Robin	Turdus migratorius	√	2
Hermit Thrush	Catharus guttatus		2
Mountain Bluebird	Sialia currucoides	√	2
Swainson’s Thrush	Catharus ustulatus		2
Townsend’s Solitaire	Myadestes townsendi		2
Veery	Catharus fuscescens		2
Western Bluebird	Silalia mexicana		2
Family Parulidae - Insectivore diet			
American Redstart	Setophaga ruticilla		2
Black-Throated Gray Warbler	Dendroica nigrescens		2
Common Yellowthroat	Geothlypis trichas		2
MacGillivray’s Warbler	Oporornis tolmiei		2
Nashville Warbler	Vermivora ruficapilla		2
Northern Waterthrush	Seiurus noveboracensis		2
Orange-Crowned Warbler	Vermivora celata		2
Townsend’s Warbler	Dendroica townsendi		2
Virginia’s Warbler	Vermivora virginiae		2
Wilson’s Warbler	Wilsonnia pusilla		2
Yellow Warbler	Dendroica petechia	√	2
Yellow-Breasted Chat	Chat Icteria virens		2
Yellow-Rumped Warbler	Dendroica coronata		2
Family Corvidae			
American Crow	Corvus brachyrhynchos		2
Black-Billed Magpie	Pica pica		2
Clark’s Nutcracker	Nucifraga columbiana		2
Common Crow	Corrus brachyrhnchos		2
Common Raven	Corvus coraz		2
Gray Jay	Perisoreus canadensis		2
Horned Lark	Eremophilia alpestris		2
Steller’s Jay	Cyanocitta stelleri		2
Family Vireonidae			
Red-Eyed Vireo	Vireo olivaceus		2
Solitary Vireo	Vireo solitarius		2
Warbling Vireo	Vireo gilvus		2
Family Laniidae			
Loggerhead Shrike	Lanius ludovicianus		2
Family Paridae			
Black-Capped Chickadee	Parus atricapillus		2
Bushtit	Psaltriparus minimus		2
Mountain Chickadee	Parus gambeli		2
Plain Titmouse	Parus inornatus		2
Family Sittidae			
Red-Breasted Nuthatch	Sitta canadensis		2

Tables C4-8

Regional Birds
(Page 6 of 6)

Common Name	Species Name	Sampled	Trophic Level
White-Breasted Nuthatch	Sitta carolinensis		2
Family Certhiidae			
Brown Creeper	Certhia familiaris		2
Family Mimidae			
Gray Catbird	Dumetella carolinensis		2
Sage Thrasher	Oreoscoptes montanus		2
Family Sturnidae			
European Starling	Sturnus vulgaris	√	2
Family Thraupidae			
Western Tanager	Piranga ludoviciana		2
Family Cardinalidae			
Black-Headed Grosbeak	Pheucticus melanocephalus		2
Lazuli Bunting	Passerina amoena		2
Family Emberizidae			
American Tree Sparrow	Spizella arborea		2
Brewer's Sparrow	Spizella Breweri		2
Chipping Sparrow	Spizella passerina		1
Dark-Eyed Junco	Junco hyemalis		2
Fox Sparrow	Passerella iliaca		2
Grasshopper Sparrow	Ammodramus savannarum		2
Lark Bunting	Calamospiza melanocorys		2
Green-Tailed Towhee	Chlorura chlorara		2
Horned Sparrow	Passer domesticus		2
Lark Sparrow	Chondestes grammacus		2
Lincoln's Sparrow	Melospiza lincolnii		2
Rufous-Sided Towhee	Pipilo erythrophthalmus		2
Sage Sparrow	Amphispiza belli		2
Savannah Sparrow	Passerculus sandwichensis		2
Song Sparrow	Melospiza melodia	√	2
Vesper Sparrow	Pooecetes gramineus		2
White-Crowned Sparrow	Zonotrichia leucophrys		2
Family Icteridae			
Brewer's Blackbird	Euphagus cyanocephalus	√	2
Brown-Headed Cowbird	Molothrus ater	√	2
Common Grackle	Quiscalus quiscula		2
Northern Oriole	Icterus galbula		2
Red-Winged Blackbird	Agelaius phoeniceus	√	2
Western Meadowlark	Sturnella neglecta		2
Yellow-Headed Blackbird	Xanthocephalus xanthocephalus	√	2
Family Passeridae			
House Sparrow	Passer domesticus		2

Sources:
Idaho Conservation Data Center (1999); List of Birds (Updated August 1997) as cited in MW, 1999.
Riparian Community Type Classification of Eastern Idaho-Western Wyoming (Youngblood, Padgett, and Winward, 1985).
Distribution, Season of Use, and Habitat of the Mammals, Birds, Reptiles, Amphibians, and Fishes of Idaho (Wilson, 1977).
Ecological Site Inventory for Pocatello Resource Area, Bureau of Land Management (Undated).

