

**APPENDIX C-2: DRAFT SCREENING LEVEL ECOLOGICAL
RISK ASSESSMENT WORK PLAN FOR THE PROCESS
AREAS OPERABLE UNIT**

Yerington Mine Site

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ACRONYMS AND ABBREVIATIONS

ARC	Atlantic Richfield Company
BAFs	bioaccumulation factors
BCGs	Biota Concentration Guides
bgs	below ground surface
COPECs	chemicals of potential ecological
CSM	conceptual site model
DOE	U.S. Department of Energy
EPA	U.S. Environmental Protection Agency
FIR	food ingestion rate
Integral	Integral Consulting Inc.
LOAEL	lowest-observed-adverse-effects level
MDA	minimum detectable activity
MDL	method detection limit
NOAEL	no-observed-adverse-effects level
Order	Unilateral Administrative Order
ORNL	Oak Ridge National Laboratory
OU	operable unit
PCBs	polychlorinated biphenyls
PRG	preliminary remediation goal
QA/QC	quality assurance/quality control
QAPP	Quality Assurance Project Plan
Site	Yerington Mine Site
SLERA	Screening Level Ecological Risk Assessment
TRV	toxicity reference value
VOC	volatile organic compound

1 INTRODUCTION

This Screening Level Ecological Risk Assessment (SLERA) work plan has been prepared by Integral Consulting Inc. (Integral), Foxfire Scientific, Inc., and Brown and Caldwell on behalf of Atlantic Richfield Company (ARC), in partial fulfillment of the requirements of Unilateral Administrative Order (Order), Docket number 9-2007-0005, which was issued by the U.S. Environmental Protection Agency (EPA) to ARC in January 2007. Among other requirements, the 2007 Order directs ARC to prepare a remedial investigation work plan for the Process Areas operable unit (OU) of the Yerington Mine Site in Yerington, Nevada (the Site) (Figure 1-1).

This introduction provides a brief review of the setting and history of the Site, current and future land use, the overall approach and applicable guidance followed in conducting the SLERA, and the sources of data that will be used in the risk assessment. The remainder of the document consists of the following sections:

- Section 2 – Data Evaluation
- Section 3 – Screening Level Problem Formulation
- Section 4 – Screening Level Ecological Effects Evaluation
- Section 5 – Screening Level Exposure Estimate
- Section 6 – Screening Level Risk Characterization
- Section 7 – Uncertainty Assessment
- Section 8 – Summary and Risk Management Recommendations
- Section 9 – References.

1.1 ENVIRONMENTAL SETTING

The physical setting of the Yerington Mine Site is within the Basin and Range physiographic province, which is part of the Great Basin sagebrush-steppe ecosystem. Mason Valley occupies a structural graben (i.e., down-dropped faulted basin) immediately east of the Singatse Range, an uplifted mountain block. Plant communities in the area vary from relatively dense associations along the Walker River immediately east of the Site to sparse brush found on the alluvial fans derived from the Singatse Range, immediately west of the Site.

In the Process Areas, chemical storage and processing activities have resulted in modifications to the natural, premining topography, including removal and compaction of surface soil and vegetated areas to construct above- and below-ground structures including roads, buildings, pipes, storage tanks, and filling stations.

In general, the abundance and diversity of wildlife in an area is directly dependent on habitat characteristics, including their type, quality and quantity. No qualitative or quantitative habitat surveys or vegetative surveys are known to have been conducted in the Process Areas. Plant and animal species expected to occur in the vicinity of the Site as a whole are discussed in the Site-wide conceptual site model (Integral and Brown and Caldwell 2007). Vegetative and wildlife habitat surveys are proposed in Section 5.5 of the Work Plan to characterize the quantity and quality of potential plant and wildlife habitat in the Process Areas and to supplement the conceptual site model (CSM) for the SLERA.

1.2 SLERA APPROACH

The SLERA is used to provide a general indication of the potential, or lack thereof, of ecological risk. A SLERA, while less detailed than a Baseline ERA, is still a complete risk assessment and allows for the calculation of ecological risk and assists in identification of the need for site-specific ecological risk assessments. The risk assessment will provide conservative estimates of risks to potentially exposed wildlife; the methodology is designed to avoid underestimation of risks to provide a conservative basis for evaluating the need for additional site-specific risk assessment, remedial action, and options for future land use.

The SLERA will be conducted in accordance with national guidance, including but not limited to the following:

- USEPA. 1997. *Ecological risk assessment guidance for Superfund: Process for designing and conducting ecological risk assessments*. 540-R-97-006. 1997.
- USEPA. 2001b. *The role of screening-level risk assessments and refining contaminants of concern in baseline ecological risk assessments*. EPA 540/F-01/014.

1.3 SLERA STUDY AREA

The Process Areas OU is the area to be evaluated by this SLERA. The horizontal and vertical extent of this study area is defined in the body of the remedial investigation work plan for the Process Areas (Section 2.0).

1.4 SOURCES OF DATA TO BE USED IN THE SLERA

Data from previous investigations and on-going investigations will be included in the SLERA. Use of data from previous and future Process Areas investigations is described in Section 4 of the work plan. Other data sources will be identified in the SLERA report.

The exposure scenarios to be evaluated in the SLERA will be based on a CSM developed specifically for the Process Areas OU. This OU-specific CSM is based on the revised Site-wide CSM (Integral and Brown and Caldwell 2007). The CSM and list of chemicals to be evaluated in the Process Areas will lay the foundation for the exposure and toxicity assessment portions of the risk assessment. The exposure assessment will quantify the potential intake of chemicals for each receptor population via any significant, complete exposure pathways, while the toxicity assessment will provide an estimate of the toxicity of chemicals of potential concern. The final component, the risk characterization, will combine information from the exposure and toxicity assessments to provide estimates of potential risk to wildlife populations.

2 DATA EVALUATION

The objective of the data evaluation is to define appropriate data that are relevant and of acceptable quality for use in the SLERA. The first step is to compile all available data for the OU and select the datasets that are relevant for characterizing OU conditions and assessing potential risks to receptors. Existing data sources that will be considered in the SLERA were identified previously in Section 1.4. The second step is to develop data quality criteria to assess the usability of individual data within these datasets for risk assessment purposes. These quality criteria are introduced in Section 2.1. The third step is to individually evaluate all selected data for use in the SLERA according to those criteria. Once data are evaluated for usability as described in Section 2.2, they will be considered with respect to site-specific habitat conditions, as discussed in Section 2.3. Finally, evaluation of chemical concentrations within the study area with respect to concentrations in background reference areas is discussed in Section 2.4.

2.1 DATA EVALUATION AND SELECTION CRITERIA

Relevant data that meet the established quality criteria outlined in the Site Quality Assurance Project Plan (QAPP) (ESI and Brown and Caldwell 2007) will be considered for use in the risk assessment. Data will be evaluated according to Guidance for Data Usability for Risk Assessment (USEPA 1992b), which provides minimum data requirements to ensure that data will be appropriate for risk assessment use. The guidance addresses the following primary issues pertinent to assessing data quality for risk assessment:

- Data sources—Evaluate the type of data collected (e.g., screening data, fixed laboratory data, etc.) and whether quality assurance/quality control (QA/QC) samples are available for the data to provide data quality information.
- Consistency of data collection methods—Evaluate sample collection methods for appropriateness for the chemical, media, and analysis; review field logs to assess quality of sample collection; and determine whether sample collection differs between sampling events and investigations.
- Analytical methods and detection limits—Evaluate methods for appropriateness and sensitivity and determine if detection limits are low enough for risk-based screening; evaluate results with elevated detection limits for relevance.
- Data quality indicators—Review data validation reports for data quality issues.
- Background samples—Assess whether appropriate quantity and location of background samples were collected.

Acceptable samples will be those collected according to approved sampling plans. When it is necessary to deviate from the sampling plan, those deviations will be documented and justified.

QA/QC samples, including field duplicates, equipment rinsate blanks, and laboratory method blanks and spikes will be evaluated to ensure that samples prepared in the field or laboratory provide data quality information.

All laboratory analytical data considered for use in the risk assessment will be reviewed and validated in accordance with the USEPA Contract Laboratory Program National Functional Guidelines for Inorganic Data Review (USEPA 2002a), as described in the Site QAPP (ESI and Brown and Caldwell 2007).

The adequacy of the available background data will be assessed as discussed in Section 2.4.

2.2 RISK ASSESSMENT DATA SELECTION CONSIDERATIONS

This section describes how the analytical results from the datasets will be evaluated and selected for the risk assessment. Specifically, the treatment of detected and undetected results, data qualifiers, duplicate and split samples, and elevated detection limits is described.

2.2.1 Detected Analytical Results

Detected results may be qualified because of QA/QC problems encountered during the laboratory analysis and identified during the validation process. These problems are typical with site investigation data and are usually associated with chemical identity and/or concentration (USEPA 1998).

Data qualifiers are described in detail in the QAPP and are briefly discussed here as they relate to use of the data. The “J” qualifier indicates that the chemical identity is certain, but the concentration is estimated by the laboratory. Because of a high degree of certainty in the identity of the chemical, all results flagged with a J qualifier will be included in the quantitative risk assessment and statistical analyses for the remedial investigation. However, inclusion of estimated concentrations adds uncertainty to the risk assessment results.

All results flagged with “R,” indicating rejection of the data during the data validation process, will be excluded from the SLERA.

SLERA guidance recommends use of the highest measured or estimated contaminant concentration for each analyte and medium for comparison to screening level values (USEPA 1997). All usable data, as described in Section 2.1, will be evaluated for each medium and analyte to determine the maximum detected value for use in the SLERA.

2.2.2 Non-Detected Data

Non-radiochemical results that are flagged with a “U” qualifier will be reported as “<X”, where “X” is the method detection limit (MDL). If an analyte is not detected in any samples for a particular medium, then it will be assumed that the chemical is not present in that medium at the site, and the chemical will be dropped from further consideration in the risk assessment. For calculation of media concentrations, results flagged with a “U” qualifier generally will be assumed to be present at one-half of the MDL. The MDL is the lowest concentration that can be seen above the normal “noise” associated with the analytical method (USEPA 1998).

2.2.3 Treatment of Radiochemical Data

For radiochemical analyses, results not rejected during data validation will be retained for use in the risk assessment. This includes results that are less than the sample-specific minimum detectable activity (MDA), including zero and negative results. The results, associated measurement error, and sample-specific MDA data will be retained, per the QAPP (ESI and Brown and Caldwell 2007).

2.2.4 Treatment of Duplicate Samples

As part of the quality assurance process, field duplicates will be collected with a subset of investigative samples. Results of duplicate analyses will be compared to investigative samples as part of the QA/QC evaluation (ESI and Brown and Caldwell 2007). Following this comparison, duplicate analyses will not be included in the risk assessment; only investigative samples will be included in the risk assessment database. This practice is consistent with the QAPP (ESI and Brown and Caldwell 2007).

