Selenium Project
Southeast Idaho Phosphate Resource Area

Final
Area Wide Human Health and Ecological Risk Assessment Work Plan

April 2002

Prepared for

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AREA WIDE INVESTIGATION
SOUTHEAST IDAHO PHOSPHATE MINING RESOURCE AREA
Contract Number C023
Task Order AWI-00-01

FINAL

AREA WIDE HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENT WORK PLAN

SELENIUM PROJECT

SOUTHEAST IDAHO PHOSPHATE MINING RESOURCE AREA

APRIL 2002

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ACRONYMS AND ABBREVIATIONS

μg/day	Microgram per day
μg/g	Microgram per gram
μg/L	Microgram per liter
95UCL	95 Upper confidence limits
ADD	Average daily dose
ATSDR	Agency for Toxic Substances and Disease Registry
AT	Averaging time
AW	Ash weight
AWHHRA	Area wide human health risk assessment
AWERA	Area wide ecological risk assessment
B	Background
BIA	U.S. Bureau of Indian Affairs
BLM	U.S. Bureau of Land Management
BTF	Biotransfer factor
BW	Body weight
C	Chemical concentration
CCME	Canadian Council of Ministers of the Environment
CF	Conversion factor
COPC	Chemical of potential concern
COPEC	Chemical of potential ecological concern
CR	Contact rate
CSM	Conceptual site model
CTE	Central tendency exposure
D	Dose
DQO	Data quality objective
DW	Dry weight
EC	Effective concentration
ECO-SSL	Ecological soil screening level
ED	Exposure duration
EF	Exposure frequency
ELCR	Excess lifetime cancer risks
EPA	U.S. Environmental Protection Agency
EPC	Exposure point concentration
ERA	Ecological risk assessment
FI	Fraction ingested
FS	U.S. Forest Service

ACRONYMS AND ABBREVIATIONS (continued)

FW	Fresh weight
g	Grams
g/day	Grams per day
g/g-day	Grams per gram-day
GMU	Game management unit
ha	Hectare
HI	Hazard index
HQ	Hazard quotient
HHRA	Human health risk assessment
HQ	Hazard quotient
HSDB	Hazardous Substances Databank
I	Impacted
IC10	Threshold of reproductive failure
ICCDB	Idaho Conservation Center Data Base
IDEQ	Idaho Department of Environmental Quality
IDFG	Idaho Department of Fish and Game
IDH	Idaho Department of Health
IDL	Idaho Department of Lands
IEUBK	Integrated Exposure Uptake Biokenetic
IMA	Idaho Mining Association
IMASC	Idaho Mining Association Selenium Committee
IR	Ingestion rate
IRIS	Integrated Risk Information System
kg	Kilogram
kg[DW]/kg-day	Kilogram [dry weight] per kilogram-day
kg/g	Kilogram per gram
kg/ha	Kilogram per hectare
kg/mg	Kilogram per milligram
L	Liter
L/day	Liter per day
LADD	Lifetime average daily dose
LOAEL	Lowest observed adverse effect level
m^3	Cubic milligrams per hour
MAC	Maximum allowable concentration
MAFF	Ministry of Agriculture, Food, and Fisheries
MDC	Maximum detected concentration
mg/kg	Milligram per kilogram
mg/kg-day	Milligram per kilogram day

ACRONYMS AND ABBREVIATIONS (continued)

mg/L	Milligram per liter
ml	Milliliter
MOU	Memorandum of understanding
MW	Montgomery Watson
NA	Not applicable
NAWQC	National Ambient Water Quality Criterion
ND	Non detect
NLM	National Library of Medicine
NOAA	National Oceanic and Atmospheric Administration
NOAEL	No observed adverse effect level
NRC	National Research Council
Nu-West	Nu-West Industries, Inc.
ORNL	Oak Ridge National Laboratory
oz	Ounce
PEC	Probable effect concentration
ppm	Part per million
ppb	Part per billion
PRG	Preliminary remediation goal
RAGS	Risk Assessment Guidance for Superfund
RCRA	Resource Conservation and Recovery Act
Resource Area	Southeast Idaho Phosphate Mining Resource Area
RfD	Reference dose
RME	Reasonable maximum exposure
SeAWAC	Selenium Area Wide Advisory Committee
SeWG	Selenium Working Group
SF	Slope factor
SJVDP	San Joaquin Valley Drainage Program
SLERA	Screening level ecological risk assessment
SQL	Sample quantitation limits
SU	Site use factor
TEC	Threshold effect concentration
TMDL	Total Maximum Daily Loading
TTC	Trophic transfer coefficient
TtEMI	Tetra Tech EM Inc.
TRV	Toxicity reference value
UF	Uncertainty factor
USDA	U.S. Department of Agriculture

ACRONYMS AND ABBREVIATIONS (continued)

USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey

1.0 INTRODUCTION

The Idaho Department of Environmental Quality (IDEQ) retained Tetra Tech EM Inc. (TtEMI) in October 2000 to perform an independent review of the existing data and preliminary risk assessment compiled and published by the Idaho Mining Association (IMA) Selenium Committee. TtEMI also was tasked with assisting the IDEQ in the development of final area wide human health and ecological risk assessments associated with past phosphate mining operations in the Southeast Idaho Phosphate Mining Resource Area (Resource Area) to support future agency risk management decisions for the region. This work is being implemented as part of an Area Wide Scope of Work, referenced in the July 2000 *Interagency Memorandum of Understanding Concerning Contamination from Phosphate Mining Operations in Southeastern Idaho* (MOU), negotiated between the IDEQ and the tribal/federal agencies with jurisdictional responsibilities in the region. The MOU specified the IDEQ as the lead agency for coordinating future activities of the area wide investigation and for establishing regional cleanup guidance to assist lead agencies in implementing future site-specific remedial efforts. The area wide investigation is incorporated as part of an Administrative Order of Consent, negotiated with the responsible mining companies.

1.1 PURPOSE AND OBJECTIVES

This work plan, prepared by TtEMI, represents the fourth deliverable of a multitask process outlined in Contract Number CO23, Task Order Number AWI-00-01 (Area Wide Data Review/Risk Assessment). The major objectives of this project as a whole are to:

- Review and assess the existing data and preliminary risk assessment
- Establish data requirements to support an area wide human health and ecological risk assessment
- Develop sampling and analysis plans and studies to fill potential data gaps
- Finalize an area wide human health and ecological risk assessment

This fourth deliverable presents the information and protocols that will be followed to produce the area wide human health risk assessment (AWHHRA) and ecological risk assessment (AWERA) for the Resource Area.

The AWHHRA and AWERA follow a tiered approach to determining the risk of mining activities to human health and ecological receptors. Both the AWHHRA and AWERA follow a deterministic approach to developing doses for humans and terrestrial ecological receptors for comparison to reference

doses. Risk to aquatic ecological receptors will be based on comparison to media benchmarks or criteria and evaluations of community structure. Overall risk to ecological receptors will be determined by a weight-of evidence approach. Based on the outcome of this risk assessment, a probabilistic approach to determine risk will be evaluated for applicability to this project following U.S. Environmental Protection Agency (EPA) guidance (EPA 1997a).

For the AWERA, the EPA Guidance for Superfund, Interim Draft Final (EPA 1997b) will be followed, as opposed to EPA's Guidelines for Ecological Risk Assessment (ERA) (EPA 1998a). EPA's ERA Guidance for Superfund is most widely employed for ERAs as opposed to the Guidelines for ERA. Both utilize the same basic principles for conducting an ERA, but the terminology is different in some cases. For instance, EPA (1998a) uses "measurement effect" for "measurement endpoint" (EPA 1997b). Regardless of the terminology used, the outcome is the same.

1.2 ORGANIZATION OF WORK PLAN

This work plan is organized into the following sections:

Section 2.0 – Location, Environmental Setting, and Background
Section 3.0 – Data Quality Objectives
Section 4.0 – General Conceptual Site Model
Section 5.0 – Selection of Chemicals of Potential Concern
Section 6.0 – Fate and Transport of Chemicals of Potential Concern
Section 7.0 – Area Wide Human Health Risk Assessment
Section 8.0 – Area Wide Ecological Risk Assessment
Section 9.0 – Data Management
Section 10.0 – References

There are three appendices:

Appendix A Glossary
Appendix B Environmental Chemistry, Human Health, and Ecotoxicology of Selenium
Appendix C Idaho Department of Environmental Quality Response to Comments on the Draft Area Wide Human Health and Ecological Risk Assessment Work Plan

Figures and tables are located the end of this document, before Appendix A.

2.0 LOCATION, ENVIRONMENTAL SETTING, AND BACKGROUND

This section presents the location, environmental setting, and background information for this work plan.

2.1 SOUTHEAST IDAHO PHOSPHATE MINING HISTORY

Phosphate mining has been practiced in southeastern Idaho throughout most of the 20th century, starting with the Waterloo Mine in 1907. The major phosphate mines in this region are open pit or contour strip operations that were developed near surface exposures of the Phosphoria Formation. The phosphate ore is transported by truck, rail, and slurry pipeline to local processing facilities in Soda Springs and Pocatello, Idaho. Production from this region represents a significant source of phosphorous for industrial and agricultural applications. Nearly 40 percent of the U.S. phosphate reserves occur in the Phosphoria Formation, in southeastern Idaho, northern Utah, and western Wyoming.

In 1996, isolated livestock losses associated with excessive selenium uptake prompted concerns about potential ecological and human health impacts from past mining operations (Montgomery Watson [MW] 1999b). In response to these concerns, five companies operating mines in the region formed an "ad hoc" Selenium Committee with the IMA to characterize environmental risks and identify mitigation measures associated with phosphate mining. The IMA Selenium Committee, composed of the companies listed in Table 1-1, was formed in 1997 to voluntarily and jointly address mining-related environmental issues from a regional basis. An Interagency/Phosphate Industry Selenium Working Group (SeWG) subsequently was established to facilitate communication and participation by cooperating federal, state, local, and tribal entities.

The SeWG consisted of voluntary representatives, including:

- IDEQ
- Idaho Department of Lands (IDL)
- Idaho Department of Fish and Game (IDFG)
- Idaho Department of Health (IDH)
- Shoshone-Bannock Tribes
- Southeastern District Health Department
- U.S. Forest Service (FS)
- U.S. Bureau of Land Management (BLM)

- U.S. Bureau of Indian Affairs (BIA)
- U.S. Fish and Wildlife Service (USFWS)
- EPA
- U.S. Geological Survey (USGS)
- Other interested stakeholders (i.e. ranchers, Greater Yellowstone Coalition, etc.)

In August 2000, the IDEQ was specified as the lead agency for coordinating future activities of the area wide investigation and for establishing regional cleanup guidance to assist lead agencies in implementing future site-specific remedial efforts. The IDEQ subsequently established an Interagency Technical Group to coordinate their activities with the other jurisdictional and administrative agencies. The IDEQ also established the Selenium Area Wide Advisory Committee (SeAWAC) to continue to solicit input from mining companies, project stakeholders, and other participants in the former SeWG.

While the IDEQ has been designated as the lead for the area wide assessments, other agencies such as the FS, BLM, and IDL are responsible for specific mine sites on their properties and are the lead agencies for the site-specific work to be conducted at individual mines.

Much of the characterization and risk assessment work conducted under the auspices of the IMA Selenium Committee is documented in a series of reports prepared by MW (MW 1998a, 1998b, 1999a, 1999b, 2000). The IMA Selenium Committee implemented a phased approach for investigating potential impacts from phosphate mining activities (MW 1999b). Because of the broad similarities in mining operations and material characteristics, those investigations and corresponding risk assessments were approached from an area wide perspective. The focus of the investigations is the 2,500-square-mile Resource Area in southeastern Idaho that consists of portions of Caribou, Bear Lake, Bonneville, and Bingham Counties (see Figure 1). This region contains 15 mines previously owned or operated by FMC Corporation; J.R. Simplot Company; Nu-West Industries, Inc., and Nu-West Mining, Inc. (Nu-West); Rhodia, Inc.; and P4 Production LLC (see Table 1-1), as well as numerous “orphaned” mine sites, primarily of underground design. One of the 15 mines, the South Maybe Canyon Mine, is being addressed separately under a consent order between Nu-West. Mine sites cover approximately 60 square miles and potentially impact about 1,200 square miles of the Resource Area.

Issues and concerns associated with the IMA studies and risk assessments are discussed in the Existing Data and Risk Assessment Review (TtEMI 2001a). The additional information deemed necessary to

complete the AWHHRA and AWERA are discussed in the Data Gaps Technical Memorandum (TtEMI 2001b).

Additional studies of the general geology of the Phosphoria Formation and site-specific investigation of selenium biogeochemistry have been or are being conducted by the various entities in SeWG (that is, USGS, FS, IDFG, USFWS, and individual mine operators). These investigations are described more fully, as appropriate, in the Existing Data and Risk Assessment Review (TtEMI 2001a).

2.2 REGIONAL ENVIRONMENTAL SETTING

The Resource Area covers about 2,500 square miles in the southeastern part of Idaho. The regional environmental setting is discussed in the following sections and is taken primarily from MW (1999b).

2.2.1 Climate

The topography of southeastern Idaho influences wind patterns, temperature, and precipitation in the Resource Area (MW 1999b). The north-to-south trending mountain ranges west of the Resource Area create a natural barrier for water-bearing Pacific air masses. Because of this rainshadow effect, the Snake River Plain region is semiarid, with a middle-latitude steppe climate. The southeastern part of the Resource Area is wetter and cooler than other parts because of increasing elevations (MW 1999b). Fall and winter is dominated by cold, dry continental air and cyclonic storms. In the cooler months, precipitation is generally from snow, while in the springtime, cool marine air from the south brings precipitation. In the summer, precipitation is associated with localized, orographic thunderstorms (MW 1999b). Average precipitation increases in an easterly direction, with 12 inches in the west and 25 to 35 inches in the central and eastern districts.

2.2.2 Regional Geology

The Resource Area is situated within the northern region of the Basin and Range Physiographic Province. The mountain ranges in southeastern Idaho generally are composed of deformed Paleozoic and Mesozoic sedimentary rocks, including thick marine clastic units, cherts, and limestones (MW 1999b). The valleys are largely filled with Quaternary alluvium and colluvium that reside over Pleistocene basalt flows. Thick rhyolite flows of the Snake River Plain region and rhyolite domes, located south of the Blackfoot Reservoir, comprise the remaining volcanic sequences in the area. Large accumulations of marine sediment occurred during the Paleozoic era over a large area of eastern Idaho, southwestern Montana, northern Utah, and western Idaho (MW 1999b). The Phosphoria Formation was deposited during Permian time, forming the

western phosphate field, part of which is located in the Resource Area. Additional information on stratigraphy and target element concentrations of ore-bearing units is provided in MW (1999b). MW (1999b) also provides additional information regarding soils and vegetation; water resources, including surface water and discussions on each major watershed located in the Resource Area; and groundwater.

2.2.3 Regional Ecology

This section briefly discusses the biological resources in the Resource Area. MW (1999b) presents a detailed discussion of the regional ecology.

2.2.3.1 Ecological Characteristics

The vegetation in the Resource Area is transitional between the Great Basin vegetation to the south and the Rocky Mountain vegetation to the north (MW 1999b). Six vegetation types within the Resource Area are a result of elevation, moisture, temperature, soil type, slope, and aspect. A list of plant species found in the Resource Area is presented in Table A.1 of Appendix A of MW (1999b). Based on previous investigations, the Resource Area contains or supports about 75 species of mammals, 272 species of birds, 16 species of reptiles, 16 species of fish, and 7 species of amphibians (USGS and USFWS 1977, USFWS 1985 and 1997, Idaho Conservation Center Data Base [ICCDB] 1999, and database, as all cited in MW 1999b). In MW (1999b), Table A.2 presents a list of mammals, Table A.3 presents a list of birds, and Table A.4 presents a list of reptiles and amphibians known or believed to reside in the Resource Area.

2.2.3.2 Threatened and Endangered Species

Several threatened and endangered species may live full time or are seasonal migrants in the Resource Area (MW 1999b): bald eagle, gray wolf, whooping crane, Ute ladies' tresses, and Canada lynx (listed species). Several species are classified as sensitive by federal and state agencies: northern goshawk; Columbian sharp-tailed grouse; western big-eared bat; wolverine; spotted frog; trumpeter swan; Harlequin duck; great gray owl; flammulated owl; boreal owl; three-toed woodpecker; spotted bat; Snake River finespotted cutthroat; Yellowstone and Bonneville cutthroat trout; Idaho sedge; slick-spot peppergrass; starveling milkvetch; Payson's bladderpod; and Cache beardtongue (MW 1999b).

2.3 HUMAN POPULATIONS

The Resource Area consists of about 2,500 square miles in Caribou, Bingham, Bannock, and Bear Lake Counties in southeastern Idaho. As stated in the 1998 Final Regional Investigation Report, "a significant portion of the project area land is within the Caribou National Forest, the Fort Hall Indian Reservation, or

is administered by the BLM" (MW 1999b). The Resource Area is sparsely populated. The largest nearby population centers are located in Pocatello, Fort Hall, Montpelier, and Soda Springs, Idaho, and Afton, Wyoming. Farming and ranching are the dominant land uses in the Resource Area (MW 1999b).

2.4 SUMMARY OF PREVIOUS INVESTIGATIONS AND ASSESSMENTS

This section presents a summary of previous investigations and assessments pertaining to human health and ecological risk assessments that have been conducted in the Resource Area.

A wide range of environmental media and facilities were sampled and analyzed, including biotic and abiotic media. Overall, the investigations were conducted using a phased approach, where preliminary sampling was used to help define the requirements for future investigations.

IMA Fall 1997 Interim Surface Water Survey: The 1997 survey represents the initial effort by the SeWG to assess surface water quality in the Resource Area. The 1997 water quality survey was intended to be a preliminary investigation that would lay the foundation for subsequent regional investigations. The results of the 1997 survey are documented in the Fall 1997 Interim Surface Water Survey Report (MW 1998a). The results showed that surface water samples collected from or near many of the mine facilities contained elevated concentrations of selenium.

1998 Regional Investigation: In 1998, media representation was increased to include groundwater, stream sediments, soil and vegetation on waste rock piles, water from waste rock pile seeps, background uplands (Phosphoria outcrops) soils, and trout fillets. The frequency of stream sampling also was increased to include the spring runoff (May), as well as the September low-flow event. The data collected in 1998 were used in the preliminary ecological and human health risk assessments and are documented in the 1998 Regional Investigation Report (MW 1999b). The preliminary assessments were intended to be refined based on new data gathered during future investigations. Samples were analyzed for a limited set of inorganic chemicals.

IMA 1999 Interim Regional Investigation: In 1999, additional investigations were conducted to collect time-critical data and implement special studies on selected biotic components in the Resource Area. Surface water was the primary environmental media sampled outside of the special studies, and the list of target elements was reduced to selenium and cadmium.

Additionally, IMA initiated four special studies in 1999 to provide information on selected biotic components in the Resource Area:

1) Bird eggs
2) Cutthroat trout
3) Elk tissue
4) Cattle tissue

IMA 1999-2000 Regional Investigation: This report presented data for surface water, sediment, and aquatic biological samples collected in September and October 1999. Media sampled included surface water, sediment, periphyton, plankton, submerged macrophytes, benthic macroinvertebrates, forage fish, salmonids, and riparian vegetation (MW 2001). Samples were analyzed for a limited set of inorganic chemicals.

IMA 2001 Waste Pile, Seep, and On-site Pond Investigations: The IMA collected samples of the waste rock piles, seeps, and on-site ponds at 14 of the mine sites during Spring 2001. These samples were analyzed for a comprehensive list of inorganic chemicals.

IMA 2001 Terrestrial Invertebrate and Small Mammal Investigation: The IMA collected small mammals, along with collocated terrestrial invertebrates, soils, and vegetation samples from waste rock piles, upland background areas (Phosphoria outcrops), impacted riparian zones, and background riparian areas, during Summer 2001. These samples were analyzed for a comprehensive list of inorganic chemicals.

IDEQ 2001 Surface Water and Sediment Investigation: As part of the Total Daily Maximum Load (TMDL) program for the Resource Area and the area wide risk assessment, IDEQ initiated collection of surface water and sediment samples for analysis from selected segments of various streams where there was a potential for impacts from phosphate mining activities. These data can be used to support the AWHHRA and AWERA and also will be used to provide baseline data for determination of TMDL requirements for streams in the Resource Area. These samples were analyzed for a comprehensive list of inorganic chemicals.

IDEQ 2001 Summer Risk Assessment Sampling: The IDEQ initiated an extensive sampling effort for the spring and summer of 2001 to collect a variety of media, including surface water, sediment, soil,

vegetation, and biota for laboratory analyses. These analytical results will be used to refine the list of chemicals of potential ecological concern (COPEC) and to identify potential exposure scenarios. These data will be used to support the AWHHRA and AWERA for the Resource Area. These samples were analyzed for a comprehensive list of inorganic chemicals.

In addition to the samples collected for analysis, aquatic community structure was analyzed in selected streams according to the EPA Rapid Bioassessment Protocols.

Additional Studies: A number of additional studies have been conducted by various government agencies, including but not limited to, USFWS, FS, and USGS. These additional studies varied in the type of samples collected, types of analyses, and collection locations. These additional studies will be evaluated to provide supporting information for the risk assessment.

Table 2-1 presents the numbers and type of data available for the area wide risk assessment.

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3.0 DATA QUALITY OBJECTIVES

The seven-step data quality objective (DQO) process, described in EPA guidance documents (EPA 1999a, 1999b, 2000b), was used in developing DQOs for this project. DQOs are qualitative and quantitative statements developed through the seven-step DQO process. The primary outputs of that iterative methodology are definition of the problem under investigation (Step 1); identification of the decisions that require inputs and resolution (Step 2); identification of those inputs (Step 3); delineation of the study boundaries (Step 4); development of decision rules (Step 5); specification of tolerable limits on errors (Step 6); and optimization of the sampling design (Step 7). DQOs and criteria for measurement data, as they apply to this project, are discussed in the following sections; a summary of the DQO steps and related components is presented in Table 3-1.

3.1 STEP 1 – STATE THE PROBLEM

The following problem statements underscore the objectives of this AWHHRA and AWERA work plan:

- Uncertainty exists in the choice of chemicals of potential concern (COPC) because of the inconclusiveness of the screening process for the preliminary human health risk assessment (HHRA) and the ERA conducted by MW.
- Unknown levels of uncertainty exist in the dose calculations modeled in the ERA conducted by MW (1999) because of paucity of site-specific biotransfer factors (BTF). Uncertainty also exists in the exposures calculated in the preliminary HHRA because of the limited amounts and locations of medium-specific sampling results considered in the preliminary HHRA.
- Calculated human health and ecological risk estimates were somewhat conservative because of the use of default and maximum values for the exposure parameters, in some instances.
- Uncertainty exists in the preliminary HHRA associated with identification of potentially significant receptor-specific carcinogenic risks and noncarcinogenic hazards to particular receptor groups, including receptors living subsistence lifestyles and Native Americans, particularly members of the Shoshone-Bannock Indian tribe, living in the Resource Area.
- Both the preliminary HHRA and ERA are based on medium-specific data collected from a limited number of locations in the Resource Area. Therefore, the risks and hazards to human and ecological receptors in specific portions of the Resource Area are unknown at this time.

3.2 STEP 2 – IDENTIFY THE DECISION

The study questions associated with this project are as follows:

- Do soil, sediment, surface water, and tissue concentrations, when used as inputs in a model to determine a daily exposure dose and screened against community or guild-specific toxicity reference values (TRV), indicate risk to potential ecological receptors?
- Do soil, sediment, surface water, and tissue concentrations, when used as inputs in a model to determine exposure scenarios and screened against human health benchmarks, indicate risk to potential subsistence groups or other sensitive populations in the Resource Area.

3.3 STEP 3 – IDENTIFY INPUTS TO THE DECISION

The inputs required to support the decision are obtained from the following sources:

- Samples of the following tissue types were collected at both impacted and background locations for laboratory analysis: aquatic plants, benthic invertebrates, fish, terrestrial plants, terrestrial invertebrates, and small mammals.
- Samples of the following media were collected at both impacted and background locations: soil, waste rock, surface water, and sediments.
- Analytical results from previous, ongoing studies:
  - Beef depuration studies
  - Elk studies
  - Studies on cadmium and selenium levels in bird eggs
  - Sheep studies
  - USGS biota sampling from Spring and Fall 2000 and Spring 2001
  - FS greenhouse studies on selenium uptake for about 200 species of terrestrial plants

3.4 STEP 4 – DEFINE THE STUDY BOUNDARIES

In this step of the DQO process, geographic and temporal boundaries and economic and practical constraints are identified.

- The area ranges from Gray's Lake in the north to Bear Lake in the south and Highways 30/34 to the west and the Wyoming border to the east and incorporates the area of Gay Mine on Fort Hall Indian Reservation by reference. This approximate 2,500-square-mile area was defined by IDEQ to be inclusive of the 15 major mine sites owned or operated by the IMA Selenium Committee

members and subject to subsequent site-specific investigations and 14 minor historic phosphate mine sites, referred to as orphan sites and subject to future regulatory screening efforts.

- The Resource Area includes parts of the Ross Fork, Portneuf River, Blackfoot River, Bear River, and Salt River watersheds.
- Sampling locations for soils, sediments, surface water, and tissue samples were chosen to coincide with mine areas and areas affected by mine runoff (referred to as investigative samples). Samples also were collected from locations unaffected by mine-related activities (referred to as background locations).

3.5 STEP 5 – DEVELOP A DECISION RULE

The decision rule associated with the principal study question is as follows:

- If biological tissue sample data and ecological dose estimate results exceed TRVs and human health exposures indicate potentially unacceptable risks and hazards (defined as risks greater than or equal to 1E-06 and hazards greater than or equal to 1), then the respective sampling locations, representing various media (surface water, soil, and sediments), will be considered contaminated and human health and ecological receptors are potentially at risk. More detailed site-specific assessments will be necessary to fully evaluate the remedial options.
- Supplemental lines of evidence will be included in the AWERA as part of an overall weight-of-evidence approach. Supplemental lines of evidence may include, but are not limited to, the following:
  - Community structure
  - Comparison of media concentrations to accepted benchmarks or criteria
  - Information from the rapid bioassessment process
  - U.S. Army Corps of Engineers database for fish tissue
  - Idaho Mining Association Selenium Committee's (IMASC) targeted laboratory bird studies
  - IMASC's targeted field and laboratory cutthroat studies

The AWHHRA will be completed following a tiered approach and is intended to represent individual-level risks. The tiered approach is presented in Figure 2. Each tier may be considered a type of decision rule – the collective purpose of the three tiers is to determine whether human receptors face significant risks and hazards and if so, those chemicals and exposure pathways driving these risks and hazards. Tier 1 is a screening step and will consist of a reasonable maximum exposure (RME) approach, with emphasis on "reasonable", using maximum detected, medium-specific concentrations applicable to the potentially complete exposure identified in the human health conceptual site model (CSM). Tier 2 represents an area wide assessment focusing on exposure scenarios associated with risks greater than or equal to 1E-06 and hazards greater than or equal to 1. Exposures, hazards, and risks are calculated under both RME and central tendency exposure (CTE) conditions on a watershed- or stream-, riparian area-, or mine-specific exposure area basis; exposure point concentrations (EPC) considered under Tier 2 are the lesser of the maximum and 95 upper confidence limit (UCL) of the mean (RME) and the mean (CTE). It should be

noted that exposure pathways associated with risks less than 1E-06 and hazards less than 1 may also be evaluated under Tier 2 for the purpose of characterizing total exposures, risks, and hazards for each receptor. Tier 3 will evaluate will evaluate risks and hazards using historical analytical data for exposure pathways evaluated on a watershed-specific basis under Tier 2 (ingestion of fish and surface). The impact of temporal changes in medium-specific concentrations will be assessed by comparing results from Tiers 2 and 3 for these two exposure pathways. Regulatory risk managers will consider results from all three tiers to evaluate risks to human receptors in the Resource Area.

3.6 STEP 6 – SPECIFY LIMITS ON DECISION ERRORS

This step establishes tolerable probability values for each type of potential decision error.

- No tolerable decision error rates were set for the sampling design because of the judgmental component of the sampling approach and the multiple data sets collected by various parties. Specifications of tolerable limits on decision errors through the use of standard statistical methods are not applicable for these parameters.

3.7 STEP 7 – OPTIMIZE THE DESIGN FOR OBTAINING DATA

The objective of optimizing the data collection design is to identify the most resource-effective design that achieves a balance between sample size and measurement performance. This design will be used to vary and establish risk thresholds for chemicals in the various media being affected by mining activities in the Resource Area.

- Design optimization through the use of standard statistical methods is not applicable to this study.
- A diverse and extensive array of inputs (Step 3) has been used to optimize the procedure for collection of collocated surface water, soil, sediment, and tissue data. The data generated by implementation of this plan are intended to refine the assessment of risk to human health and ecological receptors to define levels of risk for each media (surface water, sediment, soil, and biological tissues).
- All previous soil, waste rock, sediment, and surface water sampling analytical data were examined and mapped. The distribution of contamination was examined and tissue sampling and collocated soil and sediment locations were assigned in areas where a range of exposure concentrations would be obtained or there was a lack of sufficient data.
- Tissue sampling locations also were chosen based on the occurrence of suitable habitat for human health and ecological receptor(s) of interest.
- Background locations were selected to represent typical area wide conditions, approximate pre-mining conditions for observed impacted areas, and to support numerical and qualitative screening approaches for background comparisons.

4.0 GENERAL CONCEPTUAL SITE MODEL

Problem formulation represents a critical stage of the risk assessment process, where the goals, breadth, and focus of the assessment are determined. The major goal of the problem formulation step is to develop a CSM that addresses the following major issues:

- Environmental setting and chemicals known or suspected to exist at the site
- Chemical fate and transport mechanisms that might exist at the site
- Mechanisms of toxicity associated with chemicals and likely categories of human health and ecological receptors that could be affected
- Complete exposure pathways that might exist at the site (a complete exposure pathway is one in which the chemical can be traced or expected to travel from the source to a receptor)
- Selection of exposed populations for AWHHRA and selection of assessment and measurement endpoints for AWERA

Because of differences in exposure, separate CSMs have been developed for human health and ecological receptors and are discussed in more detail in the following section (see Figures 3 and 4).

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5.0 SELECTION OF CHEMICALS OF POTENTIAL CONCERN

Based on available analytical data and knowledge of the source areas, metals are the COPCs with selenium the primary COPC. Data sets collected prior to calendar year 2001 are inadequate to defensibly determine COPCs for the AWHHRA or COPECs for the AWERA. Additional data have been collected to support the selection of COPCs and COPECs. Based on a comprehensive data set, a screening process will be conducted to eliminate those metals that pose no significant risk or that are present at background levels. This screening process will allow the risk assessments to focus on those chemicals that pose the greatest risks.

Chemicals that pose a potential risk to humans may be different than those that pose a potential risk to ecological receptors. Therefore, separate screening processes will be conducted for the AWHHRA and the AWERA. Specific information regarding the AWHHRA and AWERA screening processes are presented in Sections 7 and 8, respectively.

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6.0 FATE AND TRANSPORT OF CHEMICALS OF POTENTIAL CONCERN

The primary source of contamination from phosphate mining activities in the Resource Area appears to be the waste rock piles associated with various mine sites. Primary chemical release mechanisms for the piles are as follows:

- Erosion from waste rock piles to surface soils
- Percolation from waste rock piles to surface soils, subsurface soils, groundwater, and surface water
- Biotic uptake from contaminated soils or sediments
- Storm water runoff from waste rock piles to surface water

Each of these primary release mechanisms results in a pathway of exposure of various metals from mining activities to human health and ecological receptors. The primary chemical is selenium but other COPCs have not been ruled out. Sources of chemicals and each of the primary chemical release mechanisms for metals are described in the following sections. These processes may vary somewhat, depending on the specific metal.

6.1 SOURCES OF CHEMICALS

The Dinwoody, Phosphoria, and Wells Formations, the "phosphate sequence", are the principal sedimentary formations from which all phosphate ore is produced (MW 1999a). The Meade Peak member of the Phosphoria Formation in southeastern Idaho is extensively mined for its phosphate content and is a marine sedimentary deposit of Permian age (MW 1999a; Piper and others 2000). An analysis of the formation indicated that it consists of two fractions: the original marine organic matter and the terrigenous, detrital source fraction. Sources of these fractions appear to include (1) detrital debris from the terrestrial environment, (2) planktonic debris that settled out of the photic zone of the water column of the ancient sea and onto the ocean floor, and (3) a hydrogenous fraction derived largely from bottom water of the ancient basin by means of inorganic reactions. The origins of these components of the Phosphoria Formation explain the increased levels of many metals.

The waste rock resulting from phosphate mining is composed of overburden and underburden materials that have been removed to access the phosphate ore bodies. The waste rock typically is deposited on the surface, where is exposed to the elements. Weathering of the waste rock results in material that more readily releases chemicals into the environment.

6.2 WIND EROSION FROM WASTE ROCK PILES TO SURFACE SOILS

In southeastern Idaho, extensive, wide-open spaces are common and create the potential for strong air currents to occur. Therefore, wind erosion and subsequent deposition may be a significant mechanism of chemical transportation in the Resource Area, particularly at locations potentially frequented by recreational users and no longer actively managed by site operators.

The potential exists for wind to erode and resuspend surface soil and transport it to other areas, both near and far away, depending on wind speed and other factors. Any metals closely associated with soil particles also will be transported. Deposition from this mechanism of transport may increase metal levels at points some distance from the source. In addition, soils transported by wind will settle on leaf surfaces of nearby plants, where they may be directly taken up by the plant, washed onto the ground by rain, or eaten by herbivores or omnivores, thereby making any metals present available to the plants and animals in the vicinity.

6.3 PERCOLATION FROM WASTE ROCK PILES TO GROUNDWATER AND SURFACE WATER

Precipitation can percolate through waste rock piles and carry chemicals into groundwater, or they may be released directly to surface water through seeps, springs, or French drains in the waste piles. Even though the Resource Area is relatively arid, percolation is one of the major transport mechanisms.

Chemicals may be carried into groundwater, but based on current information, do not appear to create a significant problem in the Resource Area. However, any chemicals dissolved in groundwater may be carried along until exiting into a stream, lake, or wetland.

6.4 STORM WATER RUNOFF FROM WASTE ROCK PILES TO SURFACE WATER

As a result of spring snowmelt and storm events, significant quantities of water may move across the waste piles as surface runoff. This surface flow will move particles of the waste rock into local streams and ponds or onto adjacent terrestrial areas. Depending on the topography of the various waste rock piles, this may be a significant transport mechanism.

6.5 SURFACE WATER TRANSPORT

Once chemicals enter local streams or surface water bodies, the material can be transported significant distances from the waste rock piles. This material can be deposited in terrestrial environments during

flood events or in areas where sediment is trapped. In some areas, chemicals may be deposited in fields or stock ponds by irrigation or pumping. This is a significant transport mechanism for movement of chemicals away from waste rock piles.

6.6 BIOTIC UPTAKE

Plants may take up metals in significant quantities. The rate of uptake is species-dependent and can vary significantly between species. In terrestrial systems, humans and animals can ingest various metals in water or food or through incidental ingestion of dust, soil, or sediment.

Aquatic plants also may take up metals in significant quantities. The rate of uptake is species-dependent and can vary significantly between species. Similar to terrestrial systems, uptake by aquatic animals can occur by ingestion of food, water, and sediments. However, in aquatic systems, direct absorption from the surrounding media may be significant for some receptors.

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7.0 AREA WIDE HUMAN HEALTH RISK ASSESSMENT

This section presents the technical approach that will be followed in preparing the AWHHRA for the Resource Area. As discussed in Section 1.0, the primary goal of the AWHHRA is to evaluate potential exposures and characterize risks and hazards associated with these exposures across the entire Resource Area for a variety of different receptor groups. While exposures, risks, and hazards may, in some instances, be evaluated and characterized in terms of different exposure areas (for example, stream segments or riparian areas) located near particular mines, these exposures, risks, and hazards will be presented and discussed in the context of the overall Resource Area and will not be identified or discussed as "mine-specific."

Section 7.0 is organized as follows. Section 7.1 identifies the primary guidance documents upon which the technical approach is based. The remainder of the section addresses the four primary elements of a typical HHRA: data evaluation and identification of COPCs (Section 7.2), exposure assessment (Section 7.3), toxicity assessment (Section 7.4), risk characterization (Section 7.5), and uncertainties (Section 7.6).

7.1 AREA WIDE HUMAN HEALTH RISK ASSESSMENT TECHNICAL APPROACH

The AWHHRA will be prepared in general accordance with EPA guidance, following a tiered approach to estimate individual-level risks in the Resource Area. Section 7.1.1 identifies some of the key EPA guidance documents that will be used to prepare the AWHHRA. Section 7.1.2 discusses the tiered approach that will be used to prepare the AWHHRA.

7.1.1 General Technical Guidance

The key EPA guidance documents that will be used to prepare the AWHHRA are listed below. This list is not comprehensive, and other EPA guidance documents, as well as documents prepared by other organizations, will be cited in the AWHHRA, as appropriate.

- EPA. 1989. *Risk Assessment (RAGS) Guidance for Superfund, Volume 1: Human Health Evaluation Manual (Part A)*. Interim Final. Office of Emergency and Remedial Response. Washington, DC. EPA/540/1-89/002. December.
- EPA. 1991. *RAGS, Volume I: Human Health Evaluation Manual, Supplemental Guidance: Standard Default Exposure Factors.* Interim Final. Office of Solid Waste and Emergency Response Directive 9285.6-03. March 25.
- EPA. 1997. *Exposure Factors Handbook*. Volumes 1 through 3. Office of Research and Development. EPA/600/P-95/002Fa, -Fb, and –Fc. August.

7.1.2 Tiered Risk Assessment Approach

In the context of the general technical guidance identified in Section 7.1.1, the AWHHRA will be conducted following a tiered risk assessment approach (the tiered approach) (see Figure 2). The primary objectives of the tiered approach are two-fold. The first objective is to provide an efficient mechanism for determining the presence or absence of potentially significant, receptor-specific carcinogenic risks (risks) and noncarcinogenic hazards (hazards) in the Resource Area. If potentially significant risks and hazards are identified based on an initial screening step, the second objective is to efficiently identify the exposure scenarios (receptor and exposure pathway combinations) and locations (for example, particular watersheds or stream segments) associated with significant and insignificant risks and hazards. Ongoing and subsequent investigations can then focus on the exposure scenarios and locations associated with significant risks and hazards, while exposure scenarios and locations associated with insignificant risks and hazards may require limited, if any, further evaluation.

In general, the tiered approach includes three basic steps. Each of these basic steps is summarized below. Application of the tiered approach to specific exposure scenarios will depend on (1) the number and location of medium-specific samples considered in the AWHHRA and (2) the nature of each of the exposure scenarios considered in the AWHHRA.

TIER 1

Tier 1 is referred to as the screening step. Scenario-specific exposures, risks, and hazards will be calculated using the maximum detected, medium-specific concentration for each COPC (see Section 7.2.3 for a discussion on COPC identification) applicable to all potentially complete exposure scenarios identified in the human health CSM (see Figure 3). Screening calculations will emphasize the use of RME concentrations and exposure parameters (see Table 7-1). For instance, subsistence lifestyle receptor will not be evaluated using maximum observed concentrations from the Resource Area stream segments, such as values from East Mill Creek, that cannot reasonably be expected to have the potential to support that scenario. Similarly, maximum soil concentrations for homegrown produce models will not use waste rock pile soils where it is indisputable that residential gardens do not and will not occur. Instead, fluvial or riparian soils will be used to represent areas where residential gardens could occur. Soil chemical concentration data from these areas are considered relevant to the evaluation of the subsistence scenario. In general, exposure scenarios resulting in insignificant risks and hazards (defined as risks less than 1E-06

and hazards less than 1 – see Sections 7.5.1 and 7.5.2, respectively) will be eliminated from further evaluation.

TIER 2

In the second step of the tiered approach, exposure scenarios determined to be associated with significant risks and hazards (defined as risks greater than or equal to 1E-06 and hazards greater than or equal to 1) are further evaluated. Exposures, hazards, and risks are calculated under both RME and CTE conditions (see Tables 7-1 and 7-2, respectively) on a watershed- or stream-, riparian area-, or mine-specific exposure area basis as discussed below using less conservative estimates of the medium-specific concentration of each COPC to which receptors may be exposed. Specifically, EPCs considered under Tier 2 are the lesser of the maximum and 95 UCL of the mean (RME conditions) and the mean (CTE conditions). This approach is consistent with EPA's "Supplemental Guidance to RAGS: Calculating the Concentration Term" (EPA 1992). Similarly, exposure parameters used under CTE conditions represent less conservative estimates of the magnitude and frequency to which receptors may be exposed to COPCs under each potentially complete exposure pathway. In general, CTE calculations will be generally consistent with EPA guidance based on area-specific knowledge.

Because exposure areas are defined on an exposure scenario-specific basis, Step 2 is subdivided into two categories. For example, receptors may ingest fish caught in a variety of streams. Accordingly, under Step 2 of the tiered approach, fish tissue EPCs will be calculated on a watershed-specific basis (an exposure area that extends beyond stream-specific areas). Each of the categories is summarized below.

- Category 2a of the tiered approach will address all exposure pathways with exposure areas that extend (or could extend) beyond stream-specific areas. Category 2a will address six exposure scenarios, including ingestion of (1) fish, (2) wild game, (3) beef cattle, (4) aquatic and terrestrial plants, (5) teas brewed from aquatic and terrestrial plants, and (6) surface water.
- Category 2b of the tiered approach will address the exposure pathways with stream-, riparian area, and mine-specific exposure areas, including ingestion of homegrown produce, ingestion of surface soil, and inhalation of particulates.

In general, exposure scenarios and pathways associated with insignificant risks and hazards will be dropped from further evaluation. However, it should be noted that exposure pathways associated with risks less than 1E-06 and hazards less than 1 may also be evaluated under Tier 2 if it is determined that these exposure pathways contribute significantly to total receptor-specific exposures, risks, and hazards.

The decision to include exposure pathways associated with Tier 1-specific risks less than 1E-06 and hazards less than 1 for evaluation under Tier 2 will be explained in the final AWHHRA report.

TIER 3

The third and final step of the tiered approach will apply only to exposure scenarios considered under Category 2a associated with surface water and fish, media that may experience significant temporal changes in concentration. Both ingestion of fish and surface water will be further evaluated in order to assess the impact of temporal changes in concentrations. Under Step 3 of the tiered approach, receptor-specific exposures, risks, and hazards will be calculated on a watershed specific basis. As necessary, these two exposure pathways may also be evaluated on a stream-specific basis. As part of the stream-specific evaluations, the potential for each stream to support a particular exposure scenario will be considered. For example, some streams in the Resource Area (for example, East Mill Creek) have been shown to support little if any aquatic life; therefore, ingestion of fish from impacted stretches of these streams is unlikely to occur. The potential for each stream to support the fish ingestion exposure scenario will be characterized through the use of stream-specific fraction-ingested (FI) values. These FI values will reflect the productivity of each stream and will be developed using a variety of criteria including, but not limited to, order; the number, type, size and species of fish present; and whether spawning has been observed in a steam. It should be noted, however, that it is considered unlikely that receptors will be exposed exclusively to fish and surface water from individual streams.

Several exposure scenarios would not be evaluated beyond Step 2 for two reasons. First, ingestion of wild game (as represented by elk) and ingestion of beef cattle (considered under Category 2a) are both evaluated using data sets that cannot be further broken down (see Section 7.2.1); in addition, comparable historical analytical data are not available. Second, ingestion of homegrown produce, ingestion of surface soil, and inhalation of particulates (considered under Category 2b) already are evaluated on a stream-specific basis. Additional details regarding the proposed exposure scenario-specific application of the tiered approach are presented in Sections 7.3.3.1 and 7.5.3.

7.2 DATA EVALUATION AND IDENTIFICATION OF CHEMICALS OF POTENTIAL CONCERN

The primary purposes of this section are to identify analytical data sets that will be used to estimate receptor-specific exposures and to discuss the methods that will be used to identify COPCs for consideration in the AWHHRA. COPCs represent chemicals that are to be evaluated under RME and

CTE conditions in the risk assessment process. The area wide COPC list may be further refined for subsequent investigations as these chemicals are addressed in each tier. This section is organized as follows:

- Section 7.2.1 discusses medium-specific analytical data sets that will be considered in the AWHHRA
- Section 7.2.2 discusses procedures that will be used to evaluate the appropriateness of including and combining various data sets in the AWHHRA
- Section 7.2.3 summarizes the COPC identification process

7.2.1 Medium-specific Data Sets

Medium-specific samples have been collected throughout the Resource Area by a variety of organizations over about the last 6 years (MW 1999a, 2000). While useful in establishing an overall context for consideration of potential exposures and risks, use of the historical data is limited because much of it (1) focused on a limited number of analytes (primarily selenium and cadmium), (2) was collected from a limited number of locations, and (3) did not address some relevant media (TtEMI 2001a, 2001b). As a result, additional medium-specific samples were collected during 2001. Additional samples were collected primarily to eliminate limitations and data gaps associated with historical data.

The AWHHRA will be based on medium-specific analytical results associated primarily with samples collected in 2001 and supplemented by historical data as appropriate. Medium-specific analytical data sets that will form the basis of Tiers 1 and 2 of the AWHHRA are summarized in Sections 7.2.1.1 through 7.2.1.6. Historical data that will form the basis of Tier 3 calculations is summarized in Section 7.2.1.7.

7.2.1.1 Surface Water and Sediment

TtEMI and IDEQ personnel collected surface water and sediment samples in Spring and Summer 2001(TtEMI 2001d). Analytical results for sediment samples will be used in the AWHHRA only to estimate COPC concentrations in fish tissue and aquatic plants if insufficient analytical results are available for these two media.

In total, surface water samples were collected from 39 sampling stations associated with 22 different streams at locations upstream and downstream of different mine sites. Similarly, sediment samples were collected from 31 sampling locations on various streams at locations upstream and downstream of

different mine sites. Surface water and sediment samples were analyzed for the list of parameters presented in Table 2-2. Streams from which surface water and sediment samples were collected and the type of the samples collected from each stream (for example, surface water or sediment and impacted or background) will be summarized in the final AWHHRA. Also, figures showing the locations of the surface water and sediment samples will be included in the final AWHHRA.

7.2.1.2 Fish Tissue

TtEMI and IDEQ personnel collected fish tissue samples in July 2001. In total, fish tissue samples were collected from seven sampling locations associated with both impacted and unimpacted streams. Fish tissue samples were analyzed for a comprehensive list of metals.

Information regarding fish tissue samples considered in the AWHHRA (for example, the streams from which fish tissue samples were collected, the type of the samples collected, and the organization and date the samples were collected) will be summarized. Also, figures showing the locations of fish tissue samples included in the AWHHRA will be added to the final AWHHRA.

7.2.1.3 Plant Tissue

TtEMI and IDEQ personnel collected samples of both aquatic and terrestrial plants in May and July 2001 (TtEMI 2001d). Specifically, tissue samples were collected from two aquatic species – water cress (*Nasturium officinale*) and water buttercup (*Cara photomycetin*) – and from four terrestrial species – wild onion (*Allium canadense)*, bitter root (*Camus spp.*), golden sage (*Artemesia spp.*), and red willow (*Salix spp.*). These plants represent species that are either ingested or used to brew teas by members of the Shoshone-Bannock tribe. These samples were collected in streams or riparian areas downstream of particular mines and from unimpacted (background) zones.

Additional plant tissue samples were collected by MW, consultants to the IMA, in Summer 2001 (TtEMI 2001e). The results from these samples will be described in the final AWHHRA. Streams and riparian areas where plant tissue samples were collected and the type of the samples collected will be summarized in the final AWHHRA. Also, figures showing the locations of plant tissue samples included in the AWHHRA will be added to the final AWHHRA.

7.2.1.4 Soil

As later discussed in Section 7.3.2.2, receptor-specific exposures, risks, and hazards associated with potential direct contact with soil and inhalation of fugitive dust are considered to be limited and will not be evaluated for all exposure scenarios in the AWHHRA. However, potential receptor-specific exposures through ingestion of plants grown in contaminated soil will be considered in the AWHHRA. Analytical results from soil samples collected in riparian areas along streams in the Resource Area will be used to estimate concentrations of COPCs in homegrown produce and, if necessary, to estimate the COPC concentrations in terrestrial plants used by Native Americans if insufficient plant tissue analytical results are available.

Soil samples from riparian areas were collected in Summer 2001 by MW, a consultant to the IMA (TtEMI 2001e). Samples were collected from locations both upstream and downstream of mining facilities. Riparian areas from which soil samples were collected and the type of the samples collected from each stream will be summarized in the final AWHHRA. Also, figures showing the locations of soil samples will be included in the final AWHHRA.

7.2.1.5 Game

Analytical results from skeletal muscle and liver samples collected from elk harvested from Idaho Game Management Units (GMU) 76 and 66A, as reported in the 1999 Interim Investigation Data Report, will be used to represent game tissue potentially ingested by human receptors (MW 2000).

7.2.1.6 Beef Cattle

Analytical results from skeletal muscle and liver samples collected from 15 steers pastured for 9 weeks on a Henry Mine reclaimed overburden pile in July and August 1999 were included as part of a feedlot depuration study in Fall 1999. Skeletal muscle and liver (as well as kidney and heart) samples were collected post-mortem (MW 2000). These tissue samples will be used to represent beef potentially ingested by human receptors. It should be noted that cattle are not typically penned on waste rock piles as was done for the beef depuration study. However, the reclaimed areas present the most palatable forage in the Resource Area and would appear to be attractants for free ranging animals. It should also be noted that use of the beef depuration study results does not address the potential for ingestion of beef from animals taken directly off pasture by the cattle owner, the rancher, or rustlers (IDH 2001). The various limitations associated with using data from the beef depuration study will be discussed in the final AWHHRA.

7.2.1.7 Historical Fish Tissue and Surface Water

MW personnel collected fish tissue and surface water samples in May 1998 (MW 1999b). In total, fish tissue samples were collected from three sampling locations associated with both impacted and unimpacted streams. Fish tissue samples were analyzed for six metals (selenium, cadmium, manganese, nickel, vanadium, and zinc). Information regarding historical fish tissue samples considered in the AWHHRA will be summarized in the final AWHHRA. Also, figures showing locations of fish tissue samples included in the AWHHRA will be presented in the final AWHHRA.

MW personnel collected surface water samples in the Spring and Fall of 1998 (MW 1998b). In total, surface water samples were collected from 57 different streams at locations upstream and downstream of different mining sites. MW also collected surface water samples from several other water bodies including waste rock pile seeps, French drains under waste rock piles, tailings and stock ponds. Surface water samples were analyzed for six metals (selenium, cadmium, manganese, nickel, vanadium, and zinc). Streams from which historical surface water samples were collected and the type of samples collected from each streams will be summarized in the final AWHHRA. Also, figures showing the locations of the surface water samples will be included in the final AWHHRA.

7.2.2 Data Evaluation

This section discusses the evaluation process that will be used to determine whether to include various data sets in the AWHHRA. EPA's Guidance for Data Usability in Risk Assessment (Part A) Final identifies five primary criteria that ideally should be satisfied before data is used in a quantitative risk assessment (EPA 1992). Those criteria are summarized below:

- Reports should be available to risk assessors that include site descriptions and present the sampling program design, sampling locations, analytical methods, detection limits, sampling results, and sample quantitation limits (SQL).
- Documentation should be available for review of sampling results as they relate to geographic locations (that is, chain-of-custody documentation, standard operating procedures, and field and analytical records).
- Sampling results should be available for each medium within an exposure area, should have been generated using a broad spectrum of analytical techniques, and should be accompanied by documentation of any field measurements needed to support fate and transport modeling.
- Acceptable analytical methods should have been used with SQLs capable of detecting concentrations of significant health concern.
- A data validation review should have been performed, including a consideration of data completeness, comparability, representativeness, precision, and accuracy.

Data sets identified in Section 7.2.1 for potential inclusion in the AWHHRA will meet all five of the criteria identified above. The AWHHRA will document that all data included in the AWHHRA meet each of the criteria.

7.2.3 Chemical of Potential Concern Identification

In general, medium-specific COPCs will be identified using the four-step process recommended in EPA's RAGS (EPA 1989). The first step in the COPC identification process is to identify all chemicals that were positively identified in at least one sample, including chemicals with no data qualifiers and chemicals with data qualifiers indicating known identities but unknown concentrations (for example, J-qualified data). As discussed in EPA's RAGS, this initial list of chemicals may be reduced based on the following factors (EPA 1989):

- Comparison with appropriate background concentrations
- Evaluation of detection frequency
- Evaluation of essential nutrients
- Use of a concentration-toxicity screen

A concentration-toxicity screen will be used only in conjunction with an evaluation of detection frequency to select COPCs for the AWHHRA. The first three factors listed above are discussed briefly in the following sections.

7.2.3.1 Comparison with Appropriate Background Concentrations

The defined Resource Area is comprised of three broad landscape background conditions; Phosphoria Formation outcrops, the mining developed zone, and the surrounding area. Phosphoria Formation outcrops consist of areas where geologic processes have exposed the potential ore, shales and/or other members of the geologic formation typically subject to regional mining activities. Because of low overburden ratios, surface mining, orphan site and exploration activities tend to correlate with these outcrop areas. However, the actual outcrop exposures, which primarily occur in the uplands and ridges of the Wasatch, Pruess and Caribou Mountain ranges in southeast Idaho, comprise a relatively small portion of the overall Resource Area, approximately 2 percent.

The mining developed zone occurs in the immediate vicinity surrounding the Phosphoria outcrops and consists of areas that are directly affected or may be affected by mining activities. Direct impacts may

include excavation, placement of waste rock piles, reclamation activities, drainage/deposition to and from potential mineralized areas including outcrops, and effects from seeps, springs, ponds or other mining-related impacts or activities. The mining developed zone comprises approximately 2 percent of the Resource Area and has been the primary focus of the area-wide investigation activities over the past five years because observed localized impacts have been restricted to this area.

The final background condition and remaining surface area in the Resource Area is comprised of the surrounding lowlands in which other activities such as agricultural and most ranching use occurs. This area is generally lower in trace metals and is reported to be selenium-deficient.

The purpose of background comparisons is to determine if industry-related activity has increased the presence of chemicals above pre-industry conditions. The ultimate goal of background comparisons in the effort is to identify the mining-related chemicals for evaluation in the AWHHRA. These are the chemicals that are present at concentrations that are a direct result of mining activities versus naturally occurring processes. The ideal situation to establish background conditions in the Resource Area would be to have records of pre-mining soil, vegetation, surface water, and other media concentrations in the region. However, available pre-mining studies in the Resource Area are very limited and subject to uncertainties associated with appropriate analyte lists, analytical methods, sampling procedures, etc.

For the purpose of conducting the COPC (and COPEC – see Section 8.3) screening background comparisons for the area wide effort, the IDEQ has decided that background comparisons should be conducted using data from the previously defined mining developed zone. The IDEQ believes upgradient and undisturbed samples from this zone best represent pre-mining conditions for the observed impacted areas within the Resource Area, which also occur in this zone. Background sampling of outcrop areas and surrounding lowlands are not expected to provide significant value in addressing historic mining impacts and are not representative of the areas in which surface water, soil, or other media impacts are known to occur.

To represent impacted areas, targeted sampling locations were selected for various media of concern on a concentration-gradient basis. In this manner, the full range of observed concentrations could be represented in a scientifically valid and cost-effective approach without collecting sample population sizes large enough to meet rigid statistical requirements. In choosing to use scientific-based qualitative methods of screening as opposed to a purely statistical approach, the IDEQ explicitly accepts slight increases in the level of statistical uncertainty in the screening results but believes this uncertainty is

within the normal tolerances associated with risk assessment, is justified from a cost-benefit perspective in light of the significantly large Resource Area, and provides results that can be further refined in the subsequent site-specific activities.

For background comparisons, an average concentration will be calculated for each chemical and media of concern using the upgradient, undisturbed mining zone sampling data sets considered to be representative of pre-mining conditions. Chemicals with single point concentrations from the medium-specific concentration gradient-based sampling sets that are more than two times the calculated medium-specific background average will be considered potentially mining-related and will be retained in the risk assessment process. Chemicals with all medium-specific concentrations less than two times the medium-specific average will be considered naturally occurring and will be eliminated from further consideration.

Similar non-statistical methods have been accepted for background comparisons for EPA Region 4 and FS Region 3 using higher numerical multipliers (e.g. 3x background) in some cases. However, IDEQ has selected a more conservative approach to ensure chemicals are not prematurely eliminated from the risk assessment process and to account for some of the uncertainty associated with smaller data sets. It should be noted that the common industry practice for determining background levels for industrial sites under the Resource Conservation and Recovery Act (RCRA) consist of collecting 3 to 5 directed samples in areas assumed to represent pre-industry conditions for the calculation of 95 UCLs. A 95 UCL typically results in a background comparison level that is 1.5 to 3 times the mean value of the data set dependent on data variability.

7.2.3.2 Evaluation of Detection Frequency

EPA's RAGS states the following: "Chemicals that are infrequently detected may be artifacts in the data due to sampling, analytical, or other problems, and therefore may not be related to site operations of disposal practices" (EPA 1989). However, RAGS cautions that an evaluation of a chemical's detection frequency in one medium must consider the following additional factors:

- A chemical's potential relationship to site operations
- A chemical's detection in other media
- The concentration at which a chemical was detected in each medium

Historically, a detection frequency of 5 percent often has been used as a basis for identifying COPCs (EPA 1989). However, this detection frequency will not be functionally useful for most medium- and

exposure area-specific data sets because of the small number of samples. Therefore, medium- and exposure area-specific data sets with only a single detection will be compared closely with the results from related media. Specifically, many of the medium-specific samples collected May through September 2001 are collocated with samples from other media. For example, fish tissue, surface water, and sediment samples were collocated, and soil and terrestrial plant tissue samples were collocated. In these instances, a chemical that is detected only once in a medium may be retained as a COPC in that medium, if the same chemical has been retained in a medium from which collocated samples were collected. For example, Chemical X was detected only once in plant tissue samples, but was retained as a COPC in the soil in which the plant was growing. In this case, Chemical X, based on professional judgment, may be retained as a COPC in plant tissue, under the assumption that the plant may take up Chemical X from the soil.

7.2.3.3 Evaluation of Essential Nutrients

As discussed in EPA guidance, chemicals that are (1) essential nutrients, (2) present at low concentrations, and (3) toxic only at very high doses may be eliminated as COPCs in a quantitative HHRA (EPA 1989). In accordance with EPA guidance, essential nutrients, such as iron, magnesium, calcium, potassium, and sodium, were eliminated as COPCs for the AWHHRA (EPA 1989). Selenium is also an essential nutrient. However, selenium is known to be present in the Resource Area at elevated concentrations and is associated with isolated instances of death and illness among livestock, sheep, and horses in the Resource Area. Therefore, selenium was retained as a COPC for the AWHHRA.

7.3 EXPOSURE ASSESSMENT

The exposure assessment addresses the potential, magnitude, and location of receptor-specific chemical exposures in the Resource Area. Specifically, this section contains a brief characterization of the exposure setting (see Section 7.3.1), discusses the human health CSM for the AWHHRA (see Section 7.3.2), and presents the algorithms and draft exposure parameter values that will be used to quantify receptor-specific exposures (see Section 7.3.3).

7.3.1 Exposure Setting Characterization

The exposure setting consists of the physical setting of the Resource Area and populations living in or near the Resource Area. Much of this information already has been discussed as part of the discussion of the regional environmental setting in Section 2.2; only a limited portion of this information will be summarized here.

The Resource Area consists of about 2,500 square miles in Caribou, Bingham, Bannock, and Bear Lake Counties in southeastern Idaho. As stated in the 1998 Final Regional Investigation Report, "a significant portion of the project area land is within the Caribou National Forest, the Fort Hall Indian Reservation, or is administered by the BLM" (MW 1999b). The Resource Area is sparsely populated. The largest nearby population centers are-located in Pocatello, Fort Hall, Montpelier, and Soda Springs, Idaho, and Afton, Wyoming. Farming and ranching are the dominant land uses in the Resource Area (MW 1999b).

As will be discussed in Section 7.3.2, receptor-specific exposures considered in the AWHHRA are of two general types. The first type of exposure involves ingestion of game (as represented by elk) that are assumed to graze throughout the Resource Area and beef cattle that, in some cases, are grazed on seleniferous pastures located throughout the Resource Area. Elk skeletal muscle and liver analytical results considered in the AWHHRA were obtained from elk harvested from Idaho GMUs 66A and 76, which occupy most of the eastern portion of the Resource Area extending from McCoy Creek (near Gray's Lake National Wildlife Refuge on the north to the Utah border to the south) and from the west, along a line running north-south (just east of the southern half of Blackfoot Reservoir) through Soda Springs and Montpelier (extending south along State Highway 89), from Montpellier to the Utah border to the Wyoming border on the east (see Figure 1). Beef skeletal muscle and liver analytical results considered in the AWHHRA were obtained from cattle penned for 9 weeks in a seleniferous pasture near the Henry Mine, east of Blackfoot Reservation (MW 1999b). However, other seleniferous pastures are located throughout the Resource Area.

The second type of exposure involves direct and indirect exposure to chemicals through ingestion of various foodstuffs, including fish tissue, native aquatic and terrestrial plants, and homegrown produce. As will be discussed in Section 7.3.2, all foodstuffs are assumed to come from Resource Area streams (fish and aquatic plant tissue) or riparian areas along Resource Area streams (terrestrial plants and homegrown produce).

The Resource Area is drained by two principal river systems, the Blackfoot and the Snake Rivers. The 1998 Final Regional Investigation Report identified four primary watersheds in the Resource Area: the Bear River, Blackfoot River, Portneuf River and Ross Fork, and Salt River watersheds (MW 1999b). As stated in Section 7.2.1, medium-specific samples considered in the AWHHRA were collected from streams and riparian areas along Resource Area streams.

7.3.2 Human Health Conceptual Site Model

The CSM links potential or actual releases to potential human exposures. Specifically, the CSM identifies (1) potential chemical sources and mechanisms of potential release, (2) potential receptors and exposure pathways, and (3) exposure scenarios. These three elements were first presented in the CSM report (TtEMI 2001c) (referred to here as the final CSM report) and are repeated here.

As described in the EPA's Risk Assessment Guidance for Superfund (1989), an exposure pathway consists of four primary elements:

(1) Source(s)
(2) Release and transport mechanisms
(3) Exposure media
(4) Receptors

The human health CSM (see Figure 3) depicts human health exposure pathways specific to the Resource Area.

7.3.2.1 Potential Chemical Sources and Mechanisms of Release

Potential contamination in the Resource Area is assumed to originate from a single source, mine site waste rock. Chemicals present in the mine site waste rock initially are released and transported through the processes of weathering and leaching. As a result of this initial release and transport, chemicals present in the mine site waste rock migrate to both surface and subsurface soil (the initial migration of chemicals from the mine site waste rock to surface and subsurface soil is discussed in detail in Section 3.1 of the final CSM report [TtEMI 2001c]).

From surface and subsurface soil, chemicals are transported through a variety of secondary, tertiary, and quaternary release and transport mechanisms into a range of exposure media. The release and transport mechanisms include: wind erosion, runoff, uptake and assimilation, leaching by percolation, deposition, and irrigation. Potential exposure media include: surface and subsurface soil, air, surface water and sediment, food items, and groundwater (as discussed in Section 3.1 of the final CSM report [TtEMI 2001c]).

7.3.2.2 Potential Receptors and Exposure Pathways

Three potentially exposed human populations have been identified for consideration in the AWHHRA, including recreational hunters and fishers, Native Americans, and subsistence lifestyle receptors. For all three populations, both adult and child receptors will be considered.

As shown in the human health CSM (see Figure 3), some of the exposure pathways are considered to be potentially complete; that is, all four of the required elements are known or assumed to be present. Other exposure pathways are considered to be incomplete; that is, one or more of the required elements – most often the receptor – is missing. Exposure pathways that are considered to be incomplete will not be considered further in the AWHHRA.

Those complete exposure pathways include ingestion of:

- Moose, elk, other wild game, and cattle by recreational hunters and fishers, Native Americans, and subsistence lifestyle receptors
- Aquatic life (fish) by recreational hunters and fishers, Native Americans, and subsistence lifestyle receptors
- Teas brewed using aquatic and terrestrial plants by Native American receptors
- Terrestrial plants and homegrown produce by Native American and subsistence lifestyle receptors, respectively
- Surface soil by subsistence receptors

Inhalation of fugitive dust from waste rock piles by hunters will also be evaluated in the AWHHRA.

Of the complete exposure pathways, some will be considered quantitatively in the AWHHRA. Additional information concerning consumption of domestic livestock is presented in Section 6.0 of the final CSM report (TtEMI 2001c).