Table C4-9

Regional Mammals
(Page 1 of 2)

Common Name	Species Name	Sampled	Trophic Level
Order Insectivora - Invertebrate diet			
Family Soricidae (Shrews)			
Merriam's Shrew	Sorex merriami		2
Order Rodentia (Rodents) - Omnivorous diet			
Family Sciuridae (Chipmunks, Marmots, & Squirrels)			
Golden-Mantled Squirrel	Citellus lateralis		1
Richardson Ground Squirrel	Citellus richardsoni		1
Townsend's Ground Squirrel	Spermophilus townsendii		2
Uinta Ground Squirrel	Citellus armatus	√	2
Rock Squirrel	Spermophilus variegatus		2
Least Chipmunk	Etuamias minimus	√	1
Uinta Chipmunk	Tamius umbrinus		1
Yellow Pine Chipmunk	Eutamias amoenus		1
Yellow-Bellied Marmot	Marmota flaviventris		1
Family Muridae (Mice, Rats, Lemmings, & Voles)			
Deer Mouse	Peromyscus maniculatus	√	2
House Mouse	Mus musculus		1
Northern Grasshopper Mouse	Onychomys leucogaster		2
Western Harvest Mouse	Reithrodontomys megalotis	√	2
Long-Tailed Vole	Microtus longieaudus		1
Mountain Vole	Microtus montanus		2
Muskrat	Ondatra zibethica		2
Bushy-Tailed Wood Rat	Neotoma cinera		1
Family Geomyidae (Pocket Gophers)			
Idaho Pocket Gopher	Thomomys idahoensis		1
Northern Pocket Gopher	Thomomys talpoides		2
Family Heteromyidae (Pocket Mice, Kangaroo Mice, & Kangaroo Rats)			
Great Basin Pocket Mouse	Perognathus parvus		2
Family Castoridae (Beaver)			
Beaver	Castor canadensis		1
Family Erethizontidae (Porcupines)			
Porcupine	Erethizone dorsatum		1
Order Carnivora - Carnivorous diet			
Family Canidae (Coyotes, Dogs, Foxes, Jackals, and Wolves)			
Coyote	Canis latrans		3
Gray Wolf	Canis lupus		3
Red Fox	Vulpes vulpes		2
Family Felidae (Cats)			
Mountain Lion	Felis concolor		3
Bobcat	Lynx rufus		3
Family Ursidae (Bears)			
Black Bear	Ursus americanus		3
Family Procyonidae (Coatis, Raccoons, and relatives)			
Raccoon	Procyon lotor		2
Family Mustelidae (Badgers, Otters, Weasels, and relatives)			
Badger	Taxidea taxus		3
Mink	Mustea vison		3
Long-Tailed Weasel	Mustela frenata		2
Short-Tailed Weasel (ermine)	Mustela erminea		3
Striped Skunk	Mephitis mephitis		2
Wolverine	Gulo gulo		2

Table C4-9

Regional Mammals
(Page 2 of 2)

Common Name	Species Name	Sampled	Trophic Level
Order Chiroptera (Bats) - Insect diet			
Family Vespertilionidae (Evening bats and Vesper bats)			
Big Brown Bat	Eptesicus fucus		2
Hoary Bat	Lasiurus cinereus		2
Pallid Bat	Antrozous pallidus		2
Silver-Haired Bat	Lasionycteris noctivagans		2
Townsend’s Big-Eared Bat	Plecotus townsendii		2
Little Brown Myotis	Myotis lucifugus		2
Long-Eared Myotis	Myotis evotis		2
Long-Legged Myotis	Myotis volans		2
Western Small-footed Myotis	Myotis ciliolabrum		2
Yuma Myotis	Myotis yumanenisis		2
Order Lagomorpha (Pikas, Hares, and Rabbits) - Herbivorous diet			
Family Leporidae (Hares and Rabbits)			
Snowshoe Hare	Lepus americanus		1
Black-Tailed Jack Rabbit	L. californicus		1
Pygmy Rabbit	Brachylagus idahoensis		1
White-Tailed Jack Rabbit	Lepus townsendii		1
Mountain Cottontail	Sylvilagus nuttallii		1
Order Artiodactyla (Hoofed Mammals) - Herbivorous diet			
Family Cervidae (Deer)			
Mule Deer	Odocoileus hemionus		1
White-Tailed Deer	Odocoileus virginianus		1
Elk	Cervus elaphus	√	1
Moose	Alces alces		1

Sources:
Idaho Conservation Data Center (1999); List of Mammals (Updated March 1998) as cited in MW, 1999..
Distribution, Season of Use, and Habitat of the Mammals, Birds, Reptiles, Amphibians and Fishes of Idaho (Wilson, 1977).

Table C4-10

Proposed Assessment Endpoints and Indicator Receptors
(Page 1 of 4)

Feeding Guild	Assessment Endpoint	Receptor	Measures of Exposure	Measures of Effect
2 ˚ Consumers Amphipians	Protect amphibians from acute (mortality) and chronic (e.g., reproductive impairment) adverse effects from direct and/or secondary exposure to metals resulting from phosphate mining activities.	Frog	Measured surface water COPEC concentrations	· Compare measured surface water concentration with acceptable levels
2 ˚ Consumers Benthic Fish	Protect benthic fish species from acute (mortality) and chronic (e.g., reproductive impairment) adverse effects from direct and/or secondary exposure to metals resulting from phosphate mining activities.	Sculpin	Measured fish tissue COPEC concentrations	· Compare measured tissue concentration with acceptable levels
2 ˚ Consumers Pelagic Fish	Protect pelagic fish species from acute (mortality) and chronic (e.g., reproductive impairment) adverse effects from direct and/or secondary exposure to metals resulting from phosphate mining activities.	Yellowstone Cutthroat Trout	Measured fish tissue COPEC concentrations	· Compare measured tissue concentration with acceptable levels
1 ˚ Consumers Terrestrial Herbivore	Protect herbivorous mammals (avian and terrestrial predator prey items) by limiting acute and adverse effects from exposure to metals resulting from phosphate mining activities.	Meadow Vole	Calculated daily dosage using exposure models, measured chemical concentrations in abiotic and biotic media, and food web interactions.	· Compare calculated dose to NOAEL dosages for similar prey species.
	Protect large herbivorous mammals (game species) by limiting acute and adverse effects from exposure to metals resulting from phosphate mining activities.	Elk	· Calculated daily dosage using exposure models, measured chemical concentrations in abiotic and biotic media, and food web interactions. · Measured elk tissue COPEC concentrations.	· Compare calculated dose to NOAEL dosages for similar species. · Compare measured tissue concentration with acceptable levels