2.2.5 Treatment of Split Samples

Split samples may be collected by EPA during the various sampling events. Only one result, either investigative or split, will be selected for each analyte for a given sample. Pairs of split sample results will not be averaged, due to the potential for inter-laboratory differences (e.g., equipment differences, differing detection limits) that could affect the comparability of the results. If split sample results are available at the time the SLERA is being conducted, a decision framework for evaluating split samples will be developed in consultation with EPA. The impact of including split sample results that are not in agreement with one another will be addressed in the uncertainty analysis.

2.3 ECOLOGICAL CONSIDERATIONS FOR CATEGORIZING DATA

Although ecological investigations to characterize the ecological habitat in the Process Areas OU have not yet been conducted, it is likely that the distribution of habitat in the Process Areas is heterogeneous in both current and future potential land use scenarios. Patchy distribution in turn influences the opportunities for exposure to contaminants, as exposure will likely be concentrated in areas with appropriate habitat (e.g., vegetated areas, artificial structures providing opportunities for nesting, and noncompacted soils that provide opportunities for invertebrate infauna and/or burrowing wildlife). Pending the results of ecological investigations to characterize habitat distribution, methods including spatial weighting of results or evaluation of subsets of data concentrated in ecological habitat may be used to evaluate how risks may change depending on the exposure area evaluated.

2.4 EVALUATION OF BACKGROUND CONCENTRATIONS

The term “background” refers to substances present in the environment that are not influenced by releases from the site under investigation and that are either naturally occurring or anthropogenic (USEPA 2002b). Naturally occurring substances are those present in the environment in forms that have not been influenced by human activity. Anthropogenic substances are those chemicals, whether natural (e.g., metals) or human-made, present in the environment as a result of human activities but not specifically related to the site in question.

The term “reference” generally refers to a relatively uncontaminated area that is suitable for sampling to evaluate background chemical concentrations. Such areas are typically identified as “background reference areas” (USEPA 2002b). According to EPA’s (2002b) *Guidance for Comparing Background and Chemical Concentrations in Soil for CERCLA Sites*, a background investigation is appropriate when certain chemicals that pose risks and may drive an action are believed to be attributable to background. In addition, EPA (1998) states:

It is imperative to select, collect, and analyze an appropriate number of background samples to be able to distinguish between onsite sources of radionuclide contaminants from radionuclides expected normally in the environment.¹

Soil and surface water samples from multiple background reference areas have been and will be collected throughout the environmental investigations to differentiate the natural or anthropogenic background concentrations of the chemicals analyzed from those associated with releases at the Site. Background samples will be analyzed, depending on the investigation, for metals and radiochemicals. General procedures for evaluating and selecting the background dataset for use in this risk assessment will be identical to those for Site data, as described above in Section 2.2, and will be consistent with procedures outlined in the Process Areas Work Plan.

¹ n.b. – The term “radiochemical” is technically more accurate than “radionuclide” and is used throughout this SLERA work plan.

To make appropriate comparisons between background reference and Process Areas chemical data, the statistical distribution of concentrations of chemicals from site-specific background samples will be characterized consistent with EPA guidance (2002b) and the Process Areas Work Plan. The site-specific background reference datasets will be evaluated to determine whether they fit normal, lognormal, or other distributions. Additional discussion of the use of the background datasets will be provided in the SLERA report.

3 SCREENING LEVEL PROBLEM FORMULATION

This section describes known and potential unconfirmed sources of chemicals in the Process Areas, chemical release mechanisms, chemical transport pathways, mechanisms of ecological toxicity and potentially affected receptors, the completeness of exposure pathways to these receptors, and assessment and measurement endpoints. The Site-wide chemical sources, release mechanisms, transport pathways, and potential routes of human exposure are summarized in the Process Areas CSM (Section 3.6).

One of the purposes of the SLERA is to determine which, if any, of the potential routes of ecological exposure may be complete now or in the future. This determination is made according to whether an exposure pathway contains the following elements (USEPA 1998):

- A source and mechanism for release of constituents
- A transport or retention medium
- A point of potential receptor contact (exposure point) with the affected medium
- An exposure route at the exposure point.

If any one of these elements is missing, the pathway is not considered complete and exposure will not occur. For example, if receptor habitat requirements and/or the location of potentially exposed receptors relative to the location of an affected exposure medium prevent contact or proximity for external radiation sources then that exposure pathway is not complete. Similarly, if a pathway to contact was initially considered in the CSM but no chemicals in the environmental medium at the point of contact are identified, the pathway is incomplete and is not carried further into the screening level ecological risk assessment.

3.1 POTENTIAL SOURCES AND RELEASE MECHANISMS

A detailed discussion of historical mining and milling operations, structures and conveyances, and chemical releases associated with past operations is provided in Sections 2.1 and 2.2 of the Process Areas Work Plan. A brief summary of potential releases of chemicals to the environment includes:

- Spilling of sulfuric acid precipitation solution—Acid may have spilled during filling or circulation via piping and pumps within the precipitation plant area as well as during transfer of spent solutions to the acid plant. Also, spent solutions may have been released via the dump leach recirculation sump.
- Leaching of spent solutions from dump leach surge pond—Spent leach solutions were stored in the dump leach surge pond. Solutions may have been released to soils through infiltration of cracks or penetrations in the pond liner.

- Leaching of spent solution from calcine washing—Spent solution was used to wash calcines via the calcine ditch to the evaporation ponds. Solids and liquids washed down this ditch were deposited in the ponds but also likely were deposited along the ditch. Liquids may have evaporated and/or leached into ditch and pond soils.
- Releases of motor and fuel oil and gasoline—Spills of oils and fuels may have occurred during fueling of mine work vehicles via the mobile fueling truck and during maintenance of work vehicles. Maintenance activities may have also included the use of degreasers and soaps that could have infiltrated soils. Also, releases may have occurred via the floor drain located in the Truck Shop. Wash waters and drains may have drained to the Upper and Lower Truck Sludge Ponds.
- Leaks or spills from oil and fuel storage tanks—Under- and aboveground storage tanks were used to store oil and fuel. Leaks from tanks and at filling stations may have occurred over time, and spills may have occurred during filling operations where tanks were or are located.
- Releases of laboratory materials—A drain line that leads to a dry well is portrayed on historical maps of the on-site laboratory. Releases of laboratory materials may have occurred via this line.
- Leaks from stored materials—Stored lubricants, oils, solvents, and transformers may have leaked in cases where the integrity of the containers or equipment was compromised.

3.2 CONTAMINANT FATE AND TRANSPORT PATHWAYS

Chemicals resulting from mining activities may originate from the various source areas within the Process Areas OU. Transport mechanisms for chemicals from primary impacted media to secondary and tertiary impacted media are depicted in the Process Areas CSM (Figure 3-1). Potential exposure media for the ecological model include:

- Ambient air
- Surface and subsurface soil (surface soil is defined as soil found from ground surface to 2 feet below ground surface (bgs); subsurface soil is found from 2 to 10 feet bgs)
- Surface water (ephemeral pooled waters)
- Vapors in indoor air/burrows.

As shown in Figure 3-1, chemicals associated with activities in the Process Areas may be released directly to surface soils or, in the case of below-ground structures such as piping, underground storage tanks, and conveyances, to subsurface soils. In addition, surface water runoff from upgradient areas, in association with rain or snowmelt, may also release contaminants to surface soils. Leaching of chemicals into subsurface soils also is identified as a

potential release mechanism. Erosion of soil surfaces in the Process Areas due to surface water runoff (e.g., stormwater or snowmelt events) also may result in transfer and deposition of chemicals in exposed surface soil to other, downgradient areas. These snowmelt and rain events can lead to the formation of temporary pools of water in low-lying areas of the Process Areas, and contaminants may accumulate in these areas as a result of deposition and evapoconcentration.

Infiltration of meteoric water (as precipitation) containing leached chemicals may provide a link between identified potential sources and groundwater. However, groundwater in the Process Areas is located at depths of greater than 95 feet bgs, which is below the depth to which ecological receptors may be expected to be exposed (Integral and Brown and Caldwell 2007 and Section 3.3 of this SLERA) and is therefore not considered a complete ecological exposure pathway for this OU.

The presence of natural or artificial physical barriers, such as vegetation or concrete slab foundations, will inhibit or reduce the transport of particles as wind-blown dust. Particulates or fugitive dust transported by wind may be deposited and accumulated in downwind areas within as well as beyond the boundaries of the Process Areas OU.

Horizontal and vertical migration of volatile or gaseous chemicals (fuel-related compounds and radon) that subsequently migrate upward and are released to ambient air may contribute to attenuation of chemicals in subsurface soil. Vapor migration is influenced by chemical and physical properties of the soil and of each individual chemical. It will be considered if volatile chemicals are measured in subsurface soil within 10 feet bgs, consistent with the expected burrowing depth of fossorial ecological receptors that may be present at the Site (Integral and Brown and Caldwell 2007).

In addition to migration of chemicals from their sources to other media, radiation may exist anywhere that radiochemicals may accumulate in soils or water. Transport of the material may occur by any of the transport pathways described above. Exposure to external radiation is limited to materials within the upper 6 inches of soil thickness; radiochemicals found below this level are shielded by the top layer of soil (Cember 1996). Geometric attenuation limits the external radiation from materials with no interposed shielding materials to within a few meters, typically less than 5 m and often less than 1 to 2 m from the source (Cember 1996).

3.2.1 Potentially Complete Exposure Routes

This section describes in general terms the likely routes of exposure of plants and animals to chemicals at the Site. Routes of exposure include:

- Respiration/inhalation
- Dermal contact/uptake

- Ingestion
- Trophic transfer
- External radiation exposure.

These routes of exposure are discussed further in the following subsections.

3.2.1.1 Respiration/Inhalation

Respiration is a potentially complete pathway for invertebrates by passive exchange of air and for vertebrates by inhaling airborne particulates or volatilized chemicals. Volatile chemicals are not expected to be present in surface soil in meaningful concentrations for risk, so inhalation of vapors in outdoor air is not a complete pathway. Inhalation is generally considered a relatively minor pathway for exposure relative to direct ingestion by wildlife of chemicals of concern. For example, the USEPA (2005) did not use inhalation of soil particles in deriving the national ecological soil-screening levels, because exposure is accounted for by the soil-ingestion route. An evaluation of risk to receptors via the inhalation pathway may be warranted, however, in cases where volatile organic compounds (VOCs) are expected site chemicals and pathways of exposure are complete. Two possible pathways for inhalation are 1) the potential for volatilization of chemicals and exposure to burrowing animals in subsurface soils, and 2) the potential for volatilization of chemicals in indoor air and exposure to animals inhabiting artificial structures. Given that volatile chemicals are expected to occur in the Process Areas OU, and that receptors that may be present at the site include burrowing animals and those that use artificial structures for roosting or denning, inhalation of volatile chemicals are considered as a potential pathway of exposure.

3.2.1.2 Dermal Contact/Uptake

Plants can accumulate chemicals through direct deposition on their leaves from particulates in air and uptake from the soil via their roots. The former pathway is not expected to be a substantial source of exposure to the plant itself, as the majority of chemical uptake by a plant is accomplished through its root system. The potential for chemicals to accumulate in plants is affected by the specific properties of the chemical, the soil physical/chemical properties, and biophysical properties of the plant. For example, large-molecular-weight chemicals (e.g., dioxins, polychlorinated biphenyls [PCBs]) have a low potential to be taken up by the roots of plants.