Other complete exposure pathways are considered to be de minimus or contribute negligibly to total receptor dose and will be evaluated only qualitatively in the AWHHRA. Complete exposure pathways that are considered to be de minimus and a brief explanation for exposure pathway-specific conclusions are provided below. While not evaluated quantitatively, de minimus exposure pathways will be qualitatively evaluated in the AWHHRA. The qualitative evaluation will include a comparison of medium-specific, chemical concentrations; relevant and appropriate criteria; and guidelines, such as EPA

Region 9 preliminary remediation goals (PRG), to ensure that the assumptions discussed below are still appropriate.

- Ingestion and Direct Contact with Surface Water. Surface water is not used as a source of drinking or household water in the Resource Area. Therefore, ingestion of chemicals in surface water is expected to occur only infrequently (for example, while hiking or hunting in the area or through inadvertent ingestion while swimming in surface water bodies). Also, inorganic chemicals are not particularly well absorbed through direct contact with surface water. As with ingestion, direct contact with surface water is expected to be infrequent – because of cold water temperatures, receptors fishing in area surface water bodies are expected to wear waders most, if not all, of the time. Therefore, ingestion of surface water will only be evaluated during recreational activities and not as the primary source of drinking water for subsistence lifestyle receptors.
- Ingestion and Direct Contact with Sediment. Exposure to chemicals through incidental ingestion of sediment is expected to be minimal, primarily because most sediment to which receptors are infrequently exposed is expected to be washed off either deliberately or inadvertently with surface water. Exposure to inorganic chemicals present in sediment that does manage to adhere to receptor's skin is also expected to be minimal, because these chemicals are poorly absorbed through the skin.
- Ingestion and Medicinal, Religious, and Other Uses of Aquatic and Terrestrial Plants by Subsistence Receptors. Subsistence receptors are expected to be exposed to chemicals in the tissues of aquatic and terrestrial plants, primarily through ingestion, and potentially through medicinal, religious, and other uses of these plants. The contribution to total exposure for the subsistence receptor associated with exposures to terrestrial and aquatic plants relative to ingestion of homegrown produce is expected to be small. As necessary, however, risks and hazards associated with exposures to terrestrial and aquatic plants as calculated for Native American receptors provide a reasonable surrogate and could be used to provide estimates of the contribution to total exposure associated with these exposure routes for the subsistence receptor.
- Ingestion and Direct Contact with Surface and Subsurface Soil by Recreational Hunter/Fisher and Native American Receptor. As noted in MW (1999b), the maximum observed concentrations of inorganic chemicals in soil are one or more orders of magnitude less than chemical-specific EPA Region 9 industrial soil PRGs. Also, the magnitude of exposure to soil by recreational hunter/fisher and Native American receptors in the Resource Area is expected to be less than was assumed in development of industrial PRGs. Also, inorganic chemicals are poorly absorbed through the skin. Therefore, exposure through ingestion and direct contact to chemicals present in surface and subsurface soil for recreational hunter/fisher and Native American receptors is expected to be minimal.
- Direct Contact with Surface and Subsurface Soil by Subsistence Receptors. The maximum observed concentrations of inorganic chemicals in soil (as presented in Table 5-1 in MW [1999b]) exceed their respective residential PRGs for cadmium, manganese, nickel, and vanadium (EPA 2001). As defined by EPA Region 9, residential PRGs are based on potential exposure through both ingestion and direct contact. However, inorganic chemicals in soil are poorly absorbed through the skin. Therefore, potential exposure through direct contact with surface and subsurface soil does not contribute significant to total exposure for subsistence receptors and will not be quantitatively evaluated.

- Ingestion and Direct Contact with Groundwater. As noted in MW (1999b), groundwater samples were collected from 20 groundwater wells inventoried in the Resource Area. Maximum concentrations of six inorganic chemicals (selenium, cadmium, manganese, nickel, vanadium, and zinc) are between one-half and one order of magnitude (5 to 10 times) lower than the EPA Region 9 tap water PRG. Mean concentrations of these same chemicals are almost two orders of magnitude less than their respective PRGs. Therefore, exposure to chemicals present in groundwater is expected to be associated with minimal risks and hazards. However, additional samples are being collected by the IDH and will be evaluated to ensure that groundwater is not an exposure pathway of concern.

Inhalation of fugitive dusts is generally expected associated with minimal risks and hazards. However, in Southeastern Idaho, extensive, wide-open spaces are common and create the potential for strong air currents to occur. Therefore, wind erosion may be a significant mechanism of chemical transportation in the Resource Area, particularly at locations potentially frequented by recreational users and no longer actively managed by site operators. Therefore, the AWHHRA will evaluate potential exposure by hunters through inhalation of fugitive dusts at or near waste rock piles.

Hunting, fishing, and camping are popular recreational activities in the Resource Area. Recreational receptors are expected to get some or all of their drinking water while engaged in these activities from Resource Area streams. Therefore, in order to be health protective, potential ingestion of surface water by receptors engaged in recreational activities (including hunting and fishing) will be evaluated in the AWHHRA.

7.3.2.3 Exposure Scenarios

Exposure scenarios exist when a point of contact exists between an affected medium and a receptor. For the AWHHRA, potentially complete exposure scenarios are defined as the coupling of a complete exposure pathway with a particular receptor group. Complete exposure pathways considered in the AWHHRA are identified in the human health CSM (see Figure 3) and are summarized in Section 7.3.2.2.

Receptors considered in the AWHHRA are as follows:

- Adult and child recreational hunters and fishers
- Adult and child Native Americans
- Adult and child subsistence lifestyle receptors

Adult receptors are assumed to be about 18 or more years old, and child receptors are assumed to be less than 6 years of age. Exposure scenarios involving each of these receptor groups are summarized below.

ADULT AND CHILD RECREATIONAL HUNTERS AND FISHERS

These receptors are assumed to be exposed through the following exposure pathways:

- Ingestion of cattle
- Ingestion of wild game (represented by elk)
- Ingestion of aquatic life (represented by fish)
- Inhalation of fugitive dust (from waste rock piles)
- Ingestion of surface water

ADULT AND CHILD NATIVE AMERICANS

These receptors are assumed to be exposed through the following exposure pathways:

- Ingestion of cattle
- Ingestion of wild game (represented by elk)
- Ingestion of aquatic life (represented by fish)
- Ingestion of aquatic and terrestrial plants (water cress, wild onion, and wild carrot)
- Ingestion of tea brewed from aquatic and terrestrial plants (red willow and silver sage)
- Inhalation of fugitive dust (from waste rock piles) while hunting
- Ingestion of surface water

ADULT AND CHILD SUBSISTENCE LIFESTYLE RECEPTORS

These receptors are assumed to be exposed through the following exposure pathways:

- Ingestion of cattle
- Ingestion of wild game (represented by elk)
- Ingestion of aquatic life (represented by fish)
- Ingestion of homegrown produce

- Ingestion of surface soil
- Inhalation of fugitive dust (from waste rock piles) while hunting
- Ingestion of surface water

7.3.3 Exposure Quantification

Exposure is defined as the contact of an organism with a chemical or physical agent. The magnitude of potential chemical exposure, which depends on the amount of a chemical available at human exchange boundaries (skin, lungs, and gut) during a specified period of time, will be quantitatively assessed in the AWHHRA.

Exposure dose equations that consider contact rate, receptor body weight, and frequency and duration of exposure will be used to estimate the intake or dose of each COPC for each receptor. Exposure doses will be calculated for the RME case, which represents the highest exposure reasonably expected to occur. If risks and hazards associated with the RME case appear to be significant (see Section 7.5 for a discussion of significance), then a decision will be made whether to calculate exposure doses for the CTE case, which represents the most likely exposure expected to occur.

An exposure can occur over a period of time. The total exposure can be divided by the time period to calculate an average exposure per unit of time. An average exposure can be expressed in terms of body weight. All exposures quantified in the AWHHRA will be normalized for time and body weight and presented in units of milligrams of chemical per kilogram of body weight per day (mg/kg-day). These exposures are termed "intakes." The equation below is a generic equation for calculating chemical intake (EPA 1989).

$$D = \frac{C \times CR \times EF \times ED}{BW \times AT}$$

where:

D = Dose: the amount of chemical at the exchange boundary (mg/kg-day); to evaluate exposure to noncarcinogenic chemicals, the intake is referred to as the average daily dose (ADD); to evaluate exposure to carcinogenic chemicals, the intake is referred to as the lifetime average daily dose

C = Chemical concentration: the average concentration (EPC) contacted over the exposure period (for example, milligrams of contaminant per kilogram of body weight [mg/kg] in fish tissue)

CR	=	Contact rate: the amount of contaminated medium contacted per unit of time or event (for example, grams per day [g/day] for fish ingestion)
EF	=	Exposure frequency: how often the exposure occurs (days per year)
ED	=	Exposure duration: how long the exposure occurs (years)
BW	=	Body weight: the average body weight of the receptor over the exposure period (kilogram [kg])
AT	=	Averaging time: the period over which exposure is averaged (days); for carcinogens, the averaging time is 25,550 days based on a lifetime exposure of 70 years; for noncarcinogens, the averaging time is calculated as exposure duration (years) x 365 days per year

Variations of this equation will be used to calculate exposure pathway-specific exposures to COPCs. Equations and parameter values proposed for use for each exposure pathway are presented in Figure 5 and Table 7-1, respectively. EPC calculations are discussed below.

7.3.3.1 Exposure Point Concentration Calculations

The EPC is defined as the concentration of a COPC that a human receptor is exposed to at an exposure point. This section summarizes how medium-specific EPCs will be derived for use in the AWHHRA.

For purposes of performing background calculations and calculating EPCs, duplicate analytical results will be averaged and represented by a single value and each analytical result reported as non detect (ND) will be replaced with a value equal to one-half of the SQL. These procedures are consistent with EPA guidance (EPA 1989, 2000c). As discussed in EPA's Guidance for Data Quality Assessment, Practical Methods for Data Analysis, EPA QA/G-9, QA00 Version (EPA 2000c), replacement of an ND analytical result with a value equal to one-half the SQL is most appropriate for data sets in which the frequency of censored or ND values is less than 15 percent. Alternate statistical procedures are available for data sets with higher percentages of ND values (EPA 2000c).

Under Step 1 of the tiered approach (see Section 3.1.2), the maximum detected medium-specific concentration of each COPC, applicable to the specific scenario based on area-specific knowledge, will be used as the EPC. Under Steps 2 and 3, and in accordance with EPA's Supplemental Guidance to RAGS: Calculating the Concentration Term, the 95 UCL of the mean or the maximum medium-specific concentration (whichever is lower) will be used as the EPC under RME conditions and the mean concentration will be used as the EPC under CTE conditions (EPA 1992).

As discussed in Section 7.1.2 and summarized in Figure 2, under Step 2, the EPC will be calculated on a watershed-specific basis (ingestion of fish, and aquatic and terrestrial [not including homegrown produce] plant-related pathways, a Resource Area basis (ingestion of beef cattle and wild game), and riparian area- or mine-specific basis (ingestion of soil, ingestion of homegrown produce, and inhalation of fugitive dust). All EPCs calculated under Tier 2 are based on 2001 analytical data only (see Table 2-1). Under Step 3, ingestion of fish and surface water, which were evaluated on a watershed-specific basis under Step 2, are evaluated on a watershed-specific basis using historical data. These exposure pathways may also be evaluated on a stream-specific basis using both 2001 and historical analytical data as necessary based on professional judgment.

7.3.3.2 Pathway-specific Intake Equations and Exposure Parameters

Pathway-specific intake equations and exposure parameters that will be used to estimate receptor-specific exposures under the RME case are presented in Figure 5 and Table 7-1, respectively. Intake equations and exposure parameter values that will be used in the AWHHRA were taken or adapted from EPA guidance documents, including RAGS (EPA 1989); Exposure Factors Handbook (EPA 1997b); and RAGS, Volume I: Human Health Evaluation Manual, Supplemental guidance: Standard Default Exposure Factors (EPA 1991). These documents provide guidance for selecting exposure parameter values and were used, along with Resource Area- and state-specific information (such as fish and game regulations), information from peer-reviewed scientific literature, and professional judgment, to identify appropriate parameter values. The basis for each of exposure parameter value is discussed in a series of footnotes associated with Tables 7-1 (RME conditions) and 7-2 (CTE conditions).

7.4 TOXICITY ASSESSMENT

The primary purpose of a toxicity assessment in the context of a risk assessment is the identification of toxicity values that will be used to quantify potential adverse effects on human health associated with potential exposure to COPCs. In support of this primary purpose, toxicity profiles are prepared for each of the COPCs. The toxicity profiles discuss the pathway-specific dose responses for each COPC, focusing on the identification of no observed adverse effect levels (NOAEL) and lowest observed adverse effect levels (LOAEL) that were used to establish pathway-specific toxicity values. The basis for, and sources of, toxicity values for carcinogenic and noncarcinogenic COPCs are discussed in Sections 7.4.1 and 7.4.2, respectively. Assessing the toxicity of lead presents some unique problems. Procedures that will be used to assess the toxicity of lead if it is selected as a COPC are discussed in Section 7.4.3. Section 7.4.4 briefly discusses toxicological profiles that will be prepared for the COPCs.

7.4.1 Toxicity Values for Carcinogenic Chemicals of Potential Concern

The potential for exposure to a given chemical to result in carcinogenic effects is evaluated differently than for noncarcinogenic effects. The upper-bound excess lifetime cancer risk (ELCR) associated with a given dose is calculated by multiplying the dose from a given route of exposure by a slope factor (SF). An SF is an upper-bound estimate of the probability of a carcinogenic response per unit dose of a chemical over a lifetime. SFs are derived through use of mathematical models based on a high-to-low dose extrapolation and under the assumption that no threshold exists for initiation of cancer. Because of the use of the nonthreshold assumption and the 95 UCL of the slope of the dose-response curve, use of SFs provides a conservative, upper-bound estimate of potential cancer risks. The actual response to a given dose of a chemical is therefore probably less than the predicted response (EPA 1989).

SFs are specific to a chemical and a route of exposure and generally are available for both the oral (ingestion or gavage) and inhalation routes. As discussed in Section 7.3.2.2, potentially complete exposure pathways that will be evaluated in the AWHHRA involve only ingestion; inhalation exposures will not be evaluated quantitatively. In accordance with EPA guidance, SFs will be identified from the following hierarchical list of sources:

- EPA's Integrated Risk Information System (EPA 2001)
- EPA's Health Effects Assessment Summary Tables (EPA 1997a)
- EPA's National Center for Environmental Assessment

7.4.2 Toxicity Values for Noncarcinogenic Chemicals of Potential Concern

Standard risk assessment models are based on the assumption that noncarcinogenic effects, unlike carcinogenic effects, exhibit a threshold; that is, a level of exposure exists below which no adverse effects are observed. The potential for noncarcinogenic health effects resulting from exposure to a COPC will be assessed by comparing an exposure estimate for intake to a reference dose (RfD). The RfD represents an estimated daily intake rate for a noncarcinogenic COPC that is believed to pose no appreciable risk of adverse effects on human health, including the health of sensitive populations, during a lifetime. RfDs also apply to the noncarcinogenic effects of potential carcinogens. An RfD is specific to a chemical and a route of exposure, such as ingestion or inhalation. As stated in Section 7.4.1, the AWHHRA will only consider exposure through ingestion.

To derive an RfD, EPA workgroups review all human and animal studies relevant to a chemical and select the study or studies pertinent to derivation of the RfD. RfDs often are derived from a measured NOAEL. The NOAEL corresponds to the dose (in milligrams per kilogram of body weight per day) that was administered during the toxicity study without inducing observable adverse effects. If a NOAEL cannot be determined, the LOAEL is used. The LOAEL corresponds to the lowest daily dose administered in the toxicity study that induces an observable adverse effect. The toxic effect characterized by the LOAEL is referred to as the "critical effect."

To derive an RfD, the NOAEL or LOAEL is divided by uncertainty factors (UF) to ensure that the RfD will be protective of human health. UFs usually occur in multiples of 10, and each factor represents a specific area of uncertainty inherent in the extrapolation from available data. UFs account for (1) variations in the general population to protect sensitive human populations such as child and elderly receptors, (2) extrapolation of data from animals to humans (interspecies extrapolation), (3) derivation of a chronic RfD based on a subchronic rather than a chronic study, and (4) derivation of an RfD based on a LOAEL instead of a NOAEL. Modifying factors may be applied to data in order to reflect additional uncertainties associated with the data. Modifying factors range from 0 to 10.

Additionally, chronic and subchronic RfDs are developed for different periods of exposure. Chronic RfDs generally are used to evaluate exposures occurring over periods of more than 7 years, and subchronic RfDs are used to evaluate exposures occurring over periods of 2 weeks to 7 years. However, in order to be sufficiently conservative, only chronic RfDs will be used to characterize hazards associated with all receptor-specific exposures. COPC-specific chronic RfDs will be identified using the same hierarchical list of sources presented in Section 7.4.1.

7.4.3 Lead

Toxicity factors are not available for lead. The potential for human health effects as a result of exposure to lead typically is estimated on the basis of calculated lead concentrations in the blood of receptors. EPA guidance recommends use of separate models for assessing risks associated with exposure to lead by children and adults. Specifically, EPA recommends using the Integrated Exposure Uptake Biokinetic (IEUBK) Model for Lead in Children, Version 0.99d, to assess lead exposure to children 0 to 7 years (84 months) of age (EPA 1994a, 1994b). To assess the risks associate with lead exposure for adults, EPA suggests using the Recommendations of the Technical Review Workgroup for Lead for an Interim Approach to Assessing Risks Associated with Adult Exposures to Lead in Soil (EPA 1996).

Exposure to COPCs through dermal exposure to soil will not be quantitatively evaluated in the AWHHRA. Also, the intake of COPCs by children is expected to exceed those of adults (on a body weight basis). Further, EPA's IEUBK model can be used to evaluate the impact of ingesting foodstuffs containing lead on the blood-lead level of children. Therefore, if lead is identified as a COPC, risks associated with potential exposure to lead will be evaluated using EPA's IEUBK model (EPA 1996).

7.4.4 Toxicological Profiles

Toxicological profiles will be prepared for each COPC. These profiles will contain a brief description of the toxic effects of each COPC and will focus on the effects most likely to be observed at the environmental exposure levels that form the basis for toxicity values. Toxic effects, other than the carcinogenic and noncarcinogenic effects quantitatively assessed, include reproductive, teratogenic, and mutagenic effects. Toxicity values, critical effects, and any UFs used to calculate toxicity values also will be summarized in toxicological profiles.

7.5 RISK AND HAZARD CHARACTERIZATION

This section presents methodologies that will be used to characterize carcinogenic risks and noncarcinogenic hazards associated with exposure pathways identified in Section 7.3.2.2. Risks and hazards will be characterized for individual COPCs, multiple COPCs within each exposure pathway, and exposures attributable to multiple exposure pathways, as appropriate. Sections 7.5.1 and 7.5.2 discuss methodologies used to characterize carcinogenic risks and noncarcinogenic hazards, respectively.

7.5.1 Risk Characterization Methodology

For carcinogenic COPCs, risk estimates represent the incremental probability that an individual will develop cancer over a lifetime as a result of exposure to the COPC (EPA 1989). ELCR will be calculated as shown in the equation below.

$$\text{ELCR (Risk)} = \text{LADD} \times \text{SF}$$

where:

LADD = Lifetime average daily dose (mg/kg-day)

SF = Slope factor $(\text{mg/kg-day})^{-1}$

Risk is expressed as probability. For example, a risk of 1E-06 indicates one additional case of cancer in an exposed population of 1 million. The SF in almost all cases represents a 95 UCL of the probability of

a carcinogenic response based on experimental data used in a multistage model. The resulting risk estimate therefore represents an upper-bound estimate of the carcinogenic risk. The actual risk probably does not exceed the estimate and is likely to be less (EPA 1989).

In the revised National Oil and Hazardous Substances Pollution Contingency Plan (EPA 1990), EPA has established an "acceptable" range for carcinogenic risk associated with exposure at Superfund sites of 1E-06 to 1E-04 (one case of cancer in an exposed population of 10,000). In general, a potential upper-bound risk of 1E-06 is used by EPA as a point of departure for determining remediation goals. Although the Resource Area is not a Superfund site, EPA's range is relevant and appropriate for use in evaluating risk levels.

Within a given exposure pathway, receptors may be exposed to more than one chemical. The total upper-bound risk associated with exposure to multiple chemicals through a single pathway is estimated as shown in the following equation:

$$Risk_{EP} = Risk_1 + Risk_2 + \ldots + Risk_i$$

where:

$Risk_{EP}$ = Total risk for a given exposure pathway

$Risk_i$ = Risk estimate for the ith COPC

At particular exposure points, receptors may be exposed through a number of exposure pathways (see the human health CSM, Figure 3). At each exposure point, the total exposure for a receptor equals the sum of exposures through various exposure pathways to which the receptor is exposed. Under each exposure scenario, exposure pathway combinations will be developed for each receptor. Initially, combinations will be based on the highest receptor-specific total risk for each exposure pathway, regardless of the relative location of these maximum risks. The total risk posed to a receptor through a combination of pathways is calculated as shown in the equation below:

$$\text{Total Risk} = \text{Risk}\ (EP_1) + \text{Risk}\ (EP_2) + \ldots + \text{Risk}\ (EP_i)$$

where:

Total Risk = Risk resulting from multiple exposure pathways

Risk (EPj) = Risk resulting from the jth exposure pathway

The approach described above is consistent with the widely held belief that the total carcinogenic risk associated with exposure to multiple carcinogenic COPCs can be estimated as the sum of the carcinogenic risks posed by individual COPCs (EPA 1986). The risk characterization will be completed following the tiered approach described in Section 7.1.2. Under each step of this tiered approach, total risks will be estimated as described above for the exposure scenarios that have been retained to that point. After Step 1 of the tiered approach, particular exposure scenarios may be dropped from further consideration because they are associated with risks less than 1E-06. Steps 2 and 3 (as described in Section 7.1.2) provide for more detailed analysis of exposure scenarios that are associated with risks greater than or equal to 1E-06, as calculated in Step 1.

7.5.2 Hazard Characterization Methodology

The potential for receptors to develop noncancerous health effects is characterized by comparing an intake for a specific exposure period (the ADD) to an RfD developed for a similar exposure period. When performed for a single chemical, this comparison yields a ratio known as the hazard quotient (HQ), which is calculated as shown in the equation below:

$$HQ = ADD/RfD$$

where:

ADD = Average daily dose (mg/kg-day)

RfD = Reference dose (mg/kg-day)

Generally, an HQ of less than or equal to 1 is considered to be health-protective. An HQ exceeding 1 indicates a potential for adverse noncarcinogenic health effects (EPA 1989). For the purposes of the AWHHRA, chronic RfDs will be used to characterize noncarcinogenic hazards for all receptor-exposure pathway combinations.

As with carcinogenic COPCs within a given exposure pathway, a receptor may be exposed to multiple chemicals associated with noncarcinogenic health effects. To estimate the total noncarcinogenic hazards for each exposure pathway, procedures outlined in Guidelines for the Health Risk Assessment of Chemical Mixtures and RAGS (EPA 1986, 1989) will be used in the AWHHRA. The total noncarcinogenic hazard attributable to exposure to multiple COPCs through a single pathway is calculated as shown below:

$$HI_{EP} = HQ_1 + HQ_2 + \ldots + HQ_i$$

where:

HI_{EP} = Total hazard index (HI) for a give exposure pathway

HQ_i = Hazard quotient for the ith COPC

This summation methodology is based on the assumption that the effects of the various COPCs to which a receptor is exposed are additive.

As discussed in Section 7.5.1 for carcinogenic COPCs, exposure pathway combinations will initially be developed for receptors, based on summing the maximum HIs, associated with each exposure pathway, regardless of the locations of these maximums. The total noncarcinogenic hazard posed to a receptor through a combination of exposure pathways will be calculated as shown in the equation below:

$$\text{Total HI} = HI\ (EP_1) + HI\ (EP_2) + \ldots + HI\ (EPj)$$

$HI\ (EP_j)$ = Hazard index resulting from the jth exposure pathway

As part of Tier 2, care will be taken to ensure that the same receptor would consistently face multiple exposure pathways before summing HIs associated with these different exposure pathways are summed. Clearly, it is inappropriate to combine HIs associated with location-specific maxima calculated assuming a receptor's entire exposure takes place at each location. It should be noted that the summing of location-specific maxima under Tier 1 is consistent with a screening level approach.

In accordance with EPA guidance, all total HIs exceeding 1 will be further evaluated (EPA 1989). The refined assessment will include development of separate total HIs based on specific target organs and systems. Typically, target organs and systems affected by each COPC are identified based on (1) effects (termed "critical effects" by EPA) that occur at levels of exposure corresponding to LOAELs, or (2) effects at exposure levels slightly exceeding LOAELs, as appropriate. For purposes of the AWHHRA, target organs and systems will be identified from a variety of sources, including EPA databases and publications (EPA 1997a, 2001), references or guidance developed by other agencies, and peer-reviewed literature and publications.

The hazard characterization will be completed following the tiered approach described in Section 7.1.2. Under each step of this tiered approach, total hazards will be estimated, as described above, for exposure

scenarios that have been retained to that point. After Step 1 of the tiered approach, particular exposure scenarios may be dropped from further consideration because they are associated with hazards less than 1. Steps 2 and 3 (as described in Section 7.1.2) provide for more detailed analysis of exposure scenarios that are associated with risks greater than or equal to 1, as calculated in Step 1.

7.5.3 Tiered Approach to Risk Characterization

As discussed in Section 7.1.2, the AWHHRA will be conducted using a tiered approach. The risk characterization will be organized in accordance with this tiered approach and will clearly present and fully document the risk characterization results, focusing on the following results and decision points:

- Tier- and exposure scenario-specific results
- Identification of all exposure scenarios determined to require no further evaluation, based on insignificant risks and hazards
- Identification of the COPCs contributing significantly (also referred to as "driving") the risk and hazard results for each exposure scenario

The tiered approach for the AWHHRA is presented in Figure 2.

7.6 UNCERTAINTIES

The AWHHRA also will identify and discuss major areas of uncertainty associated with each element of the risk assessment, including: data evaluation, exposure assessment, toxicity assessment, and risk characterization. The discussion will describe the nature of the impact of each area of uncertainty on the exposure scenario-specific risk and hazard results. The discussion of uncertainties also will include a table summarizing the magnitude (minimal, significant, and unknown) and direction (underestimation, overestimation, and unknown) of the impact of each area of uncertainty on risk and hazard results presented in the AWHHRA.

8.0 AREA WIDE ECOLOGICAL RISK ASSESSMENT

Typically in the ERA process, the ERA conducted by MW would be equivalent to a screening-level ERA and the work TtEMI will be conducting for the AWERA is equivalent to a baseline ERA. However, this process has been modified slightly, as discussed in Section 8.1.

8.1 AREA WIDE ECOLOGICAL RISK ASSESSMENT APPROACH

The Resource Area has a large aerial extent, with multiple mine sites across the area. A wide variety of habitats and receptors may be impacted by chemicals from mining activities. No single line of evidence will adequately assess potential risks to ecological receptors in the area from mining-related releases. Therefore, multiple lines of evidence will be used to assess potential risk to ecological receptors. These lines of evidence are described fully in Section 8.6.2 but will consist of: (1) development of HQs for various receptors, based on modeled doses; (2) comparison of tissue concentrations to literature effects data; (3) comparisons of chemical concentrations between impacted and reference areas; (4) comparison of media concentrations to accepted benchmarks; and (5) comparison of aquatic community structure between impacted and reference areas. The primary line of evidence will be the development of HQs for the representative receptors and effects. Because of issues concerning the quality and comparability of historic data, only data collected during calendar year 2001 will be used to develop HQs. This primary line of evidence will be supplemented by information from other lines of evidence. Empirical studies performed on native species, where available and relevant will be chosen if available. The strategy for evaluating HQs for various receptors for the Resource Area is described in the following sections.

8.1.1 Tier 1

The first tier is a “worst-case” screening-level activity directed at eliminating any chemicals that present negligible risks, chemicals occurring at background levels with no increased concentrations associated with mining activities, or chemicals that occur near or below the detection limits of laboratory measurement instrumentation. In this step, the highest observed concentration for each media and chemical, and the most conservative exposure parameters will be used to calculate an HQ for each target species and COPEC. Any chemicals that do not present a potential risk using this worst-case scenario then can be safely removed from further consideration.

8.1.2 Tier 2

In the second tier, chemicals that were not eliminated in Tier 1 will be evaluated on an area-wide basis using approximated exposure point concentrations for each media and mean exposure parameters for each

receptor intended to represent average population-level exposures. The IDEQ chose to use a targeted sampling approach to support the development of area-weighted exposure points. This approach was deemed to be scientifically valid by the Agency and provides a cost-effective method within the accepted tolerances of typical risk assessment processes without the collection of the excessive samples associated with purely statistical approaches.

Each media will be represented by average values from impacted and unimpacted data sets from the mining zone, average values from outcrop areas, and, where required for larger ranging receptors, appropriate literature-derived values representative of soils in the surrounding areas. These values will be area-weighted based on surface area ratios, stream segment lengths or other applicable weighting criteria. HQs will be developed based on NOAEL benchmarks contained in appropriate references. The dose calculation and development of HQs for each species will be conducted, as described in Section 8.7.

While the mines occupy a large area, the combined area of the mine sites is about 3 percent of the total Resource Area. Therefore, development of HQs for the Resource Area as a whole will be calculated for the following data sets to place the results in the appropriate context.

- **General Resource Area** – All data will be used to calculate EPCs using an area-weighted approach. HQs developed from this data set will represent the potential risk to overall populations of the selected receptor species in the Resource Area.
- **Background Areas** – All data from samples determined to represent background conditions in the Resource Area will be used to calculate EPCs representative of unimpacted areas. HQs developed from this data will represent the potential risk of exposure to background concentrations of chemicals.
- **Mining-impacted Areas** – All data from samples identified as directly impacted by mining activities in the Resource Area will be used to calculate EPCs. HQs developed from this data will represent potential risk to localized populations in the mine site areas. These HQs will not represent the risk at any individual mine site but will be indicative of potential impacts to localized populations at mine sites in general.

HQs derived from these three data sets will provide sufficient information to place calculated risks in an appropriate context.

8.1.3 Tier 3

For an area the size of the Resource Area, the available data for risk assessment is limited in nature and extent. Therefore, significant uncertainties are inherent in the risk assessment. These include temporal

components of chemical releases to surface water, EPCs used in calculations, and actual exposure experienced by various receptors. The third tier will analyze uncertainties and sensitivities of different parameter values used in risk assessment calculations. This will include running separate calculations based on mean COPEC concentrations from historical data and assessing uncertainties in exposure parameters to determine their effects on HQ values calculated in Tier 2. There also will be analysis of risk characterization results in terms of other lines of evidence described in Section 8.6.2.

8.2 ECOLOGICAL RISK ASSESSMENT CONCEPTUAL SITE MODEL

Unlike HHRA, which evaluates only one species, ERA involves multiple species with different degrees of exposure and toxicological responses. For the purpose of an ERA, investigations should focus on ecological receptors most likely to be affected, given the fate and transport mechanisms of chemicals involved, ecotoxicological properties of chemicals, and habitats at the site (EPA 1997b). Therefore, the ecological CSM is much more complex than the human health CSM.

8.3 IDENTIFICATION AND PRIORITIZATION OF CHEMICALS OF POTENTIAL ECOLOGICAL CONCERN

Chemicals detected in the various media sampled will be subjected to a screening process to focus the ERA on chemicals that are site-specific and pose the greatest risk to ecological receptors. Screening factors will consist of the following:

Surface Water

- Frequency of detection
- National Ambient Water Quality Criteria (1997 Federal Register 62: 42159 to 42208) (Buchman 1999)
- For background screening comparisons, an average concentration will be calculated for each chemical using data collected from streams upgradient to and in the undisturbed region of the Resource area (considered to be representative of pre-mining conditions). Average and single point concentrations that are more than two times the calculated background average will be considered impacted and will be evaluated in the risk assessment process. Concentrations less than two times the background average will be considered to be naturally occurring and will be eliminated from further consideration.

Freshwater Sediments

- Frequency of detection
- Comparison to background concentrations

- Consensus-based Freshwater Sediment Quality Guidelines (MacDonald and others 2000)
- Selected freshwater threshold effects levels from NOAA SQUIRT tables (Buchman 1999)
- Suggested toxicity threshold for selenium taken from Van Derveer and Canton (1997); San Joaquin Valley Drainage Program (1990), and Lemly and Smith (1990, as cited in Skorupa 1998)

Soils

- Frequency of detection
- Comparison to background concentrations
- Soil screening criteria, as provided for limited inorganics from Ecological Soil Screening Level Guidance (EPA 2000a); Kapustka and others (2000); and EPA (2001).

Table 8-1 presents the screening benchmarks and criteria for surface water, sediment, and soil. All comparisons to background concentrations will be conducted, as described in Section 7.2.3.1. Any chemical retained for any media will be retained for all media. Retained chemicals will be referred to as COPECs.

8.4 RESOURCE AREA ECOLOGICAL FOOD WEB

Food webs are organized by class guilds, which are linked together based on dietary relationships between them. Food webs are meant to illustrate how chemicals have the potential to be transferred within an ecosystem. The various food chains represent potential COPEC exposure pathways. The importance of a food chain as a dietary exposure pathway depends on receptor dietary habits. The boxes in the ecological CSM represent the expected feeding guilds in each of the ecosystems within the Resource Area (see Figure 4). Feeding guilds are groups of organisms that exploit similar resources for food.

8.4.1 Terrestrial Food Web

Figure 4 illustrates food web interactions for the terrestrial food web for the Resource Area. Primary producers include wheatgrass (*Agraphyron* species), alfalfa (*Medicago sativa*), and bromegrass (*Bromus* species).

Primary consumers are composed of terrestrial invertebrates and herbivorous birds and mammals. Bird diets can vary greatly, and numerous bird species also may be considered herbivorous either all or part of the year, depending on conditions such as availability of prey and life stage. Terrestrial invertebrates include plant-eating insects, such as grasshoppers, insect larvae, and beetle larvae. Other primary

consumers include herbivorous mammals and birds. Specific species of each of these guilds are presented in Figure 4.

Secondary consumers consist of terrestrial, omnivorous birds, mammals, and reptiles. Omnivorous birds and mammals may consume both plants and animals and may feed almost exclusively on one or the other, depending on season and prey population conditions. Specific species of each of these guilds are presented in Figure 4.

Tertiary consumers include carnivorous mammals and raptors. These species feed exclusively by preying on other animals. Specific species of each of these guilds are presented in Figure 4.

8.4.2 Aquatic and Riparian Food Web

Figure 4 illustrates food web interactions for freshwater and riparian areas. Primary producers include the phytoplankton and aquatic macrophytes. These organisms represent the basis of the food chain. Emergent and riparian primary producers also provide shelter and habitat for higher-trophic-level species. Specific species of each of these guilds are presented in Figure 4.

Primary consumers include zooplankton, benthic invertebrates, benthic-feeding fish, and riparian herbivorous birds and mammals. Zooplankton feed primarily on phytoplankton and other zooplankton. Benthic invertebrates, which have the potential to be present in the Resource Area, include insect larvae and freshwater oligochaetes. These organisms feed on detritus composed of dead animals and plants, suspended particulates, and microscopic invertebrates. These organisms are closely associated with sediments and are exposed to sediment contamination dermally and through direct and incidental ingestion. Benthic-feeding fish tend to be omnivorous and feed on both benthic invertebrates and aquatic plants. Aquatic and riparian herbivorous birds and mammals consume vegetation found in the aquatic or riparian environment. Specific species of each of these guilds are presented in Figure 4.

Secondary consumers include fish; amphibians; aquatic and riparian, omnivorous birds and mammals; aquatic and riparian piscivorous birds; aquatic and riparian, benthic-feeding birds; and aquatic and riparian, carnivorous mammals. Specific species of each of these guilds are presented in Figure 4.

8.5 ECOLOGICAL EFFECTS, COMPLETE EXPOSURE PATHWAYS, AND ECOSYSTEMS POTENTIALLY AT RISK

This section discusses COPEC fate and transport, complete exposure pathways, and ecosystems potentially at risk. This risk assessment work plan will address all potential metal COPECs, but at this time, individual metals have not yet been identified. Based on the preliminary screening conducted by the IMA, selenium is the only chemical currently identified as a probable concern. However, as discussed in Section 8.3, the previous screening was not defensible based on limited analyses and samples. Therefore, many of the metals found in the area may be COPECs Specific ecological effects of selenium are discussed in Sections 8.5.1.1 and 8.5.1.2. Ecotoxicological effects of other metals retained as COPECs will be discussed in the report resulting from this work plan. The remaining portions of Section 8.5 are broadly applicable to most metal chemicals.

8.5.1 Ecological Effects of Selenium

An understanding of how selenium adversely affects ecological receptors is required to identify significant potential exposure pathways that should be evaluated in the ERA. This understanding facilitates identification of the most sensitive receptors. A more in-depth discussion of the ecological effects of selenium has been presented in the Existing Data and Risk Assessment Review (TtEMI 2001a).

Selenium is much less toxic to most plants and invertebrates than to vertebrates (Skorupa 1998). Among vertebrates, reproductive toxicity is one of the most sensitive endpoints. Egg-laying vertebrates, such as birds and fish, seem to have substantially lower thresholds for reproductive toxicity than mammals.

8.5.1.1 Uptake and Toxicity of Selenium in Terrestrial Ecosystems

Plants are very effective at removing selenium from contaminated soils (Irwin and others 1997). Selenium is absorbed by plants as selenite or selenate, which is then converted to the organic form of selenium. It is believed that selenate is taken up actively, while selenite uptake is largely passive (Peterson and Girling 1981). Selenium is translocated to all parts of the plant (Broyer and others 1972). Selenium toxicity in plants has symptoms that include chlorosis, stunting, and yellowing of leaves.

Selenium accumulators can take up and accumulate very high concentrations of selenium (over 1,000 parts per million) in their tissues without injurious effects. Obligate selenium accumulators, which grow only in soils where metabolic needs can be satisfied, include many species of *Astragalus* and some species of *Brassica, Haplopappus, Machaeranthera, Oonopsis, Stanleya,* and *Zylorhiza* (Irwin and others

1997). Facultative selenium accumulators can tolerate, but do not require, elevated soil selenium levels and include many species of *Aster* and some species of *Astragalus, Atriplex, Castelleja, Comandra, Grayia, Grindelia, Gutierrezia, Machaeranthera, and Mentzelia.* These plants take up high levels of selenium and metabolize it into water-soluble selenate, and when the plants die, the water-soluble organic selenium compounds released by decay become more bioavailable to other plants and animals.

Almost no selenium toxicity data exist for terrestrial invertebrates (Skorupa 1998). No documented field cases exist of fish and other wildlife populations being affected adversely by selenium-induced alterations of invertebrate population indices, such as invertebrate community structure and invertebrate density. As indicated for plants, the direct toxic effects of consuming selenium-contaminated invertebrates are apparently more important than any indirect ecological effects such as changes in invertebrate population structure (Skorupa 1998). The effects of selenium of particular interest in terrestrial ecosystems include systemic and reproductive effects, general toxic effects, and mortality.

Consumption of selenium-accumulating forage plants by livestock has induced illness and death from selenium poisoning. Selenium-accumulating plants tend to be deeper-rooted than grasses and survive more arid conditions, therefore remaining as the principal forage for grazing in time of drought (Wilbur 1983, as cited in Eisler 1985).

8.5.1.2 Uptake and Toxicity of Selenium in Aquatic and Riparian Ecosystems

Selenium, in natural waters, commonly occurs as a mixture of several chemical species. Two inorganic chemical species, selenite and selenate, are usually the predominant forms (Masscheleyn and Patrick 1993, as cited in Skorupa 1998). Waterborne selenium partitions between the water column and suspended, detrital particulate matter and to assess risk for waterborne selenium toxicity, unfiltered water samples should be analyzed for both particulate and dissolved selenium (Eastern Research Group 1998, as cited in Skorupa 1998).

Once in the water column, selenium enters the food chain through bioconcentration by phytoplankton, which are then consumed in large quantities by crustaceans and bivalves. Fish and waterfowl, in turn, eat crustaceans and bivalves. Bioconcentration, bioaccumulation, and biomagnification of selenium can increase selenium levels more than 1,000-fold from water to fish and animals (Saiki and Lowe 1987, as cited in Taylor and others 1992). The greatest increase in concentration occurs between water and phytoplankton and other aquatic plants; subsequent steps in the food chain typically increase selenium concentrations by a factor of 2 to 6 (Lemly and Smith 1987, as cited in Taylor and others 1992).

Current understanding of selenium toxicology indicates that ecological effects are caused primarily by selenium in the food chain, rather than selenium dissolved in the water column (Philips 1988; Luoma and others 1992, all as cited in Taylor and others 1992). Waterborne selenium is not very toxic to fish and wildlife (Skorupa 1998). Selenium affects survival, growth, and reproduction of some aquatic invertebrates (Jarvinen and Ankley 1999). The effects of selenium of particular interest in aquatic ecosystems include reproductive and systemic effects and mortality.

8.5.2 Complete Exposure Pathways

For ecological receptors, potential exposure pathways for movement of chemicals resulting from phosphate mining activities in southeastern Idaho include the following:

- Ingestion of windblown particles and dust
- Incidental ingestion of surface soil, sediment, and surface water during grooming, foraging, or feeding
- Dermal uptake of metals
- Dietary uptake of metals through contaminated forage or prey items and surface water ingestion

Some of these exposure pathways are more important than others. The most important exposure pathways for ecological receptors are:

- Incidental ingestion of surface soil, surface water, and sediment during grooming, foraging, or feeding (assumed to include incidental ingestion of windblown particles and dust)
- Dietary uptake of metals through contaminated forage and prey items

These pathways are believed to be the most significant, because a high probability exists that ecological receptors will receive direct contact doses from soils and sediments (given that these are the most contaminated media), as well as potentially contaminated terrestrial and benthic invertebrates that may accumulate selenium. These two pathways are likely to contribute the greatest percentage of overall ecological risks.

Other pathways (although potentially complete) were determined less likely to contribute to the exposure of ecological receptors. Of the potentially complete exposure pathways, dermal absorption was excluded because of a lack of data to assess the effect of dermal adsorption of selenium, which may be negligible

because of normal grooming activity and already taken into account through incidental ingestion by the ingestion pathway. Inhalation exposures are also poorly understood in an ecological risk context, because no toxicity data are available for comparison.

8.5.3 Ecosystems Potentially at Risk

An important part of the problem formulation process is to identify the environmental setting and ecosystems that are potentially at risk. A detailed discussion of the southeastern phosphate mining area is presented in MW (1999b). Using this information and other studies, the following discussion describes the ecosystems potentially at risk.

Vegetation in the project area is transitional between the Great Basin vegetation to the south and the Rocky Mountain vegetation to the north (MW 1999b). Six vegetation types are found within the project area and are a result of elevation, moisture, temperature, soil type, slope, and aspect:

- Conifer-Aspen Community
- Mountain Brush Community
- Sagebrush-Grass Community
- Riparian Community
- Marshland Community
- Agricultural and urban lands
- Lotic Aquatic Community

Based on previous investigations, the project area supports or contains habitat for up to 75 species of mammals, 272 species of birds, 16 species of reptiles, 16 species of fish, and seven species of amphibians (USGS and FS 1977; FS 1985, 1997; ICCDB 1999, all as cited in MW 1999b). A list of known species to occur in the Resource Area is presented in MW (1999b). All species identified as potential receptors for the AWERA are taken from these species lists.

The Resource Area is divided into two major riverine systems, the Bear River and the Snake River (MW 1999a). Other major streams in the Resource Area include the Blackfoot, Portneuf, and Salt Rivers, all tributaries of the Snake River. The southern portion of the Resource Area is located in the Bear River watershed. The Blackfoot, Portneuf River and Ross Fork River, and Salt River watersheds drain the remainder of the Resource Area. All of these streams support abundant aquatic populations of periphyton, benthic macro-invertebrates, and fish.

Several plant and animal species that are classified as threatened or endangered may be present or are thought to be present as seasonal migrants in the Resource Area and are listed in MW (1999b).

The ecological CSM presented in Figure 4 was developed to assist in the identification of specific receptors that might be directly or indirectly exposed to COPECs and to perform the exposure assessment. The ecological CSM illustrates the following:

- Abiotic media (that is, soil, sediment, and water)
- Trophic levels, primary producers, and primary, secondary, and tertiary consumers
- Trophic-level compartments represented by guilds (that is, a group of species from similar classes that occupy a particular trophic level and exploit similar resources)
- Major dietary relationships between compartments

The ecological CSM illustrates the interlocking patterns of the various inclusive food chains. A food chain is a straight line from a food source to a series of organisms feeding on the source or other organisms feeding on the source. A food web shows how energy or, in this case, chemicals, may be transferred within an ecosystem. A food chain represents a potential COPEC exposure pathway. The importance of the exposure pathway depends on the receptor's dietary habits and the COPEC.

Food webs are organized by class guilds, which are linked together based on dietary relationships between them. Food webs are meant to illustrate how chemicals have the potential to be transferred within an ecosystem. The various food chains represent potential COPEC exposure pathways. The importance of a food chain as a dietary exposure pathway depends on receptor dietary habits. The boxes in the ecological CSM represent the expected feeding guilds in each of the ecosystems within the Resource Area. Feeding guilds are groups of organisms that exploit similar resources for food.

8.6 ASSESSMENT AND MEASUREMENT ENDPOINTS

To assess ecological risks, identification of potential assessment and measurement endpoints are presented as one of the problem formulation components. Assessment endpoints represent potentially significant ecological impacts and are selected based on ecosystems, communities, and species that are of particular concern at the site under study. For each assessment endpoint, one or more measurement endpoints are selected to integrate modeled or field data with the individual assessment endpoint. Measurement endpoints are measurable responses to a stressor that are related to the valued assessment

endpoint (Suter 1993). Table 8-2 presents assessment endpoints for each guild in terrestrial, aquatic, and riparian ecosystems and the associated assessment receptor.

8.6.1 Assessment Endpoints

Acceptance of assessment endpoints should depend on whether (1) the exposure pathway is complete, (2) the metal is bioavailable, and (3) the assessment endpoint is expected to be the most toxicological sensitive to metal exposure.

8.6.1.1 Assessment Endpoints for the Terrestrial Food Web Ecosystem

Using the terrestrial, habitat-specific food web, assessment endpoints may be selected to focus the risk analysis and characterization (see Figure 4 and Table 8-2). Herbaceous plant abundance, habitat, and productivity are attributes to be preserved in a terrestrial ecosystem. As food, herbaceous plants provide an important pathway for energy and nutrient transfer from soil to herbivorous and omnivorous receptors. Herbaceous plants also provide critically important habitat for terrestrial animals. Woody plant habitat and productivity are critical attributes to be protected. Herbivore productivity is an attribute to be protected in the terrestrial ecosystem, because herbivores incorporate energy and nutrients from plants and transfer it to higher trophic levels. Herbivores are integral to the success of terrestrial plants through dispersal of plant seeds.

Soil invertebrate productivity and function as decomposers are attributes to be preserved in a terrestrial ecosystem. They provide a mechanism for the physical breakdown of detritus for microbial decomposition, which is a vital function. Soil invertebrates function as a major source of food for omnivorous birds, mammals, and reptiles.

Omnivore productivity is an important attribute to be protected, because omnivores incorporate energy and nutrients from lower trophic levels and transfer it to higher-level omnivores and carnivores.

Based on knowledge of metal and metalloid toxicity, site-specific terrestrial assessment endpoints would include the following terrestrial guilds:

- Terrestrial plants
- Terrestrial invertebrates
- Terrestrial, herbivorous birds

- Terrestrial, herbivorous mammals
- Terrestrial, omnivorous birds
- Terrestrial, omnivorous mammals
- Reptiles
- Terrestrial, carnivorous mammals
- Terrestrial, carnivorous birds

Although some individual receptors have a greater exposure potential than others, each assessment endpoint is toxicologically sensitive to metals and is expected to have a complete exposure pathway.

Terrestrial Plants

Some terrestrial plants are highly effective at removing various metals from metal-contaminated soil. Some metals are not essential for plant growth, but in some plants they can cause toxicity, as exemplified by chlorosis, stunting, and yellowing of leaves. Plants that bioaccumulate metals may transform the metal into organic forms that becomes highly bioavailable when the plant is eaten or dies. Plant-consuming, terrestrial invertebrates; terrestrial, herbivorous birds and mammals; and terrestrial, omnivorous birds and mammals are potentially at risk. Terrestrial plants will not be directly assessed; however, protection of terrestrial plants will be afforded through protection of guilds that use this resource, as defined below.

Terrestrial Invertebrates

Terrestrial invertebrates include soil invertebrates, such as earthworms, and other invertebrates, such as various insects that feed directly on plants. These receptors are important in soil stabilization and are an important food source for omnivorous birds and mammals, thereby providing for the transfer of energy to higher trophic levels. Significant exposure is predicted for terrestrial insects that feed on plants. However, metals may not be directly toxic to terrestrial invertebrates, but consumers of these terrestrial invertebrates are highly susceptible to toxic effects of accumulated metals. For example, no selenium toxicity data exists for terrestrial invertebrates, and the toxic effects of directly consuming selenium-contaminated invertebrates are more important than any indirect, ecological effects. Omnivorous birds and mammals are most at risk from consuming terrestrial invertebrates. Terrestrial invertebrates will not be directly assessed; however, protection of terrestrial invertebrates will be afforded through protection of guilds that use this resource, as defined below.

Terrestrial, Herbivorous Birds and Associated Assessment Endpoints

Terrestrial, herbivorous birds are expected to be highly exposed to metals, based on their expected diet requirements and through incidental ingestion of metal-contaminated soil. As an example, selenium exposure in the diet of terrestrial herbivorous birds is associated with reproductive abnormalities, congenital malformations, selective bioaccumulation, and growth retardation. Terrestrial, herbivorous birds are a potential assessment endpoint as follows:

- Protection of terrestrial, herbivorous birds that may ingest contaminated plants and surface water and incidental ingestion of associated soil from potentially lethal, reproductive, systemic, or general toxic effects of metals resulting from phosphate mining activities

Assessment endpoints and associated receptors are presented in Table 8-2.

Terrestrial, Herbivorous Mammals and Associated Assessment Endpoints

Excessive metals in the herbivorous mammal's food source may cause systemic or general toxic effects. Terrestrial, herbivorous mammals are a potential assessment endpoint as follows:

- Protection of terrestrial, herbivorous mammals that may ingest contaminated plants and surface water and incidental ingestion of associated soil from potentially systemic or general toxic effects of metals resulting from phosphate mining activities

Assessment endpoints and associated receptors are presented in Table 8-2.

Terrestrial, Omnivorous Birds and Associated Assessment Endpoints

Terrestrial, omnivorous birds are expected to be highly exposed to metals based on their expected diet requirements (terrestrial plants and invertebrates) and through incidental ingestion of metals-contaminated soil. As an example, selenium exposure in the diet of terrestrial, omnivorous birds and incidental ingestion of associated soil is associated with reproductive abnormalities, congenital malformations, selective bioaccumulation, and growth retardation.

Terrestrial, omnivorous birds are a potential assessment endpoint as follows:

- Protection of terrestrial, omnivorous birds that may ingest contaminated food and surface water and associated soil or sediment from potentially lethal, mutagenic, reproductive, systemic, or general toxic effects of metals resulting from phosphate mining activities

Assessment endpoints and associated receptors are presented in Table 8-2.

Terrestrial, Omnivorous Mammals and Associated Assessment Endpoints

Excessive metals in the omnivorous mammal's food source may cause systemic or general toxic effects. As an example, there have been no well-documented cases of widespread selenosis reported for wild mammals, including terrestrial, omnivorous mammals, and selenium does not biomagnify at this level in the food chain. Terrestrial, omnivorous mammals are a potential assessment endpoint as follows:

- Protection of terrestrial omnivorous mammals that may ingest contaminated plants, prey, and surface water and incidental ingestion of associated soil and sediment from potentially systemic or general toxic effects of metals resulting from phosphate mining activities

Assessment endpoints and associated receptors are presented in Table 8-2.

Reptiles

Mortality in reptiles caused by metal intoxication has not been reported (Linder and Grillitsch 2000). Ambient levels of metals in free-ranging reptiles rarely have been reported in the literature. Food ingestion is the major cause of metal exposure in reptiles. Based on the available data, reptiles do not seem to biomagnify metals to the extent that would correspond to their trophic level (Linder and Grillitsch 2000). Reptiles will not be directly assessed because of the indication that this guild is not affected by the presence of excess metals, nor is an adequate database available for proper comparison in order to assess risk. It is assumed that protection of the terrestrial ecosystem for the other guilds will confer some protection for reptiles.

8.6.1.2 Assessment Endpoints for the Aquatic or Riparian Food Web Ecosystem

As in the terrestrial ecosystem, phytoplankton and aquatic macrophytes provide for the transfer of energy from sediments to herbivorous invertebrates, herbivorous birds and mammals, and omnivorous birds and

mammals. Benthic invertebrate productivity and function as a decomposer are attributes to be preserved in an aquatic ecosystem. They provide a mechanism for the physical breakdown of detritus for microbial decomposition, which is a vital function. Benthic invertebrates function as a major source of food for benthic-feeding fish, amphibians, and omnivorous birds. Omnivore productivity is an important attribute to be protected, because omnivores incorporate energy and nutrients from lower trophic levels and transfer it to higher-level omnivores and carnivores.

Based on knowledge of toxicity of various metals, site-specific aquatic or riparian assessment endpoints would include the following:

- Phytoplankton and aquatic macrophytes
- Zooplankton and benthic invertebrates
- Aquatic and riparian, herbivorous birds
- Aquatic and riparian, herbivorous mammals
- Benthic fish
- Aquatic and riparian, omnivorous birds
- Aquatic and riparian, omnivorous mammals
- Aquatic and riparian, piscivorous birds
- Aquatic and riparian, benthic-feeding birds
- Aquatic and riparian, omnivorous mammals
- Aquatic and riparian, carnivorous mammals
- Fish
- Amphibians

Although some individual receptors have a greater exposure potential than others, each assessment endpoint is toxicologically sensitive to various metals and is expected to have a complete exposure pathway.

Phytoplankton and Aquatic Macrophytes

Phytoplankton and aquatic macrophytes are highly effective at removing metals from metal-contaminated sediment. As an example, selenium is not essential for plant growth. Plants that bioaccumulate selenium transforms the selenium into organic forms that becomes highly bioavailable when the plant is eaten or dies. Plant-consuming benthic invertebrates, herbivorous birds and mammals, and terrestrial, omnivorous

birds and mammals are potentially at risk from metals contamination. Phytoplankton and aquatic macrophytes will not be directly assessed; however, protection of phytoplankton and aquatic macrophytes will be afforded through protection of guilds that use this resource, as defined below.

Zooplankton and Benthic Invertebrates

Significant exposure is predicted for zooplankton and benthic invertebrates. Invertebrates are an important source of protein for various fish and omnivorous and benthic-feeding birds. As an example of metal toxicity, selenium appears to affect the survival of zooplankton (rotifers and cladocerans) and benthic invertebrates (midge larvae) (Jarvinen and Ankley 1999), and consumers of these invertebrates are highly susceptible to toxic effects of accumulated selenium. Some selenium toxicity data exists for benthic invertebrates, and the toxic effects of directly consuming selenium-contaminated invertebrates are important. Amphibians, benthic-feeding fish, fish, and benthic-feeding birds are most at risk from metals toxicity from consuming benthic invertebrates. Zooplankton and benthic invertebrates will not be directly assessed; however, protection of zooplankton and benthic invertebrates will be afforded through protection of guilds that use this resource, as defined below.

Aquatic and Riparian, Herbivorous Birds and Associated Assessment Endpoints

Aquatic and riparian, herbivorous birds are expected to be highly exposed to metals, based on their expected diet requirements and through incidental ingestion of metal-contaminated sediment or soil. As an example, selenium exposure in the diet and drinking water of aquatic and riparian, herbivorous birds is associated with reproductive abnormalities, congenital malformations, selective bioaccumulation, and growth retardation. Aquatic and riparian, herbivorous birds are a potential assessment endpoint as follows:

- Protection of riparian, herbivorous birds that may ingest contaminated plant food and incidental ingestion of associated soil, sediment, and surface water from potentially lethal, reproductive, systemic, or general toxic effects of metals resulting from phosphate mining activities

Assessment endpoints and associated receptors are presented in Table 8-2.

Aquatic and Riparian, Herbivorous Mammals and Associated Assessment Endpoints

Excessive metals in the aquatic and riparian, herbivorous mammal's food source may cause systemic or general toxic effects. As an example, there have been no well-documented cases of widespread selenosis reported for wild mammals, and selenium does not biomagnify at this level in the food chain. Aquatic and riparian, herbivorous mammals are a potential assessment endpoint as follows:

- Protection of aquatic and riparian, herbivorous mammals that may ingest contaminated plant food and incidental ingestion of associated soil, sediment, or surface water from potentially systemic or general toxic effects of metals resulting from phosphate mining activities

Assessment endpoints and associated receptors are presented in Table 8-2.

Benthic Fish and Associated Assessment Endpoints

Protection of benthic fish is imperative, because aquatic and riparian, piscivorous birds; aquatic and riparian, benthic-feeding birds; aquatic and riparian, omnivorous mammals and birds; and amphibians feed on adult and young benthic fish. As an example, elevated selenium can cause reproductive failure in fish, resulting in reproductive failure, anemia, reduced hatch, reduced growth, reduced swimming rate, and chromosomal aberrations (Hodson and others 1980; Adams 1976; Bovee and O'Brien 1982; and Krishnaja and Rege 1982, as cited in Eisler 1985). Lemly (1993a and 1996a, as cited in Skorupa 1998) concluded that the most precise way to assess risk associated with exposure of fish to selenium was to measure selenium levels in gravid ovaries. Benthic fish are a potential assessment endpoint as follows:

- Protection of benthic fish from contaminated food and associated sediments form potentially lethal, mutagenic, reproductive, systemic, or general toxic effects of metals resulting from phosphate mining activities

Assessment endpoints and associated receptors are presented in Table 8-2.

Aquatic and Riparian, Omnivorous Birds and Associated Assessment Endpoints

Aquatic and riparian, omnivorous birds are expected to be highly exposed to metals, based on their expected diet requirements (aquatic and terrestrial plants and invertebrates) and through incidental ingestion of metal-contaminated soil, sediment, or water. As an example, selenium exposure in the diet

and drinking water of aquatic and riparian, omnivorous birds is associated with reproductive abnormalities, congenital malformations, selective bioaccumulation, and growth retardation. Aquatic and riparian, omnivorous birds are a potential assessment endpoint as follows:

- Protection of aquatic and riparian, omnivorous birds that may ingest contaminated food and associated soil, sediment, or water from potentially lethal, mutagenic, reproductive, systemic, or general toxic effects of metals resulting from phosphate mining activities

Assessment endpoints and associated receptors are presented in Table 8-2.

Aquatic and Riparian, Piscivorous Birds and Associated Assessment Endpoints

Aquatic and riparian, piscivorous birds are expected to be highly exposed to metals, based on their expected diet requirements (benthic fish and other fish species) and through incidental ingestion of metal-contaminated sediment or water. As an example, selenium exposure in the diet and drinking water of aquatic and riparian, piscivorous birds is associated with reproductive abnormalities, congenital malformations, selective bioaccumulation, and growth retardation. Aquatic and riparian, piscivorous birds are a potential assessment endpoint as follows:

- Protection of aquatic and riparian, piscivorous birds that may ingest contaminated food and associated sediment or water from potentially lethal, mutagenic, reproductive, systemic, or general toxic effects of metals resulting from phosphate mining activities

Assessment endpoints and associated receptors are presented in Table 8-2.

Aquatic and Riparian Benthic-Feeding Birds and Associated Assessment Endpoints

Aquatic and riparian benthic-feeding birds are expected to be highly exposed to metals based on their expected diet requirements (benthic invertebrates) and through incidental ingestion of metal-contaminated sediment or water. As an example, selenium exposure in the diet and drinking water of aquatic and riparian benthic-feeding birds is associated with reproductive abnormalities, congenital malformations, selective bioaccumulation, and growth retardation.

Aquatic and riparian benthic-feeding birds are a potential assessment endpoint as follows:

- Protection of aquatic and riparian benthic-feeding birds that may ingest contaminated food and associated sediment or water from potentially lethal, mutagenic, reproductive, systemic, or general toxic effects of metals resulting from phosphate mining activities

Assessment endpoints and associated receptors are presented in Table 8-2.

Aquatic and Riparian, Omnivorous Mammals and Associated Assessment Endpoints

Excessive metals in the omnivorous mammal's food source may cause systemic or general toxic effects. As an example, there have been no well-documented cases of widespread selenosis reported for wild mammals including aquatic and riparian, omnivorous mammals, and selenium does not magnify at this level in the food chain. Aquatic and riparian, omnivorous mammals are a potential assessment endpoint as follows:

- Protection of aquatic and riparian, omnivorous mammals that may ingest contaminated plant food and incidental ingestion of associated soil, sediment, or water from potentially systemic or general toxic effects of metals resulting from phosphate mining activities

Assessment endpoints and associated receptors are presented in Table 8-2.

Riparian, Carnivorous Mammals and Associated Assessment Endpoints

Excessive ingestion of metals by aquatic and riparian, carnivorous mammals may cause systemic or general toxic effects. Aquatic and riparian, carnivorous mammals are a potential assessment endpoint as follows:

- Protection of aquatic and riparian, carnivorous mammals that may ingest contaminated prey and incidental ingestion of associated soil, sediment, and water from potentially systemic or general toxic effects of metals resulting from phosphate mining activities

Assessment endpoints and associated receptors are presented in Table 8-2.

Fish and Associated Assessment Endpoints

Protection of fish is imperative because aquatic and riparian, piscivorous birds; benthic-feeding birds; aquatic and riparian, omnivorous mammals and birds; and amphibians feed on adult and young fish. As an example, elevated selenium can result in reproductive failure, anemia, reduced hatch, reduced growth, reduced swimming rate, and chromosomal aberrations (Hodson and others 1980; Adams 1976; Bovee and O'Brien 1982; and Krishnaja and Rege 1982, as cited Eisler 1985). Lemly (1993a and 1996a, as cited in Skorupa 1998) concluded that the most precise way to assess risk associated with exposure of fish to selenium was to measure the selenium levels in gravid ovaries. Fish are a potential assessment endpoint as follows:

- Protection of fish from contaminated food and associated sediments or water from potentially lethal, mutagenic, reproductive, systemic, or general toxic effects of metals resulting from phosphate mining activities

Assessment endpoints and associated receptors are presented in Table 8-2.

Amphibians

Amphibians may be an important source of food for riparian, omnivorous birds and mammals and riparian, carnivorous mammals. Little data exists on the toxicity of metals to amphibians (Sparling and others 2000). As an example of metal toxicity, Skorupa (1998) suggests that based on how similar the toxic threshold values are for fish and bird eggs, two other classes of egg-laying vertebrates, it is probably safe to assume the following for amphibians:

- Reproductive impairment is among the most sensitive response variables
- Populations producing eggs with equal to or greater than 10 mg/kg selenium are reproductively impaired

Amphibians will not be directly assessed because of the paucity of metal toxicity data; however, protection to amphibians will be afforded through protection of guilds that use this resource, as defined above.

Some overlap may occur between habitat requirements of the species listed for the aquatic/riparian ecosystem and the terrestrial ecosystem.

8.6.1.3 Assessment Endpoints for Tertiary Consumers

Carnivore productivity is an attribute to be protected, because these carnivores provide food to other carnivores, omnivores, scavengers, and microbial decomposers. In addition, carnivores affect abundance, reproduction, and recruitment of lower trophic levels, such as herbivores and omnivores, through predation.

Based on knowledge of the metal toxicity, site-specific, tertiary consumer endpoints would include the following:

- Carnivorous mammals
- Raptors

Although some individual receptors have a greater exposure potential than others, each assessment endpoint is toxicologically sensitive to metals and is expected to have a complete exposure pathway.

Carnivorous Mammals and Associated Assessment Endpoints

Excessive metals in the carnivorous mammal's food source may cause systemic or general toxic effects. However, there have been no well-documented cases of widespread selenosis reported for wild mammals, including carnivorous mammals, and selenium does not magnify at this level in the food chain. Carnivorous mammals are a potential assessment endpoint as follows:

- Protection of carnivorous mammals that may ingest contaminated prey and incidental ingestion of associated soil, sediment, or water from potentially systemic or general toxic effects of metals resulting from phosphate mining activities

Assessment endpoints and associated receptors are presented in Table 8-2.

Raptors and Associated Assessment Endpoints

Raptors are expected to be exposed to metals, based on their expected diet requirements and through incidental ingestion of contaminated soil, sediment, or water. As an example, selenium exposure in the diet and drinking water of raptors is associated with reproductive abnormalities, congenital

malformations, selective bioaccumulation, and growth retardation (Eisler 1985). Raptors are a potential assessment endpoint as follows:

- Protection of raptors that may ingest contaminated prey and associated soil, sediment, or water from potentially lethal, mutagenic, reproductive, systemic, or general toxic effects of metals resulting from phosphate mining activities

Assessment endpoints and associated receptors are presented in Table 8-2.