Proposed Assessment Endpoints and Indicator Receptors

Feeding Guild	Assessment Endpoint	Receptor	Measures of Exposure	Measures of Effect
	Protect grazing livestock by limiting acute and adverse effects from exposure to metals resulting from phosphate mining activities.	Beef Cattle	· Calculated daily dosage using exposure models, measured chemical concentrations in abiotic and biotic media, and food web interactions. · Measured COPEC concentrations in beef cattle tissue.	· Compare calculated dose to NOAEL dosages for similar species. · Compare measured tissue concentration with acceptable levels
1 ˚ Consumers Avian Herbivore	Protect herbivorous bird species from acute (mortality) and chronic (e.g., reproductive impairment) adverse effects from direct and/or secondary exposure to metals resulting from phosphate mining activities.	American Goldfinch	· Calculate daily dosage using exposure models, measured chemical concentrations in abiotic and biotic media, and food web interactions. · Measured COPEC concentrations in bird eggs.	· Compare calculated dose to NOAEL dosages for similar species. · Compare measured egg concentration with acceptable levels
2 ˚ Consumers Terrestrial Omnivore	Protect small omnivorous mammals (avian and terrestrial predator prey items) by limiting acute and adverse effects from exposure to metals resulting from phosphate mining activities.	Deer Mouse	· Calculated daily dosage using exposure models, measured chemical concentrations in abiotic and biotic media, and food web interactions. · Measured COPEC concentrations in mouse tissue.	· Compare calculated dose to NOAEL dosages for similar species. · Compare measured tissue concentration with acceptable levels
	Protect omnivorous mammals by limiting acute and adverse effects from exposure to metals resulting from phosphate mining activities.	Raccoon	· Calculated daily dosage using exposure models, measured chemical concentrations in abiotic and biotic media, and food web interactions.	· Compare calculated dose to NOAEL dosages for similar prey species.

Table C4-10

Proposed Assessment Endpoints and Indicator Receptors

Feeding Guild	Assessment Endpoint	Receptor	Measures of Exposure	Measures of Effect
2 ˚ Consumers Avian Omnivore	Protect omnivorous bird species from acute (mortality) and chronic (e.g., reproductive impairment) adverse effects from direct and/or secondary exposure to metals resulting from phosphate mining activities.	American Robin	· Calculate daily dosage using exposure models, measured chemical concentrations in abiotic and biotic media, and food web interactions. · Measured COPEC concentrations in bird eggs.	· Compare calculated dose to NOAEL dosages for similar species. · Compare measured egg concentration with acceptable levels
	Protect omnivorous water bird species from acute (mortality) and chronic (e.g., reproductive impairment) adverse effects from direct and/or secondary exposure to metals resulting from phosphate mining activities.	Mallard	· Calculate daily dosage using exposure models, measured chemical concentrations in abiotic and biotic media, and food web interactions. · Measured COPEC concentrations in bird eggs.	· Compare calculated dose to NOAEL dosages for similar species. · Compare measured egg concentration with acceptable levels
3 ˚ Consumers Terrestrial Predator	Protect upper trophic level aquatic feeding terrestrial species from acute (mortality) and chronic (e.g., reproductive impairment) adverse effects from direct and/or secondary exposure to metals resulting from phosphate mining activities.	Mink	· Calculated daily dosage using exposure models, measured chemical concentrations in abiotic and biotic media, and food web interactions.	· Compare calculated dose to NOAEL dosages for similar prey species.
	Protect upper trophic level terrestrial species from acute (mortality) and chronic (e.g., reproductive impairment) adverse effects from direct and/or secondary exposure to metals resulting from phosphate mining activities.	Coyote	· Calculated daily dosage using exposure models, measured chemical concentrations in abiotic and biotic media, and food web interactions.	· Compare calculated dose to NOAEL dosages for similar prey species.

Table C4-10

Proposed Assessment Endpoints and Indicator Receptors
(Page 4 of 4)

Feeding Guild	Assessment Endpoint	Receptor	Measures of Exposure	Measures of Effect
3 ˚ Consumers Avian Predator	Protect upper trophic level aquatic feeding avian species from acute (mortality) and chronic (e.g., reproductive impairment) adverse effects from direct and/or secondary exposure to metals resulting from phosphate mining activities.	Great Blue Heron	· Calculated daily dosage using exposure models, measured chemical concentrations in abiotic and biotic media, and food web interactions.	· Compare calculated dose to NOAEL dosages for similar prey species.
	Protect upper trophic level avian species from acute (mortality) and chronic (e.g., reproductive impairment) adverse effects from direct and/or secondary exposure to metals resulting from phosphate mining activities.	Northern Harrier	· Calculated daily dosage using exposure models, measured chemical concentrations in abiotic and biotic media, and food web interactions.	· Compare calculated dose to NOAEL dosages for similar prey species.

