UPPER COLUMBIA RIVER

Expansion of the Problem Formulation Chapter of the UCR Baseline Ecological Risk Assessment Work Plan

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ACRONYMS AND ABBREVIATIONS

ATSDR	Agency for Toxicological Substances and Disease Registry
AVS/SEM	acid volatile sulfide/simultaneously extracted metals
AWQC	ambient water quality criteria
BERA	baseline ecological risk assessment
CBR	critical body residue
CB-SQG	consensus-based sediment quality guideline
COPC	chemical of potential concern
CSM	conceptual site model
CWA	Clean Water Act
CWQG	Canadian water quality guidelines
DDT	dichloro-diphenyl-trichloroethane
DQO	data quality objective
Eco-SSL	ecological soil screening level
ECOTOX	EPA's Ecotoxicity Database
EPA	U.S. Environmental Protection Agency
EPT	ephemeroptera, plecoptera, and trichoptera
EqP	equilibrium partitioning theory
ERA	ecological risk assessment
ESB	equilibrium partitioning sediment benchmark
FETAX	Frog Embryo Teratogenesis Assay -*Xenopus*
FOD	frequency of detection
FSCA	Fish Sample Collection Area
K_{OW}	octanol-water partition coefficient
LOE	lines of evidence
mPECQ	mean probable effects concentration quotient
NAWQC	national ambient water quality criteria
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
PEC	probable effect concentrations

QAPP	quality assurance project plan
RATL	reptile and amphibian toxicological literature database
RI/FS	remedial investigation and feasibility study
RME	reasonable maximal exposure
SLERA	screening level ecological risk assessment
SMDP	scientific management decision point
TAI	Teck American Incorporated
TEC	threshold effect concentration
TIE	toxicity identification evaluation
TOC	total organic carbon
TRV	toxicity reference value
UCL	upper confidence limit
UCR	Upper Columbia River

UNITS OF MEASURE

cm	centimeter
mg/kg-day	milligrams per kilograms per day
mm	millimeter

1 INTRODUCTION

The Baseline Problem Formulation is a critical component of planning a Baseline Ecological Risk Assessment (BERA) and defines the questions that need to be addressed during the BERA. Problem formulation is a systematic process that identifies factors to be addressed in a BERA and consists of five major activities (USEPA 1997), including

- "Refining preliminary contaminants of ecological concern;"
- "Further characterizing the ecological effects of contaminants;"
- "Reviewing and refining information on contaminant fate and transport, complete exposure pathways, and ecosystems potentially at risk;"
- "Selecting assessment endpoints; and"
- "Developing a conceptual model with working hypotheses (or questions) that the site investigation will address."

The U.S. Environmental Protection Agency (EPA) requested Teck American Incorporated (TAI) to expand upon the problem formulation section of the February 2011 BERA work plan (TAI 2011) in a stand-alone document. This more detailed expansion of the problem formulation section of the BERA work plan defines issues that need to be addressed during the BERA of the Upper Columbia River (UCR; herein the 'Site') and, in so doing, identifies the anticipated goals, scope, and focus of the risk assessment. This problem formulation plan will contribute to the development of sampling plans (further defined in specific Quality Assurance Project Plans [QAPPs]) and the data quality objective (DQO) process by establishing assessment and candidate measurement endpoints that will be used in the BERA. Information developed during the problem formulation process is intended to provide a basis for establishing the risk questions/working hypotheses, exposure pathway models, and measurement endpoints that are expected to be used in the QAPPs and in the BERA. The problem formulation planning process is also intended to describe how information collected during the site investigation will be used to characterize exposures, ecological effects, and ecological risks, including associated uncertainties. The result of the problem formulation planning process is a clear plan to develop a scientific management decision point (SMDP) consisting of agreement on five items: chemicals of potential concern, the assessment endpoints, the exposure pathways, the risk questions, and conceptual model integrating these components (USEPA 1997).

The following expansion of the problem formulation plan is intended to be a living document that may be revised in the future, through additional discussion and refinement. Future modifications to the plan may be proposed as new data become available and will be documented by clearly explaining the previous problem formulation elements, the proposed new strategy, and the justification for the modifications.

1.1 BACKGROUND INFORMATION

This is an expansion of the Problem Formulation plan; background information of the Site has previously been described (refer to Section 2 of the BERA work plan; TAI 2011). This document expands upon the problem formulation section of the BERA work plan and is a companion document that includes additional detail than in the overall BERA work plan to increase transparency. This more detailed expansion and refinement of the problem formulation section of the BERA work plan defines the issues that need to be addressed during the BERA of the UCR Site and, in doing so, plans the goals, scope, and focus of the assessment. This problem formulation plan will contribute to the development of sampling plans (further defined in specific QAPPs) and the data quality objectives process by establishing the measurement endpoints that are anticipated to be used in the BERA.

Transport and fate of chemicals are governed by hydrodynamic mechanisms, atmospheric mechanisms, other physical processes, and chemical reactions. Physical-chemical transport and reaction pathways as they relate to the conceptual site model (CSM) were summarized in the December 2008 Remedial Investigation/Feasibility Study (RI/FS) work plan (USEPA 2008a; refer to Section 6.2). The relative importance of different processes detailed and described in the CSM may differ among reaches within the Site, depending on the specific characteristics of that reach (e.g., riverine vs. lacustrine) or upland location.

For those chemicals for which a risk analysis will be conducted, relevant toxicological data will be reviewed to identify which groups of ecological receptors, or individual test species, are among the most sensitive. Relative sensitivities of various receptors and candidate test species, and wildlife receptor species will inform test- and focal-species selection. An initial analysis of relative species sensitivities is presented in the Screening Level Ecological Risk Assessment (SLERA; TAI 2010).

1.2 SITE DESCRIPTION

Areas of interest have been discussed in previous documents (BERA work plan [TAI 2011]; see Section 2) and could be considered to include four divisions:

- Riverine reaches of the UCR (Reaches 1 and 2);
- Transitional reaches of the UCR (Reach 3);
- Lacustrine reaches of the UCR (Reaches 4a, 4b, 5, 6); and
- Upland habitats.

Habitats that occur within the Site include riverine, lacustrine (including shallow and deep habitats within the reservoir), and other wet habitats, such as inundated shallow areas along the shoreline or at the mouth of tributaries that contain submerged vegetation (these may include, but are not necessarily jurisdictional wetlands[1]). Also of interest are terrestrial riparian habitats and terrestrial upland habitats. The potential for contamination of upland lakes or wetlands will be evaluated.

[1] Jurisdictional wetlands are defined under Section 404 of the Clean Water Act as: Those areas that are inundated or saturated by surface or groundwater (hydrology) at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation (hydrophytes) typically adapted for life in saturated soil conditions (hydric soils). Wetlands generally include swamps, marshes, bogs, and similar areas(40 CFR 232.2(r)).

2 TOXICITY REFERENCE VALUES

Toxicity reference values (TRVs) are used in problem formulation to refine the list of chemicals of potential concern (COPCs) identified in the SLERA. They are similar to ecological benchmark values in that they represent concentrations of COPCs below which adverse effects to exposed organisms are unlikely to occur and above which such effects may occur at some level of severity and frequency. TRVs are generally derived by reviewing toxicity data reported in the scientific literature. Reasonable maximal exposure estimates for receptors of concern will be compared to TRVs to provide information regarding whether or not each COPC will be carried forward into the risk analysis. TRVs will also be used in the risk characterization of the BERA, once exposure point concentrations have been measured with acceptable precision.

A list of prospective TRVs will be developed in consultation with EPA and will be described in future technical memoranda or QAPPs. TRV development will include a documented process for reviewing data and information contained in the scientific literature. The scientific literature will be searched for toxicity information on COPCs. Such toxicity data will be obtained through searches of databases such as BIOSIS, TOXLINE, Agricola, and Environmental Sciences and Pollution Management. Compiled sources of toxicity information, such as Agency for Toxicological Substances and Disease Registry (ATSDR) toxicological profiles; Environment Canada reptile and amphibian toxicological literature database (RATL), state terrestrial criteria, and EPA's Ecotoxicology (ECOTOX) Database will also be accessed to support identification of TRVs. EPA's ecological soil screening levels (Eco-SSL) and Clean Water Act (CWA) guidance identify rules for selecting literature values that may be incorporated into the process.

Surface water and sediment benchmarks that might be used as ecotoxicity values will be compiled from national and regional sources. The current and recommended national ambient water quality criteria (NAWQC; USEPA 2010), state, and tribal water quality criteria, and the Canadian water quality guidelines (CWQG; CCME 2007)—all of which are protective of aquatic life—will be compiled and used during the selection of TRVs for surface water. Consensus-based sediment quality guidelines (CB-SQGs; MacDonald et al. 2000), tribal criteria, and site-specific studies provide similar benchmarks for sediments, and will be among the primary sources for TRVs for sediment.

Benchmarks for dietary exposure of fish and for wildlife will be developed as a daily ingested dose (milligrams per kilogram per day [mg/kg-day]) of a COPC that is associated with an adverse effect, as needed. This benchmark can then be compared to a rate of daily ingestion of a COPC from all environmental media within the diet of a wildlife species.

The ecotoxicological thresholds compiled by Sample et al. (1996) represent a primary source of TRVs for wildlife species.

Benchmarks for selected organic or organometallic compounds that are expressed as a concentration in a whole organism, and indicate exposures associated with adverse effects on growth, survival, or reproduction are referred to as critical body residues (CBRs) (e.g., McCarty et al. 1985, 1991) and will be used in the BERA to assess risks to fish and, possibly, to plants and higher trophic level wildlife. It is expected that not all COPCs will have toxicity information available for all receptor groups. Those chemical-receptor pairs for which such information is not available will be discussed in the uncertainty section of the BERA.