8.6.2 Measurement Endpoints

After assessment endpoints are identified for each guild, possible measurement endpoints can be determined. Measurement endpoints are measurable responses to a stressor that are related to the valued assessment endpoint (Suter 1993).

Multiple lines of evidence, which serve as measurement endpoints, have been considered for integration in order to determine ecological risk for the various identified guilds:

- Collect, analyze, and evaluate tissue residue data
- Compare concentrations of COPECs in tissues to levels reported in the scientific literature to be harmful
- Measurement of COPEC concentrations in selected food items
- Comparison of concentrations in food items to levels from areas not impacted by phosphate mining activities
- Model chemical levels in food items to calculate a potential dose and compare this dose to appropriate toxicity threshold values
- Evaluate differences in aquatic community structure between impacted and background areas
- Cutthroat trout toxicity studies

Table 8-3 presents the list of measurement endpoints used to assess each assessment endpoint receptor. The tissues of terrestrial plants; aquatic macrophytes; terrestrial invertebrates; benthic invertebrates; small, herbivorous and omnivorous mammals; and benthic and other fish have been collected and analyzed. Tissue residue data are a strong indicator of chemical bioavailability. These tissue concentrations then can be compared to similar literature concentration levels to determine if a potential risk exists to these respective guilds. In addition, these data can be used to model a daily dose ingested by higher-level mammals and birds.

The exposure dose will be compared to a TRV. TRVs are available for birds and mammals. Some uncertainties are associated with this measurement endpoint:

- The assumption that the chosen receptor adequately represents the guild of interest
- The assumption that food items chosen for tissue collection and analysis are those most commonly consumed by the receptor
- Possible difficulty in finding an adequate area free from phosphate mining activities for comparison
- The fact that TRVs are developed from laboratory data and may not be accurate surrogates for wildlife

There are adequate TRVs that can be used to assess risk to birds and mammals. Therefore, the use of tissue residue data to model doses to upper-trophic-level receptors will be used as a measurement endpoint for this AWERA.

TtEMI does not recommend any special studies, such as collection and analysis of bird eggs, because of the present ongoing study. TtEMI believes that the risk assessment can be completed by collection of appropriate tissues with subsequent analysis. These data provide a solid, site-specific assessment of risk, and can be used to evaluate risk for that trophic level, as well as to model risk to upper-trophic-level receptors.

8.7 ECOLOGICAL EFFECTS AND EXPOSURE ASSESSMENT

The total exposure from ingestion for each receptor of concern will be calculated as the sum of the dietary and soil, sediment, or surface water exposure estimates. The following generic equation will be customized for each terrestrial, aquatic, and riparian assessment endpoint:

$$\text{Dose}_{\text{Total}} = (\text{SUF})(\text{TTC})\frac{\left[(C_{\text{media}} \text{ x } IR_{\text{media}}) + (C_{\text{prey}})(IR_{\text{prey}})\right]}{BW}$$

where:

C_{meida} = Concentration of chemical in soil, sediment, or surface water (mg/kg, µg/kg, mg/L, or µg/L)

C_{prey} = $(C_{\text{media}})(\text{BTF})$

IR = Ingestion rate (the amount of prey items, water, sediment, and soil ingested per day)

BW	=	Body weight of receptor species
SUF	=	Site use factor to account for the amount of time that the organism spends using the site
TTC	=	Trophic transfer coefficient to account for the fraction of a chemical that is absorbed by the receptor from the consumed media

The resulting dose then is compared to a dose that serves as the TRV, and the ratio (presented as an HQ) is indicative of potential risks to ecological receptors.

For the AWERA, the same equation will be used to calculate an exposure dose for each assessment endpoint. A dose representing the most conservative exposure will be used for the Tier 1 assessment (see Table 8-4). For the Tier 2 assessment, a dose representing a site-specific exposure scenario will be calculated using mean exposure parameters, along with area-weighted EPCs of COPECs in soil, sediment, terrestrial or aquatic plant, terrestrial or aquatic invertebrates, fish, and small mammal tissues (see Table 8-5). One representative BTF for each trophic level will be calculated for the AWERA, using site-specific soil and tissue data. A trophic transfer coefficient of 1 will be used, because site-specific tissue data are being used.

The Tier 1 assessment will present a worst-case scenario (using conservative exposure parameters), and the Tier 2 assessment will present a more site-specific scenario (using mean exposure parameters), which then can be used in a risk management process to arrive at a risk value that can be applied to manage metals levels in appropriate media resulting from mining activities in the Resource Area.

8.7.1 Ecological Reference Values and Toxicity Reference Values

TRVs are screening-level, benchmark values for higher-trophic-level receptors such as birds and mammals. In general, a TRV is a dose level at which a particular biological effect may occur in an organism, based on laboratory toxicological investigations. For bird and mammal receptors, TRVs are compared to estimates of site-specific, daily chemical doses ingested from food and media in the HQ approach to model potential risk. Separate HQs will be calculated for TRVs, based on NOAEL values for comparison purposes. The proposed TRVs for both mammals and birds that will be used for this project are present in Table 8-6.

8.7.2 Allometric Conversions

In cases where the species representing the measurement endpoint was different from the species used to develop the TRV, dietary concentrations were converted to dose (that is, milligram of COPEC per kilogram of body weight per day) for comparison with estimated COPEC ingestion rates in receptor species. All TRVs were adjusted, based on the difference in body weights between the study organisms that the literature values were based upon and the body weight of the measurement endpoint receptor. For example, when toxicological data and dose levels were available for laboratory rats, but were needed for the deer mouse, an allometric conversion estimates a similar dose level for the deer mouse. The underlying assumption of allometric conversion is that a given effect on a species of small mammal is similar to the effect on a species of larger mammal, per unit of body weight, and vice versa.

The recommendation of Sample and Arenal (1999) will be followed for allometric conversions. Sample and Arenal (1999) investigated the allometric relationships for acute avian and mammalian toxicity data across a wide variety of chemicals to determine the applicability of existing allometric factors and to determine if allometric relationships differ between birds and mammals. A total of 194 chemicals for birds and 167 chemicals for mammals were reviewed. The range of chemicals included alkaloids, inorganics, organochlorines, and drugs. The mean, chemical-specific scaling factor determined was 1.20 and 0.94 for birds and mammals, respectively (Sample and Arenal 1999). These scaling factors will be expressed as follows:

For small mammals:

$$TRV_{receptor} = TRV_{test\ organism} (\text{Body weight}_{test\ organism} / \text{Body weight}_{receptor})^{1-0.94}$$

For birds:

$$TRV_{receptor} = TRV_{test\ organism} (\text{Body weight}_{test\ organism} / \text{Body weight}_{receptor})^{1-1.2}$$

8.7.3 Uncertainty Factors

Published methods for conducting ecological assessments differ in the way in which uncertainty is addressed, including the magnitude and type of UFs recommended (Opresko and others 1993; Suter 1993; and Calabrese and Baldwin 1993; as cited in Navy 1998). One method of accounting for the uncertainty inherent in the derivation of TRVs is to use UFs. UFs are values by which the TRV is divided to overlay

a level of conservatism to data that are, for one reason or another, incomplete. For example, uncertainty resulting from the lack of data on chronic exposure has been addressed traditionally by dividing the proposed TRV by a number, usually 10. Use of UFs is not expected at this time. However, should adjustments be required, they will be developed on a case-by-case basis, in consultation with the IDEQ.

9.0 DATA MANAGEMENT

The database that will be used to assess risk from phosphate mining activities will consist of the data collected as a result of this work plan for the preliminary HHRA and AWERA and other studies, as specified in Section 3.3. Because the data were collected from various areas and no one area has a large amount of data for a specific parameter, statistical analysis of the data probably will not be conducted. However, the database will be used to determine EPCs and BTFs from one media to the next.

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FIGURES

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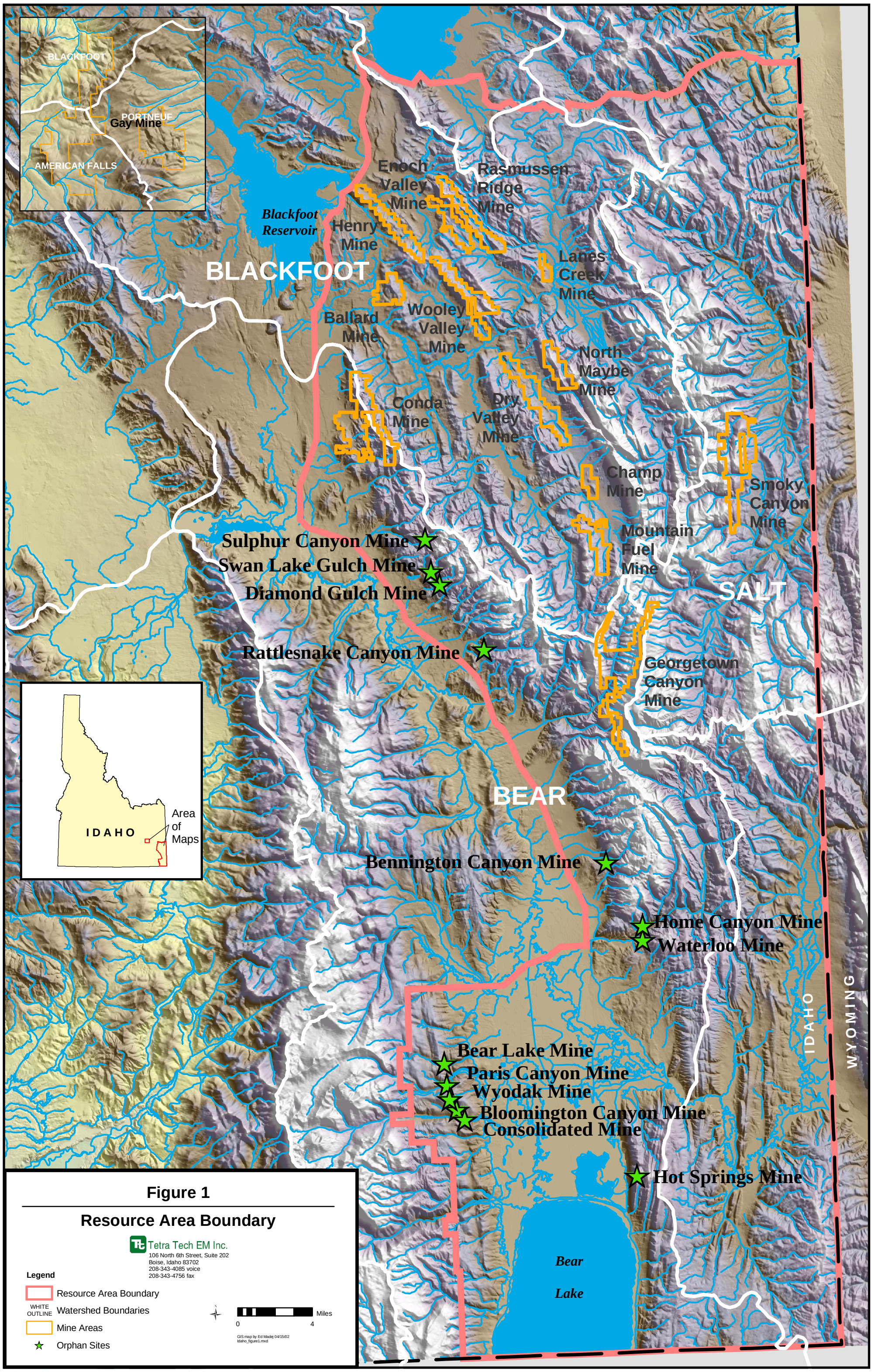

Figure 1

Resource Area Boundary

Tetra Tech EM Inc.
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Process

Tier 1

Purpose: Initial screening of all potentially complete exposure scenarios (see Figure 2 - Human Health Conceptual Site Model [CSM])

Data: Medium- specific 2001 analytical data (see Table 2-1)

EPCs: Maximum detected medium/scenario - specific concentrations

Exposure Parameters: Reasonable maximum exposure (RME) (Table 7-1)

Tier 2

Purpose: Area-wide assessment - risks and hazards characterized under both RME and central tendency exposure (CTE) conditions

Detail: *Category 2a* - Exposure pathways that extend (or could extend) beyond stream -, riparian area -, or mine-specific exposure areas, including ingestion of (1) fish, (2) wild game, (3) beef cattle, (4) aquatic and terrestrial plants, (5) tea brewed from aquatic and terrestrial plants, and (6) surface water
Category 2b - exposure pathways with stream -, riparian area -, and mine-specific exposure areas including (1) ingestion of home grown produce, (2) ingestion of surface soil, and (3) inhalation of fugitive dust

Data: 2001 analytical data only (see Table 2-1)

EPCs: For the fish ingestion exposure pathway, EPCs, will be calculated under both RME and CTE conditions as area-wide averages weighted by stream-specific productivity. For all other exposure pathways, EPCs will be calculated according to EPA (1992) -- RME - lesser of maximum and 95 UCL; CTE - mean

Exposure Parameters: RME (Table 7-1), CTE (Table 7-2)

Tier 3

Purpose: Watershed-specific evaluations of the (1) fish ingestion and (2) surface water ingestion exposure pathways based on historical data [Note: detailed stream-specific evaluations will be performed as necessary based on professional judgement]

Data: Historical and 2001 (see Table 2-1) analytical data sets

EPCs: Calculated for each data set per EPA (1992) as described in Tier 2

Exposure Parameters: RME (Table 7-1), CTE (Table 7-2)

Decision Points

Select medium-specific chemicals of potential concern (COPC) - see section 7.2.3

Identify exposure pathways associated with insignificant risks (<1E-06) and hazards (HI<1). Eliminate COPCs associated with risks less than 1E-07 and HI less than 0.1

Based on RME results only - exposure scenarios with insignificant risks (<1E-06) and hazards (HI<1) are not further evaluated

Notes:

Additional exposure, risks, and hazards due to background dietary and nutrient supplements will be factored into both exposure pathway - specific and total exposure results.

U.S. Environmental Protection Agency (EPA), 1992. "Supplemental Guidance to RAGS: Calculating the Concentration Term. "Office of Solid Waste and Emergency Response. Publication 9285.7-48I. May.

EPC - Exposure Point Concentration

SOUTHEAST IDAHO PHOSPHATE MINING RESOURCE AREA

FIGURE 2
TIERED APPROACH FOR THE AREA-WIDE HUMAN HEALTH RISK ASSESSMENT

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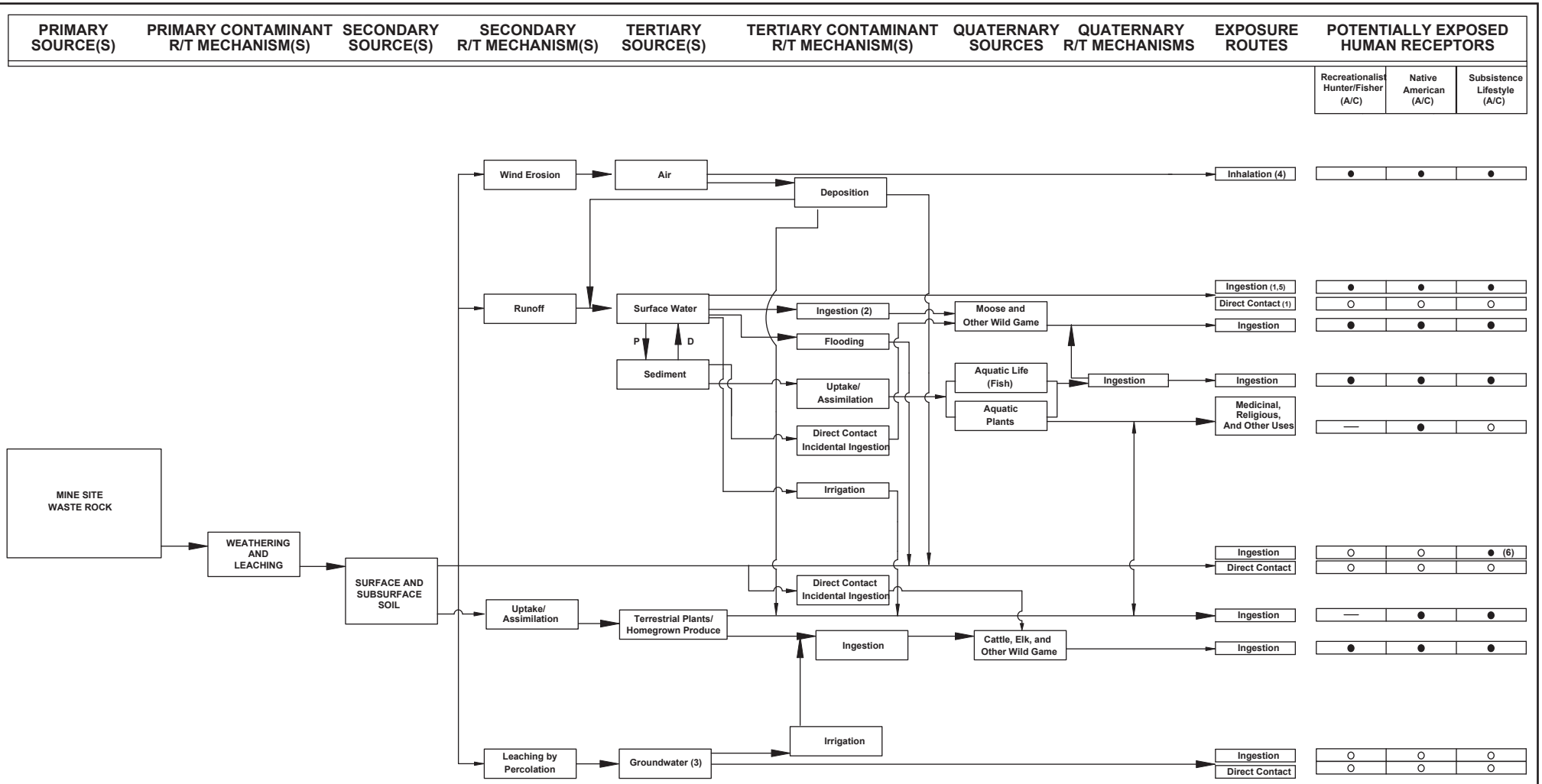


1 = Includes exposure to both surface water and sediment

2 = Includes ingestion of surface water by moose, elk, cattle, and other wild game

3 = Groundwater also may be hydraulically connected to surface water in the study area. However, this R/T mechanism is expected to be less significant than other R/T mechanisms and therefore is not shown in this figure.

4 = Includes exposure to fugitive dust from waste rock piles only

5 = Includes exposure to surface water during recreational activities (e.g. hunting, fishing, etc.) only

6 = Includes exposure to riparian area soil at the receptor's residence only

● = Potentially complete exposure pathways - considered quantitatively in the HHRA

○ = Potentially complete, but de minimus exposure pathway - considered qualitatively in the HHRA

— = Incomplete exposure pathway - not considered further in the HHRA

NOTES

A/C = Adult and Child Receptors

D = Dissolution

P = Precipitation

R/T = Release and Transport

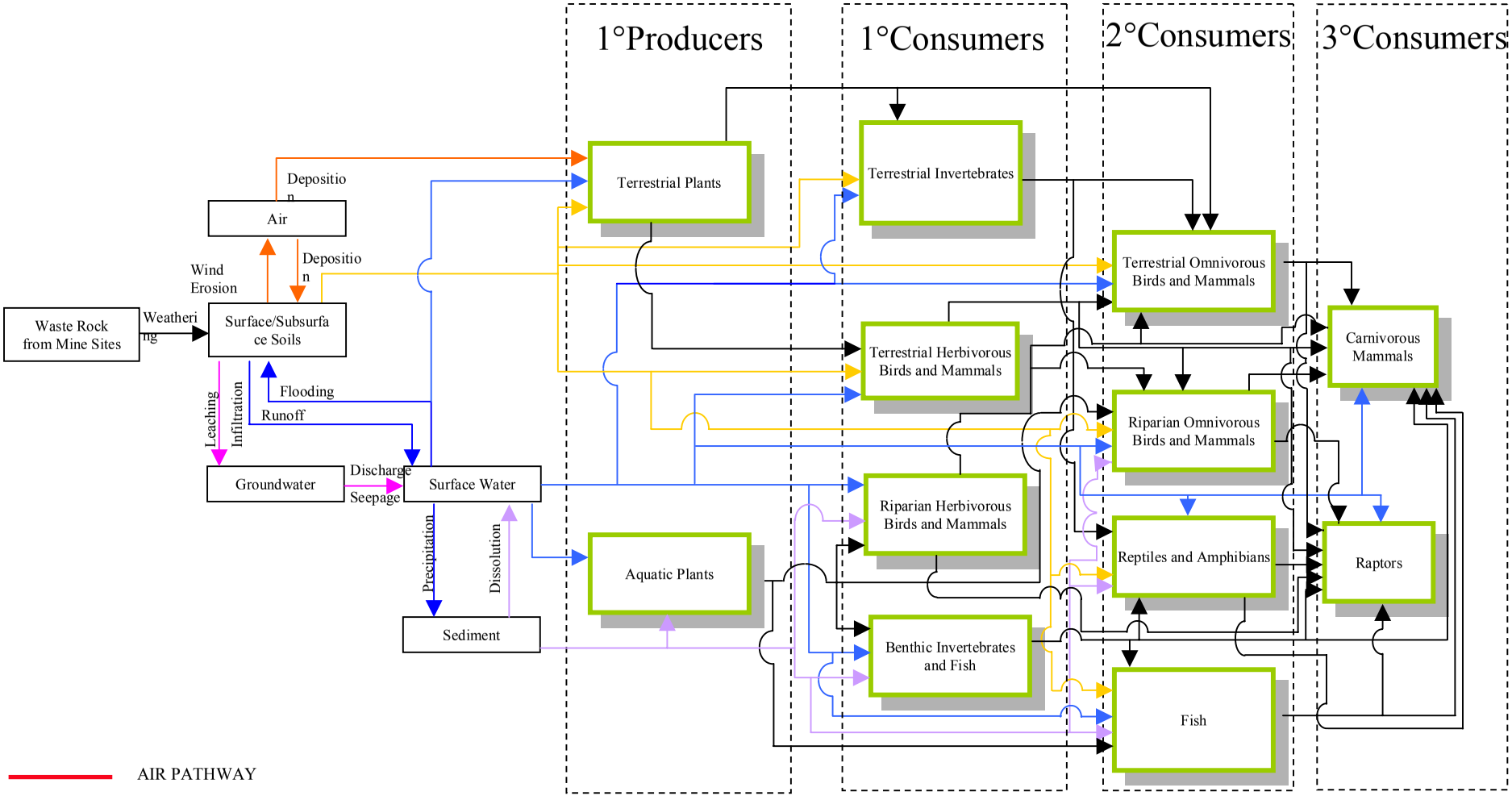
HHRA = Human Health Risk Assessment

SOUTHEAST IDAHO PHOSPHATE MINING RESOURCE AREA

FIGURE 3

CONCEPTUAL SITE MODEL AREA-WIDE HUMAN HEALTH RISK ASSESSMENT

Tetra Tech EM Inc.



AIR PATHWAY

GROUNDWATER PATHWAY

SURFACE WATER PATHWAY

SEDIMENT PATHWAY

FOOD INGESTION PATHWAY

SOIL PATHWAY

SOUTHEAST IDAHO PHOSPHATE
MINING RESOURCE AREA

FIGURE 4
CONCEPTUAL SITE MODEL
AREA WIDE ECOLOGICAL RISK ASSESSMENT

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1°Producers

Terrestrial Plants
- Blue joint grass – *Calamagrostis canodensis*
- Blue bunch wheat grass – *Agrophyron spicatum*
- Brome grass – *Bromus* species
- Idaho fescue – *Festuca idahoensis*
- Meadow milk vetch – *Astragalus diversitollus*
- Big sagebrush – *Artemisia tridentata*
- Antelope bitterbrush – *Purshia tridentata*
- Willow – *Salix* species
- Quaking aspen – *Populus tremuloides*
- Rabbitbrush – *Chrysthamnus viscidiflorus*
- Alfalfa - *Medicago sativa*
- Wheat grass – *Agrophyron* species
- Indian paintbrush – *Castelleja* species

Aquatic Plants (Semi-aquatic marsh plants are also listed below)
- Periphyton
- Common spike rush – *Eleocharis palustis*
- Bulrush – *Scirpus* species
- Elk sedge – *Carex geyeri*
- Needle spike rush – *Eleocharis aciculans*

1°Consumers

Terrestrial Invertebrates
- Grasshoppers
- Insect larvae
- Beetle larvae

Herbivorous Birds
- Chipping sparrow – *Spizella passerina*
- Northern bobwhite – *Colinus virginianus (surrogate)*
- House finch – *Carpodacus mexicanus*
- Grey partridge – *Perdix perdix*
- Morning dove – *Zenaida macroura*
- Cassin's finch – *Carpodacus cassinnii*
- Pine grosbeak – *Pinicola enucleator*
- White-winged crossbill – *Loxia leucoptera*

Terrestrial Herbivorous Mammals
- Black-tailed jackrabbit – *Lepus californicus*
- Eastern cottontail – *Sylvilagus floridanus (surrogate)*
- Elk – *Cervus elaphus*
- Moose – *Alces alces*
- Mule deer – *Odocoileus hemionus*
- Long-tailed vole – *Microtus longicaudus*
- Yellow-bellied marmot - *Marmota flaviventris*
- Least chipmunk – *Eutamias minimus*
- Richardson ground squirrel – *Spermophilus richardsoni*

Benthic Invertebrates
- Insect larvae
- Oligochaetes

Benthic Fish
- Common carp – *Cyprinus carpio*
- Bear Lake sculpin – *Cottus extensus*
- Longnose sucker – *Catostomus catostomus*
- Mountain sucker – *Catostomus platyrhynchus*
- White sucker – *Catostomus commersoni*

Domestic Livestock
- Cattle
- Horses
- Sheep

Highlighting denotes indicator species

2°Consumers

Terrestrial Omnivorous Birds
- American robin – Turdus migratorius
- Western meadowlark – *Sturnella neglecta*
- Sage mrouse – *Centrocercus urophasianus*
- Sage thrasher – *Oreoscoptes montanus*
- Sage sparrow – *Amphispiza belli*
- Loggerhead shrike – *Lanius ludovicianus*
- Long-billed curlew – *Numenius americanus*
- Black-billed magpie – *Pica pica*
- Northern oriole – *Icterus galbula*
- Ring necked pheasant – *Phasianus colchicus*
- Red-winged blackbird – *Agelaius phoeniceus*
- Gadwall duck – *Anas strepera*
- Mallard – *Anas platyrhynchas*
- Canada goose – *Branta canadensis*
- American coot – *Fulica americana*

Omnivorous Mammals
- Deer mouse – *Peromyscus maniculatus (Terrestrial)*
- Northern pocket gopher – *Thomomys talpoides*
- Great Basin pocket mouse – *Perognathus parvus*
- Townsend's ground squirrel – *Spermophilus townsendii*
- Wolverine – *Gulo gulo*
- Raccoon – *Procyon lotor (Aquatic and riparian)*
- Muskrat – *Ondatra zibethica*
- Striped skunk – *Mephitis mephitis*

Reptiles and Amphibians
- Western toad – *Bufo boreas*
- Leopard frog – *Rana pipens*
- Gopher snake – *Pituophis melanoleucus*
- Western garter snake – *Thamnophis elegans*

Fish
- Yellowstone cutthroat trout – *Onchorhynchus clarki bouvieri*
- Rainbow trout – *Onchorhynchus mykiss (surrogate)*
- Mountain whitefish – *Prosopium williamsoni*

Highlighting denotes indicator species

3°Consumers

Carnivorous Mammals
- Coyote – *Canis latrans*
- Bobcat – *Lynx rufus*
- Badger – *Taxidea taxus*
- Gray wolf – *Canis lupus*
- Black bear – *Ursus americanus*

Raptors
- Northern Harrier – *Circus cyaneus*
- American kestrel – *Falco sparverius*
- Peregrine falcon – *Falco peregrinus anatum*
- Red-tailed hawk – *Buteo jamaicensis*
- Golden eagle – *Aquila chrysaetos*

Highlighting denotes indicator species

FIGURE 4 (continued)
CONCEPTUAL SITE MODEL
AREA WIDE ECOLOGICAL RISK ASSESSMENT

Tetra Tech EM Inc.

FIGURE 5

HUMAN HEALTH EXPOSURE DOSE EQUATIONS
AREA WIDE HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENT WORK PLAN
SOUTHEAST IDAHO PHOSPHATE MINING RESOURCE AREA

AQUATIC AND TERRESTRIAL PLANTS (INCLUDING HOMEGROWN PRODUCE)

Ingestion

$$ADD_{(mg/kg-day)} = \frac{EPC_{ap/tp} \times IR_{ap/tp} \times EF \times ED \times CF1 \times FI_{pt}}{AT_{non}}$$

$$LADD_{(mg/kg-day)} = \frac{EPC_{ap/tp} \times IR_{ap/tp} \times EF \times ED \times CF1 \times FI_{pt}}{AT_{carc}}$$

Ingestion – Tea

$$ADD_{(mg/kg-day)} = \frac{EPC_{pt} \times IR_{pt} \times EF_{pt} \times ED \times FI_{pt}}{BW \times AT_{non}}$$

$$LADD_{(mg/kg-day)} = \frac{EPC_{pt} \times IR_{pt} \times EF_{pt} \times ED \times FI_{pt}}{BW \times AT_{carc}}$$

AQUATIC LIFE

$$ADD_{(mg/kg-day)} = \frac{EPC_{al} \times IR_{al} \times FI_{al} \times EF \times ED \times CF1}{BW \times AT_{non}}$$

Ingestion

$$LADD_{(mg/kg-day)} = \frac{EPC_{al} \times IR_{al} \times FI_{al} \times EF \times ED \times CF1}{BW \times AT_{carc}}$$

CATTLE

$$ADD_{(mg/kg-day)} = \frac{EPC_{c} \times IR_{c} \times FI_{c} \times EF \times ED \times CF1}{AT_{non}}$$

Ingestion

$$LADD_{(mg/kg-day)} = \frac{EPC_{c} \times IR_{c} \times FI_{c} \times EF \times ED \times CF1}{AT_{carc}}$$

FIGURE 5 (continued)

HUMAN HEALTH EXPOSURE DOSE EQUATIONS
AREA WIDE HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENT WORK PLAN
SOUTHEAST IDAHO PHOSPHATE MINING RESOURCE AREA

WILD GAME

$$ADD_{(mg/kg-day)} = \frac{EPC_{wg} \times IR_{wg} \times FI_{wg} \times EF \times ED \times CF}{AT_{non}}$$

$$LADD_{(mg/kg-day)} = \frac{EPC_{wg} \times IR_{wg} \times FI_{wg} \times EF \times ED \times CF}{AT_{carc}}$$

SOIL

$$ADD_{(mg/kg-day)} = \frac{EPCs \times IRs \times EF \times ED \times CF2}{BW \times AT_{non}}$$

$$LADD_{(mg/kg-day)} = \frac{EPCs \times IRs \times EF \times ED \times CF2}{BW \times AT_{carc}}$$

Notes:

ADD	Average daily dose
AT	Averaging time
BW	Body weight
CF	Conversion factor
ED	Exposure duration
EF	Exposure frequency
EPC	Exposure point concentration
FI	Fraction ingested
InR	Inhalation rate
IR	Ingestion rate
LADD	Lifetime average daily dose

TABLES

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TABLE 1-1

LIST OF AREA WIDE MINES AND OPERATORS, SOUTHEAST IDAHO
AREA WIDE HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENT WORK PLAN
SOUTHEAST IDAHO PHOSPHATE MINING RESOURCE AREA

Company	Mines	
	Active	Inactive
Astaris Production LLC	Dry Valley Mine	Gay Mine[1]
J.R. Simplot Company	Smoky Canyon Mine	Lanes Creek Mine Conda Mine Gay Mine[1]
Nu-West	Rasmussen Ridge Mine[2]	Mountain Fuel Mine Champ Mine North Maybe Canyon Mine South Maybe Canyon Mine[3] Georgetown Canyon Mine
P4 Production LLC[4]	Enoch Valley Mine	Henry Mine Ballard Mine
Rhodia Inc.		Wooley Valley Mine

Notes:

1 Gay Mine was leased by FMC Corporation and J.R. Simplot Company, individually and jointly.

2 Rasmussen Ridge Mine is leased by Nu-West Industries, Inc., an affiliated company of Nu-West Mining, Inc. (Nu-West).

3 South Maybe Canyon Mine is not included in the scope of the Selenium Project. It currently is being addressed under a consent order with Nu-West and the U.S. Forest Service.

4 P4 Production LLC is joint venture between Monsanto and Solutia, Inc.

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TABLE 2-1

MEDIUM-SPECIFIC SUMMARY OF SAMPLES CONSIDERED QUANTITATIVELY
AREA WIDE HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENT WORK PLAN
SOUTHEAST IDAHO PHOSPHATE MINING RESOURCE AREA

Stream or Stream-specific Riparian Area [1]	Fish Tissue		Plant Tissue				Soil[4]	Insect	Surface Water[2]		Sediment[2]	
			Aquatic		Terrestrial							
	TtEMI/ IDEQ [2]	USFWS [3]	TtEMI/ IDEQ [2]	MW [4]	TtEMI/ IDEQ [2]	MW [4]			TtEMI/ IDEQ [2]	MW [4]	TtEMI/ IDEQ [2]	MW [4]
Little Blackfoot River (I)	---	---	---	---	---	---	---	---	5	31	---	12
State Land Creek (I)	---	---	---	---	---	---	---	---	3	---	1	---
Trail Creek (I)	---	---	---	---	---	---	---	---	3	6	---	3
Goodheart Creek (I)	---	---	---	---	---	---	---	---	2	---	1	---
Wooley Valley Creek (I)	---	---	---	---	---	---	---	---	3	---	---	---
Blackfoot River (I)	---	---	---	---	3	---	3	---	11	40	3	11
Angus Creek (I)	---	---	---	---	---	---	---	---	2	---	---	1
Middle Angus Creek (I)	---	---	---	---	---	---	---	---	4	---	---	---
No Name Creek (I, B)	---	---	---	---	3	---	3	---	6	1	2	1
Rasmussen Creek (I)	---	---	---	---	2	---	2	---	3	4	---	2
Spring Creek (I, B)	4	---	4	---	---	---	---	2	8	---	3	---
East Mill Creek (I)	1	---	2	---	2	---	2	1	8	3	3	1
Smoky Creek (I, B)	---	---	---	---	---	---	---	---	6	6	1	3
South Fork Sage Creek (I)	---	---	---	---	---	---	---	---	4	3	1	2
Sage Creek (I, B)	1	---	3	---	---	---	---	1	10	8	3	4
Deer Creek (I)	---	---	---	---	---	---	---	---	3	1	1	1
Montpelier Creek (I, B)	---	---	---	---	---	---	---	---	6	---	2	---
Georgetown Creek (I)	---	---	---	---	---	---	---	---	3	5	1	3
Caldwell Creek (B)	---	---	---	---	---	---	---	---	4	8	1	3
Slug Creek (B)	---	---	---	---	---	---	---	---	3	6	1	3
Diamond Creek (B)	---	---	---	---	1	---	1	---	3	4	1	2
Sheep Creek (B)	---	---	---	---	---	---	---	---	3	6	1	3

TABLE 2-1 (continued)

MEDIUM-SPECIFIC SUMMARY OF SAMPLES CONSIDERED QUANTITATIVELY
AREA WIDE HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENT WORK PLAN
SOUTHEAST IDAHO PHOSPHATE MINING RESOURCE AREA

Stream or Stream-specific Riparian Area [1]	Fish Tissue		Plant Tissue					Insect	Surface Water[2]			
			Aquatic		Terrestrial							
	IDEQ [2]	USFWS	TtEMI/ IDEQ [2]	[4]	IDEQ [2]	MW [4]			TtEMI/	MW [4]	TtEMI/ IDEQ [2]	MW [4]
Crow Creek (B)	---	---	---	---	---	---	---	---	3	---	1	---
Maybe Creek (I)	---	---	---	---	---	---	---	1	1	---	1	---
Kendall Creek (B)	1	---	1	---	---	---	---	1	1	---	1	---
Grizzly Creek (B)	---	---	---	---	---	---	---	---	---	2	---	1
Dry Valley Creek (I)	---	---	---	---	---	---	---	---	---	10	---	1
Lanes Creek (I)	---	---	---	---	---	---	---	---	---	4	---	2
Formation Creek (B)	---	---	---	---	---	---	---	---	---	2	---	---
Right Hand Fork Creek (I)	---	---	---	---	---	---	---	---	---	9	---	3
Portneuf River (I, B)	---	---	---	---	---	---	---	---	---	8	---	2
Ross Fork River (I, B)	---	---	---	---	---	---	---	---	---	4	---	2
Lincoln Creek (I, B)	---	---	---	---	---	---	---	---	---	4	---	2

Notes:

1 The streams and stream-specific riparian areas are organized according to the watershed that the portion of each stream sampled falls into.

2 TtEMI. 2001d. "Tetra Tech and IDEQ Spring/Summer/Fall Sampling Plan." Prepared for IDEQ.

3 USFWS. Date unknown. "Fish Tissue Results for the Study Area."

4 TtEMI. 2001e. "Sampling Plan for MW Spring/Summer Sampling." Prepared for IDEQ.

B Background
I Impacted
IDEQ Idaho Department of Environmental Quality
MW Montgomery Watson
TtEMI Tetra Tech EM Inc.
USFWS U.S. Fish and Wildlife Service

TABLE 2-2

LIST OF METALS ANALYZED AND DETECTION LIMITS FOR SURFACE WATER, SEDIMENT, SOIL, AND TISSUE SAMPLES AREA WIDE HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENT WORK PLAN SOUTHEAST IDAHO PHOSPHATE MINING RESOURCE AREA

ANALYTE	SURFACE WATER (µg/L)	SEDIMENT (µg/g)	SOIL (µg/g)	INSECT TISSUE (µg/g)	PLANT TISSUE (µg/g)	FISH TISSUE (µg/g)
Aluminum	0.050-50.0	2-20	NA	0.26-24.8	0.43 – 3.2	0.94 – 1.3
Antimony	0.20-2.50	0.04- 1.6	1.6	0.04-3.6	0.01 – 1.4	0.14 – 0.19
Arsenic	0.50-1.00	0.075 - 0.5	0.5	0.05-5	0.03 – 1.1	0.19 – 0.27
Barium	3-10	0.019 - 0.3	0.18	0.08-7.4	0.11 – 0.82	0.41 – 0.58
Beryllium	0.10-5	0.019 - 0.08	0.08	0.01-0.6	0.004 – 1	0.02- 0.03
Boron	10-25	1 - 2	2	0.07-6.2	0.12 – 1.3	0.23 – 0.33
Cadmium	0.10-0.20	0.02 - 0.2	0.2	0.01-0.6	0.005 – 0.12	0.02 – 0.03
Calcium	20-200	NA	NA	3.7-351	4.6 – 34.7	13.4 – 18.7
Chromium	0.10-0.50	0.075 – 1	0.18	0.04-1.2	0.005 – 0.24	0.16 – 0.22
Cobalt	NA	NA	NA	0.03-3	0.04 – 0.44	0.11 – 0.16
Copper	0.13-50	0.28 – 1	0.28	0.04-3.8	0.06 – 10	0.71-1.0
Iron	10	NA	NA	0.46-43.4	1.1 – 11.2	1.6-2.3
Lead	0.10-0.25	0.02 - 1.5	1.5	0.03-3	0.005 – 3	0.11-0.16
Magnesium	5-200	NA	NA	2.8-259	4.1 – 42	9.8-13.8
Manganese	2-5	0.1 – 2.2	0.1	0.03-2.4	0.04 – 3	0.09-0.013
Mercury	0.0002-0.50	0.0042-0.075	0.0042	0.01-0.02	0.01 – 8	0.28-0.44
Molybdenum	0.10-2.50	1 - 3.8	3.8	0.03-2.6	0.005 – 0.48	0.1-0.14
Nickel	0.13-0.40	0.04 - 0.5	0.5	0.03-2.8	0.12 –5	0.11-0.15
Potassium	300-500	NA	NA	3.7-345	NA	NA
Selenium	1-50	0.04 – 5	0.04	0.05-4.6	0.04 – 0.95	0.17-0.25
Silver	0.05-0.25	0.01 - 0.2	0.2	0.03-3.2	0.06 – 0.63	0.12-0.64
Sodium	300-2000	100	100	7.6-711	11.7 –120	26.9-37.9
Thallium	0.05-2.50	0.01 - 2	2	0.05-4.6	0.003 – 1.1	0.17-0.25
Uranium	0.05-0.10	0.01 - 2	2	NA	0.003 – 0.8	NA
Vanadium	0.05-1.00	0.16 – 3.1	0.16	0.04-3.6	0.04 – 1	0.42-0.6
Zinc	10-50	0.14 - 1	0.14	0.03-2.8	0.11 – 10	0.15-0.21

Note:

µg/L Microgram per liter
µg/g Microgram per gram

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TABLE 3-1

DATA QUALITY OBJECTIVES
AREA WIDE HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENT WORK PLAN
SOUTHEAST IDAHO PHOSPHATE MINING RESOURCE AREA

STEP 1	STEP 2	STEP 3	STEP 4	STEP 5	STEP 6	STEP 7
State the Problem	Identify the Decision	Identify the Inputs to the Decision	Define Study Boundaries	Develop Decision Rules	Specify Tolerable Limits on Errors	Optimize Sampling Design
Uncertainty exists in the choice of COPCs because of the inconclusiveness of the screening process for the preliminary HHRA and the ERA (MW 1999b). Unknown levels of uncertainty exist in the dose calculations modeled in the ERA conducted by MW (1999b) because of the paucity of site-specific biotransfer factors. Uncertainty also exists in the exposures calculated in the preliminary HHRA because of the limited amounts and locations of medium-specific sampling results considered in the preliminary HHRA. Calculated human health and ecological risk estimates were somewhat conservative because of the use of default and maximum values for exposure parameters, in some instances. Because of the uncertainty associated with the ERA dose calculations and the additional uncertainty associated with medium-specific exposures (or lack thereof) calculated for the preliminary HHRA, the IDEQ does not know at what concentrations chemicals in surface soils, sediments, surface water, and various biological tissues (for example, fish, beef cattle, and plants) pose a risk. Uncertainty in the preliminary HHRA associated with identification of potentially significant, receptor-specific carcinogenic risks and noncarcinogenic hazards to particular receptor groups, include receptors living subsistence lifestyles and Native Americans, particularly members of the Shoshone-Bannock Indian tribe, living in the Resource Area. Both the preliminary HHRA and the ERA are based on medium-specific data collected from a limited number of locations in the Resource Area. Therefore, the risks and hazards to human and ecological receptors in specific portions of the Resource Area are unknown at this time.	Do soil, sediment, surface water, and tissue concentrations, when used as inputs in a model to determine a daily dose and screened against community or guild-specific TRVs, indicate risk to potential ecological receptors? Do soil, sediment, surface water, and tissue concentrations, when used as inputs in a model to determine exposure scenarios and screened against human health benchmarks, indicate risk to potential subsistence groups or other sensitive populations in the Resource Area?	Analytical results for the following tissue types are now being and were previously collected at both investigative and background locations: aquatic plants, benthic invertebrates, fish, terrestrial plants, terrestrial invertebrates, and small mammals. Analytical results for the following media are now being and were previously collected at both investigative and background locations: soil, waste rock, surface water, and sediments. Analytical results from previous on-going studies: - Beef depuration studies. - Elk studies - Studies on cadmium and selenium levels in bird eggs - Sheep studies - USGS biota studies for Spring and Fall 2000 and Spring 2001 FS greenhouse studies on selenium uptake for about 200 species of terrestrial plants	The Resource Area ranges from Gray's Lake in the north, to Bear Lake in the south, Highways 30/34 to the west and the Wyoming border to the east, and incorporates the area of Gay Mine on Fort Hall Indian Reservation by reference. This approximate 2,500 square mile area was defined by IDEQ to be inclusive of the 15 major mine sites owned or operated by the IMA Selenium Committee members and subject to subsequent site-specific investigations, and 14 minor historic phosphate mine sites referred to as orphan sites and subject to future regulatory screening efforts. The Resource Area includes parts of the Ross Fork, Portneuf, Blackfoot, Bear, and Salt River watersheds. Sampling locations for soils, sediments, surface water, and tissue samples were chosen to coincide with mine areas and areas affected by mine runoff (referred to as investigative samples). Samples also were collected from locations unaffected by mine-related activities (referred to as background locations).	If biological tissue sample data and ecological dose estimate results exceed TRVs, and human health exposures indicate potentially unacceptable risks and hazards (defined as risks greater than or equal to 1E-06 and hazards greater than or equal to 1), then the respective sampling locations, representing various media (surface water, soil, and sediments), will be considered contaminated and human health and ecological receptors are potentially at risk. Supplemental lines of evidence will be included in the AWERA as part of an overall weight-of-evidence approach. Supplemental lines of evidence may include, but are not limited to, the following: - Community structure - Information from the rapid bioassessment process - U.S. Army Corps of Engineers database for fish tissue The AWHHRA will be completed following a tiered approach and is intended to represent individual-level risks. The tiered approach is presented in Figure 7-1. Each tier may be considered a type of decision rule – the collective purpose of the three tiers is to determine whether or not human receptors face significant risks and hazards and, if so, those chemicals and exposure pathways driving these risks and hazards. Tier 1 is a screening step and will consist of an RME approach with emphasis on "reasonable" using maximum detected, medium-specific concentrations applicable to the potentially complete exposure identified in the human health CSM. Tier 2 represents an area wide assessment for exposure scenarios associated with risks greater than or equal to 1E-06 and hazards greater than or equal to 1. Exposures,	No tolerable decision error rates were set for the sampling design because of the judgmental component of the sampling approach. Specifications of tolerable limits on decision errors through the use of standard statistical methods are not applicable for these parameters.	Design optimization through the use of standard statistical methods is not applicable to this study. A diverse and extensive array of inputs (Step 3) has been used to optimize the procedure for collection of collocated surface water, soil, sediment, and tissue data. The data generated by implementation of this plan are intended to refine the assessment of risk to human health and ecological receptors and to define levels of risk for each media (surface water, sediment, soil, and biological tissues). All previous soil, waste rock, sediment, and surface water sampling analytical data were examined and mapped. The distribution of contamination was examined and tissue sampling and collocated soil and sediment locations were assigned in areas where a range of exposure concentrations would be obtained or there was a lack of sufficient data. Tissue sampling locations also were chosen based on the occurrence of suitable habitat for the human health and ecological receptor(s) of interest. Background locations were selected to represent typical area wide conditions, approximate pre-mining conditions for observed impacted areas, and to support numerical and qualitative screening approaches for background comparisons.

TABLE 3-1 (continued)

DATA QUALITY OBJECTIVES
AREA WIDE HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENT WORK PLAN
SOUTHEAST IDAHO PHOSPHATE MINING RESOURCE AREA

STEP 1	STEP 2	STEP 3	STEP 4	STEP 5	STEP 6	STEP 7
State the Problem	Identify the Decision	Identify the Inputs to the Decision	Define Study Boundaries	Develop Decision Rules	Specify Tolerable Limits on Errors	Optimize Sampling Design
				hazards, and risks are calculated under both RME and CTE conditions on a watershed- or stream-, riparian area-, or mine-specific exposure area basis; exposure point concentrations considered under Tier 2 are the lesser of the maximum and 95 UCL (RME) and the mean (CTE). Tier 3 will evaluate will evaluate risks and hazards for localized conditions on a stream-specific basis for exposure pathways evaluated on a watershed-specific basis under Tier 2 (ingestion of fish and aquatic and terrestrial plant-related exposure pathways). Risks to human receptors in the Resource Area will be evaluated by regulatory risk managers considering the results from all three tiers.		

Notes:

95 UCL	95 Percent upper confidence limit
AWERA	Area wide ecological risk assessment
AWHHRA	Area wide human health risk assessment
BTF	Biotransfer factor
COPC	Chemical of potential concern
CSM	Conceptual site model
CTE	Central tendency exposure
ERA	Ecological risk assessment
FS	U.S. Forest Service
HHRA	Human health risk assessment
IDEQ	Idaho Department of Environmental Quality
MW	Montgomery Watson
RME	Reasonable maximum exposure
TRV	Toxicity reference value
USGS	U.S. Geological Survey

TABLE 7-1

HUMAN HEALTH EXPOSURE PARAMETER VALUES
REASONABLE MAXIMUM EXPOSURE SCENARIO
AREA WIDE HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENT WORK PLAN
SOUTHEAST IDAHO PHOSPHATE MINING RESOURCE AREA

Parameter	Recreational Hunter/Fisher		Native American		Subsistence Lifestyle		Notes
	Adult	Child	Adult	Child	Adult	Child	
Exposure Point Concentration in Aquatic and Terrestrial Plants (EPC_{ap}/EPC_{tp}) (mg/kg)	NA	NA	Tier-specific	Tier-specific	Tier-specific	Tier-specific	1
Exposure Point Concentration in Aquatic Life (EPC_{al}) (mg/kg)	Tier-specific	Tier-specific	Tier-specific	Tier-specific	Tier-specific	Tier-specific	2
Exposure Point Concentration in Surface Water (EPC_{SW}) (µg/L)	Tier-specific	Tier-specific	Tier-specific	Tier-specific	Tier-specific	Tier-specific	2
Exposure Point Concentration in Cattle and Wild Game - Skeletal Muscle and Offal (EPC_{cwg}) (mg/kg)	Tier-specific	Tier-specific	Tier-specific	Tier-specific	Tier-specific	Tier-specific	3
Exposure Point Concentration in Plant-based Tea (EPC_{pt}) (mg/L)	NA	NA	Tier-specific	Tier-specific	NA	NA	4
Exposure Point Concentration in Soil (EPC_s) (mg/kg)	NA	NA	NA	NA	Tier-specific	Tier-specific	5
Terrestrial Plant Ingestion Rate (IR_{tp}) (kg[DW]/kg-day)	NA	NA	Plant-specific	Plant-specific	Plant-specific	Plant-specific	6,7
Aquatic Plant Ingestion Rate (IR_{ap}) (kg[DW]/kg-day)	NA	NA	Plant-specific	Plant-specific	NA	NA	6
Plant-Based Tea Ingestion Rate (IR_{pt}) (L/day)	NA	NA	0.288	0.034	NA	NA	8
Cattle Ingestion Rate - Skeletal Muscle (IR_{sm}) (g/kg-day)	2.02	3.73	2.46	4.54	2.02	3.73	9
Cattle Ingestion Rate - Offal (IR_o) (g/kg-day)	0.089	0.42	0.25	0.45	0.089	0.42	10
Aquatic Life Ingestion Rate (IR_{al}) (g/day)	25	9	37.5	13.5	170	61.2	11
Surface Water Ingestion Rate (IR_{SW}) (L/day)	2.35	1.5	2.35	1.5	2.35	1.5	12
Soil Ingestion Rate (IR_s) (mg/day)	NA	NA	NA	NA	100	200	13
Fraction Plant Ingested (FI_{pt}) (unitless)	NA	NA	0.25	0.25	0.75	0.75	14
Fraction Cattle Ingested (FI) (unitless)	0.157	0.157	0.157	0.157	0.157	0.157	15
Fraction Aquatic Life Ingested (FI_{al}) (unitless)	Stream- and watershed-specific	Stream- and watershed-specific	Stream- and watershed-specific	Stream- and watershed-specific	Stream- and watershed-specific	Stream- and watershed-specific	16
Fraction Soil Ingested (FI_s) (unitless)	NA	NA	NA	NA	1	1	17
Wild Game Ingestion Rate - Skeletal Muscle (IR_{wg}) (g/kg-day)	0.026	0.0378	0.0024	0.0035	0.026	0.0378	18
Wild Game Ingestion Rate - Offal (IR_{wgo}) (g/kg-day)	0.001	0.004	0.00024	0.00035	0.001	0.004	19
Fraction Wild Game Ingestion (FI_{wg}) (unitless)	0.29	0.29	0.29	0.29	0.58	0.58	20
Inhalation Rate (InR) (m^3/hr)	1.0	1.0	1.0	1.0	1.0	1.0	21
Exposure Frequency Plant-based Tea (EF_{pt}) (days/year)	NA	NA	91	91	NA	NA	22

TABLE 7-1 (continued)

HUMAN HEALTH EXPOSURE PARAMETER VALUES
REASONABLE MAXIMUM EXPOSURE SCENARIO
AREA WIDE HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENT WORK PLAN
SOUTHEAST IDAHO PHOSPHATE MINING RESOURCE AREA

Parameter	Recreational Hunter/Fisher		Native American		Subsistence Lifestyle		Notes
	Adult	Child	Adult	Child	Adult	Child	
Exposure Frequency - Particulates ($EF_{P,SW}$) (days/year)	6	6	6	6	17	17	23
Exposure Frequency (EF) (days/year)	365	365	365	365	365 (350)	365 (350)	22
Exposure Duration (ED) (years)	30 (24)	6	30 (24)	6	30 (24)	6	25
Exposure Time (ET) (hours/day)	4	4	4	4	4	4	26
Conversion Factor1 (CF1) (kg/g)	0.001	0.001	0.001	0.001	0.001	0.001	--
Conversion Factor 2 (CF2) (kg/mg)	NA	NA	NA	NA	1E-06	1E-06	--
Body Weight (BW) (kg)	70	15	70	15	70	15	--
Averaging Time for Noncarcinogens (AT_{non}) (days)	10,950	2,190	10,950	2,190	10,950	2,190	27
Averaging Time for Carcinogens (AT_{carc}) (days)	25,550	25,550	25,550	25,550	25,550	25,550	27

Notes:

1 The only aquatic plant evaluated in the AWHHRA is the water cress (*Nasturium officinale*). The EPC of each COPC in water cress will be calculated from the analytical results from water cress samples collected in the Resource Area. Under Tier 1, the MDC of each COPC will be used as the EPC. Under Tier 2, EPCs will be calculated on a watershed-specific basis if sufficient samples were collected (if not, the EPC will be calculated based on all available water cress samples), based on procedures recommended in EPA's guidance titled, Calculating the Concentration Term (1992). Under Tier 3, the EPC will be calculated on a stream-specific basis, following the same guidance used under Tier 2.

COPC-specific EPCs in terrestrial plants will be calculated, following procedures recommended in EPA's Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilities (1998b). Terrestrial plants are divided into three categories for consideration in the AWHHRA: (1) exposed aboveground produce, (2) protected aboveground produce, and (3) belowground produce. Equations used to calculated EPCs are presented below:

EXPOSED AND PROTECTED ABOVEGROUND PRODUCE

$$Pr = Cs \times Br_{ag}$$

TABLE 7-1 (continued)

HUMAN HEALTH EXPOSURE PARAMETER VALUES
REASONABLE MAXIMUM EXPOSURE SCENARIO
AREA WIDE HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENT WORK PLAN
SOUTHEAST IDAHO PHOSPHATE MINING RESOURCE AREA

BELOWGROUND PRODUCE

$Pr = Cs \times Br_{bg}$

where:

Pr	=	Concentration of COPC in produce from root uptake (mg/kg)
Cs	=	Average soil concentration over exposure duration (mg COPC/kg soil) (calculated as 95 UCL consistent with EPA [1992])
Br_{ag}	=	Plant-soil bioconcentration factor for aboveground produce (unitless) (Baes and others 1984)
Br_{bg}	=	Plant-soil bioconcentration factor for belowground produce (unitless) (Baes and others 1984)

Under Tier 1, the MDC of each COPC in soil will be used as the Cs value. Under Tier 2, EPCs for homegrown produce will be calculated on a stream-specific basis, according to procedures recommended in EPA's guidance titled, Calculating the Concentration Term (1992).

2 Under Tier 1, EPCs in aquatic life will be calculated as the MDC of each COPC from analytical results for fish fillet samples collected from streams in the Resource Area. Under Tier 2, EPCs will be calculated as a weighted average based on stream-specific productivity for each watershed for which fish fillet samples have been collected. Under Tier 3, EPCs will be calculated on a on a stream-specific basis, according to procedures recommended in EPA's Calculating the Concentration Term (1992). Also see Section 7.1.2.

Under Tier 1, EPCs for surface water will be calculated as the MDC for surface water samples collected from streams in the Resource Area. Under Tier 2, EPCs will be calculated on a stream-specific basis, according to EPA's guidance titled, Calculating the Concentration Term (1992).

3 EPCs in cattle (beef skeletal muscle and liver) and wild game (elk skeletal muscle and liver) grazed or living in the Resource Area will be calculated based on the tissue-specific analytical results presented in the 1999 Interim Investigation Data Report (MW 2000). Under Tier 1, the MDC of each COPC will be used as the EPC. Under Tier 2, COPC-specific EPCs will be calculated in accordance with EPA-recommended procedures (EPA 1992). Beef skeletal muscle and liver values used to calculate EPCs are from tissue samples that have undergone depuration. Also see Section 7.1.2.

4 EPCs for plants used by Native American populations to make tea (silver sage and red willow) will be calculated based on plant-specific tissue sample analytical results or COPC-specific soil concentrations using soil-plant bioconcentration factors, as described in footnote 1 for aboveground plants. More specifically, Under Tier 1, the greater of the MDC of each COPC in plant tissues or the plant tissue concentration estimated based on the soil MDC will be used as the EPC. Under Tier 2, EPCs will be calculated on a watershed-specific basis if sufficient samples were collected (if not, the EPC will be calculated based on all available silver sage and red willow samples), based on procedures recommended in EPA's guidance titled, Calculating the Concentration Term (1992). Under Tier 3, the EPC will be calculated on a stream-specific basis, following the same guidance used under Tier 2. For streams without silver sage or red willow samples, plant tissue EPCs will be based on COPC-specific soil concentrations calculated in accordance with EPA's Calculating the Concentration Term (1992).

TABLE 7-1 (continued)

HUMAN HEALTH EXPOSURE PARAMETER VALUES
REASONABLE MAXIMUM EXPOSURE SCENARIO
AREA WIDE HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENT WORK PLAN
SOUTHEAST IDAHO PHOSPHATE MINING RESOURCE AREA

The EPCs in plant-based teas will be calculated based on plant tissue EPCs calculated in the manner described above, using the following methodology. No direct information is available regarding the metal content of infusions ("teas") produced from native plants of southeastern Idaho. Several general studies of foodstuffs, such as Ministry of Agriculture, Food, and Fisheries (MAFF) (1998) and the Federal Drug Administration (2001) give some information on the intake of metals from beverages, including teas. However, while providing data on the concentration of metals in infusions, neither study provides data on the concentration of metals in the dry tea. Therefore, estimates of the transfer of metals from dry tea into the infusion cannot be made.

However, evidence exists that infusions made from tea (*Camellia sinensis*), known to take up aluminum, contain elevated levels of aluminum, particularly compared with other beverages (MAFF 1998). Therefore, while data are scarce, it is reasonable to assume that a fraction of the metals present in plant material will be transferred into an infusion made from that material. The primary mechanism for the uptake of metals in soil by plants is diffusion (sometimes modified by chelation, precipitation, and other processes). As a first approximation, the plant-soil bioconcentration factor for forage (Br_{forage}), as defined in EPA (1998a) will be used to estimate the fraction of metals in plant material that is dissolved in an infusion.

A review of commercial teas indicates that about 2.2 g of tea are required to produce one 6-oz (177.4-mL) cup of tea. The amount of material necessary to produce 1 L of tea can be estimated as:

2.2 g of tea/177.4 mL tea = x g of tea/1,000 mL; x = 12.4 g tea

It is assumed that native plant material is not as strong as commercially prepared teas. Therefore, it was assumed that twice as much native material (24.8 g) is required to produce 1 L of tea. The concentration of each COPC in teas produced from native materials can be estimated as:

mg COPC/kg native material x 0.0248 kg native material x Br_{forage}

= mg COPC/kg infusion = mg COPC/L infusion (assuming the density of the infusion equals 1 kg/1 L)

Also see Section 7.1.2.

5 Under Tier 1, the MDC of each COPC in soil from riparian areas will be used as the EPC. Under Tier 2, soil EPCs will be calculated on a riparian, area-specific basis, in accordance with EPA's Calculating the Concentration Term guidance (1992) (also see Section 7.1.2).

6 Because no information was identified regarding Native American-specific ingestion rates for water cress (*Nasturium officinale*), wild onion (*Allium canadense*), and wild carrot (*Daucus carota*), ingestion rates (IRtp for wild onion and wild carrot and IRap for water cress) were calculated for Native American adult and child receptors, based on information contained in EPA's Exposure Factors Handbook (1997c). Specifically, Table 9-13 presents mean per capita intake rates for various raw agricultural commodities. Using green onion to represent wild onion, it can be shown that both green onion and water cress represent less than 0.1 percent of the total daily intake of vegetables (calculated by summing all vegetable-specific intakes from Table 9-13) – green onion represents about 0.07 percent and water cress represents about 0.01 percent. In order to be conservative for use in representing the RME scenario, it was assumed that both wild onion and water cress were consumed at a rate equal to 0.1 percent of the total vegetable intake of Native

Americans. The total RME intake of vegetables by Native Americans was estimated as 10.7 g/kg-day as consumed, by summing the 95th percentile intakes of exposed, protected, and root vegetables for Native Americans (Tables 9-9, 9-10, and 9-11, respectively).

Therefore, the intake of both wild onion and water cress was estimated as follows:

0.001 x 10.7 g/kg-day as consumed = 0.0107 g/kg-day as consumed

In order to convert from wet weight (as consumed) to dry weight, this value was multiplied by (100 – percent water)/100 = 0.10; assuming both wild onion and water cress are about 90 percent water (see Table 9-27). Therefore,

0.0107 g/kg-day as consumed x 0.10 x 1 kg/1000g = 1.07E-06 kg [DW]/kg-day

Adult and child ingestion rates for wild carrot are assumed to equal those for wild onion.

7 The adult- and child-specific ingestion rates for exposed aboveground, protected aboveground, and belowground (root) vegetables were adopted from EPA's Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilities (EPA 1998b) and are presented below:

	Adult	Child
Exposed aboveground produce (Cr_{ag})	0.0003	0.00042
Protected aboveground produce (Cr_{pp})	0.00057	0.00077
Belowground produce (Cr_{bg})	0.00014	0.00022

Note: all intake rates are presented in units of kg [DW]/kg-day

8 EPA's Exposure Factors Handbook presents several tables that provide various estimates, including mean values, for daily intake of tea (1997c). Table 3-14 presents the results of a study of beverage intake in Great Britain (Hopkins and Ellis 1980). Table 3-21 presents results collected as part of the USDA's Continuing Survey of Food Intakes by Individuals (1995). Table 3-26 presents the results of a study of total fluid intake derived from various sources by women aged 15 to 49 years old (Ershow and others 1991). Study-specific tea intake estimates are presented below.

- Hopkins and Ellis (1980): mean tea intake (0.584 L/day); 95 UCL of the mean (0.608 L/day)
- USDA (1995): mean tea intake – all individuals (0.114 L/day); children (age 5 and under) (0.017 L/day); adults (age 20 and over) (0.140 L/day)
- Ershow and others (1991): mean tea intake (control women) (0.148 L/day); 95th percentile (0.630)

TABLE 7-1 (continued)

HUMAN HEALTH EXPOSURE PARAMETER VALUES
REASONABLE MAXIMUM EXPOSURE SCENARIO
AREA WIDE HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENT WORK PLAN
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Based on these results, the following conclusions were drawn. First, the results from the study of Great Britain receptors (Hopkins and Ellis 1980) may not be representative of Resource Area receptors, because individuals from Great Britain are expected to intake more tea than U.S. receptors. Second, the mean tea intake rates of adults (age 20 and over) and of control women (age 15 to 49) are similar – 0.140 and 0.148 L/day, respectively (USDA 1995; Ershow and others 1991). Therefore, for the purposes of the AWHHRA, the mean or CTE tea intake value for adults was estimated as the mean of these two values or 0.144 L/day (about 4 oz [0.118 L] per day). The RME tea intake rate for adults was estimated as twice the CTE rate, or 0.288 L/day (about 8 oz [0.237 L] per day). Similarly, the mean or CTE child tea intake rate was estimated as 0.017 L/day, based on the mean value for children 5 years and under from USDA (1995). As for adults, the RME child tea intake rate was estimated as twice the mean intake rate, or 0.034 L/day.

9 Table 11-3 from EPA's Exposure Factors Handbook presents per capita intake of beef. For the purposes of characterizing the RME scenario, it was assumed that receptors ingested beef at a rate equal to the 95th percentile. Therefore, the RME ingestion rates for recreational hunter and fisher and subsistence lifestyle receptors were estimated as 2.3 g/kg-day as consumed (total or general population). Similarly, the beef ingestion rate for Native American receptors was estimated as 2.8 g/kg-day as consumed.

Both the total or general population -and Native American-specific ingestion rates are average intake rates across all age groups. In order to distinguish between adult and child intake rates, the overall intake rates (2.3 and 2.8 g/kg-day as consumed, respectively) were adjusted using factors specific to adults and children. These factors were calculated as ratios of time-weighted mean intake rates for adults age 20 through 69 and children less than 6 years old each over the total mean intake rate for beef (0.825 g/kg-day as consumed) for the "total" population as shown below.