Notes:

COPEC - chemical of potential concern

NOAEL - no observed adverse effects level

Table C4-11

Ecposure Parameters for Ecological Receptors

Exposure Parameter	Exposure Value											
	Long-Tailed Vole *Microtus*	**Elk** *Cervus elaphus*	**Beef Cattle** *Bos taurus*	**American Goldfinch** *Spinus tristis*	**Deer Mouse** *Peromyscus*	**Raccoon** *Procyon lotor*	**American Robin** *Turdus migratorius*	**Mallard** *Anas platyrhynchos*	**Mink** *Mustela vison*	**Coyote** *Canis latrans*	**Great Blue Heron** *Ardea herodias*	**Northern Harrier** *Circus cyaneus*
Body Weight (g) [a]	37 [h,i]	2.9E+05 [k]	4.6E+05 [m]	16 [q]	19.5 [h]	5,800 [h]	81 [h]	1,171 [h]	852 [h]	13,600 [k]	2,390 [h]	449 [x]
Male Range (g)	17 - 52.4	178,000 - 497,000	453,600 - 545,000	11 - 20	15.7 - 22.3	4,300 - 7,600	77.4 - 86.2	1225 - 1246	1,040 - 1,233	9,100 - 18,100	2,277 - 2,875	290 - 390 [y]
Female Range (g)	17 - 43.5	171,000 -292,000	385,600 - 453,600	11 - 20	14.8 - 20.3	3,700 - 6,400	80.6 - 83.6	1043 - 1095	550 - 586	9,100 - 18,100	1,867 - 2,541	390 - 600 [y]
Fraction of Prey Items in Diet (%)												
Plant Matter	98 [h,i]	100 [l]	100	100 [q]	61.5 [h]	61 [h]	44.7 [h]	25.3 [h]	3 [h]	9.2 [t]	0 [s]	0 [z]
Invertebrates	2	0	0	0	38.5	19	55.3	74.7	0	9.2	12.5	2
Terrestrial Animal Tissue	0	0	0	0	0	11	0	0	40	81.6	12.5	98
Aquatic Animal Tissue	0	0	0	0	0	9	0	0	57	0	75	0
Ingestion Rate of Prey (g dw/d) [b]	11.5 [i]	2,294	3,092	4	3.8	154	11	56	398	3,897	147	49
Soil/Sediment Ingestion Rate (g dw/d) [c]	0.28	45.9	61.8	0.43	0.076	14.5	1.10	1.86	37.38	109.12	1.0	0.3
Fraction of Soil/Sediment in the Diet (%)	2.4 [j,i]	2 [j]	2 [j,n]	10.4 [j,r]	2 [j]	9.4 [j]	10.4 [j,r]	3.3 [j]	9.4 [j,s]	2.8 [j,u]	0.7 [w]	0.7 [w]
Water Ingestion Rate (l/d) [d]	0.005	4	25	0.004	0.0029	0.48	0.01	0.07	0.086	1.0	0.11	0.03
Home Range (acres)	0.03 [h,i]	16,640 [l]	-- [o]	0.022 [s]	0.27 [h]	2,271 [h]	0.7 [h]	1,193 [h]	50 [h]	7,240 [v]	21 [h]	642 [x]
Area being Evaluated (acres) [e]	SS	SS	SS	SS	SS	SS	SS	SS	SS	SS	SS	SS
Site Utilization Factor (unitless) [f]	SS	SS	SS	SS	SS	SS	SS	SS	SS	SS	SS	SS
Exposure Duration (percent of year) [g]	1	1	0.33 [p]	1 [q]	1	1	1	1	1	1	1	1

Notes:

[a] Average body weight for males and females combined.

[b] Calculated using Equations 25 (mink and coyote), 29 (elk and cattle), 33 (raccoon), 37 (passerines), 61 (American robin and mallard), and 63 (great blue heron and northern harrier) from Nagy (2001). The food ingestion rate for the long-tailed vole and deer mouse were based on values in Table 1 (Nagy, 2001) for those species.

[c] Calculated as percent soil ingestion rate multiplied by the food ingestion rate (g/d).

[d] Calculated using Equation 3-15 (all birds) and Equation 3-17 (all mammals) from USEPA, 1993.

[e] Exposure area based on the total area of each site.

[f] Site utilization factors are calculated as the exposure area divided by the home range. Instances where the home range > exposure area are reported as 1.

[g] Exposure duration (percent of year exposed) is assumed to be 1 for most species based on species range maps.

[h] Wildlife Exposure Factors Handbook (USEPA, 1993).

[i] Meadow vole used as a surrogate species.

[j] Soil ingestion rates as percent of diet from Bayer (1994).

[k] Senseman, R. 2002. "Cervus elaphus" (On-line), Animal Diversity Web. Accessed February 22, 2011 http://animaldiversity.ummz.umich.edu/site/accounts/information/Cervus_elaphus.html.

[l] An Evaluation of the Effects of Selenium on Elk, Mule Deer, and Moose in SE Idaho (Kuck, 2003a).

[m] Body weight for beef cattle (Dhuyvetter, 1995).

[n] The elk was used as a surrogate for the soil ingestion rate for beef cattle.

[o] Cattle home range dependent on grazing boundaries

[p] Cattle exposure duration

[q] From Cornell Lab of Ornithology web site (www.birds.cornell.edu).

[r] The American woodcock was used as a surrogate to determine the soil ingestion rate for the American Goldfinch.

[s] Life history account from Zeiner, D.C. et al. (1988-1990). Maintained by California Wildlife Habitat Relationship Program of the California Department of Fish and Wildlife. Accessed at http://www.dfg.ca.gov/biogeodata/CWHR/cawildlife.aspx.

[t] Diet composition based on study of coyotes in the Cuyahoga Valley National Park, Ohio (Cepak, 2004).

[u] The red fox was used as a surrogate to determine the soil ingestion rate for the coyote.

[v] Mean coyote homerange for southeastern Idaho from Woodruff and Keller (1982).

[w] Sediment ingestion percent for bald eagle reported in Pascoe et al. (1996) used to calculate the sediment ingestion rate for the great blue heron and northern harrier.

[x] Northern harrier average body weight reported in Slater and Rock (2005).