3 ASSESSMENT AND CANDIDATE MEASUREMENT ENDPOINTS FOR EVALUATING RISKS TO ECOLOGICAL RECEPTORS

3.1 CONCEPTUAL SITE MODEL

The CSM (Figure 1) as previously described in the RI/FS work plan (USEPA 2008a) and the SLERA (TAI 2010) was formulated following collaborative meetings between TAI, EPA, and the participating parties held in a workshop format on April 16 to 18, 2007. It represents the current understanding about how COPCs might be transported from their source, through the various environmental media, to an ecological receptor. CSMs specific to different aquatic and terrestrial habitats are provided in the BERA work plan (TAI 2011) and will be refined as appropriate.

3.2 INFORMING SAMPLING AND ANALYSIS PLANS

Sampling to fill existing data gaps is currently planned to include synoptic analyses of sediment chemistry and invertebrate bioassays, benthic invertebrate tissue analysis (also with synoptic sediment chemistry), and analyses of sediment chemistry to better delineate the nature and extent of risk and soil chemistry (including relict floodplains, areas of windblown dust, and uplands). If additional sampling is required, results from the initial studies will inform the scope and requirements of any subsequent studies, consistent with EPA guidance (USEPA 1997). Analysis plans will also be developed for implementation of dietary models for fish and wildlife exposure assessment, and development of TRVs.

3.3 PRELIMINARY RISK QUESTIONS

As part of the problem formulation process, assessment endpoints, risk questions, and candidate measurement endpoints have been identified (Table 1). These elements of the problem formulation are discussed in the following sections.

3.3.1 Selection of Assessment Endpoints

Selection of assessment endpoints is an important component of the BERA. Assessment endpoints describe both the ecological entity to be protected (i.e., a species, ecological resource, or habitat type) and the characteristics of the entity to be protected (e.g., reproductive success). They are developed based on known information concerning the chemicals present, the ecosystems, communities, and species that occur, and the risk management goals. Development of assessment endpoints aids in clearly defining the goal of the risk assessment and helps to focus associated risk analyses.

Assessment Endpoint No 1: Survival and Growth of Plants (Aquatic and Terrestrial)

Aquatic plants play an important role in ecosystems, particularly in seasonally flooded areas with submerged grasses and other 'wetland' plants. Aquatic plant communities in the UCR include phytoplankton species, submergent plant species, and emergent plant species. Many birds, aquatic mammals, amphibians, fish, and invertebrate species rely on aquatic plant communities for nesting and breeding habitat. In addition, these communities provide food for herbivores as well as refuge for higher-trophic-level organisms and habitat for their prey. The physical presence of aquatic plants reduces the velocity and volume of water flowing close to river banks, decreasing erosion and protecting adjacent upland areas from flooding. Terrestrial plants play a correspondingly important role in upland areas, providing a wide variety of habitats and source of sustenance for ecological receptors.

Both aquatic and terrestrial plants are also an important source of energy in their ecosystems and play an important role in the cycling of nutrients. Nutrients in the soil and the water column are taken up and stored in plant tissues; they are passed up the food web and further cycled as herbivorous fauna consume plant tissues. Decomposing plant litter is consumed by detritivorous organisms that return organic matter and nutrients to the sediment or soil.

Chemicals in the ecosystem may impact the survival and growth of plant species and adversely affect plant communities. In addition, chemicals might be taken up by plants and transferred through the food web through consumption by higher-trophic-level species. The specific assessment endpoints are as follows:

- Survival and growth of aquatic plants (section 4.1); and
- Survival and growth of terrestrial plants (section 4.2).

Assessment Endpoint No 2: Survival, Growth, and Reproduction of Aquatic Invertebrates (Benthic and Pelagic) and Terrestrial Invertebrates

Aquatic invertebrate communities include those species that are present in surficial sediments (benthic invertebrates) and those that occur in the water column (pelagic invertebrates or zooplankton). Generally, the uppermost 10 to 15 cm of sediments contains the greatest proportion of benthic invertebrates, feeding on decaying vegetation, decaying animal biomass, and feces. Some species, such as mussels and aquatic worms, may exist in deeper sediments[i]. Both infaunal and epifaunal benthic invertebrates comprise a significant portion of biomass in sediments and serve as a principal food resource for higher-trophic-level consumers (i.e., fish and wildlife). The benthic invertebrate community acts as the link between detrital material deposited on the river bed and the higher trophic levels. Pelagic invertebrates (zooplankton) represent an important source of food for fish.

Terrestrial invertebrates reside in and on the soils of floodplain and upland areas near the UCR. They include microinvertebrates (e.g., nematodes), macroinvertebrates (e.g., annelid worms, beetles, ants), and other arthropods. Many soil invertebrates represent key elements of terrestrial food webs because they are detritivores, recycling carbon from dead plant material back into the soil. Invertebrates also live and forage above ground. Examples include foliar invertebrates such as Lepidoptera (moths and butterflies, most importantly the caterpillar stages), and Arachnida (spiders). These species are an important food source for invertivorous birds and bats and may be exposed to contaminants taken up by plants.

Chemicals within the ecosystem can directly impact the survival, growth, and reproduction of the invertebrate communities and might also be transferred through the food web through prey consumption by higher-trophic level fauna. The specific assessment endpoints are as follows:

- Survival, growth, and reproduction of zooplankton (section 4.3);
- Survival, growth, and reproduction of benthic invertebrates (section 4.3); and
- Survival, growth, and reproduction of terrestrial invertebrates (section 4.4).

Assessment Endpoint No 3: Survival, Growth, and Reproduction of Fish

Several feeding guilds of fish comprise the fish community in the UCR. Each feeding guild plays a distinct role in the dynamics of the aquatic ecosystem. Detritivorous fish feed predominantly on detritus, and are frequent prey of higher-trophic-level fish and birds. Omnivorous/herbivorous fish feed upon both vegetation and invertebrates, and also may serve as prey for piscivorous fish, birds, and mammals. Invertivorous fish feed predominantly on benthic and pelagic invertebrates. Both omnivores and invertivores impact invertebrate community composition and size, and also transfer energy and nutrients to higher-trophic-level fish, birds, and mammals. Piscivorous fish feed predominantly on smaller fish species and serve as top fish predators. Chemicals within the ecosystem can potentially have adverse effects on the fish populations by directly impacting the survival, growth, and reproduction of fish species and may also pass up the food chain as fish are eaten by other fish or by piscivorous wildlife. Specific assessment endpoints are as follows (all in section 4.5):

- Survival, growth, and reproduction of omnivorous fish;
- Survival, growth, and reproduction of insectivorous fish;
- Survival, growth, and reproduction of benthivorous/detritivorous fish; and
- Survival, growth, and reproduction of piscivorous fish.

Assessment Endpoint No 4: Survival, Growth, and Reproduction of Amphibians and Reptiles

Amphibians play an important role in energy flow in aquatic systems. They feed on aquatic invertebrates and small fish and are prey items for birds, mammals, and fish. Many fish species consume tadpoles. Adult amphibians are preyed on by some fish and various birds and mammals. In some aquatic systems, amphibians provide an important pathway by which nutrients and energy are transferred between the aquatic and terrestrial ecosystems. Reptiles are primarily terrestrial species, with the exception of turtles. They are important consumers of plants, invertebrates, small birds, and mammals.

The survival, growth, and reproduction of amphibians and reptiles might be adversely affected by chemicals in the aquatic or terrestrial ecosystems. Specific assessment endpoints are as follows (all in section 4.6):

- Survival, growth, and reproduction of amphibians; and
- Survival, growth, and reproduction of reptiles.

Assessment Endpoint No 5: Survival, Growth, and Reproduction of Birds

Birds utilizing the UCR or its surrounding uplands represent several different feeding guilds, each filling a distinct ecological role in the ecosystem. Herbivorous birds feed predominantly on plants and provide a direct pathway of energy and nutrients from primary producers to higher levels in the food chain, both aquatic and terrestrial. They also influence aquatic plant community composition, population size, and structure, and serve as prey for organisms higher in the food chain. Invertivorous birds feed on flying insects, benthic invertebrates, and/or soil invertebrates. These species also provide a pathway of energy and nutrients to higher levels in the food chain. Omnivores and invertivores help regulate insect community composition, population size, and structure, and serve as prey for organisms higher in the food chain. Piscivorous birds feed on fish and may serve as one of the top predators in the UCR. They provide another pathway for energy and nutrients to be transferred from the aquatic to the terrestrial ecosystem, and regulate fish community composition, and population size and structure. Similarly, carnivorous raptors (e.g., hawks, owls, and eagles) are some of the top predators in the terrestrial food chain. Chemicals present in the food chain may adversely affect bird populations by impacting the survival, growth, and reproduction of avian species. Specific assessment endpoints are as follows (all in section 4.7):

- Survival, growth, and reproduction of aerial feeding insectivorous birds;
- Survival, growth, and reproduction of herbivorous birds;
- Survival, growth, and reproduction of omnivorous birds;
- Survival, growth, and reproduction of sediment and soil-probing birds;
- Survival, growth, and reproduction of piscivorous birds; and
- Survival, growth, and reproduction of carnivorous birds.

Assessment Endpoint No 6: Survival, Growth, and Reproduction of Mammals

As with birds, mammals utilizing the UCR or surrounding upland areas represent several different feeding guilds. Piscivorous mammals provide a pathway for energy and nutrients to be transferred from the aquatic to the terrestrial ecosystem and may serve as prey for other predators. By feeding on fish and invertebrates, they influence fish and invertebrate community composition, population size, and structure. Upland mammals include burrowing animals, large grazing mammals, and carnivores. Carnivores, insectivores, and piscivores are relatively high on the food chain and may be exposed to higher levels of some chemicals due to biomagnification up the food chain, whereas burrowing animals and grazers may be more exposed by direct ingestion of contaminated soils (through incidental ingestion while eating and from grooming). Chemicals present in the food chain may adversely affect mammal populations by impacting their survival, growth, and reproduction. Specific assessment endpoints are as follows (all in section 4.7):

- Survival, growth, and reproduction of invertivorous mammals;
- Survival, growth, and reproduction of herbivorous mammals;
- Survival, growth, and reproduction of omnivorous mammals;
- Survival, growth, and reproduction of piscivorous mammals; and
- Survival, growth, and reproduction of carnivorous mammals.