Many animals are equipped with protective outer coverings that reduce or prevent the absorption of environmental chemicals.² For this reason, dermal exposure is usually considered a less important pathway than oral ingestion in accounting for exposure to contaminants

² For example, the hardened exoskeleton of many invertebrates, the fur of mammals, the feathers of birds, the scales of reptiles.

(USEPA 2001a). In developing soil screening levels, USEPA (2001a) indicates that conditions likely to increase contact with soil and therefore potential exposure to chemicals include:

- Species with little or no fur or feathers
- Species that spend long periods of time exposed to soil (i.e., in burrows)
- Where the contaminants of concern may be significantly more toxic via the dermal pathway compared to the oral pathway (e.g., some pesticides)
- Where dermal exposures may be substantially higher compared to oral exposures (i.e., pesticides applied directly to trees or soil surfaces).

For the Process Areas, the dermal exposure route is potentially complete for a variety of ground-dwelling animals, especially for infaunal invertebrates and burrowing mammals (pocket gopher and shrew) that live predominantly within the soil. However, the dermal route of exposure is not considered significant and will not be quantified for these receptors because trace metals have a low potential for dermal uptake or dermal toxicity and because pesticides or other organic compounds that have a high potential for dermal uptake or dermal toxicity are not likely to be present at elevated levels (USEPA 2001a).

Dermal exposure to airborne particulates is not a complete pathway for animals. Dermal contact with airborne particulates is expected to occur primarily via contact with surface soil or surface water onto which particulates have settled and is addressed in exposure routes associated with those media.

Dermal exposure to surface water is expected to be limited to those receptors that come to surface water bodies to drink. Because surface water in the Process Areas is limited to ephemeral pooled bodies of water, the periods of availability and dermal exposure are expected to be brief. Therefore, this pathway is considered potentially complete for some receptors, but insignificant.

3.2.1.3 Direct Ingestion

Direct ingestion of chemicals and absorption via the alimentary canal is an important route of exposure for biota. Invertebrates can ingest soil and sediment directly while burrowing or foraging. Mammals and birds can ingest soil directly while foraging and cleaning their fur or feathers (Beyer et al. 1994). While some terrestrial receptors (e.g., jackrabbits, gophers and shrews) derive most if not all of their water through their prey, others, such as deer and coyote, may regularly seek out surface water to drink and therefore may be exposed to chemicals in the surface water medium. Ephemeral pooled waters that form in the Process Areas in association with precipitation or snowmelt events may provide a temporally brief but potentially complete pathway of exposure to receptors that seek out surface water for drinking.

3.2.1.4 Trophic Transfer

Trophic transfer refers to chemical exposure via consumption of other plants or animals. Any animal that eats another plant or animal that contains chemicals of concern in turn has the potential to be exposed to those chemicals of concern. The extent to which trophic transfer occurs depends on a number of factors, including the exposure of lower trophic level plants or prey to chemicals of concern, their ability to bioaccumulate those chemicals, the extent to which those chemicals are partitioned in their tissues and which parts are eaten by the higher trophic level consumer.. Trophic transfer may be of particular importance for hydrophobic, bioaccumulative chemicals like PCBs or DDT that are not readily metabolized or eliminated and may biomagnify in higher trophic level consumers. Consequently, the receptors of interest in the CSM (Figure 3-1) represent a variety of trophic guilds³ and trophic levels.

Exposure to airborne particulates via trophic transfer for all receptors is considered a potentially complete but insignificant pathway for all receptors, because direct contact of airborne particulates with vegetation and inhalation exposure routes from airborne particulates to potential prey for this medium are considered insignificant pathways (see discussion above).

3.2.1.5 External Radiation Exposure

Plants and animals can receive an external radiation exposure from the materials in the vicinity of the receptor for extended periods of time. Plants may receive an external exposure from radiochemicals in the surface soils and/or in deeper soils comprising the plant's root zone. For animals, external exposure from surface soils may occur for animals that burrow, roost, sleep, or otherwise routinely inhabit an area in close proximity to the soil. Surface waters may be a source of external exposure to aquatic plants and animals, and migrating waterfowl that are in or on the water for significant periods of time. Although a potentially complete exposure pathway, external exposure in general is a minor contributor to a receptor's overall radiation dose and therefore is represented as a potentially complete but insignificant exposure route for all media and all receptors.

3.2.2 Mechanisms of Ecotoxicity and Potentially Affected Receptors

The ecological conceptual site model (Figure 3-1) uses known or expected ecological relationships of flora and fauna at the Site to present a suite of potential receptors that are representative of the various trophic guilds within the biological communities and that have the potential to be exposed to chemicals of concern in the Process Areas OU by the pathways described above. The ecological communities expected in the vicinity of the Site from which these representative receptors are chosen are discussed in the Site-wide CSM (Integral and Brown and Caldwell 2007).

³ A trophic guild consists of a group of related species or taxa that exploit similar food resources.

This section discusses the receptors chosen to represent trophic guilds of the biological communities of the Process Areas OU and the exposure pathways relevant to each guild. Terrestrial receptors are expected to be associated with limited areas of the Process Areas that contain vegetation and/or cover. These areas include fringe habitat at the margins of the Site, and abandoned or lightly used artificial structures that may serve as nesting or roosting habitat for some species. Aquatic receptors (aquatic plants, invertebrates, waterfowl) are not expected in the Process Areas, where pooled waters may serve as a temporary drinking water source for some terrestrial receptors, but these waters are expected to be too ephemeral to provide aquatic habitat. For consistency with the Site-wide CSM (Integral and Brown and Caldwell 2007), aquatic receptors, including aquatic invertebrates, Canada goose, and eared grebe, have been retained in the CSM (Figure 3-1); however, given the lack of aquatic habitat within the Process Areas, these receptors are not associated with any complete exposure pathways. In addition, barn swallow is a receptor in the Site-wide CSM but is not presented in the Process Areas CSM. This receptor is associated primarily with foraging on emergent aquatic insects, which is not considered a complete exposure pathway for the Process Areas OU. For the Process Areas, therefore, the barn swallow was replaced by a bat (*Myotis* spp.) to represent aerial invertivores.

3.2.3 Plants

Plants are separated into two terrestrial types because different exposure media and pathways are important for these groups.

Forbs and grasses are herbaceous annual and perennial plants that are consumed by a variety of herbivorous and omnivorous animals of the sagebrush-steppe habitat. Median rooting depth for forbs and grasses in arid conditions with approximate 125 mm (5 inches) of mean annual precipitation is less than 0.5 m (1.6 foot) of soil (Schenk and Jackson 2002). Complete exposure routes for terrestrial forbs and grasses include:

- Dermal contact with airborne particulates
- Dermal contact with and uptake from surface soil
- Absorbed external radiation via surface soil.

Woody plants are perennial plants that continue to add to their above-ground growth in successive years. These plants tend to be somewhat less palatable and therefore less preferred by some herbivores relative to forbs and grasses. This category includes sagebrush, rabbitbrush, bitterbrush, and similar woody shrubs. In general, woody plants in semi-arid conditions have deeper rooting depths than the grasses and forbs (Schenk and Jackson 2002). Median rooting depth for shrubs and semi-shrubs in arid conditions, with approximate 125 mm (5 inches) of mean annual precipitation is less than 1.5 m (5 feet); although some shrubs may have maximum root depths of 5 m (16.5 feet). Complete exposure pathways for woody plants include:

- Dermal contact with airborne particulates
- Dermal contact with and uptake from and surface and subsurface soil
- Absorbed external radiation via soil and subsurface soil.

3.2.4 Invertebrates

Terrestrial invertebrates are divided into epifauna that live at the surface (e.g., grasshoppers, many spiders, true flies), and infauna that live some or all of their life cycle underground (e.g., some spiders, ants, beetle larvae). Complete exposure pathways for epifaunal invertebrates include:

- Inhalation of airborne particulates
- Direct contact with surface soil
- Incidental ingestion of surface soil while consuming food
- Trophic transfer by consuming vegetation or prey that may have been exposed via surface soil and airborne particulates
- Absorbed external radiation from surface soil.

Although many infaunal invertebrates live in the first several inches of soil below ground, some species that may be present in the area can have much deeper burrows. For example, several species of ants in the Great Basin-Mojave desert ecosystem are known to have burrows extending a meter or more in depth (Jensen and Hooten 2000). Complete exposure pathways for infaunal invertebrates include:

- Inhalation of airborne particulates
- Direct contact with surface and subsurface soil
- Incidental ingestion of surface and subsurface soil while consuming food
- Trophic transfer by consuming vegetation or prey that may have been exposed via airborne particulates, surface and subsurface soil, and groundwater
- Absorbed external radiation from surface and subsurface soil
- Inhalation of vapor in burrows.

3.2.5 Mammals and Birds: Primary Consumers

Trophic relationships among species can provide insight into many of the ecological processes, particularly with respect to exposure to chemicals via ingestion and trophic transfer exposure routes. Potential bird and mammal receptors of concern for the ecological model were chosen as representatives of feeding guilds likely to be present at the Site. Primary consumers include

birds and mammals that feed primarily on vegetative matter. Feeding guilds include browsers and granivores/herbivores.

Browsers feed on a range of woody and herbaceous vegetation. Mule deer and jackrabbit were chosen as representatives of this feeding guild. Both species will consume green, leafy vegetation when it is available, such as forbs and grasses but will readily switch to woody plants particularly in the drier months when forbs and grasses are not as abundant. Jackrabbits do not create deep burrows, but they may create shallow depressions in the first few inches of soil for thermoregulation and cover (Reid 2006). Complete exposure routes for mule deer include:

- Inhalation of airborne particulates.
- Direct contact with surface soil. Opportunities for direct contact with soil are likely limited to resting periods so this pathway is considered potentially complete but insignificant.
- Direct ingestion of ephemeral pooled surface water and incidental ingestion of surface soil while consuming food.
- Trophic transfer by consuming vegetation that may have been exposed via airborne particulates, surface soil and subsurface soil.
- Absorbed external radiation from surface water and surface soil.

Complete exposure pathways for jackrabbit include:

- Inhalation of airborne particulates
- Direct contact with surface soil
- Incidental ingestion of surface soil while consuming vegetation
- Trophic transfer by consuming vegetation that may have been exposed via airborne particulates, surface soil and subsurface soil
- Absorbed external radiation from surface soil

Granivores/herbivores feed on a combination of herbaceous vegetation, including stems, leaves, and seeds of plants. A bird and a mammal were chosen to represent vertebrate taxa in this feeding guild.

Chukar, a ground-nesting bird that has been observed on the Site, eats a combination of seeds and herbaceous plants, and may seasonally incorporate insects in its diet. Complete exposure pathways for chukar include:

- Inhalation of airborne particulates.

- Dermal contact with surface soil. Opportunities for direct contact with soil are likely limited to resting periods so this pathway is considered potentially complete but insignificant relative to other routes of exposure.
- Direct ingestion of ephemeral pooled surface water (chukar may ingest surface water at least seasonally [RRCIA 2007]) and incidental ingestion of surface soil while consuming food.
- Trophic transfer by consuming vegetation that may have been exposed via airborne particulates, surface and subsurface soil. Because the diet of the chukar is primarily forbs and grasses that are not typically exposed to deep (>3 feet) subsurface soils (Seattle Audobon Society 2007), the subsurface soil trophic transfer pathway are considered potentially complete but insignificant.
- Absorbed external radiation from surface soil.