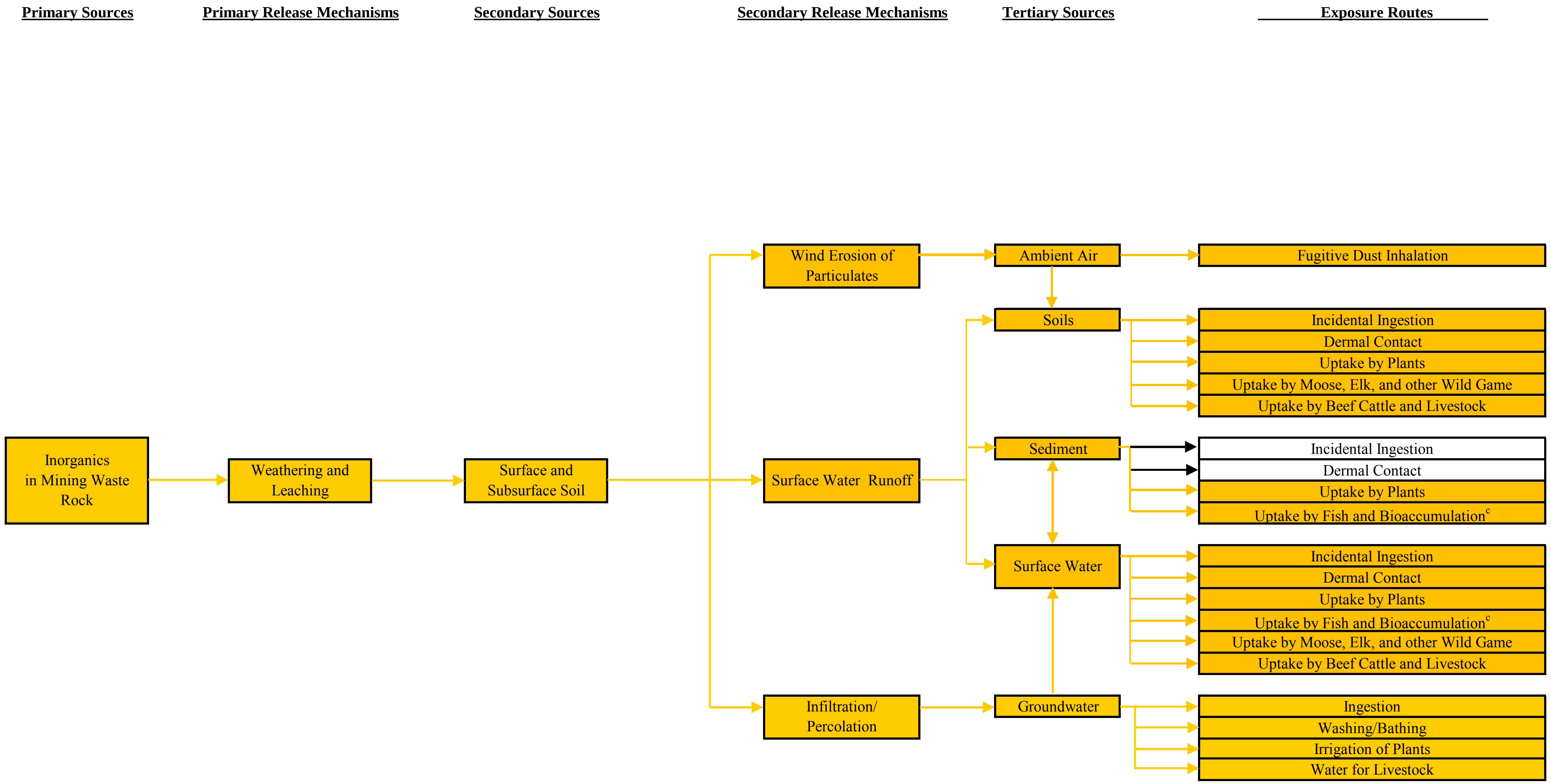
[y] Northern harrier body weight ranges from Limas, B (2001).

[z] Percent prey items in northern harrier diet from Bildstein, K.L. (1987).

d – day
dw – dry weight
g – gram
l – liter
SS – site-specific

FIGURES

FIGURE C3-1
HUMAN HEALTH CONCEPTUAL SITE MODEL
P4 PRODUCTION RI/FS



Potential Receptors[a, b]

Tertiary Source	Exposure Route	Recreational Hunter	Recreational Fisher	Recreational Camper/Hiker	Native American	Hypothetical Future Resident	Seasonal Rancher
Ambient Air	Fugitive Dust Inhalation	●	●	●	●	●	●
Soils	Incidental Ingestion	●	●	●	●	●	●
Soils	Dermal Contact	●	●	●	●	●	●
Soils	Uptake by Plants	○	○	○	●	●	○
Soils	Uptake by Moose, Elk, and other Wild Game	●	○	○	●	•	○
Soils	Uptake by Beef Cattle and Livestock	○	○	○	○	•	●
Sediment	Incidental Ingestion	○	•	•	•	•	○
Sediment	Dermal Contact	○	•	•	•	•	○
Sediment	Uptake by Plants	○	○	○	●	○	○
Sediment	Uptake by Fish and Bioaccumulation[c]	○	●	○	●	●	○
Surface Water	Incidental Ingestion	○	●	•	●	●	○
Surface Water	Dermal Contact	○	●	•	●	●	○
Surface Water	Uptake by Plants	○	○	○	●	○	○
Surface Water	Uptake by Fish and Bioaccumulation[c]	○	●	○	●	●	○
Surface Water	Uptake by Moose, Elk, and other Wild Game	●	○	○	●	•	○
Surface Water	Uptake by Beef Cattle and Livestock	○	○	○	○	•	●
Groundwater	Ingestion	○	○	○	○	●	●
Groundwater	Washing/Bathing	○	○	○	○	●	●
Groundwater	Irrigation of Plants	○	○	○	○	●	○
Groundwater	Water for Livestock	○	○	○	○	○	●

(yellow arrow) Potentially Complete Exposure Pathway
(black arrow) Potentially Complete but Insignificant Pathway
(dashed arrow) Incomplete Pathway
● Complete Exposure Pathway
• Potentially Complete but Insignificant Pathway
○ Incomplete Exposure Pathway

Notes:
[a] All potential receptors are both current and future receptors except for hypothetical future residential receptor.
[b] It is also possible that some biota consumption pathways could be applicable to multiple receptors. For example, a recreational hunter could also fish; a recreational fisherman could also hunt; a recreational camper/hiker could hunt and/or fish. Such alternative exposure pathways will be evaluated qualitatively in the Uncertainty Analysis section of the HHERA.
[c] Bioaccumulation in aquatic receptors represents uptake to the appropriate trophic level for ingestion and for fishing.