3.3.1.1 Population and Community Level Assessments

Assessment endpoints will be evaluated at one of the following levels:

- Population level – USEPA (1997, 1998) define a population as, "an aggregate of individuals of a species within a specified location in space and time." Fish, amphibians, reptiles, birds, and mammals are typically evaluated at the population level. Adverse effects to the population of a receptor species are of concern to risk managers.
- Community level – Lower trophic-level receptors such as terrestrial and aquatic plants and invertebrates are typically evaluated at the community level. A community is defined as, "...an assemblage of populations of different species within a specified location in space or time" (USEPA 1997, 1998).

All assessment endpoints at the UCR Site will be evaluated at the population level, for the component of the population that uses the Site. For measurements made at the community level, endpoint evaluations will also consider the site populations.

3.3.2 Risk Questions

Following selection of assessment endpoints, risk questions (working hypotheses) and measures of effect will be identified to provide a basis for evaluating risk to ecological receptors associated with exposure to COPCs (USEPA 1997). A risk question is an operational statement of an investigator's research assumption made in order to evaluate logical or empirical consequences (USEPA 1997, 1998). For the purpose of this risk assessment problem formulation, working hypotheses are presented as risk questions about the relationship between the assessment endpoints and the responses of receptors when exposed to chemicals at the Site. The risk questions that are posed for each receptor group are presented in Table 1.

3.3.3 Candidate Measurement Endpoints

Three categories of measures that are, in combination, predictive of the assessment endpoints (USEPA 1998) will be evaluated for the UCR Site:

- Measures of exposure;
- Measures of ecological effects; and
- Measures of ecosystem and receptor characteristics.

Criteria considered in the selection of measures include (USEPA 1997):

- Corresponds to or is predictive of an assessment endpoint;
- Can be readily measured or evaluated;
- Is appropriate to the exposure pathway;
- Is associated with low natural variability; and
- Is appropriate to the scale of the UCR.

The scale of the UCR may be larger or smaller than the home range of a receptor of interest. Therefore, the scale may be defined in ecological terms. Localized effects will, as determined by EPA, be evaluated based on exposure to the receptors of interest.

3.3.3.1 Measure of Exposure

Measures of exposure are measures of the contact or co-occurrence of the stressor and the receptor (USEPA 1998). Measures of exposure initially selected for the BERA include concentrations of COPCs in the following media:

- Surface water;
- Sediment porewater;
- Sediment;
- Tissue of benthic macroinvertebrates and fish;
- Soil; and
- Other biota, as determined by EPA.

Additional exposure measures may be required, depending upon the results of analyses based on these media (e.g., soil invertebrates or plants). QAPPs will provide detailed descriptions of proposed methods for measuring COPCs in these media.

3.3.3.2 Measures of Ecological Effects

Measures of ecological effects are used to evaluate the response of the receptors when they are exposed to the stressor (USEPA 1998). Measures of effect are measurable changes in an attribute of an assessment endpoint or its surrogate in response to a stressor to which it is exposed (USEPA 1998). In practice, measurable changes can be based on site-specific measurements of effects, or extrapolation from empirical measurements at other sites, or from laboratory studies (e.g., application of TRVs or benchmarks to predict effects). A technical memorandum or memoranda will provide detailed descriptions of how TRVs or benchmarks will be derived[ii].

3.3.4 Selection of Candidate Measurement Endpoints

It would not be practical or possible to incorporate all of the possible measurement endpoints in the BERA; therefore, it is necessary to identify measurement endpoints that would provide the most useful information for evaluating ecological risks associated with exposure to environmental contaminants in the study area. Accordingly, priority candidate measurement endpoints are provided in Table 1. Some of the data required to address these major endpoints have already been obtained, such as concentrations of COPCs in surface water and fish; other data will be collected or modeled in the future, as determined by EPA.

3.4 COPC REFINEMENT

COPC refinement across the UCR Site, and as used to inform sampling QAPPs, will be done on a medium-by-medium basis and should be consistent with the use of each medium as a measurement endpoint for each applicable assessment endpoint. Therefore, refinement for each receptor group/assessment endpoint will inform QAPPs, but only COPCs eliminated as potential risk drivers for all medium-dependent receptors can be dropped from analyses of that medium.

The SLERA used a simplified screening process wherein maximum bulk sediment chemical concentrations across the entire Site were compared to the conservative screening benchmark (i.e., threshold effect concentrations [TECs]). Per EPA guidance (USEPA 1997), the list of COPCs will be refined further. For those COPCs for which the nature and extent of contamination and potential conservative risk is known, as determined by EPA, the list will be narrowed by first comparing reasonable maximal exposure (RME) concentrations to toxicity benchmark values or TRVs. The 90th percentile concentration for the Site will be used, as determined by EPA, as the RME concentration, assuming it is most appropriate based on the resulting underlying data distributions. COPCs for which the RME exceeds the TRV will be retained and further evaluated. COPCs for which TRVs are not available, and for which there is insufficient literature to derive a TRV, will be addressed in the uncertainty section of the BERA.

As another step in the process of COPC refinement, comparison of concentrations of COPCs at the Site to background concentrations will inform the determination of potential site-related risk. If site concentrations are not above background, then the COPC is considered to either not pose an unacceptable risk (if below benchmark values), or pose a risk that is not site related (if above a benchmark value). Any analyte with site concentrations above background and above a benchmark value indicates a potentially unacceptable site-related risk that must be addressed in the risk assessment. If benchmark values are not available and the COPC is above background levels, the risks associated with exposure to that COPC will be addressed in the BERA as an uncertainty. Selection of background data sets will be made in consultation with EPA. If no acceptable data set is available or if existing acceptable data are inadequate for EPA to reach a decision on unacceptable risk, sampling in acceptable background locations could be performed, as determined by and in consultation with EPA.

Examining the frequency of detection (FOD) for each analyte will be performed in consultation with EPA. A FOD analysis will be conducted only if the detection limits are lower than benchmark values. The FOD analysis will specifically evaluate the spatial occurrence of COPCs, including those infrequently detected COPCs, to appropriately evaluate COPCs along established study-area spatial/physical divisions. This analysis will be informed by the Phase 1 RI and other toxicity results, as determined by EPA for inclusion in the RI. The detection analysis also will evaluate the possibility that detected concentrations are clustered in hot spots. Data will be examined spatially in a manner consistent with the site CSM to assess whether there are clusters of concentrations above benchmark or with other spatial attributes that might indicate risk within a localized area or habitat type, regardless of whether the overall RME exceeds a benchmark value.

4 RISK ANALYSIS PLAN

Development of a risk analysis plan represents the final stage of the problem formulation process. During risk analysis planning, risk questions and working hypotheses are initially proposed and evaluated to determine how they will be assessed using available and new data (USEPA 1997). The risk analysis plan includes four components (USEPA 1997):

- Developing risk questions and working hypotheses;
- Selecting candidate measurement endpoints;
- Refinement of the preliminary contaminants of ecological concern; and
- Methods for conducting the analysis phase, including when and how comparisons of COPC site concentrations will be compared to background.

Outstanding data gaps and uncertainties associated with the risk assessment are also identified during risk analysis planning. Risk analysis plans are briefly described below for each receptor group and in Table 1. Refining preliminary COPCs and background comparisons are described in Section 3.4.

4.1 AQUATIC PLANTS

Assessment Endpoints. Survival and growth of aquatic plants

Risk Questions/Working Hypotheses. Are the levels of contaminants in surface water, porewater, or sediments from the UCR greater than benchmarks for the survival or growth of aquatic plants?

Risk to aquatic plants will be assessed quantitatively for those chemicals for which there is information on sediment or water concentrations that result in adverse effects. Many of the COPCs do not have such information, so risks from these COPCs will be addressed in the uncertainty analysis.

Receptors. Aquatic plants consist of rooted and non-rooted macrophytes and algae. These include both wholly submerged and emergent vegetation. In the riverine portion of the UCR, periphyton are dominated numerically by diatoms (96 percent), followed by green algae (4.0 percent) and cyanobacteria (0.1 percent). Also documented is the presence of growths of the filamentous green algae Cladophora, also known as blanket weed. Bacillariophyceae (diatomic algae), Cryptophyceae, and Chlorophyceae (green algae) are the dominant taxa among the phytoplankton in the lacustrine portion of the Site. Macrophyte beds are generally sparse throughout the UCR, and tend to be limited to areas of tributary mouths and embayments. Sixteen species of macrophytes have been identified in the UCR, including willow (*Salix alba*), Eurasian water milfoil (*Myriophyllum spicatum*), and several species of pondweed (*Potamogeton* spp., *Stuckenia pectinata* and *Elodea canadensis*). Submerged grasses also are found seasonally at some locations.

Candidate Measurement Endpoints. Measured concentrations of COPCs in surface water, sediments, porewater, and associated physical/chemical measurements will be compared to available toxicity benchmarks for plants that are relevant to the various species and conditions that occur throughout the UCR (i.e., by reach and habitat type).

Analysis Plan. For assessing risks to phytoplankton, comparison of COPC concentrations in surface water will be made to ambient water quality criteria (AWQC). For rooted macrophytes, comparisons will be made between COPC concentrations in surface water, sediments, beach sediments[iii], or porewater, and the selected TRVs. Background concentrations will be considered as described above. No additional surface-water chemistry data will be collected specifically for assessing risks to aquatic plants, because sufficient data have been collected in the surface water study. The benthic macroinvertebrate study will provide additional sediment chemistry and porewater chemistry data (see below).

Exposure point concentrations will be determined in consultation with EPA. For comparison to AWQC, measured surface water and porewater concentrations (including estimates of porewater COPC concentrations derived from toxicity testing studies)[iv] will be plotted as a function of river mile and sediment type and compared to the selected TRV. For rooted macrophytes, the upper confidence limit (UCL) on the mean of samples taken within a reasonably small distance of plant communities will be used as the exposure estimate. The specific approach will be derived in consultation with EPA and documented in a QAPP.