Pocket gophers were chosen as a mammalian representative of the granivore/herbivore feeding guild; these small mammals eat a variety of above- and underground plant materials and create burrows that extend from 18 inches to as deep as 6 feet below the surface (CDTS 1998).

Potentially complete pathways for pocket gophers include:

- Inhalation of airborne particulates
- Direct contact with surface soil and subsurface soil
- Direct ingestion of surface and subsurface soils incidental to consuming food
- Trophic transfer by consuming vegetation that may have been exposed via airborne particulates, surface soil and subsurface soil
- Absorbed external radiation from surface and subsurface soil
- Inhalation of vapor in burrows.

3.2.6 Birds and Mammals: Secondary Consumers

Secondary consumers feed primarily on animal matter. Feeding guilds include invertivores, rodentivores, and predators/scavengers.

Invertivores obtain most of their energy through the consumption of insects and other arthropods. A bird (killdeer) and two mammals (a shrew and a bat) displaying a variety of nesting and feeding strategies were chosen to represent this feeding guild.

Killdeer are primarily upland birds that forage primarily at the soil surface on a wide variety of terrestrial invertebrates. Complete exposure pathways for killdeer include:

- Inhalation of airborne particulates

- Dermal contact with surface soil
- Ingestion of surface soil incidental to consuming food
- Trophic transfer by consuming prey that may have been exposed via airborne particulates, surface soil and subsurface soil
- Absorbed external radiation from surface soil.

Several species of insectivorous *Myotis* bat live in desert scrub habitats, including those in the Great Basin. *Myotis* bats often reside in either small groups or alone in buildings, shutters, and other artificial structures. These nocturnal bats feed nightly on flies, beetles, spiders and small moths, and are most likely preyed upon by owls, snakes, and other mammals (Harris 2002).

Complete exposure pathways for *Myotis* bats include:

- Inhalation of airborne particulates
- Trophic transfer by consuming prey that may have been exposed via airborne particulates, surface soil and subsurface soil
- Inhalation of vapors in indoor air.

Merriam's shrew is an insectivore that inhabits the sagebrush-steppe habitat of the Great Basin. This small, aggressive mammal is typically found under cover of vegetation and may use the burrows of other rodents. Shrews are rarely eaten by mammalian predators because they have distasteful scent glands, although snakes and owls may prey on them. Complete exposure pathways for shrew include:

- Inhalation of airborne particulates.
- Dermal contact with surface soil and subsurface soil.
- Ingestion of surface and subsurface soil incidental to consuming food.
- Trophic transfer by consuming prey that may have been exposed via airborne particulates, surface soil and subsurface soil
- Absorbed external radiation from surface and subsurface soil.
- Inhalation of air in burrows. Shrews are not primarily fossorial, but they will opportunistically use burrows of other rodents, so this pathway is considered complete but insignificant.

Rodentivores primarily consume rodents. The kit fox, which has been observed at the Site, eats a variety of rodents, including pocket gophers, mice, and kangaroo rats; they may also prey on ground-nesting birds and occasionally consume berries. Complete exposure pathways for the kit fox include:

- Inhalation of airborne particulates

- Dermal contact with surface soil, subsurface soil (when denning or digging for prey) and ephemeral pooled surface water
- Direct ingestion of ephemeral pooled surface water and ingestion of surface and subsurface soil incidental to consuming food
- Trophic transfer by consuming prey that may have been exposed via airborne particulates, surface soil, subsurface soil, and surface water
- Absorbed external radiation from surface soil, subsurface soil, and surface water.

Predators/scavengers: Several top predators, including many raptors, canids, and felids, are predators and opportunistic scavengers and omnivores. The coyote was chosen to represent this group, as the coyote's diet in the Great Basin ecosystem is focused largely around small mammals, but also incorporates a wide range of other foods, including human garbage, carrion, and invertebrates. Complete exposure pathways for the coyote include:

- Inhalation of airborne particulates
- Dermal contact with surface soil, subsurface soil (when denning⁴) and ephemeral pooled waters
- Direct ingestion of ephemeral pooled surface water and ingestion of surface soil incidental to consuming food
- Trophic transfer by consuming prey that may have been exposed via airborne particulates, surface soil, subsurface soil and surface water
- Absorbed external radiation from surface soil, subsurface soil and surface water.

3.3 ASSESSMENT AND MEASUREMENT ENDPOINTS

Assessment endpoints are explicit expressions of the environmental value that is to be protected, operationally defined by an ecological entity and its attributes (USEPA 1998).

Assessment endpoints need to be ecologically relevant, susceptible (as defined by exposure and sensitivity), and relevant to management goals for the site. Each assessment endpoint is framed as a risk statement, with associated measurement attributes, including measurement of exposure and measurement of effects. Initial assessment endpoints proposed for the Process Areas SLERA include:

⁴ Coyotes, like kit fox, may use underground dens and may potentially be exposed to subsurface soil in association with this activity; however, unlike kit fox, coyote do not tend to dig for their prey (UMMZ 2007a) and therefore predation is not viewed as a potential mechanism for ingestion exposure to subsurface soil for this receptor.

- Viability of the avian and mammalian wildlife community⁵: Are concentrations of chemicals and radiochemicals of concern present in on-site media sufficient to adversely affect any of the birds and mammals within the Process Areas OU?
- Viability of terrestrial plant and terrestrial invertebrate communities: Are concentrations of chemicals and radiochemicals of concern present in on-site media sufficient to adversely affect plants and invertebrates within the Process Areas OU?

Two kinds of measurements will be used to evaluate each of these assessment endpoints:

- Measurements of Exposure: Determine concentrations of site-related chemicals and radiochemicals in on-site matrices of the Process Areas OU.
- Measurements of Effects: Determine if maximum concentrations of site-related chemicals and radiochemicals exceed screening level values that are protective of survival, growth, and reproduction of the exposed receptors.

3.4 PROCESS AREAS CONCEPTUAL SITE MODEL

Sections 3.1 through 3.4 have described the chemical sources and transport mechanisms, exposure media and routes, and representative ecological receptors for the Process Areas OU. A conceptual site model diagram depicting these processes, pathways and relationships is provided in Figure 3-1.

⁵ Viability refers to the maintenance of sufficient survival, growth, and reproduction rates to sustain species populations typical of the area. Community is defined as an assemblage of interacting species within a geographic area.

4 SCREENING LEVEL ECOLOGICAL EFFECTS EVALUATION

The ecological effects evaluation provides a method for linking concentrations of contaminants to ecotoxicological effects on receptors. Section 4.1 discusses the selection of toxicity data, Section 4.2 discusses dose conversions and substitutions used in the effects evaluation, Section 4.3 presents screening level values for relevant media and exposure pathways, and Section 7 discusses uncertainties associated with the effects evaluation.

4.1 SELECTION OF TOXICITY DATA

The results of the screening level problem formulation will be used to develop a screening-level exposure estimate and risk calculations. Aqueous and soil exposure concentrations will be compared with eco-toxicity SLVs. This comparison will provide the basis for eliminating from further comparison contaminants and exposure pathways that pose negligible risks, and identify whether exposure pathways and contaminants of concern exist that suggest the need for additional site management options.

Consistent with USEPA (1997) guidance, ecotoxicological screening values should be no-observed adverse effects levels (NOAELs) for chronic exposure to a contaminant. SLVs will be developed for soil and surface water matrices and additional parameters consistent with Site-related receptors and exposure conditions. For soils, conservative SLVs will be identified as a point of departure and further refined consistent with receptors that are present at the site and which may be exposed to soil as a result of foraging behavior. For water, conservative wildlife SLVs developed by Sample et al. (1996) are used as an initial point of departure in this Work Plan to: 1) place existing data in a wildlife framework; and 2) to preliminarily identify chemicals of interest for potential avian and mammalian receptors. Eco-toxicity SLVs will also be evaluated for use in modeling risk of inhalation of VOCs by burrowing ecological receptors that may be exposed to volatile compounds in burrow air. Finally, guidance establishing threshold acceptable radiochemical doses to ecological receptors will be used as a starting point for evaluating exposure of ecological receptors to radiochemicals that may be present in the OU.

4.2 DOSE CONVERSIONS

For some data reported in the literature, conversions are necessary to allow the data to be used for species other than those tested or for measures of exposure other than those reported. In Section 4.3, toxicity reference value (TRVs) used as a basis for calculating threshold levels of contaminants in Site media were expressed as a dose (units of mg/kg body weight d), so no conversions were necessary. However, supplementary exposure parameters (e.g., food

ingestion rate) used in the development of these calculations necessitated transformations including unit conversion from a wet-weight basis to a dry-weight basis for the food ingestion rate and use of allometric equations to calculate ingestion rate (USEPA 1993). In some cases, exposure parameters were not available for the species in question, in which case the parameter was selected for a similar species using best professional judgment. These dose conversions and substitutions are clearly identified in the tables supporting the development of the screening values.

4.3 SCREENING LEVEL VALUES

The selection and, where appropriate, derivation from toxicity values, of aqueous and soil screening level values for chemicals and radiochemicals are presented in this section.

4.3.1 Soil Screening Level Values for Plants and Terrestrial Invertebrates

Consistent with recommendations from Region 9 EPA, Eco-SSL values (USEPA 2007) were considered as a primary source for use as screening level values. Eco-SSL methods are used to derive risk-based soil screening levels (as mg chemical/kg soil) that are broadly applicable to the evaluation of frequently encountered chemicals of potential ecological concern (COPECs) at hazardous waste sites across the United States. However, Eco-SSLs are available for a limited number of metals, and are unavailable for VOCs and other classes of organic chemicals. Secondary sources of screening level values from the Oak Ridge National Laboratory (ORNL) for plants (Efroymson et al. 1997a) and for soil invertebrates (Efroymson et al. 1997b) were therefore used to supplement the Eco-SSLs. The final list of selected SLVs for plants and invertebrates is presented in Table 4-1.

4.3.2 Soil Screening Level Values for Wildlife

Consistent with recommendations from Region 9 EPA, Eco-SSL Values were considered as a primary source for use as screening level values. Eco-SSL methods are used to derive risk-based soil screening levels (as mg chemical/kg soil) that are broadly applicable to the evaluation of frequently encountered COPECs at hazardous waste sites across the United States.

4.3.2.1 Back-calculation of threshold soil concentrations for wildlife using TRVs

As discussed in Section 4.3.1, Eco-SSLs are available for a limited number of metals, and are unavailable for VOCs and other classes of organic chemicals. In these cases, conservative TRVs were used as a starting point in order to back-calculate to a chemical concentration in soil that is not expected to pose risk to wildlife. Uptake of contaminants by ingestion of biota is not considered as part of the exposure model at this time. This screening-level ecological risk assessment focuses on exposure to the soil and surface water media present in the Process

Areas. In addition, availability of plants and invertebrates, and consumption of biota by receptors at the site, have not yet been quantified and are the subjects of ongoing wildlife investigations as described in this work plan.