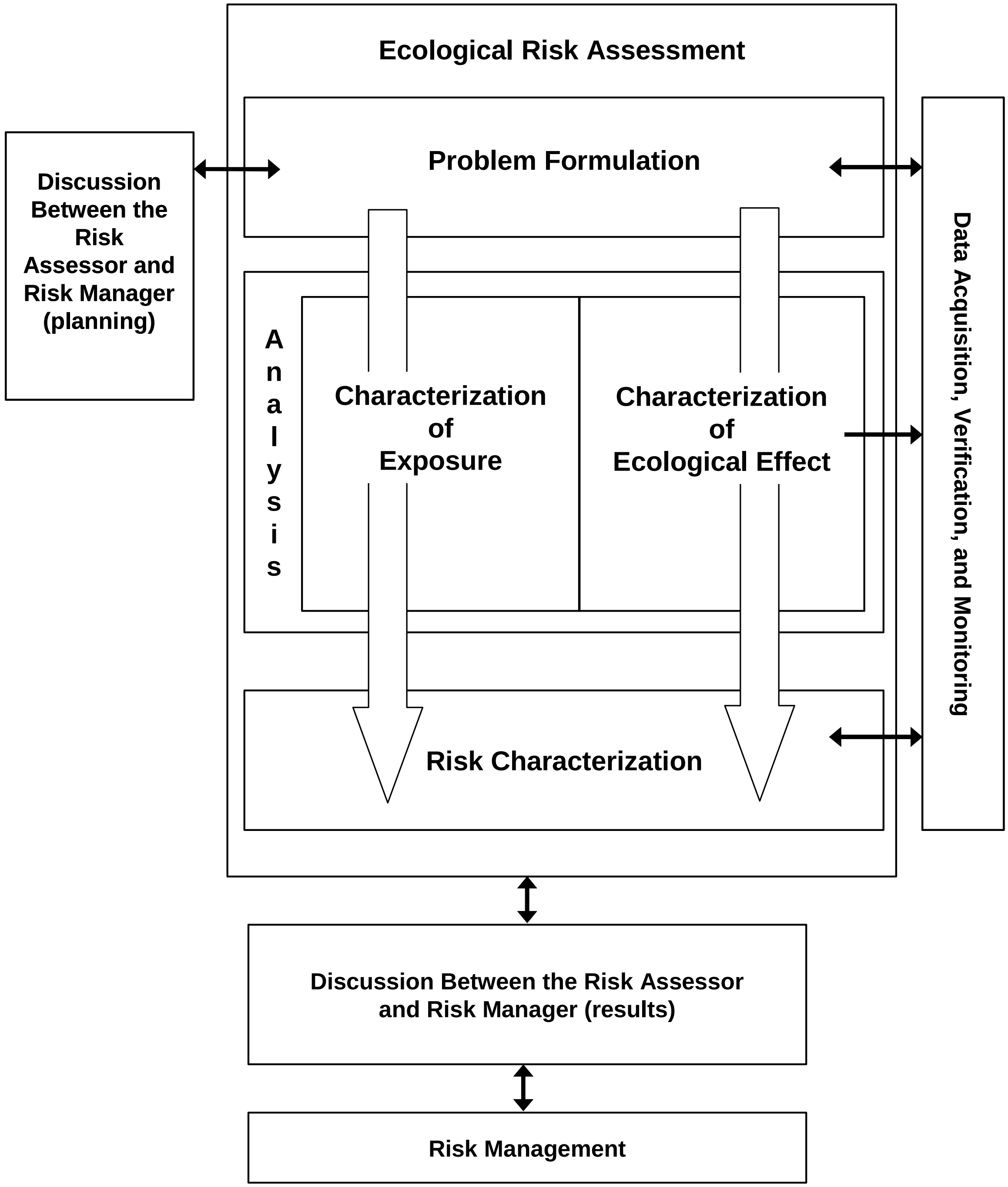
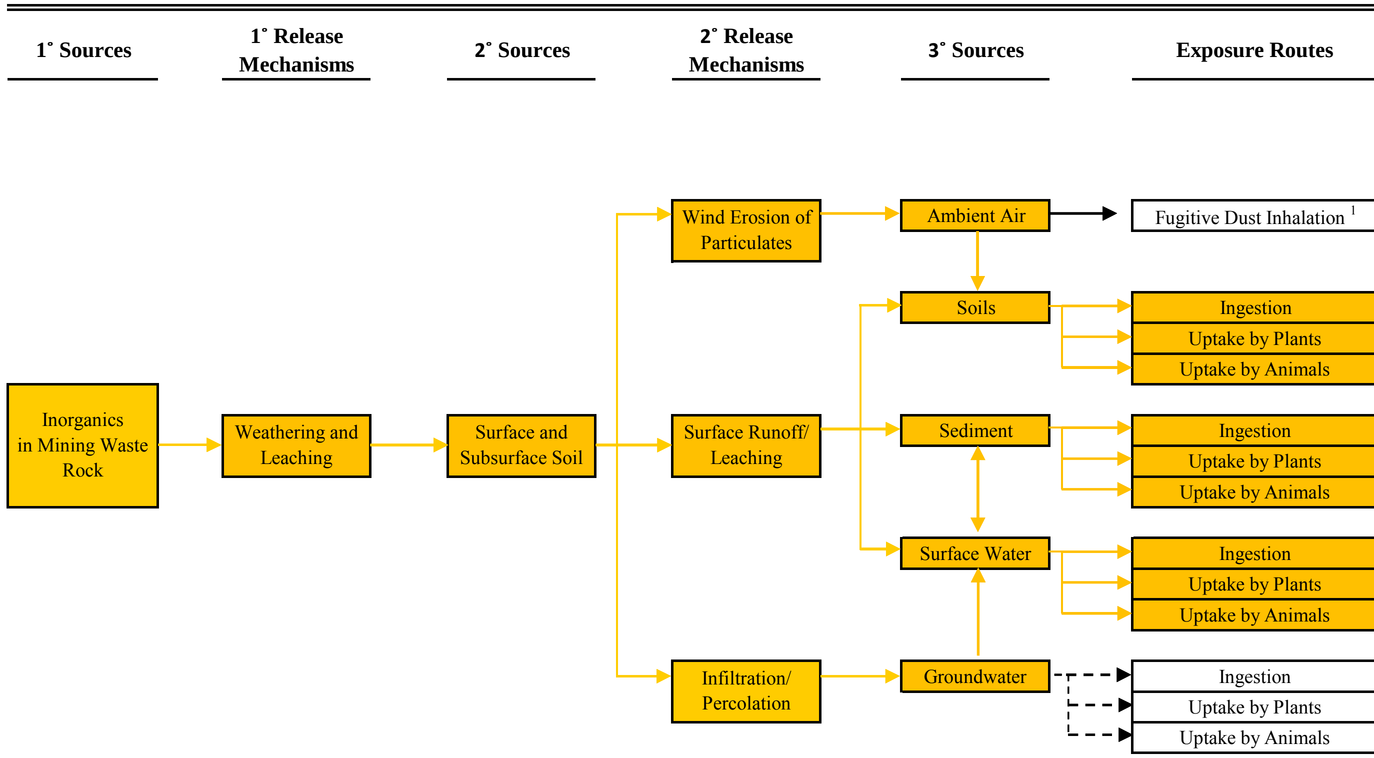