4.2 TERRESTRIAL PLANTS

Assessment Endpoints. Survival and growth of terrestrial plants

Risk Questions/Working Hypotheses. Are the levels of contaminants in soils greater than benchmarks for the survival or growth of terrestrial plants?

Risk to terrestrial plants will be assessed quantitatively for those chemicals for which there are appropriate TRVs. Many of the COPCs do not have such information, so risks from these COPCs will be addressed in the uncertainty analysis.

Receptors. Terrestrial plants consist of grasses, forbes, woody shrubs, and trees. As detailed in Appendix B of the BERA work plan (TAI 2011), the predominant ecoregion present across the Site is Northern Rocky Mountain Forest-Steppe -Coniferous Forest - Alpine Meadow Province, characterized by an evergreen and deciduous, needle leaf forest including western white pine (*Pinus monticola*), Douglas-fir (*Pseudotsuga menziesii*), and western larch (*Larix occidentalis*), with interspersed mountain grasslands. The Intermountain Semi-Desert Province ecoregion occurs at the southern end of the Site as a large, high-elevation plain with rolling hills; dominant vegetation includes big sagebrush (*Artemisia tridentata*), mountain grasslands, and ponderosa pine (*Pinus ponderosa*). Comparisons of soil concentrations to plant toxicity thresholds will be assumed to be predictive of risk to the entire plant community. Therefore, individual plant species will be targeted for risk analysis only if they represent a specific food source for a wildlife receptor of particular concern. Should plant bioassays be considered using site soils, appropriate local species will be selected in consultation with EPA.

Candidate Measurement Endpoints. Measured concentrations of COPCs in soil will be compared to available plant TRVs such as the Eco-SSLs and state terrestrial standards that are relevant to the various species and conditions that occur throughout the UCR (i.e., by reach and habitat type).

Analysis Plan. For assessing risks to terrestrial plants, existing soil data will be assembled and presented in the context of potential fate and transport routes (air deposition from stacks or windblown sediment, and relict floodplains)[v], in consultation with EPA. The existing data will inform plans to sample soils from relict floodplains, areas where windblown sediment settles, and in representative areas in the uplands that may have been exposed to smelter emissions. COPC concentrations in soils will be compared to TRVs. Background concentrations will be considered as described above. Depending upon results of the initial survey, consideration will be given to additional sampling in other areas.

The exposure point concentration will be determined in consultation with EPA. For small relict floodplains as well as larger upland areas, initial analyses will include use of the 95 percent UCL on the mean to estimate overall risk and geostatistical plotting of landscape features with existing and any newly acquired soil contaminant concentration data in these areas. These analyses will be used to determine whether locally elevated concentrations exist. For terrestrial plants, risks will also be evaluated using point-by-point comparisons to the selected TRVs, as determined by EPA.

4.3 AQUATIC INVERTEBRATES

Assessment Endpoints. Survival, growth, and reproduction of aquatic invertebrates

Risk Questions Working Hypotheses. Are the levels of contaminants in surface water, sediments, porewater, and invertebrate tissues greater than benchmarks for the survival, growth, or reproduction of aquatic invertebrates? Is the survival, growth, or reproduction of benthic invertebrates exposed to UCR sediments unacceptably lower than that for benthic invertebrates exposed to reference sediments? Benchmarks used to determine TRVs will, as determined by EPA, include, but are not limited to: sediment quality guidelines and regulatory standards, literature-based toxicity thresholds, concentration-response relationships, and water quality criteria.

Risk to aquatic invertebrates will be assessed quantitatively for those chemicals for which there is information on surface water, sediment, or porewater concentrations that result in adverse effects. Certain COPCs do not have such information, so risks from these COPCs will be addressed in the uncertainty analysis.

Receptors. A summary of benthic macroinvertebrate surveys conducted in the UCR is presented in Appendix A of the BERA work plan (TAI 2011). Species selected for bioassays will be evaluated to ensure that they are sufficiently sensitive to be protective of the major invertebrate species of concern such as amphipods, trichoptera, plecoptera, oligochaetes, ephemeroptera, and mussels. Selection will be made in consultation with EPA, but will include *Hyallela azteca* and *Chironomus dilutus* and may, in consultation with EPA, include a freshwater mussel such as *Lampsilis siliquoidea*.

Candidate Measurement Endpoints. Concentrations of COPCs in surface water, sediment, toxicity-test porewater, and invertebrate tissue compared to benchmarks, including the results of laboratory bioassays (see below). Survival, growth, biomass, and reproduction of benthic invertebrates in laboratory toxicity tests.

Analysis Plan: Toxicity. Benthic invertebrates will be assessed using multiple lines of evidence that address different exposure pathways. Proposed methods are described below. Epibenthic and infaunal invertebrates will be assessed using a multi-step approach. The first step will use existing sediment quality values and chemical data to rank sediment stations in the UCR over appropriate, as determined by EPA, concentration gradients with consideration of sediment classes. Bioassays will also be conducted at stations representing observed gradients and sediment types. Slag-enriched sediment has been identified as one specific sediment class that will be evaluated. Sediment chemistry and bioassay results will be used with the intent to develop toxicity thresholds and predictive concentration-response models of chemistry-to-effects to assess risk from bulk sediment at other site locations (adjusted for bioavailability differences, as appropriate). In addition, *H. azteca* tissue at the end of the 28-day tests will be archived and may be analyzed, at EPA's direction, to provide a supplemental line of evidence.

Sediment exposures of benthic organisms will include measures of porewater concentrations to determine whether a predictive site-specific relationship can be developed between the chemistry and toxicity data. Porewater quality will be monitored at appropriate intervals and using technology determined in consultation with EPA. The porewater chemistry measurements provide data needed to apply the biotic ligand model to evaluate metal toxicity in sediment porewater.

Data collection activities will be conducted in future sampling events to fulfill the data requirement for the above approach, as described herein. It is not possible to determine the precise number of samples that need to be collected to support the development of reliable concentration-response models a priori; however, 100 to 130 sediment toxicity-test samples is the initial target for planning purposes. Following each round of testing (e.g., 25 to 50 samples per batch, including reference stations), the resultant data will be examined and evaluated to determine if more data are required and to specifically identify data gaps to be filled in the subsequent batch of toxicity testing (i.e., to identify the data needed to develop concentration-response relationships sufficient for risk determination). Interpretations of the resultant sediment toxicity data will need to recognize that relationships between toxicity and chemistry may vary among different types of sediment samples that occur within the study area.

Surface sediment grab samples will be collected from approximately 50 stations in Round 1 sampling, to be agreed upon in the sediment QAPP. Stations will be selected to represent gradients of COPC concentrations (e.g., mean probable effects concentration quotient [mPECQ]), a measure or estimate of the percent slag[vi], and bioavailability measures (e.g., total organic carbon [TOC]). Other considerations informing sample location selection will include concentrations of non-slag COPCs, sediment types, and past sampling experience. The sample station selection process also may include the use of geostatistical tools, which will be updated as needed following each of the required rounds of testing. Spatial aspects of sample locations (e.g., lateral position of sampling location in river, longitudinal sedimentation position [e.g. riverine, lacustrine or transitional river reach; bathymetric and depositional zones]) will also be recorded as factors for analysis. Sediment and porewater chemistry will be measured in all samples (to the extent practicable for field samples of porewater), with the list of analytes to be determined in consultation with EPA. Whole-sediment bioassays using the amphipod

H. azteca and the midge *C. dilutus* will be performed on splits of samples collected. Sediment samples will have material greater than 2 mm removed.

Specifically, bioassays to be performed include:

- 10-day whole-sediment toxicity tests with the midge *C. dilutus* (endpoints survival, weight, and biomass; USEPA 2000; ASTM 2011a);
- 28-day whole-sediment toxicity tests with the amphipod, *H. azteca* (endpoints - survival, weight, and biomass; USEPA 2000; ASTM 2011a).

In addition, reproductive endpoints will be assessed on at least 12 split-samples. These split-samples will be selected to include those stations with moderately to highly elevated metal concentrations. Specific bioassays to be performed on these 12 samples will include:

- 50- to 65-day whole-sediment toxicity tests with the midge *C. dilutus* (endpoints - survival, weight, emergence, number of eggs/surviving female, number of egg cases, egg hatching success, viability of young; using the adapted method starting with 7-day old larvae; USEPA 2000; ASTM 2011a). Additional recommended endpoints include biomass, the number of eggs produced per replicate chamber, and the number of eggs per egg case.
- 42-day whole-sediment toxicity tests with the amphipod, *H. azteca* (endpoints - survival, weight, biomass, neonates/surviving female; USEPA 2000; ASTM 2011a).

In consultation with EPA, additional lines of evidence may be necessary which could include a freshwater mussel whole sediment toxicity test (e.g., the 28-day *Lampsilis siliquoidea* test with endpoints of survival, weight, and biomass; USEPA 2000, ASTM 2011a, b)[vii].

Results from the bioassays will be used to evaluate if there are significant differences in the survival, growth, or reproduction of benthos exposed to site and reference sediments[viii]. If significant differences are identified, these data will be used to evaluate a) the magnitude of effects; and b) the relationship between COPC concentrations and observed effects. These results will also be used to evaluate the relative value of respective bioassays for future sediment sampling efforts. If meaningful concentration-response relationships can be developed, they will be used to classify each sediment sample from the UCR relative to the risks posed to benthic invertebrates. Such risk classifications will include the methods of MacDonald et al. (2009)[ix]. Importantly, the evaluations based on surface-water chemistry and porewater chemistry will also be considered in the risk classification system. Should significant responses be identified in the bioassays that are not clearly attributable to previously measured factors, or are inadequate for remedial decision making, further evaluation (e.g., toxicity identification evaluation [TIE]) will be considered and may be required by EPA to discern if the observed effects are due to certain classes of COPCs. TIEs would be conducted according to EPA guidance and studies reported in the scientific literature (e.g., USEPA 2007; Hockett and Mount 1996). In addition to TIE experiments like those described by USEPA (2007), concentrations of COPCs would be measured in the tissues of *H. azteca* as a component of the TIE toxicity testing to provide another line of evidence for interpreting the toxicity test results.