Adult time-weighted intake (see age range-specific intake rates in Table 11-3)

(0.789 [20 to 39 years] x 20 years)/ 50 years + (0.667 [40 to 69 years] x 30 years)/50 years = 0.7158

Child time-weighted intake

(0.941[<1 year] x 1 year)/6 years + (1.46 [1 to 2 years] x 2 years)/6 years + (1.392 [3 to 5 years] x 3 years)/6 years = 1.34

Adult and child factors were calculated as the ratios of the adult and child time-weighted intakes over the mean "total" beef intake as follows:

Adult factor: 0.7158/0.825 = 0.87

Child factor: 1.34/0.825 = 1.62

Finally, adult and child beef intake rates were calculated as the product of the 95th percentile beef ingestion rate for the general population (2.3 g/kg-day) and the adult and child factors:

Adult beef ingestion rate: 2.3 x 0.87 = 2.00 g/kg-day as consumed

Child beef ingestion rate: 2.3 x 1.62 = 3.73 g/kg-day as consumed

The same process was used for the Native American receptors, with the exception that instead of basing calculations on the 95th percentile beef ingestion rate for the general population, the calculations were based on the 95th percentile beef ingestion rate for Native Americans (2.8 g/kg-day as consumed – see Table 11-3).

Therefore, adult and child ingestion rates for beef skeletal muscle are summarized below. Note: all intakes are in units of g/kg-day as consumed.

	Adult	Child
Recreational hunter/fisher	2.00	3.73
Subsistence lifestyle	2.00	3.73
Native American	2.46	4.54

10 EPA's Exposure Factors Handbook clarifies that ingestion of organ meats and sausages (and presumably offal in general) are not included in the meat-specific ingestion rates presented (1997c) (see Table 11-3). Therefore, intakes of beef should be summed with intakes of organ meats, sausages, and offal in general. For the purposes of the AWHHRA, it was conservatively assumed that recreational hunter and subsistence lifestyle receptors would, over the course of 1 year, ingest a mass of beef tissue other than skeletal muscle equivalent to 50 percent of one beef liver (about 5 pounds). Therefore, ingestion rates for adult and child receptors were calculated as follows:

Adult receptor: 5 pounds x (1 kg/2.2 pounds) x 1000 g/kg x 1/70 kg x 1/365 days = 0.089 g/kg-day

Child receptor 5 pounds x (1 kg/2.2 pounds) x 1000 g/kg x 1/15 kg x 1/365 days = 0.42 g/kg-day

COPC concentrations of these other beef tissues will be estimated using liver concentrations.

For the purposes of evaluating subsistence lifestyle and Native American receptors, it was assumed that these receptors ingested beef tissue other than skeletal muscle at a rate equal to about 10 percent of the skeletal muscle ingestion rate based on the work of Harris and Harper (1997). These investigators noted that native peoples ate more parts of fish and animals than just the fillet or steak. They recommended using a placeholder value of 10 percent of the total fish ingestion rate (assumed to be 540 g/day for members of the Confederated Tribes of the Umatilla Indian Reservation) to represent "other organs" (Harris and Harper 1997). For the purposes of the AWHHRA, this 10 percent value will be used to represent each of the meat types evaluated in the risk assessment. Therefore, both adult and child subsistence lifestyle and Native American receptors are assumed to ingest beef

tissue other than skeletal muscle at a rate equal to about 10 percent of the skeletal muscle ingestion rate. The selenium concentrations of these other beef tissues will be estimated using liver concentrations.

11 The ingestion rate for aquatic life for recreational hunters/fishers was identified as 25 g/day, based on the EPA-recommended 95th percentile ingestion rate for recreational anglers (1997c). EPA's Exposure Factors Handbook also discusses several studies of Native American populations indicating that ingestion rates for Native American populations can be estimated as being from similar to about 100 percent higher than for the general population (West and others 1989; Ebert and others 1993; Peterson and others 1994; Fiore and others 1989; and Fitzgerald and others 1995). Based on best professional judgment, it was assumed that the ingestion rate of aquatic life for Native American adults was 50 percent higher than for recreational hunters and fishers, or 37.5 g/day. Finally, the ingestion rate for subsistence lifestyle adults was assumed to be equal to the EPA-recommended Native American subsistence ingestion rate of 170 g/day (EPA 1997c).

In order to determine receptor-specific, child aquatic life ingestion rates, the adult rates were multiplied by a factor calculated as the ratio of child (0 to 9 years old) to adult (greater than or equal to 20 years old) total fish consumption rates (see Table 10-1 in EPA 1997c). The ratio was calculated as: (16.5 g/day)/(46.3 g/day) = 0.36.

Therefore, the receptor-specific aquatic life ingestion rates were calculated as:

Recreational hunter/fisher child:	25 g/day x 0.36 =	9 g/day
Native American child:	37.5 g/day x 0.36 =	13.5 g/day
Subsistence lifestyle child:	170 g/day x 0.36 =	61.2 g/day

These adult and child fish ingestion rates are considered to represent caps on the amount of fish ingested by each receptor. The rates presented will be used in Step 1 of the tiered approach. However, for the purpose of evaluating ingestion of fish across a watershed (see Step 2 of the tiered approach), an evaluation will be made regarding the ability of streams from a given watershed to support chronic intake of fish. To the extent that a watershed is determined to be unable to support chronic fish ingestion, RME fish ingestion rates will be adjusted downwards. Under Step 3 of the tiered approach, a similar process will be conducted on a stream-specific basis.

12 Receptor-specific tap water ingestion rates were used to represent the amount of surface water ingested. It was assumed that for each recreational day, the receptor would ingest water only from streams in the Resource Area. This assumption may be conservative for receptors engaged in day trips; however, the assumption is expected to accurately represent receptors engaged in overnight camping in the Resource Area.

13 Based on EPA's Superfund Standard Default Exposure Factors for the Central Tendency and Reasonable Maximum Exposure (1993a) and Exposure Factors Handbook (1997c).

14 It was assumed that the recreational hunter/fisher did not ingest plants growing in the Resource Area. It was assumed that the subsistence lifestyle receptor ingests only produce (plants) grown in home gardens located contaminated flood plains (riparian areas) along streams in the Resource Area. The fraction ingested value for the subsistence lifestyle receptor was calculated on two primary factors: (1) length of the growing season and (2) size of the home garden.

The Resource Area can be divided into "warmer" counties such as Bannock, Franklin, and Oneida and "cooler" such as Bear Lake and Caribou. The growing season for the warmer counties is estimated to be about 110 to 120 days and in cooler counties is estimated to be about 90 to 100 days (TtEMI 2002). In cooler counties, the cooler nighttime temperatures can slow the growth of warmer season plants. As a result, plants such as corn, tomatoes, and warm season squashes may not grow well in counties such as Bear Lake and Caribou. However, plants such as beans, beets, carrots, peas, potatoes, and spinach can be raised without significant difficulty in these cooler counties. Many of the stream segments potentially impacted by mining activities are located at some of the higher elevations in Bear Lake and Caribou Counties. It is expected that growing seasons along these streams would be among the smallest in the cooler counties. Therefore, a fraction plant ingested value was estimated as 0.75, based on the ratio of the shortest estimate of growing season in cooler counties (90 days) to the longest estimate of growing season in warmer counties (120 days). Based on review of the locations at which flood plain soil samples have been collected, this fraction plant ingested value may be further reduced if it is judged that insufficient growing space is available in a stream-specific flood plain.

With regard to the fraction of wild onion, wild carrot, and water cress ingested by Native American receptors, it is acknowledged that the 14 active and former mine sites in the Resource Area have a cumulative area equal to about 2 percent of the total Resource Areas, or about 5 percent of the potentially impacted area (60 square miles for the mine sites [see Drawing 1-1 from MW 2000])/(1,200 square miles for the potentially impacted area [MW 1999b]). However, based on the proposed ingestion rates for wild onion and water cress, it is estimated that Native American receptors would only need to gather about five or six plants to meet the total estimated mass of each species ingested over 1 year (Note: wild onion example -- 0.0107 g/kg BW – day x 70 kg BW x 365 days = 27.3 g wild onion as consumed per year). It is reasonable to believe that a Native American receptor could gather five or six plants of each species on a single trip. Samples of wild onion and watercress of sufficient volume to meet annual ingestion requirements were collected from various sampling locations in the Resource Area. Receptors would be expected to return to known locations of these plants. However, there are certainly other sources of wild onion and watercress (and also wild carrot), besides locations in the Resource Area, potentially impacted by mine releases. Therefore, it was assumed that Native American receptors gather wild onion, watercress, and wild carrot from locations potentially impacted by mine releases in the Resource Area about every fourth year. This equates to a fraction ingested of 0.25 under RME conditions.

15 The deterministic $F_{beef, site}$ value of 0.157 was adopted from the Final 1998 Regional Investigation Report (MW 1999b) as the FI_c value for the AWHHRA. This value is an estimate of the 95th percentile of a distribution merging separate beta distributions for the general public (μ assumed to be 0.50 - see MW 1999b) and ranchers who have cattle grazing on leases containing seleniferous pastures (μ assumed to be 0.167—the fraction of cattle on leases within the Soda Springs District of the Caribou National Forest that have the potential to be exposed to seleniferous pasture). The beta distribution derived for the general population was given 100 times more weight than the beta distribution for ranchers, because the rancher population

was assumed to be about 1 percent the size of the general population. For a more detailed explanation of the basis of this value, the reader is directed to the Final 1998 Regional Investigation Report (MW 1999b).

16 All watersheds evaluated in the AWHHRA will be evaluated using a FI value of 1 based on the presence of sufficient fish biomass to support the receptor-specific fish ingestion rates. As necessary, stream-specific FI values will be determined and applied in the AWHHRA. FI values will be determined based on consideration of a variety of factors, including but not limited to, the following: stream order; the type, size, and number of fish present; and documentation that particular streams contain notable spawning grounds.

17 Subsistence receptors may be exposed both at their home and throughout the Resource Area. For the purpose of assessing potential exposure at their homes, a FI value of 1 was assumed in order to allow health-protective consideration of homebound individuals such as the elderly and young children. As stated in Section 7.3.2.2, potential exposure through soil ingestion to subsistence lifestyle, recreational, and Native American receptors associated with activities that may require receptors to move beyond the mine-affected areas (such as hunting, fishing, and gathering), exposure through soil ingestion is expected to be insignificant and will not be quantified.

18 Table 11-6 in EPA's Exposure Factors Handbook presents per capita game intake rates (grams/kilogram-day as consumed) for various ethnicities including Native American (1997c). It was judged that a 95th percentile ingestion rate was appropriate for evaluating the RME case. However, Table 11-6 presents only mean ingestion rates. In order to estimate receptor-specific 95th percentile ingestion rates the following assumptions were made. First, recreational hunter and subsistence lifestyle receptors were represented by "total" ingestion rates and Native American receptors were represented by "Native American" ingestion rates. Second, the ratio of mean to 95th percentile game ingestion rates was assumed to be the same as the ratio of mean to 95th percentile total meat ingestion rates (see Table 11-1). Therefore, the following ethnicity-specific 95th percentile game ingestion rates were estimated (all ingestion rates in units of g/kg-day as consumed):

Total (to represent recreational hunter and subsistence lifestyle receptors):

$$\frac{(0.01\ [\text{mean game intake} - \text{Table 11-6}]) \times (5.06\ [95^{th}\ \text{percentile total meat intake} - \text{Table 11-1}])}{(2.146\ [\text{mean total meat intake} - \text{Table 11-1}])}$$

$$= 0.0236$$

Native American:

$$\frac{(0.001\ [\text{mean game intake} - \text{Table 11-6}]) \times (5.09\ [95^{th}\ \text{percentile total meat intake} - \text{Table 11-1}])}{(2.269\ [\text{mean total meat intake} - \text{Table 11-1}])}$$

$$= 0.0022$$

TABLE 7-1 (continued)

HUMAN HEALTH EXPOSURE PARAMETER VALUES
REASONABLE MAXIMUM EXPOSURE SCENARIO
AREA WIDE HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENT WORK PLAN
SOUTHEAST IDAHO PHOSPHATE MINING RESOURCE AREA

In order to distinguish between adult and child intake rates, the overall intake rates (0.0257 and 0.0022 g/kg-day as consumed, respectively) were adjusted using factors specific to adults and children. These factors were calculated as ratios of time-weighted mean intake rates for adults age 20 through 69 and children less than 6 years old each over the mean game intake rates (see Table 11-6) as detailed below.

Adult time-weighted intake (see age range-specific intake rates in Table 11-6)

(0.01 [20 to 39 years] x 20 years)/ 50 years + (0.012 [40 to 69 years] x 30 years)/50 years = 0.011

Child time-weighted intake

(0.014[<1 year] x 1 year)/6 years + (0.026 [1 to 2 years] x 2 years)/6 years + (0.01 [3 to 5 years] x 3 years)/6 years = 0.016

Adult and child factors were calculated as the ratios of the adult and child time-weighted intakes over the mean "total" beef intake as follows:

Adult factor: 0.011/0.01 = 1.1

Child factor: 0.016/0.01 = 1.6

Finally, adult and child game intake rates were calculated as the product of the overall game ingestion rates for the total (representing recreational and subsistence lifestyle receptor populations) and Native American populations (0.0236 and 0.0022 g/kg-day as consumed, respectively) and the adult and child factors:

Adult- and child-specific game intake rates calculated in this manner are presented below:

	Adult	Child
Recreational hunter/fisher	0.026	0.0378
Subsistence lifestyle	0.026	0.0378
Native American	0.0024	0.0035

Note: all intakes are in units of g/kg-day as consumed.

19 It was assumed that recreational hunter and subsistence lifestyle receptors ingested offal from wild game at the same ratio to wild game skeletal muscle in the same offal to skeletal muscle proportion identified for beef cattle. Native American receptors were assumed to ingest offal at an ingestion rate equal to 10 percent of the estimated skeletal muscle ingestion rate based on Harris and Harper (1997).

20 Appendix I of MW's 1999 Interim Investigation Data Report indicates that about 29 percent of elk in Idaho GMUs 66A and 76 (representing much of the Resource Area) from which skeletal muscle and liver tissue samples were collected contained elevated tissue selenium concentrations (2000).

Therefore, it was assumed that recreational and Native American hunters will hunt throughout Idaho GMUs 66A and 76 and will have an approximately 29 percent chance of encountering and taking an elk with elevated selenium concentrations. Therefore, a FI_{wg} value of 0.29 was assigned to these two receptor groups. In contrast, it was assumed that subsistence lifestyle hunters would hunt closer to home (assumed to be in areas of elevated selenium concentrations) and would, therefore, encounter elk with elevated selenium concentrations more frequently than either recreational or Native American hunters. While subsistence lifestyle receptors may be attracted to some of the same features of habitat and access that attract recreational hunters from the general population, subsistence lifestyle receptors are expected to more frequently visit and hunt at remote portions of the Resource Area, including in the vicinity of some of the active or abandoned mines in the Resource Area, because of their proximity to the subsistence lifestyle receptor's home and/or the subsistence lifestyle receptor's greater knowledge of localized conditions. Therefore, in order to account for the potentially greater frequency with which subsistence lifestyle receptors may encounter elk with elevated selenium concentrations, as compared with recreational hunters, a FI_{wg} of 0.58 (twice the value for the other two receptor groups) was assigned to the subsistence lifestyle receptor.

21 It was assumed that receptors may be exposed near waste rock piles engaged in hunting large game (such as elk and deer). Because receptors are expected to be hunting primarily from blinds, the activity level is expected to be minimal. Therefore, inhalation rates associated with light activity rates (see Table 5-23 from EPA 1997c) were selected to represent RME conditions.

22 Elders of the Shoshone-Bannock tribe indicate that the Native American community drinks teas brewed from plants that grow in riparian areas along streams in the Resource Area. The plants used in the teas include silver sage (*Artemesia*) and red willow (*Salix*), which are present for several weeks in the spring. It was assumed that sufficient plant material is gathered to produce teas over a 3-month period (about mid-April through mid-July) or 91 days/year.

23 Based on review of Idaho's 2000 Big Game Rules (www2.state.id.us/fishgame/common/regulations/regulations.htm), hunting seasons for elk and deer in GMUs 66A and 76 generally run from about August 30 through December. Assuming that snow cover is present from about mid-November, this leaves about 11 weeks of hunting. It was assumed recreational hunters and Native American receptors would hunt 1 day per week for about 50 percent of the available weeks, 6 days/year in these GMUs. The subsistence lifestyle is assumed to hunt closer to home and possibly more often. Therefore, the subsistence lifestyle receptor was assumed to hunt about 2 days per week over about 75 percent of the available weeks, 17 days/year.

24 Fish, game, beef, and plant ingestion rates are all daily rates averaged over an entire year (365 days). The exposure frequency for soil ingestion (350 days/year) is based on EPA's Risk Assessment Guidance for Superfund (1989).

25 Exposure durations were obtained from EPA (1991).

26 Hunters were assumed to spend about 4 hours/day hunting large game from blinds located near waste rock piles.

27 The averaging time for noncarcinogens reflect exposure durations of 6 and 30 years for child and adult receptors, respectively: 6 years x 365 days/year = 2,190 days and 30 years x 365 days/year = 10,950 days (EPA 1989). The averaging time for carcinogens reflects a 70-year lifetime: 70 years x 365 days/year = 25,550 days.

TABLE 7-1 (continued)

HUMAN HEALTH EXPOSURE PARAMETER VALUES
REASONABLE MAXIMUM EXPOSURE SCENARIO
AREA WIDE HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENT WORK PLAN
SOUTHEAST IDAHO PHOSPHATE MINING RESOURCE AREA

95 UCL	=	95 Percent upper confidence limit
μg/L	=	Micrograms per liter
AT	=	Averaging time
AWHHRA	=	Area wide human health risk assessment
BW	=	Body weight
CF	=	Conversion factor
COPC	=	Chemical of potential concern
CTE	=	Central tendency exposure
DW	=	Dry weight
ED	=	Exposure duration
EF	=	Exposure frequency
EPA	=	U.S. Environmental Protection Agency
EPC	=	Exposure point concentration
FI	=	Fraction ingested
g	=	Gram
g/day	=	Gram per day
g/kg-day	=	Gram per kilogram-day
GMU	=	Game management unit
kg	=	Kilogram
kg[DW]/kg-day	=	Kilogram [dry weight] per kilogram-day
kg/g	=	Kilogram per gram
kg/mg	=	Kilogram per milligram
L	=	Liter
L/day	=	Liters per day
m^3/hr	=	Cubic milligrams per hour
MAFF	=	Ministry of Agriculture, Food, and Fisheries
MDC	=	Maximum detected concentration
mg/day	=	Milligrams per day
mg/kg	=	Milligram per kilogram
mg/L	=	Milligram per liter
mL	=	Milliliters
MW	=	Montgomery Watson
NA	=	Not applicable
oz	=	Ounce
RME	=	Reasonable maximum exposure
TtEMI	=	Tetra Tech EM Inc.
USDA	=	U.S. Department of Agriculture

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TABLE 7-2

HUMAN HEALTH EXPOSURE PARAMETER VALUES
CENTRAL TENDENCY EXPOSURE SCENARIO
AREA WIDE HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENT WORK PLAN
SOUTHEAST IDAHO PHOSPHATE MINING RESOURCE AREA

Parameter	Recreational Hunter/Fisher		Native American		Subsistence Lifestyle		Notes
	Adult	Child	Adult	Child	Adult	Child	
Exposure Point Concentration in Aquatic and Terrestrial Plants (EPC_{ap}/EPC_{tp}) (mg/kg)	NA	NA	Tier-specific	Tier-specific	Tier-specific	Tier-specific	1
Exposure Point Concentration in Aquatic Life (EPC_{al}) (mg/kg)	Tier-specific	Tier-specific	Tier-specific	Tier-specific	Tier-specific	Tier-specific	2
Exposure Point Concentration in Surface Water (EPC^{SW}) (µg/L)	Tier-specific	Tier-specific	Tier-specific	Tier-specific	Tier-specific	Tier-specific	2
Exposure Point Concentration in Cattle and Wild Game - Skeletal Muscle and Offal (EPC_{cwg}) (mg/kg)	Mean	Mean	Mean	Mean	Mean	Mean	3
Exposure Point Concentration in Plant-based Tea (EPC_{pt}) (mg/L)	NA	NA	Tier-specific	Tier-specific	NA	NA	4
Exposure Point Concentration in Soil (EPC_s) (mg/kg)	Mean	Mean	NA	NA	Mean	Mean	5
Terrestrial Plant Ingestion Rate (IR_{tp}) (kg[DW]/kg-day)	NA	NA	Plant-specific	Plant-specific	Plant-specific	Plant-specific	6,7
Aquatic Plant Ingestion Rate (IR_{ap}) (kg[DW]/kg-day)	NA	NA	Plant-specific	Plant-specific	NA	NA	6
Plant-Based Tea Ingestion Rate (IR_{pt}) (L/day)	NA	NA	0.144	0.017	NA	NA	8
Cattle Ingestion Rate – Skeletal Muscle (IR_{sm}) (g/kg-day)	0.72	1.34	0.87	1.61	0.72	1.34	9
Cattle Ingestion Rate – Offal (IR_o) (g/kg-day)	0.044	0.21	0.087	0.16	0.044	0.21	10
Aquatic Life Ingestion Rate (IR_{al}) (g/day)	8	2.9	12	4.3	70	25.2	11
Surface Water Ingestion Rate (IR_{SW}) (L/day)	1.41	0.74	1.41	0.74	1.41	0.74	12
Soil Ingestion Rate (IR_s) (mg/day)	NA	NA	NA	NA	50	100	13
Fraction Plant Ingested (FI_{PT}) (unitless)	NA	NA	0.125	0.125	0.75	0.75	14
Fraction Cattle Ingested (FI) (unitless)	0.051	0.051	0.051	0.051	0.051	0.051	15
Fraction Aquatic Life Ingested (FI_{al}) (unitless)	Stream- and watershed-specific	Stream- and watershed-specific	Stream- and watershed-specific	Stream- and watershed-specific	Stream- and watershed-specific	Stream- and watershed-specific	16

TABLE 7-2 (continued)

HUMAN HEALTH EXPOSURE PARAMETER VALUES
CENTRAL TENDENCY EXPOSURE SCENARIO
AREA WIDE HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENT WORK PLAN
SOUTHEAST IDAHO PHOSPHATE MINING RESOURCE AREA

Parameter	Recreational Hunter/Fisher		Native American		Subsistence Lifestyle		Notes
	Adult	Child	Adult	Child	Adult	Child	
Fraction Soil Ingested (FI_s) (unitless)	NA	NA	NA	NA	1	1	17
Wild Game Ingestion Rate – Skeletal Muscle (IR_{wg}) (g/kg-day)	0.011	0.016	0.001	0.0016	0.011	0.016	18
Wild Game Ingestion Rate – Offal (IR_{wgo}) (g/kg-day)	4.85E-03	1.80E-03	1.0E-04	1.6E-04	4.85E-03	1.80E-03	19
Fraction Wild Game Ingestion (FI_{wg}) (unitless)	0.29	0.29	0.29	0.29	0.29	0.29	20
Inhalation Rate (InR) (m^3/hr)	0.5	0.4	0.5	0.4	0.5	0.4	21
Exposure Frequency Plant-based Tea (EF_{pt}) (days/year)	NA	NA	45	45	NA	NA	22
Exposure Frequency Particulates (EF_p) (days/year)	3	3	3	3	8	8	23
Exposure Frequency (EF) (days/year)	365	365	365	365	365 (350)	365 (350)	24
Exposure Duration (ED) (years)	9	6	9	6	9	6	25
Exposure Time (ET) (hours/day)	4	4	4	4	4	4	26
Conversion Factor1 (CF1) (kg/g)	0.001	0.001	0.001	0.001	0.001	0.001	
Conversion Factor 2 (CF2) (kg/mg)	NA	NA	NA	NA	1E-06	1E-06	--
Body Weight (BW) (kg)	70	15	70	15	70	15	--
Averaging Time for Noncarcinogens (AT_{non}) (days)	3,285	2,190	3,285	2,190	3,285	2,190	27
Averaging Time for Carcinogens (AT_{carc}) (days)	25,550	25,550	25,550	25,550	25,550	25,550	27

Notes:

1 The only aquatic plant evaluated in the AWHHRA is the water cress (*Nasturium officinale*). The EPC of each COPC in water cress will be calculated from the analytical results from water cress samples collected in the Resource Area. Under Tier 2, EPCs will be calculated on a watershed-specific basis if sufficient samples were collected (if not, the EPC will be calculated based on all available water cress samples), based on procedures recommended in (EPA's guidance titled, Calculating the Concentration Term (1992). The mean value will be used as the EPC. Under Tier 3, the EPC will be calculated as the mean on a stream-specific basis, following the same guidance used under Tier 2.

COPC-specific EPCs in terrestrial plants will be calculated, following procedures recommended in EPA's Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilities (1998b). Terrestrial plants are divided into three categories for consideration in the AWHHRA: exposed aboveground produce, protected aboveground produce, and belowground produce. Equations used to calculated EPCs are presented below:

EXPOSED AND PROTECTED ABOVEGROUND PRODUCE

$$Pr = Cs \times Br_{ag}$$

BELOWGROUND PRODUCE

$$Pr = Cs \times Br_{bg}$$

where

Pr	=	Concentration of COPC in produce due to root uptake (mg/kg)
Cs	=	Average soil concentration over exposure duration (mg COPC/kg soil) (calculated as 95 UCL consistent with EPA [1992])
Br_{ag}	=	Plant-soil bioconcentration factor for aboveground produce (unitless) (Baes and others 1984)
Br_{bg}	=	Plant-soil bioconcentration factor for belowground produce (unitless) (Baes and others 1984)

Under Tier 2, EPCs for homegrown produce will be calculated as the mean on a stream-specific basis, according to procedures recommended in EPA's guidance titled, Calculating the Concentration Term (1992).

2 Under Tier 2, EPCs will be calculated as a weighted average based on stream-specific productivity for each watershed for which fish fillet samples have been collected. Under Tier 3, EPCs will be calculated as mean values on a on a stream-specific basis, according to procedures recommended in EPA's Calculating the Concentration Term (1992). Also see Section 7.1.2.

Under Tier 2, EPCs for surface water will be calculated as mean values on a stream-specific basis according to EPA's guidance titled, Calculating the Concentration Term (1992).

3 EPCs in cattle (beef skeletal muscle and liver) and wild game (elk skeletal muscle and liver) grazed or living in the Resource Area will be calculated, based on the tissue-specific analytical results presented in the 1999 Interim Investigation Data Report (MW 2000). Under Tier 2, COPC-specific EPCs will be calculated as mean values, in accordance with EPA-recommended procedures (EPA 1992). Beef skeletal muscle and liver values used to calculate EPCs are from tissue samples that have undergone depuration. Also see Section 7.1.2.

4 EPCs for plants used by Native American populations to make tea (silver sage and red willow) will be calculated, based on plant-specific tissue sample analytical results or COPC-specific soil concentrations using soil-plant bioconcentration factors, as described in Footnote 1 for aboveground plants. Under Tier 2, EPCs will be calculated as mean values on a watershed-specific basis if sufficient samples were collected (if not, the EPC will be calculated, based on all available silver sage and red willow samples), based on procedures recommended in EPA's guidance titled, Calculating the Concentration Term (1992). Under Tier 3, the EPC will be calculated as mean values on a stream-specific basis, following the same guidance used under Tier 2. For streams without silver sage or red willow samples, plant tissue EPCs will be based on COPC-specific soil concentrations calculated in accordance with EPA's Calculating the Concentration Term (1992).

The EPCs in plant-based teas will be calculated, based on the plant tissue EPCs calculated in the manner described above, using the following methodology. No direct information is available regarding the metal content of infusions ("teas") produced from native plants of southeastern Idaho. Several general studies of foodstuffs, such as MAFF (1998) and Federal Drug Administration (2001) give some information on the intake of metals from beverages, including teas. However, while providing data on the concentration of metals in infusions, neither study provides data on the concentration of metals in the dry tea. Therefore, estimates of the transfer of metals from dry tea into the infusion cannot be made.

However, evidence exists that infusions made from tea (*Camellia sinensis*), known to take up aluminum, contain elevated levels of aluminum, particularly compared with other beverages (MAFF 1998). Therefore, while data is scare, it is reasonable to assume that a fraction of the metals present in plant material will be transferred into an infusion made from that material. The primary mechanism for the uptake of metals in soil by plants is diffusion (sometimes modified by chelation, precipitation, and other processes). As a first approximation, the plant-soil bioconcentration factor for forage (Br_{forage}), as defined in EPA (1998a) will be used to estimate the fraction of metals in plant material that is dissolved in an infusion.

A review of commercial teas indicates that about 2.2 g of team are required to produce one 6-oz (177.4-mL) cup of tea. The amount of material necessary to produce 1 L of tea can be estimated as:

2.2 g of tea/177.4 mL tea = x g of tea/1,000 mL; x = 12.4 g tea

It is assumed that native plant material is not as strong as commercially prepared teas. Therefore, it was assumed that twice as much native material (24.8 g) is required to produce 1 L of tea. The concentration of each COPC in teas produced from native materials can be estimated as:

mg COPC/kg native material x 0.0248 kg native material x Br_{forage}

= mg COPC/kg infusion = mg COPC/L infusion (assuming the density of the infusion equals 1 kg/1 L)

Also see Section 7.1.2.

5 Under Tier 2, soil EPCs will be calculated as mean values on a riparian area-specific basis, in accordance with EPA's Calculating the Concentration Term guidance (1992) (also see Section 7.1.2).

6 Because no information was identified regarding Native American-specific ingestion rates for water cress (*Nasturium officinale*), wild onion (*Allium canadense*), and wild carrot (*Daucus carota*), ingestion rates (IR_{tp} for wild onion and wild carrot and IR_{ap} for water cress) were calculated for Native American adult and child receptors, based on information contained in EPA's Exposure Factors Handbook (1997c). Specifically, Table 9-13 presents mean per capita intake rates for various raw agricultural commodities. Using green onion to represent wild onion, it can be shown that both green onion and water cress represent less than 0.1 percent of the total daily intake of vegetables (calculated by summing all vegetable-specific intakes from Table 9-13) – green onion represents about 0.07 percent and water cress represents about 0.01 percent. In order to represent the CTE scenario, it was assumed that both wild onion and water cress were consumed at a rate equal to 0.1 percent of the total vegetable intake of Native Americans. The total CTE intake of vegetables by Native Americans was estimated as 3.1 g/kg-day as consumed, by summing the mean intakes of exposed, protected, and root vegetables for Native Americans (Tables 9-9, 9-10, and 9-11, respectively).

Therefore, the intake of both wild onion and water cress was estimated as follows:

0.001 x 3.1 g/kg-day as consumed = 3.1E-03 g/kg-day as consumed

In order to convert from wet weight (as consumed) to dry weight, this value was multiplied by (100 – percent water)/100 = 0.10; assuming both wild onion and water cress are about 90 percent water (see Table 9-27). Therefore,

3.1E-03 g/kg-day as consumed x 0.10 x 1 kg/1000g = 3.1E-07 kg [DW]/kg-day

Adult and child ingestion rates for wild carrot are assumed to equal those for wild onion.

7 The adult- and child-specific ingestion rates for exposed aboveground, protected aboveground, and belowground (root) vegetables were adopted from EPA's Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilities (1998b) and are presented below:

	Adult	Child
Exposed aboveground produce (Cr_{ag})	0.0003	0.00042
Protected aboveground produce (Cr_{pp})	0.00057	0.00077
Belowground produce (Cr_{bg})	0.00014	0.00022

Note: all intake rates are presented in units of kg [DW]/kg-day

8 EPA's Exposure Factors Handbook presents several tables that provide various estimates, including mean values, for daily intake of tea (1997c). Table 3-14 presents the results of a study of beverage intake in Great Britain (Hopkins and Ellis 1980). Table 3-21 presents results collected as part of the USDA Continuing Survey of Food Intakes by Individuals (1995). Table 3-26 presents the results of a study of total fluid intake derived from various sources by women aged 15 to 49 years old (Ershow and others 1991). Study-specific tea intake estimates are presented below.

- Hopkins and Ellis (1980): mean tea intake (0.584 L/day); 95 percent upper confidence limit of the mean (0.608 L/day)
- USDA (1995): mean tea intake – all individuals (0.114 L/day); children (age 5 and under) (0.017 L/day); adults (age 20 and over) (0.140 L/day)
- Ershow and others (1991): mean tea intake (control women) (0.148 L/day); 95th percentile (0.630)

Based on these results, the following conclusions were drawn. First, the results from the study of Great Britain receptors (Hopkins and Ellis 1980) may not be representative of Resource Area receptors because, individuals from Great Britain are expected to intake more tea than U.S. receptors. Second, the mean tea intake rates of adults (age 20 and over) and of control women (age 15 to 49) are similar – 0.140 and 0.148 L/day, respectively (USDA 1995; Ershow and others 1991). Therefore, for the purposes of the AWHHRA, the mean or CTE tea intake value for adults was estimated as the mean of these two values or 0.144 L/day (about 4 oz [0.118 L] per day). Similarly, the mean or CTE child tea intake rate was estimated as 0.017 L/day, based on the mean value for children 5 years and under from USDA (1995).

9 Table 11-3 from EPA's Exposure Factors Handbook presents per capita intake of beef. For the purposes of characterizing the CTE scenario, it was assumed that receptors ingested beef at a rate equal to the mean for the "total" population (1997c). Therefore, CTE ingestion rates for recreational hunter and fisher and subsistence lifestyle receptors were estimated as 0.825 g/kg-day as consumed (total or general population). Similarly, the beef ingestion rate for Native American receptors was estimated as 0.995 g/kg-day as consumed.

Both the total or general population -and Native American-specific ingestion rates are average intake rates across all age groups. In order to distinguish between adult and child intake rates, the overall intake rates (2.3 and 2.8 g/kg-day as consumed, respectively) were adjusted using factors specific to adults and children. These factors were calculated as ratios of time-weighted mean intake rates for adults age 20 through 69 and children less than 6 years old each over the total mean intake rate for beef (0.825 g/kg-day as consumed) for the "total" population as shown below.

Adult time-weighted intake (see age range-specific intake rates in Table 11-3)

(0.789 [20 to 39 years] x 20 years)/ 50 years + (0.667 [40 to 69 years] x 30 years)/50 years = 0.7158

Child time-weighted intake

(0.941[<1 year] x 1 year)/6 years + (1.46 [1 to 2 years] x 2 years)/6 years + (1.392 [3 to 5 years] x 3 years)/6 years = 1.34

Adult and child factors were calculated as the ratios of the adult and child time-weighted intakes over the mean "total" beef intake as follows:

Adult factor: 0.7158/0.825 = 0.87

Child factor: 1.34/0.825 = 1.62

Finally, adult and child beef intake rates were calculated as the product of the mean beef ingestion rate for the general population (0.825 g/kg-day) and the adult and child factors:

Adult beef ingestion rate: 0.825 x 0.87 = 0.72 g/kg-day as consumed

Child beef ingestion rate: 0.825 x 1.62 = 1.32 g/kg-day as consumed

The same process was used for the Native American receptors, with the exception that instead of basing calculations on the mean beef ingestion rate for the general population, calculations were based on the mean beef ingestion rate for Native Americans (0.995 g/kg-day as consumed – see Table 11-3).

Therefore, adult and child ingestion rates for beef skeletal muscle are summarized below. Note: all intakes are in units of g/kg-day as consumed.

	Adult	Child
Recreational hunter/fisher	0.72	1.34
Subsistence lifestyle	0.72	1.34
Native American	0.87	1.61

10 EPA's Exposure Factors Handbook clarifies that ingestion of organ meats and sausages (and presumably offal in general) are not included in the meat-specific ingestion rates presented (1997c) (see Table 11-3). Therefore, intakes of beef should be summed with intakes of organ meats, sausages, and offal in general. For the purposes of the AWHHRA, it was conservatively assumed that recreational hunter and subsistence lifestyle receptors would, over the course of 1 year, ingest a mass of beef tissue other than skeletal muscle equivalent to 25 percent of one beef liver (about 2.5 pounds). Therefore, ingestion rates for adult and child receptors were calculated as follows:

Adult receptor:	2.5 pounds x (1 kg/2.2 pounds) x 1000 g/kg x 1/70 kg x 1/365 days	=	0.044 g/kg-day
Child receptor	2.5 pounds x (1 kg/2.2 pounds) x 1000 g/kg x 1/15 kg x 1/365 days	=	0.21 g/kg-day

COPC concentrations of these other beef tissues will be estimated using liver concentrations.

For the purposes of evaluating subsistence lifestyle and Native American receptors, it was assumed that these receptors ingested beef tissue other than skeletal muscle at a rate equal to about 10 percent of the skeletal muscle ingestion rate, based on the work of Harris and Harper (1997). These investigators noted that native peoples ate more parts of fish and animals than just the fillet or steak. They recommended using a placeholder value of 10 percent of the total fish ingestion rate (assumed to be 540 g/day for members of the Confederated Tribes of the Umatilla Indian Reservation) to represent "other organs" (Harris and Harper 1997). For the purposes of the AWHHRA, this 10 percent value will be used to represent each of the meat types evaluated in the risk assessment. Therefore, both adult and child subsistence lifestyle and Native American receptors are assumed to ingest beef tissue other than skeletal muscle at a rate equal to about 10 percent of the skeletal muscle ingestion rate. Selenium concentrations of these other beef tissues will be estimated using liver concentrations.

11 The ingestion rate for aquatic life for recreational hunters/fishers was identified as 8 g/day, based on the EPA-recommended mean ingestion rate for recreational anglers (EPA 1997c). EPA's Exposure Factors Handbook also discusses several studies of Native American populations, indicating that ingestion rates for Native American populations can be estimated as being from similar to about 100 percent higher than for the general population (West and others 1989; Ebert and others 1993; Peterson and others 1994; Fiore and others 1989; and Fitzgerald and others 1995). Based on best professional judgment, it was assumed that the ingestion rate of aquatic life for Native American adults was 50 percent higher than for recreational hunters and fishers, or 12 g/day. Finally, the ingestion rate for subsistence lifestyle adults was assumed to be equal to the EPA-recommended Native American subsistence ingestion rate of 70 g/day (EPA 1997c).

In order to determine receptor-specific child aquatic life ingestion rates, the adult rates were multiplied by a factor calculated as the ratio of child (0 to 9 years old) to adult (greater than or equal to 20 years old) total fish consumption rates (see Table 10-1 in EPA 1997). The ratio was calculated as: (16.5 g/day)/(46.3 g/day) = 0.36.

Therefore, the receptor-specific aquatic life ingestion rates were calculated as:

Recreational hunter/fisher child:	8 g/day x 0.36	=	2.9 g/day
Native American child:	12 g/day x 0.36	=	4.3 g/day
Subsistence lifestyle child:	70 g/day x 0.36	=	25.2 g/day

These adult and child fish ingestion rates are considered to represent caps on the amount of fish ingested by each receptor. The rates presented will be used in Step 1 of the tiered approach. However, for the purpose of evaluating ingestion of fish across a watershed (see Step 2 of the tiered approach), an evaluation will be made regarding the ability of streams from a given watershed to support chronic intake of fish. To the extent that a watershed is determined to be unable to support chronic fish ingestion, CTE fish ingestion rates will be adjusted downwards. Under Step 3 of the tiered approach, a similar process will be conducted on a stream-specific basis.

12 Receptor-specific tap water ingestion rates were used to represent the amount of surface water ingested. It was assumed that for each recreational day, the receptor would ingest water only from streams in the Resource Area. This assumption may be conservative for receptors engaged in daytrips; however, the assumption is expected to accurately represent receptors engaged in overnight camping in the Resource Area.

13 Based on EPA's Superfund Standard Default Exposure Factors for the Central Tendency and Reasonable Maximum Exposure (1993a) and Exposure Factors Handbook (1997c).

14 It was assumed that the recreational hunter/fisher did not ingest plants growing in the Resource Area. It was assumed that the subsistence lifestyle receptor ingests only produce (plants) grown in home gardens located contaminated flood plains (riparian areas) along streams in the Resource Area. The fraction ingested value for the subsistence lifestyle receptor was calculated on two primary factors: (1) length of the growing season and (2) size of the home garden.

The Resource Area can be divided into "warmer" counties such as Bannock, Franklin, and Oneida and "cooler" such as Bear Lake and Caribou. The growing season for the warmer counties is estimated to be about 110 to 120 days and in cooler counties is estimated to be about 90 to 100 days (TtEMI 2002). In cooler counties, cooler nighttime temperatures slow the growth of warmer season plants. As a result, plants such as corn, tomatoes, and warm season squashes may not grow well in counties such as Bear Lake and Caribou. However, plants such as beans, beets, carrots, peas, potatoes, and spinach can be raised without significant difficulty in these cooler counties. Many of the stream segments potentially impacted by mining activities are located at some of the higher elevations in Bear Lake and Caribou Counties. It is expected that growing seasons along these streams would be among the smallest in the cooler counties. Therefore, a fraction plant ingested value was estimated as 0.75, based on the ratio of the shortest estimate of growing season in cooler counties (90 days) to the longest estimate of growing season in warmer counties (120 days). Based on review of the locations at which flood plain soil samples have been collected, this fraction plant ingested value may be further reduced if it is judged that insufficient growing space is available in a stream-specific flood plain.

With regard to the fraction of wild onion, wild carrot, and water cress ingested by Native American receptors, it is acknowledged that the 14 active and former mine sites in the Resource Area have a cumulative area equal to about 2 percent of the total Resource Area or 5 percent of the potentially impacted area (60 square miles for the mine sites [see Drawing 1-1 from MW 2000])/(1,200 square miles for the potentially impacted area [MW 1999b]). However, based on proposed ingestion rates for wild onion and water cress, it is estimated that Native American receptors would only need to gather about five or six plants to meet the total estimated mass of each species ingested over 1 year (Note: wild onion example -- 0.0107 g/kg BW – day x 70 kg BW x 365 days = 27.3 g wild onion as consumed per year). It is reasonable to believe that a Native American receptor could gather five or six plants of each species on a single trip. Samples of wild onion and watercress of sufficient volume to meet annual ingestion requirements were collected from various sampling locations in the Resource Area. Receptors would be expected to return to known locations of these plants. However, there are certainly other sources of wild onion and watercress (and also wild carrot), besides locations in the Resource Area, potentially impacted by

mine releases. Therefore, it was assumed that Native American receptors gather wild onion, watercress, and wild carrot from locations potentially impacted by mine releases in the Resource Area about every fourth year. This equates to a fraction ingested of 0.25 under RME conditions. The fraction ingested under CTE conditions was assumed to be one-half of the RME value.

15 The mean estimate of the variable $F_{beef, site}$, 0.051, was adopted from the Final 1998 Regional Investigation Report (MW 1999b, 2001).

16 All watersheds evaluated in the AWHHRA will be evaluated using a FI value of 1 based on the presence of sufficient fish biomass to support the receptor-specific fish ingestion rates. As necessary, stream-specific FI values will be determined and applied in the AWHHRA. FI values will be determined based on consideration of a variety of factors, including but not limited to, the following: stream order; the type, size, and number of fish present; and documentation that particular streams contain notable spawning grounds.

17 Subsistence receptors may be exposed both at their home and throughout the Resource Area. For the purpose of assessing potential exposure at their homes, an FI value of 1 was assumed in order to allow health-protective consideration of homebound individuals such as the elderly and young children. As stated in Section 7.3.2.2, potential exposure through soil ingestion to subsistence lifestyle, recreational, and Native American receptors associated with activities that may require receptors to move beyond the mine-affected areas (such as hunting, fishing, and gathering), exposure through soil ingestion is expected to be insignificant and will not be quantified.

18 Table 11-6 in EPA's Exposure Factors Handbook presents per capita game intake rates (grams/kilogram-day as consumed) for various ethnicities including Native American (1997c). It was judged that a mean ingestion rate was appropriate for evaluating the CTE case. Recreational hunter and subsistence lifestyle receptors were represented by the "total" or general population mean ingestion rate of 0.01 g/kg-day as consumed and Native American receptors were represented by the "Native American" mean ingestion rate of 0.001 g/kg-day.

In order to distinguish between adult and child intake rates, the overall intake rates (0.01 and 0.001 g/kg-day as consumed, respectively) were adjusted using factors specific to adults and children. These factors were calculated as ratios of time-weighted mean intake rates for adults age 20 through 69 and children less than 6 years old each over the mean game intake rates (see Table 11-6) as detailed below.

Adult time-weighted intake (see age range-specific intake rates in Table 11-6)

(0.01 [20 to 39 years] x 20 years)/ 50 years + (0.012 [40 to 69 years] x 30 years)/50 years = 0.011

Child time-weighted intake

(0.014[<1 year] x 1 year)/6 years + (0.026 [1 to 2 years] x 2 years)/6 years + (0.01 [3 to 5 years] x 3 years)/6 years = 0.016

Adult and child factors were calculated as the ratios of the adult and child time-weighted intakes over the mean "total" beef intake as follows:

Adult factor: 0.011/0.01 = 1.1

Child factor: 0.016/0.01 = 1.6

Finally, adult and child game intake rates were calculated as the product of the overall game ingestion rates for the total (representing recreational and subsistence lifestyle receptor populations) and Native American populations (0.01 and 0.001 g/kg-day as consumed, respectively) and the adult and child factors:

Adult- and child-specific game intake rates calculated in this manner are presented below:

	Adult	Child
Recreational hunter/fisher	0.011	0.016
Subsistence lifestyle	0.011	0.016
Native American	0.0011	0.0016

Note: all intakes are in units of g/kg-day as consumed.

19 It was assumed that recreational hunter and subsistence lifestyle receptors ingested offal from wild game at the same ratio to wild game skeletal muscle in the same offal to skeletal muscle proportion identified for beef cattle. Native American receptors were assumed to ingest offal at an ingestion rate equal to 10 percent of the estimated skeletal muscle ingestion rate based on Harris and Harper (1997).

20 Appendix I of MW's 1999 Interim Investigation Data Report indicates that about 29 percent of elk in Idaho GMUs 66A and 76 (representing much of the Resource Area) from which skeletal muscle and liver tissue samples were collected contained elevated tissue selenium concentrations. Therefore, it was assumed that recreational and Native American hunters will hunt throughout Idaho GMU 76 and will have an approximately 29 percent chance of encountering and taking an elk with elevated selenium concentrations. Therefore, a FI_{wg} value of 0.29 was assigned to these two receptor groups. Subsistence lifestyle receptors may be attracted to some of the same features of habitat and access that attract recreational hunters from the general population. Therefore, in order to account for the potential similarities between hunting habits of the three receptor groups, an FI_{wg} of 0.29 also was used to represent the subsistence lifestyle receptor.

21 It was assumed that receptors potentially exposed while hunting large game from blinds would have low activity levels. Therefore, inhalation rates associated with a sedentary activity level were selected to represent CTE conditions (see Table 5-23 from EPA 1997c).

22 Elders of the Shoshone-Bannock tribe indicate that the Native American community drinks teas brewed from plants that grow in riparian areas along streams in the Resource Area. The plants used in the teas include silver sage (*Artemesia*) and red willow (*Salix*), which are present for several weeks in the spring. It was assumed that sufficient plant material is gathered to produce teas over a 3-month period (about mid-April through mid-July) or 91 days/year under RME conditions. The EF_{pt} value was assumed to be one-half the RME value or 45 days/year under CTE conditions.

23 It was assumed that hunters would be exposed about one-half as often under CTE conditions as was assumed under RME conditions. See Footnote 22 in Table 7-1.

TABLE 7-2 (continued)

HUMAN HEALTH EXPOSURE PARAMETER VALUES
CENTRAL TENDENCY EXPOSURE SCENARIO
AREA WIDE HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENT WORK PLAN
SOUTHEAST IDAHO PHOSPHATE MINING RESOURCE AREA

24 Fish, game, beef, and plant ingestion rates are all daily rates averaged over an entire year (365 days). The exposure frequency for soil ingestion (350 days/year) is based on EPA's Risk Assessment Guidance for Superfund (1989).

25 Exposure durations were obtained from EPA (1991).

26 Hunters were assumed to spend about 4 hours/day hunting large game from blinds located near waste rock piles.

27 The averaging time for noncarcinogens reflect exposure durations of 6 and 30 years for child and adult receptors, respectively: 6 years x 365 days/year = 2,190 days and 30 years x 365 days/year = 10,950 days (EPA 1989). The averaging time for carcinogens reflects a 70-year lifetime: 70 years x 365 days/year = 25,550 days.

95 UCL = 95 Percent upper confidence limit
AT = Averaging time
AWHHRA = Area wide human health risk assessment
BW = Body weight
CF = Conversion factor
COPC = Chemical of potential concern
CTE = Central tendency exposure
DW = Dry weight
ED = Exposure duration
EF = Exposure frequency
EPA = U.S. Environmental Protection Agency
EPC = Exposure point concentration
FI = Fraction ingested
g = Gram
g/day = Gram per day
g/kg = Gram per kilogram
g/kg-day = Gram per kilogram-day
GMU = Game management unit
kg = Kilogram
kg/g = Kilogram per gram
kg[DW]/kg-day = Kilogram [dry weight] per kilogram-day
kg/mg = Kilogram per milligram
L/day = Liters per day
m^3/hr = Cubic meters per hour
MAFF = Ministry of Agriculture, Food, and Fisheries
mg/kg = Milligram per kilogram
mL = Milliliters
MW = Montgomery Watson
NA = Not applicable
oz = Ounce
RME = Reasonable maximum exposure
TtEMI = Tetra Tech EM Inc.
USDA = U.S. Department of Agriculture

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TABLE 8-1

CRITERIA AND BENCHMARKS FOR SURFACE WATER, SEDIMENT, AND SOIL
AREA WIDE HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENT WORK PLAN
SOUTHEAST IDAHO PHOSPHATE MINING RESOURCE AREA

Metal	Surface Water[1] (µg/L)		Sediments[2] (mg/kg)		Soil (mg/kg)			
					EPA Region 4[3]		EPA ECO-SSLs[11]	
	Acute	Chronic	TEC	PEC	Value	Source[13]	Plant	Soil Invertebrate
Aluminum	750.0[4]	87.0[4]	255,000[14]		50.0	2		
Antimony	88.0	30.0	3.0[15]		3.5	5	Pending	NA
Arsenic	340.0	150.0	9.79	33.0	10.0	2	37.0	Pending
Barium					165.0	5		
Beryllium	130.0[5]	5.3[5]			1.1	5		
Boron					0.5	2		
Cadmium	4.3*	2.2*	0.99	4.98	1.6	5	29.0	110.0
Chromium	570.0*	74.0*	43.4	111.0	0.4	2,3	5.0	Pending
Cobalt					20.0	1,2,4	31.8[12]	
Copper	13.0*	9.0*	31.6	147.0	40.0	5	Pending[12]	61.0
Lead	65.0*[,6]	2.5*[,6]	35.8	128.0	50.0	1,2		
Manganese			630.0[14]		100.0	2		
Mercury	1.4[7]	0.77[7]	0.18	1.06	0.1	2		
Molybdenum					2.0	2		
Nickel	470.0*	52.0*	22.7	48.6	30.0	2	30.5[12]	
Selenium	13.0 to 186.0[8]	5.0[8]	4.0[17]		0.81	5	0.8[12]	
Silver	1.7*[,9]	0.12	4.5[15]		2.0	2		
Thallium	1,400.0[10]	40.0[10]			1.0	2		
Uranium					5.0	2		
Vanadium					2.0	2		
Zinc	120.0*	120.0*	123.0[16]		50.0	2	190.0	120.0

TABLE 8-1 (continued)

CRITERIA AND BENCHMARKS FOR SURFACE WATER, SEDIMENT, AND SOIL
AREA WIDE HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENT WORK PLAN
SOUTHEAST IDAHO PHOSPHATE MINING RESOURCE AREA

Notes:

* Hardness-dependent value with 25 mg/L as minimum and 400 mg/L as maximum calcium carbonate; value entered is for 100-mg/L calcium carbonate. Value must be corrected for hardness.

1 Taken from Buchman, M.F. 1999. "NOAA Screening Quick Reference Tables." National Oceanic and Atmospheric Administration (NOAA) HAZMAT Report 99-1. Coastal Protection and Restoration Division. Seattle, Washington; and 1997 Federal Register 62: 42159 to 42208).

2 Taken from MacDonald, D.D., C.G. Ingersoll, and T. Berger. 2000. "Development and Evaluation of Consensus-based Sediment Quality Guidelines for Freshwater Ecosystems." *Archives of Environmental Contamination and Toxicology.* Volume 39. Pages 20 to 31.

3 Taken from EPA, Region IV. 2001. "Recommended Ecological Screening Values (mg/kg) for Soil." Based on Friday, G.P. 1998. "Ecological Screening Values for Surface Water, Sediment, and Soil." Westinghouse Savannah River Company, Savannah River Technology Center. WSRC-TR-98-00110. Aiken, South Carolina. Found at the following Internet site: http://www.epa.gov/region4/waste/ots/ecolbul.htm.

4 For pH 6.5 to 9.0 and expressed as total recoverable.

5 Lowest observable effect level from 45 Federal Register 79326.

6 Values represent change to filtered basis.

7 Derived from inorganic mercury but applied to total mercury. Does not account for food web uptake.

8 Freshwater acute value depends on ratio of selenite to selenate.

9 Acute value was adjusted by two to be comparable to 1985 derivations.

10 Lowest observable effect level from 45 Federal Register 79340.

11 Taken form EPA. 2000. "Ecological Soil Screening Level Guidance, Draft."

12 Taken from Kapustka, L.A., D.L Eskew, and R.S. Wentsel. 2000. "Phytotoxicity Testing for Ecological Soil Screening Levels (Eco-SSLs): Cobalt, Selenium, Nickel, and Pentachlorophenol." Poster Presentation, 21st Annual Meeting, Society of Environmental Toxicology and Chemistry, 12 to 16 November, Nashville, Tennessee.

13 Sources for soil data from EPA Region 4: (1) Beyer, W.N. 1990. "Evaluating Soil Contamination." U.S. Fish and Wildlife Service. *Biological Report*. Volume 90. Number 2. Pages 1 to 25; (2) Efroymson, R.A., M.E. Will, and G.W. Suter, III. 1997a. "Toxicological Benchmarks for Contaminants of Potential Concern for Effects on Soil and Litter Invertebrates and Heterotrophic Processes." Oak Ridge National laboratory. ES/ER/TM-126/R2 and Efroymson, R.A., M.E. Will, G.W. Suter, III, and A.C. Wooten. 1997b. "Toxicological

TABLE 8-1 (continued)

CRITERIA AND BENCHMARKS FOR SURFACE WATER, SEDIMENT, AND SOIL
AREA WIDE HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENT WORK PLAN
SOUTHEAST IDAHO PHOSPHATE MINING RESOURCE AREA

Benchmarks for Screening Contaminants of Potential Concern for Effects on Terrestrial Plants: 1997 Revision." Oak Ridge National Laboratory. ES/ER/TM-85/R3; (3) Canadian Council of Ministries of the Environment. 1997. "Recommended Canadian Soil Quality Guidelines." Winnipeg, Manitoba, Canada; (4) Ministry of Housing, Spatial Planning and Environment. 1994. "Intervention Values and Target Values – Soil Quality Standards." Directorate General for Environmental Protection, Department of Soil Protection. The Hague, The Netherlands; (5) Crommentuijn, T., M.D. Polder, and E.J. van de Plassche. 1997. "Maximum Permissible Concentration and Negligible Concentrations for Metals, Taking Background Concentrations into Account." RIVM Report No. 60151001. The Netherlands.

[14] Value represents the lowest threshold effects level for *Hyalella azteca* as taken from Buchman (1999).

[15] Value represents the upper effects threshold based on Microtox® studies as taken from Buchman (1999).

[16] Value represents the threshold effects level as taken from Buchman (1999).

[17] Value represents the toxicity threshold as recommended by Van Derveer and Canton (1997), San Joaquin Valley Drainage Program (1990) and Lemly and Smith (1987) as cited in Skorupa, J. 1998. "Selenium." In P.L. Martin and D.E. Larsen (editors). Guidelines for Interpretation of the Biological Effects of Selected Constituents in Biota, Water, and Sediment. National Irrigation Water Quality Program Information Report No. 3. Department of the Interior. Pages 139-184. November.