Figure C4-1. Framework for Ecological Risk Assessment (Reproduced from USEPA 1997d Ecological Risk Assessment Guidance for Superfund).

FIGURE C4-2
ECOLOGICAL CONCEPTUAL SITE MODEL
P4 PRODUCTION RI/FS



Potential Ecological Receptors

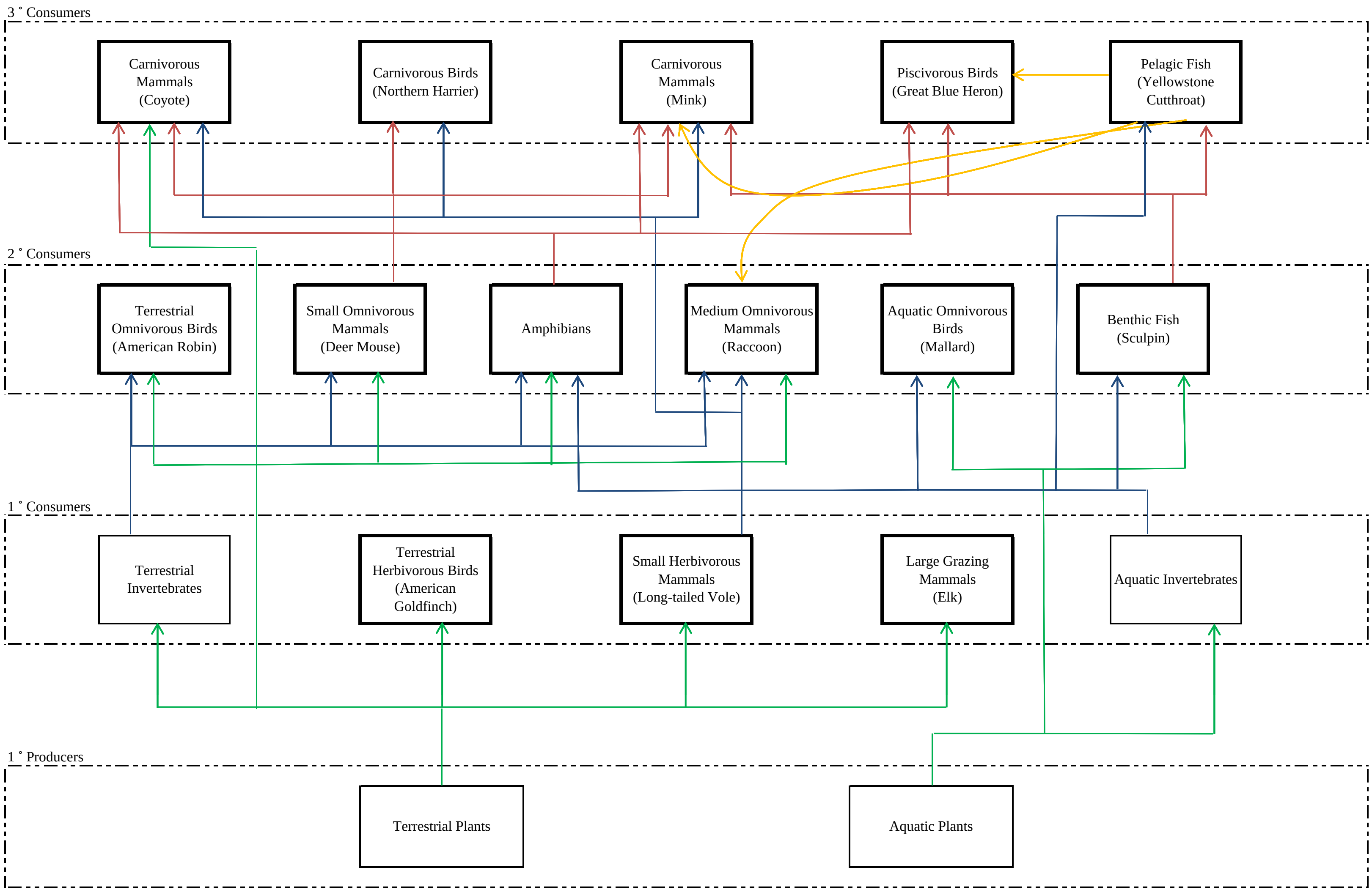
3° Source	Exposure Route	Aquatic Invertebrates	Benthic and Pelagic Fish [2]	Terrestrial and Aquatic Plants [3]	Terrestrial Invertebrates [4]	Reptiles [5]	Amphibians [6]	Terrestrial Herbivore [7]	Avian Herbivore [8]	Terrestrial Omnivore [9]	Avian Omnivore [10]	Terrestrial Predator [11]	Avian Predator [12]
Ambient Air	Fugitive Dust Inhalation [1]	○	○	○	○	●	●	●	●	●	●	●	●
Soils	Ingestion	○	○	○	● (shaded)	● (shaded)	● (shaded)	● (shaded)	● (shaded)	● (shaded)	● (shaded)	● (shaded)	● (shaded)
Soils	Uptake by Plants	○	○	● (shaded)	● (shaded)	● (shaded)	● (shaded)	● (shaded)	● (shaded)	● (shaded)	● (shaded)	○	○
Soils	Uptake by Animals	○	○	○	○	● (shaded)	● (shaded)	○	○	● (shaded)	● (shaded)	● (shaded)	● (shaded)
Sediment	Ingestion	● (shaded)	● (shaded)	○	○	● (shaded)	● (shaded)	● (shaded)	● (shaded)	● (shaded)	● (shaded)	● (shaded)	● (shaded)
Sediment	Uptake by Plants	● (shaded)	● (shaded)	● (shaded)	○	● (shaded)	● (shaded)	○	● (shaded)	● (shaded)	● (shaded)	●	○
Sediment	Uptake by Animals	● (shaded)	● (shaded)	○	○	● (shaded)	● (shaded)	○	○	● (shaded)	● (shaded)	● (shaded)	● (shaded)
Surface Water	Ingestion	● (shaded)	● (shaded)	○	● (shaded)	● (shaded)	● (shaded)	● (shaded)	● (shaded)	● (shaded)	● (shaded)	● (shaded)	● (shaded)
Surface Water	Uptake by Plants	● (shaded)	● (shaded)	● (shaded)	○	● (shaded)	● (shaded)	○	● (shaded)	● (shaded)	● (shaded)	○	○
Surface Water	Uptake by Animals	● (shaded)	● (shaded)	○	○	● (shaded)	● (shaded)	○	○	● (shaded)	● (shaded)	● (shaded)	● (shaded)
Groundwater	Ingestion	○	○	○	○	○	○	○	○	○	○	○	○
Groundwater	Uptake by Plants	●	●	●	○	●	●	●	●	●	●	○	○
Groundwater	Uptake by Animals	○	●	○	○	●	●	○	○	●	●	●	●

Notes:

Symbol	Meaning
Yellow solid arrow	Potentially Complete Exposure Pathway