Bioaccumulation Considerations. Invertebrate-tissue chemistry is an important line of evidence in the assessment of risks to fish, birds, and other organisms that eat benthic invertebrates. Invertebrate tissue chemistry may also be used as another line of evidence to evaluate risks to benthic invertebrates themselves. For example, tissue data from laboratory toxicity tests can provide information on the bioavailability of sediment-associated COPCs and on their accumulation in invertebrate tissues[x]. This information can be used to supplement and help interpret field-collected data.

To support the development of site-specific measures of toxicity at the UCR Site, 28-day whole-sediment toxicity tests will be conducted using sediment samples from the UCR representing a broad gradient of COPC concentrations, slag content[xi], and organic carbon concentrations. In addition to measuring the survival, growth, and biomass of the amphipod, *H. azteca*, two indicators of exposure to COPCs will also be measured, including:

- Whole-sediment chemistry (<2.00 mm size fraction); and
- Porewater chemistry (e.g., with porewater samples obtained from peepers placed in replicate exposure chambers and by centrifugation of sediment samples).

The body of data from these specific tests and analyses will support interpretation of the sediment-toxicity studies, and development of relationships between exposure to COPCs and the responses of benthic invertebrates. Concentration-response relationships for whole sediment and/or porewater are expected to provide site-specific lines of evidence for evaluating risks to benthic invertebrates associated with exposure to contaminants in whole sediment and/or porewater in the UCR.

It is understood that not all benthic invertebrates derive their exposure to COPCs via the same exposure pathways. For this reason, benthic invertebrates subjected to the above-mentioned laboratory toxicity tests will be archived; and benthic invertebrates will be collected from various locations in the UCR and subjected to chemical analysis. While the resultant invertebrate tissue data will be used primarily for food-web modeling (i.e., estimating average daily doses of COPCs for higher trophic-level receptors), these tissue data may also be used as a supplemental line-of-evidence for assessing risks to certain benthic invertebrates (e.g., ephemeroptera, plecoptera, and trichoptera [EPT] taxa). Co-located sediment samples will be collected with the field-collected invertebrates to support dietary evaluations and/or modeling. Relationships between field and laboratory collected invertebrate-tissue chemistry and relevant literature-based data may further inform the benthic risk assessment.

4.4 TERRESTRIAL INVERTEBRATES

Assessment Endpoints. Survival, growth, and reproduction of terrestrial invertebrates

Risk Questions/Working Hypotheses. Are COPCs in soil from the UCR greater than benchmarks for the survival, growth, or reproduction of terrestrial invertebrates?

Receptors. The soil invertebrate community includes soft-bodied animals such as earthworms (*Eisinia* spp.) and potworms (Enchytraeids) and hard-bodied animals such as beetles (Coleoptera**)**, ants (Hymenoptera), and springtails (Collembola). Comparisons of soil concentrations to invertebrate toxicity thresholds will be assumed to be predictive of risk to the entire soil invertebrate community. Should soil bioassays be required by EPA, species selected will be sufficiently sensitive to the primary risk drivers to be protective of the major invertebrate species of concern, such as those discussed above. Selection will be made in consultation with EPA and will be consistent with state regulations. The species selected are likely to include standard test organisms representative of soft-bodied animals, such as *Eisiniafoetida* (earthworms), and hard-bodied animals, such as *Folsomia candida* (springtails). Additionally, any studies that are needed to refine uptake ratios (soil:biota) for prediction of wildlife dietary risks will target locally abundant species and/or other appropriate species that would be likely to provide useful data.

Candidate Measurement Endpoints. Measured COPC concentrations in soil and associated physical/chemical measurements. Protective assumptions are to be applied based on relevant CSM upland and riparian area divisions. Concentrations of COPCs within soil invertebrate tissue will be measured if site-specific invertebrate uptake factors are required to accurately estimate wildlife dietary exposure.

Analysis Plan. For assessing risks to soil invertebrates, soils will be sampled from relict floodplains, areas along the river where windblown sediments are expected to settle, and areas in the uplands along the riverine portion of the Site that may have been exposed to smelter emissions. COPC concentrations in soils will be compared to Eco-SSLs or literature-derived TRVs. Background concentrations will be considered as described above. Depending upon results of the initial survey, consideration will be given to additional sampling in other areas.

The exposure point concentration will be determined in consultation with EPA. For small relict floodplain areas, initial analysis will include use of the 95 percent UCL on the mean to estimate overall risk; geostatistical plotting of the data in these areas, and in larger upland areas, will be used to determine whether locally elevated concentrations exist.

4.5 FISH

Assessment Endpoints. Survival, growth, and reproduction of UCR fish

Risk Questions/Working Hypotheses. Are the levels of contaminants in surface water, porewater, or sediments from the UCR greater than benchmarks for the survival, growth, or reproduction of fish? Are the levels of contaminants in fish tissues from the UCR greater than critical tissue values for the survival, growth, or reproduction of fish? Is the survival or growth of fish exposed to surface water, porewater, and/or sediments from the Site significantly lower than that for reference media? Are COPC concentrations in diet (including incidental sediment ingestion by bottom-feeding fish such as suckers and sturgeon) greater than dietary benchmarks for survival, growth, or reproduction of fish?

Receptors. There are over 30 species of fish that occur within the UCR. The 2009 sampling event targeted the following fish size classes, based on total length.

- <15 cm (small size class);
- ≥15 to ≤30 cm (medium size class); and
- >30 cm (large size class).

These size classes correspond to the sizes of fish that are typically consumed by piscivorous fish and wildlife. Fish species targeted within each size class represent varying feeding guilds (e.g., omnivores and piscivores). A goal of six species from each of three feeding guilds within each size class was targeted to achieve representation across guilds. Target species included:

<u><15 cm size class</u>

- Primary species are yellow perch (omnivore), rainbow trout (insectivore), and largescale sucker (benthivore/detritivore);
- Secondary species are bluegill (omnivore), whitefish (insectivore), and longnose or bridgelip sucker (benthivore/detritivore); and
- Tertiary species are redside shiner, crappie, pumpkinseed, and smallmouth bass (omnivores), pikeminnow (insectivore), and sculpin (benthivore/detritivore).

>15 to <30 cm size class

- Primary species are largescale sucker (benthivore/detritivore), kokanee (insectivore), and walleye (piscivore);
- Secondary species are longnose or bridgelip sucker (benthivore/detritivore) lake whitefish (insectivore), and smallmouth bass (piscivore); and
- Tertiary species are sculpin (benthivore/detritivore), mountain whitefish (insectivore), and pikeminnow (piscivore).

>30 cm size class

- Walleye, burbot, and smallmouth bass (piscivores) – fillet and remainder;
- Largescale sucker (benthivore/detritivore) – fillet and remainder (without gut contents);
- Rainbow trout (omnivore) – fillet and remainder; and
- Kokanee and whitefish (insectivores) – fillet and remainder.

Candidate Measurement Endpoints. Measurement endpoints will include the measured COPC concentrations in surface water, porewater, and/or sediments, and associated physical/chemical measurements; COPC concentrations in the tissues (whole body) of fish and associated variables (e.g., percent lipids, fish species, fish length, weight, age); survival and growth of fish (i.e., sturgeon) in laboratory toxicity tests of sediment and water (Sturgeon Level of Effort: Investigations 1 and 3); survival and growth of fish (i.e., sturgeon) in site-collected water tests conducted in the field (Sturgeon Level of Effort: Investigation 2); and COPC concentrations in prey items and associated physical/chemical measurements.

Analysis Plan. Fish tissue samples have been collected from UCR (October 2009) and analyzed for all inorganic COPCs and for organic chemicals with Log K_{OW} >5.

Total exposure from non-metabolized organic chemicals will be assessed by comparing whole-body-tissue residue data to TRVs using a hazard quotient approach. For chemicals that are metabolized or otherwise regulated by fish (such as polycyclic aromatic hydrocarbons [PAHs] and metals), a tissue residue approach is not appropriate (McCarty and MacKay 1993). Metabolized or regulated chemicals will be assessed by comparing estimated dietary concentrations to dietary TRVs. Fish ingestion patterns of food and sediment will be applied when calculating dietary concentrations. This dietary exposure approach requires an approximation of the COPC concentration in the diet of a representative receptor species. Analysis of whole-body composite samples of representative receptor species that are potential prey will be used to determine exposure.

Lipophilic contaminants (e.g., polychlorinated biphenyls [PCBs], dichloro-diphenyl-trichloroethanes [DDTs]) are stored in lipid tissue if not immediately metabolized in the body. Therefore, whole-body concentrations are often correlated with lipid content of the organism. For this reason, lipid normalization of whole-body concentrations in fish will be conducted for lipophilic COPCs that are assessed using a tissue residue approach. However, body residue TRVs are not typically lipid-normalized and require that an estimate of lipid content be generated in order to develop a lipid-normalized TRV. When the variability in percent lipids is low (less than ±10 percent of mean), the mean percent lipid for that species will be used to normalize TRVs. Where variability is high (greater than ±10 percent of mean), the TRV normalization will be bracketed using a range of lipid content for that species. Both lipid-normalized and non-normalized tissue concentrations will then be used to characterize exposure. The correlation between lipid content and contaminant concentrations will be performed and evaluated in consultation with EPA.

Direct toxicity of surface water will be assessed by comparing surface water concentrations to chronic AWQC or other relevant toxicity values using the hazard quotient approach. If there are sufficient literature data available, TRVs will be developed for all pathways (e.g., uptake from water column, dietary exposure, direct exposure to sediment) and the resulting information used in a weight-of-evidence analysis. Toxicity of sediment to fish will be evaluated by comparing measured concentrations of COPCs to the selected TRVs.

In the exposure assessment, more realistic assumptions of chemical exposure will be employed (e.g., use of 95 percent UCL on the mean within each FSCA). Chemical concentrations in whole body tissues for each receptor of concern will be analyzed to determine exposure point concentrations for each fish species or feeding guild. Chemical concentrations in food will be calculated from concentrations in each component of the fish species' diet and each component's fraction of the diet. Direct toxicity of COPCs in surface water and/or sediment will be evaluated using the results of laboratory toxicity tests with fish species.