EPA	U.S. Environmental Protection Agency
µg/L	Micrograms per liter
mg/kg	Milligrams per kilogram
mg/L	Milligrams per liter
NA	Not applicable
PEC	Probable effect concentration
TEC	Threshold effect concentration

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TABLE 8-2

PROPOSED ASSESSMENT ENDPOINTS AND ASSOCIATED RECEPTORS
AREA WIDE HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENT WORK PLAN
SOUTHEAST IDAHO PHOSPHATE MINING RESOURCE AREA

Guild	Receptor(s)	Assessment Endpoint
Terrestrial Ecosystem		
1° Producers – Terrestrial Plants	NA	Assessed through other communities and guilds
1° Consumers – Terrestrial Invertebrates	NA	Assessed through other communities and guilds
1° Consumers – Terrestrial, Herbivorous Birds	Chipping sparrow – *Spizella passerina* Surrogate – Northern Bobwhite (*Colinus virginianus*)	Protection of terrestrial, herbivorous birds that may ingest contaminated plants and surface water and incidental ingestion of associated soil from potentially lethal, reproductive, systemic, or general toxic effects of metals resulting from phosphate mining activities
1° Consumers – Terrestrial, Herbivorous Mammals	Black-tailed jackrabbit – *Lepus californicus* Surrogate – Eastern Cottontail (*Sylvilagus floridanus*)	Protection of terrestrial, herbivorous mammals that may ingest contaminated plants and surface water and incidental ingestion of associated soil from potentially systemic or general toxic effects of metals resulting from phosphate mining activities
2° Consumers – Terrestrial, Omnivorous Birds	American Robin – *Turdus migratorius*	Protection of terrestrial, omnivorous birds that may ingest contaminated food and surface water and associated soil or sediment from potentially lethal, mutagenic, reproductive, systemic, or general toxic effects of metals resulting from phosphate mining activities

TABLE 8-2 (continued)

PROPOSED ASSESSMENT ENDPOINTS AND ASSOCIATED RECEPTORS
AREA WIDE HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENT WORK PLAN
SOUTHEAST IDAHO PHOSPHATE MINING RESOURCE AREA

Community or Guild	Receptor(s)	Assessment Endpoint
Terrestrial Ecosystem (continued)		
2° Consumers – Terrestrial, Omnivorous Mammals	Deer Mouse – *Peromyscus maniculatus*	Protection of terrestrial, omnivorous mammals that may ingest contaminated plants prey, and surface water and incidental ingestion of associated soil and sediment from potentially systemic or general toxic effects of metals resulting from phosphate mining activities
2° Consumers – Reptiles	NA	Assessed through other communities and guilds
Aquatic and Riparian Ecosystem		
1° Producers – Phytoplankton and Aquatic Macrophytes	NA	Assessed through other communities and guilds
1° Consumers – Zooplankton and Benthic Invertebrates	NA	Assessed through other communities and guilds
1° Consumers – Aquatic and Riparian, Herbivorous Birds	Song Sparrow – *Melospiza melodia*	Protection of aquatic and riparian, herbivorous birds that may ingest contaminated plant food and incidental ingestion of associated soil, sediment, or surface water from potentially lethal, reproductive, systemic, or general toxic effects of metals resulting from phosphate mining activities
1° Consumers – Aquatic and Riparian, Herbivorous Mammals	Long-tailed Vole – *Microtus longicaudus* Surrogate – Meadow vole (*Microtus pennsylvanicus*)	Protection of aquatic and riparian, herbivorous mammals that may ingest contaminated plant food and incidental ingestion of associated soil, sediment, or surface water from potentially systemic or general toxic effects of metals resulting from phosphate mining activities

TABLE 8-2 (continued)

PROPOSED ASSESSMENT ENDPOINTS AND ASSOCIATED RECEPTORS
AREA WIDE HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENT WORK PLAN
SOUTHEAST IDAHO PHOSPHATE MINING RESOURCE AREA

Guild	Receptor(s)	Assessment Endpoint
Aquatic and Riparian Ecosystem (continued)		
1° Consumers – Benthic Fish	Common carp – *Cyprinus carpio*	Protection of benthic fish from contaminated food and associated sediments form potentially lethal, mutagenic, reproductive, systemic or general toxic effects of metals resulting from phosphate mining activities
2° Consumers – Aquatic and Riparian, Omnivorous Birds	Yellow-headed blackbird – *Xanthocephalus xanthocephalus* Surrogate will be the Red-winged blackbird – *Agelaius phoeniceus*	Protection of aquatic and riparian, omnivorous birds that may ingest contaminated food and associated soil, sediment, or water from potentially lethal, mutagenic, reproductive, systemic, or general toxic effects of metals resulting from phosphate mining activities
2° Consumers – Aquatic and Riparian, Piscivorous Birds	Great blue heron – *Ardea herodias*	Protection of aquatic and riparian, piscivorous birds that may ingest contaminated food and associated sediment or water from potentially lethal, mutagenic, reproductive, systemic, or general toxic effects of metals resulting from phosphate mining activities
2° Consumers – Aquatic and Riparian, Benthic-feeding Birds	Mallard – *Anas platyrhynchas*	Protection of aquatic and riparian, benthic-feeding birds that may ingest contaminated food and associated sediment or water from potentially lethal, mutagenic, reproductive, systemic, or general toxic effects of metals resulting from phosphate mining activities

TABLE 8-2 (continued)

PROPOSED ASSESSMENT ENDPOINTS AND ASSOCIATED RECEPTORS
AREA WIDE HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENT WORK PLAN
SOUTHEAST IDAHO PHOSPHATE MINING RESOURCE AREA

Guild	Receptor(s)	Assessment Endpoint
Aquatic and Riparian Ecosystem (continued)		
2° Consumers – Aquatic and Riparian, Omnivorous Mammals	Raccoon – *Procyon lotor*	Protection of aquatic and riparian, omnivorous mammals that may ingest contaminated plant food and incidental ingestion of associated soil, sediment, or water from potentially systemic or general toxic effects of metals resulting from phosphate mining activities
2° Consumers – Aquatic and Riparian, Carnivorous Mammals	Mink – *Mustela vison*	Protection of aquatic and riparian, carnivorous mammals that may ingest contaminated prey and incidental ingestion of associated soil, sediment, or water from potentially systemic or general toxic effects of metals resulting from phosphate mining activities
2° Consumers – Fish	Large-spotted Snake River cutthroat trout (Yellowstone cutthroat trout)– *Oncorhynchus clarki bouvieri* Surrogate is the Rainbow trout – *Oncorhynchus mykiss*	Protection of fish from contaminated food and associated sediments and water from potentially lethal, mutagenic, reproductive, systemic or general toxic effects of metals resulting from phosphate mining activities
2° Consumers – Amphibians	NA	Assessed through other communities and guilds
Tertiary Consumers		
3° Consumers – Carnivorous Mammals	Coyote – *Canis latrans*	Protection of carnivorous mammals that may ingest contaminated prey and incidental ingestion of associated soil, sediment, or water from potentially systemic or general toxic effects of metals resulting from phosphate mining activities

TABLE 8-2 (continued)

PROPOSED ASSESSMENT ENDPOINTS AND ASSOCIATED RECEPTORS
AREA WIDE HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENT WORK PLAN
SOUTHEAST IDAHO PHOSPHATE MINING RESOURCE AREA

Guild	Receptor(s)	Assessment Endpoint
Tertiary Consumers (continued)		
3° Consumers – Raptors	Northern Harrier (*Circus cyaneus*)	Protection of raptors that may ingest contaminated food and associated soil, sediment, or water from potentially lethal, mutagenic, reproductive, systemic, or general toxic effects of metals resulting from phosphate mining activities

Notes:

NA Not applicable

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TABLE 8-3

LIST OF MEASURMENT ENDPOINTS USED TO ASSESS THE ASSESSMENT ENDPOINT RECEPTOR
AREA WIDE HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENT WORK PLAN
SOUTHEAST IDAHO PHOSPHATE MINING RESOURCE AREA

Guild	Receptor	Assessment Endpoint	Measurement Endpoints
Terrestrial Ecosystem			
Terrestrial, Herbivorous Birds	Chipping sparrow Surrogate - Northern bobwhite	Protection of terrestrial, herbivorous birds that may ingest contaminated plants and surface water and incidental ingestion of associated soil from potentially lethal, reproductive, systemic, or general toxic effects of metals resulting from phosphate mining activities.	1. Measurement of COPEC concentrations in selected food items 2. Compare concentrations in food items to levels from areas not impacted by phosphate mining activities 3. Model chemical levels in food items to calculate a potential dose and compare this dose to appropriate toxicity threshold values
Terrestrial, Herbivorous Mammals	Black-tailed jackrabbit Surrogate – Eastern Cottontail	Protection of terrestrial, herbivorous mammals that may ingest contaminated plants and surface water and incidental ingestion of associated soil from potentially systemic or general toxic effects of metals resulting from phosphate mining activities.	1. Measurement of COPEC concentrations in selected food items 2. Compare concentrations in food items to levels from areas not impacted by phosphate mining activities 3. Model chemical levels in food items to calculate a potential dose and compare this dose to appropriate toxicity threshold values

TABLE 8-3 (continued)

LIST OF MEASURMENT ENDPOINTS USED TO ASSESS THE ASSESSMENT ENDPOINT RECEPTOR
AREA WIDE HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENT WORK PLAN
SOUTHEAST IDAHO PHOSPHATE MINING RESOURCE AREA

Guild	Receptor	Assessment Endpoint	Measurement Endpoints
Terrestrial Ecosystem (continued)			
Terrestrial, Omnivorous Birds	American robin	Protection of terrestrial, omnivorous birds that may ingest contaminated food and surface water and associated soil or sediment from potentially lethal, mutagenic, reproductive, systemic, or general toxic effects of metals resulting from phosphate mining activities.	1. Measurement of COPEC concentrations in selected food items 2. Compare concentrations in food items to levels from areas not impacted by phosphate mining activities 3. Model chemical levels in food items to calculate a potential dose and compare this dose to appropriate toxicity threshold values
Terrestrial, Omnivorous Mammals	Deer mouse	Protection of terrestrial, omnivorous mammals that may ingest contaminated plants, prey, and surface water and incidental ingestion of associated soil and sediment from potentially systemic or general toxic effects of metals resulting from phosphate mining activities.	1. Collect, analyze, and evaluate tissue residue data. 2. Measurement of COPEC concentrations in selected food items 3. Compare concentrations in food items to levels from areas not impacted by phosphate mining activities 4. Model chemical levels in food items to calculate a potential dose and compare this dose to appropriate toxicity threshold values

TABLE 8-3 (continued)

LIST OF MEASURMENT ENDPOINTS USED TO ASSESS THE ASSESSMENT ENDPOINT RECEPTOR
AREA WIDE HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENT WORK PLAN
SOUTHEAST IDAHO PHOSPHATE MINING RESOURCE AREA

Guild	Receptor	Assessment Endpoint	Measurement Endpoints
Aquatic and Riparian Ecosystem			
Aquatic and Riparian, Herbivorous Birds	Song sparrow	Protection of aquatic and riparian, herbivorous birds that may ingest contaminated plant food and incidental ingestion of associated soil, sediment, or surface water from potentially lethal, reproductive, systemic, or general toxic effects of metals resulting from phosphate mining activities.	1. Measurement of COPEC concentrations in selected food items 2. Compare concentrations in food items to levels from areas not impacted by phosphate mining activities 3. Model chemical levels in food items to calculate a potential dose and compare this dose to appropriate toxicity threshold values
Aquatic and Riparian, Herbivorous Mammals	Long-tailed vole Surrogate – Meadow vole	Protection of aquatic and riparian, herbivorous mammals that may ingest contaminated plant food and incidental ingestion of associated soil, sediment, or surface water from potentially systemic or general toxic effects of metals resulting from phosphate mining activities.	1. Collect, analyze, and evaluate tissue residue data 2. Measurement of COPEC concentrations in selected food items 3. Compare concentrations in food items to levels from areas not impacted by phosphate mining activities 4. Model chemical levels in food items to calculate a potential dose and compare this dose to appropriate toxicity threshold values

TABLE 8-3 (continued)

LIST OF MEASURMENT ENDPOINTS USED TO ASSESS THE ASSESSMENT ENDPOINT RECEPTOR
AREA WIDE HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENT WORK PLAN
SOUTHEAST IDAHO PHOSPHATE MINING RESOURCE AREA

Guild	Receptor	Assessment Endpoint	Measurement Endpoints
Aquatic and Riparian Ecosystem (continued)			
Benthic Fish	Common carp	Protection of benthic fish from contaminated food and associated sediments form potentially lethal, mutagenic, reproductive, systemic or general toxic effects of metals resulting from phosphate mining activities.	1. Collect, analyze, and evaluate tissue residue data 2. Measurement of COPEC concentrations in selected food items 3. Compare concentrations in food items to levels from areas not impacted by phosphate mining activities 4. Evaluate differences in aquatic community structure between impacted and background areas 5. Cutthroat trout toxicity studies
Aquatic and Riparian, Omnivorous Birds	Yellow-headed blackbird Surrogate-Red-winged blackbird	Protection of aquatic and riparian, omnivorous birds that may ingest contaminated food and associated soil, sediment, or water from potentially lethal, mutagenic, reproductive, systemic, or general toxic effects of metals resulting from phosphate mining activities.	1. Measurement of COPEC concentrations in selected food items 2. Compare concentrations in food items to levels from areas not impacted by phosphate mining activities 3. Model chemical levels in food items to calculate a potential dose and compare this dose to appropriate toxicity threshold values

TABLE 8-3 (continued)

LIST OF MEASURMENT ENDPOINTS USED TO ASSESS THE ASSESSMENT ENDPOINT RECEPTOR
AREA WIDE HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENT WORK PLAN
SOUTHEAST IDAHO PHOSPHATE MINING RESOURCE AREA

Guild	Receptor	Assessment Endpoint	Measurement Endpoints
Aquatic and Riparian Ecosystem (continued)			
Aquatic and Riparian, Piscivorous Birds	Great blue heron	Protection of aquatic and riparian, piscivorous birds that may ingest contaminated food and associated sediment or water from potentially lethal, mutagenic, reproductive, systemic, or general toxic effects of metals resulting from phosphate mining activities.	1. Measurement of COPEC concentrations in selected food items 2. Compare concentrations in food items to levels from areas not impacted by phosphate mining activities 3. Model chemical levels in food items to calculate a potential dose and compare this dose to appropriate toxicity threshold values
Aquatic and Riparian, Benthic-feeding Birds	Mallard	Protection of aquatic and riparian, benthic-feeding birds that may ingest contaminated food and associated sediment or water from potentially lethal, mutagenic, reproductive, systemic, or general toxic effects of metals resulting from phosphate mining activities.	1. Measurement of COPEC concentrations in selected food items 2. Compare concentrations in food items to levels from areas not impacted by phosphate mining activities 3. Model chemical levels in food items to calculate a potential dose and compare this dose to appropriate toxicity threshold values

TABLE 8-3 (continued)

LIST OF MEASURMENT ENDPOINTS USED TO ASSESS THE ASSESSMENT ENDPOINT RECEPTOR
AREA WIDE HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENT WORK PLAN
SOUTHEAST IDAHO PHOSPHATE MINING RESOURCE AREA

Guild	Receptor	Assessment Endpoint	Measurement Endpoints
Aquatic and Riparian, Omnivorous Mammals	Raccoon	Protection of aquatic and riparian, omnivorous mammals that may ingest contaminated plant food and incidental ingestion of associated soil, sediment, or water from potentially systemic or general toxic effects of metals resulting from phosphate mining activities.	1. Measurement of COPEC concentrations in selected food items 2. Compare concentrations in food items to levels from areas not impacted by phosphate mining activities 3. Model chemical levels in food items to calculate a potential dose and compare this dose to appropriate toxicity threshold values
Aquatic and Riparian, Carnivorous Mammals	Mink	Protection of aquatic and riparian, carnivorous mammals that may ingest contaminated prey and incidental ingestion of associated soil, sediment, or water from potentially systemic or general toxic effects of metals resulting from phosphate mining activities.	1. Measurement of COPEC concentrations in selected food items 2. Compare concentrations in food items to levels from areas not impacted by phosphate mining activities 3. Model chemical levels in food items to calculate a potential dose and compare this dose to appropriate toxicity threshold values

TABLE 8-3 (continued)

LIST OF MEASURMENT ENDPOINTS USED TO ASSESS THE ASSESSMENT ENDPOINT RECEPTOR
AREA WIDE HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENT WORK PLAN
SOUTHEAST IDAHO PHOSPHATE MINING RESOURCE AREA

Guild	Receptor	Assessment Endpoint	Measurement Endpoints
Aquatic and Riparian Ecosystem (continued)			
Fish	Large-spotted Snake river cutthroat trout Surrogate- Rainbow trout	Protection of fish from contaminated food and associated sediments and water from potentially lethal, mutagenic, reproductive, systemic or general toxic effects of metals resulting from phosphate mining activities.	1. Collect, analyze, and evaluate tissue residue data 2. Measurement of COPEC concentrations in selected food items 3. Compare concentrations in food items to levels from areas not impacted by phosphate mining activities 4. Evaluate differences in aquatic community structure between impacted and background areas 5. Cutthroat trout toxicity studies
Carnivorous Mammals	Coyote	Protection of carnivorous mammals that may ingest contaminated prey and incidental ingestion of associated soil, sediment, or water from potentially systemic or general toxic effects of metals resulting from phosphate mining activities.	1. Measurement of COPEC concentrations in selected food items 2. Compare concentrations in food items to levels from areas not impacted by phosphate mining activities 3. Model chemical levels in food items to calculate a potential dose and compare this dose to appropriate toxicity threshold values

TABLE 8-3 (continued)

LIST OF MEASURMENT ENDPOINTS USED TO ASSESS THE ASSESSMENT ENDPOINT RECEPTOR
AREA WIDE HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENT WORK PLAN
SOUTHEAST IDAHO PHOSPHATE MINING RESOURCE AREA

Guild	Receptor	Assessment Endpoint	Measurement Endpoints
Aquatic and Riparian Ecosystem (continued)			
Raptors	Northern harrier	Protection of raptors that may ingest contaminated food and associated soil, sediment, or water from potentially lethal, mutagenic, reproductive, systemic, or general toxic effects of metals resulting from phosphate mining activities.	1. Measurement of COPEC concentrations in selected food items 2. Compare concentrations in food items to levels from areas not impacted by phosphate mining activities 3. Model chemical levels in food items to calculate a potential dose and compare this dose to appropriate toxicity threshold values

Notes:

COPEC Chemical of potential ecological concern

TABLE 8-4

SUMMARY OF CONSERVATIVE EXPOSURE PARAMETERS FOR BIRDS AND MAMMALS
AREA WIDE HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENT WORK PLAN
SOUTHEAST IDAHO PHOSPHATE MINING RESOURCE AREA

Exposure Parameter	Assumptions	Reference and Basis of Value
Body Weight (grams/kilograms)		
Northern bobwhite	189/0.189	Robel (1969, as cited in EPA 1993), based on lowest mean body weight of both sexes for three seasons from Kansas
Eastern cottontail	700.0/0.7	Lord (1963, as cited in EPA 1993), based on lowest body weight for both sexes from Illinois
American robin	63.5/0.64	Based on the lowest body weight of an adult robin of both sexes from Pennsylvania (Clench and Leberman 1978, as cited in EPA 1993)
Deer mouse	20.0/0.02	Millar (1989, as cited in EPA 1993), based on lowest mean body weight for both males and females form North America
Song sparrow	23.15	Smith and Arcese (1988)
Meadow vole	35.5/0.036	Myers and Krebs (1971, as cited in EPA 1993), based on lowest mean for both males and females all year from south Indiana
Red-winged blackbird	43.0	Beletsky (1996)
Great blue heron	2,090.0/2.09	Lowest body weight (Butler 1992)
Mallard duck	1,043.0/1.043	Nelson and Martin (1953, as cited in EPA 1993), based on mean lowest body weight for females throughout the United States
Raccoon	5,900.0/5.9	Sanderson (1984, as cited in EPA 1993), based on lowest body weights of wild caught males and females from Illinois.
Mink	568.0/0.568	Mitchell (1961, as cited in EPA 1993), based on the lowest mean body weight for females for summer and fall from Montana
Coyote	9,500/9.5	Based on females from Minnesota (Windberg and others 1997)
Northern harrier	435.0/0.435	Bildstein (1988, as cited in MacWhirter and Bildstein 1996)
Dietary Composition		
Northern bobwhite	85.6% Vegetation; 14.4% invertebrates	Handley (1931, as cited in EPA 1993), based on average percentage from birds in the southeastern United States
Eastern cottontail	100% vegetation	EPA (1993)
American robin	50% Vegetation and 50% invertebrates	EPA (1993)

TABLE 8-4 (continued)

SUMMARY OF CONSERVATIVE EXPOSURE PARAMETERS FOR BIRDS AND MAMMALS
AREA WIDE HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENT WORK PLAN
SOUTHEAST IDAHO PHOSPHATE MINING RESOURCE AREA

Exposure Parameter	Assumptions	Reference and Basis of Value
Dietary Composition (continued)		
Deer mouse	54.5% vegetation and 55.5% invertebrates	Flake (1973, as cited in EPA 1993), based on average of four seasons diet for mice from Colorado short grass prairie
Song sparrow	Primarily herbivorous and granivorous; may consume insects and other invertebrates during yoke formation	University of Michigan (2000) (http://animaldiversity.ummz.umich.edu/accounts/melospiza/m._melodia$narrative.html)
Meadow vole	98% vegetation and 2% invertebrates	Lindroth and Batzli (1984, as cited in EPA 1993), based on average of two studies during four seasons in Illinois
Red-winged blackbird	90% plant material, seeds, and grains in fall and winter; 70% insects and 17% grain during the breeding season	Diet during fall and winter taken from Bent (1985), Martin and others (1961), and Crase and DeHaven (1978), as cited in Zeiner and others (1990) Diet of males and females during breeding season in agricultural and non-agricultural land in Ontario, Canada based on McNicholl (1987)
Great blue heron	72% Fish, 17% invertebrates, and 11% miscellaneous	Prey ingestion percentages (Zeiner and others 1990)
Mallard duck	25.3% vegetation and 74.7% invertebrates	Swanson and others (1985, as cited in EPA 1993), based on spring breeding season in south-central North Dakota prairie pothole area

TABLE 8-4 (continued)

SUMMARY OF CONSERVATIVE EXPOSURE PARAMETERS FOR BIRDS AND MAMMALS
AREA WIDE HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENT WORK PLAN
SOUTHEAST IDAHO PHOSPHATE MINING RESOURCE AREA

Exposure Parameter	Assumptions	Reference and Basis of Value
Dietary Composition (continued)		
Raccoon	48.48% vegetation, 31.78% invertebrates, 9.28% mammals, 6.33% reptiles/amphibians, 1.75% fish, 1.5% birds, and 0.91% other not identified	Tabatabai and Kennedy (1988) and Hamilton (1951), as cited in EPA (1993), based on average of percent wet volume of digestive tract or stomach contents of raccoons from Tennessee (four seasons) and New York (summer only)
Mink	54% trout, 19% other fish, 7.5% invertebrates. 2.5% amphibians, 5.5% birds and mammals, 9% vegetation, and 2.5% unidentified	Alexander (1977, as cited in EPA 1993), based on stomach contents for four seasons from Michigan streams and rivers
Coyote	90% mice, rats, rabbits, squirrels, and carrion. Some deer and ground nesting birds. Various fruits, berries, seeds, and grasses consumed when available	Omnivorous based on http://www.ukans.edu/~mammals/canis-latr.html
Northern harrier	80% mammals, 15% birds, 3% reptiles and amphibians, and 2% invertebrates	Bildstein (1987), based on pellet content in the northern part of the harrier range and another study by Brown and Amadon (1968)

TABLE 8-4 (continued)

SUMMARY OF CONSERVATIVE EXPOSURE PARAMETERS FOR BIRDS AND MAMMALS
AREA WIDE HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENT WORK PLAN
SOUTHEAST IDAHO PHOSPHATE MINING RESOURCE AREA

Exposure Parameter	Assumptions	Reference and Basis of Value
Food Ingestion Rate (grams per day)		
Northern bobwhite	27.095	Value shown is calculated using mean body weight (BW=193.9 grams) in an allometric equation for all birds, food requirements for omnivores (10.5 x [BW in grams]$^{0.681}$)/14 (Nagy and others 1999)
Eastern cottontail	100.63	Value shown is calculated using mean body weight (BW=1,800 grams) in an allometric equation for herbivorous mammals, food requirements for herbivores (7.94 x [BW in grams]$^{0.646}$)/10 (Nagy and others 1999)
American robin	17.61	Value shown is calculated using mean body weight (BW=103 grams) in an allometric equation for all birds, food requirements for omnivores (10.5 x [BW in grams]$^{0.681}$)/14 (Nagy and others 1999)
Deer mouse	3.54	Value shown is calculated using mean body weight (BW=22 grams) in an allometric equation for rodents, food requirements for omnivores (5.48 x [BW in grams]$^{0.712}$)/14 (Nagy and others 1999)
Song sparrow	6.37	Value shown is calculated using mean body weight (BW= 23.15 grams) in an allometric equation for all birds, food requirements for omnivores (10.5 x [BW in grams]$^{0.681}$)/14 (Nagy and others 1999)
Meadow vole	7.44	Value shown is calculated using mean body weight (BW= 39 grams) in an allometric equation for rodents, food requirements for herbivores (5.48 x [BW in grams]$^{0.712}$)/10 (Nagy and others 1999)
Red-winged blackbird	9.7	Value shown is calculated using mean body weight (BW= 43 grams) in an allometric equation for all birds, food requirements for omnivores (10.5 x [BW in grams]$^{0.681}$)/14 (Nagy and others 1999)
Great blue heron	133.56	Value shown calculated using mean body weight (BW=2,500 grams) in an allometric equation for all birds, food requirements for piscivores (10.5 x [BW in grams]$^{0.681}$)/16.2 (Nagy and others 1999)
Mallard duck	124.22	Value shown calculated using mean body weight (BW=1,814 grams) in an allometric equation for all birds, food requirements for omnivores (10.5 x [BW in grams]$^{0.681}$)/14 (Nagy and others 1999)
Raccoon	155.17	Value shown is calculated using mean body weight (BW=7,100 grams) in an allometric equation for omnivorous mammals, food requirements for omnivores (6.03 x [BW in grams]$^{0.678}$)/14 (Nagy and others 1999)
Mink	31.7	Value shown is calculated using mean body weight (BW= 1,040 grams) in an allometric equation for omnivorous mammals, food requirements for omnivores (6.03 x [BW in grams]$^{0.678}$)/14 (Nagy and others 1999)
Coyote	251.115	Value shown is calculated using mean body weight (BW=12,000 grams) in an allometric equation for omnivorous mammals, food requirements for omnivores (6.03 x [BW in grams]$^{0.678}$)/14 (Nagy and others 1999)
Northern harrier	48.23	Calculated using mean body weight (BW=654 grams) in an allometric equation for all birds, food requirements for all birds (10.5 x [BW]$^{0.681}$)/18 (Nagy and others 1999)

TABLE 8-4 (continued)

SUMMARY OF CONSERVATIVE EXPOSURE PARAMETERS FOR BIRDS AND MAMMALS
AREA WIDE HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENT WORK PLAN
SOUTHEAST IDAHO PHOSPHATE MINING RESOURCE AREA

Exposure Parameter	Assumptions	Reference and Basis of Value
Water Ingestion Rate (liters per day)		
Northern bobwhite	0.020	Value shown is based on the following equation: $IR_{water} = 0.059 \times BW(kg)^{0.67}$ (EPA 1993)
Eastern cottontail	0168	Value shown is based on the following equation: $IR_{water} = 0.099 \times BW(kg)^{0.90}$ (EPA 1993)
American robin	0.013	Value shown is based on the following equation: $IR_{water} = 0.059 \times BW(kg)^{0.67}$ (EPA 1993)
Deer mouse	0.319	Actual value shown is based on the following equation: $IR_{water} = 0.099 \times BW(kg)^{0.90}$ (EPA 1993)
Song sparrow	0.0047	Value shown is based on the following equation: $IR_{water} = 0.059 \times BW(kg)^{0.67}$ (EPA 1993)
Meadow vole	0.005	Actual value shown is based on the following equation: $IR_{water} = 0.099 \times BW(kg)^{0.90}$ (EPA 1993)
Red-winged blackbird	0.007	Value shown is based on the following equation: $IR_{water} = 0.059 \times BW(kg)^{0.67}$ (EPA 1993)
Great blue heron	0.109	Actual value shown is based on the following equation: $IR_{water} = 0.059 \times BW(kg)^{0.67}$ (EPA 1993)
Mallard duck	0.088	Actual value shown is based on the following equation: $IR_{water} = 0.059 \times BW(kg)^{0.67}$ (EPA 1993)
Raccoon	0.489	Actual value shown is based on the following equation: $IR_{water} = 0.099 \times BW(kg)^{0.90}$ (EPA 1993)
Mink	0.059	Actual value shown is based on the following equation: $IR_{water} = 0.099 \times BW(kg)^{0.90}$ (EPA 1993)
Coyote	0.930	Actual value shown is based on the following equation: $IR_{water} = 0.099 \times BW(kg)^{0.90}$ (EPA 1993)
Northern harrier	0.044	Estimated based on the following equation: $IR_{water} = 0.059 \times BW(kg)^{0.67}$ (EPA 1993)
Soil/Sediment Ingestion Rate (grams per day)		
Northern bobwhite	0.54	Ingestion of soil (I_{soil}) as percentage of food intake reported at 2% for omnivores (Beyer 1994)
Eastern cottontail	2.42	Ingestion of soil (I_{soil}) as percentage of food intake reported at 2.4% for herbivores (Beyer 1994)
American robin	0.35	Ingestion of soil (I_{soil}) as percentage of food intake reported at 2% for omnivores (Beyer 1994)
Deer mouse	0.07	Deer mouse consumption habits are assumed to be similar to those of the white-footed mouse. Ingestion of soil (I_{soil}) as percentage of food intake reported at 2% for white-footed mouse (Beyer 1994)
Song sparrow	0.1274	Ingestion of soil (I_{soil}) as percentage of food intake reported at 2% for omnivores (Beyer 1994)
Meadow vole	0.18	Ingestion of soil (I_{soil}) as percentage of food intake reported at 2.4% for meadow vole (Beyer 1994)
Red-winged blackbird	0.241	Ingestion of soil (I_{soil}) as percentage of food intake reported at 2% for omnivores (Beyer 1994)
Great blue heron	0.93	Ingestion of sediment (I_{sed}) as percentage of food intake based on 0.7 percent of IR, which is based on studies of the bald eagle (Pascoe and others 1996)
Mallard duck	4.10	Ingestion of sediment (I_{sed}) as percentage of food intake reported at 3.3% for mallard (Beyer 1994)

TABLE 8-4 (continued)

SUMMARY OF CONSERVATIVE EXPOSURE PARAMETERS FOR BIRDS AND MAMMALS
AREA WIDE HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENT WORK PLAN
SOUTHEAST IDAHO PHOSPHATE MINING RESOURCE AREA

Exposure Parameter	Assumptions	Reference and Basis of Value
Soil/Sediment Ingestion Rate (grams per day) (continued)		
Raccoon	14.59	Ingestion of soil/sediment ($I_{soil/sed}$) as percentage of food intake reported at 9.4% for raccoon (Beyer 1994)
Mink	2.98	Mink food consumption habits are assumed to be similar to those of the raccoon. Ingestion of soil/sediment ($I_{soil/sed}$) as percentage of food intake reported at 9.4% for raccoon (Beyer 1994)
Coyote	7.03	Coyote food consumption habits are assumed to be similar to those of the red fox. Based on ingestion of soil (I_{soil}) as percentage of food intake reported at 2.8% for the red fox (Beyer 1994)
Northern harrier	0.34	Harrier food consumption habits are assumed to be similar to those of bald eagles. Based on 0.7% of estimated sediment ingestion rate for bald eagle in Pascoe and others (1996)
Home Range (acres)		
Northern bobwhite	38.55	Urban (1972, as cited in EPA 1993), based on highest mean home range of postnesting females from southern Illinois
Eastern cottontail	7.39	Dixon and others (1981, as cited in EPA 1993), based on highest mean range of females during winter in Wisconsin
American robin	0.395	Based on mean territory size for both sexes from New York in dense conifers and unspecified forest (Howell 1942, as cited in the EPA 1993)
Deer mouse	0.23	Bowers and Smith (1979, as cited in EPA 1993), based on highest mean of female range from Idaho desert area
Song sparrow	4.25	Based on the highest home range of adult females in Marin County, California (Halliburton and Mewaldt 1976)
Meadow vole	0.03	Douglass (1976, as cited in EPA 1993), based on greatest range both sexes during summer from alluvial bench in Montana
Red-winged blackbird	0.555	Highest mean territory size based on observations in uplands and marshlands (Weatherford and Robertson 1977; Eckert and Weatherford 1977; and Searcy and Yasukawa 1995 as cited in Yasukawa and Searcy 1995)
Great blue heron	20.76	Largest feeding territory for both sexes in winter in an Oregon estuary (Bayer 1978, as cited in EPA 1993)
Mallard duck	1,776.65	"Dwyer and others (1979); Kirby and others (1985, as cited in EPA 1993), based on mean of reported mean values of adult males and females."
Raccoon	8,127	Fritzell (1978, as cited in EPA 1993), based on highest male and female home ranges in North Dakota prairie pothole area
Mink	4,524	Mitchell (1961, as cited in EPA 1993 and http://www.sibr.com/mammals/M158.html), based on highest male home ranges in Montana from heavy and sparse vegetation riverine area

TABLE 8-4 (continued)

SUMMARY OF CONSERVATIVE EXPOSURE PARAMETERS FOR BIRDS AND MAMMALS
AREA WIDE HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENT WORK PLAN
SOUTHEAST IDAHO PHOSPHATE MINING RESOURCE AREA

Exposure Parameter	Assumptions	Reference and Basis of Value
Home Range (Acres) (continued)		
Coyote	7,240.00	Woodruff and Keller (1982)
Northern harrier	3,706.50	Highest home range of eight studies (Smith and Murphy 1973; Rees 1976; Toland 1985a; Martin 1987; Serrantino 1987, as cited in MacWhirter and Bildstein 1996)

Notes:

BW Body weight
EPA U.S. Environmental Protection Agency
g/day Grams per day
IR Ingestion rate
kg Kilogram

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TABLE 8-5

SUMMARY OF MEAN EXPOSURE PARAMETERS FOR BIRDS AND MAMMALS
AREA WIDE HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENT WORK PLAN
SOUTHEAST IDAHO PHOSPHATE MINING RESOURCE AREA

Exposure Parameter	Mean	Reference and Basis of Value
Body Weight (grams per kilogram)		
Northern bobwhite	191.13/0.191	Robel (1969, as cited in EPA 1993) based on average body weight of both sexes for three seasons from Kansas
Eastern cottontail	1,231.0/1.231	Lord (1963, as cited in EPA 1993) based on mean for both sexes from Illinois
American robin	77.3/0.077	Based on the mean body weight of an adult robin form Pennsylvania (Clench and Leberman 1978, as cited in EPA 1993)
Deer mouse	21.0/0.021	Millar (1989, as cited in EPA 1993) based on body weights for both males and females from North America
Song sparrow	23.48	Smith and Arcese (1988)
Meadow vole	37.25/0.037	Myers and Krebs (1971, as cited in EPA 1993) based on average body weights of males and females from collections made all year from south Indiana
Red-winged blackbird	59.0	Beletsky (1996)
Great blue heron	2,090.0/2.09	Body weight (Butler 1992)
Mallard duck	1,134.0/1.134	Nelson and Martin (1953, as cited in EPA 1993) based on average of mean body weights for both males and females from throughout the United States
Raccoon	6,666/6.7	Sanderson (1984, as cited in EPA 1993) based on mean body weights of wild caught males and females from Illinois
Mink	852/0.852	Mitchell (1961, as cited in EPA 1993) based on the average of mean body weights for both males and females for summer and fall from Montana
Coyote	10,500/10.5	Based on females from Minnesota (Windberg and others 1997; Berg and Chesness 1978)
Northern harrier	513.0 /0513	Bildstein (1988, as cited in MacWhirter and Bildstein 1996)
Dietary Composition		
Northern bobwhite	85.6% Vegetation; 14.4% invertebrates	Handley (1931, as cited in EPA 1993) based on average percentage from birds in the southeastern United States
Eastern cottontail	100% vegetation	EPA (1993)
American robin	50% Vegetation and 50% invertebrates	EPA (1993)
Deer mouse	54.5% vegetation and 55.5% invertebrates	Flake (1973, as cited in EPA 1993) based on average of four seasons diet for mice from Colorado short grass prairie
Song sparrow	Primarily herbivorous and granivorous; may consume insects and other invertebrates during yoke formation	University of Michigan (2000) (http://aniumaldiversity.ummz.umich.edu/accounts/melospiza/m._melodia$narrative.html)

TABLE 8-5 (continued)

SUMMARY OF MEAN EXPOSURE PARAMETERS FOR BIRDS AND MAMMALS
AREA WIDE HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENT WORK PLAN
SOUTHEAST IDAHO PHOSPHATE MINING RESOURCE AREA

Exposure Parameter	Mean	Reference and Basis of Value
Dietary Composition (continued)		
Meadow vole	98% vegetation and 2% invertebrates	Lindroth and Batzli (1984, as cited in EPA 1993) based on average of two studies during four seasons in Illinois
Red-winged blackbird	90% plant material, seeds, and brains in fall and winter; 70% insects and 17% grain during the breeding season	Diet during fall and winter taken from Brent (1985), Martin and others (1961), and Crase and DeHaven (1978), as cited in Ziener and others (1990) Diet of males and females during breeding season in agricultural and non-agricultural land based on McNicholl (1987)
Great blue heron	72% Fish, 17% invertebrates, and 11% miscellaneous	Prey ingestion percentages (Zeiner and others 1990)
Mallard duck	25.3% vegetation and 74.7% invertebrates	Swanson and others (1985, as cited in EPA 1993), based on spring breeding season in south central North Dakota prairie pothole area
Raccoon	48.48% vegetation, 31.78% invertebrates, 9.28% mammals, 6.33% reptiles/amphibians, 1.75% fish, 1.5% birds, and 0.91% other not identified	Tabatabai and Kennedy (1988) and Hamilton (1951) as cited in EPA (1993) based on average of percent wet volume of digestive tract or stomach contents of raccoons from Tennessee (four seasons) and New York (summer only)
Mink	54% trout, 19% other fish, 7.5% invertebrates., 2.5% amphibians, 5.5% birds and mammals, 9% vegetation, and 2.5% unidentified	Alexander (1977, as cited in EPA 1993), based on stomach contents for four seasons from Michigan streams and rivers
Coyote	90% mice, rats, rabbits, squirrels, and carrion. Some deer and ground nesting birds. Various fruits, berries, seeds, and grasses consumed when available.	Omnivorous, based on http://www.ukans.edu/~mammals/canis-latr.html

TABLE 8-5 (continued)

SUMMARY OF MEAN EXPOSURE PARAMETERS FOR BIRDS AND MAMMALS
AREA WIDE HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENT WORK PLAN
SOUTHEAST IDAHO PHOSPHATE MINING RESOURCE AREA

Exposure Parameter	Mean	Reference and Basis of Value
Dietary Composition (continued)		
Northern harrier	80% mammals, 15% birds, 3% reptiles and amphibians, and 2% invertebrates	Bildstein (1987), based on pellet content in the northern part of the harrier range and another study by Brown and Amadon (1968)
Food Ingestion Rate (grams per day)		
Northern bobwhite	26.83	Published value of 0.078 g/g-day in Koerth and Guthery (1991, as cited in EPA 1993), based on average of ingestion rates for both sexes over four seasons from captive breed birds in southern Texas. Value shown is calculated using mean body weight (BW=191.13 grams) in an allometric equation for all birds, food requirements for omnivores (10.5 x [BW in grams]$^{0.681}$)/14 (Nagy and others 1999)
Eastern cottontail	78.73	Value shown is calculated using mean body weight (BW=1,231 grams) in an allometric equation for herbivorous mammals, food requirements for herbivores (7.94 x [BW in grams]$^{0.646}$)/10 (Nagy and others 1999)
American robin	14.48	Value shown is calculated using mean body weight (BW=77.3 grams) in an allometric equation for all birds, food requirements for omnivores (10.5 x [BW in grams]$^{0.681}$)/14 (Nagy and others 1999)
Deer mouse	3.42	Published value of 0.27 g/g-day based on average of five studies of nonbreeding and lactating females and one nonbreeding male (EPA 1993). Value shown is calculated using mean body weight (BW=21 grams) in an allometric equation for rodents, food requirements for omnivores (5.48 x [BW in grams]$^{0.712}$)/14 (Nagy and others 1999)
Song sparrow	6.43	Value shown is calculated using mean body weight (BW= 23.48 grams) in an allometric equation for all birds, food requirements for omnivores (10.5 x [BW in grams]$^{0.681}$)/14 (Nagy and others 1999)
Meadow vole	7.201	Published value of 0.325 g/g-day Ognev (1950, as cited in EPA 1993), based on midpoint of mean from study in Russia. Value shown is calculated using mean body weight (BW=37.25 grams) in an allometric equation for rodents, food requirements for herbivores (5.48 x [BW in grams]$^{0.712}$)/10 (Nagy and others 1999)
Red-winged blackbird	12.05	Value shown is calculated using mean body weight (BW= 59.0 grams) in an allometric equation for all birds, food requirements for omnivores (10.5 x [BW in grams]$^{0.681}$)/14 (Nagy and others 1999)
Great blue heron	118.22	Value shown calculated using mean body weight (BW=2,090 grams) in an allometric equation for all birds, food requirements for piscivores (10.5 x [BW in grams]$^{0.681}$)/16.2 (Nagy and others 1999)

TABLE 8-5 (continued)

SUMMARY OF MEAN EXPOSURE PARAMETERS FOR BIRDS AND MAMMALS
AREA WIDE HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENT WORK PLAN
SOUTHEAST IDAHO PHOSPHATE MINING RESOURCE AREA

Exposure Parameter	Mean	Reference and Basis of Value
Food Ingestion Rate (grams per day) (continued)		
Mallard duck	90.21	Value shown calculated using mean body weight (BW=1,134 grams) in an allometric equation for all birds, food requirements for omnivores (10.5 x [BW in grams]$^{0.681}$)/14 (Nagy and others 1999)
Raccoon	168.56	Value shown is calculated using mean body weight (BW=6,666 grams) in an allometric equation for omnivorous mammals, food requirements for omnivores (6.03 x [BW in grams]$^{0.678}$)/14 (Nagy and others 1999)
Mink	41.79	Published value of 0.22 g/g-day (EPA 1993) estimated value for male for year-round. Value shown is calculated using mean body weight (BW=852.25 grams) in an allometric equation for omnivorous mammals, food requirements for omnivores (6.03 x [BW in grams]$^{0.678}$)/14 (Nagy and others 1999)
Coyote	229.38	Value shown is calculated using mean body weight (BW=10,500 grams) in an allometric equation for omnivorous mammals, food requirements for omnivores (6.03 x [BW in grams]$^{0.678}$)/14 (Nagy and others 1999)
Northern harrier	40.88	Calculated using mean body weight (BW=513.0 grams) in an allometric equation for all birds, food requirements for all birds (10.5 x [BW]$^{0.681}$)/18 (Nagy and others 1999)
Water Ingestion Rate (liters per day)		
Northern bobwhite	0.019	Reported value of 0.105 g/g-day from EPA (1993), based on estimate for male and female in summer. Value shown is based on the following equation: $IR_{water} = 0.059 \times BW(kg)^{0.67}$ (EPA 1993)
Eastern cottontail	0.12	Published value of 0.097 g/g-day, based on estimate for both sexes (EPA 1993). Value shown is based on the following equation: $IR_{water} = 0.099 \times BW(kg)^{0.90}$ (EPA 1993)
American robin	0.011	Published value of 0.14 g/g-day (EPA 1993). Value shown is based on the following equation: $IR_{water} = 0.059 \times BW(kg)^{0.67}$ (EPA 1993)
Deer mouse	0.31	Published value of $IR_{water} = 0.19$ g/g-day, based on Ross (1930); Dice (1922, as cited in EPA 1993) based on two laboratory studies in Illinois for both sexes. Actual value shown is based on the following equation: $IR_{water} = 0.099 \times BW(kg)^{0.90}$ (EPA 1993)
Song sparrow	0.0053	Value shown is based on the following equation: $IR_{water} = 0.059 \times BW(kg)^{0.67}$ (EPA 1993)
Meadow vole	0.005	Published value of 0.14 g/g-day EPA (1993) based on estimated value for both sexes. Actual value shown is based on the following equation: $IR_{water} = 0.099 \times BW(kg)^{0.90}$ (EPA 1993)
Red-winged blackbird	0.0089	Value shown is based on the following equation: $IR_{water} = 0.059 \times BW(kg)^{0.67}$ (EPA 1993)
Great blue heron	0.097	Published value of 0.045 g/g-day, based on estimated value for both sexes (EPA 1993). Actual value shown is based on the following equation: $IR_{water} = 0.059 \times BW(kg)^{0.67}$ (EPA 1993)
Mallard duck	0.064	Actual value shown is based on the following equation: $IR_{water} = 0.059 \times BW(kg)^{0.67}$ (EPA 1993)

TABLE 8-5 (continued)

SUMMARY OF MEAN EXPOSURE PARAMETERS FOR BIRDS AND MAMMALS
AREA WIDE HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENT WORK PLAN
SOUTHEAST IDAHO PHOSPHATE MINING RESOURCE AREA

Exposure Parameter	Mean	Reference and Basis of Value
Water Ingestion Rate (liters per day) (continued)		
Raccoon	0.553	Published value of 0.083 g/g-day (EPA 1993), based on estimated rate for female. Actual value shown is based on the following equation: $IR_{water} = 0.099 \times BW(kg)^{0.90}$ (EPA 1993)
Mink	0.0857	Published value of 0.11 g/g-day (EPA 1993), based on estimated rate for female. Actual value shown is based on the following equation: $IR_{water} = 0.099 \times BW(kg)^{0.90}$ (EPA 1993)
Coyote	0.822	Actual value shown is based on the following equation: $IR_{water} = 0.099 \times BW(kg)^{0.90}$ (EPA 1993)
Northern harrier	0.0377	Estimated based on the following equation: $IR_{water} = 0.059 \times BW(kg)^{0.67}$ (EPA 1993)
Soil/Sediment Ingestion Rate (grams per day)		
Northern bobwhite	0.54	Ingestion of soil (I_{soil}) as percentage of food intake reported at 2% for omnivores (Beyer 1994)
Eastern cottontail	1.89	Ingestion of soil (I_{soil}) as percentage of food intake reported at 2.4% for herbivores (Beyer 1994)
American Robin	0.29	Ingestion of soil (I_{soil}) as percentage of food intake reported at 2% for omnivores (Beyer 1994)
Deer mouse	0.07	Deer mouse consumption habits are assumed to be similar to those of the white-footed mouse. Ingestion of soil (I_{soil}) as percentage of food intake reported at 2% for white-footed mouse (Beyer 1994)
Song sparrow	0.1286	Ingestion of soil (I_{soil}) as percentage of food intake reported at 2% for white-footed mouse (Beyer 1994)
Meadow vole	0.173	Ingestion of soil (I_{soil}) as percentage of food intake reported at 2.4% for meadow vole (Beyer 1994)
Red-winged blackbird	0.241	Ingestion of soil (I_{soil}) as percentage of food intake reported at 2% for white-footed mouse (Beyer 1994)
Great blue heron	0.83	Ingestion of sediment (I_{sed}) as percentage of food intake based on 0.7% of IR, which is based on studies of the bald eagle (Pascoe and others 1996)
Mallard duck	2.98	Ingestion of sediment (I_{sed}) as percentage of food intake reported at 3.3% for mallard (Beyer 1994)
Raccoon	15.84	Ingestion of soil/sediment ($I_{soil/sed}$) as percentage of food intake reported at 9.4% for raccoon (Beyer 1994)
Mink	3.92	Mink food consumption habits are assumed to be similar to those of the raccoon. Ingestion of soil/sediment ($I_{soil/sed}$) as percentage of food intake reported at 9.4% for raccoon (Beyer 1994)
Coyote	6.42	Coyote food consumption habits are assumed to be similar to those of the red fox. Based on ingestion of soil (I_{soil}) as percentage of food intake reported at 2.8% for the red fox (Beyer 1944)
Northern harrier	0.286	Harrier food consumption habits are assumed to be similar to those of bald eagles. Based on 0.7% of estimated sediment ingestion rate for bald eagle in Pascoe and others (1996)

TABLE 8-5 (continued)

SUMMARY OF MEAN EXPOSURE PARAMETERS FOR BIRDS AND MAMMALS
AREA WIDE HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENT WORK PLAN
SOUTHEAST IDAHO PHOSPHATE MINING RESOURCE AREA

Exposure Parameter	Mean	Reference and Basis of Value
Home Range (Acres)		
Northern bobwhite	28.61	Urban (1972, as cited in EPA 1993), based on average of mated and unmated males, nesting and post-nesting females from southern Illinois
Eastern cottontail	5.96	Trent and Rongstad (1974) and Dixon and others (1981, as cited in EPA 1993), based on average of males and females during summer, spring, and winter in Wisconsin
American robin	0.395	Based on adults of both sexes from New York in dense conifers and unspecified forest (Howell 1942, as cited in EPA 1993)
Deer mouse	0.279	Bowers and Smith (1979, as cited in EPA 1993), based on average of male and female range from Idaho desert area
Song sparrow	3.34	Based on the home range on adult males and females in Marin County, California (Halliburton and Mewaldt 1976)
Meadow vole	0.018	Douglass (1976, as cited in EPA 1993), based on average of both sexes during summer and winter from alluvial bench in Montana
Red-winged blackbird	0.494	Mean territory size based on observations in uplands and marshlands (Weatherford and Robertson 1977; Eckert and Weatherford 1977, and Searcy and Yasukawa 1995 as cited in Yasukawa and Searcy 1995)
Great blue heron	20.75	Foraging home range based on Krebs (1974, as cited in Zeiner and others 1990)
Mallard duck	1,074.9	Dwyer and others (1979); Kirby and others (1985, as cited in EPA 1993), based on mean of reported mean values for adult females
Raccoon	4,159	Fritzell (1978, as cited in EPA 1993), based on mean adult male and female home ranges during the spring and summer in North Dakota prairie pothole area
Mink	1,532	Mitchell (1961, as cited in EPA 1993 and http://www.sibr.com/mammals/M158.html), based on male and female home ranges in Montana from heavy and sparse vegetation riverine area
Coyote	7,240.0	Woodruff and Keller (1982)
Northern harrier	642.5	Median home range of 8 studies (Smith and Murphy 1973; Rees 1976; Toland 1985a; Martin 1987; Serrantino 1987, as cited in MacWhirter and Bildstein 1996)

Notes:

BW	Body weight	g/g-day	Grams per gram-day
EPA	U.S. Environmental Protection Agency	IR	Ingestion rate
g/day	Grams per day	kg	Kilogram

TABLE 8-6

TOXICITY REFERENCE VALUES FOR BIRDS AND MAMMALS
AREA WIDE HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENT WORK PLAN
SOUTHEAST IDAHO PHOSPHATE MINING RESOURCE AREA

COPEC		Mammal TRV (mg/kg-day)	Bird TRV (mg/kg-day)
		TRV (Unadjusted*)	TRV (Unadjusted*)
Aluminum	Dose	1.93	109.7
	Reference	Ondreicka and others (1966)	Carriere and others (1986)
Antimony	Dose	0.125	NA
	Reference	Schroeder and others (1968b)	NA
Arsenic	Dose	0.32	5.5[1]
	Reference	Schroeder and others (1968a)	Stanley and others (1994)
Barium	Dose	5.1	20.8
	Reference	Perry and others (1983)	Johnson and others (1960)
Beryllium	Dose	0.66	NA
	Reference	Schroeder and Mitchener (1975)	NA
Boron	Dose	28.0	28.8
	Reference	Weir and Fisher (1972)	Smith and Anders (1989)
Cadmium	Dose	0.06	0.08[2] (0.78)
	Reference	Webster (1988)	Cain and others (1983)
Chromium III	Dose	2,737.0	1.0
	Reference	Ivankovic and Preussmann (1975)	Haseltine and others (Unpublished data, as cited in Sample and others 1996)
Chromium IV	Dose	13.14	1.0
	Reference	Steven and others (1976 as cited in Eisler 1986)	Haseltine and others (Unpublished data as cited in Sample and others 1996)
Copper	Dose	2.67[3,4] (26.67)	2.3 [3, 5] (22.99)
	Reference	Pocino and others (1991)	Norvell and others (1975)
Lead	Dose	8.0	1.13
	Reference	Azar and others (1973)	Edens and others (1976)
Mercury	Dose	0.25 – rodents 0.027 [2] (0.27) – large mammals	0.039[6] (0.078)
	Reference	EPA (1995), Khera and Tabacova (1973)	EPA-Great Lakes, Heinz (1974, 1975, 1976, 1979)
Molybdenum	Dose	0.26	3.5
	Reference	Schroeder and Mitchener (1971)	Lepore and Miller (1965)
Nickel	Dose	0.133[2] (1.33)	1.38[3] (13.79)
	Reference	Smith and others (1993)	Cain and Pafford (1981)
Selenium	Dose	0.05	0.23
	Reference	Harr and others (1966)	Heinz and others (1989)
Thallium	Dose	0.48	NA
	Reference	Downs and others (1960)	NA

TABLE 8-6 (continued)

TOXICITY REFERENCE VALUES FOR BIRDS AND MAMMALS
AREA WIDE HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENT WORK PLAN
SOUTHEAST IDAHO PHOSPHATE MINING RESOURCE AREA

COPEC		Mammal TRV (mg/kg-day)	Bird TRV (mg/kg-day)
		TRV (Unadjusted*)	TRV (Unadjusted*)
Uranium	Dose	3.07	16.0
	Reference	Paternain and others (1989)	Haseltine and Sileo (1983)
Vanadium	Dose	0.21	11.4
	Reference	Domingo and others (1986)	White and Dieter (1978)
Zinc	Dose	9.60[2,4] (96.03)	17.2[2] (172.0)
	Reference	Aughey and others (1977)	Gasaway and Buss (1972)

Notes:

* The unadjusted TRV appears in parenthesis. This dose is the TRV without UFs applied. This TRV represents the no observed adverse effects level.

[1] The diversity of test organisms in the cadmium data set was limited. There is high confidence in The TRV for waterfowl, but lower confidence if the TRV is applied to other birds.

[2] The UF of 10 for low-effect to no-effect level conversion is applied to arrive at a TRV.

[3] The UF of 10 for subchronic to chronic conversion applied to arrive at a TRV.

[4] TRV was adjusted for, or is close to, nutritional requirements.

[5] This TRV is very conservative for granivorous birds.

[6] An UF of 2 has been applied to the dose for low-effect level conversion.

COPEC Chemical of potential ecological concern
mg/kg-day Milligram per kilogram-day
TRV Toxicity reference value
UF Uncertainty factor

Sources:

Sample, B.E., D.M. Opresko, and G.W. Suter, II. 1996. "Toxicological Benchmarks for Wildlife: 1996 Revision." Oak Ridge National Laboratory. ES/ER/TM-86/R3.

U.S. Department of the Navy. 1998. "Development of Toxicity Reference Values for Conducting Ecological Risk Assessments at Naval Facilities in California, Interim Final Technical Memorandum." September.

APPENDIX A

GLOSSARY

Assessment endpoint. An explicit expression of the ecological values that is to be protected.

Benthic. Pertains to those organisms that live and feed on the bottom of a pond, river, lake, or ocean.

Biotransfer factor (BTF). The average facility specific ratio of soil or sediment concentration to tissue concentration**.**

Carnivorous. Indicates a diet composed of animal tissue.

Central tendency exposure (CTE). The average exposure expected to occur at a site. In practice, the CTE is estimated by combining mean or 50th percentile exposure parameter values.

Chemical of potential concern (COPC). Chemical that is potentially found at a site under investigation and whose data are of such a quality for use in a quantitative risk assessment.

Chemical of potential ecological concern (COPEC). A substance at a site under investigation that has the potential to affect ecological receptors adversely because of its concentration, distribution, and mode of toxicity.

Community. An assemblage of populations of different species within a specific location and time.

Conceptual site model (CSM). Presents the working hypotheses describing the potential source(s) of stressor chemicals, the mechanisms by which the chemicals may be released into and transported throughout the environment, and the pathways by which human and ecological receptors may be exposed the these chemical stressors. For the ecological risk assessment, the CSM describes ecosystem or ecosystem components at risk, and presents the relationships between measurement and assessment endpoints and exposure pathways. For the human health risk assessment, the CSM identifies the human receptors that may be at risk and presents the receptor-specific exposure pathways.

***De minimus*.** A concentration or level of some attribute that is so low as to be insignificant or of no consequence.

Dose. Used in terms of the measure of exposure to a COPC by ingestion or absorption.

Ecological risk assessment (ERA). The process that evaluates the likelihood that adverse ecological effects may occur or are occurring as a result of exposure to one or more stressors. The ecological risk assessment process follows the guidance as provided by the U.S. Environmental Protection Agency's "Ecological Risk Assessment Guidance for Superfund" (EPA 1997b).

Essential nutrient. A compound that is required to support human metabolic function.

Exposure pathway. The course a chemical follows from a source to an exposed organism. Each exposure pathway includes a source, release mechanism, a receiving or transfer mechanisms, an exposure point, an exposure route, and a receptor.

Exposure point concentration (EPC). The concentration of a chemical at an exposure point such as tissue, soil, sediment, or surface water.

Exposure scenario. An exposure pathway associated with a particular receptor (for example, a subsistence lifestyle receptor) and a particular set of exposure conditions (for example, reasonable maximum exposure (RME) conditions).

Food chain. It is the pathway by which substances in tissues of lower-trophic-level organisms are transferred to the higher-level organisms that feed on the lower levels.

Food web. A diagrammatic of the feeding relationships within an ecosystem. It consists of a series of interconnecting food chains. Only some of the many possible relationships are shown.

Fugitive dust. Resuspended soil particles generated by wind erosion.

Guild. A group of organism of the same class that share a similar feeding requirement.

Hazard quotient (HQ). The ratio of an exposure level of a chemical, such as a dose, to a toxicity value selected for the ecological risk assessment for that chemical, such as a no observed adverse effect level.

Herbivorous. Indicates a diet that is composed strictly of plant materials.

Human health risk assessment (HHRA). The process that evaluates the likelihood that adverse effects occur or are could occur to human receptors as a result of exposures to one or more stressors. The HHRA process follows EPA guidance including "Risk Assessment Guidance for Superfund: Volume I – Human Health Evaluation manual (Part A)" (EPA 1989).

Lowest observed adverse effect level (LOAEL). The lowest concentration of a stressor evaluated in a toxicity test that causes a statistically significant difference in effect compared with controls or a reference site.

Measurement endpoint. Measurement endpoints are measurable responses to a stressor that are related to the valued assessment endpoint.

No observed adverse effect level (NOAEL). The highest concentration of a stressor evaluated in a toxicity test that causes no statistically significant difference in effect compared with controls or a reference site.

Offal. Waste parts of a butchered animal.

Omnivorous. Indicates a diet composed of both plant and animal matter.

Reasonable maximum exposure (RME). The highest exposure that is reasonably expected to occur at a site. In practice the RME is estimated by combining upper-bound (for example, 90 to 95th percentile) values for some but not all exposure parameters.

Receptor. The ecological entity exposed to a stressor that has the potential to induce an adverse response in that receptor.

Riparian. The particular environment situated along the bank of a stream, lake, or pond.

Site use factor (SUF). The ratio of a species home range, breeding range, or feeding or foraging range to the area of contamination of the site being studied.

Subsistence lifestyle receptor. For the purposes of the area wide HHRA, this term is defined as an individual that obtains a significant proportion of their foodstuffs by their own hand (for example, by

hunting, fishing, and growing their own produce) and not from commercial sources. This receptor is assumed, however, to obtain their drinking water from municipal sources.

Toxicity reference value (TRV). A numerical expression at which a particular biological effect may occur in an organism, based on laboratory toxicological investigations.

APPENDIX B

ENVIRONMENTAL CHEMISTRY, HUMAN HEALTH, AND ECOTOXICOLOGY OF SELENIUM

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B1.0 INTRODUCTION

Selenium is a semimetallic trace element that has chemical properties similar to sulfur (Skorupa and others 1996). The major source of selenium is weathering of natural rock (Eisler 1985). Selenium is widely distributed in nature and is particularly abundant with sulfide minerals of metals such as iron, lead, and copper. Collectively, the data indicate that selenium favorably or adversely affects growth, survival, and reproduction of algae and higher plants, microorganisms, crustaceans, mollusks, insects, fish, birds, and mammals. It is interesting to note that both selenium deficiency and toxicity cause similar effects, for example, reproductive depression, anemia, weight loss, and immune dysfunction (Koller and Exon 1986; Agency for Toxic Substances and Disease Registry [ASTDR] 1994, as cited in Skorupa and others 1996).

B1.1 ENVIRONMENTAL CHEMISTRY

Selenium chemistry is complex, and selenium exists in nature as six stable isotopes (Eisler 1985). The two predominant isotopes also occur in three allotropic forms and in five valence states. Two of the common valence states are selenite (+4) and selenate (+6). Soluble selenates occur in alkaline soils and are reduced slowly to selenites, which are then readily taken up by plants. In drinking water, selenates represent the dominant chemical species. Selenites are less soluble than the corresponding selenates and are easily reduced to elemental selenium (Eisler 1985). Both selenite and selenate are biotransformed into organic chemical species after uptake by primary producers. The relative toxicity of various chemical forms of selenium is generally as follows (from most to least toxic): hydrogen selenide ~ selenomethionine (organic form of selenium) (in diet) > selenite ~ selenomethionine (in water) > selenate > elemental selenium ~ metal selenides ~ methylated selenium compounds (Moore and others 1990, as cited in Irwin and others 1997). In aquatic food chains, the chemical species of selenium is not an important factor after its incorporation into the food chain (Skorupa and others 1996; Skorupa 1998).

Elemental selenium is insoluble and largely unavailable to various organisms, both plant and animal (Eisler 1985). Selenides of mercury, silver, copper, and cadmium are very insoluble, although their insolubility may be the basis for the reported detoxification of methyl mercury by ingestion of selenite and for the decreased heavy metal toxicity associated with selenite. Therefore, metallic selenides are biologically important in sequestering both selenium and heavy metals in a largely unavailable form (Eisler 1985).

In acid soils, the amount of bioavailable selenium decreases, and this process may be accelerated by active agricultural or industrial practices (Eisler 1985). In dry areas with alkaline soils and oxidizing conditions, elemental selenium and selenides in rocks and volcanic soils may oxidize to levels that increase selenium bioavailability. Concentrations of selenium in water are a function of the drainage system and of water pH. Lakin (1973, as cited in Eisler 1985) reported that in Colorado streams where the pH was 6.1 to 6.9, the selenium was less than 1 part per billion (ppb), but where the pH was 7.8 to 8.2, the selenium concentration was 270 to 400 ppb.

Volatilization rates for selenium from soils are modified by temperature, moisture, time, season, concentration of water-soluble selenium, and microbiological activity (Eisler 1985). Selenites and selenates are absorbed by plants, reduced, and then incorporated into amino acid synthesis. Selenium has higher bioavailability in plant-type foods than in foods of animal origin (Lo and Sandi 1980, as cited in Eisler 1985).

B1.2 BACKGROUND CONCENTRATIONS

Eisler (1985), Irwin and others (1997), and Skorupa (1998) all address selenium background levels. Background selenium levels in the earth's crust and in various types of soils range from 0.08 to 0.6 parts per million (ppm) (from various authors, as cited in Eisler 1985 and Irwin and others 1997) and average about 0.05 milligrams per kilogram (mg/kg) (Skorupa 1998). In freshwater sediments, the range is from 0.2 to 14.5 ppm (from various authors, as cited in Eisler 1985; Irwin and others 1997; Skorupa 1998). In ocean sediments, selenium concentrations range from 0.34 to 4.80 ppm (de Geoij and others 1974, as cited in Eisler 1985).

Selenium concentrations have been reported to range from (1) less than 0.01 to 30 ppb in river water, (2) 0.001 to 1.4 ppb in lake water, (3) 0.009 to less than 6.0 ppb in seawater, and (4) less than 0.002 to 480 ppb in groundwater (from various authors, as cited by Eisler 1985; Irwin and others 1997; Skorupa 1998).

Table B-1 presents the background concentrations of selenium in plants, invertebrates, fish, reptiles and amphibians, birds, and mammals, as presented by Skorupa (1998).

B2.0 HUMAN HEALTH

Selenium is considered to be an essential nutrient in humans. It is a component of the enzyme glutathione peroxidase, which protects membrane lipids and possibly other cellular components from damage by oxidants and free radicals. About 50 to 100 micrograms per day (µg/day) is required in the human diet. Selenium deficiencies have been shown to result in degenerative muscle disease and retarded growth in experimental animals and in cardiomyopathy (Keshan disease) in humans (National Research Council [NRC] 1989; National Library of Medicine [NLM] 2001].

Selenium toxicity has been observed in human populations living in seleniferous areas where the selenium soil content of soil is high, contributing to high selenium concentrations in foods. Chronic ingestion of high selenium concentrations can result in discolored and decayed teeth, skin eruptions, gastrointestinal distress, lassitude, and hair and nail loss. Chronic inhalation exposure may cause gastrointestinal disorders, liver and spleen damage, anemia, mucosal irritation, and lower back pain. Acute poisoning symptoms, as may be observed in industrial exposures, include nervousness, drowsiness, and convulsions (Stokinger 1981; Seiler and Sigel 1988; Goyer 1991; ATSDR 1996; NLM 2001).

Selenium and most of its compounds are classified in Group D, or not classifiable as to human carcinogenicity; in fact, several studies suggest that normal amounts of dietary selenium may protect against cancer. However, ingested selenium sulfide has been shown to be carcinogenic in animals and warrants a B2 (probable human carcinogen) classification. Findings of laboratory experiments indicate that selenium may be embryotoxic and teratogenic (U.S. Environmental Protection Agency [EPA] 2001; NLM 2001).

Absorption depends on the chemical form of selenium involved, but limited data indicate that both elemental selenium and selenious acid are absorbed through inhalation. Insoluble elemental selenium is probably not absorbed from the gastrointestinal tract; however, estimates of the absorption of selenium compounds from the gastrointestinal tract range from 44 to 100 percent. There appears to be a homeostatic mechanism for maintaining a certain level of selenium in the body. Selenium is preferentially deposited in the kidneys and liver and is primarily excreted in urine. When excretory capabilities are exceeded, toxicity can develop (EPA 1984; NRC 1989; ATSDR 1996; NLM 2001).

The oral reference dose (RfD) for selenium is 0.005 milligram per kilogram per day (mg/kg per day) (EPA 2001). This value was calculated based on a comparative study of Chinese populations living in areas with low, medium, and high environmental concentrations of selenium. All subjects were evaluated for clinical and biochemical signs of selenium intoxication, and some were shown to have the critical effect of clinical selenosis. An UF of 3 was used to account for intraspecies variability. Confidence in the oral RfD is high because of two studies that corroborate each other's no-observed-adverse-effect-level. No inhalation RfD for selenium is available from EPA. The oral RfD also should be compared to the recommended dietary allowance of 0.001 mg/kg per day (NRC 1989).

B3.0 ECOTOXICOLOGY

This section presents ecotoxicology information on selenium for selected plants, invertebrates, amphibians and reptiles, fish, birds, livestock, and mammalian wildlife. Selenium is much less toxic to most plants and invertebrates than to vertebrates (Skorupa and others 1996). Reproductive toxicity is one of the most sensitive endpoints for vertebrates. However, egg-laying vertebrates, such as birds and fish, have substantially lower thresholds for reproductive toxicity than mammals (Westfall and others 1938; Clark 1987; Hawkes and others 1994, as cited in Skorupa and others 1996).

Skorupa and others (1996) indicate that in general, thresholds for selenium toxicity in vertebrates begin at concentrations less than one order of magnitude above normal background levels. When environmental, dietary, or tissue levels of selenium equal or exceed 10 times normal background concentrations, toxic effects are likely. Immunotoxic effects have been documented for birds and mammals at tissue concentrations of selenium less than five times normal background (Whiteley 1989; Schamber and others 1995, as cited in Skorupa and others 1996).

The high propensity for biotic uptake of selenium is explained partially by its biochemical similarity to sulfur (Skorupa 1998).

B3.1 BIOACCUMULATION

Selenite and selenate, the most common aqueous forms of selenium, are biotransformed into organic chemical species after uptake by primary producers, such as algae (Ogle and others 1988, as cited in Skorupa 1998). Laboratory studies have clearly demonstrated that the bioconcentration potential of selected organic selenium compounds, including selenomethionine, is much greater than for common inorganic selenium such as selenate and selenite (Moore and others 1990, as cited in Irwin and others

1997). Plants easily take up selenate compounds from water and change them to organic selenium compounds such as selenomethionine (ATSDR 1994, as cited in Irwin and others 1997). The speciation of dissolved selenium in aqueous media primarily influences how much aquatic loading is required to bioaccumulate dangerous concentrations of selenium in the food chain. Waterborne speciation does not appear to influence the unit toxicity of food chain incorporated selenium (U.S. Fish and Wildlife Service [USFWS] 1990b; Besser and others 1993, as cited in Skorupa 1998). Once selenium is incorporated into the food chain, the matter of speciation in not an "…important interpretive factor" (Skorupa 1998). Toxicologically, food chain selenium in nature appears to be rather uniform; that is, the toxicity profile is very similar to that of selenomethionine (Woock and others 1984; Hamilton and others 1990, Heinz 1996, as cited in Skorupa 1998). This is important, considering that dietary exposure is the primary route of exposure for fish, birds, and other wildlife. Animals readily absorb dietary plant selenium, and 70 to 80 percent is quickly metabolized and eliminated. The remaining selenium is bound to blood and other tissues and is only slowly eliminated (Olson 1978, as cited in Skorupa 1998). Therefore, selenium easily enters the metabolic pathway and is highly bioaccumulative.

Bioconcentration, bioaccumulation, and biomagnification of selenium can increase selenium levels more than 1,000-fold from water to phytoplankton, fish, and other animals (Saiki and Lowe 1987, as cited in Taylor and others 1992). Preliminary data indicate that the potential for bioaccumulation or bioconcentration of selenium is moderate for mammals, birds, and fish. Bioaccumulation is very high for higher plants and low or limited for crustaceans, mollusks, and lower animals and plants (mosses, lichens, and algae) (Jenkins 1981, as cited in Irwin and others 1997). The greatest step increase occurs between water and phytoplankton and other aquatic plants; subsequent steps in the food chain typically increase selenium concentrations by a factor of 2 to 6 (Lemly and Smith 1987, as cited in Taylor and others 1992). Bioconcentration factors estimated for uptake of selenium as selenomethionine at initial concentrations of 1 microgram per liter (μg/L) were about 16,000 for algae, 200,000 for daphnids, and 5,000 for bluegills (Besser and others 1993, as cited in Irwin and others 1997).

There is some evidence that selenium can biomagnify through the food chain (Lemly 1989, as cited in Irwin and others 1997). Lemly (1996) reports that based on some field studies, the body burdens continue to rise from two to six times through the food chain in a pattern suggestive of biomagnification (Woock and Summers, 1984; Lemly 1985a, 1986; Saiki 1986a; Lemly and Smith 1987; Saiki and Lowe 1987; Barnum and Gilmore 1988; Hothem and Ohlendorf 1989, as cited in Lemly 1996). Lemly (1989, as cited in Irwin and others 1997) noted that biomagnification factors for 5 to 30 μg/L (ppb) waterborne selenium in aquatic systems typically range from three to seven.

B3.2 PLANTS

Plants are very effective at removing selenium from contaminated soils (Irwin and others 1997). Selenium is not proven essential for plant growth. It is absorbed by plants as selenite, selenate, or in organic form, and the selenate may be more toxic. It is believed that selenate is taken up actively, while selenite uptake is largely passive (Peterson and Girling 1981). Selenium is translocated to all parts of the plant (Broyer and others 1972). Toxicity symptoms include chlorosis, stunting, and yellowing of the leaves. The mechanism of toxicity is thought to be indiscriminate replacement of sulphur by selenium in proteins and nucleic acids, with disruptions in metabolism (Trelease and others 1960).

Selenium accumulators can take up and accumulate very high concentrations of selenium (over 1,000 ppm) in their tissues without injurious effects. Obligate selenium accumulators, which grow only in soils where metabolic needs can be satisfied, include many species of *Astragalus* and some species of *Brassica, Hapopapus, Machaeranthera, Oonopsis, Stanleya,* and *Zylorhiza* (Irwin and others 1997). Facultative selenium accumulators can tolerate, but do not require, elevated soil selenium levels and include many species of *Astragalus, Atriplex, Castelleja, Comandra, Grayia, Grindelia, Gutierrezia, Machaeranthera, and Mentzelia.* These plants take up high levels of selenium and metabolize them into water-soluble selenate, and when the plants die, the water soluble organic selenium compounds released by decay become more bioavailable to other plants and animals.

Table B-2 presents selenium concentrations in field populations of selected species of terrestrial plants and animals, as summarized by Eisler (1985). As can be seen by the data presented in Table B-2, selenium bioaccumulates in species of *Aster* and *Astragalus* to very high levels. In about 24 of some 200 species of *Astragalus*, selenium is accumulated to very high levels and is required by these species for good growth. Wilbur (1983, as cited in Eisler 1985) reported the highest selenium concentrations in *A. racemosus* of 15,000 ppm dry weight. Consumption of these and other selenium-accumulating forage plants by livestock has induced illness and death from selenium poisoning. Selenium-accumulating plants tend to be deeper rooted than grasses and survive more arid conditions, therefore remaining as the principal forage for grazing in time of drought (Wilbur 1983, as cited in Eisler 1985).