Black solid arrow	Potentially Complete but Insignificant Pathway
Dashed arrow	Incomplete Pathway
● (shaded)	Complete Exposure Pathway
●	Potentially Complete but Insignificant Pathway
○	Incomplete Exposure Pathway

[1] The direct exposure pathways of dermal contact and inhalation of contaminants are not evaluated for ecological receptors due to lack of relevant toxicological information. Ingestion represents the highest exposure scenario for direct contact pathways.
[2] The selected indicator receptor for the assessment endpoint of benthic fish is the sculpin; the selected indicator receptor for pelagic fish is the cutthroat trout.
[3] Not a direct assessment endpoint, will be evaluated qualitatively.
[4] Not a direct assessment endpoint, will be evaluated qualitatively.
[5] Not a direct assessment endpoint, will be evaluated qualitatively.
[6] Amphibians are a direct assessment endpoint.
[7] The selected indicator receptors for the assessment endpoint of terrestrial herbivore are the long-tailed vole, elk and beef cattle.
[8] The selected indicator receptor for the assessment endpoint of avian herbivore is the American goldfinch.
[9] The selected indicator receptors for the assessment endpoint of terrestrial omnivore are the deer mouse and raccoon.
[10] The selected indicator receptors for the assessment endpoint of avian omnivore are the American robin and mallard duck.
[11] The selected indicator receptors for the assessment endpoint of terrestrial predator are the mink and coyote.
[12] The selected indicator receptors for the assessment endpoint of avian predator are the great blue heron and the northern harrier.

FIGURE C4-3
FOOD WEB MODEL
P4 PRODUCTION RI/FS



Note
Receptors in bolded boxes were selected as indicator receptors for quantitative evaluation in the ecological risk assessment.
Green line - consumption pathways of 1 ˚ Producers
Blue line - consumption pathways of 1 ˚ Consumers
Red line - consumption pathways of 2 ˚ Consumers
Orange line - consumption pathways of 3 ˚ Consumers