4.6 AMPHIBIANS AND REPTILES

Assessment Endpoints. Survival, growth, and reproduction of amphibians and reptiles

Risk Questions/Working Hypotheses. Are levels of COPCs in surface water, porewater, sediments or soils from the UCR greater than benchmarks for the survival, growth, or reproduction of amphibians or reptiles? Is the survival, growth or reproduction of amphibians and reptiles exposed to surface water, porewater, and/or sediments or soils from the UCR significantly lower than that for amphibians or reptiles exposed to reference media?

Receptors. Two salamander species (e.g., tiger salamander, *Ambystoma tigrinum*), two toad species, and six frog species have been reported to occur in the UCR (see Appendix B of the BERA work plan [TAI 2011]). Reptile species observed in the UCR include the painted turtle (*Chrysemys picta*), five lizard species, western skink (*Eumeces skiltonianus*), and eight snake species (see Appendix B of the BERA work plan [TAI 2011]). The suitability of using amphibians as surrogates for reptiles will be assessed by performing a comparative evaluation of toxicity based on a literature search. If any reptile toxicity data are available for site-related COPCs, and if the assumption is shown to be adequately protective, amphibians will be used as surrogates for reptiles. Amphibians and reptiles will be addressed by evaluating multiple species, dependent on the scientific information available. Receptors of concern will be selected in consultation with EPA to represent different feeding guilds and habitat types, such as the tiger salamander (a ubiquitous carnivore found primarily in upland habitats near areas of slow moving water) or the herbivorous tadpoles of the Pacific tree frog (*Hyla regilla*) that utilize riparian areas.

Candidate Measurement Endpoints. Because the toxicity data available for amphibians are primarily based on surface water exposure (measured using standard laboratory toxicity testing such as Frog Embryo Teratogenesis Assay -*Xenopus*; FETAX), surface water chemistry data will be used to assess risks to aquatic life stages. Exposure of eggs to sediment will be quantified using sediment chemistry and porewater data from known or likely habitat areas. Soil, sediment, and/or beach sediment[xii] chemistry will provide an exposure metric for adult life stages, through incidental ingestion, dietary uptake, and/or dermal exposure. Literature-based TRVs will be derived for adult amphibians (and possibly reptiles) if the requisite data are available. Risks to reptiles will likely be inferred from amphibian risks. When a TRV is not available for a COPC, risks associated with this COPC will be described in the uncertainty section of the BERA.

Analysis Plan. Comparisons will be made between COPC concentrations in surface water, sediment and/or porewater, or soil against benchmarks and/or available literature-based toxicity thresholds. Comparisons will also be made to background concentrations, as described above. Media concentrations will be evaluated at a spatial scale and habitat that is appropriate to the focal species under consideration (e.g., riparian or wetland-like areas, relict floodplains, and locally wet areas in the uplands). If considered necessary by EPA, additional sampling will be performed in order to adequately establish an appropriate spatial scale of available data to assess site gradients and sediment or soil types. In addition to evaluation of individual data stations, geospatial mapping of all sediment, water, or soil concentrations will be one tool used inform the determination of whether locally elevated concentrations exist.

4.7 AVIAN AND MAMMALIAN COMMUNITIES

Assessment Endpoints. Survival, growth, and reproduction of birds and mammals

Risk Questions/Working Hypotheses. Are the levels of COPCs in diets (considering exposure to drinking water, and incidental ingestion of soil or sediments) higher than TRVs for birds or mammals? Are the concentrations of COPCs in sediments or soils greater than benchmarks for the survival, growth, or reproduction of birds or mammals?

Receptors. As presented within Appendix B of the BERA work plan (TAI 2011) there are over 75 species of mammals and 200 species of birds that occur within the UCR, either as residents or migrants. Large resident mammals include mule deer (*Odocoileus hemionus*), bighorn sheep (*Ovis canadensis*), moose (*Alces alces*), elk (*Cervus canadensis*), bobcat (*Felis lynx*), mountain lion (*F. concolor*), red fox (*Vulpes vulpes*), coyote (*Canis latrans*), and black bear (*Ursus americanus*). Smaller mammals include moles, badgers, skunks, porcupines, rabbits, squirrels, chipmunks, marmots, pikas, bats, gophers, rats, voles, shrews, and mice. Aquatic-associated mammals include mink (*Mustela vison*), muskrat (*Ondatra zibethicus*), beaver (*Castor canadensis*), raccoons (*Procyon lotor*), and river otter (*Lutra canadensis*). A variety of birds use the UCR including raptors such as bald eagles (*Haliaeetus leucocephalus*) and osprey (*Pandion haliaetus*), as well as songbirds (Passerines) including species of jays, sparrows, flycatchers, swallows, and chickadees. Many types of water birds are present as well, such as common merganser (*Mergus merganser*), Canada goose (*Branta canadensis*), mallard (*Anas platyrhynchos*), red-necked grebe (*Podiceps grisegena*), common loon (*Gavia immer*), and various other aquatic-dependent birds, including belted kingfishers (*Megaceryle alcyon*) and great blue heron (*Ardea herodias*).

<u>*Herbivores*</u>

Herbivorous birds in the vicinity of the UCR that consume mostly aquatic vegetation as well as some aquatic organisms include geese and various diving and dabbling ducks. Herbivores may incidentally ingest sediment while feeding. Upland herbivorous species include grouse, doves, pigeons, pheasant, and turkeys, which may also incidentally ingest soil while feeding. Focal species selected to represent the herbivorous feeding guild, such as the mallard and grouse, will be determined in consultation with EPA.

Herbivorous mammals in the vicinity of the UCR are primarily upland species, such as large ungulates (deer and elk) and small rodents (gophers, squirrels, and voles). Muskrats and beaver are examples of aquatic-associated herbivorous mammals. Focal species selected to represent this feeding guild, such as the vole and muskrat, will be determined in consultation with EPA.

Carnivore/Omnivore

Diving birds in the UCR that ingest primarily invertebrates and small fish include hooded mergansers, grebes, and loons. Any of these are good representative species for diving birds. Representative birds such as the mallard (omnivore), the kingfisher (aquatic-dependent carnivore), and the American kestrel (*Falco sparverius*; upland carnivore) will be determined in consultation with EPA.

Mammalian carnivores include the bobcat, mountain lion, coyote, and red fox, which prey on both large and small mammals. There are no mammalian carnivores strictly associated with the aquatic ecosystem, but the upland area potentially impacted by smelter emissions is likely to be inhabited by mammalian carnivores. The red fox is recommended as a representative mammalian species, due to its relatively small size and limited home range. If other representative species are to be analyzed, that will be determined in consultation with EPA.

Sediment-and Soil-probing Invertivore/Omnivore

Sediment-probing birds consume mostly sediment- or soil-associated invertebrates and may incidentally ingest a relatively large amount of sediments or soils. These birds include sandpipers and killdeer, which are known to breed in the vicinity of the UCR. Of the bird species evaluated for consumption of soil and sediment by EPA (1993), sandpipers were found to have the highest sediment ingestion rate. Therefore, spotted sandpiper (*Actitis macularia*) is recommended as a representative species based on sediment exposure and presence of breeding population. A representative upland bird that similarly probes the soil is the American robin (*Turdus migratorius*). If other representative species are to be analyzed, that will be determined in consultation with EPA.

Mammals that eat sediment or soil dwelling invertebrates include the omnivorous raccoon (an aquatic-associated mammal) and water shrews (aquatic) or shrews (terrestrial). These species will be chosen as representative of this feeding guild. If other representative species are to be analyzed, that will be determined in consultation with EPA.

Piscivores

Piscivorous birds feeding from the UCR include ospreys, herons, terns, eagles, kingfishers, and western gulls. Of these, the osprey and the bald eagle are recommended as representative species of piscivores at the Site. Most of the osprey's prey is fish, and bald eagles are assumed to consume primarily fish. Consumption of secondary aquatic consumers, such as invertivorous fishes, gives bald eagle and osprey the highest potential exposure to biomagnifying chemicals. Chemical exposure in the UCR for these two species is likely to be different because the bald eagle is present year-round and the osprey is a migratory species, present only from spring through fall.

Other piscivores that will be considered for inclusion as representative species are the great blue heron and kingfisher, based on their presence at the Site, breeding habitat, special regulatory status, or societal importance. However, the kingfisher is more omnivorous and may be better suited as a focal species for that feeding guild. The great blue heron will be considered as a piscivore using wetland and riparian areas (although it does consume frogs and mice, when available). If other representative piscivorous species are to be analyzed, that will be determined in consultation with EPA.

Piscivorous mammalian species that use the UCR are mink and river otter. Mink is recommended as the focal species for this feeding guild because it is more strictly piscivorous than the otter. There are no upland piscivorous mammals. If other representative species are to be analyzed, that will be determined in consultation with EPA.

Candidate Measurement Endpoints. It is likely that risks to wildlife at the UCR Site primarily occur via the dietary route. Therefore, data needed to complete the ecological risk assessment are chemical concentrations in dietary items, water, soil, and sediment in foraging areas. Where available, "disturbed sediment" surface water will also be evaluated. Fish and water samples have been collected, and plans are being developed for collection of soil, invertebrate tissue, surface sediment, and soil samples. Toxicity reference values will be used as measures of effects, and will be derived in consultation with EPA, either from published benchmarks such as the Eco-SSLs or from the scientific literature.

Analysis Plan. Risk to birds and mammals will be assessed by estimating daily exposure from food and water/sediment/soil ingestion pathways and comparing this to a dietary-based TRV. Concentrations of chemicals in food consumed by each representative species will be determined or modeled using data collected at the Site. Inputs needed for estimating dietary intake for each representative species (e.g., feeding rates, body size) can be obtained from EPA's Wildlife Exposure Factors Handbook (USEPA 1993) and regionally relevant sources. The exposure factors that will be used to estimate average daily doses of COPCs for each of the selected focal species will be presented in a technical memorandum or memoranda for approval by EPA[xiii].