In aquatic ecosystems, the primary producers, such as algae, serve as the primary source of energy and are the base of most aquatic food chains. Aquatic macrophytes are very important in selenium cycling and as a major source for detrital-based food chains (Skorupa 1998). There are no studies in the literature that

report selenium toxicity thresholds for plants that are based on selenium exposure, as measured from field-collected data (Skorupa 1998).

Selenium has been observed to cause growth retardation in freshwater green algae (Hutchinson and Stokes 1975; Klaverkamp and others 1983, as cited in Eisler 1985). The toxicity test lowest observed adverse effect levels (LOAEL) for sublethal effects on green algae were 10 to 300 µg/L for selenate and 75 µg/L for selenite (Vocke and others 1980; EPA 1987, as cited in Skorupa 1998). Toxicity test LOAELs for sublethal effects on water were 200 µg/L for selenate and 3,000 µg/L for selenite (Berry and Savage 1986, as cited in Skorupa 1998).

B3.3 INVERTEBRATES

Invertebrate populations are important sources of protein for fish and birds. Consequently, selenium-induced alterations of invertebrate populations could indirectly impact population dynamics of fish and birds. Skorupa (1998) summarizes the data on selenium toxicity to invertebrates. Based on assorted studies (Maier and Knight, 1994; Birkner, 1978; Saike and Lowe 1987; Hothem and Ohlendorf, 1989; Schuler and others 1990; Crane and others 1992; Saiki and others 1993; Welsh and Maughan 1994, as cited in Skorupa 1998), background selenium concentrations in aquatic invertebrates ranged from 0.4 to 4.5 mg/kg (typically less than 2.0 mg/kg). Background concentrations in terrestrial invertebrates ranged from less than 0.1 to 2.5 mg/kg (typically less than 1.5 mg/kg) (Wu and others 1995; San Joaquin Valley Drainage Program [SJVDP] 1990, as cited in Skorupa 1998).

Tissue concentrations of selenium in field-collected aquatic invertebrates are strongly related to waterborne concentrations of selenium (Birkner 1978; Wilber 1980; Lillebo and others 1988, as cited in Skorupa 1998). Many factors affect toxicity test results, but the lowest waterborne thresholds for acute toxicity is about 200 µg/L for selenite and 500 µg/L for selenate (EPA 1987; Maier and others 1987; Ingersoll and others 1990, as cited in Skorupa 1998). Lowest thresholds for chronic toxicity occur at about 25 to 100 µg/L for selenite or selenate and probably at less than 0.5 µg/L for waterborne selenomethionine (Johnston 1987; EPA 1987; Boyum and Brooks 1988; Ingersoll and others 1990, as cited in Skorupa 1998).

There is almost no selenium toxicity data for terrestrial invertebrates (Skorupa 1998). There are no documented field cases of fish and other wildlife populations being affected adversely by selenium-induced alterations of various invertebrate population indices, such as invertebrate community structure

and invertebrate density. As indicated for plants, the direct toxic effects of consuming selenium-contaminated invertebrates is more important than any indirect ecological effects, such as changes in population structure (Skorupa 1998).

B3.4 AMPHIBIANS AND REPTILES

Based on several studies, Skorupa (1998) suggests a whole-body background value for selenium of 0.7 to 3.0 mg/kg (typically less than 2.0 mg/kg) for both amphibians and reptiles (California Department of Fish and Game 1993; Bryne and others 1975; Ohlendorf and others 1988b; and Burger 1992, as cited in Skorupa 1998). Normal background concentrations of selenium in amphibian and reptile eggs appear to be the same as for fish and bird eggs, typically averaging 1 to 3 mg/kg (Heinz and others 1991, as cited in Skorupa 1998).

Toxicity test data found African clawed frog (*Xenopus laevis*) larvae sensitive to greater than 1,000 µg/L of waterborne selenite (Browne and Dumont 1979, as cited in Skorupa 1998 and Linder and Grillitsch 2000). The LC50 for waterborne selenite for the eggs and larvae of the narrow-mouthed toad was 90 µg/L (Birge and others 1975, as cited in Skorupa 1998 and Linder and Grillitsch 2000).

Reptile mortality as a result of metal intoxication has never been reported (Linder and Grillitsch 2000). There is a paucity of studies on the ecotoxicology of metals in reptiles dealing with any aspects other than tissue-metal levels in free-ranging animals. Ambient levels of metals rarely have been reported in the literature on metal residues in free-ranging amphibians and reptiles. Food was found to be the major source of metal exposure in reptiles. Based on the available data, reptiles do not seem to biomagnify metals to the extent corresponding to their trophic level (Linder and Grillitsch 2000).

Skorupa (1998) suggests that based on how similar the toxic threshold values are for fish and bird eggs, two other classes of egg-laying vertebrates, it is probably safe to assume the following for amphibians and reptiles:

- Reproductive impairment is among the most sensitive response variables.
- Populations producing eggs with equal to or greater than 10 mg/kg of selenium are reproductively impaired.

Skorupa (1998) also suggests that based on existing knowledge, wholebody concentrations at or above 10 times normal background concentrations (or greater than 20 mg/kg) are probably toxic to populations of sensitive species.

B3.5 FISH

Lemly (1993a, 1996a, as cited in Skorupa 1998) concluded that the most precise way to assess risks associated with exposure of fish to selenium is to measure the selenium levels in gravid ovaries. Review of the literature indicates that background levels of selenium in eggs are similar for birds and fish and exposure-response curves for embryo teratogenesis are broadly similar (Hamilton and Waddell 1994; Skorupa and Ohlendorf 1991; and Lemly 1993b, as cited in Skorupa 1998).

National and global monitoring programs reveal that most species of fish, based on a wholebody basis, average less than 4 mg of selenium per kg (Walsh and others 1977; Schmitt and Brumbaugh 1990; and Jenkins 1980, as cited in Skorupa 1998). The lowest concentration of selenium in fish gonads and eggs resulting in total reproductive failure is 25 to 30 mg/kg (Crane and others 1992, as cited in Skorupa 1998). Skorupa (1998) indicates that 7 to 13 mg/kg in gonad or egg tissue are the estimated true range for reproductive impairment in sensitive species (such as perch and bluegill).

Experimental LOAELs for reproductive impairment from lethal larval dietary exposure to salmon, bluegill, and razorback suckers is 3 to 8 mg/kg as food chain selenium or selenomethionine (Skorupa 1998). Sorensen (1991, as cited in Irwin and others 1997) reported that excess selenium as low as 3 to 8 ppb (0.003 to 0.008 ppm) in water can cause numerous, life-threatening changes in feral freshwater fish. EPA (1987, as cited in Irwin and others 1997) provided acute (96-hour LC50) values for teleost fish as typically ranging from 620 to 66,000 ppb (0.620 to 66.0 ppm). Where biomagnification is allowed to occur, toxic effects are seen at concentrations as low as 12 ppb in laboratory studies and 2.5 ppb in the field. LC50s for Coho and silver salmon ranged from 16.9 to 38.0 ppm for 96-hour water exposures, with most values ranging between 21 and 28 ppm (EPA 1997, as cited in Irwin and others 1997). For Chinook salmon, values ranged from 46.6 to 96.8 for 96-hour water exposures.

When edible tissue concentrations of selenium in fish were known to exceed 2 mg/kg (wet weight), consumption advisories were issued in California (Fan and others 1988; Saiki and others 1991, as cited in Skorupa 1998). No human consumption was advised when tissue selenium levels exceeded 5 mg/kg (wet weight) (Texas Parks and Wildlife Department 1990, as cited in Skorupa 1998).

B3.6 BIRDS

Selenium exposure in the diet or drinking water of avian species is associated with reproductive abnormalities, congenital malformations, selective bioaccumulation, and growth retardation (Eisler 1985). Selenium has been observed to cause reduced hatching of eggs, decreased egg weight, decreased egg production, anemia, and embryo deformation, including deformed eyes, beaks, wings, and feet (Ort and Latshaw 1978; Harr 1979, as cited in Eisler 1985).

Bird eggs are the most reliable tissues for interpretive purposes as an indication of reproductive impairment (Ohlendorf and others 1986; Heinz and others 1987, 1989; Skorupa and Ohlendorf 1991; CH2M Hill and others 1993; Ohlendorf and others 1993; Skorupa 1994; Sieler and Skorupa 1995; Heinz 1996; Skorupa 1998a, as cited in Skorupa 1998). Based on a review of experimental and field data, the embryotoxic threshold (primarily embryo mortality) for selenium in bird eggs of sensitive to moderately sensitive species is about 6 to 10 mg/kg (dry weight) (Heinz 1996, as cited in Skorupa 1998). Heinz (1989, as cited in Skorupa 1998) and Heinz and Fitzgerald (1993b, as cited in Skorupa 1998) found that nonbreeding adult birds could tolerate higher levels of selenium, but still recommend that their dietary exposure not exceed 10 to 15 mg of selenium per kg.

Waterfowl feeding on zooplankton or on algae appear to be more sensitive to selenium contamination than those feeding on seeds (Lillebo and others 1986, as cited by Irwin and others 1997). Mallards, cinnamon teal, and pintails, which consume large amounts of seeds, are less at risk than gadwells and northern shovelers, which consume primarily algae and zooplankton. Chicken and Japanese quail are more sensitive to selenium toxicity than are mallard ducks, which are more sensitive than screech owls and black-crowned night herons (Moore and others 1990, as cited in Irwin and others 1997).

Domestic chickens are extremely sensitive to selenium (Eisler 1985). Ort and Latshaw (1978, as cited in Eisler 1985) recorded reduced hatching of eggs in chickens fed 7 to 9 ppm of selenium in feedstuffs. Similar effects were recorded for Japanese quail at 6 and 12 ppm of dietary selenite (El-Bergearmi and others 1977, as cited in Eisler 1985). Eisler (1985) reported that studies at the Patuxent Wildlife Research Center indicated that 100 ppm of dietary selenium was fatal within 1 month to adult mallards, but survival was high at 25 ppm after 3 months.

B3.7 LIVESTOCK AND MAMMALIAN WILDLIFE

Poisoning in nature has been reported for free-range domestic livestock, primarily horses, cows, and sheep (Rosenfield and Beath 1946; Olson 1986; Raisbeck and others 1993, as cited in Skorupa 1998). In livestock, there are three basic types of poisoning from selenium (Eisler 1985): acute, which results from a single feeding of highly seleniferous weeds; "blind stagger", which results from feeding on moderate amounts of seleniferous weeds over an extended period of time; and chronic, known as the "alkali disease", caused by feeding on moderately seleniferous grains and other forage grasses over an extended period of time. Alkali disease has been observed in cattle, hogs, and horses that graze on feed containing elevated levels of selenium. Adverse effects include deformed hooves; hair loss; lassitude; articular cartilage erosion; reduced conception; increased reabsorption of fetuses; and heart, kidney, and liver degeneration (Eisler 1985).

Acute poisoning is associated with plant selenium levels of 400 to 800 ppm. Acute selenium poisoning in domestic livestock is characterized by lowered head, drooped ears, abnormal movements, diarrhea, elevated temperature, rapid pulse, labored breathing, bloating with abdominal pain, increased urination, and dilated pupils (Eisler 1985). Chronic selenosis has been induced by dietary exposure to natural selenite, selenate, or seleniferous feedstuffs at dietary concentrations between 1 ppm (rat) and 44 ppm (horse) or from water containing 0.5 to 2.0 ppm of selenium. Chronic exposure is indicated by skin lesions, lymph channel inflammation, loss of hair and nails, anemia, enlarged organs (liver, spleen, and pancreas), fatigue, dizziness, and lassitude. No effective treatment for counteracting toxic effects of large amounts of ingested selenium is known.

There have been no well-documented cases of widespread selenosis reported for wild mammals, as compared to multiple examples for fish and birds (Skorupa 1998). Chronic effects of selenium on mammals include reproductive abnormalities such as congenital malformations; reduced numbers of young in litters; high mortality of young; infertility among surviving young in rats, mice, swine, and cattle; and intestinal lesions (Harr 1978; National Research Council 1983, as cited in Eisler 1985).

Skorupa (1998) published several interpretative guidance values for selenium effects in mammals. Background levels (reported as dry weight) are reported as ranging from less than 1 to 4 mg/kg (typically less than 2 mg/kg) for whole body, less than 1 mg/kg for muscle, 1 to 10 mg/kg (typically less than 5 mg/kg as a mean) in liver of mammals in an aquatic environment, 0.1 to 0.5 milligrams per liter (mg/L) (typically 0.2 to 0.3 as a mean) for blood, and less than 1 to 3 mg/kg (typically 0.5 to 1.5 as a mean) for

hair (Skorupa 1998). Reproductive depression has been reported when the selenium concentration in hair is greater than 10 mg/kg (dry weight). The veterinary toxicological handbook threshold for the liver in domestic livestock is 45 to 60 mg/kg (dry weight) (Skorupa 1998). The overt toxicity threshold for dietary selenium exposure in domestic livestock is 3 to 5 mg/kg (dry weight) (Skorupa 1998). There should be a complete ban on human consumption of edible tissue containing selenium equal to or greater than 5 mg/kg (wet weight) (Skorupa 1998).

B3.8 PROTECTION FROM SELENIUM DEFICIENCY AND SELENOSIS

Eisler (1985) indicates that based on all investigations that he reviewed, there was agreement on four points, as follows:

- Insufficient selenium in the diet may have harmful and sometimes fatal effects.
- Exposure to grossly elevated levels of selenium in the diet or water is inevitably fatal over time to terrestrial and aquatic animals.
- There is a narrow concentration range separating effects of selenium deficiency from those of selenosis.
- Additional research is needed on selenium metabolism, physiology, recycling, interactions with other compounds or formulations, and chemical speciation to elucidate the role of selenium in nutrition and toxicity.

Livestock appear to be protected against selenosis when their diets contain less than 4,000 ppb of natural (not supplemented) selenium (Eisler 1985) and less than 50 ppb in livestock drinking water. Accidental poisoning of livestock and fish and other wildlife occurs when soils are deliberately supplemented with purified selenium or when soils or aquifers are contaminated as a result of faulty waste disposal practices. Table B-3 provides some recommended selenium levels that appear to be protective of selenosis.

B3.9 AQUATIC AND TERRESTRIAL GUIDELINES FOR SELENIUM

This section presents information on selenium guidelines that have been developed for both the aquatic and terrestrial environment by various governmental agencies in the United States and elsewhere.

Skorupa (1998) presented a summary of comprehensive biotic effects of selenium in water, sediment, diet, water bird eggs, and fish. These values are presented in Table B-4.

B3.9.1 Aquatic Guidelines

The following freshwater ambient water quality criteria have been issued for total selenium (EPA 1991, 1993, 1996, as cited in Skorupa 1998):

- Acute: 20.0 µg/L for 1-hour average
- Chronic: 5.0 µg/L for 4-hour average
- Drinking water maximum concentration level: 50 µg/L

Oak Ridge National Laboratory (ORNL) (Sample and others 1996) has developed ecological risk assessment freshwater benchmarks for various concentrations of selenium. To be considered as unlikely to represent an ecological risk, field concentrations should be below all of the following benchmarks:

- National Ambient Water Quality Criterion (NAWQC) - Acute: 20
- NAWQC - Chronic: 5 µg/L
- Lowest chronic value - fish: 88.32 µg/L
- Lowest chronic value - daphnids: 91.65 µg/L
- Lowest chronic value - nondaphnid invertebrates: no information
- Lowest chronic value - aquatic plants: 100 µg/L
- Lowest chronic value - all organisms: 8.32 µg/L
- Lowest test effective concentration 20 (EC20) - fish: 40 µg/L
- Lowest test EC20 - daphnids: 25 µg/L
- Sensitive species test EC20: 2.60 µg/L

In 1989, the USFWS evaluated the findings of toxicity research and recommended the following total recoverable selenium concentrations, accounting for known biomagnification through the food chain and associated reproductive toxicity, as target safe levels for cleanup of Kesterson Reservoir and the San Luis Drain (Irwin and others 1997):

- Water - 2 ppb
- Sediment - 4 ppm dry weight
- Food for warm water fishes - 5 ppm dry weight. Skeletal muscle should not contain more than 5 ppm total selenium and liver and gonads not more than 10 ppm

- Food for waterfowl - 3 ppm dry weight

Canada derived an interim assessment criterion of 1 µg/L for selenium in water (Canadian Council of Ministers of the Environment [CCME] 1991). In addition, they developed remediation criteria for water, as follows:

- Freshwater aquatic life - 1 µg/L
- Irrigation - 20 to 50 µg/L
- Livestock watering - 50 µg/L
- Drinking water - 10 µg/L

B3.9.2 Wildlife Benchmarks

Sample and others (1996) have derived screening benchmarks for wildlife based on no observed adverse effect levels. These values are presented in Table B-5.

To be considered unlikely to represent an ecological risk, water concentrations should be below the following benchmarks for each species present (Opresko and others 1994, as cited in Irwin and others 1997):

Species	Water Concentration (ppm)
Mouse (test species)	0.000
Short-tailed shrew	0.429
Little brown bat	0.741
White-footed mouse	0.277
Meadow vole	0.485
Cottontail rabbit	0.230
Mink	0.238
Red fox	0.170
Whitetail deer	0.095

Selenium levels of less than 0.01 mg/L should be used to protect livestock/cattle (Irwin and others 1997).

Table B-6 presents toxicity effects thresholds for plants, invertebrates, fish, amphibians and reptiles, birds, and mammals based on the extensive review selenium toxicity conducted by Skorupa (1998).

B3.9.3 Soils

There is some limited information on guidelines for selenium levels in soils. Most of these values were developed outside of the United States (Irwin and others 1997):

- Maximum allowable concentration (MAC) levels of selenium (dry weight):
    - Stuttgart – 10 ppm
    - London – 3 ppm
- Ontario Ministry of Agriculture and Food for MAC in soils treated with sewage sludge: 1.6 ppm dry weight
- New Jersey Department of Environmental Protection 1987 soil cleanup value for selenium is 4 mg/kg dry weight (Beyer 1990)
- Quebec considers 1 ppm as the background concentration, 3 ppm as moderately contaminated soils, and 10 ppm as a threshold that requires immediate cleanup (Beyer 1990, as cited in Irwin and others 1997)
- Ontario considers 1.6 ppm of selenium as the maximum concentration for proposed redevelopment as agriculture and 5 ppm as the maximum for proposed redevelopment as residential or parkland (Beyer 1990, as cited in Irwin and others 1997)
- Suggested safe application (kilograms per hectare [kg/ha]) of trace compounds to Missouri soils without further investigations should not exceed maximum cumulative value of 18 kg/ha (Beyer 1990, as cited in Irwin and others 1997).
- Canada developed interim assessment criteria for soil of 1 microgram per gram (μg/g) (ppm) (CCME 1991). In addition, they also developed interim remediation criteria for soil, as follows:
    - Agricultural - 2 μg/g (ppm)
    - Residential/Parkland - 3 μg/g (ppm)
    - Commercial/Industrial - 10 μg/g (ppm)

B3.9.4 Plants

There are several proposed guidelines to protect plants by controlling the levels of selenium in soils:

- Levels of selenium considered to be phytotoxic Kabata-Pendias and Pendias (1992, as cited in Irwin and others 1997):
    - Vienna – 10 ppm dry weight
    - Warsaw – 10 ppm dry weight

- Ontario – 5 ppm dry weight

- ORNL has determined that the total selenium concentration in soils that would be unlikely to pose an ecological risk to plants should be below 1 mg/kg in soils and 0.7 mg/L in solution (Will and Suter 1995).

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TABLE B-1

BACKGROUND CONCENTRATION OF SELENIUM IN PLANTS AND ANIMALS[1]
AREA WIDE HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENT WORK PLAN
SOUTHEAST IDAHO PHOSPHATE MINING RESOURCE AREA

Medium	Background (mg/kg dry weight, except as noted)
Plants:	
Freshwater Algae	0.1 to 1.5
Freshwater Macrophytes	0.1 to 2.0
Terrestrial Plants	0.01 to 0.6
Invertebrates:	
Aquatic	0.4 to 4.5
Terrestrial	0.1 to 2.5
Fish:	
Liver	2.0 to 8.0
Other Tissues	1.0 to 4.0
Reptiles and Amphibians:	
Liver	2.9 to 3.6
Other Tissues	1.0 to 3.0
Birds (Whole body):	Less than 2.0
Muscle	1.0 to 3.0
Eggs	Less than 5.0
Liver	Less than 10.0
Feathers	1.0 to 4.0
Whole Blood	0.1 to 0.4 mg/L
Mammals (Whole body):	Less than 1.0 to 4.0
Muscle	Less than 1.0
Liver	1.0 to 10.0
Hair	Less than 1.0 to 3.0
Milk	Less than 0.05 mg/L
Whole Blood	0.1 to 0.5 mg/L

Notes:

[1] Information based on Skorupa, J.P. 1998. "Selenium." Pages 139 through 184. In P.L. Martin and D.E. Larsen (Editors). *Guidelines for Interpretation of the Biological Effects of Selected Constituents in Biota, Water, and Sediment.* National Irrigation Water Quality Program Information Report No. 3. Department of the Interior. November.

mg/kg Milligrams per kilogram
mg/L Milligrams per liter

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TABLE B-2

SELENIUM CONCENTRATIONS IN FIELD POPULATIONS OF TERRESTRIAL PLANTS AND ANIMALS
AREA WIDE HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENT WORK PLAN
SOUTHEAST IDAHO PHOSPHATE MINING RESOURCE AREA

Ecosystem, Taxonomic Group, Organism, Tissue, Location, and Other Variables	**Concentration[1] (ppm)**	
Macrophytes		
Western wheat grass (*Agropyron smithii*) South Dakota- plant top	11.5 (0.0 to 8.4) DW	Jenkins 1980
Little bluestem, (*Andropogon scoparius*)- plant top	0.0 to 6.0 DW	Jenkins 1980
Asparagus (*Asparagus officinale*) Western United States	2.7 to 11.0 DW	
Aster, whole *Aster caerulescens* *A. commutatus* *A. multiflora* *A. occidentalis*	 560.0 DW Maximum 590.0 DW Maximum 320.0 DW 284.0 DW	Jenkins 1980
Milk Vetch *Astragalus argillosus* Top Root *A. beathii* Top Root *A. bisulcatus* Top Seed *A.* confertiflorus Top *A. crotulariae* Top Root	 385.0 DW 27.0DW 1,963.0 DW 66.0 DW Maximum 10,239.0 DW 305.1 DW 1,372.0 2,000.0 DW 45.0 DW	Jenkins 1980
Locoweed, *Astragalus* spp.	Maximum 46,000.0 AW Maximum 6,000.0 DW	Jenkins 1980
Saltbush, *Atriplex* spp.	300.0 to 1,734.0 DW	Jenkins 1980
Oats, *Avena sativa*	2.0 to 15.0 DW	Jenkins 1980
Buffalo grass, *Bouteloua dactyloides*	2.7 (0.0 to 12.0) DW	Jenkins 1980

TABLE B-2 (continued)

SELENIUM CONCENTRATIONS OF FIELD POPULATIONS OF TERRESTRIAL PLANTS AND ANIMALS
AREA WIDE HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENT WORK PLAN
SOUTHEAST IDAHO PHOSPHATE MINING RESOURCE AREA

Ecosystem, Taxonomic Group, Organism, Tissue, Location, and Other Variables	Concentration[1] (ppm)	
Macrophytes (continued)		
Indian paint brush, *Castillaja* spp.	0.0 to 1,812.0 DW	Jenkins 1980
Gumweed, *Grindelia squarrosa*	38.0 (0.0 to 2,160.0) DW	Jenkins 1980
Broomweeds, *Gutierrezia* spp. *Haplopappus* spp.	 Up to 723.0 DW up to 4,800.0 DW	Jenkins 1980
Annelids		
Earthworms, whole From normal soil From selenite enriched soil From soil amended with sewage sludge Whole Casts From control field Whole Casts	 2.2 FW 7.5 FW 15.0to 22.4 DW 0.6 to 0.7 DW 22.1DW 0.6 DW	 Birkner 1978 Helmke and others 1979 Helmke and others 1979
Arthropods		
Sow bug, *Porcellio* spp.	0.9 FW	Jenkins 1980
Fly larvae, whole, from *Astragalus* plant with 1,800 ppm, selenium	20.0 FW	Jenkins 1980
Birds		
Blackbird, *Turdus merula*	2.1 DW	Nielson and Gissel-Nielson 1975
House sparrow, *Passer domesticus*	0.6 DW	Nielson and Gissel-Nielson 1975
Pheasant, *Phasianus colchicus*	0.6 DW	Nielson and Gissel-Nielson 1975
Mammals		
Beaver, *Castor canadensis* Liver Kidney Intestine Muscle	 0.2 FW 0.3 FW 0.4 FW 0.09 FW	Wren 1984

TABLE B-2 (continued)

SELENIUM CONCENTRATIONS OF FIELD POPULATIONS OF TERRESTRIAL PLANTS AND ANIMALS
AREA WIDE HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENT WORK PLAN
SOUTHEAST IDAHO PHOSPHATE MINING RESOURCE AREA

Ecosystem, Taxonomic Group, Organism, Tissue, Location, and Other Variables	**Concentration[1] (ppm)**	
Mammals (continued)		
Otter, *Lutra canadensis* Liver Kidney Intestine Muscle	 2.1 FW 1.9 FW 1.10W 1.2 FW	Wren 1984
Field mole, *Microtus agrestris* Whole	 0.5 DW	Nielson and Gissel-Nielson 1975
White-tailed deer, *Odocoileus virginianus* Muscle	0.16 (0.05 to 0.49) DW	Ullrey and Others 1981
Raccoon, *Procyon lotor* Liver Kidney Muscle	 2.8 FW 1.9 FW 0.2 FW	Wren 1984
Rat, *Rattus norvegitus* Whole	 0.4 DW	Nielson and Gissel-Nielson 1975
Rock Squirrel, *Spermophiles variegatus* Kidney	 8.9 to 53.0 (Maximum 90.0) DW	Sharma and Shupe 1977
Mole, *Talpa europaea* Whole	 2.6 DW	Nelson and Gissel-Nielson 1975

Notes:

1 Hyphenated values indicate the range, and single numbers indicate the mean.

2 Taken from Eisler, R. 1985. "Selenium Hazards to Fish, Wildlife, and Invertebrates: A Synoptic Review." U.S. Fish and Wildlife Report. *Biological Report*. Volume 85, Number 1.5. October.

AW	Ash weight	FW	Fresh weight
DW	Dry weight	ppm	Parts per million

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TABLE B-3

PROPOSED SELENIUM LEVELS PROTECTIVE AGAINST SELENOSIS [1]
AREA WIDE HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENT WORK PLAN
SOUTHEAST IDAHO PHOSPHATE MINING RESOURCE AREA

Criterion	Selenium Concentration (ppb)	Reference
Aquatic Life Protection		
Freshwater: As Inorganic Selenite As Inorganic Selenate	 Up to 35 in water (24 hour average), not to exceed 260 at any time Less than 760	 U.S. Environmental Protection Agency 1980
Livestock Protection		
Drinking Water	Less than 50	National Academy of Sciences 1974; Wilber 1983
Diet: Total Natural Feeds (Natural) Forage (Natural)	 Less than 2,000 (DW) Less than 4,000 Less than 2,000 Less than 5,000	 National Research Council 1983 Wilber 1983 Frost 1972 Frost 1972
Crop Protection		
Irrigation Water	Less than 50	Birkner 1978; Wilber 1983

Notes:

[1] Taken from Eisler, R. 1985. "Selenium Hazards to Fish, Wildlife, and Invertebrates: A Synoptic Review." U.S. Fish and Wildlife Report. *Biological Report*. Volume 85, Number 1.5. October.

DW Dry weight
ppb Parts per billion

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TABLE B-4

SUMMARY OF COMPREHENSIVE BIOTIC EFFECTS OF SELENIUM[1]
AREA WIDE HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENT WORK PLAN
SOUTHEAST IDAHO PHOSPHATE MINING RESOURCE AREA

Medium	No Effect[2]	Level of Concern[3]	Toxicity Threshold[4]	
Water (total recoverable selenium - µg/L)[5]	<1.0	1.0 to 2.0	> 2.0	Peterson and Nebeker (1992), as cited in Skorupa (1998)
Sediment (mg/kg dry weight)	< 1.0	1.0 to 4.0	> 4.0	Van Derveer and Canton (1997), SJVDP (1990), and Lemly and Smith (1987), as cited in Skorupa (1998)
Diet (mg/kg/day, dry weight)	< 2.0	2.0 to 3.0	> 3.0	Lemly (1996a) as cited in Skorupa (1998)
Water bird eggs (mg/kg dry weight)	< 3.0	3.0 to 6.0	> 6.0	No-effect level from Skorupa and Ohlendorf (1991) and toxicity threshold from Skorupa (1998a), as cited in Skorupa (1998)
Fish, whole-body (mg/kg dry weight):				Lemly (1996a), as cited in Skorupa (1998)
Warm-water species	< 3.0	3.0 to 4.0	> 4.0	
Cold-water species	< 2.0	2.0 to 4.0	> 4.0	

Notes:

1 Information taken from Skorupa, J.P. 1998. "Selenium." Pages 139 to 184. In P.L. Martin and D.E. Larsen (Editors). *Guidelines for Interpretation of the Biological Effects of Selected Constituents in Biota, Water, and Sediment.* National Irrigation Water Quality Program Information Report No. 3. Department of the Interior. November.

2 Concentrations that are lower than this value produce no discernable, adverse effects on fish or wildlife. These values are typical of background concentrations in uncontaminated environments.

3 Concentrations of selenium in this range rarely produce discernable, adverse effects. These values are elevated above typical background concentrations.

4 Selenium concentrations above this value appear to produce adverse effects on some fish and other wildlife organisms.

5 Total recoverable selenium is equivalent to unfiltered water samples.

µg/L Micrograms per liter mg/kg Milligrams per kilogram mg/kg/day Milligrams per kilogram day

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TABLE B-5

NO OBSERVED ADVERSE EFFECTS LEVEL-BASED TOXICOLOGICAL BENCHMARKS FOR SELECTED AVIAN AND MAMMALIAN WILDLIFE SPECIES[1]
AREA WIDE HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENT WORK PLAN
SOUTHEAST IDAHO PHOSPHATE MINING RESOURCE AREA

Analyte	Form	Endpoint Species	Estimated Wildlife NOAEL (mg/kg/day)	Food (mg/kg)	(mg/L)
Selenium	Selenate	Little brown bat	0.523	1.568	3.267
Selenium	Selenate	Short-tailed shrew	0.440	0.733	1.998
Selenium	Selenate	White-footed mouse	0.399	2.585	1.331
Selenium	Selenate	Meadow vole	0.366	2.956	2.463
Selenium	Selenate	Mink	0.154	1.123	1.554
Selenium	Selenate	Cottontail rabbit	0.147	0.744	1.520
Selenium	Selenate	Red fox	0.106	1.056	1.251
Selenium	Selenate	River otter	0.091	0.813	1.143
Selenium	Selenate	Whitetail deer	0.056	1.822	0.857
Selenium	Sodium selenite	Rough-winged swallow	0.500	0.663	2.149
Selenium	Sodium selenite	American robin	0.500	0.414	3.632
Selenium	Sodium selenite	Belted kingfisher	0.500	0.987	4.625
Selenium	Sodium selenite	American woodcock	0.500	0.660	4.950
Selenium	Sodium selenite	Cooper's hawk	0.500	2.888	6.456
Selenium	Sodium selenite	Barn owl	0.500	1.864	6.657
Selenium	Sodium selenite	Barred owl	0.500	4.268	7.628
Selenium	Sodium selenite	Red-tailed hawk	0.500	5.165	8.797
Selenium	Sodium selenite	Osprey	0.500	2.500	9.740
Selenium	Sodium selenite	Great blue heron	0.500	2.845	11.295
Selenium	Sodium selenite	Wild turkey	0.500	16.667	15.263
Selenium	Selenomethionine	Rough-winged swallow	0.400	0.530	1.719

TABLE B-5 (continued)

NO OBSERVED ADVERSE EFFECTS LEVEL-BASED TOXICOLOGICAL BENCHMARKS FOR SELECTED AVIAN AND MAMMALIAN WILDLIFE SPECIES[1]
AREA WIDE HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENT WORK PLAN
SOUTHEAST IDAHO PHOSPHATE MINING RESOURCE AREA

Analyte	Form	Endpoint Species	Estimated Wildlife NOAEL (mg/kg/day)	Food (mg/kg)	Water (mg/L)
Selenium	Selenomethionine	American robin	0.400	0.331	2.906
Selenium	Selenomethionine	Belted kingfisher	0.400	0.789	3.700
Selenium	Selenomethionine	American woodcock	0.400	0.528	3.960
Selenium	Selenomethionine	Cooper's hawk	0.440	2.542	5.681
Selenium	Selenomethionine	Barn owl	0.440	1.640	5.858
Selenium	Selenomethionine	Barred owl	0.440	3.756	6.712
Selenium	Selenomethionine	Red-tailed hawk	0.440	4.545	7.741
Selenium	Selenomethionine	Osprey	0.440	2.200	8.571
Selenium	Selenomethionine	Great blue heron	0.400	2.276	9.036
Selenium	Selenomethionine	Wild turkey	0.400	13.333	12.211
Selenium	Selenomethionine	Belted kingfisher	1.800	3.552	16.650
Selenium	Selenomethionine	Great blue heron	1.800	10.243	40.662

Notes:

[1] Information taken from Sample, B.E., D.M. Opresko, and G.W. Suter II. 1996. "Toxicological Benchmarks for Wildlife: 1996 Revision." Oak Ridge National Laboratory. ES/ER/TM-86/R3. Oak Ridge, Tennessee. June.

mg/kg/day Milligrams per kilogram per day
mg/kg Milligrams per kilogram
mg/L Milligrams per liter
NOAEL No observed adverse effects level

TABLE B-6

SUMMARY OF SELENIUM EFFECT THRESHOLDS FOR VARIOUS TYPES OF ORGANISMS[1]
AREA WIDE HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENT WORK PLAN
SOUTHEAST IDAHO PHOSPHATE MINING RESOURCE AREA

Interpretive Guidance	Effective Concentration Threshold
Plants	
Experimental LOAEL for sublethal effects (growth) in algal tissue	Plant selenium concentration 4.0
Experimental LOAEL for sublethal effects (growth) in macrophyte tissue (lettuce)	Plant selenium concentration 250.0
Experimental LOAEL for lethal effects in macrophyte (lettuce) tissue	Plant selenium concentration 800.0
Toxicity test LOAEL for sublethal effects on green algae	Waterborne selenium exposure (µg/L) 10.0 to 300.0 selenate 75.0 selenite
Toxicity test LOAEL for sublethal effects on blue-green algae	Waterborne selenium exposure (µg/L) 100.0 selenomethionine 3,000.0 selenate 3,000.0 selenite
Toxicity test LOAEL for sublethal effects on macrophyte (lettuce)	Waterborne selenium exposure (µg/L) 200.0 selenate 3,000 selenite
Irrigation water standard to protect crop plants	Waterborne selenium exposure (µg/L) ≤ 50.0 total
Invertebrates	
Experimental LOAEL for sublethal effects (growth), midge larvae and amphipod tissue concentrations	Invertebrate selenium concentration 2.5 to 15.0
Experimental LOAEL for sublethal effects (respiration rate) in crayfish	Invertebrate selenium concentration 30.0 (hepatopancreas)
Experimental LOAEL for reproductive effects, amphipod tissue concentration	Invertebrate selenium concentration 32.0
Experimental LOAEL for sublethal effects (growth) in midge larvae	Dietary selenium exposure 2.1
Experimental NOAEL for acute toxicity in amphipods	Dietary selenium exposure 300.0
No clear community-level effects on benthic macro-invertebrates, outdoor macrocosm studies	Waterborne selenium exposure (µg/L) 25.0 inorganic mixture
Altered protozoan species diversity	Waterborne selenium exposure (µg/L) 20.0 to 160.0 (selenite)
Toxicity test LOAELs for acute toxicity in midge larvae amphipods	Waterborne selenium exposure (µg/L) 4.0 (selenomethionine) 200.0 (selenite) 500.0 (selenate)
Toxicity test LOAEL for sublethal (growth) effects on protozoans	Waterborne selenium exposure (µg/L) 3.0 (selenite)
Toxicity test LOAELs for chronic toxicity in midge larvae and amphipods	Waterborne selenium exposure (µg/L) < 0.5 (Selenomethionine) 25.0 to 100.0 (selenite) 25.0 to 100.0 (selenate)

TABLE B-6 (continued)

SUMMARY OF SELENIUM EFFECT THRESHOLDS FOR VARIOUS TYPES OF ORGANISMS[1]
AREA WIDE HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENT WORK PLAN
SOUTHEAST IDAHO PHOSPHATE MINING RESOURCE AREA

Interpretive Guidance	Effective Concentration Threshold (mg/kg, unless otherwise denoted)
Invertebrates (continued)	
Experimental LOAEL for drinking water toxicity in house flies	Waterborne selenium exposure (µg/L) 4,000.0 (selenite)
Lowest validated concentration in edible tissue (trout fillet) warranting human health advisory	Fish selenium concentration 2.0
Outdoor macrocosm LOAEL for reproductive impairment (bluegill)	Fish selenium concentration 16 to 18 (gonad and egg tissue)
Estimated true threshold range (≈ IC10) for reproductive impairment in sensitive species (perch and bluegill)	Fish selenium concentration 7.0 to 13.0 (gonad and egg tissue)
Experimental LOAEL for total reproductive failure (bluegill)	Fish selenium concentration 15.0 to 20.0 (whole body, parental)
Estimated true threshold range (≈ IC10) for reproductive impairment in sensitive species (perch, bluegill, salmon)	Fish selenium concentration 4.0 to 6.0 (whole body, parental or offspring)
Complete reproductive failure (IC10) in sensitive species (bluegill)	Dietary selenium exposure 30.0 to 35.0 (food chain selenium or selenomethionine)
Estimated true threshold range (≈ IC10) for reproductive failure in sensitive species (bluegill), parental exposure only	Dietary selenium exposure 10.0 (food chain selenium or selenomethionine)
Experimental LOAEL's for reproductive impairment from lethal larval dietary exposure (salmon, bluegill, and razorback suckers)	Dietary selenium exposure 3.0 to 8.0 (food chain selenium or selenomethionine)
Health advisories recommend limited fish consumption by healthy adults and no consumption by children and pregnant women	Edible tissue selenium 2.0 (wet weight)
Complete ban on human consumption of fish recommended	Edible tissue selenium 5.0 (wet weight)
Amphibians and Reptiles	
Presumptive reproductive impairment threshold	Biomass selenium concentration ≥ 10.0 (eggs)
Presumptive adverse effects threshold on a whole body basis (10 x normal)	Biomass selenium concentration ≥ 20.0 (whole body)
Lowest toxicity test Lethal Concentration 50 for amphibian eggs and larvae	Waterborne selenium exposure (µg/L) 90.0
Birds	
Embryo teratogenesis threshold (≈ IC10), wild ducks (sensitive taxon)	Bird selenium concentration 23.0 (in ovo)
Embryo viability (≈ egg hatchability) threshold, captive mallards	Bird selenium concentration 10.0 (in ovo)
Embryo teratogenesis threshold (≈ IC10), American avocets (tolerant taxon)	Bird selenium concentration 74.0 (in ovo)
Embryo viability (= egg hatchability) threshold, American avocets	Bird selenium concentration 61.0 to 80.0 (in ovo)
Hepatic threshold for juvenile and adult toxicity	Bird selenium concentration 30.0 (liver)
Muscle threshold for juvenile and adult toxicity	Bird selenium concentration ≈ 20.0 (breast muscle)
Provisional feather threshold warranting further study	Bird selenium concentration 5.0 (breast feathers)

TABLE B-6 (continued)

SUMMARY OF SELENIUM EFFECT THRESHOLDS FOR VARIOUS TYPES OF ORGANISMS[1]
AREA WIDE HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENT WORK PLAN
SOUTHEAST IDAHO PHOSPHATE MINING RESOURCE AREA

Interpretive Guidance	(mg/kg, unless otherwise denoted)
Birds (continued)	
Provisional blood threshold warranting further study	Bird selenium concentration 1.0 (whole blood) (wet weight)
Reproductive impairment threshold	Bird selenium concentration 3.0 to 8.0
Toxicity threshold for nonbreeding birds exposed to winter stress	Bird selenium concentration 10.0 to 15.0
Health advisories recommend limited consumption by healthy adults and no consumption by children and pregnant women	Edible tissue selenium 2.0 (wet weight)
Complete ban on human consumption recommended	Edible tissue selenium 5.0 (wet weight)
Mammals	
Reproductive depression threshold hair	Mammal selenium concentration (dry weight) > 10.0
Overt equine selenosis threshold, blood	Mammal selenium concentration (dry weight) 1.0 mg/L
Human chronic selenosis threshold, blood	Mammal selenium concentration (dry weight) 3.0 mg/L
Acute lethal toxicity LOAEL, sea lions, blood	Mammal selenium concentration (dry weight) 5.0 mg/L
Veterinary toxicological handbook threshold, domestic livestock, liver	Mammal selenium concentration (dry weight) 45.0 to 60.0
Sublethal effects threshold, lifetime exposure of rats	Dietary selenium exposure (dry weight) 1.4
Chronic selenosis threshold, humans	Dietary selenium exposure (dry weight) 1.9
Reduced longevity threshold, lifetime exposure, rats	Dietary selenium exposure (dry weight) 3.0
LOAEL for reproductive selenosis, in rats	Dietary selenium exposure (dry weight) 3.0
Overt toxicity thresholds, domestic livestock	Dietary selenium exposure (dry weight) 3.0 to 5.0
Sublethal effects LOAEL, dogs	Dietary selenium exposure (dry weight) 7.0
Health advisories recommend limited consumption by healthy adults and no consumption by children or pregnant women	Edible tissue selenium (wet weight) ≥ 2.0
Complete fan on human consumption recommended	Edible tissue selenium (wet weight) ≥ 5.0

TABLE B-6 (continued)

SUMMARY OF SELENIUM EFFECT THRESHOLDS FOR VARIOUS TYPES OF ORGANISMS[1]
AREA WIDE HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENT WORK PLAN
SOUTHEAST IDAHO PHOSPHATE MINING RESOURCE AREA

Notes:

[1] Information taken from Skorupa, J.P. 1998. "Selenium." Pages 139 to 184. In P.L. Martin and D.E. Larsen (Editors). *Guidelines for Interpretation of the Biological Effects of Selected Constituents in Biota, Water, and Sediment.* National Irrigation Water Quality Program Information Report No. 3. Department of the Interior. November.

IC10	Threshold of reproductive failure
LOAEL	Lowest observed adverse effects level
µg/L	Micrograms per liter
mg/kg	Milligrams per kilogram
mg/L	Milligrams per liter
NOAEL	No observed adverse effects level

APPENDIX C

IDAHO DEPARTMENT OF ENVIRONMENTAL QUALITY
RESPONSE TO COMMENTS ON THE
DRAFT
AREA WIDE HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENT

APPENDIX C: PUBLIC COMMENTS AND IDEQ RESPONSES REGARDING THE DRAFT AREA WIDE RISK ASSESSMENT WORK PLAN

The Idaho Department of Environmental Quality (IDEQ) conducted a formal 30-day public comment period from November 1st through November 30th, 2001 to solicit comments on the Draft Area Wide Risk Assessment Work Plan. The Idaho Mining Association Selenium Committee (IMA), Greater Yellowstone Coalition (GYC), US Bureau of Land Management (BLM), US Fish & Wildlife Service (USFWS) and University of Idaho submitted formal comments. The specific comments and IDEQ responses (***italicized)*** are enclosed.

The Area Wide Risk Assessment Work Plan presents the procedures and approach for estimating regional risks to human health and the environment from historic phosphate mining operations in Southeast Idaho. The results are intended to assist the Agency in developing contemporaneous regional remedial action goals and objectives, and to support future site-specific risk management activities. The area wide effort is meant to provide a holistic assessment of existing human health and ecological impacts in Southeast Idaho, and to establish a basis for addressing localized impacts in a focused, yet integrated manner. Remedial decision-making will be conducted at each individual mine site upon completion of comprehensive site-specific investigations, risk evaluations and alternative selection processes, under the direction of the appropriate lead/support Agencies. Regional goals and objectives established by the IDEQ will be periodically updated to reflect changes in regulatory requirements, new regional data or shifts in scientific consensus.

The Area Wide Risk Assessment Work Plan, as well as the forthcoming results, are primarily products of the IDEQ and their contractor, intended to support State priorities and governing regulatory requirements. However, all procedures and published documents are pre-planned and coordinated with technical representatives of the other federal, state and tribal agencies with jurisdictional interests in the Resource Area to arrive at some level of consensus. Draft documents and results are also presented to participants of the Selenium Area Wide Advisory Committee (SeAWAC) to solicit stakeholder input, although, final decision-making authority lies with the Agency and does not necessarily represent stakeholder consensus on all issues.

The comments received on the draft risk assessment work plan ranged from general concerns to very detailed technical points. The general concerns can be segregated into several broad areas and warrant some preliminary discussion, while the specific technical comments are directly addressed by the Agency in the enclosed documents.

The first general area of concern is the quality, comparability and use of available area wide data sets. The area wide investigation effort has been on going since 1997 and consists of a significant amount of information generated during each consecutive field season. Upon assuming the lead Agency role for the Area Wide Investigation in the summer of 2000, the IDEQ performed an extensive evaluation of the existing data and an analysis of critical data gaps for preliminary regulatory decision-making. While the Agency expressed concerns regarding non-conventional data validation and reduction methods used in earlier studies, it was determined that the sample collection and laboratory analysis methods for the majority of the data was adequate for use in the regional risk estimation process. However, most of the historic data sets were limited to analysis of selenium and cadmium, and the Agency chose to evaluate an expanded list of potential mining-related constituents to document the comprehensive screening of the final list of contaminants of potential concern for risk assessment purposes.

In 2001, the Agency collected additional samples in various media to allow for screening of this expanded analyte list. To ensure data consistency, the Agency continued to use the University of Idaho analytical laboratory and standard industry practice sampling methodologies. Based on the findings of earlier investigations and in an attempt to perform the Agency investigative efforts in a resource effective manner, a directed sampling approach was selected to provide representative background information and concentration gradient-based results for known areas of impact versus a purely random sampling approach.

Selected background samples were collected from upgradient, undisturbed areas representative of pre-mining conditions for each media. Media concentrations in excess of two times the average background concentration will be considered elevated and will be further evaluated in the risk assessment process. The initial list of constituents for risk assessment consideration will be discussed in detail in an Appendix to the risk assessment document. A final list of Contaminants of Potential Concern for future site-specific investigations will be developed upon completion of the risk assessment process but may be modified by the assigned Lead Agency to reflect unique site conditions.

Other sample locations were selected to represent the full spectrum of previously observed concentrations from both impacted and unimpacted areas to develop average exposure point concentrations and to assess concentration-dependent ecological effects. Many of the samples were collected in locations sampled during previous annual events to allow temporal data comparisons. During the sampling effort, it became apparent that the record low water years in 2000 and 2001were having a significant but manageable effect on observed area wide concentrations and that relatively wide ranging temporal data fluctuations were occurring. As a result, the Agency concluded that although the majority of the area wide data sets were comparable in quality; they should be evaluated separately due to temporal effects. The work plan uses the 2001 data set for the Tier 2 baseline risk assessment because of the inclusion of the expanded mining-related analyte list. The historic data sets for selenium, and possibly cadmium, will be evaluated in Tier 3 to assess temporal risk fluctuations resulting from annual precipitation variations.

Overall, the Agency is satisfied that the quantity and quality of data available from area wide efforts are sufficient for the regional assessment and within the tolerances of uncertainty normally associated with risk management planning. However, the Agency also recognizes that additional sampling will be required to characterize individual mine sites, delineate local impacts/subpopulation risks, and support site-specific remedial decision-making, particularly in cases where statistical or probabilistic methods are proposed for Agency consideration by mine operators.

The second general area of concern can best be described as a difference of opinion regarding deterministic versus probabilistic approaches to the Area Wide risk assessment. This concern also goes to the level of conservatism applied to the risk assessment process. The Agency has developed a pragmatic approach to the risk evaluation process while recognizing our regulatory obligation of protecting public health and the environment.

The Agency agrees, in theory, that probabilistic approaches to risk assessment, when properly applied, may result in more realistic estimates of risk than deterministic methods. However, this conclusion assumes the availability of reliable distribution function information and statistically-based toxicological references for appropriate species. The USEPA is in the process of developing acceptable probabilistic methods and has published an interim policy for the use of probabilistic approaches that requires the inclusion of concurrent deterministic results in addition

to an in-depth discussion of the development of stochastic input variables/reference value distributions. The IDEQ has concluded that the current lack of USEPA-approved ecological reference values and the absence of area wide distribution functions derived from statistically adequate population sizes prohibits the use of a probabilistic approach for the area wide risk assessment effort and would introduce additional uncertainty. It is apparent from stakeholder comments on the preliminary risk assessment efforts performed by the IMA in 1998 that a probabilistic approach to the area wide risk assessment would require the questionable development of many distributions used in the models and would, most likely, result in a lack of acceptance by the other agencies and involved parties. The Agency believes a probabilistic approach may be better managed on a site-specific basis where statistically derived sample population sizes could be applied and sub-population impacts considered within reasonable boundaries.

Notwithstanding the previous conclusion, the Agency also recognizes the problems inherent with deterministic (point-estimate) models and the high-level of conservatism that typically results through compounding worst-case parameters in deterministic risk models. The Agency considers this additional conservatism to be appropriate in the evaluation of individual-level human health risks. Although to provide regulatory risk managers with a balanced perspective of the calculated human health risk estimates in the area wide risk assessment process, both Reasonable Maximum Exposure (RME) and Central Tendency Exposure (CTE) risk estimates will be provided using USEPA guidance.

For the Area Wide ecological baseline risk assessment, the Agency has directed the use of central tendency deterministic modeling that applies area weighted average exposure point concentrations for population-level evaluations as well as mean reference values for the parameters in the USEPA risk models, where discretion is allowed. The Agency intends that this approach result in a slightly conservative area wide risk estimate that represents exposures and effects to average members of each target population. Tier 1 of the ecological risk assessment also provides for a RME screening step to establish upper bound estimates that would apply to more sensitive portions of the target population. Regulatory risk managers will be able to use these contrasting results for their risk planning and decision making activities.

The last area of general concern goes to the appropriateness and representativeness of the risk models selected for the area wide risk assessment, and the integration of area-specific studies in the risk management process. Obviously, the Agency's initial focus in the risk assessment activities is on public health and safety issues. Adverse effects from selenium exposures in humans are relatively rare and most commonly associated with overdoses of selenium supplements or restricted high-selenium diets in impoverished or under developed areas. It should be noted that the participants in the Area Wide Investigations are unaware of any indications of human health impacts occurring from selenium exposures in the study area and that the human health component of the Area Wide Risk Assessment is strictly precautionary. For the area wide human health risk evaluation, three lifestyle scenarios are considered.

The first scenario is an adult and child subsistence lifestyle assuming a diet consisting of livestock, game and homegrown produce harvested from the resource area. Subsistence lifestyles are normally associated with the "Grizzly Adams" type individual residing in a wilderness environment and living solely "hand to mouth" off the land through poaching, gathering, fishing, etc. The health consultation developed by the Idaho Department of Health (IDH), as well as the IDEQ, recognizes that this is not a realistic scenario for the Resource Area due to the lack of true wilderness areas, relatively high sportsman access, careful monitoring by land management agencies and the mining industry presence. However, the Agency is aware that portions of the

local population in the vicinity of the Resource Area have the potential for supplementing their diet with a significant, but unquantified, contribution of foodstuffs from the study area. The Agency has concluded, with IDH concurrence, that the most reasonable and efficient approach to assessing potential risks from ingestion of resource area game, livestock, and gardens is to assume a modified-subsistence scenario that conservatively considers a rural-based "subsistence" lifestyle as defined in the work plan. This definition allows for some realistic adjustments to the ingestion assumptions such as drinking water from domestic wells, a portion of dietary needs from commercial sources, and a limited contribution of foodstuffs from home-grown gardens. If this estimate indicates a negligible risk, then concerns for lesser dietary exposures can be eliminated. If, however, a significant risk is indicated under this scenario, then the additional efforts of collecting regional data to determine actual dietary use of Resource Area foodstuffs may be warranted.

Similarly, reference literature seems to indicate that the risk of effects from selenium exposure in children is no higher, and may even be lower, than in adults. However, the Agency holds that it would be inappropriate to neglect a child component to the risk assessment since this is typically a requirement for USEPA acceptance of risk estimate products, the additional effort in incorporating the child component is minimal, and public reviewers would expect this component to be addressed.

The second lifestyle scenario under consideration is a recreational user including hunters, fishers and campers. At the request of several commenters, this scenario now includes the addition of ingestion of drinking water from potential surface water sources, and consideration of the inhalation of dust from recreational vehicles in unrestricted areas.

The third and final lifestyle scenario being considered is Native American use, which is similar to the recreational use scenario with the exception of recognizing extended treaty right access in the Resource Area and the potential cultural use of several surrogate plant species identified by tribal representatives.

With regards to the representativeness of selected risk assessment models, a number of comments were provided concerning the specific target species proposed for use in the assessment. It is common to use surrogate species to represent certain classifications, guilds or communities of similar species or habitat users. While there are inherent uncertainties associated with use of surrogate species evaluations, risk assessors recognize the potential for interspecies differences. The surrogate species designated for use in the area wide ecological assessment were selected based on the availability of reference information related to selenium exposure. The lack of applicable toxicological data for many species in the Resource Area prevents the direct evaluation of risk effects from exposure to selenium or other constituents, and surrogate evaluation is the best alternative for assessment purposes. The Agency recognizes that other species may not react to exposures in identical manners, and therefore, cites further justification for the need of some level of conservatism in the risk estimation process.

Concerning integration of area-specific studies in the risk management process, the Agency will consider any relevant information provided throughout the process of addressing selenium issues in Southeast Idaho. Regulatory agencies would prefer to make decisions based on area-specific data and investigations; however, the Agency also recognizes that the applicability and use of area wide information may be limited to the scope and breadth of the individual study or experimental design. The Agency is aware of a number of ongoing studies, regulatory reviews and independent research activities that may ultimately impact our understanding of selenium science as well as the regulatory decision-making process. The Agency has chosen to proceed

with the regional risk assessment/management process under our established schedule, but will remain open to periodic review and revision of our regional goals and objectives throughout the resolution of associated issues.

In conclusion, the risk assessment process is a tool for regulatory risk management decision-making, and as such, must be conducted in a manner that provides the Agency risk managers with some level of confidence in interpreting the results. The risk assessment process is intended to identify the primary issues and areas of risk management concerns for the Agency, and provide relative risk comparisons that allow the Agency to develop general contemporaneous regional goals and objectives in support of future site-specific activities. Prior to selecting or implementing any remedial alternatives, more comprehensive studies will be performed at each subject mine site and localized risk estimates will be developed. The existing regional goals and objectives will be periodically reviewed to reflect changes in regulatory requirements, new area-specific information or shifts in scientific consensus.

The Agency appreciates the involvement of the formal commenters, and we have incorporated a significant portion of the suggested modifications into the final work plan. In cases where the Agency disagrees with the comments that were provided, we have attempted to explain our justification for the selected approach while recognizing and respecting the fact that technical opinions may differ. We look forward to continued efforts to resolve the associated issues in Southeast Idaho and we hope to see the formal commenters, stakeholders and other involved participants remain engaged in this process. Questions regarding the Selenium Area Wide Investigation should be referred to Rick Clegg, IDEQ at 208-547-1940 (or rclegg@deq.state.id.us).

IDEQ Responses to IMA Comments of 11/30/01 on Draft Area Wide Risk Assessment Work Plan

IDAHO MINING ASSOCIATION
Selenium Committee

FMC Corporation
J.R. Simplot Company
Monsanto Company
Nu-West Industries, Inc.
Rhodia, Inc.

November 30, 2001

Mr. Richard Clegg
Idaho Department of Environmental Quality
224 South Arthur
Pocatello, Idaho 83204

Re: Idaho Mining Association Selenium Committee's Comments on
"Draft Area Wide Human Health and Ecological Risk Assessment Work Plan", October 2001

Dear Mr. Clegg:

On behalf of the Idaho Mining Association Selenium Committee (IMASC), attached herein are the comments on the Draft Area Wide Human Health and Ecological Risk Assessment Work Plan (hereafter referred to as the "Work Plan"). For the record, IMASC is re-submitting the comments that were submitted on October 19, 2001. In addition, we are submitting additional comments that are directed at the risk assessment inputs as presented in the Work Plan.

The IMASC appreciates the effort that has gone into the Work Plan as well as the overall effort of Idaho Department of Environmental Quality (IDEQ) and Tetra Tech EM Inc. (TtEMI) on the area wide investigation to date. The IMASC believes that this area wide effort and the IDEQ policies guiding the process have been constructive and effective. We feel that the area wide risk assessment is critical to reaching the appropriate response to the concerns over selenium (and other potential constituents of concern) in the Southeast Idaho Phosphate Resource Area. We are also convinced that the application of sound scientific principles and approaches to the risk assessment process is of primary importance that will result in a defensible outcome.

In the constructive spirit of these beliefs, we are providing the attached specific comments to the Work Plan. These comments are divided into the following:

- Re-submittal of the October 19 comments consisting of:
  - General comments
  - Clarification of past IMASC approaches and work products referenced in the Work Plan; and
  - Comments on the proposed technical risk assessment approach in the Work Plan.
- Additional comments on the Human Health Risk Assessment Inputs.
- Additional comments on the Ecological Risk Assessment Inputs.

While the IMASC feels that all of the attached comments are important and should be addressed in the final Work Plan, we wish to highlight some of our general concerns and suggestions here as expressed below:

- The historical efforts (prior to the year 2001) to characterize the selenium impacts from phosphate mining operations in the Southeast Idaho Phosphate Resource Area have been effectively conducted in a manner open to discussion and input from stakeholders. The acceptance of this approach is partly evidenced by the growing number of interested persons and stakeholders attending the SeAWAC meetings. IMASC is concerned that the design and implementation of some investigations performed by the IDEQ during the summer of 2001 were not open to discussion, input or scientific purview. We are also concerned that the risk assessment, which is critically vital, will also be conducted in a similar fashion. The IMASC believes that the proposed tiered-approach risk assessment should be conducted, in part, in an open forum involving the appropriate stakeholders.

Response: The IDEQ has made every attempt to continue Area Wide efforts in a manner open to discussion and input by all stakeholders and interested parties, and we appreciate the involvement of all participants to date. Since assuming the role of lead Agency on the investigation, every deliverable product has gone through a review process by both the Interagency Technical Group and Selenium Area Wide Advisory Committee (SeAWAC). The risk assessment draft documents have the added community involvement mechanism of a formal 30-day public comment period to ensure an adequate opportunity for review by all interested parties.

Proposed sampling activities for the 2001 Spring and Summer sampling events were presented in detail to the SeAWAC at separate meetings prior to being implemented in the field. At the IMASC's request, a courtesy copy of the Agency's Spring Sampling and Analysis Work Plan was provided to interested SeAWAC participants and resulted in no technical comments. Additionally, in an unprecedented attempt to keep the Agency's activities transparent, the IMASC's Quality Assurance representatives were allowed to audit the Agency's field sampling team's activities. The summer sampling event was conducted primarily by internal IDEQ staff from the Regional Beneficial Use Reconnaissance Program (BURP) utilizing Agency-established programmatic procedures and rapid bioassessment protocols developed for use throughout the State since 1994.

Similarly, the Area Wide risk assessment activity is being conducted to support Agency decision-making and regulatory obligations for the protection of human health and the environment. In December 2000, the IDEQ Department Director informed IMASC representatives that the subject risk evaluation process would be designed to meet the Agency's regulatory needs in a manner that allowed an opportunity for review and comment by all stakeholders, but would be performed internally without any undue influence by the responsible parties. A committee or open forum approach to this effort is not considered appropriate.

- During the October 10, 2001 SeAWAC meeting, TtEMI stated that the ecological risk assessment to be performed per the Work Plan would be an area wide risk assessment, i.e., oriented toward appropriate population-level assessment endpoints. IMASC agrees with this approach. However, the Work Plan does not clearly define the approach as an area wide, population-level ecological risk assessment.

Response: The Agency agrees that population-level ecological assessments are appropriate for the Area Wide effort but not necessarily for site-specific risks. The Agency is applying the use of area-weighted average exposure point concentrations to represent average population-level exposures for selected target species. Individual or subpopulation risk estimates would require the

exclusive use of maximum observed concentrations or impacted area averages, and are more appropriate for site-specific risk characterizations.

- There is only a 5-fold difference between FDA's recommended daily allowance for selenium (0.001 mg/kg/day) and EPA's purportedly toxic reference dose for selenium (0.005 mg/kg/day). Given that the average American's daily dietary intake of selenium is about double the FDA's recommended daily allowance, there is only a two and one-half fold difference between the average American's daily dietary intake and the toxic reference dose for selenium. Therefore, the use of a deterministic human health risk assessment model, with conservative inputs as indicated in the Work Plan, will result an unacceptable risk estimate whether or not such risks exist. Meaningful evaluation of selenium risk demands use of a high-resolution risk assessment modeling approach that can only be provided by performing the risk assessment modeling stochastically. The use of a low-resolution deterministic risk assessment model merely provides screening-level results that, per EPA policy, provide an inadequate basis for requiring any remediation measures.

Response: The IMA's comment on the FDA and EPA levels is correct and the rationale for the selected concentrations is discussed in detail in ATSDR's Toxicological Profile for Selenium. The Agency has chosen to proceed with deterministic risk assessment procedures as discussed in our summary of general areas of concern preceding the public comment letters. Deterministic methods have been used for remedial selection for decades and continue to be used by the USEPA, therefore, the Agency disagrees with the assertion that deterministic results are merely screening level and cannot support remedial actions. However, the Area Wide effort does not include a remediation component, therefore, individual mine operators will have the opportunity to collect sufficient data from individual mine sites to conduct probabilistic modeling for consideration during remedial alternative selection, if so desired.

- The draft Work Plan proposes the use of statistical methods on data that were generated with a non-random or non-systematic sampling approach. The IMASC believes that this violates sound scientific principles.

Response: The Agency will review the cited use of statistical methods in the work plan and will remove any inappropriate statistical procedures. The Agency discussed with the SeAWAC the cost-benefit factors of approaching this regional effort on a purely statistical basis in development of our Area Wide scopes of work. We determined a directed sampling approach was more resource effective, provided concentration gradient data within the tolerances of typical risk assessment efforts, and was superior to using rigid statistical approaches in the absence of adequate random sample population sizes. The Agency contends the selected use of certain descriptive statistical methods for representative data is a common industry practice and is appropriate without violation scientific principles.

- The draft Work Plan proposes exposure scenarios which include an adult and child subsistence lifestyle receptor. This exercise would be unrealistic as there is no evidence or reason to believe that such a receptor exists or is likely to exist in the future. The *Health Consultation* prepared by the Idaho Division of Health for the Agency for Toxic Substances and Disease Registry, dated June 27, 2001, states "A person who poaches elk and fish or has a subsistence type of existence on wild game and fish may not be a realistic scenario for this area."…"However, a subsistence hunter and fisherman who ate fish, beef, or elk each day is a very unlikely and perhaps unrealistic scenario for the Resource Area."

Response: The Agency has modified the definition of "subsistence lifestyle" to reflect a more realistic regional "worst case" rural-resident approach that assumes a majority of the dietary needs are met through the immediate environment but excludes poaching and allows for some foodstuffs from commercial sources. The IDH is a partner with IDEQ in the human health risk assessment effort and concurs with the subsistence lifestyle screening approach. It is indisputable that a segment of the local population relies heavily on local livestock, wild game and fish for a significant portion of their diet. It may be possible to eliminate any public concerns using this subsistence lifestyle approach without committing additional resources to quantify actual regional dietary practices.

- The IMASC has utilized only scientifically sound methods to characterize the potential impacts of selenium and other constituents during the regional investigations of the past few years. Yet, it appears that the Work Plan seems to favor other, limited data for the risk assessment inputs. Even more important, there appears to be a rush on the part of IDEQ to develop and base site-specific remedial investigation (and possibly corrective action) decisions upon risk assessment model outputs when high-quality empirical data has been generated or is in the process of being generated by targeted field and laboratory studies performed on native wildlife species and local domestic livestock.

Response: The Agency has chosen to proceed with the risk assessment/management activities in accordance with the schedule established by IDEQ upon assuming the lead Agency role over eighteen months ago. Any regional goals or objectives developed by IDEQ in this process will remain open to modification to reflect changes in regulatory requirements, new scientific consensus and/or additional area-specific data throughout the resolution of issues associated with historic phosphate mining in Southeast Idaho. A sufficient amount of regional data is available to continue the regulatory risk assessment process and it would be inappropriate to delay the progress of the Area Wide project in speculation of the regulatory relevance of results or conclusions from studies that have not been completed, published or peer-reviewed.

