APPENDIX A: DRAFT BASELINE HUMAN HEALTH RISK ASSESSMENT WORK PLAN FOR THE PROCESS AREAS OPERABLE UNIT

Yerington Mine Site

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ACRONYMS AND ABBREVIATIONS

ARC	Atlantic Richfield Company
ATSDR	U.S. Agency for Toxic Substances and Disease Registry
bgs	below ground surface
BLM	U.S. Bureau of Land Management
COPC	chemical of potential concern
CSF	cancer slope factor
CSM	conceptual site model
CTE	central tendency exposure
EPA	U.S. Environmental Protection Agency
EPC	exposure point concentration
HEAST	Health Effects Assessment Summary Tables
HHRA	human health risk assessment
Integral	Integral Consulting Inc.
IRIS	Integrated Risk Information System
LOAEL	lowest-observed-adverse-effects level
MDA	minimum detected activity
MDL	method detection limit
MVEC	Mason Valley Environmental Committee
NOAEL	no-observed-adverse-effects level
OU	operable unit
PCB	polychlorinated biphenyl
PEM	particulate emission factor
PM10	particulate matter smaller than 10 μm
PPRTV	provisional peer-reviewed toxicity value
QAPP	quality assurance project plan
QA/QC	quality assurance/quality control
RBA	relative bioavailability adjustment

RfC	reference concentration
RfD	reference dose
RI	remedial investigation
RME	reasonable maximum exposure
Site	Yerington Mine Site
SSL	soil screening level
UAO	unilateral administrative order
UCL	95th percentile upper confidence limit of the mean
URF	unit risk factor
WOE	weight of evidence

1 INTRODUCTION

This baseline human health risk assessment work plan for the process areas operable unit 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 (UAO), 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 UAO directs ARC to prepare a baseline human health risk assessment (HHRA) work plan for the Process Areas operable unit (OU) of the Yerington Mine Site in Yerington, Nevada (Site) (Figure 1-1). The UAO also requires ARC to develop a remedial investigation work plan for the Process Areas OU (referred to herein as "Process Areas RI [remedial investigation] Work Plan").

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 risk assessment, and a list of 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 – Chemical Sources, Release Mechanisms, and Transport Pathways
- Section 4 – Exposure Assessment
- Section 5 – Toxicity Assessment
- Section 6 – Risk Characterization
- Section 7 – References.

Supporting information for the baseline HHRA, such as data summary tables and intake and risk calculations, will be provided in appendices to the final baseline HHRA report.

1.1 HUMAN POPULATION AREAS

No residential areas are located on the Site, and the closest off-site residential areas include the community of Weed Heights and the private land owners in the Sunset Hills residential areas including residences along Locust Drive and north of Luzier Lane (Figure 1-2). Other off-site resident populations include the town of Yerington and the Yerington Paiute Tribe Reservation and Colony. Weed Heights borders the Site to the west, while Yerington is approximately 1 mile to the east and southeast of the Site. The Yerington Paiute Tribe Reservation is approximately 2.5 miles to the north (Figure 1-1). Approximately 2,250 people (1,200 households) live within 1 mile and 5,730 people (2,700 households) live within 3 miles of the Site boundary (U.S. Census 2007; ATSDR 2006). Most of these people live in the town of

Yerington and population density is lower to the north and west of the Site, though new residential development is occurring to the north (ATSDR 2006). Members of the Yerington Paiute Tribe include approximately 175 members living east of the Site in the Yerington Colony and approximately 400 members living on the reservation north of the Site (ATSDR 2006). Commercial and industrial businesses operate in Weed Heights, the town of Yerington, and along Highway 95A between the Site and the town of Yerington.

1.2 NATURAL SETTING

The abundance and diversity of wildlife in an area is directly dependent on habitat characteristics including type, quality, and quantity. No qualitative or quantitative habitat surveys or vegetative surveys are known to have been conducted at the Site. Plant and animal species expected to occur in the vicinity of the Site are discussed in the Site-wide Conceptual Site Model (Integral and Brown and Caldwell 2007). Habitat surveys will be performed during the remedial investigation to characterize the Process Areas OU, as described in the Process Areas RI Work Plan, Appendix C.

1.3 CURRENT AND FUTURE LAND USE

Portions of the Site are owned by the U.S. Bureau of Land Management (BLM), a private owner, and Arimetco. Arimetco's property within the Site is currently managed by bankruptcy probate (Brown and Caldwell 2005a). Mining and ore beneficiation operations at the Site are not presently occurring and, with the exception of fluid management associated with Arimetco heap leach process components, the Process Areas are not currently active (Brown and Caldwell 2005a). Electrical, gas, and water services to all buildings within the Process Areas have been disconnected, except for the administration building and the equipment garage (Brown and Caldwell 2005a). All heavy mining equipment and haul trucks have been removed from the mine site (Brown and Caldwell 2005a).