Exposure concentrations for each of the representative focal species will be derived from tissue, soil, water, sediment, and/or "disturbed sediment" surface water concentrations over an area that is generally equivalent to the size of the foraging area of the species of concern. Should more definition or accuracy of intake estimates be required, the information will be mapped and a spatially explicit analysis conducted (e.g., Wickwire et al. 2004).

5 WEIGHT-OF-EVIDENCE PROCESS

A weight-of-evidence evaluation looks at all the data that have been assembled for each assessment endpoint. Each measurement type contributes a different type of understanding to the risk analysis; all may be used to evaluate risk, and not all measurements are of the same quality or relevance. Differences in type, quality, and environmental relevance of candidate measurement endpoints have a significant bearing on their applicability to the risk assessment and conclusions. Therefore, during the risk characterization, each of the lines of evidence will be reviewed and evaluated. The weight-of-evidence process will be described in a technical memorandum.

6 UNCERTAINTY ANALYSIS

Uncertainty analysis is an important step of the ecological risk assessment (ERA) process. Uncertainty analysis increases the confidence of an ERA by explicitly describing the magnitude and direction of uncertainties (USEPA 1998). There are inherent uncertainties throughout the ERA process that must be identified and evaluated for their impacts on risk estimation.

Uncertainties will be identified in three primary areas: 1) knowledge of the Site, 2) parameters used to evaluate risk, and 3) models used to represent and estimate risk. For example, information may be lacking about receptors at the Site, and this knowledge gap would represent an uncertainty. In consultation with EPA, lack of information about toxicity of some of the COPCs will be addressed by comparisons to background, extrapolation from similar chemicals, or through the use of bioassays. Parameters such as sediment chemical concentrations are inherently variable, and this uncertainty will be considered in the determination of sample sizes and location. Models, which are simplified representations of physical and biological processes, may be oversimplified or fail to capture important aspects of the processes under investigation. Such uncertainties, along with their implications for the final risk estimate, will be identified, discussed, and reviewed in context of the risk characterization.

There are multiple methods described in EPA guidance for analyzing uncertainties (USEPA 2001). The simplest method is to incorporate various exposure and effects scenarios in the risk estimation process that capture the range of uncertainties in assumptions. Any proposed application of geospatial analyses will include an initial variogram analysis to show spatial autocorrelation before interpolating or performing geostatistical analysis of the data. Risk estimates can be expressed as point estimates with statistical measures of uncertainty (e.g., confidence limits, percentiles). Another method to analyze uncertainty is sensitivity analysis, where parameter values are iteratively varied to examine the effect of the parameter on the risk estimate. Simulation software (e.g., @Risk®, CrystalBall®) can be used to conduct Monte Carlo analysis for the purpose of examining uncertainty. This probabilistic approach is commonly applied and EPA supplies guidance regarding the application of probabilistic techniques to the BERA process. For the UCR, in addition to exposure and effects scenarios, one or more of these methods will be applied in the uncertainty analyses in consultation with EPA.

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Clarification Meeting Endnotes

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[i] This refers to sediments deeper than the top 15 cm. EPA will not direct Teck to sample sediments deeper than the top 15 cm at this time; this is a place holder should future data identify resources of concern deeper than 15 cm at which time EPA may, at their discretion, require Teck to conduct additional sampling.

[ii] EPA fully intends to provide flexibility throughout this Plan in the type of documents used to present technical information. This and other similar statements should read"… technical memorandum or memoranda or QAPPs…".

[iii] "beach sediments" was listed separately from "sediments" to be certain they were not forgotten when retrieving data; this could have been written as "sediments, including beach sediments,…"

[iv] "porewater" in this sentence includes both field and laboratory measurements.

[v] Identification of where the areas of likely windblown dust are located will be done with modeling and other methods to be detailed in the QAPP.

[vi] The following phrase, "a measure or estimate of the percent slag", was meant to replace "Zn:V ratio" in order to broaden the measures of slag that could be used (including, but not limited to, other chemical ratios or measures).

[vii] This is meant to be a new paragraph and not another bullet, as it describes tests that potentially could be done and therefore is not part of the list of those that will be done.

[viii] EPA means the term "significant differences" to include biological significance and not refer to statistical significance only. EPA will look at both statistical differences and biological significance (adverse effects). If both occur, then Teck will conduct further evaluations, as stated.

[ix] The MacDonald et al. (2009) reference was provided as an example of the use of the reference envelope approach.

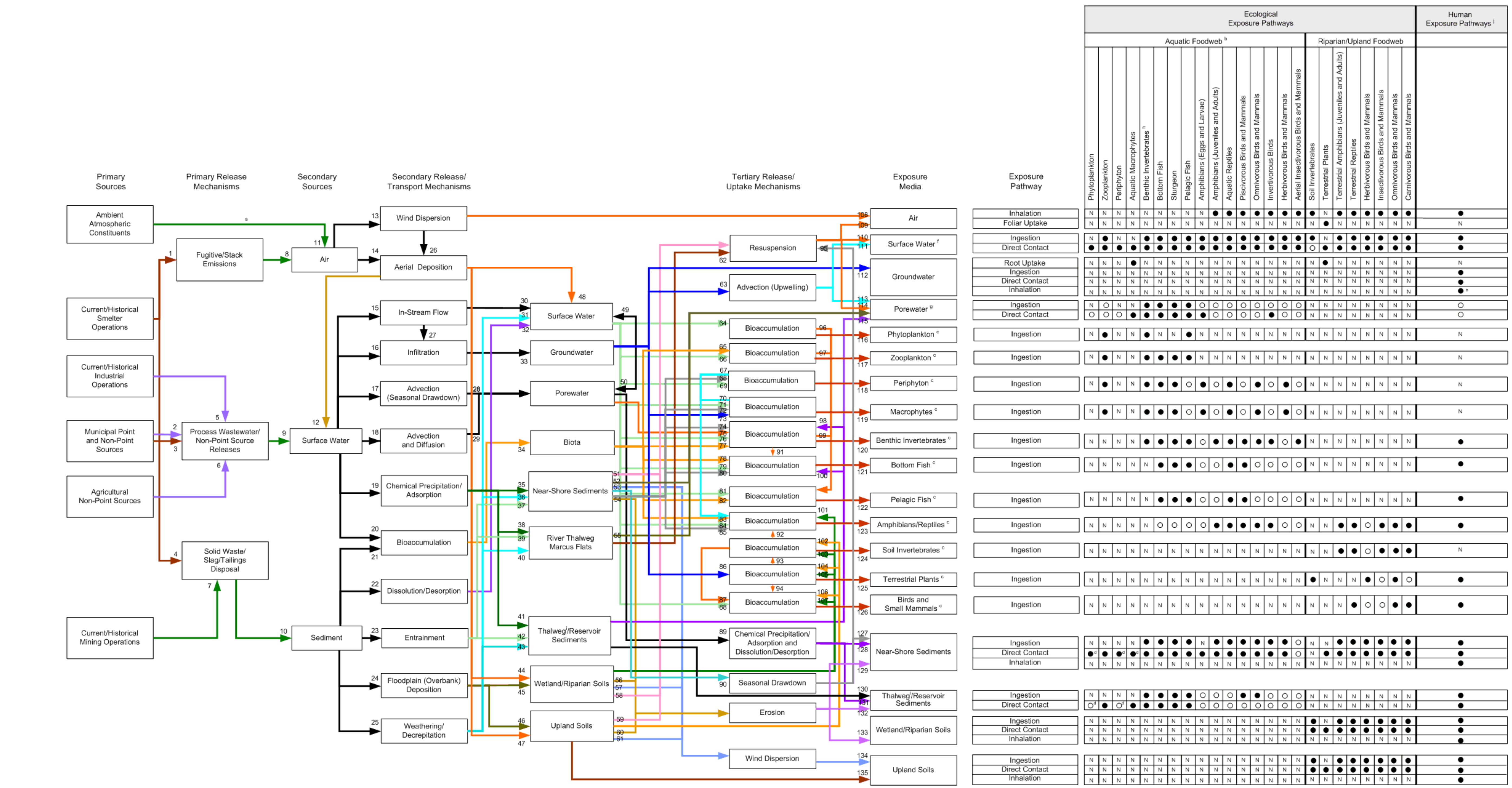
[x] EPA has identified tissue residue as a secondary line of evidence to be used as another explanatory factor when results from the bioassays are unequivocal and not easily explained.

[xi] EPA has used "slag content" to refer to whatever measures will be agreed upon to identify slag, and notes that this has not yet been determined. EPA intends this wording to be consistent with the broad definition of "slag content" used previously in this Plan (see Endnote vi).

[xii] As stated in Endnote iii, "beach sediments" was listed separately from "sediments" to be certain they were not forgotten when retrieving data; this could have been written as "sediments, including beach sediments,…"

[xiii] As stated in Endnote ii, EPA fully intends to provide flexibility throughout this Plan in the type of document used to present technical information. This and other similar statements should read"… technical memorandum or memoranda or QAPPs…".

FIGURES



Legend:

- ● Exposure Pathway Potentially Complete
- ○ Incomplete Exposure Pathway
- N Pathway Not Applicable

Notes:

a The different colors used for the arrows linking the boxes were selected to help distinguish the various linkages visually, and have no technical meaning.
b Differential exposure pathways exist for different life stages of some receptors (fish and amphibian eggs, larvae, adults). These will need to be considered/outlined in the final CSM.
c Upon death, receptor contributes, as solid-phase and liquid-phase detritus to the dietary, dermal, and incidental ingestion pathways...dietary is probably of importance
d Chemisorption onto external organic material
e Inhalation of COCs contained in media via Sweatlodge pathway
f Surface water may be affected by groundwater discharge from the side banks during pool drawdown.
g Porewater may be affected or replaced via groundwater advection.
h Includes mussels
i Thalweg refers to the pre-reservoir channel.
j The human health risk assessment will be performed by the EPA. This CSM represents the current understanding of the human health exposure pathways at the time the work plan was prepared. The human exposure media (biotic and abiotic) and pathways will be refined dependent upon the results of the planned Tribal Exposure Survey and more detailed input from the Spokane Tribes of the Colville Indian Reservation.