Soil screening values are generated by solving for soil concentrations from an exposure equation that defines the hazard quotient. The hazard quotient relates the estimated dose of a contaminant by a receptor via the incidental soil ingestion pathway to a threshold acceptable dose:

$$HQ = \frac{\{S_j \times P_s \times AF_{sj} \times FIR\} + \sum_i^N [B_{ij} \times P_i \times AF_{ij} \times FIR]}{TRV_j} \times AUF \quad \text{Equation-1}$$

Where:

- S_j = Contaminant concentration for contaminant (j) in sediment (mg/kg dry weight)
- P_s = Sediment ingestion as proportion of diet (kg sed dry weight/kg diet dry weight)
- FIR = Food ingestion rate (kg diet dry weight/kg bw/day)
- AF_{sj} = Absorbed fraction of contaminant (j) from sediment (s) (unitless)
- B_{ij} = Contaminant concentration (j) in biota type (i) (mg/kg dry weight)
- P_i = Proportion of biota type (i) in diet (kg biota dry weight/kg diet dry weight)
- AF_{ij} = Absorbed fraction of contaminant (j) from biota type (i) (unitless)
- TRV_j = Toxicity reference value (mg/kg bw/day)
- AUF = Area use factor (unitless).

The following parameters are set to 1:

- HQ , so that the estimated dose is equal to the threshold acceptable dose
- AUF , receptors assumed to reside and forage exclusively within the site
- AF_{sj} , assuming all of the contaminant is absorbed
- AF_{ij} , assuming all of the contaminant is absorbed
- P_i , assuming a single food type for the predator (and therefore a single value for B_{ij})

Given these assumptions, the equation reduces to:

$$TRV_j = FIR (S_j \times P_s + B_{ij}) \quad \text{Equation-2}$$

Where the parameters are assigned using:

S_j = The variable that is solved for, that will yield the screening level for the concentration of contaminant in soil

P_s = Available from USEPA 1993 and Beyer 1994

FIR = Available in USEPA 1993 and USEPA 2005 both for individual species and allometric equations

TRV_j = No observed adverse effects level (NOAELs) based on a hierarchical selection approach.

Consistent with recommendations from Region 9 EPA, TRVs developed for Ecological SSLs (USEPA 2003) were given first priority in calculation of SLVs for the Process Areas. Secondary sources for TRVs were San Francisco Bay Regional Toxicity Reference Values (DeVries 2007), and finally ORNL values (Sample et al. 1996) were used if no Eco-SSL or San Francisco Bay Regional TRVs were available (Table 4-2). NOAELs provide a threshold level at or below which no adverse effect is expected in the receptor, and were available for all three data sets. ORNL NOAELs are based on chronic toxicity endpoints or, if only a subchronic endpoint was available, an uncertainty factor of equal to or less than 10 was applied (Sample et al. 1996).

B_{ij} is defined for bioaccumulation from soil by plants:

For plant uptake from soil, USEPA 2005 provides B_{ij} in two formats:

$$B_{ij} = a * S_j + b \quad \text{Equation-3}$$

$$\ln B_{ij} = a * \ln(S_j) + b \quad \text{Equation-4}$$

Where:

a = slope of relationship in uptake equation,

b = y-intercept of relationship in uptake equation.

Solving for S_j in Equation 2 using Equation 3:

$$S_j = \frac{TRV_j - FIR(b)}{FIR (P_s + a)} \quad \text{Equation 5}$$

Solving for S_j in Equation-2 using Equation-4.

Step 1: Un-transforming Equation-4 yields: $B_{ij} = S_j^a \times e^b$

Step 2: Substituting the un-transformed B_{ij} yields:

$$\frac{TRV_j}{FIR} = S_j \times P_s + (S_j^a \times e^b) \quad \text{Equation 6}$$

This equation can be solved for S_j using Excel's Solver utility, by solving for S_j . Using the solver utility, the left side of Equation 6 (which is known) can be used to solve for the right side (which has the unknown parameter S_j).

Calculated screening level values using these equations are presented in Table 4-3.

4.3.2.2 Representative receptors for calculating threshold soil concentrations

Soil screening level values were calculated for herbivorous avian and mammalian receptors that may occur within the Process Areas. The herbivore feeding guilds were selected because they are directly linked to plant uptake from soils and are likely to have higher exposure via food consumption than higher trophic level carnivores. The available toxicity information was reviewed for surrogate bird and mammal species similar to those that may be present in the Process Areas. Conservative values were selected and screening level values were calculated as described in Section 4.3.2.1 above.

Avian receptors

A potential pathway of exposure to contaminants of concern is by birds visiting the site and consuming soil incidental to foraging for food at the Site. A ground-foraging bird is used for modeling exposure in this case, because it is expected that these birds will forage on food items in close contact with the soil, such as seeds, grasses, and insects, and thus display a high probability for incidental soil ingestion. Chukar was used as the surrogate receptor for this class of organisms.

Mammalian Receptors

For mammals, exposure routes of concern are consumption of terrestrial prey and incidental ingestion of soil while foraging and inhalation in subsurface burrows. For the soil and food ingestion route, mule deer was selected as a surrogate for large mammal receptors, and meadow vole was selected as the surrogate receptors for small mammal receptors. Screening level values were calculated for both of these receptors and the lower of the two was selected for initial site screening (Table 4-4). For the inhalation route, meadow vole was selected as the surrogate receptor for exposure to chemicals in burrows.

Values for wildlife parameters (e.g., food ingestion rate [FIR], Ps) used to support the calculation of soil screening level values are provided in Table 4-5.

4.3.3 Screening Level Values for Wildlife Exposure to Contaminants in Burrows

Contaminants are expected to be present in relatively low concentrations in surface air; therefore, airborne constituents are therefore expected to pose little risk to free-living organisms on or above the ground surface. However, for burrowing wildlife, inhalation of burrow or indoor air containing contaminants, particularly volatile constituents, is potentially a complete contaminant exposure pathway. Vapor-phase contaminants are not prone to bioaccumulation, so the pathways considered for burrow air are limited to inhalation of vapors and does not extend to dietary concerns for wildlife.

A specialized model is presented for inhalation of contaminants. This model is applicable for vertebrate wildlife exposure to contaminants in a confined space, particularly underground burrows.

Soil screening values are generated by solving for soil concentrations from an exposure equation that defines the hazard quotient. The hazard quotient, which relates the estimated dose of a contaminant by a receptor to a threshold acceptable dose, can be expressed as:

$$HQ_{ij,air} = \frac{C_{aj} \times IR_i}{TRV_{ij,air} \times BW_i} \quad \text{Equation 7}$$

Where

C_{aj} = concentration of chemical j in air inside the burrow (mg/m^3)

IR_i = inhalation rate for the fossorial receptor of concern i (m^3/d)

$TRV_{ij,air}$ = Toxicity reference value for chemical j for the fossorial receptor of concern i (mg/kg bw day)

BW_i = body weight of the receptor i (kg)

Consistent with (USEPA 2003) guidance for the calculation of chemical dose via inhalation, a conversion factor was used to relate concentrations of VOCs in burrow air to concentrations in soil:

$$C_{aj} = \frac{C_{sj}}{VF} \quad \text{Equation 8a}$$

Where:

C_{sj} = Concentration of chemical j in soil (mg/kg)
 VF = volatilization factor for 1,1,1-TCA, of 15,000 m³/kg.

Similarly, for non-VOCs:

$$C_{aj} = C_{sj} \times PEF \quad \text{Equation 8b}$$

Where:

PEF = Particulate Emission Factor of 7.6×10^{-10} kg/m³.

Equations 8a and 8b are consistent with the route-to-route extrapolation guidance for moving between oral and inhalation toxicity values provided in EPA's Soil Screening Guidance (USEPA 1996). The equations assume no dispersion and are therefore highly conservative as they are based on assuming continuous exposure to the concentration in the burrow (USEPA 2001a).

Equations 8a and 8b can be substituted into the hazard quotient equation above as:

$$HQ_{ij} = \frac{\frac{1}{BW_i} \times \left(\frac{C_{sj}}{VF} \times IR_i \right)}{TRV_{ij}} \quad \text{Equation 9a}$$

And

$$HQ_{ij} = \frac{\frac{1}{BW_i} \times (C_s \times PEF \times IR_i)}{TRV_{ij}} \quad \text{Equation 9b}$$

Where:

TRV_{ij} = No observed adverse effects level (NOAELs) based on a hierarchical selection approach (in mg/kg bw d).

Selection of appropriate TRVs is described above in Section 4.3.2.1 and summarized in Table 4-2).

These equations can then be solved for a threshold level of contaminant in soil at or below which no effects on ecological receptors are expected, by setting the relationship of dose to TRV to unity (HQ=1), and solving for S_j . For VOCs this solution is:

$$1 = \frac{\left(\frac{C_{sj}}{VF} \times IR_i \right)}{BW \times TRV_j} \quad \text{Equation 10a}$$

And finally

$$C_{sj} = \frac{TRV_j \times BW \times VF}{IR} \quad \text{Equation 10b}$$

And for non-VOCs this solution is:

$$1 = \frac{(C_{sj} \times PEF \times IR_i)}{BW \times TRV_j} \quad \text{Equation 11a}$$

And finally

$$C_{sj} = \frac{TRV_j \times BW}{PEF \times IR_i} \quad \text{Equation 11b}$$

Table 4-3 provides the screening level values calculated for the inhalation pathway for a fossorial receptor using this approach.

4.3.4 Surface Water Screening Level Values

As discussed in Section 3.2, ephemeral pooled waters resulting from snowmelt and runoff events may provide a temporally brief but potentially complete pathway for wildlife that ingests drinking water. ARC has adopted the NOAEL and LOAEL values in Table 4-6 as preliminary SLVs to screen existing aqueous samples for risks to birds and mammals via consumption of water and to facilitate development of this Work Plan.

4.3.5 Screening Level Values for Radiochemicals

Screening level values for radiochemicals are presented in Table 4-7. These screening level values are based on USDOE (2002) guidance for evaluating radiological doses to biota. DOE's graded approach for evaluating radiation doses to biota consists of a three-step process which is designed to guide a user from an initial, conservative general screening to, if needed, a more rigorous analysis using site-specific information. The three-step process includes:

1. Assembling radiochemical concentration data and knowledge of sources, receptors, and routes of exposure for the area to be evaluated.

2. Applying a general screening methodology that provides limiting radiochemical concentration values (i.e., Biota Concentration Guides - BCGs) in soil, sediment, and water.
3. If needed, conducting an analysis through site-specific screening, site-specific analysis, or an actual site-specific biota dose assessment conducted within an ecological risk assessment.

The problem formulation section of this SLERA provides a discussion of Step 1, and the screening level methodology described in Step 2 is applied here using BCGs for terrestrial birds and mammals (Table 4-7), consistent with guidance for SLERA and with USDOE's (2002) recommendation for screening.

5 SCREENING LEVEL EXPOSURE ASSESSMENT

The sources of chemicals in the Process Areas, release and transport mechanisms for chemicals found or thought to exist in the Process Areas, and the media in and pathways by which receptors may contact the chemicals of concern are discussed in the previous sections. The ecological characteristics, or exposure parameters, of the receptors that influence the magnitude and duration of exposure are presented here.