With regards to the data utilized for risk assessment inputs, the current work plan proposes the use of a significant portion of the all the data collected to date. The 2001 data set was selected as the primary Tier 2 baseline risk assessment input source because it provides information on the expanded target analyte list developed by the Agency. However, the historic IMASC data sets are also being used to assess temporal variations for the constituents and media available. The Agency does not accept the basis for implying that the historic IMASC data sets are more scientifically sound or superior to recently generated results, and has previously pointed out the statistical inadequacies of some of the former studies and conclusions. However, the Agency also recognizes the complexity of conducting phased regional investigations and the resource constraints associated with collecting statistically valid random sample sizes for an area of this size, which is why we purposely chose to use a directed sampling approach.

The IMASC appreciates the opportunity to comment on the draft Work Plan and trust that our comments will be useful.

Sincerely

Idaho Mining Association Selenium Committee

Robert L. Geddes
Selenium Committee Co-Chair
Monsanto Company

Bruce H. Winegar
Selenium Committee Co-Chair
J.R. Simplot Company

Attachment

cc:

Rob Hartman, FMC Corporation
Scott Sprague, Agrium Inc.
Dan Bersanti, Rhodia, Inc.
Alan Prouty, J.R. Simplot Company
Kim Gower, J.R. Simplot Company
Dave Farnsworth, Monsanto Company
Mike Vice, Monsanto Company
Greg Möller, University of Idaho
John Ratti, University of Idaho
Marc Bowman, Montgomery Watson
Bill Wright, Montgomery Watson
Bruce Narloch, Montgomery Watson

IMA Selenium Committee Comments
on the
Draft
Area Wide Human Health and Ecological Risk Assessment Work Plan Selenium Project

COMMENTS ORIGINALLY SUBMITTED ON OCTOBER 19, 2001.

General Comments

- Section 2.4, pp. 8-9. The SeAWAC and the IMASC were not provided an opportunity to review draft or final work plans for the two IDEQ sampling events listed. This did not allow for open discussion, input or scientific purview.

Response: As previously mentioned, the Spring sampling work plans were provided at the request of the IMASC and all sampling events, including Summer activities, were presented in detail at SeAWAC meetings prior to their implementation. However, IDEQ-sponsored TMDL and BURP sampling activities were based on Agency-established programmatic procedures and were not considered hierarchically appropriate for a formal project-level work plan review process.

- Section 7.2, pp. 19-25. A lot of work appears to be slated for the final work plan that was not present in this draft version. The IMASC understands that much of this data and information is forthcoming from field studies performed this past summer. The IMASC is concerned about finalizing this Work Plan without the opportunity to review the data and information referenced for inclusion in the final Work Plan.

Response: The Agency draft work plan presents the approach for conducting the human health and ecological risk assessments and will be finalized based on evaluation of public comments. Specific data and references, not available at the time of publication, will be included in the draft risk assessment, once complete. The draft risk assessment document will be subject to SeAWAC review and a formal 30-day public comment period, which will provide a mechanism for voicing any concerns on information not previously published in the draft work plan.

- Section 7.5.3, p. 40. IMASC believes that the tiered approach risk assessment would be best implemented in an open forum.

Response: The Agency disagrees. The Area Wide risk assessment is a regulatory decision-making tool that should not be relegated to committee consensus or open forum majority rule. The IDEQ has encouraged stakeholder/public input and the free exchange of opinions in the regulatory process but the Agency is ultimately responsible for interpreting, evaluating and managing area wide risks without undue influence. See IDEQ response to first IMA Cover Letter comment.

Clarifications on Referenced Past IMASC Work

- Section 2.4, p. 7. Under the description of the 1998 regional investigation, no mention of co-located sampling of IMASC's soil and vegetation on waste rock dumps, dump seeps, and

background uplands (Phosphoria outcrops) is made. The agencies have attempted to characterize this sampling effort as one in which the soil and vegetation samples were not co-located, but the only professional Ph.D. statistician to review the design has determined the samples of the two media to indeed be co-located (E. Garton, personal communication). Co-located sampling of aquatic habitats was also done by IMASC but is not acknowledged.

Response: The referenced description is intended to provide a synopsis of previous investigations and does not make mention of the interagency characterizations of sample collocation issues. Further elaborations are not deemed necessary to meet the intent of the summary, however, the list of media will be expanded to include surface water and aquatic habitat.

- Section 2.4, p. 7. The document that is referred to as the "IMA 1999 Interim Investigation" was the "Interim Regional Investigation".

Response: Corrected

- Section 2.4, p. 8. The document that is referred to as the "IMA 2000 Regional Investigation" was the "1999-2000 Regional Investigation".

Response: Corrected

- Section 3.1, p. 9. The COPC screening process for the IMASC's preliminary risk assessments was not inconclusive. The initial regional investigation work plan specifically identified six targeted trace elements (Se, Cd, Mn, Ni, V, and Zn). As additional information was obtained during the course of the regional investigation, this list was pared down to two (Se and Cd), then later supplemented (Se, Mo, and Cd). IMASC has stated that these are regional COPCs and has acknowledged that some additional COPCs may be appropriately identified on a site-specific basis. At this time, IMASC is unaware of any data that refute the identification of Se, Mo, and Cd as a comprehensive list of regional COPCs.

Response: The Agency chose to expand the list of targeted trace elements and will make a regulatory determination of the final list of COPCs for subsequent investigations.

- Section 3.1, pp. 9. The uncertainties associated with the use of non-site-specific biotransfer factors (BTFs) in the preliminary ERA are known to be quite high, resulting in conservative, overestimation of risks. The uncertainties associated with the use of "limited amounts and locations of medium-specific sampling results" in the preliminary HHRA are known to be high, again resulting in conservative, overestimation of risk.

Response: Comment noted.

- Section 3.1, p. 10. The preliminary risk assessments were never intended to determine what concentrations pose risks; rather, they were intended to help determine whether the concentrations that exist pose unacceptable risks.

Response: The Agency agrees and has removed the statement from the text.

- Section 3.1, p. 10. None of the targeted trace elements are known to be carcinogenic by any pathway defined in this work plan to be potentially operative (see Figure 2). IMASC has

acknowledged the need to evaluate a Native American exposure scenario. It should be noted, however, that most members of the Shoshone-Bannock Tribes reside outside the Resource Area. IMASC questions the validity and utility of and need for a subsistence lifestyle scenario. No one in the study area is currently known to exist within such a subpopulation, and IDH has gone on the record as stating that such a scenario is unrealistic. The IMASC believes that the IDEQ's resources (as well as those of the mining companies in the Resource Area) would be better utilized on performing risk assessments on realistic populations.

Response: Several of the constituents added to the expanded target analyte list are known or suspected carcinogens. Since the COPC screening is part of this process, an evaluation method is included as a contingency. Use of the subsistence lifestyle is addressed by IDEQ's response to the fifth comment in the IMASC's Cover Letter.

- Section 3.1, p. 10. When medium-specific data were limited, a considerable conservative bias was imposed on the preliminary risk assessments by using what data did exist from highly contaminated areas that are not representative of the Resource Area. As the HHRAs have consistently failed to demonstrate an unacceptable level of risk, such conservative bias should not dismiss the preliminary effort. The ERAs, where preliminary risk calculations were not able to dismiss the possibility of unacceptable risk, are different, but IMASC used the preliminary results to initiate targeted field and laboratory validation studies. This will help to reduce uncertainties dramatically.

Response: Numerous interagency concerns were raised on the preliminary HHRA and ERA process resulting in the issuance of an Interagency disclaimer letter. Due to this lack of consensus by the Selenium Working Group, the Agency has chosen to conduct baseline assessments for both human health and ecological risks. We will consider the results of any targeted field or laboratory studies as they become available.

- Section 7.3.1, pp. 25-26. When discussing the cattle study on the Henry Mine, it should be noted that the experimental cattle were penned on seleniferous pasture for 9 weeks. Normally, beef cattle in Southeastern Idaho are free ranging and not confined to seleniferous pasture.

Response: The Agency has just recently received the vegetation data from this study and is in the process of reviewing the information. Therefore, we have refrained from making any conclusive statements regarding seleniferous pasture conditions or the conservatism of this study.

- Section 8.0, p. 41. The comment here ignores the IMASC's efforts in the areas of implementing targeted field and laboratory studies (for birds and cutthroat), and refined population-level risk assessments (for birds).

Response: The results from the referenced studies are not currently available and, therefore, cannot be included in work plan discussions. As stated, the Agency will consider the applicability of any studies on regional goals and objectives as they become available.

Comments on the Proposed Technical Approach

- Section 3.2, p. 10. These decisions appear to be vague. From an ecological perspective, a more appropriate decision would be whether the measurement endpoints indicate the potential for unacceptable risk to the assessment endpoints (both of which should be appropriately defined on a population or community basis). Also, the decisions are worded in a way that implies only screening-level assessments will be performed. Only two credible decisions can be made on the basis of a screening-level assessment: 1) more study is required, or 2) there is no problem. One cannot prove, per EPA guidance, the existence of a problem to the point of requiring remediation with a screening-level assessment.

Response: Regulatory decisions regarding acceptable or unacceptable risks will be made during the risk management process, not in the assessment. While the Agency considers the baseline assessment described to be beyond a screening level activity, the Area Wide effort does not encompass a remedial selection component.

- Section 3.3, pp. 10-11. Inputs to the specified decisions are not limited to data generated from field and laboratory studies, but also include all the models and sub-models into which the data are entered and processed.

Response: Agreed, accepted regulatory models and sub-models are specified by EPA guidance.

- Section 3.5, p. 11. The likelihood of an estimated incremental lifetime cancer rate in excess of 1E-06 or a hazard quotient in excess of 1.0 needs to be taken into account before a location or medium is deemed to be at risk. If the determination is limited to "potentially at risk," that is as far as a screening-level model can go, with an emphasis on "potentially". The next step would be to construct a more realistic model to test the resulting hypothesis by quantifying potentiality and quantitatively disclosing uncertainties (both natural variability and lack of knowledge) and their effects on the assessments.

Response: The choice of the terminology "potentially at risk" was used to recognize the inherent limitations and uncertainties in any risk assessment process. Exceedances of HQ and ECLR values do not constitute a certainty of effects regardless of the model constructed and therefore requires evaluation by risk managers. The AWHHRA will be completed using a tiered approach that provides data of increasing specificity. Risks and hazards will ultimately be characterized considering the results from all three tiers and the accompanying uncertainty analysis.

- Section 3.5, p. 11. Other supplemental lines of evidence worth mentioning include: IMASC's human and ecological health risk assessments, IMASC's targeted field and laboratory bird studies, and IMASC's targeted field and laboratory cutthroat studies.

Response: The bird and fish studies have been added as potential lines of evidence.

- Section 3.5, pp. 11-12. In general, realistic exposure scenarios for realistic subpopulations should be used to characterize human health risks beyond the screening phase. Also, population-level assessment endpoints should be used to characterize ecological health risks beyond the screening phase.

Response: The Agency contends that part of characterizing realistic populations includes consideration of sensitive portions, thereof. Selected upper bound models may provide an opportunity to eliminate concerns in cases where realistic subpopulation characteristics are indeterminable. The Agency agrees that population-level ecological risks are appropriate for the Area Wide effort but subpopulation and individual-level risks should also be considered in future site-specific decisions.

- Section 3.6, p. 12. Per EPA guidelines, no bounding estimate of risk shall be used to require remedial action. A bounding estimate of risk has been defined as one lying beyond the 98th to 99.9th percentile of legitimate risk estimates. Any risk estimate shown to be more unlikely should be regarded as erroneous from any perspective regarding remediation decision making. However, bounding estimates may be used to justify the need for additional studies or modeling refinements.

Response: The Area Wide Scope of Work does not include remediation selection. However, the risk assessment process is being conducted using a tiered approach considering both RME and CTE scenarios. Central tendency exposures and effects are well within the 98th percentile of risk estimates.

- Section 4.0, p. 13. A complete exposure pathway is one in which a receptor can be expected to experience exposure to a contaminant at a sufficient level to cause potential harm—for humans, harm to an individual, for non-humans, harm to a population or higher level of ecological organization.

Response: This is incorrect; a complete exposure pathway has nothing to do with the level of harm. The EPA defines a complete exposure pathway as the course a chemical or physical agent takes from a source to an exposed organism. The purpose of a risk assessment is to determine the potential for harm from complete exposure pathways.

- Section 5.0, p. 13. The IMASC believes that the contaminant of primary concern is selenium. Selenium is not a heavy metal; rather, it is a metalloid. No evidence has been presented to invalidate the COPC screening conducted by IMASC in the 1998 regional investigation work plan. Such a screening process is illustrated by Example 1 in Appendix A of EPA's *Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments – Interim Final* (EPA, 1997). The process used in the example is analogous to IMASC's 1998 work.

Response: The Agency agrees that selenium is the primary contaminant of concern. Technically speaking, the term "metalloid" is no longer used by chemists to describe the group of solid non-metals, including selenium, exhibiting moderate electrical conductivity. However, the Agency agrees that the term heavy metal is also an erroneous description and will modify the text accordingly. The final COPC list will be determined by the Agency.

- Section 6.0, p. 14. Selenium (a metalloid, not a metal) is the primary COPC.

Response: Agreed.

- Section 6.1, p. 14. The final paragraph refers to contaminant releases from waste rock. Waste rock contains no contaminants. All substances found in waste rock are naturally occurring so, by definition, can not be regarded as contamination. Contamination of the

environment occurs when natural substances in waste rock are released at an unacceptable rate. This is an important distinction.

Response: The text will be modified to refer to chemicals, elements or constituents prior to release.

- Section 6.2, p. 15. No evidence has been presented that demonstrates wind erosion to be a significant transport mechanism. Mining regulations have long prohibited conditions conducive to fugitive dust generation.

Response: The fact that mining regulations place controls on fugitive dust generation supports the existence of this transport mechanism. At the request of other commenters, the Agency has included an inhalation pathway for consideration at sites potentially used by recreational users and no longer actively managed by site operators.

- Section 7.1.2, p. 18. Category 2b is not clear to the IMASC, please elaborate.

Response: The text will be clarified.

- Section 7.1.2, pp. 18-19. Step 3 should be limited only to those streams where certain exposure scenarios could reasonably occur. For example, 1st order streams generally don't support a sustainable fishery, and the IMASC is not aware that streams on FS, BLM, and state lands support garden plots.

Response: Stream classification is dependent on scale; perennial 1st order streams may support fish or their prey, and are subject to Idaho's water quality criteria. Individual streams will be evaluated for their potential to support sustainable fishing and fish tissue EPCs will be developed on a watershed basis with consideration of contributing stream productivity. The Agency has not expended resources to survey the existence of garden plots in the Resource Area and will not do so without an indication from the assessment process of potential risks from this source.

- Section 7.2.1, p. 19. IMASC does not agree with the decision to use historical Se and Cd data to simply supplement the samples collected in 2001. We feel the historical data sets are of very high quality, are more extensive, span a much longer timeframe such that the data takes into account year-to-year variability, and were collected in a manner that more appropriate for statistical analysis.

Response: The Agency has determined that each data set should be handled separately to express temporal variability. The 2001 data set is used in Tier 2 because it includes the wider range of potential mining-related analytes. Tier 3 performs the same computations with historic data and provides risk managers with a sense of temporal risk fluctuations.

- Section 7.2.1.3, p. 21. IMASC believes that the lack of background data for plants ingested by members of the tribes is a quality data gap.

Response: The Agency collected surrogate vegetation species from the Resource Area as designated by tribal representatives. Samples were collected from both impacted and unimpacted (background) zones for use in the assessment process.

- Section 7.2.1.4, p. 21. It is noteworthy that concentrations of COPCs in homegrown produce have to be estimated from soil data which indicates that no homegrown produce exists that could have been sampled. Since insufficient tissue from plants ingested by members of the tribes were not found for sampling and chemical analysis, this unrealistic scenario would not appear to pose a significant (or measurable) exposure.

Response: Homegrown produce concentrations will be estimated by modeling because resources were not expended by the Agency (or obviously the IMASC) to survey the region for this potential pathway. The draft work plan cited methods for estimating plant tissue concentrations for Tribal use considerations if sufficient tissue could not be collected. However, sufficient plant tissue was sampled and analyzed for the surrogate species identified by Tribal representatives for Resource Area use considerations.

- Section 7.2.1.6, p. 22. Use of the beef depuration study data needs to be qualified as conservative. Normally, beef cattle in the study area are not penned in on waste rock dumps like these experimental animals were.

Response: The Agency is currently reviewing the recently submitted data regarding levels of selenium in the particular forage vegetation to evaluate the level of conservatism of this study. The Agency has no definitive evidence regarding area livestock grazing practices, particularly the potential practice of ranchers/herders culling livestock from their herds without feedlot (depuration) time. While cattle are not typically penned on waste rock dumps, the reclaimed areas present the most palatable forage in the study area and would appear to attract free ranging animals. We would need further information to conclude this study represents a "worst case" scenario.

- Section 7.2.1, pp. 19-22. In general, consumption of lamb is adequately evaluated (at least at this time) through use of the beef cattle data as a surrogate. The consumption rate of sheep is far lower than that of cattle, and sheep are probably more mobile and free ranging than are cattle.

Response: Both reference literature and repeated sheep losses in the Resource Area demonstrate significant physiological differences between sheep and cattle, and in general, the Agency does not intend to use cattle as surrogates for sheep in risk decisions, particularly in grazing management issues. However, based on our review of available post-mortem sheep tissue analysis and steer study results, we agree that the use of surrogate beef concentrations adequately represents potential human ingestion of domestic livestock products.

- Section 7.2.3.1, pp. 23-24. There is no basis for a null hypothesis of normality for environmental concentration data. The better null hypothesis is lognormality, as true negative concentrations are impossible. A normal distribution always includes negative values, and often a substantial fraction of negative values when erroneously applied to environmental trace elements. The null hypothesis for the background distribution constitutes a critical assumption, because with sample sizes fewer than 50, it will be difficult to reject the null hypothesis even if it's untrue. The effect of modeling background concentrations as normally distributed in the highly mineralized study area will be to erroneously attribute naturally occurring concentrations to mining-related contamination.

Response: The work plan does not state that a normal distribution will be assumed for the data. The work plan presents several different methods for determining the actual distribution of a data set. The treatment of any censored data will be in accordance with EPA guidance.

- Section 7.2.3.1, p. 24. The use of the t-test and the Wilcoxon Rank Sum test will only be suitable if the background-area and impacted-area data were obtained under a random or systematic sampling design, and each datum is categorized. Much of the 2001 data (with exception of the summer 2001 data collected by IMASC) were not collected under a randomized design, but rather were collected in a judgemental manner. The use of statistics on such data is inappropriate. IMASC's background data were collected under either a randomized or systematic design and can be used to quantify operational upper bounds of background distributions to which individual data from the impacted areas can be compared. Such comparisons can be used to determine whether or not contamination exists at a given location. An upper tolerance bound approach is recommended, but the number of comparisons made is an issue that must be considered and taken into account so as to avoid the multiple comparison problem, a problem which drastically inflates the Type I (false alarm) error rate. The USFS Forest Products Laboratory at the University of Wisconsin has published a simple program that allows multiple comparisons to be addressed by calculating tolerance bounds on an experiment-wide basis. The program can be found at the following website: http://www1.fpl.fs.fed.us/tolerance.html. Tables of statistical constants used to calculate tolerance bounds are limited to a few error rates, but this program can use any error rate calculated from the desired experiment-wise rate of 0.05. The confidence level (1 minus the false-alarm rate), CL, to input in the program is calculated from the desired experiment-wide rate of 0.95 (1 – 0.05) as follows:

  $CL = 0.95^{(1/c)}$, where c is the number of potentially impacted locations being compared to the upper tolerance bound being calculated.

Response: The Agency selected sampling areas representative of average conditions (impacted and unimpacted) based on professional judgement and review of previous sampling results. This directed sampling method was used because a statistically adequate number of random samples to represent an area of this size was considered prohibitive. Reasonable approximations of background values can be derived from the cumulative data collected to date and reference literature for the study area and typical western soils. While a statistical approach would be academically satisfying, it would provide little benefit to the risk estimation process. This sampling approach was presented it to the SeAWAC prior to implementation without objection.

With regards to the suitability of IMASC's background data, the Agency considers previous background sampling designs to be inadequate in terms of representativeness. Phosphoria formation outcrop locations were selected as soil background locations (while randomly selected, samples were not independent because of pre-determined conditions). While this may represent an approximate background for areas of the historic mine sites that have converted into mine pits or a minimal amount of surface area represented by an outcrop condition, it does not represent surface soil background levels for areas where waste rock piles have been placed or original soil conditions in impacted terrestrial, riparian or fluvial zones that are under consideration.

Additionally, the outcrop background locations used for previous IMA background calculations consisted of only three separate outcrop locations with five samples at each. At most this represents 15 samples although the Agency would argue that it is simply an average of three locations. Regardless, it is far below the fifty sample minimum requirement purported to be of significance in the previous discussion of adequate background determinations. In

comparison, the approximations made by the Agency will be as scientifically valid as those previously presented.

Based on a review of previous investigative results, it is apparent that rigid statistical testing is not required to distinguish the presence of elevated concentrations of contaminants in impacted areas and therefore, non-statistical standard industry approaches similar to those accepted by USEPA Region 4 and Forest Service Region 3 will be used by the Agency for background screening comparisons. Average background concentrations will be calculated for each constituent/media from undisturbed, upgradient mining zone data sets that are representative of pre-mining conditions. Concentrations in excess of two times the background average will be considered impacted and evaluated in the risk assessment process.

As further precedent for this approach, a common industry practice for establishing industrial site background comparison levels under the Resource Conservation and Recovery Act (RCRA) is to collect 3-5 directed samples from areas believed to represent pre-industrial conditions for the calculation of a 95% Upper Confidence Limit (UCL). UCLs typically result in values that are approximately 1.5 to 3 times the mean value dependent on data variability. This method requires neither, random sampling or a large data set for statistical analysis. In using the proposed non-statistical approach, the IDEQ explicitly accepts slight increases in the level of statistical uncertainty in the background screening results but we are confident that the uncertainty is within the normal tolerances associated with the risk assessment process.

- Section 7.2.3.1, p. 24. The 1999 elk data showed no evidence of elevated Cd in elk tissue. There are elevated levels of Se in both liver and muscle, but the levels in muscle are regarded by USDA's FSIS as safe for human consumption (assuming that concentrations in elk muscle less than FSIS's interim standard of 1.1 mg/kg (wet weight) for beef muscle are without a doubt safe). Exposures to elk liver are unlikely to pose a chronic problem due to the small amounts consumed.

Response: The referenced section does not indicate that elevated cadmium concentrations were observed in the elk data.

- Section 7.2.3.2, pp. 24-25. It is unlikely that an analyte that is detected only once could pose an unacceptable level of risk. A non-detect indicates existence at a very low concentration, supposedly one that is non-toxic if the DQOs are met.

Response: In general, the Agency agrees dependent on the number of samples collected and the magnitude of the concentration observed.

- Section 7.2.3.3, p. 25. Selenium is an essential nutrient.

Response: Agreed, the text will be revised.

- Section 7.3.2.3, p. 30. The need to conduct an assessment on children is questionable given that Se is the contaminant of, by far, most concern, and scientific evidence demonstrates that children are not the sensitive subpopulation for chronic selenosis. In the study by Yang et al. that was published in 1989, the basis for EPA's reference dose, women in the highest Se-containing region of China suffered no reported effects on reproduction, and children under 12 years of age were the least sensitive subpopulation (i.e., showed no signs of toxicity). In addition, the *Health Consultation* prepared by the Idaho Division of Health for the Agency for Toxic Substances and Disease Registry, June 27, 2001, states "…children do not seem to be more sensitive to the chronic effects of selenium than adults."

Response: As discussed in the introductory summary, the baseline risk assessment includes a child component to ensure completeness of reasonable receptor pathways, and EPA and public acceptance of the assessment process.

- Section 7.3.2.3, p. 30. We disagree with the inclusion of subsistence lifestyle receptors because such a lifestyle is an unlikely scenario in the Resource Area. The IDH *Health Consultation* states "However, a subsistence hunter and fisherman who ate fish, beef or elk each day is a very unlikely and perhaps unrealistic scenario for the Resource Area."

Response: See IDEQ's response to the fifth comment in the IMASC's Cover Letter

- Sections 7.3.3.1 and 7.3.3.2, pp. 32-34, and Table 7-1. In general, given that there is only a factor of 5 separating the Se RDA from EPA's RfD, it will be virtually impossible to generate a hazard quotient that does not exceed 1.0 using deterministic modeling with conservative inputs, even if no unacceptable level of risk exists. Probably the only way to do so would be to accept BLM's recommendation to ignore background dietary doses (which in the United States are only about a factor of 2.6 less than EPA's RfD) and background nutritional supplementation doses in the model. However, one would have to justify that background dietary Se and nutrient supplement Se are always non-toxic while the incremental dietary Se derived from exposures in Southeastern Idaho are toxic. This is an impossibility. As a result, deterministic modeling using conservative inputs, a low-resolution, screening-level approach to risk estimation, is almost assured of being inadequate. This scenario requires a high-resolution assessment that acknowledges, incorporates, and discloses the effects of uncertainties, i.e., a stochastic assessment is more appropriate. The justification presented in the Work Plan in selecting (what the IMASC considers to be) a biased output for a low-resolution calculation will result in a product that is assured of being over conservative. This applies not only to exposure point concentrations, but to all other exposure variables, as well.

Response: See IDEQ's response to the third comment in the IMASC's Cover Letter.

- Section 7.4, pp. 34-36. The same concern regarding the use of conservatively biased inputs to a simplistic, screening-level deterministic model that were raised under the exposure assessment above apply to the toxicity assessment, too. In general, toxicity factors often contribute more uncertainty than all exposure factors combined in a given assessment. For example, EPA claims a dose that is one-third a dose at which toxic effects have never been documented is potentially toxic. As a result, EPA's reference dose for Se is close to the average American dietary intake, and is readily exceeded by those individuals taking oft-recommended levels of Se as a nutritional supplement.

Response: The proposed use of toxicity factors and slope factors is consistent with EPA guidance. Uncertainties associated with use of these factors will be addressed in the AWHHRA and the Agency will consider the sensitivity of selected model inputs during the risk management evaluation process.

- Section 7.5.1, p. 37. We are assuming that ECLR is the "excess lifetime cancer rate." This is not a function of total dose, but rather the incremental or excess dose above background. Background exposures must be subtracted out. The NCP is quite specific in stating that it is the excess (i.e., incremental) risk that is to be controlled.

Response: "ECLR" refers to the "excess lifetime cancer risks". The Agency disagrees with the IMA's interpretation of the NCP's provision. The NCP refers only to "controlling" incremental risk; in other words, the PRP is not responsible for risks below background levels. The background risk must be included in the initial assessment calculations to determine the overall cumulative risk to the target organism.

- Section 7.5.1, p. 37. For most naturally occurring carcinogens (e.g., As), EPA's endorsed SF represents a maximum likelihood estimate, not a 95% UCL estimate. The risk estimate that results from the use of any deterministic representation of an SF is not an upper-bound estimate of carcinogenic risk. What such a calculation represents can only be known within the context of a fully stochastic risk assessment that acknowledges, incorporates, and discloses the effects of uncertainties.

Response: The text will be revised to identify the SFs as upper bound estimates of the probability of a response. The Agency disagrees with the assertion that deterministic representation cannot estimate an upper bound risk.

- Section 7.5.1, p. 37. The NCP states that an acceptable range of carcinogenic risk is 10^{-6} to 10^{-4}. It is of importance that no significant digits are specified—only orders of magnitude. Thus, incremental lifetime cancer rates as high as 3×10^{-4} (half an order of magnitude above 1×10^{-4}) can and have been deemed acceptable within Region 10 of EPA in general and Idaho in specific. In fact, EPA has deemed ILCRs as high as 5×10^{-4} as acceptable (even though on a logarithmic scale, the scale that is obviously invoked by the regulation, 5×10^{-4} rounds to $1\text{x}10^{-3}$).

Response: Comment noted.

- Section 7.5, pp. 37-40. For clarity in general, we note that the use of "mg/kg-day" means, in more precise notation, mg/(kg·day), and that "(mg/kg-day)-1" equates to kg·day/mg.

Response: Comment noted.

- Section 7.5.2, pp. 39-40. If location-specific HQs and HIs are being developed (supposedly because there are sufficient data), it is inappropriate to combine the maxima from different locations to generate a meaningless conservative sum of what will likely be conservative estimates.

Response: The AWHHRA is being prepared in a manner consistent with EPA's RAGs. Clearly, it is inappropriate to combine HQs and HIs associated with location-specific maxima assuming a receptor's entire exposure takes place at each location. However, location-specific results may be combined on a weighted average basis such as the ingestion of fish from several different stream segments.

- Section 7.6, p. 41. We do not believe you can quantify magnitudes of uncertainties without conducting a stochastic assessment.

Response: The Agency does not propose to quantify the associated uncertainties and do not agree that all uncertainties can be quantified even through stochastic methods. We will discuss uncertainties in qualitative terms only, for the benefit of the subsequent risk manager's evaluations.

- Section 8.1, p. 41. The primary line of evidence should be the results of empirical studies performed on native organisms where such studies are available.

Response: The Agency agrees, where relevant and conclusive studies are available.

- Section 8.1, p. 41. Initial work done by IDEQ this spring indicated that the historic data collected by IMASC was of high quality. If IDEQ's data collection efforts this year are also of high quality, they should be comparable. We feel strongly that historic high quality data must be utilized as year-to-year variability is critical information.

Response: Agreed; historic data is proposed for use in Tier 3 specifically for this reason.

- Section 8.1.1, pp. 41-42. The screening-level effort described herein is not worst case. Using non-representative data further invalidates the use of this phrase (see the next comment).

Response: The Agency disagrees and believes our data to be representative.

- Section 8.1.2, p. 42. IDEQ has stated that it's data collection effort was biased. It is possible to calculate a so-called "area wide mean" for environmental concentrations, but it is impossible to state what such a value represents. A randomized or systematic sampling effort would have been needed to make such calculations meaningful.

Response: The Agency has never stated that our data is "biased" and the repeated use of this term is apparently intended to infer a derogatory result from the Agency's directed sampling efforts. As discussed by academic participants in previous SeAWAC meetings, all data is biased in some aspect. The fact that the IMASC's random samples were consistently collected from a predetermined set of locations introduces a judgemental bias in many of the historic studies.

Area-weighted average concentrations can be adequately derived from the concentration gradient directed sampling for use as population-level exposure estimates. We are not confident that the sample sizes used in historic randomly sampled media studies provide an alternative for the development of mean values that result in any higher levels of accuracy. We have previously discussed, with the SeAWAC, the need for statistically-derived minimum sample populations (based on data variability) prior to the use of data in rigid statistical arguments. Randomness in and of itself does not make a data set statistically "meaningful". Furthermore, it is a commonly accepted practice to use descriptive statistics, such as mean, median and range values on data sets that may be inadequate for other statistically rigid tests but representative of site conditions.

- Section 8.1.2, p. 42. Does IDEQ have data representative of the 97% of the Resource Area that is classified as non-mining? The non-mining data are likely biased toward areas of mineralization. This is appropriate for background mining areas, but inappropriate for characterizing all non-mining areas within the Resource Area.

Response: Relatively accurate non-mining area background concentrations can be estimated through the use of available references with little impact on the outcome of the assessment. It is known that most of the areas outside mineralized zones are selenium deficient. A sampling effort of the magnitude required for non-mining area characterization would be an inappropriate use of resources for the level of accuracy that would be gained and the negligible effect on risk estimation. The Agency has concluded that data from the selected unimpacted

background areas are adequately representative of pre-mining conditions for the observed areas of impact.

- Section 8.1.3, p. 43. This paragraph is misleading. Even with an infinite amount of environmental data, there will be significant uncertainties in any risk assessment. Quite often the greatest uncertainty lies in the toxicity sub-model and in organismal behavioral exposure variables. Uncertainties in the environmental data are often relatively insignificant. Given that IDEQ's assessment is being limited to the use of conservative environmental data only, it may be impossible to quantify the uncertainty associated with the use of this environmental data in the assessment.

Response: This comment appears to nullify the majority of the IMASC's concerns in previous comments concerning the uncertainties with the use of the Agency's environmental data. Nevertheless, the Agency's assessment is not limited to the use of "conservative" data only since the directed sampling locations were selected to be representative of the entire spectrum of observed concentrations in the study area. Finally, it is impossible to precisely quantify the actual uncertainties in an assessment under any conditions, and we have not proposed to do so.

- Section 8.1.3, p. 44. What method(s) will be used to conduct background comparisons? We believe this data is not statistically valid for such a comparison.

Response: See the Agency's response to IMA's comment on Section 7.2.3.1, p. 24.

- Section 8.4, p. 44. Please define the various terms used herein. For example, food web, class guild, food chain, feeding guild, and community.

Response: The text will be modified to include defined terms.

- Section 8.4.1, p. 44. The first paragraph gives the erroneous impression that Astragalus is a dominant primary producer on waste rock dumps. From the data we have seen, wheatgrass, bromegrass, and alfalfa are likely far more dominant than any of the species listed here.

Response: The Agency agrees and the text will be modified.

- Section 8.5, p. 46. "Based on the preliminary screening conducted by the IMASC, selenium is the only contaminant currently identified as a probable concern. However, as discussed in Section 8.3, the previous screening was not defensible based on limited analyses and samples." The first sentence is false. IMASC's preliminary screening identified six target trace elements of potential regional concern—Se, Cd, Mn, Ni, V, and Zn. Refinement reduced this to two—Se and Cd. Even further refinement resulted in three—Se, Mo, and Cd. Section 8.3 says nothing about previous screening, let alone claiming that it was not defensible.

Response: The Agency chose to expand the initial list of potential mining-related trace elements for regulatory consideration and will perform screening to determine the final list of contaminants of concern for subsequent investigations.

- Section 8.5.1.1, p. 46. Unless plants are harvested or eaten, the plants do not remove Se from soil. The plants growing on waste rock dumps are not harvested; rather, they decompose and thus return to the soil. Additionally, please note that waste rock is not contaminated with Se.

The Se in waste rock occurs naturally, therefore the Se in waste rock is not considered to be a contaminant.

Response: Plants can extract selenium from soil and may change the chemical form and availability of Se from its original state. The Agency finds no reference to contaminated waste rock in this section.

- Section 8.5.1.1, p. 47. The first full paragraph on this page needs to be rewritten for clarity. Is the second reference to Skorupa (1998) trying to claim that Se doesn't cause population-level impacts but that this isn't important because it's the organismal-level impacts that count?

Response: This section will be revised for clarity.

- Section 8.5.1.2, p. 47. IMASC has taken paired filtered and unfiltered samples and analyzed them for total Se and never found a discernable difference. Did IDEQ filter the water samples it took this year? If so, how, where and when were they filtered? If they were not filtered immediately on site, the filtered sample results will not reflect the accurate amount of Se because of the equilibrium changes attributable to temperature and pH changes.

Response: Paired surface samples were also collected by the Agency throughout the field season and samples were filtered on site. Minor temperature and pH changes may effect speciation but should have little effect on total selenium concentrations.

- Section 8.5.1.2, p. 48. Given that IDEQ acknowledges that the aquatic ecotoxicity of Se is primarily attributable to biotic exposures rather than abiotic exposures, the IMASC cutthroat feeding study work being performed by Dr. Hardy is highly relevant. IMASC cannot overemphasis that inclusion of highly relevant data from this study in the risk assessment process is critically important.

Response: The Agency cannot include data until it is provided, however, important links may exist between biotic and abiotic conditions that may not be apparent under laboratory conditions. Furthermore, the risk assessment process and regulatory water quality criteria are not solely based on cutthroat trout feeding effects.

- Section 8.5.3, p. 50, and Figure 4. It would help to focus Figure 4 by selecting indicator species to represent each compartment listed on the second page of the figure. Risk estimates are not going to be calculated for each species on that page, but rather only for select indicator species. Highlighting those that will be used as indicator species in the assessment would be helpful.

Response: Indicator species will be highlighted.

- Section 8.5.3, p. 50. We suggest redefining food chain and food web. We also suggest redefining feeding guild as it is not synonymous with community.

Response: The text will be modified to include definition of terms.

- Table 8-1 and Section 8.6.1, pp. 51-62. We cannot determine whether the assessment endpoints are appropriate ecosystem-, community-, or population-level endpoints; or inappropriate organismal-level endpoints. Please specify.

Response: Regional risks are directed on population level effects, however, some discussion of localized subpopulation effects may be included for the benefit of site-specific risk manager's future consideration.

- Section 8.6.1, p. 51. The societal value of the ecosystem component needs to be incorporated into the determination. The role an organism plays in the environment must be considered. IDFG has defined the cutthroat trout to be a keystone species in the upper Blackfoot drainage. In addition, IDEQ has defined the cutthroat trout to be a pollution intolerant species, but no one has assigned such status to the amoeba. All these reasons were taken into account by the IMASC and other members of the SeWG when the decision was made to conduct targeted field and laboratory cutthroat studies.

Response: Cutthroat trout are an important species for the Blackfoot watershed and appropriately warrant particular attention in targeted field and laboratory studies. However, ecological health determinations can be based on more than single species effects. Societal value judgments will be determined by regulatory risk management evaluations.

- Section 8.6.1.1, pp. 51-55. Some ecological sense needs to be judiciously applied. For example, are we to assume that the goal of maintaining woody plant productivity on waste rock dumps is one to uphold for the SE Idaho Se Project? Historically-approved reclamation seed mixtures don't appear to have held that value. There is no evidence to indicate that if herbivore productivity on waste rock dumps is not maintained that the terrestrial community will somehow fail. Waste rock dumps are virtually devoid of subsurface soil macroinvertebrates, as are corresponding upland background plots. Neither system has failed or is on the verge of failing because of the lack of this community. The terrestrial plant community is not at risk because of waste rock, as plants grow readily if the physical properties (not the chemical properties) of the waste rock are conducive to plant growth.

Response: The work plan specifically states that terrestrial plant communities are not going to be directly assessed. However, the effects of terrestrial plant ingestion must be considered.

- Section 8.6.1.2, pp. 55-61. See the previous comment.

Response: Comment noted.

- Section 8.6.1.3, pp. 61-62. The comparison of the size of a typical waste rock dump to the size of a typical foraging range for most carnivores explains why impacts to carnivores are virtually impossible.

Response: Site use is a risk assessment input parameter to be considered in the model.

- Section 8.6.2, pp. 62-63. Additional measurement endpoints that are relevant to this project include the evaluation of empirical data obtained from targeted field and laboratory studies performed on native species and the modeling of population dynamics to determine if significant adverse impacts to populations might exist.

Response: Data from targeted studies will be considered upon submittal and will be used to the extent applicable.

- Section 8.7, pp. 63-64. We question the use of the generic equation. This is an equation for the estimation of the total dose from ingestion of abiotic and biotic media. Why is C_{media} multiplied by BTF before being multiplied by IR_{media}? The product of C_{media} and BTF is defined as C_{prey}, so multiplying the concentration of a contaminant in prey by the ingestion rate of an abiotic medium does not make sense. Also, we question multiplying C_{prey} by BTF? Since C_{prey} is defined to already have BTF in it, BTF^2 is not required. We have seen, in some cases, the use of BTF^2 altering the unit dimensions, and invalidating the equation. Also, if TTC is a bioavailability factor, this factor can be different for abiotic and biotic media ingested. Therefore, it should not be factored out and presented in this manner.

Response: The formula contained a typographical error that has been corrected.

- Section 8.7.3, pp. 65-66. IMASC would like to be consulted in the event the use of UFs to modify TRVs is seriously considered.

Response: The Agency has previously committed to review of risk-related products by participants of the SeAWAC prior to subsequent public comment periods or final publication.

ADDITIONAL HUMAN-HEALTH RISK ASSESSMENT COMMENTS

General Comments on Figure 3

- The lifetime average daily dose (LADD) equations should be using incremental exposure point concentrations (EPCs) because carcinogens are regulated under CERCLA on an incremental (excess over background) basis, per 40 CFR 300.430(e)(2)(i)(A)(2):

> *"For known or suspected carcinogens, acceptable exposure levels are generally concentration levels that represent an excess upper bound lifetime cancer risk to an individual…."*

Response: The Agency will include background exposures in the lifetime average daily dose calculation but will apply controls, when applicable, based on incremental risk.

- Because systemic toxicants are not regulated on an incremental basis, background contributions to dose must be included. For example, normal dietary doses of Se would be expected to be much greater than most exposures that could be reasonably experienced on mine-affected areas, and nutritional supplemental doses of Se can be even higher. Se derived from mine-affected areas is no more or less toxic than Se derived from background sources.

Response: Comment noted.

Specific Comments to Figure 3

- Aquatic and Terrestrial Plant Ingestion. These equations implicitly assume that 100% of the plants ingested are contaminated. Such an assumption is overly conservative, especially for the Native American scenario where most of the population resides well off the study area. A fraction-ingested variable should be added to both the average daily dose (ADD) and LADD equations so as to make assumptions explicit.

Response: Tables 7-1 and 7-2 include a "fraction plant ingested" term that was mistakenly omitted from Figure 3. The equation for ingestion of aquatic and terrestrial plants will be revised accordingly and Figure 3 is now Figure 5.

- Aquatic and Terrestrial Plant Tea Ingestion. As mentioned in the previous comment, these equations assume that 100% of one's tea is derived from contaminated sources within the study area. In addition to remedying this problem, the equation should be modified to account for the fact that the extraction efficiency from the plant material is far less than 100%. Thus, IMASC believes that in addition to a fraction-ingested variable being appropriate, a fraction-extracted (while steeping) is also appropriate to make this a more realistic model.

Response: A fraction-ingested term will be added to the LADD and ADD equations for ingestion of tea and to Tables 7-1 and 7-2. The amount of COPC that is extracted from the plant material into the tea is estimated as part of calculating the EPC for plant-based tea as described in footnote 16 to Tables 7-1 and 7-2."

- Cattle Ingestion. Unless EPC_c is measured at slaughter, both equations incorrectly assume no depuration of contaminant levels in tissue between the time exposure to contaminated pasture is terminated and slaughter. IMASC's beef study showed that there is a significant level of Se depuration once cattle are removed from contaminated grasslands.

Response: As noted in Footnote 3 to Table 7-1, the EPC for beef ingestion will be based on the tissue-specific analytical results presented in the "1999 Interim Investigation Data Report";" the beef tissue results presented in this report are for the beef depuration study conducted by the IMASC. Tthe footnote will be revised to indicate that the EPC for beef ingestion will be based on tissue that has undergone depuration. However, additional calculations may be provided to evaluate the potential effects of "culled" cattle ingestion not provided full depuration.

- Soil Ingestion. Both equations assume 100% of the soil ingested is derived from contaminated areas. This is highly unlikely, as humans are quite mobile far beyond the mine-affected areas, especially if they are living a subsistence lifestyle. A fraction-ingested variable should be added to both the ADD and LADD equations so as to make assumptions explicit.

Response: Subsistence receptors may be exposed both at their home and throughout the Resource Area. For the purpose of assessing potential exposure at their home, a fraction ingested value of 1 will be used to allow health-protective consideration of homebound individuals such as children and elderly. Potential exposure by subsistence lifestyle receptors to contaminants in impacted soil associated with activities outside their residential properties

(such as hunting, fishing, and hiking) is assumed to be insignificant and will not be evaluated in the AWHHRA..

General Comments on Table 7-1

- In the SeAWAC meeting of 10/10/01, IMASC understood from the IDEQ presentation that their deterministic modeling would be performed using mean values as inputs. This table does not appear to reflect that approach, as most values have a statistical conservative bias. For example, the UCL (upper confidence limit) of the mean is a conservatively biased estimate of the mean in that it is expected, with 95% confidence, to overestimate the mean. Furthermore, using mean values as inputs does not assure a deterministic model output from being overly conservative because most input variables are lognormally distributed and the mean of a lognormal distribution is often a high-end percentile of that distribution, and the product of means of skewed distributions is not the mean of their product. Also, values for a central tendency estimate of risk are not provided (although so-called central tendency estimates of risk typically result in overestimations for reasons provided above). Because of the small differences in what are regarded as essential and toxic doses for Se, IMASC believes that evaluating the risk models stochastically is necessary to avoid significant overestimation of risk and thus predicting a risk whether one exists or not.

Response: The Agency proposes the use of mean or approximated area-weighted averages for inputs where discretion is allowed under EPA-approved methods. The EPA suggests the use of certain conservative inputs in their models to allow for sensitive portions of a target population. Our intent was never to remove all conservatism from the Area Wide assessment process and it would be inappropriate to do so in light of inherent uncertainties. We do agree that "worst case" exposure concentrations or 100% site use assumptions result in indisputable unrealistic values for population level exposures and have chosen a central tendency approach for ecological considerations.

The Area Wide risk assessment process is intended to provide a tool for developing general regional goals and objectives and should include some level of conservatism to ensure the protection of public health and the environment. Site-specific risk estimates will support the remedial alternative selection process and the IMASC members will be permitted to collect adequate data to develop stochastic risk estimates for consideration during that process.

- Background contribution variables do not appear to be included. Background contributions must be added to systemic toxicant dose estimates in order for them to be valid, and must be subtracted from carcinogenic dose estimates in order for them to be valid.

Response: Background contributions are included in the area weighted average exposure term. The Agency does not agree that background contributions should be subtracted from carcinogenic dose estimates in the initial risk estimate.

Specific comments on Table 7-1

- Exposure point concentrations. As noted above, upper confidence limits (UCLs) are indicated to be the inputs, yet this seems to be inconsistent with the stated approach to be used as presented at the SeAWAC meeting of 10/10/01. Also, there is no indication as to how background contributions are being addressed (i.e., adding them for systemic toxicants, subtracting them for carcinogens).

Response: Table 7-1 presents the terms to be used for developing Reasonable Maximum Exposure (RME) Scenario values for the Human Health Risk Assessment (HHRA), which requires more conservative EPA-specified methodologies for assessing individual-level risks. Consistent with the tiered approach, Table 7-1 will be revised to include terms for developing central tendency exposure (CTE) scenario values. Additional text will be provided regarding the use and development of background contributions for the HHRA.

- Terrestrial and aquatic plant ingestion rates. As noted in footnote 6, these estimates have a conservative statistical bias and are not consistent with the stated approach to be used as presented by IDEQ in the SeAWAC meeting of 10/10/01.

Response: A conservative bias is appropriate in considering individual level human health risk estimates and EPA's guidance on conducting acceptable human health risk assessments leaves little room for discretion. However, the work plan will be revised to include a CTE component to the HHRA. The input discussion on 10/10/01 to the SeAWAC focused primarily on our approach to ecological risk characterization on a population level basis and developing estimates of the associated exposure point concentrations for target species populations. Ecological risk assessment (ERA) issues will likely guide future site-specific remedial decision making and we apologize if the IMASC interpreted the 10/10/01 presentation to indicate that the methods for the HHRA and ERA were identical.

- Tea ingestion rate. The basis for the value is "best professional judgment." Best professional judgment is applied to available information. What is the rationale for such judgment in this case? What is the information upon which the judgment is applied?

Response: EPA's "Exposure Factors Handbook" presents several tables that provide various estimates, including mean values, for daily intake of tea (EPA 1997). Table 3-14 presents the results of a study of beverage intake in Great Britain (Hopkins and Ellis 1980). Table 3-21 presents results collected as part of the U.S. Department of Agriculture's (USDA) "Continuing Survey of Food Intakes by Individuals" (CSFII) (USDA 1995). Table 3-26 presents the results of a study of total fluid intake derived from various sources by women aged 15 to 49 years old (Ershow and others 1991). Study-specific tea intake estimates are presented below.

- ***Hopkins and Ellis (1980): mean tea intake (0.584 L/day); 95 percent upper confidence limit of the mean (0.608 L/day)***

- ***USDA (1995): mean tea intake – all individuals (0.114 L/day); children (age 5 and under) (0.017 L/day); adults (age 20 and over) (0.140 L/day)***

- ***Ershow and others (1991): mean tea intake (control women) (0.148 L/day); 95th percentile (0.630)***

Based on these results, the following conclusions were drawn. First, the results from the study of Great Britain receptors (Hopkins and Ellis 1980) may not be representative of study area receptors because individuals from Great Britain are expected to intake more tea than U.S. receptors. Second, the mean tea intake rates of adults (age 20 and over) and of control women (age 15 to 49) are similar – 0.140 and 0.148 L/day, respectively (USDA 1995 and Ershow and others 1991). Therefore, for the purposes of the AWHHRA, the mean or CTE tea intake value for adults was estimated as the mean of these two values or 0.144 L/day (about 4 ounces [0.118 L] per day). The RME tea intake rate for adults was estimated as twice the CTE rate or 0.288

L/day (about 8 ounces [0.237 L] per day). Similarly, the mean or CTE child tea intake rate was estimated as 0.017 L/day, based on the mean value for children 5 years and under from USDA (1995). As for adults, the RME child tea intake rate was estimated as twice the mean intake rate or 0.034 L/day.

- Cattle ingestion rate. What are the units of the "time-weighted mean intake rates" and "total mean intake rate for beef"? They appear to be different than g/kg-day as consumed. It appears that IDEQ's "mean" adult beef ingestion rate would be 2.02 g/(kg*d) x 70 kg ≅ 140 g/d = 0.14 kg/d. This appears to be overestimated by about a factor of two (cf. the mean of 0.063 kg/d presented by IMASC in their preliminary risk assessment). Per footnote 9, do hunters and fishermen not eat beef? How is the beef ingestion to be partitioned between skeletal muscle and offal? Will offal be represented by liver?

Response: The units for both "time-weighted mean intake rates" and "total mean intake rate for beef" are g/kg-day as consumed. A set of example calculations is provided for purposes of clarification. The adult and child beef intake rates for the recreational hunter/fisher and subsistence lifestyle receptors (2.00 and 3.73 g/kg-day as consumed, respectively) were calculated as follows:

The 95th percentile beef ingestion rate for the "total" population can be found on the first line of Table 11-3 – 2.327 g/kg-day as consumed, which was rounded to 2.3 g/kg-day as consumed.

This "total" ingestion rate was converted to adult and child-specific ingestion rates using factors calculated for adults and children as the ratios of time-weighted mean intake rates for adults age 20 to 69 years old and children less than 6 years old over the mean intake rate of 0.825 g/kg-day as consumed for the "total" population. The adult and child factors were calculated using time-weighted intake rates which were calculated as follows (all intake units are g/kg-day as consumed):

Adult time-weighted intake (see age range-specific intake rates in Table 11-3)–
(0.789 [20 to 39 years] x 20 years)/ 50 years + (0.667 [40 to 69 years] x 30 years)/50 years = 0.7158

Child time-weighted intake
(0.941[<1 year] x 1 year)/6 years + (1.46 [1 to 2 years] x 2 years)/6 years + (1.392 [3 to 5 years] x 3 years)/6 years = 1.34

Adult and child factors were calculated as the ratios of the adult and child time-weighted intakes over the mean "total" beef intake as follows:
Adult factor: 0.7158/0.825 = 0.87
Child factor: 1.34/0.825 = 1.62

Finally, adult and child beef intake rates were calculated as the product of the 95th percentile beef ingestion rate for the general population (2.3 g/kg-day) and the adult and child factors:
Adult beef ingestion rate: 2.3 x 0.87 = 2.00 g/kg-day as consumed
Child beef ingestion rate: 2.3 x 1.62 = 3.73 g/kg-day as consumed

The same process was used for the Native American receptors with the exception that instead of basing the calculations on the 95th percentile beef ingestion rate for the general population,

the calculations were based on the 95th percentile beef ingestion rate for Native Americans (2.8 g/kg-day as consumed – see Table 11-3).

Both recreational hunter/fisher and subsistence lifestyle receptors are assumed to ingest beef, game, and fish. For the purpose of evaluating each type of meat on its own, exposures will be calculated using RME meat-specific ingestion rates. However, for the purpose of evaluating total exposure, mean meat-specific ingestion rates will be used.

EPA's "Exposure Factors Handbook" clarifies that ingestion of organ meats and sausages (and presumably offal in general) are not included in the meat-specific ingestion rates presented (see Table 11-3). Therefore, intakes of beef should be summed with intakes of organ meats, sausages, and offal in general. For the purposes of the AWHHRA, it was assumed that recreational hunters would, over the course of one year, ingest beef tissue equivalent to one beef liver in addition to skeletal muscle. Based on the proposed adult beef ingestion rate, the mass of one beef liver represents about 4.4 percent of the mass of skeletal muscle ingested as shown below:

Skeletal tissue ingested in one year -- 2.00 g/kg-day as consumed x 70 kg BW x 365 days/year = 51,100 g/year = 51.1 kg/year = 112 pounds/year

One beef liver (5 pounds/year)/112 pounds/year= 0.044 or 4.4 percent

Therefore, both adult and child recreational hunter receptors are assumed to ingest beef tissue other than skeletal muscle at a rate equal to about 4.4 percent of the skeletal muscle ingestion rate. The selenium concentrations of these other beef tissues will be estimated using liver concentrations.

For the purposes of evaluating subsistence lifestyle and Native American receptors, it was assumed that these receptors ingested beef tissue other than skeletal muscle at a rate equal to about 10 percent of the skeletal muscle ingestion rate based on the work of Harris and Harper (1997). These investigators noted that native peoples ate more parts of fish and animals than just the fillet or steak. They recommended using a place holder value of 10 percent of the total fish ingestion rate (assumed to be 540 g/day for members of the Confederated Tribes of the Umatilla Indian Reservation) to represent "other organs" (Harris and Harper 1997). For the purposes of the AWHHRA, this 10 percent value will be used to represent each of the meat types evaluated in the risk assessment. Therefore, both adult and child subsistence lifestyle and Native American receptors are assumed to ingest beef tissue other than skeletal muscle at a rate equal to about 10 percent of the skeletal muscle ingestion rate. The selenium concentrations of these other beef tissues will be estimated using liver concentrations.

- Aquatic life ingestion rate. All of the values are overestimated relative to the mean of 0.0080 g/d (wet weight) presented by IMASC. This is especially true given that most of the affected streams are regulated as catch-and-release fisheries (for cutthroat, the most abundant of the sport fish in the streams), and the most affected of the streams do not support enough of a fish population to constitute a potential chronic source of human food.

Response: The proposed RME rates will be used as caps on the amount of fish ingested by each receptor. That is, for the purpose of evaluating ingestion of fish across a watershed (see Step 2 of the tiered approach), an evaluation will be made regarding the ability of streams from a given watershed to support chronic intake of fish. To the extent that a watershed is determined to be unable to support chronic fish ingestion, the RME fish ingestion rate will be

adjusted downwards. Under Step 3 of the tiered approach, a similar process will be conducted on a stream-specific basis. The evaluation under CTE conditions will be conducted following a similar methodology based on CTE fish ingestion rates calculated as mean intake rates.

- Soil ingestion rate. These values are overestimates and do constitute "central tendency" estimates. For example, studies have indicated mean values for children on the order of 20 mg/d (Stanek and Calabrese, 1995, "Daily estimates of soil ingestion in children," Environmental Health Perspectives 103(3):276-285). Thompson and Burmaster (1991, "Parametric distributions for soil ingestion by children," Risk Analysis 11:339-342) report child soil ingestion rate estimates as follows: median of about 60 mg/d, mean of about 80 mg/d, and 95th percentile of about 200 mg/kd.

Response: As noted elsewhere, the Work Plan will be revised to consider both RME and CTE conditions. It is expected that soil ingestion rates under CTE conditions will be set equal to mean soil ingestion rates. Based on Table 4-23 from EPA's "Exposure Factors Handbook," mean soil ingestion rates for children and adults are 100 and 50 mg/day, respectively (EPA 1997).

- Fraction plant ingested. To the best of our knowledge, there are no observed gardens in contaminated floodplains. In fact, we assume that USFS regulations would prohibit gardens along the banks of those streams most affected as they lie within USFS lands. It doesn't seem reasonable that a subsistence receptor could derive 100% of his edible plants from contaminated floodplains, given that the area of such floodplains is limited and at quite high elevations with a very short growing season. More important, as stated in the Health Consultation prepared by the Idaho Division of Health for the Agency for Toxic Substances and Disease Registry, dated June 27, 2001, a subsistence-type lifestyle "is a very unlikely and perhaps unrealistic scenario for the Resource Area." The assumption that Native Americans harvest 25% of their wild onions, wild carrots, and watercress from impacted areas seems overly conservative given that only a very small percentage of the resource area is impacted by mining activities. On what information was best professional judgment exercised?

Response: The study area can be divided into "warmer" counties such as Bannock, Franklin, and Oneida and "cooler" such as Bear Lake and Caribou. The growing season for the warmer counties is estimated to be about 110 to 120 days and in cooler counties is estimated to be about 90 to 100 days (Tetra Tech 2002). A UICES representative stated that in cooler counties the cooler nighttime temperatures especially can slows the growth of warmer season plants. As a result, plants such as corn, tomatoes, and warm season squashes may not grow well in counties such as Bear Lake and Caribou (Tetra Tech 2002). However, plants such as beans, beets, carrots, peas, potatoes, and spinach can be raised without significant difficulty in these cooler counties. While the UICES representative noted that it would be possible to grow all necessary produce in a home garden in cooler counties, it is acknowledged that many of the stream segments potentially impacted by mining activities are located at some of the higher elevations in Bear Lake and Caribou counties. It is expected that growing seasons along these streams would be among the smallest in the cooler counties. Also, it is acknowledged that the flood plain of some of the impacted stream segments may be small enough to limit the size of a theoretical garden along these streams.

A fraction plant ingested will be added to the homegrown produce intake equation. A basic value for this parameter is estimated as 0.75 based on the ratio of the shortest estimate of growing season in cooler counties (90 days) to the longest estimate of growing season in warmer counties (120 days). Based on review of the locations at which flood plain soil samples

have been collected, this fraction plant ingested value may be further reduced if it is judged that insufficient growing space is available in a stream-specific flood plain.

With regard to the fraction of wild onion, wild carrot, and water cress ingested by Native American receptors, it is acknowledged that the 14 active and former mine sites in the study area have a cumulative area equal to about 5 percent of the total study area (60 square miles for the mine sites [see Drawing 1-1 from MW 2000])/(1,200 square miles for the study area [MW 1999]). However, based on the proposed ingestion rates for wild onion and water cress, it is estimated that Native American receptors would only need to gather about 5 or 6 plants to meet the total estimated mass of each species ingested over 1 year (Note: wild onion example -- 0.0107 g/kg BW – day x 70 kg BW x 365 days = 27.3 g wild onion as consumed per year. It is reasonable to believe that a Native American receptor could gather 5 or 6 plants of each species on a single trip. Samples of wild onion and watercress of sufficient volume to meet annual ingestion requirements were collected from various sampling locations in the study area. Receptors would be expected to return to known locations of these plants. However, it is acknowledged that there are certainly other sources of wild onion and watercress (and also wild carrot) besides locations in the study area potentially impacted by mine releases. Therefore, it is assumed that Native American receptors gather wild onion, watercress, and wild carrot from locations potentially impacted by mine releases in the study area about every fourth year. This equates to a fraction ingested of 0.25 under RME conditions. Under CTE conditions, it is assumed the fraction ingested value is assumed to be reduced by half (0.125).

- Fraction cattle ingested. The value of 0.157 was derived from much more than just the assumption mentioned in footnote 13. Also, 0.157 is an estimate of the 95th percentile, not the mean. The mean estimate for this variable, as derived by the participants of the November 1999 risk assessment workshop, is 0.051. (Note that MW, 1999, erroneously specifies the mean and standard deviation to be 0.51 and 0.52; they are 0.051 and 0.052, respectively.)

Response: The Agency has reviewed and accepted the rationale and supporting information for the development of this parameter. The basis for the fraction cattle ingested value of 0.157 used to evaluate RME conditions will be clarified and the fact that this value is an estimate of the 95th percentile will be noted. For the purposes of evaluating CTE conditions, the mean estimate for this variable as derived by the participants of the November 1999 risk assessment workshop, 0.051, will be used.

- Fraction aquatic life ingested. Participants of the November 1999 risk assessment workshop defined the mean of this variable to be 0.90; thus, 1.0 is an overestimate of the mean as determined by the workshop participants. In footnote 14, ground-truthing calculations are presented regarding the numbers of fish caught. First, the assumption of 16-inch fish being found in the most impacted streams, which, at best, are very tiny nursery streams, is untenable. Second, the assumption that one could catch 24 to 36 fish of edible size from such streams is also untenable. Third, there are catch-and-release regulations on virtually all of these streams that apply to cutthroat (the most numerous of the stream game fish). Fourth, after demonstrating that the subsistence fisher would have to catch 162 fish per year and admitting that this is an unrealistically high estimate, the untenable value is retained; thereby negating the value of the ground truthing effort. In short, IMASC believes that the numbers of fish are within the realm of possibility for Blackfoot Reservoir and the Blackfoot River. However, they seem well outside the realm of possibility for first-order streams, such as those that are believed to be highly impacted.

Response: Stream- and watershed-specific fraction ingested (FI) values will be determined and applied in the AWHHRA. FI values will be determined based on consideration of a variety of factors including, but not limited to the following: stream order; the type, size, and number of fish present; and documentation that particular streams contain notable spawning grounds.

- Wild game ingestion rate. The "total meat intakes" look quite similar to the beef ingestion rates used in footnote 9. The use of ratios of 95th percentiles is questionable and certainly not as robust as using the ratios of means or, probably better yet, medians. How is the game ingestion to be partitioned between skeletal muscle and offal? IMASC suggests that the partitioning be done in proportion to the relative weight of liver and skeletal muscle.

Response: The "total meat intake" values presented in footnotes 9 and 15 are indeed the same. As stated in footnote 15, Table 11-6 presents only mean game intake rates. In order to estimate 95th percentile game intake rates, it was assumed that the ratio of mean to 95th percentile game intake rates was the same as the ratio of mean to 95th percentile total meat intakes. Therefore, mean values were used in the calculation. The intake of elk tissue other than skeletal muscle (for example, other organs, sausages, offal, etc.) will be estimated as described in the response regarding the cattle ingestion rate.

- Fraction wild game ingestion. The statistics from the MW report cited were actually for two adjoining game management units. And, a preliminary analysis of the 2000 elk data confirm the odds of shooting a Se-elevated elk within the area (2000 data are quite similar to those from 1999). On what basis is the subsistence hunter assumed to be preferentially dwelling in contaminated areas? IMASC assumes that the subsistence hunter would be attracted to the same features of habitat and access that attract the hunters from the general population. Because of this, the likelihood of a subsistence hunter encountering a Se-elevated elk should be similar to, not different than, that of a hunter from the general population. More important, the Health Consultation prepared by the Idaho Division of Health for the Agency for Toxic Substances and Disease Registry, dated June 27, 2001, states "A person who poaches elk and fish or has a subsistence type of existence on wild game and fish may not be a realistic scenario for this area."…"However, a subsistence hunter and fisherman who ate fish, beef, or elk each day is a very unlikely and perhaps unrealistic scenario for the Resource Area."

Response: The Work Plan will be revised to state that the fraction wild game value is based on statistics from two adjoining game management units (76 and 66A). The subsistence lifestyle receptors are assumed to be living in more remote portions of the study area than are recreational hunters or Native Americans who are assumed to live primarily in population centers, including the Ft. Hall Indian Reservation. Subsistence lifestyle receptors may be attracted to some of the same features of habitat and access that attract hunters from the general population. However, subsistence lifestyle receptors are also expected to more frequently visit and hunt at remote portions of the study area including in the vicinity of some of the active or abandoned mines in the study area, because of their proximity to the subsistence lifestyle receptor's home and/or the subsistence lifestyle receptor's greater knowledge of localized conditions. In order to account for the potentially greater frequency with which subsistence lifestyle receptors may encounter elk with elevated selenium concentrations, as compared with recreational hunters, the fraction ingested value for the recreational hunter was doubled to represent the subsistence lifestyle receptor.

It should also be noted that as stated elsewhere, the IDH has recently acknowledged that while its Health Consultation stated that a subsistence scenario is unlikely, this scenario is not out of the question (IDH 2001). Therefore, IDH representatives agreed that the subsistence lifestyle receptor should be retained for consideration in the AWHHRA (IDEQ 2001).

- Exposure frequency. Two exposure frequencies are presented—350 and 365 d/yr. The one used by EPA is 350 d/yr.

Response: Tissue ingestion rates as presented in EPA's "Exposure Factors Handbook" and as used in the Work Plan, are calculated as annual averages (EPA 1997). Therefore, these ingestion rates must be used in conjunction with an exposure frequency of 365 days/year.