Figure 1. Sitewide Conceptual Site Model

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Table 1. Assessment and Candidate Measurement Endpoints, Risk Questions, Candidate Focal Species/Feeding Guilds, and Analysis Approach Proposed for the Problem Formulation Expansion of the UCR BERA Work Plan

Assessment Endpoint	Risk Questions	Candidate Measurement Endpoints Needed for BERA	Candidate Focal Species/Feeding Guilds	Analysis Approach
Aquatic Plants				
1a. Survival and Growth of Aquatic Plants	Are the levels of COPCs in surface water, porewater, or sediments from the UCR Site greater than benchmarks for the survival or growth of aquatic plants?	COPC concentrations in surface water, porewater, sediment, and associated physical/chemical measurements	Rooted and non-rooted submergent and emergent macrophytes and algae	• COPC concentrations in surface water, porewater, and sediments vs. benchmarks / literature-based toxicity thresholds
Terrestrial Plants				
1b. Survival and-Growth of Terrestrial Plants	Are the levels of COPCs in soils from the UCR Site greater than benchmarks for the survival or growth of terrestrial plants?	COPC concentrations in soils and associated physical/chemical measurements	Grasses, forbes, woody shrubs, and trees	• COPC concentrations in soils vs. benchmarks/ literature-based toxicity thresholds
Aquatic Invertebrates				
2a. Survival, Growth, and Reproduction of Aquatic Invertebrates	Are the levels of COPCs in surface water, sediments, or porewater from the UCR greater than benchmarks for the survival, growth, or reproduction of aquatic invertebrates?	COPC concentrations in surface water, porewater, and sediment, and associated physical/chemical measurements	Benthic invertebrate communities (e.g., *Hyalella azteca* and *Chironomus dilutus)*	• COPC concentrations in surface water, sediment, near-bottom water and pore-water vs. benchmarks/ literature-based toxicity thresholds
	Is the survival, growth, or reproduction of aquatic invertebrates exposed to sediments from the UCR Site unacceptably lower than in reference sediments?	Survival, growth, reproduction, and tissue concentrations of aquatic invertebrates in laboratory toxicity tests		• COPC concentrations in sediment vs. toxicity thresholds developed from site-specific concentration-response curves • Matching chemistry data to support interpretation of toxicity test data from Site and reference samples. • TIEs may be used to identify the cause of toxicity
	If required, then as determined by EPA, are the levels of COPCs in invertebrate tissues greater than effect levels for the survival, growth, or reproduction of aquatic invertebrates?	Field collected and/or laboratory derived invertebrate tissues and associated physical/chemical measurements		• COPC concentrations in tissues vs. literature-based toxicity thresholds

Table 1. Assessment and Candidate Measurement Endpoints, Risk Questions, Candidate Focal Species/Feeding Guilds, and Analysis Approach Proposed for the Problem Formulation Expansion of the UCR BERA Work Plan

Assessment Endpoint	Risk Questions	Candidate Measurement Endpoints Needed for BERA	Candidate Focal Species/Feeding Guilds	Analysis Approach
Terrestrial Invertebrates				
2b. Survival, Growth, and Reproduction of Terrestrial Invertebrates	Are the levels of COPCs in soil from the UCR Site greater than benchmarks for the survival, growth, or reproduction of terrestrial invertebrates?	COPC concentrations in soil and associated physical/chemical measurements	Soft-bodied animals (e.g., *Eisinia foetida*; earthworms) Hard-bodied animals (e.g., *Folsomia candida*; springtails)	• COPC concentrations in soil vs. benchmarks/ literature-based toxicity thresholds
	If required, then as determined by EPA, is the survival, growth or reproduction of terrestrial invertebrates exposed to soils from the UCR Site significantly lower than that in reference soils?	Survival, growth, and/or reproduction of terrestrial invertebrates in laboratory toxicity tests		Matching chemistry data to support interpretation of toxicity test data from Site and reference samples
Fish				
3. Survival, Growth and Reproduction of Fish	Are the levels of COPCs in surface water, porewater or sediments from the UCR Site greater than benchmarks for the survival, growth, or reproduction of fish?	COPC concentrations in surface water, porewater and sediments, and associated physical/chemical measurements	Omnivores (yellow perch, bluegill, redside shiner, crappie, pumpkinseed, and smallmouth bass, rainbow trout), insectivores (rainbow trout, whitefish, pikeminnow, kokanee, lake whitefish, mountain whitefish), benthivores/detritivores (largescale sucker, longnose or bridgelip sucker, sculpin) piscivores (walleye, smallmouth bass, pikeminnow, burbot).	• COPCs in surface water, porewater, and sediment vs. Sediment Quality Criteria/ benchmarks/ literature-based toxicity thresholds.
	Are the levels of COPCs in fish tissues from the UCR Site greater than critical tissue values for the survival, growth, or reproduction of fish?	COPC concentrations in the tissues (whole body) of fish from the UCR and reference areas, and associated variables (e.g., percent lipids, fish species, fish length, weight, age)		• COPCs in whole fish vs. literature-based tissue residue toxicity thresholds
	Are the levels of COPCs in the diets of fish utilizing habitats at the UCR Site greater than toxicity thresholds for the survival, growth, or reproduction of fish?	COPC concentrations in dietary items of fish and associated physical/chemical measurements		• Compare modeled dietary uptake concentrations with literature-based fish diet benchmarks/ literature-based toxicity thresholds
	Is the survival or growth of fish exposed to surface water, porewater, or sediments from the UCR Site significantly lower than that for reference media?	Survival and/or growth of fish in laboratory toxicity tests		• Use matching chemistry data to support interpretation of sturgeon toxicity data from Site and reference areas

Table 1. Assessment and Candidate Measurement Endpoints, Risk Questions, Candidate Focal Species/Feeding Guilds, and Analysis Approach Proposed for the Problem Formulation Expansion of the UCR BERA Work Plan

Assessment Endpoint	Risk Questions	Candidate Measurement Endpoints Needed for BERA	Candidate Focal Species/Feeding Guilds	Analysis Approach
Amphibians and Reptiles				
4a. Survival, Growth, and Reproduction of Amphibians	Are the levels of COPCs in surface water, porewater, sediment, or soil from the UCR Site greater than benchmarks for the survival, growth, or reproduction of amphibians?	COPC concentrations in water, porewater, sediment, soil, and associated physical/chemical measurements	Salamander species (e.g., tiger salamander, *Ambystoma tigrinum*) Toad species (see Appendix B of BERA Work Plan) Frog species (see Appendix B of BERA Work Plan)	• COPC concentrations in surface water, porewater, sediment and soil vs. benchmarks/ available literature-based toxicity thresholds
	If required, then as determined by EPA, is the survival, growth or reproduction of amphibians exposed to surface water, porewater, whole-sediments or soils from the UCR Site significantly lower than that for reference media?	Survival, growth, or reproduction of amphibians in laboratory toxicity tests. Fetal and embryonic toxicity in amphibians (African clawed toad) as measured using standard laboratory toxicity testing (e.g., FETAX)		• Use matching chemistry data to support interpretation of amphibian toxicity data from Site and reference areas
4b. Survival, Growth and Reproduction of Reptiles	Are the levels of COPCs in surface water, porewater, sediment, or soil from the UCR Site greater than benchmarks for the survival, growth, or reproduction of reptiles?	COPC concentrations in water, sediments, pore water, and soil, and associated physical/chemical measurements	For example: Painted turtle (*Chrysemys picta*), Lizard species, Western skink (*Eumeces skiltonianus*), snake species (see Appendix B of BERA Work Plan)	• COPC concentrations in surface water, porewater, sediment and soil vs. benchmarks/ available literature-based toxicity thresholds
Birds				
5. Survival, Growth and Reproduction of Birds	Do the daily doses of COPCs received by birds from consumption of the tissues of prey species and other media at the UCR Site exceed TRVs for survival, growth, or reproduction of birds?	Concentrations of COPCs in surface water, sediment, soil, and the modeled and/or measured tissues of prey species (i.e., whole-body tissue residues) and associated measurements (e.g., prey size)	Herbivorous birds Omnivorous birds Aerial Feeding Insectivorous birds Sediment- and soil-probing birds Piscivorous birds Carnivorous birds	• Modeled dietary uptake concentrations for birds vs. literature-based toxicity thresholds
	Are the concentrations of COPCs in sediments or soils from the UCR Site greater than benchmarks for the survival, growth, or reproduction of birds?	COPC concentrations in soil, sediment and associated physical/chemical measurements		• COPCs in soil and sediments vs. benchmarks /literature-based toxicity thresholds for birds

Table 1. Assessment and Candidate Measurement Endpoints, Risk Questions, Candidate Focal Species/Feeding Guilds, and Analysis Approach Proposed for the Problem Formulation Expansion of the UCR BERA Work Plan

Assessment Endpoint	Risk Questions	Candidate Measurement Endpoints Needed for BERA	Candidate Focal Species/Feeding Guilds	Analysis Approach
Mammals				
6. Survival, Growth and Reproduction of Mammals	Do the daily doses of COPCs received by mammals from consumption of the tissues of prey species and from other media at the UCR Site exceed the TRVs for survival, growth or reproduction of mammals?	Concentrations of COPCs in surface water, sediment, soil, modeled and/or measured tissues of prey species (i.e., whole-body tissue residues), and associated measurements (e.g., prey size)	Herbivorous mammals Omnivorous mammals Invertivorous mammals Piscivorous mammals Carnivorous mammals	• Modeled dietary uptake concentrations for mammals vs. literature-based toxicity thresholds
	Are the concentrations of COPCs in sediments or soils from the UCR Site greater than benchmarks for the survival, growth, or reproduction of mammals?	COPC concentrations in soil, sediment and associated physical/chemical measurements		• COPCs in soil and sediment vs. benchmarks /literature-based toxicity thresholds for mammals