5.1 EXPOSURE PARAMETERS FOR RECEPTORS OF CONCERN

Consistent with the Site-wide CSM (Integral and Brown and Caldwell 2007), potential receptors of concern were identified to represent trophic guilds of animals expected to be present in the ecological communities of the Great Basin sagebrush-steppe ecosystem. Exposure parameters for the receptors evaluated in this SLERA are designed to be conservative so as not to underestimate potential risks to the ecological communities of the Process Areas. Such conservative assumptions include:

- **Area Use Factors** (the ratio of habitat area available to the receptor's estimated home range area): This SLERA assumes that the home range of receptors is entirely within the contaminated area; thus, the animals are exposed 100 percent of the time. This is a conservative assumption. However, the results of the habitat study (Appendix C-1) may provide additional information regarding the proportion of the OU that could support ecological receptors and may be used to refine this assumption. Should a full ERA be conducted for the Process Areas, information from the habitat survey, as well as species- and site-specific home range information would be needed to accurately estimate the percentage of time an animal would use an area.
- **Conservative FIR**: Conservative estimates for food ingestion rates, such as Eco-SSL high-end estimates of FIR (USEPA 2005), were selected when available in order to maximize estimated dose to receptors.
- **Bioaccumulation**: Anticipated Site chemicals include primarily metals and VOCs; therefore, biomagnification via trophic transfer is not expected. If, however, the investigation does reveal the presence of bioaccumulative contaminants of concern, bioaccumulation models will be incorporated into the SLERA and reasonably conservative bioaccumulation factors (BAFs) will be used to assess the potential for transfer of chemicals through the food web.

5.2 MAGNITUDE, DURATION, AND FREQUENCY OF EXPOSURE

Exposure analysis quantifies the magnitude and spatial and temporal patterns of exposure as they relate to the assessment endpoints and risk questions (USEPA 1997). At the level of the screening level ecological risk assessment, the magnitude of exposure is conservatively set by using maximum concentrations for sampled media. Similarly, the duration and frequency of exposure are conservatively estimated by assuming that the AUFs are one and that exposure is continuous (Section 5.1). In addition, conservative assumptions about exposure have been built into the calculation of screening level values by using TRVs that are based on chronic exposures to contaminants (Section 4.3). The degree to which these assumptions affect the risk characterization will be addressed in Section 7.

6 SCREENING LEVEL RISK CHARACTERIZATION

6.1 CALCULATION OF THE HAZARD QUOTIENT

The hazard quotient (HQ) is the ratio of the representative exposure concentration of a COPC in a given medium to a threshold effects concentration of the same constituent in the medium of concern. For a given exposure medium, the HQ is calculated as:

$$HQ = \frac{\text{exposure concentration}}{\text{effects concentration}}$$

Screening level guidance describes a conservative approach in using maximum concentrations for comparison to the threshold effect concentration for a given medium and analyte. Therefore, maximum detected concentrations will be used for comparison to screening level values to calculate analyte-specific hazard quotients.

6.2 CALCULATION OF THE HAZARD INDEX

If there is more than one COPC in a given medium or in multiple media, the hazard index provides an estimation of the potential cumulative effects of multiple contaminants. The summary effects index is the hazard index (HI), and is simply the sum of the HQs for all COPCs in the medium of concern that share a common toxicological endpoint. The mathematical expression for the HI is:

$$HI_j = \sum_i HQ_{i,j}$$

where,

$HQ_{i,j}$ is the receptor-specific HQ for each COPC in medium j

HI_j is the receptor-specific HI for medium j .

6.3 CRITERIA FOR COPEC SELECTION

Screening for the selection of COPECs will follow a process that includes:

1. Using validated analytical, maximum detected chemical concentrations in the medium of interest are compared to screening concentrations as described above.
2. For naturally occurring chemicals, concentrations in the Process Areas will be compared to concentrations in the background chemical data set.

3. For chemicals exceeding screening values and/or background area concentrations, an evaluation of the frequency and distribution of threshold exceedences will be performed, including the following specific criteria:
 - a. Chemicals not exceeding screening values ($HQ < 1$) will not be carried forward as COPECs unless they share a common toxicity endpoint with other chemicals and collectively exceed an $HI = 1$, in which case all will be re-evaluated in a more detailed SLERA or in the BERA.
 - b. If a chemical concentration is greater than the screening benchmark, but is not significantly different from background concentrations, the chemical will not be carried forward as a COPEC.

7 UNCERTAINTY ASSESSMENT

An uncertainty analysis is an important part of risk estimation, and includes summarizing the uncertainties identified during all phases of the risk assessment, evaluating the impact of those uncertainties on the risk assessment, and identifying (to the extent possible) actions that could reduce uncertainty. USEPA (1992a; 1998) identifies four overlapping areas where uncertainty could occur:

- The CSM—assumptions are made regarding stressor effects, impacted environment selection, and target species selection.
- Site information and data—in the absence of information or data necessary to conduct the risk assessment (e.g., characteristics of the physical or biological environment), assumptions may be necessary.
- Natural Variability—natural variability is a basic characteristic of stressors, receptors, habitat, and other factors influencing the distribution of ecological components; thus, uncertainty resulting from natural variability can be acknowledged and described but not reduced.
- Error—errors can be introduced during any phase of the investigation, including design, sampling, and analysis.

Uncertainties may be evaluated qualitatively and quantitatively. An evaluation of uncertainties will be provided in the SLERA report, including a table identifying specific factors that may result in an over- or under-estimation of risks.

8 SUMMARY AND RISK MANAGEMENT RECOMMENDATIONS

The results of the SLERA for the Process Areas will be used to eliminate any contaminants and exposure pathways that pose negligible risks and to identify any exposure pathways and preliminary contaminants of concern that exceed *de minimis* levels for inclusion in a baseline ecological risk assessment, if needed. EPA and ARC shall subsequently determine if a Site-wide ecological risk assessment is required given the results of the OU-specific SLERAs.

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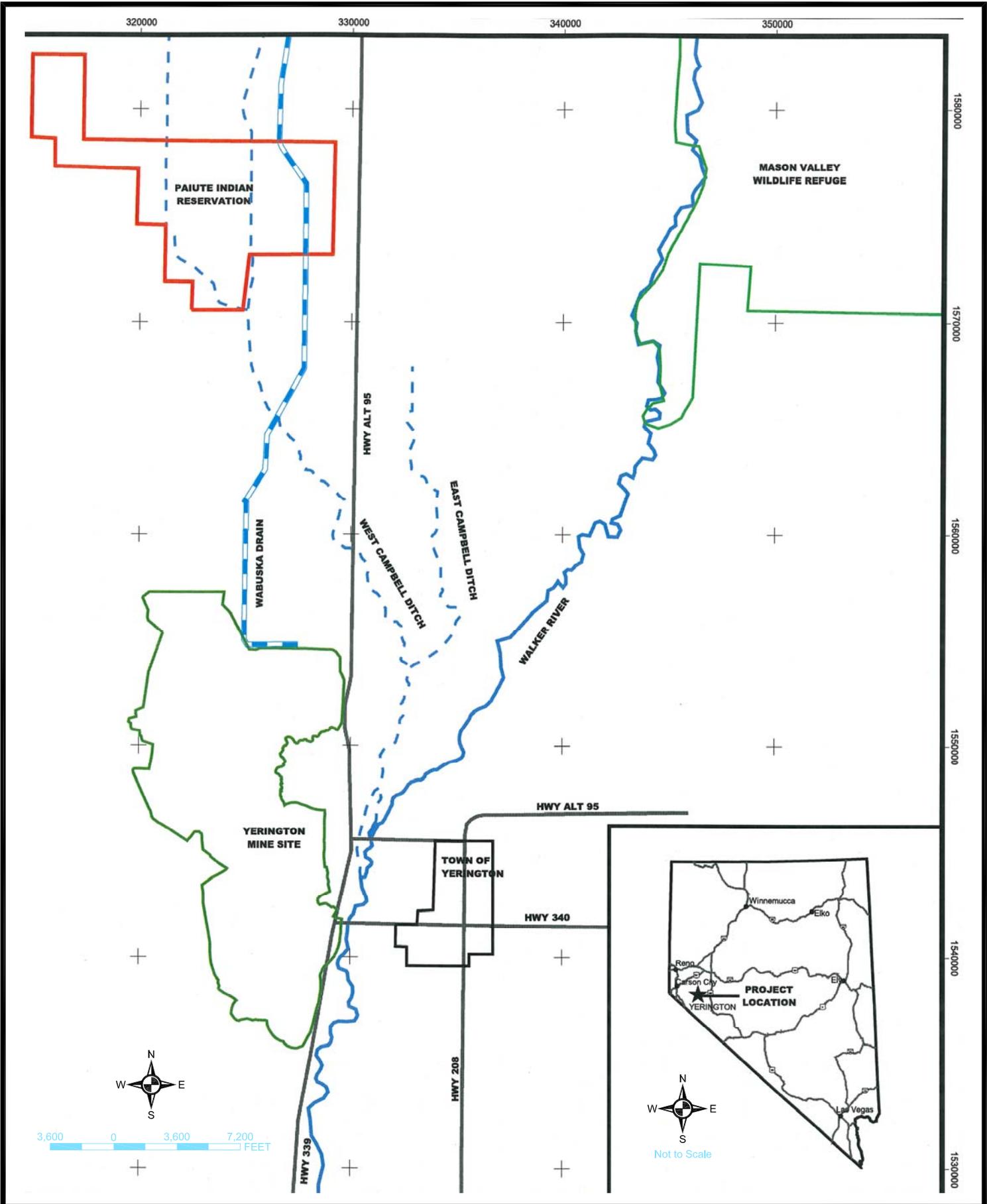
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FIGURES

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Date: May 2007

Atlantic Richfield Company

Project Number: 132034

Figure 1-1

Project Location



BROWN AND CALDWELL

TABLES

Table 4-1. Soil Screening Level Values for Plants and Soil Invertebrates

Parameter	Soil Screening levels for Plants ^a (mg/kg)	Soil screening levels for Invertebrates ^a (mg/kg)	
Benzene	--	--	
Bromobenzene	--	--	
Bromochloromethane	--	--	
Bromodichloromethane	--	--	
Bromoform	--	--	
Bromomethane	--	--	
n-Butylbenzene	--	--	
sec-Butylbenzene	--	--	
tert-Butylbenzene	--	--	
Carbon tetrachloride	--	--	
Chlorobenzene	--	40	c,d
Chloroethane	--	--	
2-Chlorotoluene	--	--	
4-Chlorotoluene	--	--	
Chloroform	--	--	
Chloromethane	--	--	
1,2-Dibromo-3-chloropropane	--	--	
Dibromochloromethane	--	--	
1,2-Dibromoethane	--	--	
Dibromomethane	--	--	
1,2-Dichlorobenzene	--	--	
1,3-Dichlorobenzene	--	--	
1,4-Dichlorobenzene	--	20	c,d
Dichlorodifluoromethane	--	--	
1,1-Dichloroethane	--	--	
1,2-Dichloroethane	--	--	
1,1-Dichloroethene	--	--	
cis-1,2-Dichloroethene	--	--	
trans-1,2-Dichloroethene	--	--	
Dichlorofluoromethane	--	--	
1,2-Dichloropropane	--	700	c,d
1,3-Dichloropropane	--	--	
2,2-Dichloropropane	--	--	
1,1-Dichloropropene	--	--	
Ethylbenzene	--	--	
Hexachlorobutadiene	--	--	
Isopropylbenzene	--	--	
p-Isopropyltoluene	--	--	
Methylene chloride	--	--	
Naphthalene	--	--	
n-Propylbenzene	--	--	
Styrene	300	b	
tert-butyl methyl ether	--	--	
1,1,2,2-Tetrachloroethane	--	--	
1,1,2,2-Tetrachloroethene	--	--	
1,1,1,2-Tetrachloroethane	--	--	