ADDITIONAL ECOLOGICAL RISK ASSESSMENT COMMENTS

General Comments

- Section 8.1 of the Work Plan states that only data collected during calendar year 2001 will be used in the area-wide ecological risk assessment. The 2001 sampling investigation included the collection of vegetation, terrestrial invertebrate, and rodent tissue samples. These data will be valuable in assessing terrestrial and, to some degree, riparian ecological exposures and effects, as described in Section 8.6.2 of the Work Plan. However, the IMASC (with oversight and guidance from the Selenium Working Group) planned and implemented the collection of considerable aquatic data prior to 2001 that would be extremely useful in the evaluation of potential impacts to aquatic and riparian species. These data include sampling results for benthic macroinvertebrates, submergent macrophytes, periphyton, plankton, and fish. It is unclear from the Work Plan why these data are not being considered, or how potential exposures and impacts to aquatic/riparian species such as the mallard (*Anas platyrhynchas*), raccoon (*Procyon lotor*), and great blue heron (*Ardea herodias*) will be evaluated in the absence of such site-specific data.

Response: The 2001 data is used for Tier 2 purposes because it presents correlated media for an expanded list of analytes. Other available data will be considered for use in Tier 3, where applicable. Potential exposures and impacts to aquatic/riparian species are evaluated through food chain/ingestion modeling and will be supplemented with historic data, where needed.

- The measurement endpoints described in Section 8.6.2 indicate that 'multiple lines of evidence' will be used to evaluate potential ecological risks to the identified guilds or communities. However, it is unclear what specific data or types of assessment (e.g., comparisons of abiotic/biotic concentrations to literature benchmarks, or modeling of exposures and risks) will be used as measurement endpoints for a particular assessment endpoint receptor. Therefore, it is not possible to correlate measurement endpoints with specific assessment endpoints, or to evaluate the adequacy of the ecological risk characterization methods described in the Work Plan. A table summarizing the measurement endpoints that are to be evaluated for each assessment endpoint would greatly improve this understanding.

Response: A table (Table 8-3) that summarizes the measurement endpoints used to assess the assessment endpoint receptors was added to the work plan.

- The rationale used in the selection of indicator receptors and/or surrogates for evaluation of ecological assessment endpoints is not clear. For example, the northern bobwhite (*Colinus virginianus*) was proposed as a surrogate species for the chipping sparrow (*Spizella passerina*), which was selected as a representative receptor for terrestrial herbivores. However, the northern bobwhite is an *omnivorous* species. The rainbow trout (*Oncorhynchus mykiss*) was selected as a surrogate species for the large-spotted Snake River cutthroat trout (*Oncorhynchus clarki bouvieri*). However, the Selenium Working Group sponsored a multi-year toxicity study in native cutthroat trout harvested from the Upper Blackfoot River. Therefore, the selection of rainbow trout as a means of evaluating potential impacts to native cutthroat trout rather than using site-specific data is unclear. The red fox (*Vulpes vulpes*) was selected as a surrogate for the coyote (*Canis latrans*), representing tertiary carnivorous mammals. However, the red fox is an omnivorous mammal and is not referred to in the remainder of the Work Plan (e.g., Table 8-2). Therefore, it is unclear what purpose the red fox serves as a surrogate species. Finally, the northern harrier (*Circus cyaneus*) was proposed as a surrogate species for the northern saw-whet owl (*Aegolius acadicus*). However, the northern harrier is diurnal while the northern saw-whet owl is nocturnal. Hence, these species have different behavioral patterns and diets, and are not mutually representative.

Response: There is no "strictly" herbivorous avian species found in the study area. However, the chipping sparrow was chosen because its diet is primarily herbivorous. The northern bobwhite was chosen as the surrogate because there is more life history information available for that species. This discrepancy will be dealt with in the uncertainty section. The rainbow trout was chosen again because of the volume of information available on the life history and toxic response for the rainbow trout. The data on the native cutthroat trout can also be used to fine-tune the assessment. Use of the red fox as a surrogate was a typo. There is enough life history information to use the coyote directly. A correction to Table 8-2 will be made. The northern harrier will be retained as the ecological assessment endpoint since there is more life history information available for it.

- The process used in the selection of ecological toxicity values is not presented, and in some cases it is not possible to verify or reproduce the proposed toxicity values. The two references that were cited as sources of mammalian and avian toxicity values were *Toxicological Benchmarks for Wildlife: 1996 Revision* (Sample et al., 1996) and *Development of Toxicity Reference Values for Conducting Ecological Risk Assessments as Naval Facilities in California, Interim Final Technical Memorandum* (U.S. Department of Navy, 1998). The latter document was sponsored by the U.S. Navy and the toxicity values contained therein were developed by the USEPA Region IX Biological Technical Advisory Group (BTAG) for use at Naval facilities located within California. This document has not been released to the public for comment nor has it been peer-reviewed. Therefore, the applicability of this document to the area-wide ecological risk assessment for the Phosphate Region of Southeastern Idaho should be explained. It is not clear why some of the toxicity values presented in Table 8-2 were derived from one of the above sources, while other values were derived from the other source. In addition, it is apparent that some of the toxicity values presented in Table 8-2 were obtained from neither source. It would be helpful if the hierarchy of criteria used in the selection of toxicity values was provided in Section 8.7.1. The reference in Table 8-2 to 'Low-TRV' is not explained, and suggests that there may be values other than 'Low-TRVs'. Will other TRVs also be used in the area-wide ecological risk assessment?

Response: Toxicity reference value hierarchy/rationale will be included in the text. The toxicity reference values (TRV) chosen represent the best information presently available. The Navy document referenced in the work plan went through extensive review by several agencies and the referenced values were chosen after careful consideration by all parties involved. A copy of this document can be provided to IMASC upon request. The values from the Navy document were chosen first for those chemicals without TRVs, then the study by Sample and others (1996) was consulted to derive the TRVs for the remaining chemicals. IDEQ is not aware that any of the TRVs came from other sources than those referenced. The values from the Navy document were chosen as being better representative for the Resource Area since they are applicable to California.

The term "Low-TRV" can be modified simply to be "TRV" as a high TRV was not used. At one time IDEQ considered using both a high and a low TRV. Only one TRV will be used. The TRV values presented in Table 8-6 represent the chronic, no observed adverse effect level. No other TRVs will be used in the area wide risk assessment (AWRA).

- The ecological assessment endpoints presented in Section 8.6.1 and Table 8-1 suggest that the intended level of protection for the site-wide ecological risk assessment is at the organismal (i.e., individual) level. Although the protection of individuals is often considered to be appropriate for special status (e.g., Threatened or Endangered) species, population or community survival may be an appropriate level of protection for non-sensitive status species (USEPA, 1997; 1998). Since the majority of indicator species that were selected for evaluation in the site-wide ecological risk assessment are not special status species, IMASC believes that population level effects are the appropriate level of protection for the site-wide ecological risk assessment.

Response: The Agency uses an area-weighted exposure concentration to translate the EPC to population level protection. However, future site-specific risk decisions should also give consideration to potential subpopulation and/or individual effects.

Specific Comments

- Section 8.1, p. 41. It is stated that only data collected during calendar year 2001 will be used in the area-wide ecological risk assessment. The 2001 sampling investigation included the collection of vegetation, terrestrial invertebrate, and rodent tissue samples. These data will be valuable in assessing terrestrial and, to some degree, riparian ecological exposures and effects, as described in Section 8.6.2. It should also be noted that the IMASC (under the oversight and guidance of the Selenium Working Group) planned and implemented the collection of considerable aquatic data prior to 2001 that would be extremely useful in the evaluation of potential impacts to aquatic and riparian species. These data include sampling results for benthic macroinvertebrates, submergent macrophytes, periphyton, plankton, and fish. It is unclear why these data are not being considered.

Response: See response to this comment in previous General Comment section.

- Section 8.1.2, p. 42. Text states that the Tier 2 ecological assessment will use a 'statistically derived' mean exposure point concentration (EPC) for each media. This statement appears inconsistent with text in Section 9.0, which states "…statistical analysis of the data probably

will not be conducted." These apparent contradictions should be resolved, or methods of deriving the EPC should be clarified.

Response: The Agency will clarify development of the area weighted exposure point concentration for ecological risk characterization.

- Section 8.5.1.1, p. 56. Please consider providing common names with scientific names for plant species.

Response: This section summarizes a number of plant families without indicating particular species. However, where applicable, the Agency uses scientific species names to avoid any confusion arising from varied and inconsistent common name usage.

- Section 8.5.1.1, p. 47. Please make the following change to the 4th sentence of the 2nd paragraph on Page 47, "As indicated for plants, the direct toxic effects of consuming selenium-contaminated invertebrates are more important than any indirect ecological effects such as changes in invertebrate population structure (Skorupa, 1998)."

Response: Corrected.

- Section 8.6.1, pp. 51-62. The ecological assessment endpoints that are presented in this section and in Table 8-1 suggest that the intended level of protection for the site-wide ecological risk assessment is at the organismal (i.e., individual) level. Although the protection of individuals is often considered to be appropriate for special status (e.g., Threatened or Endangered) species, population or community survival may be an appropriate level of protection for non-sensitive status species (USEPA, 1997; 1998). Since the majority of indicator species that were selected for evaluation in the site-wide ecological risk assessment are not special status species, IMASC believes that population level effects are the appropriate level of protection for the site-wide ecological risk assessment.

Response: See response to this comment in previous section.

- Section 8.6.1.1, p. 53. In the 1st paragraph under Terrestrial Herbivorous Mammal Community and Associated Assessment Endpoints, the 2nd sentence does not appear to support the 1st sentence, although the 2nd sentence is cited as an example of systemic or general toxic effects of metals. Please reword or clarify this point.

Response: Text will be corrected.

- Section 8.6.1.3, p. 62. Please support with the appropriate reference(s) the statement, "…selenium exposure in the diet and drinking water of raptors is associated with reproductive abnormalities, congenital malformations, selective bioaccumulation, and growth retardation."

Response: References will be cited.

- Section 8.6.2, p. 62. The evaluation of potential ecological risks will be based upon 'multiple lines of evidence'. However, it is unclear what specific data or types of assessment (e.g., comparisons of abiotic/biotic concentrations to literature benchmarks, or modeling of exposures and risks) will be used as measurement endpoints for a particular assessment

endpoint receptor. Therefore, it is not possible to correlate measurement endpoints with specific assessment endpoints, or to evaluate the adequacy of the ecological risk characterization methods. A table summarizing the measurement endpoints that are to be evaluated for each assessment endpoint would greatly improve this understanding.

Response: See response to this comment in previous section.

- Section 8.6.2, p. 63. We suggest changing "Assume" to "The assumption" in the 1st two bullets of the 1st paragraph on Page 63.

Response: Comment noted.

- Section 8.7, p. 64. It would be helpful if the equation for calculating HQ was presented in this section, along with an explanation of how the HQ is indicative of potential hazards to ecological receptors. In addition, it is not stated whether a hazard index (HI) will be calculated to evaluate potential cumulative effects to indicator receptors.

Response: Hazard indexes are not categorically included in the work plan but may be calculated in instances where a significant cumulative effect is indicated.

- Section 8.7, p. 64. We recommend providing additional explanation and/or equations for calculating exposure doses using site-specific abiotic media and tissue concentrations. These methods may vary depending upon the nature of the media and trophic level, as described in USEPA (1999).

Response: Comment noted.

- Section 8.7, p. 64. The last paragraph in this section states that the results of the Tier 2 ecological risk assessment "…can be used in a risk management process to arrive at a risk value that can be applied to manage metals levels in appropriate media resulting from mining activities in the resource area." As described in the above comments, it is unclear from the Work Plan what specific data and studies will be used in the Tier 2 assessment. It is possible that additional evaluations or studies not described in this Work Plan (e.g., Dr. Ratti's bird egg study, Dr. Hardy's cutthroat trout toxicity study, Dr. Garten's population level assessment, or additional monitoring or validation studies may be appropriate for refining or augmenting the results of the Tier 2 ecological assessment before risk management decisions regarding the potential management of metal(s) in Resource Area media are made. Please revise this statement, accordingly.

Response: Further embellishment is not necessary. Any relevant studies, now or in the future, may result in a refinement or augmentation of the Agency's risk management process, which will be on-going throughout the resolution of issues associated with the management of trace metals in the Resource Area.

- Table 8-1. The rationale used in the selection of indicator receptors and/or surrogates for evaluation of ecological assessment endpoints is not clear. Several examples are as follows:

  - The northern bobwhite (*Colinus virginianus*) was proposed as a surrogate species for the chipping sparrow (*Spizella passerina*), which was selected as a representative receptor for <u>terrestrial herbivores</u>. However, the northern bobwhite is an *omnivorous* species.

- The rainbow trout (*Oncorhynchus mykiss*) was selected as a surrogate species for the large-spotted Snake River cutthroat trout (*Oncorhynchus clarki bouvieri*). However, the Selenium Working Group sponsored a multi-year toxicity study in native cutthroat trout harvested from the Upper Blackfoot River. Therefore, the selection of rainbow trout as a means of evaluating potential impacts to native cutthroat trout rather than using site-specific data is unclear.
- The red fox (*Vulpes vulpes*) was selected as a surrogate for the coyote (*Canis latrans*), representing tertiary carnivorous mammals. However, the red fox is an omnivorous mammal and is not referred to in the remainder of the Work Plan (e.g., Table 8-2). Therefore, it is unclear what purpose the red fox serves as a surrogate species.
- The northern harrier (*Circus cyaneus*) was proposed as a surrogate species for the northern saw-whet owl (*Aegolius acadicus*). However, the northern harrier is diurnal while the northern saw-whet owl is nocturnal. Hence, these species have different behavioral patterns and diets, and are not mutually representative.

The rationale for selection of the above surrogate receptors should be clearly explained.

Response: See response to this comment in previous "General Comments" section.

- Table 8-2. It is our understanding that food ingestion rates, as calculated using the indicated algorithm, have units of g/day, not g/g-day. This potential error could have a profound effect on the estimated exposure doses and risks for each receptor.

Response: Food ingestion rates are presented in grams/day and will be corrected in the Table.

- Table 8-3. The following comments pertain to the mean exposure parameters proposed for indicator receptors:

  - The mean body weight for the raccoon is based on females only, although male body weights are also available in *Wildlife Exposure Factors Handbook* (USEPA, 1993). Body weights for most of the other indicator receptors were based on both sexes.

Response: The body weight of the one adult male will be included in the mean body weight. The appropriate corrections to Table 8-3(now Table 8-5) will be made.

  - Mink mean body weights were based on juveniles and adults. However, none of the other indicator species included juvenile body weights.

Response: The body weights will be recalculated to insure that only adult males and females are included. The appropriate corrections to Table 8-3(now Table 8-5) will be made.

  - Food ingestion rates are calculated in g/day, not g/g-day, using the indicated algorithm.

Response: Using the algorithm presented the food ingestion rates are in grams/day. The appropriate corrections to Table 8-3 (now Table 8-5) will be made.

  - Meadow vole food ingestion rate was not calculated, as stated in the reference column.

Response: The correct food ingestion rate is 7.201 grams/day. Table 8-3 (now Table 8-5) will be corrected as appropriate.

- Soil ingestion rates are based on food ingestion rates, and are given in g/day not g/g-day.

Response: The soil ingestion rates are based on food ingestion rates and there are in grams/day. Table 8-3 (now Table 8-5) will be corrected as appropriate.

- The mean home range for the American Robin was based on *breeding territory* size during spring, only, which may underestimate actual home range.

Response: The included information is incorrect and will be replaced by a home range of 0.395 acres based on Howell (1942 as cited in EPA 1993). Table 8-3 (now Table 8-5) will be corrected as appropriate.

- The mean home range for the raccoon was based on females only. With males, the home range increases from 1,991.6 ha to 4159 ha.

Response: The original intent was to include males and doing so puts the mean home range at 1,683 hectares or 4,159 acres. Table 8-3 (now Table 8-5) will be corrected as appropriate.

- The mean home range for the mallard duck is based on males *and* females, not just females as stated in the reference column.

Response: The correction to Table 8-3 (now Table 8-5) will be made.

- The mean home range for mink was based on females, only. This value is low compared to other ranges and means available for mink.

Response: Zeiner and others state that "in Montana, males had large home ranges; up to 4.8 km (3 mi) in diameter, encompassing about 1832 ha (4524 ac)." This information will be incorporated with the data on females to arrive at a home range of 620 ha or 1,532 acres. Table 8-3 (now Table 8-5) will be corrected as appropriate.

References

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Response References

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IDEQ Responses to USFWS Comments of 9/25/01 on Draft Area Wide Risk Assessment Work Plan

(Transcribed from E-mail message forwarded to IDEQ on 9/25/01-rlc)

From: Susan_Burch@R1.FWS.Gov
To: DEQ.POC(RCLEGG).DEQ.INTERNET (davisj@ttemi.com)
Date: Tue, Sep 25, 2001 2:08 PM
Subject: Comments on the Draft Ecological Risk assessment-SE Idaho Phosphate

Hi Rick and Joe,

Since I was so late in finishing comments for the ERA, I forgot to include Don's comments he sent over last week. Please add them to my comments sent over earlier today. Thanks!

Susan
----Forwarded by Susan Burch/ESBO/R1/FWS/DOI on 09/25/2001 02:03 PM----

Don Steffeck
09/12/2001
05:22 PM

To: Susan Burch/ESBO/R1/FWS/DOI@FWS
cc:
Subject: comments on the draft ecological risk assessment-SE Idaho phosphate

Hi Susan,

I've quickly reviewed the draft ERA, and offer the following for you to include in FWS comments, if you don't mind collating my views into your comment letter. Please let me know if you have any?'s. Thanks, Don

In general, it's my understanding that when there is a paucity of data and much uncertainty, as described on page 11, then the assumptions used to develop models or other evaluations, should be done conservatively because of the potential to impact natural resources. This general philosophy should be discussed in the ERA and followed during the decision-making process.

Response: The IDEQ agrees and believes that an adequate level of conservatism is provided in the described approach to support pragmatic decisions that will be protective of human health and the environment. The ecological risk assessment will be addressed in a tiered manner, which is discussed in Section 8.1. In Tier 1 (see Section 8.1.1) the highest observed concentration for each media and constituent, and the most conservative exposure parameters (see Table 8-4) will be used to calculate an HQ for each target species and chemical of potential ecological concern. Any constituents that do not present a potential risk using this worst-case scenario can then be safely removed from further consideration. In Tier 2 (see Section 8.1.2) the constituents that do present a "worst case" risk from the Tier 1 assessment will be evaluated on an Area Wide basis using an Area Wide weighted average exposure point concentration for each media and mean exposure parameters for each receptor (see Table 8-5). In Tier 3 (see Section

8.1.3), the uncertainties and sensitivities of different parameter values used in the risk assessment calculations will be analyzed.

Page 12, third bullet; please add the USGS biota sampling from spring 2000, fall 2000, and spring 2001, to the list of on-going studies.

Response: Corrected.

Page 16, 6.0, third bullet; please add biotic uptake to the list contaminant release mechanisms.

Response: Corrected.

Page 23, 7.2.1.2; second paragraph, the fish tissue samples should include the USGS fish study for 2000-2001.

Response: Corrected.

Page 33, last bullet; it's stated that maximum concentrations in wells are 5 to 10 times lower than the tap water preliminary remediation goals (PRG). The data used was for 20 wells from a MW report dated 1999. We suggest that the PRG be provided and all groundwater data be included in the evaluation. We note that a well concentration from MW 1998 sampling for selenium was 0.033 ppm and the water quality criteria for protection of aquatic life is 0.05 ppm, which is much closer to concern levels than stated. Page 47, last sentence of 8.2; it's stated that only the chemicals left after a screening process will be referred to as COPECs. It's our understanding that the COPECs are the list of potential chemicals of concern identified prior to screening. Because of the paucity of data, as described on page 11, what is the justification for doing the screening? A minimal amount of data argues for retaining a wider COPEC list because it's more likely a constituent may be missed. By screening the COPECs, this problem will be exacerbated. We suggest that the reasoning for screening needs to be clarified, and a screened list of chemicals should be designated by a different term than COPEC.

Response: Groundwater quality standards for selenium in the State of Idaho are based on the Federal Maximum Contaminant Level (MCL) of 0.050 mg/L for drinking water and do not effect aquatic life. Additional groundwater studies are projected for site-specific investigations to assess localized impacts, however, based on studies conducted to date, the Agency is unaware of any exceedances of this standard in domestic wells, local public water supplies, or other drinking water aquifers. Groundwater is not considered an ecological exposure pathway media unless it becomes accessible at which time it becomes a surface water concern.

The initial target parameters in the risk assessment process are typically referred to as Preliminary Contaminants of Concern and that list is refined during the Preliminary Risk Assessment process. Due to Interagency concerns with the initial screening effort, the IDEQ expanded the list of potential mining-related constituents to perform

additional screening activities and to develop a final COPEC list for future studies. The purpose of reducing the list is to focus limited resources on actual problem areas and define the scope of future activities.

The quantity and quality of the targeted concentration-gradient data collected in the Area Wide effort, as well as decades of geologic information developed by the USGS, adequately supports this screening effort and provides a relatively high level of confidence that regional concerns will be addressed. Our sampling approach systematically measured constituent concentrations, using fate and transport considerations, beginning with the source term and tracing concentrations through final receptors/media. The rationale for eliminating specific constituents from our expanded analyte list will be discussed in the risk assessment document.

Page 48, last paragraph; we suggest that reptiles be added as possible secondary consumers.

Response: The IDEQ did not include amphibians or reptiles in the risk studies because of the general lack of reference value information regarding selenium exposure in these species, however, we will add reptiles as a potential secondary consumer. Based on our review of the limited scientific literature available, it appears that levels established for the protection of fish and waterfowl in similar habitats would adequately protect reptiles and amphibians in riparian areas.

Page 49, sections 8.4 and 8.4.1; it stated that selenium is the only currently identified COPEC. This needs clarification, there are over 20 COPECs identified by the workgroup, if this is in reference to MW reports it should be so stated. We suggest adding over COPECs to this analysis. We suggest that the extensive database developed by the Department of Interior be reviewed and included in this analysis, the final reports can be accessed at www.usbr.gov/NIWQP.

Response: At the time of publication, selenium was the only IDEQ-confirmed COPEC pending the additional screening by the Agency of the expanded mining-related target analyte list developed by the Interagency Technical Group. The IMA previously identified cadmium and molybdenum as additional COPECs during their voluntary activities. The text has been modified to indicate that other COPECs will be considered in the risk assessment process.

Page 52, second paragraph, the dermal absorption and inhalation pathways were excluded because of a lack of data. We suggest that a more appropriate approach would be to assume a worst-case scenario because of this data weakness, rather than exclusion from consideration.

Response: Inhalation pathways have been added to recreational user scenarios for the human health assessment. However, inhalation and dermal absorption exposure pathways are excluded from the ecological risk assessment, not because of a lack of Area Wide data, but because of the lack of toxicological data and necessary reference

value information to quantify any associated risks to potential receptors. However, other researchers have also concluded that these pathways for trace metals are negligible in comparison to the ingestion and food chain paths.

Page 52, last paragraph and bullets; we suggest that a lotic aquatic community be added to the ecosystems potentially at risk.

Response: A lotic aquatic community has been added to the list of ecosystems potentially at risk.

Page 55, last paragraph and bullets; we suggest that top mammalian and bird predators be added to the list of builds based on consumption of small mammals feeding on vegetation/insects in the vicinity of the waste piles.

Response: Section 8.6.1.3 presents the assessment endpoints for the tertiary consumers, which include top mammalian and bird predators. It was separated in this manner to recognize that these predators feed on terrestrial, aquatic and riparian guild members.

Page 65, amphibian community; during the aquatic sampling conducted by the FWS, we observed and collected a large number of salamanders that had died in a wetland area near a mine, we suggest that amphibians be directly assessed, possibly with site specific data if necessary.

Response: The IDEQ requests that the referenced data be provided for review prior to making a determination on the addition of this community to the Area Wide risk assessment process. The Agency is aware of the previous occurrence of salamander deaths in the region that were confirmed to be a result of viral infections, but we have not seen any evidence of regional or localized impacts attributed to selenium exposures. However, as stated earlier, the general lack of toxicological information on amphibians prevents the direct assessment of this guild. The USFWS is encouraged to commission additional studies on this issue if it is of particular interest to their Agency.

Page 67, second paragraph and bullets; under multiple lines of evidence, we suggest that on-site toxicity data be included and we would like a discussion on the cut-throat trout toxicity data discussed in the MW 1998 work plan.

Response: The Agency is awaiting publication of the referenced cutthroat trout studies conducted by the University of Idaho prior to evaluating its applicability, however, the study has been added as a potential line of evidence.

Page 68, first 2 paragraphs; we suggest that site-specific toxicological data be considered in addition to the other biological information being collected. We think that this will add to the credibility of the ERA and assist in subsequent decision-making.

Response: The Agency will use relevant and applicable Area Wide- and site-specific toxicological data, whenever available. We would ask that the USFWS provide any

known toxicological data or specific studies that are currently available for this purpose that have not been cited for use as supplemental lines of evidence.

Page 69; 8.6.1, last sentence; it stated that table 8-3 presents the proposed TRVs. Tables 8-2 and 8-3 are reversed in order in the appendix. Will the high or low TRV be used in the ERA?

Response: References to high and low TRVs have been deleted. The Agency will use the low TRV (NOAEL), exclusively, for ecological risk estimates.

Page 69; 8.6.2, last sentence; it's assumed that there will be no interspecific differences in effects by a contaminant. It is well known that interspecific differences are common. We suggest a more detailed explanation be provided.

Response: While interspecies differences in effects are known to occur, the risk assessment process commonly uses surrogate species and allometric conversions to estimate effects of contaminants within certain classifications of species. The IDEQ has determined that this is a legitimate approach and that an assumption of minimal interspecies differences is adequately compensated for in the use of conservative TRVs.

(*E-mail attachment of 9/25/01-rlc)*

Acronyms and Abbreviations. GMU's should be added to the list. This acronym is used on page 25, section 7.2.1.5 (Game).

Response: GMU has been added to the list of abbreviations.

There should be a space between the acronyms and abbreviations that begin with the letter F, and those that begin with the letter G.

Response: Corrected.

There is not an Idaho Department of Natural Resources. Perhaps the sample collection event discussed on page 23, section 7.2.1.1. occurred with the Idaho Department of Environmental Quality.

Response: Corrected.

Page 3. The use of acronyms and abbreviations should be consistent when listing agency SeWG representatives.

Response: The text will be reviewed for consistency.

Page 7, Section 2.2.3.2, Threatened and Endangered Species. Delete peregrine falcon – it is recovered and has been delisted. The Canada Lynx is not proposed but a listed species.

Response: Peregrine falcon has been removed from the list and Canada Lynx added.

The extent of the area covered in the Area-Wide Investigation is not clear from the document. Page 4 states the "focus of the investigation" is a 2,500 square-mile area, page 6 and 13 states the "study area" covers 5,328 square miles, yet page 8 states the "study area" (for human populations) consists of about 1,200 square miles. Please clarify the difference between these study areas.

Response: The Resource Area subject to the Area Wide Investigation is approximately 2,500 square miles bounded by Gray's Lake to the north, Bear Lake to the south, the Wyoming border to the east, and Highways 30/34 to the west. It also incorporates the Gay Mine on Fort Hall Indian Reservation by reference. These boundaries were established by IDEQ to be inclusive of historic mining activities in southeast Idaho and will be cited accordingly. The fifteen primary mine sites, owned or operated by the Idaho Mining Association Selenium Committee members, occur in an area of approximately 1,200 square miles and was often referenced as the study area in previous IMA documents. This area is subject to additional site-specific investigations and contains the majority of observed impacts to date. We are not sure what the 5,328 square mile area refers to, but we suspect this may have been a typographical error in earlier versions of the draft work plan.

Page 12, Section 3.2. Water should be added to the list of soil, sediment, and tissue for inputs into the model.

Response: Corrected.

Page 12, Section 3.3. Sentences in the first two bullets identifying "inputs to the decision" should be reworded to clarify the samples collected at both the investigative and background locations. Analytical results for tissue were not collected but determined for tissue types that are now being and were previously collected. The sentence for the last bullet item seems to be missing a word or words. "Previous on-going studies" appears to contradict and should be reworded to "previous and/or on-going studies".

Response*: *The first two bullets have been reworded for clarification. The last bullet was a typographical error and should have been included under the third bullet. This has been corrected.

Page 13, Section 3, 4, bullet 3. Were surface and ground-water samples included in the samples chosen to coincide with mine areas and areas affected by mine runoff? If so, these should be added to the list.

Response: Surface water samples are included. The Idaho Department of Health conducted a limited domestic well survey and previous investigations included sampling of existing mine site wells. However, comprehensive groundwater investigations were

considered prohibitive on an "area wide basis" and have been deferred to subsequent site-specific investigations.

Page 17, Section 6.2. The word soils is misspelled in the section title.

Response: The plural form of "soil" is used to denote the presence of various soil types in the area.

Same section, second paragraph. It may be appropriate to mention the additional pathway of ingestion of contaminated soils by herbaceous mammals and invertebrates.

Response: Incidental ingestion of soils by herbivorous mammals will be added as a potential pathway.

Page 17-18, Section 6.4, 6.5. Storm water runoff from waste dumps may not reach surface waters but will still deposit contaminated material in terrestrial environments. This pathway is not clearly identified in these sections.

Response: Section 6.4 and 6.5 address this issue and discuss the potential for depositional effects.

Page 23, Sections 7.2.1.1. Replace Idaho Department of Natural Resources (IDNR) with DEQ.

Response: Corrected.

Same Section, second paragraph. Stream locations are missing from this paragraph. The letter "xx" should be replaced with the appropriate number of streams sampled. Additionally, Table "xx" summarizing streams and type of samples collected should be added to the document. Table "xx" is also referred to on page 24.

Response: Surface water was collected at 30-32 locations in three separate events and sediments were collected at 20 locations. The surface water sampling effort represented 20 different stream segments. Table xx refers to Table 2-1, which was not included at the time of publication because late season sampling efforts were still occurring. The final work plan will contain the corrected table.

Page 23, Section 7.2.1.2. Replace IDNR with DEQ.

Response: Corrected.

Same section, second paragraph. The USFWS is not aware of fish tissue samples collected by our agency; perhaps the U.S. Geological Survey should be the agency referred to in this section.

Response: Corrected.

Same section, third paragraph. The terms "I or "B" are not defined in the test or in the list of Acronyms and Abbreviations. These terms are also used on page 24, section 7.2.1.3.

Response: Corrected.

Page 24, Section 7.2.1.3. Replace IDNR with DEQ.

Response: Corrected.

Same section, second paragraph. The tense of the sentence should be re-written to reflect that samples and species were collected in summer 2001, not will be collected.

Response: Corrected.

Page 25, Section 7.2.1.4, second paragraph. Same comment as above; soil samples were collected. Replace "xx" samples with the appropriate number collected from the riparian areas. Additionally, replace "yy" riparian areas with the accurate number of sites.

Response: Corrected.

Page 30, Section 7.3.2, fifth paragraph. The study area is drained by the Blackfoot, not the Black River system. However, page 53 states that the two major riverine systems in the Resource Area are the Bear River and Snake River. Insert the actual number where samples were collected in place of "xx" streams and "yy" riparian areas. Figure 'x" should be inserted into the document and named appropriately.

Response: Corrected

Page 31, Section 7.3.2, bullet items. Delete one set of the double bullets.

Response: Corrected.

Page 46, Section 8.2. Provide some discussion within the text to clarify how the use of statistical comparison to background concentration will be used as a screening factor in the Ecological Risk Assessment.

Response: Additional clarification will be added to the text concerning background comparison methods.

Page 47, Section 8.3.1. Figure 3 is not found in the document, however, Figure 2 is continued on the next page and may be the actual figure referred to in the text. Cheat grass is listed in the text on page 47 as a primary producer for the terrestrial food web, but is not listed on Figure 2. We recommend cheat grass be deleted from the text. Blue bunch wheat grass (Agrophyron spicatum) is misspelled on Figure 2.

Response: Section 8.3.1 has been deleted and applicable information is contained in 8.4.1. The figure reference should be Figure 4, the Ecological Risk Assessment Conceptual Site Model. Cheat grass has been replaced with wheat grass, alfalfa and brome grass. The spelling of blue bunch wheat grass has been corrected.

Page 51, Section 8.4.2, last bullet item. Surface water should be included as an exposure pathway during grooming, foraging, or feeding and for dietary uptake of metals. Wildlife such as moose spend a great deal of time in water and may drink from contaminated ponds or seeps.

Response: Section 8.4.2 has changed to 8.5.2 and includes this information in the second to last bullet.

Page 53, Section 8.4.3, second paragraph. The Ross River should be identified as the Ross Fork River.

Response: Corrected.

Page 57, Section 8.5.1.1, Terrestrial Herbivorous Bird Community and Associated Assessment Endpoints. We suggest surface water be included into the assessment endpoint statement as a contaminated substance that may be ingested by the terrestrial bird community. We understand that the receptor for this community/guild identified in Table 8.1, Chipping sparrow, may have limited exposure to surface water, however, this is an important pathway to other species listed in Figure 2.

Response: Corrected; Section renumbered 8.6.1.1.

Page 57, Section 8.5.1.1, Terrestrial Herbivorous Mammal Community and Associated Assessment Endpoints. We suggest surface water be included into the assessment endpoint statement as a contaminated substance that may be ingested by terrestrial herbivorous mammals. As stated previously, moose spend a great deal of time in water and may ingest contaminated water.

Response: Corrected; Section renumbered 8.6.1.1.

Page 57-58, Section 8.5.1.1, Terrestrial Omnivorous Bird Community and Associated Assessment Endpoints. We suggest sediment and surface water be included into the assessment endpoint statement as contaminated substances that may be ingested by the terrestrial omnivorous bird community. Figure 2 lists waterfowl species as part of this community. These birds ingest sediment and water during feeding.

Response: Corrected; Section renumbered 8.6.1.1.

Page 58, Section 8.5.1.1, Terrestrial Omnivorous Mammal Community and Associated Endpoints. Surface water should be included into the assessment endpoint

statement as a contaminated substance that may be ingested by this community/guild. The raccoon and muskrat (Figure 2) spend a large portion of their time in and around water.

Response: Corrected; Section renumbered 8.6.1.1.

Page 64, Section 8.5.1.2, Riparian Carnivorous Mammal Community and Associated Assessment Endpoints. The example provided to demonstrate the toxic effects of metals in the riparian carnivorous mammal's food source does not support the preceding statement regarding systemic or general toxic effects. Further, the assessment endpoint should be worded to reflect the riparian carnivorous mammals ingest food and not plant food, as stated. However, overall this statement is confusing and may be missing a work or words that would clarify the sentence.

Response: Corrected; Section renumbered 8.6.1.2.

Page 64, Section 8.5.1.2, Fish Community and Associated Assessment Endpoints. The second sentence the phrase reproductive failure is used twice – "elevated selenium can cause reproductive failure in fish, resulting in reproductive failure…". The sentence should be reworded to reflect the systemic effect of metals or selenium that can lead to reproductive failure and other things. The word "form" should be replaced with from in the assessment endpoint statement.

Response: Corrected; Section renumbered 8.6.1.2.

Page 66, Section 8.5.1.3, Carnivorous Mammal Community and Associate Assessment Endpoints. The assessment endpoint should be changed to reflect that the carnivorous mammal might ingest contaminated food, and not plant food.

Response: Corrected; Section renumbered 8.6.1.3.

Page 66, Raptor Community and Associated Assessment Endpoints. We recommend that selenium be dropped from "selenium-contaminated". The general discussion of the ecological risk assessment is to metals released from phosphate mining activities and not specific to selenium at this point.

Response: Corrected; Section renumbered 8.6.1.3.

Figure 2. 1 Producers, Terrestrial Plants: Blue bunch wheat grass is misspelled as "Clue bunch wheat grass". 1 Consumers: Delete the category of Domestic Livestock. 2 Consumers, Terrestrial Omnivorous Birds: the genus species for American Coot should be italicized. Reptiles and Amphibians: the Leopard frog is misspelled as "Leopard from". 3 Consumers, Raptors: genus species names for the American kestrel, Peregrine falcon, and Red-tailed hawk should be italicized.

Response: The IDEQ recognizes that domestic livestock is not conventionally included in risk assessment processes but has chosen to retain this category in the Conceptual

Site Model illustration to represent the ongoing concerns with Resource Area livestock impacts. The other items have been corrected.

Table 8-1. Terrestrial herbivorous birds. Both the chipping sparrow and bobwhite quail are omnivorous, feeding on insects and seeds. The chipping sparrow feeds mostly on insects during the summer and seeds in the fall and winter. The diet of the bobwhite quail is primarily seeds – buds, berries, acorns, roots, and insects. More insects are eaten in summer and as young birds. It may not be possible or practical to have a solely terrestrial herbivorous bird species. Terrestrial herbivorous mammals. The jackrabbit and cottontail are cophrophagic species, as are many rodents and some mammals. Could this behavior result in a difference in the bioavailability of metals than for other mammals?

Response: The IDEQ recognizes the lack of a completely herbivorous avian species but has tried to represent this classification through surrogate species with predominant herbivorous diets that have an adequate availability of risk reference data. Similarly, the effects of cophrophagia on metals bioaccumulation in the jackrabbit and cottontail are unlikely to be quantified through the use of risk assessment reference values. Both of these issues will be included in the discussion of uncertainties to be provided in the risk assessment.

IDEQ Responses to BLM Comments of 10/30/01 on the Draft Area Wide Risk Assessment Work Plan

BUREAU OF LAND MANAGEMENT

NATIONAL SCIENCE AND TECHNOLOGY CENTER
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Memorandum

To: Peter Oberlindacher, BLM Idaho State Office

From: Karl Ford, Ph.D., Toxicologist

Date: October 30, 2001

Subject: Comments on Draft Work Plan, Area Wide Human Health and Ecological Risk Assessment, Selenium Project

I have reviewed the document and have the following comments. If you have any questions, feel free to call me at 303-236-6622.

1. Page 1, paragraph 1. If I'm not mistaken, IDEQ has the lead role and other agencies have a support role in the project. Perhaps that should be stated early in reference to the developers of the risk assessment. Or, does the contractor work only for IDEQ and if so, what is the role of the agencies?

Response: The contractor's agreement is with the IDEQ and all technical and contract direction is given by IDEQ. However, IDEQ coordinates closely with the other supporting agencies to ensure that the work conducted by the contractor satisfies the needs of the support agencies and represents some level of consensus.

2. Page 1, end of page. Reference is made to a high and low TRV approach. See my comment below.

Response: The technical approach of using high and low TRVs to evaluate ecological risk has been modified. Only no observed adverse effects level (NOAEL) reference values will be used to evaluate ecological risk. The Work Plan will be modified to accurately present this approach.

IDEQ Responses to BLM Comments of 10/30/01 on the Draft Area Wide Risk Assessment Work Plan

3. Page 4, paragraph 1, sentence 1. Use of the term "lead agencies" in the second part of the sentence is confusing.

Response: The text will be clarified to explain that while IDEQ has been designated as the lead for the area wide assessment, other agencies such as the U.S. Forest Service and BIA are responsible for specific mine sites on their properties and are the lead agencies for the site-specific work to be conducted at individual mines. Other jurisdictional agencies are participating in the overall process as support agencies through a formal Memorandum of Understanding (MOU).

4. Section 2.3. More information on the population and private land use distribution would be helpful in evaluating the human receptors defined by the contractor in later sections. How many people live where in relationship to the source areas?

Response: Most of the impacted areas are on state or federal lands that have no full-time residents. As stated in the Work Plan, the area is sparsely populated with most of the population living in towns that are actually outside the Resource Area. The text will be modified to clarify that the population centers are actually outside of the Resource Area.

5. Page 9, reference to Table 2-1. The table is empty?

Response: Table 2-1 is a summary of media-specific samples that will be used to support the risk assessments. At the time of the preparation of this draft Work Plan, additional sampling was being conducted to support the risk assessments. The actual number and locations of the samples were not final pending data delivery, so the table was left blank. The table will be filled in for the final Work Plan.

6. Page 9-10, bullets. In the introductory sentence concerning the 1999 MW risk assessment references "ERA" and "preliminary HHRA", clarify that you are referring to the previous MW risk assessment.

Response: The text will be clarified.

7. Section 3.2 and throughout. Defining the term "dose" versus "intake" would be helpful as they are not the same.

Response: The terms will be defined in the Work Plan.

8. Page 11, Section 3.5. First decision rule is circular. Perhaps substitute "remediation may be warranted" after the word "then".

Response: The area wide risk assessment is not intended to make remedial decisions. The

text will be modified to indicate that more detailed site-specific assessments will be necessary to fully evaluate the remedial options.

9. Page 12, first bullet. Perhaps emphasize the use of the 3 tiers as your decision rules.

Response: The discussion will be modified to present the tiers as decision rules.

10. Page 13, Section 5.0. Terminology needs to be consistent. EPA guidance uses the word Chemicals, not Contaminants. In this section and elsewhere (e.g. Section 7.0), acronyms COC, COPC, COPEC are used without definition.

Response: The document will be reviewed and terminology will be defined and made consistent.

11. Page 18, STEP 2. Explain how you will compute EPCs for exposure areas.

Response: The text will be revised to explain the computation of EPCs during Step 2. In general, area weighted averages will be used to calculate EPCs.

12. Page 18, second bullet. Explain why you need a second bullet here.

Response: There was a typographical error in the text. The bullet will be modified to clarify the statement.

13. Page 19, Section 7.2.1. The number and types of samples available for the risk assessment should be shown in a table to give the review some confidence that there are sufficient number of samples available from important locations and media to actually perform the risk assessment.

Response: Table 2-1 will show the numbers and types of samples collected to support the risk assessment. The table will also show the general location from which the samples were collected.

14. Page 20, paragraph 2. Second sentence is totally baffling. "It should be noted..."

Response: The sentence will be removed from the document.

15. Page 20, paragraph 3. What is meant by the future tense? Is more sampling contemplate?

Response: At the time the draft Work Plan was prepared, some sampling had not been completed. All sampling to support the risk assessment has now been completed. The text will

be revised to correct the tense.

16. Same paragraph... "(list analytes)"?

Response: The text will be modified to add the missing information.

17. Page 20, paragraph 4. What is meant by a "comprehensive list of metals?" Next paragraph "form" should be "from."

Response: A table (Table 2-2) was added to the Work Plan that shows the chemicals that were analyzed for each media. The text will reference this table for information. The typographical error will be corrected.

18. Page 21, paragraph 4 refers to Section 4.3.2, but there is no such section. A conclusion is reached about eliminating several pathways without any explanation and all historical soil data is therefore discarded. I can't agree without more explanation.

Response: The incorrect section reference will be corrected. The text will be modified to describe that inhalation of fugitive dust will be evaluated for the recreational exposure scenario and is not discarded as a potential exposure pathway.

19. Page 22, paragraph 2. More information on the exposure of the beef cattle is needed for a reviewer to evaluate its use.

Response: The Henry Mine beef depuration study is the only information available on tissue concentrations in beef pastured in seleniferous pastures. The cattle were only allowed to feed in the overburden dump during a 9-week period and not roam freely as is the normal practice. While the study was not as complete as may be desired, it is believed to present cattle tissue concentrations that represent the high end of exposure for humans consuming beef. The text will be revised to explain that these values likely represent high-end exposure concentrations.

20. Page 22, 5th bullet. Analytical issues for selenium include a need to get to <1 ppb selenium in water and 1 ppm in soil/sediment/tissue. Has this been accomplished? If not, risk assessment may not be productive.

Response: The new table (Table 2-2) added to the Work Plan showing chemicals that were analyzed for each media will include a column showing the detection limit for each chemical and media.

21. Page 26, top paragraph. Reference is made to "seleniferous pastures." How are these defined and are they mapped and have they been sampled?

Response: Seleniferous pastures are loosely defined as those pastures whose soil contains

concentrations of selenium significantly elevated above background. While some seleniferous pastures have been mapped and sampled, most have not.

22. Page 27, Figure 2 and rest of Section 7.3.2. The CSM shows soils to be de minimus for all receptors. I am not convinced. The fifth bullet, page 28 shows ingestion of soil by subsistence receptors as a complete exposure pathway (I agree), but no mention is made of same for Native Americans. Is this because they don't live in affected areas? Explain. The next sentence after the bullet should be clarified and justified (Of the complete....).

Response: The text will be modified to better explain the assumptions in the risk assessment concerning soil exposure.

23. Page 28, bullet 1 (Inhalation...). The justification is weak for discarding the pathway although I may ultimately agree that it is not a major pathway. Farming and ranching is inherently a dusty lifestyle, both while working and at home. As stated elsewhere, the wind is high in this area. Has any monitoring been done? I do agree with the second sentence.

Response: As discussed in the response to Comment 4, the area is sparsely populated and most of the contaminated sites are on state or federal lands. Therefore, exposure to farmers and ranchers is not a significant pathway. However, no monitoring has been conducted. Therefore, as discussed in the response to Comment 18, inhalation of fugitive dust will be considered for the recreational scenario expected to be the most exposed group for inhalation of fugitive dusts.

24. Page 28, last bullet bottom of page. Do recreational users not drink surface water? Might their exposure from water be as great as from eating a few fish per outing?

Response: Ingestion of surface water will be added to the exposure assumptions for recreational users.

25. Page 29, 3rd bullet (Ingestion and Direct Contact...). I am not convinced by the rationale. Ingestion of soil normally drives all risk assessments. The industrial PRG is 10,000 ppm for selenium and is irrelevant to residents; but EPA's residential SSL is 390 ppm. Do we have those concentrations? Are there no subsistence (does this mean farmer/rancher?) residents nor Native Americans living in the area? Where do the mine workers live? See Comment 4.

Response: The referenced section does not discuss ingestion of contaminated soils except to state that the EPA Region IX preliminary remediation goals for residential exposure are based on direct contact and ingestion routes of exposure. The pathway being discussed is for direct contact (dermal absorption) of contaminants in soil. Based on the concentrations present and the chemical properties of the contaminants, absorbing contaminants through the skin

represents a de minimus pathway. Almost all local human population lives outside of the Resource Area as discussed in the response to Comment 4.

26. Page 29, last bullet. Groundwater is dismissed based on sampling 20 domestic wells. Does that mean that groundwater is not contaminated nearer the source areas? Are there monitoring wells present? Might someone want to develop groundwater in these areas in the future?

Response: Localized groundwater contamination may exist in the immediate vicinity of the waste rock dumps. However, based on limited sampling by Idaho Department of Health of groundwater resources that may be used by humans for drinking water, no significant contamination was detected. Therefore, for the area wide assessment, groundwater is expected to be an insignificant exposure pathway. However, evaluation of groundwater will be required for the site-specific investigations to be conducted at each individual mine.

27. Pages 30-31. I will disagree with these lists until my previous questions have been addressed.

Response: Comment noted.

28. Pages 34-35 state inhalation will not be considered. See comment 22.

Response: Comment noted.

29. Page 36, 3rd full paragraph (Exposure to...). Do you mean dermal contact?

Response: The exposure referred to is dermal contact. The text will be modified to clarify the exposure.

30. Pages 41 and 62 list 5 "lines of evidence," but asserts the use of the HQ as it's primary line of evidence. I disagree with that because tissue concentrations are more definitive than use of TRVs and calculational models which tend to have high uncertainty. Tissue concentrations are associated with known adverse impacts. I suggest that tissue concentrations be used to evaluate the high-end concentrations, whereas lower concentrations may have to be modeled via the HQ approach.

Response: The discussion concerning the weight of evidence approach will be modified. There is a significant difference in how terrestrial and aquatic communities are assessed. Tissue benchmarks are not as well developed for terrestrial receptors. Therefore, the modified text will present separate lines of evidence for terrestrial and aquatic communities. A table (Table 8-3) has been added to the Work Plan that shows which lines of evidence will be used for assessment of the respective receptors.

31. Page 42, bullet 1. See comment 11.

Response: Comment noted.

32. Page 43, bullet 2. How many background samples do you have and how do you know they are representative?

Response: The number of background samples varies by media. The majority of background samples were collected using a directed sampling strategy in the undisturbed and upgradient areas of the mining zone expected to represent pre-mining conditions. The overall Resource Area is in excess of 2,500 square miles. The collection of a sufficient number of background samples to adequately represent an area this size is not feasible based on reasonable project constraints. The background samples will be supplemented by data collected by USGS, the State of Idaho or other background soil references.

33. Page 46, Section 8.5. I find it disconcerting that there is but one reference to the work of Dennis Lemly in this section.

Response: Comment noted.

34. Pages 62 and 65. Many of the ecological references are not shown in the Reference List and cannot be verified.

Response: The references will be reviewed and all missing references will be incorporated in the Final Work Plan.

35. Page 64, Section 8.7.1. Mention is made of using NOAEL and LOAEL TRVs. Is this what my comment 2 is about? Why does Table 8-4 not show them. Table 8-4 is confusing with two headings but only 1 data point. Is it intended to show a NOAEL and a LOAEL?

Response: Please see the response to Comment 2.

36. Page 64, Section 8.7.1. Are the TRVs dry weight or wet weight? Are food/prey media concentrations dry weight or wet weight and what conversions are to be used?

Response: All information presented is on a dry-weight basis. No conversions are required.

37. Page 65 equations. I don't know where this reference is as it is not in the List of References. Caserett and Doull's Toxicology recommend a body weight scaling of 2/3 whereas you recommend 0.94.

Response: Sample and Arenal (1999) have conducted an extensive evaluation of scaling

factors for both birds and mammals. This work is the basis for the scaling factor used and is intended to represent the best current estimate for scaling factors. The reference will be added to the reference list.

38. EPA is currently revising its ambient water quality criterion for selenium. Most experts do not think the old criterion adequately protective. How will this factor into the risk assessment for aquatic life?

Response: There is no certain timetable for completion of the reevaluation of the AWQC for selenium. It is likely that the revision will not occur before the area wide risk assessment is completed. Therefore, it will probably not impact the assessment for protection of aquatic life. However, if the criterion is revised, the risk assessment will be reevaluated to determine the effect on the assessment. The IDEQ Regional Risk Management guidance is also intended to be a contemporaneous document that is periodically updated to reflect regulatory changes, new area wide findings or shifts in scientific consensus.

39. I do not see any TRVs for other than mammals or birds?

Response: The only HQ calculations being conducted are for birds and mammals. Therefore, no additional TRVs are necessary. However, there will be comparisons to surface water, sediment, and soil concentrations for other lines of evidence. Therefore, tables with the criteria used for comparison will be added to the Work Plan.

IDEQ Responses to U of I Comments of 11/26/01 on the Draft Area Wide Risk Assessment Work Plan

(Transcribed from University of Idaho E-mail message of 11/26/01-rlc)

To: RICHARD CLEGG

Subject: Draft Work Plan for Southeast Idaho Selenium Risks Public Comments

Message: On 2001-11-26 at 17:56:00,
The following information was submitted:
From Host: 129.101.141.122
Name = Greg Moller
Email_Address = gmoller@uidaho.edu
Affiliation = University of Idaho

Comments = As you are aware, the ecological risk debate in the selenium science arena is energetic and evolving. In developing your risk model, I encourage you to take a balanced view of all the work that appears in the scientific literature, the work that will appear shortly and the significance of that knowledge as applied to this specific site. In this regard, I would like to offer the following:

Avian risk assessment: Bird egg selenium risk thresholds are not a settled science. Current agency recommendations are significantly lower than some published alternate estimations. Additionally, there are 2 review and analysis papers currently being submitted for peer-review that have both calculated the threshold at 13-14 ug Se/g in the egg. The lead scientists for these works, Harry Ohlendorf and Bill Adams, would probably be willing to visit with you to discuss their general findings and the timeframe for review and publication.

Response: The Agency is aware of the status of evolving selenium science and the uncertainties associated with Mean Egg Selenium (MES) levels. In an attempt to provide a balanced evaluation, we have consistently reviewed all available literature regarding this issue and have numerous academic publications indicating higher MES values in our Area Wide information repository for consideration in the regulatory process. It should be noted that the regulatory risk assessment process is based on handbook reference dose values for avian species and the use bird egg thresholds is usually as a supplemental line of evidence.

Salmonid risk assessment: Much of the basis of current agency risk thresholds are derived from warm water species in lentic environments. Recent work by the BC Ministry of the Environment and researchers at Simon Fraser University, (Arch. Environ. Tox. 2000 Jul(1):46-52), suggests that cutthroat trout in adapted lotic environments may have tolerance to high selenium exposures (21, 36, 12 ug Se/g in egg, liver, muscle respectively w/ no effect).

Response: The Agency is also aware of the controversy surrounding cold water versus warm water species environments. While there may be some difference in professional opinion regarding the ambient concentrations that are considered protective, the Agency has yet to find any academic literature that proposes a water quality

concentration at or in excess of the observed concentrations in the impacted streams of interest in the study area. Additionally, it is unlikely that regional surface water decisions will be based on single species risk-driven concentrations since the Idaho Water Quality regulations and Federal Clean Water Act specify the selenium criteria for watershed management purposes.

My point is thus: there are some agency science hazard guidelines that may be used that do not incorporate the latest science in this issue. Incorporating the new science may have the same RA outcome or a different one.

I do not intend this to be a thorough review of the current science, but just an indication of the evolving nature of the inputs to the Se risk assessment process.

As you know, the University of Idaho has undertaken two very large studies to address avian and salmonid Se risk in the Blackfoot watershed.

These studies have been designed to address the target issues or higher trophic level Se risk appropriate to a bioaccumulative contaminant like Se. The scientists engaged in these studies are examining broad potential for impact including species-specific effects, population effects, genetic differentiation and multi-generational effects. These studies are in response to data needs for a thorough assessment of Se impacts in a site-specific manner. To my knowledge, these are the largest, most comprehensive studies of their kind ever attempted. These are hypothesis driven; statistically designed experiments that will no doubt provide a great deal of new knowledge on the potential for Se risk at this site. I am however concerned that in an apparent rush to conclude an area-wide assessment process, your risk assessment will rely on information produced for ecosystems and species that may not be directly comparable to this unique site. I would encourage you to allow for this information to be incorporated into the first draft of your risk model. To this end, I would encourage you to work directly with the principal investigators of the work to see how this may be best accomplished in recognition of your needs to move the regulatory management of this situation forward. Without early recognition and incorporation of the new and developing science in your risk assessment process, I foresee a judicial empanelment of formal third party scientists to address any difference of outcome; a potentially messy and undesirable fix. I encourage you to tack towards scientific consensus and I recognize that this will indeed be a challenge.

Response: The Agency agrees that the ongoing studies are likely to provide valuable scientific information and we look forward to reviewing the results, once published. However, we do not agree that the regulatory process should be put on hold pending speculative results of studies that have been repeatedly extended over the last several years when sufficient data is currently available to proceed with the process. It is not the Agency's intent to "rush" the Area Wide effort to a conclusion. However, we are proceeding on the schedule established by the Interagency Technical Group over eighteen months ago upon assuming the lead Agency role and after filling what we considered to be critical risk assessment process and area-specific data gaps.

IDEQ Responses to U of I Comments of 11/26/01 on the Draft Area Wide Risk Assessment Work Plan

The initial development of contemporaneous IDEQ Regional goals and objectives does not mark the end of the Area Wide project but the beginning of a risk management process that will continue to be fluid and adaptive throughout the resolution of the associated Phosphate Mining Resource Area issues. The Agency will continue to revisit any changes in regulatory standards, availability of additional regional or site-specific data, and/or shifts in accepted scientific consensus throughout the conclusion of this overall effort, which is likely to continue for many years based on the individual mine site investigation schedule. We appreciate the University of Idaho's past contributions to the effort and look forward to your continued support in the future.

IDEQ Responses to GYC Comments of 11/29/01 on Draft Area Wide Risk Assessment Work Plan

November 29, 2001

Rick Clegg
DEQ Satellite Office
15 West Center
Soda Springs, ID 83276

Re: Draft Area Wide Human Health and Ecological Risk Assessment Work Plan

Dear Rick:

On behalf of the Greater Yellowstone Coalition (GYC), I appreciate the opportunity to offer comments on the Draft Area Wide Human Health and Ecological Risk Assessment Work Plan. As you know, GYC has been actively involved in this issue for quite some time. We would like to offer the following general comments, since time constraints have kept us from more detailed analysis of the work plan:

Data Sets

The Draft plan states on page 22 that the use of historical data in establishing an overall context for consideration of potential exposures and risks is limited because the data focused primarily on selenium and cadmium, was collected from a limited number of locations, and did not address some relevant media at all. Therefore, additional samples were collected to eliminate limitations and data gaps. Are these several forms of data comparable? For instance, were data sets acquired using comparable or like methodology?

Response: The IDEQ conducted an extensive review of existing historical data and determined that the methods and quality of the majority of the data was generally acceptable for use in the risk assessment process. The field and laboratory methods used by the IMA and IDEQ, as well as the resulting data, were also comparable. However, because of temporal fluctuations resulting from annual precipitation variances and differences in the analyte lists, the Agency will evaluate risks using separate data set calculations.

More over, the draft plan states that a detection frequency of 5 percent is often used by the EPA as the basis for identifying potential contaminants, yet this detection frequency will not be functional for this area because data sets contain a small number of samples (pg. 27). It appears that more data is needed to make this risk assessment adequately portray area conditions.

Response: The Agency has determined that an adequate number of samples exist for screening potential contaminants of concern. The statement in the draft plan

indicates that the typical 5% detection frequency will not be used to eliminate potential contaminants to allow for these smaller data sets. The chemical-specific screening decisions and rationale for not including particular constituents from the IDEQ's expanded analyte list into the final Contaminant of Potential Concern (COPC) list will be detailed in the risk assessment results document.

Further, background data sets should be adequately established and scientifically justified. This data should come from undisturbed areas, not simply upstream from investigative samples as is proposed in the draft work plan (pg. 26).

Response: The Agency has concluded that adequate data is available to approximate regional background levels. The current data sets include areas upstream of mining as well as undisturbed areas that are representative of pre-mining conditions. Collecting additional background samples to statistically represent a 2,500 square mile study area would be resource limiting and would provide little effect on the overall assessment. Observed background concentrations are within the literature-reported ranges for background concentrations in the western states.

Water

The draft work plan states that surface water and sediment samples were collected by TtEMI and IDEQ in May, June, and September of 2001, and that results from these samples will be used in the Area Wide Human Health Risk Assessment (AWHHRA) only to estimate the concentrations of contaminants of potential concern in fish tissue and aquatic plants if insufficient analytical results are available in these two media (Draft pg. 22).

First, GYC is concerned that the accuracy of surface water surveys is likely poor due to inconsistent sampling methods. Specifically, grab sampling and manual sampling are inconsistent and not always representative of conditions. To be ruled un-impacted a surface water feature should be sampled with better methods.

Response: The surface water sampling methods used by IDEQ, TtEMI and the IMA are consistent with industry standards as well as State and Federal guidelines. The methods included depth integrated sampling, and analysis for total and dissolved constituents. The Agency finds that the methods used provided representative results within the tolerances accepted for normal industry standards.

The draft plan states that these results will only be used in the risk assessment to estimate contaminants of potential concern in fish and plant tissue if insufficient analytical results are available for these two media (Ibid.). How will this be done? How will the IDEQ ensure that comparable data is being used?

Response: The cited statement indicates that surface water concentrations will be used to estimate contaminants of potential concern in fish and aquatic plant tissue only if sufficient tissue sample results are not available. The draft work plan was written prior to completing seasonal sampling events and this alternative was included as a contingency. In fact, adequate fish and aquatic plant tissue have been collected from the study area and will be used in assessing risks.

More importantly, the draft plan states that surface water in the area is not used for drinking or household water, and therefore may not contribute to the total receptor dose (pg. 31). However, hunting and camping are popular recreational activities in the area and boiling surface water may actually concentrate contaminants in the water. This should be considered a complete exposure pathway and deserved more attention in the Final Work Plan.

Response: As requested, the Agency has added surface water ingestion as a completed exposure pathway in the recreational use scenario. While boiling water may concentrate contaminants in water, the higher temperatures may also increase volatilization of elements like selenium. Risk assessment parameters are developed with conservatively-based assumptions that would provide protective estimates for minor concentration differences such as those noted.

Furthermore, sediment and soil sampling will likely reveal more extensive Selenium contamination. Again, Montgomery-Watson grab sampling methods are not very consistent or representative. More continuous sampling is needed to rule a stream un-impacted. Therefore, we urge IDEQ not to rely on data collected by the Idaho Mining Association or Montgomery-Watson.

Response: The IDEQ has determined that the IMA historical data is adequate for use in combination with other sources and lines of evidence. The Agency has determined the sampling results to date are sufficiently representative for the specified use, and meet State and Federal guidelines for determining regional stream impacts. The Agency used a directed sampling approach that included targeted sampling of both impacted and unimpacted areas. Our results will allow for the evaluation of expected concentration gradients occurring in various media in the Resource Area. Additional sampling will be conducted on a site-specific basis prior to selecting remedial alternatives.

Elk

The draft plan also states that analytical data from skeletal and liver samples collected from elk harvested in Idaho Game Units (GMU) 76 and 66A will be used to represent game tissue potentially ingested by human receptors. The elk studies so far cannot be used to generate a Human Health Risk Assessment (HHRA). The sample collection method was too variable to be useful. The elk were scattered from normal habitat by hunting pressure and positions recorded were inaccurate. Also, using voluntary hunter kills can skip key risk groups (sustenance poachers and natives), and miss important elk populations under-represented by hunt kills. Several years' worth of data will be needed for HHRA, let alone ERA.

Response: The subject elk data were collected by the IMA and Idaho Fish & Game in 1999 and 2000, and consisted of a significantly high number of samples collected in the vicinity of active and reclaimed mining areas. The Agency has determined that the results of these surveys allow a reasonable approximation of potential human exposure from ingestion of game. The survey indicated that the elk observed with elevated selenium levels (~15%) were harvested within a relatively short distance of individual mine sites.

Fish

In addition, page 12 of the draft states that IMA field and laboratory bird and cutthroat trout studies may be used in the area-wide Ecological Risk Assessment. Besides incomplete background (due to arbitrary disposal of 1/3 proposed sites), the salmonid studies potentially suffer from small sample numbers as well. Much more sampling will have to be done before a Human Health Risk Assessment can be completed.

Response: The Agency will consider relevant data regarding issues in Southeast Idaho from any credible source. The studies referenced have not been published, peer-reviewed or provided to the IDEQ for consideration. The cited studies may have applications in the Ecological Risk Assessment but do not impact human health risk assessment inputs. It should be noted that the Agency will carefully evaluate any information received, in terms of weight of evidence and scientific consensus, prior to potential use in the risk management planning process. We will attempt to avoid making decisions based on single lines of evidence, whenever possible.

For instance, the Hagerman Fish studies could be flawed. The variation in diet between Blackfoot and Henry's cutthroat could skew results in diet study. Also it is not clear why only selenomethinone was used in the feed instead of free selenium, selenium hydroxides, selenates or mixes thereof. Using selenomethinone might not naturally mimic the Blackfoot cutthroat's selenium exposure, skewing the results. Raising the Blackfoot cutthroat eggs in selenium free waters with selenium free food likely decreased mortality and tetragenic effects in the egg viability study, especially when they hatch during the spring selenium surge. Will this study be used in the Selenium Project?

Response: Selenomethinone has a high potential for absorption and is the plant-converted compound in nature of greatest concern. Therefore, the Agency agrees that it is a reasonable dietary chemical for representing an upper bound ingestion result. The Agency has not received any published results from this study, and cannot speculate on its use in the selenium project. It should be noted that the USEPA encourages the use of site-specific and species-specific data where available, and the Agency expects the study to have value in providing additional information on cutthroat trout regardless of it's applicability in the regulatory process. Nevertheless, the Agency suspects that surface water requirements for selenium-related issues will continue to be driven by State and Federal water quality criteria rather than single-species risk issues.

IDEQ Responses to GYC Comments of 11/29/01 on Draft Area Wide Risk Assessment Work Plan

Conclusion

The draft work plan states that the purpose of the Area Wide Human Health And Ecological Risk Assessment Work Plan is to evaluate existing impacts on a regional basis, provide a tool for future risk management, and assist the development of regional guidance for subsequent site-specific activities (pg.1). This appears to be a very important step and lays the groundwork for future cleanup of areas contaminated with waste from phosphate mines.

Therefore, it is very important that detailed, accurate information is used to assess the potential effects selenium and other contaminants pose to human health and the environment. GYC would very much like to see the problems associated with these activities corrected. However, it is not obvious from the draft work plan and other observations that the IDEQ is relying on complete information, nor do they have all the facts related to the threats posed by selenium contamination in the region. In addition, while information seems to be incomplete, it appears that it will be quite some time before any on the ground work for reclamation and remediation is completed. We urge the IDEQ to complete this process as quickly as possible.

Response: The Agency is proceeding with the area wide risk assessment/management process in accordance with the schedule established by IDEQ upon assuming the lead agency role. The area wide effort does not contemplate the selection of any specific remedial actions but simply the development of contemporaneous regional risk management guidance. This guidance, in the form of general remedial action goals and objectives, will be periodically revisited to incorporate changes in regulatory guidance, new data or shifts in scientific consensus. Remedial decisions will be made on an individual mine site basis upon completion of site-specific investigations, risk estimation and remedial alternative selection processes under the direction of appropriate federal, state and tribal lead and support agencies.

Without this information, future remediation and restoration of the area may be compromised as risks and contamination may be estimated to conservatively. We hope that our concerns are addressed in the final work plan. Please keep us informed as this project progresses.

Sincerely,

Jen Woodie
Greater Yellowstone Coalition