Table 4-1. Soil Screening Level Values for Plants and Soil Invertebrates

Parameter	Soil Screening levels for Plants ^a (mg/kg)		Soil screening levels for Invertebrates ^a (mg/kg)	
Toluene	200	b	--	
1,2,3-Trichlorobenzene	--		20	c,d
1,2,4-Trichlorobenzene	--		20	c,d
1,1,1-Trichloroethane	--		--	
1,1,2-Trichloroethane	--		--	
Trichloroethene	--		--	
Trichlorofluoromethane	--		--	
1,2,3-Trichloropropane	--		--	
1,2,4-Trimethylbenzene	--		--	
1,3,5-Trimethylbenzene	--		--	
Vinyl chloride	--		--	
Xylene (total)	--		--	
o-Xylene	--		--	
m-Xylene	--		--	
p-Xylene	--		--	
Aluminum	50	b	--	
Antimony	5	b	78	
Arsenic	18		60	c,d
Barium	500	b	330	
Beryllium	10	b	40	
Boron	0.5	b	--	
Cadmium	32		140	
Calcium	--		--	
Chromium	1	b	0.4	c,d
Cobalt	13		--	
Copper	70		80	
Iron	--		--	
Lead	120		1,700	
Magnesium	--		--	
Manganese	220		450	
Mercury	0.3	b	0.1	c,d
Molybdenum	2	b	--	
Nickel	38		280	
Potassium	--		--	
Selenium	1	b	70	c,d
Silver	560		--	
Sodium	--		--	
Thallium	1	b	--	
Thorium	--		--	
Uranium	5	b	--	
Vanadium	2	b	--	
Zinc	50	b	200	c,d

Notes:

^a Unless otherwise indicated, source of value is USEPA. 2007. Ecological Soil Screening Levels. <http://www.epa.gov/ecotox/ecoss/>. Accessed on August 21, 2007. Last updated on August 14, 2007. U.S. Environmental Protection Agency, Washington, DC.

^b Efroymson et al.(1997a)

^c Efroymson et al. (1997b)

^d Efroymson et al. benchmark for invertebrates based on earthworms

Table 4-2. Final TRVs Used for the Calculation of Soil Screening Level Values for the Process Areas OU

Parameter	NOAEL- Birds (mg/kg bw d)		NOAEL- Mammals (mg/kg bw d)		NOAEL- Fossorial Mammal (mg/kg bw d)	
Benzene	--		4	b	24	b
Bromobenzene	--		--		--	
Bromochloromethane	--		--		--	
Bromodichloromethane	--		--		--	
Bromoform	--		--		--	
Bromomethane	--		--		--	
n-Butylbenzene	--		--		--	
sec-Butylbenzene	--		--		--	
tert-Butylbenzene	--		--		--	
Carbon tetrachloride	--		4.5	b	26.9	b
Chlorobenzene	--		--		--	
Chloroethane	--		--		--	
2-Chlorotoluene	--		--		--	
4-Chlorotoluene	--		--		--	
Chloroform	--		4.2	b	25.2	b
Chloromethane	--		--		--	
1,2-Dibromo-3-chloropropane	--		--		--	
Dibromochloromethane	--		--		--	
1,2-Dibromoethane	--		--		--	
Dibromomethane	--		--		--	
1,2-Dichlorobenzene	--		--		--	
1,3-Dichlorobenzene	--		--		--	
1,4-Dichlorobenzene	--		--		--	
Dichlorodifluoromethane	--		--		--	
1,1-Dichloroethane	--		--		--	
1,2-Dichloroethane	17.2	b	7.9	b	47.2	b
1,1-Dichloroethene	--		8.4	b	50.4	b
cis-1,2-Dichloroethene	--		6.9	b,c	51.1	b,c
trans-1,2-Dichloroethene	--		6.9	b,c	51.1	b,c
Dichlorofluoromethane	--		--		--	
1,2-Dichloropropane	--		--		--	
1,3-Dichloropropane	--		--		--	
2,2-Dichloropropane	--		--		--	
1,1-Dichloropropene	--		--		--	
Ethylbenzene	--		--		--	
Hexachlorobutadiene	--		--		--	
Isopropylbenzene	--		--		--	
p-Isopropyltoluene	--		--		--	
Methylene chloride	--		1.6	b	9.8	b
Naphthalene	--		--		--	
n-Propylbenzene	--		--		--	
Styrene	--		--		--	
tert-butyl methyl ether	--		--		--	
1,1,1,2-Tetrachloroethane	--		--		--	
1,1,1,2-Tetrachloroethene	--		0.21	b	1.27	b

Table 4-2. Final TRVs Used for the Calculation of Soil Screening Level Values for the Process Areas OU

Parameter	NOAEL- Birds (mg/kg bw d)		NOAEL- Mammals (mg/kg bw d)		NOAEL- Fossorial Mammal (mg/kg bw d)	
1,1,1,2-Tetrachloroethane	--		--		--	
Toluene	--		--		--	
1,2,3-Trichlorobenzene	--		--		--	
1,2,4-Trichlorobenzene	--		--		--	
1,1,1-Trichloroethane	--		158	b	944	b
1,1,2-Trichloroethane	--		--		--	
Trichloroethene	--		0.106	b	0.636	b
Trichlorofluoromethane	--		--		--	
1,2,3-Trichloropropane	--		--		--	
1,2,4-Trimethylbenzene	--		--		--	
1,3,5-Trimethylbenzene	--		--		--	
Vinyl chloride	--		0.048	b	0.285	b
Xylene (total)	--		0.319	b	1.908	b
o-Xylene	--		--		--	
m-Xylene	--		--		--	
p-Xylene	--		--		--	
Aluminum	109.7	b	0.293	b	1.754	b
Antimony	--		0.019	b	0.114	b
Arsenic	2.24		1.04		0.32	
Barium	20.8	b	1.5	b	9	b
Beryllium	--		0.19	b	1.11	b
Boron	28.8	b	7.9	b	47	b
Cadmium	1.47		0.77		0.06	e
Calcium	--		--		--	
Chromium	2.66	b,d	2.4	b,d	4597	b,d
Cobalt	7.61		1.2		1.2	
Copper	2.3	e	2.67	e	2.67	e
Iron	--		--		--	
Lead	1.63		4.7		1	e
Magnesium	--		--		--	
Manganese	77.6	e	13.7	e	13.7	e
Mercury	0.039	e	0.027	e,f	0.25	e,g
Molybdenum	3.5	b	0.04	b	0.24	b
Nickel	6.71		1.7		0.133	e
Potassium	--		--		--	
Selenium	0.23	e	0.05	e	0.05	e
Silver	--		--		--	
Silver	--		--		--	
Sodium	--		--		--	
Thallium	--		0.48	e	0.48	e
Thorium	--		--		--	
Uranium	16	b	0.458	b	2.742	b
Vanadium	0.344		4.16		0.327	b
Zinc	17.2		9.6		9.6	e
Radium-226	--		--		--	
Radium-228	--		--		--	

^a Eco-SSL is used as the primary source for the TRV unless noted otherwise. Secondary sources in order of priority were Region 9 BTAG values (DeVries 2007) and ORNL values (Sample et al. 1996).

^b ORNL (Sample et al. 1996)

^c TRV for 1,2-dichloroethene used for both cis- and trans-

^d Chromium III TRV

^e Region 9 BTAG (DeVries 2007)

^f Value is for large mammals

^g Value is for rodents

Table 4-3. Proposed Wildlife Screening Level Values for the Process Areas OU and Comparison to Background Soil Concentrations for Washington State

Parameter	Avian ^a		Mammalian ^b		Mammalian ^c		WA DOE Background Concentrations in Soil	
	SLV (mg/kg)		SLV (mg/kg)		Inhalation SLV (mg/kg)		State	Spokane Basin
Benzene	--		111	d	339,258	d	--	--
Bromobenzene	--		--		--		--	--
Bromochloromethane	--		--		--		--	--
Bromodichloromethane	--		--		--		--	--
Bromoform	--		--		--		--	--
Bromomethane	--		--		--		--	--
n-Butylbenzene	--		--		--		--	--
sec-Butylbenzene	--		--		--		--	--
tert-Butylbenzene	--		--		--		--	--
Carbon tetrachloride	--		125	d	380,251	d	--	--
Chlorobenzene	--		--		--		--	--
Chloroethane	--		--		--		--	--
2-Chlorotoluene	--		--		--		--	--
4-Chlorotoluene	--		--		--		--	--
Chloroform	--		117	d	356,220	d	--	--
Chloromethane	--		--		--		--	--
1,2-Dibromo-3-chloropropane	--		--		--		--	--
Dibromochloromethane	--		--		--		--	--
1,2-Dibromoethane	--		--		--		--	--
Dibromomethane	--		--		--		--	--
1,2-Dichlorobenzene	--		--		--		--	--
1,3-Dichlorobenzene	--		--		--		--	--
1,4-Dichlorobenzene	--		--		--		--	--
Dichlorodifluoromethane	--		--		--		--	--
1,1-Dichloroethane	--		--		--		--	--
1,2-Dichloroethane	210	d	220	d	667,206	d	--	--
1,1-Dichloroethene	--		234	d	712,441	d	--	--
cis-1,2-Dichloroethene	--		192	d	722,336	d	--	--
trans-1,2-Dichloroethene	--		192	d	722,336	d	--	--
Dichlorofluoromethane	--		--		--		--	--
1,2-Dichloropropane	--		--		--		--	--
1,3-Dichloropropane	--		--		--		--	--
2,2-Dichloropropane	--		--		--		--	--
1,1-Dichloropropene	--		--		--		--	--
Ethylbenzene	--		--		--		--	--
Hexachlorobutadiene	--		--		--		--	--
Isopropylbenzene	--		--		--		--	--
p-Isopropyltoluene	--		--		--		--	--
Methylene chloride	--		45	d	138,530	d	--	--
Naphthalene	--		--		--		--	--
n-Propylbenzene	--		--		--		--	--
Styrene	--		--		--		--	--
tert-butyl methyl ether	--		--		--		--	--
1,1,2,2-Tetrachloroethane	--		--		--		--	--
1,1,2,2-Tetrachloroethene	--		5.9	d	17,952	d	--	--
1,1,1,2-Tetrachloroethane	--		--		--		--	--
Toluene	--		--		--		--	--
1,2,3-Trichlorobenzene	--		--		--		--	--
1,2,4-Trichlorobenzene	--		--		--		--	--
1,1,1-Trichloroethane	--		4,404	d	***	d	--	--

Table 4-3. Proposed Wildlife Screening Level Values for the Process Areas OU and Comparison to Background Soil Concentrations for Washington State

Parameter	Avian ^a SLV (mg/kg)		Mammalian ^b SLV (mg/kg)		Mammalian ^c Inhalation SLV (mg/kg)		WA DOE Background Concentrations in Soil	
							State	Spokane Basin
1,1,2-Trichloroethane	--		--		--		--	--
Trichloroethene	--		3.0	d	8,990	d	--	--
Trichlorofluoromethane	--		--		--		--	--
1,2,3-Trichloropropane	--		--		--		--	--
1,2,4-Trimethylbenzene	--		--		--		--	--
1,3,5-Trimethylbenzene	--		--		--		--	--
Vinyl chloride	--		1.3	d	4,029	d	--	--
Xylene (total)	--		8.9	d	26,971	d	--	--
o-Xylene	--		--		--		--	--
m-Xylene	--		--		--		--	--
p-Xylene	--		--		--		--	--
Aluminum	1,340	d	8.2	d	***	d	--	--
Antimony	--		0.3		***	d	--	--
Arsenic	43		46		***	d	7	9
Barium	1,079	d	2,000		***	d	--	--
Beryllium	--		21		***	d	--	--
Boron	352	d	220	d	***	d	--	--
Cadmium	0.8	e,f	0.4	e,f	***	d	1	1
Calcium	--		--		--		--	--
Chromium	26		34		***	d	--	--
Cobalt	120		230		***	d	--	--
Copper	28	e	49		***	d	36	22
Iron	--		--		--		--	--
Lead	11	e,f	56		***	d	17	15
Magnesium	--		--		--		--	--
Manganese	5,720	d	1,511	d	***	d	1100	700
Mercury	0.5	d	0.8	d	***	d	0	0.02
Molybdenum	43	d	1.1	d	***	d	--	--
Nickel	210		130		***	d	38	16
Potassium	--		--		--		--	--
Selenium	4.4		1.1		***	d	--	--
Silver	4.2		14		--		--	--
Sodium	--		--		--		--	--
Thallium	--		5		***	d	--	--
Thorium	--		--		--		--	--
Uranium	196		13		***	d	--	--
Vanadium	7.8		280		***	d	--	--
Zinc	210		107		***	d	86	66

Notes:

Values are Eco-SSL SLVs (USEPA 2007b) unless otherwise indicated.

^a Avian SLV is based on Chukar

^b Mammalian SLV is the lower of the mule deer or meadow vole values.

^c Mammalian inhalation SLV is based on meadow vole

^d Calculated SLV based on literature-based TRVs and exposure equations

^e Value is less than WA state background level

^f Value is less than Spokane Basin background level

*** Inhalation model indicates SLV > 1,000,000 mg/kg dw

Table 4-4. Comparison of Calculated SLVs for Mule Deer and Meadow Vole

Parameter	Herbivorous Mammal ^a SLV (mg/kg dw)	Fossorial Mammal ^b SLV (mg/kg dw)
Benzene	111.5	266.3
Bromobenzene	--	--
Bromochloromethane	--	--
Bromodichloromethane	--	--
Bromoform	--	--
Bromomethane	--	--
n-Butylbenzene	--	--
sec-Butylbenzene	--	--
tert-Butylbenzene	--	--
Carbon tetrachloride	125.4	298.5
Chlorobenzene	--	--
Chloroethane	--	--
2-Chlorotoluene	--	--
4-Chlorotoluene	--	--
Chloroform	117.1	279.7
Chloromethane	--	--
1,2-Dibromo-3-chloropropane	--	--
Dibromochloromethane	--	--
1,2-Dibromoethane	--	--
Dibromomethane	--	--
1,2-Dichlorobenzene	--	--
1,3-Dichlorobenzene	--	--
1,4-Dichlorobenzene	--	--
Dichlorodifluoromethane	--	--
1,1-Dichloroethane	--	--
1,2-Dichloroethane	220.2	523.8
1,1-Dichloroethene	234.1	559.3
cis-1,2-Dichloroethene	192.3	567.1
trans-1,2-Dichloroethene	192.3	567.1
Dichlorofluoromethane	--	--
1,2-Dichloropropane	--	--
1,3-Dichloropropane	--	--
2,2-Dichloropropane	--	--
1,1-Dichloropropene	--	--
Ethylbenzene	--	--
Hexachlorobutadiene	--	--
Isopropylbenzene	--	--
p-Isopropyltoluene	--	--
Methylene chloride	44.6	108.8
Naphthalene	--	--
n-Propylbenzene	--	--
Styrene	--	--
tert-butyl methyl ether	--	--
1,1,2,2-Tetrachloroethane	--	--
1,1,2,2-Tetrachloroethene	5.9	14.1
1,1,1,2-Tetrachloroethane	--	--
Toluene	--	--
1,2,3-Trichlorobenzene	--	--

Table 4-4. Comparison of Calculated SLVs for Mule Deer and Meadow Vole

Parameter	Herbivorous Mammal ^a SLV (mg/kg dw)	Fossorial Mammal ^b SLV (mg/kg dw)
1,2,4-Trichlorobenzene	--	--
1,1,1-Trichloroethane	4404.1	10475.9
1,1,2-Trichloroethane	--	--
Trichloroethene	3.0	7.1
Trichlorofluoromethane	--	--
1,2,3-Trichloropropane	--	--
1,2,4-Trimethylbenzene	--	--
1,3,5-Trimethylbenzene	--	--
Vinyl chloride	1.3	3.2
Xylene (total)	8.9	21.2
o-Xylene	--	--
m-Xylene	--	--
p-Xylene	--	--
Aluminum	8.2	19.5
Antimony	10.0	22.9
Arsenic	514.1	59.1
Barium	242.3	568.2
Beryllium	18.7	56.1
Boron	220.2	521.6
Cadmium	5.6	1.1
Calcium	--	--
Chromium	1118.6	803671.3
Cobalt	1240.6	432.9
Copper	1890.1	401.6
Iron	--	--
Lead	841.8	236.5
Magnesium	--	--
Manganese	3934.5	1511.5
Mercury	0.8	2.8
Molybdenum	1.1	2.7
Nickel	65.5	20.2
Potassium	--	--
Selenium	2.5	1.1
Silver	--	--
Silver	--	--
Sodium	--	--
Thallium	13.4	5.3
Thorium	--	--
Uranium	12.8	30.4
Vanadium	4759.6	128.8
Zinc	267.6	106.5

Notes:

^a Mammalian herbivore represented by mule deer

^b Mammalian fossorial represented by meadow vole

Table 4-5. Ingestion Parameters used to Support Calculations for Screening Level Values in Soil

Species	Parameter	Value	Source of Value
Chukar	fraction soil in diet	0.104	Beyer et al. 1994: chukar value unavailable; American woodcock value used
	food ingestion rate (kg dw/kg bw-d)	0.074	USEPA (1993), Eq 3-3: $(0.0582 * (BW(kg)^{0.651})) / BW(kg)$
	body weight (kg)	0.50	(Christenson 1970): Mean body weights of adult females
Mule deer	fraction soil in diet	0.02	(Beyer et al. 1994): upper bound of value reported for mule deer
	food ingestion rate (kg dw/kg bw-d)	0.035	(USEPA 1993), Eq 3-7: $((0.0687 * BW(kg)^{0.822})) / bw(kg)$
	body weight (kg)	43	(UMMZ 2007b): Lower bound of range reported for adult female mule deer
Meadow vole	fraction soil/sediment in diet	0.024	(Beyer et al. 1994)
	Food ingestion rate (kg dw/kg bw-d)	0.088	USEPA (2005)
	Body weight (kg)	0.036	Myers & Krebs (1971) as cited in USEPA 1993: average wt for adult male meadow vole for study in S Indiana
	Inhalation rate (m ³ /d)	0.038	(USEPA 1993), Eq 3-20: $0.5458 * BW(kg)^{0.80}$

Table 4-6. Surface water screening level values for the Process Area OU

Chemical	Units	Avian SLVs			Mammalian SLVs		
		NOAEL ^a	LOAEL	Notes	NOAEL	LOAEL	Notes
Aluminum	mg/L	471.4	--	b	4,474	44,738	e
Antimony	ug/L	--	--		290	2,898	e
Arsenic	ug/L	22,100	55,200	b	292	2,921	e
Barium	ug/L	--	--		23,100	--	e
Beryllium	ug/L	3,770	--	c	2,830	--	e
Bismuth	mg/L	--	--		--	--	
Boron	mg/L	124	430	b	120	401	e
Cadmium	ug/L	6,230	85,950	b	4,132	41,323	e
Calcium	mg/L	--	--		--	--	
Chloride (Cl)	mg/L	--	--		--	--	
Chromium	ug/L	4,300	21,490	b,d	11725000	--	e
Total							
Cobalt	ug/L	--	--		--	--	
Copper	ug/L	202,000	265,100	b	65,200	85,800	e
Fluoride	mg/L	33.5	137.5	b	174.7	293.8	e
Gallium	mg/L	--	--		--	--	
Iron	mg/L	--	--		--	--	
Lead	ug/L	4,860	48,560	b	34,270	342,720	e
Lithium	mg/L	--	--		--	--	
Magnesium	mg/L	--	--		--	--	
Manganese	ug/L	4,284,000	--	b	377,000	1,217,000	e
Mercury	ug/L	1,930	3,870	b	--	--	
Molybdenum	ug/L	15,040	151,690	b	600	6,030	e
Nickel	ug/L	332,610	459,810	b	171,360	342,720	e
Potassium	mg/L	--	--		--	--	
Scandium	mg/L	--	--		--	--	
Selenium	ug/L	2,149	4,297	b	857	1,414	e
Silicon	mg/L	--	--		--	--	
Silver	ug/L	--	--		--	--	
Sodium	mg/L	--	--		--	--	
Strontium	mg/L	1,127	--	e	--	--	
Thallium	ug/L	32	320	e	32	320	e
Tin	mg/L	29.2	72.6	b	54.2	81.1	e
Titanium	mg/L	--	--		--	--	
Uranium	ug/L	68,800	--		6,995	13,966	e
Vanadium	ug/L	48,989	--	b	835	8,352	e
Zinc	ug/L	62,300	562,900	b	685,400	1,370,900	e

Notes:

^a No-observed-adverse-effect level (NOAEL) and lowest-observed-adverse effect level (LOAEL) from Sample et al. 1996.

^b The most sensitive avian receptor is the Rough-wing Swallow unless otherwise noted.

^c River otter. No data were available for birds.

^d Based on Cr+3

^e White-tail deer

Table 4-7. US Department of Energy Biota Concentration
Guidelines (BCGs) for soil and surface water

Parameter	Terrestrial Animal, soil BCG (pCi/g)	Terrestrial Animal, surface water BCG (pCi/L)
Radium-226	50	8,107
Radium-228	44	6,752

Source: USDOE (2002)