Current Site uses are limited primarily to activities surrounding maintenance of pumpback pond mechanisms and characterization, monitoring, and mitigation. No specific uses of the Process Areas are currently in place. Public access is prohibited through the use of perimeter fencing and no trespassing/warning signs.

Future use of the Site is expected to remain as mining/mineral processing or other industrial activities, given the current extensive site modifications for mining and the zoning designation for the Site as industrial. The Mason Valley Environmental Committee (MVEC) submitted a proposal to EPA in February 2007 that outlines preferred uses of the Site (MVEC 2007). In this proposal, land use designations for the Process Areas are divided between "light industrial" and "commercial–office" use. In addition, the Lyon County Planning Commission is in the process of updating the Comprehensive Master Plan for unincorporated areas of the county, including the greater Yerington area and the Site. It is expected that the land use designation for the Site will be industrial or other commercial use.

1.4 RISK ASSESSMENT APPROACH AND APPLICABLE GUIDANCE

The primary objective of the baseline HHRA is to evaluate potential adverse health effects attributable to exposure to Site-related contaminants in the absence of additional remedial action. The risk assessment will provide conservative estimates of risks to potentially exposed populations; the methodology is designed to avoid underestimation of risks and will likely overestimate risks to provide a conservative basis for evaluating the need for any additional remedial action and options for future land use.

The baseline HHRA will be conducted in accordance with national guidance, including but not limited to:

- Risk Assessment Guidance for Superfund, Human Health Evaluation Manual, Part A (U.S. EPA 1989)
- Guidance for Data Usability in Risk Assessment, Parts A and B (U.S. EPA 1992)
- Soil Screening Guidance for Radionuclides (U.S. EPA 2000)
- Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites (U.S. EPA 2002b).

The exposure scenarios evaluated in the HHRA will be based on a conceptual site model (CSM) developed specifically for the Process Areas OU. This OU-specific CSM is based on the draft *Revised Site-wide CSM for the Yerington Mine Site* (Integral and Brown and Caldwell 2007). The CSM and list of chemicals to be evaluated within the Process Areas OU 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 population via significant, complete exposure pathways, while the toxicity assessment will provide an estimate of the toxicity of chemicals of potential concern (COPCs). The final component, the risk characterization, will combine information from the exposure and toxicity assessments to provide estimates of potential risk to human populations.

1.5 RISK ASSESSMENT STUDY AREA

The extent of the study area is provided in the data quality objectives discussion in the Process Areas RI Work Plan. The geographical study boundary for the Process Areas OU is limited to the main Process Area, bounded on the northeast by the Sulfide Tailings, on the northwest by the Calcine Ditch and the Oxide Tailings, on the southwest by the Phase IV Heap Leach Pad and Mega Pond, and on the southeast by Burch Drive. Small peripheral Process Areas, such as crushing and pump stations, located away from the main Process Area, are also included in the study boundary.

Groundwater underlying the Process Areas OU will be evaluated in the baseline HHRA for the Site-wide groundwater OU. The Site-wide groundwater OU baseline HHRA will use data collected from all on- and off-site wells to estimate human health risks associated with contact with groundwater, including groundwater underlying the Process Areas OU.

1.6 SOURCES OF ENVIRONMENTAL DATA TO BE USED IN THE HHRA

Data from previous Process Areas investigations and ongoing background soil and radiochemical investigations will be included in the baseline HHRA. Previous investigations are described in *Data Summary Report for Process Areas Soil Characterization* (Brown and Caldwell 2005b), *Review of Yerington Mine Characterization Activities* (TRG 2004), *Fourth Quarter 2005 Yerington Mine Site Air Quality Monitoring Report* (Brown and Caldwell 2006), and *Fourth Quarter 2006 Air Quality Monitoring Report, Yerington Mine Site* (Brown and Caldwell 2007). Use of data from previous and future investigations is described in Section 2 of this work plan.

2 DATA EVALUATION

The objective of the data evaluation procedure is to define appropriate data that are relevant and of acceptable quality for use in the HHRA. The first step is to compile all available data for the Site and select the datasets that are relevant for characterizing Process Areas conditions and assessing potential risks to receptor populations. Existing data sources that will be considered in the HHRA were identified previously in Section 1.6. Data obtained from historical and future investigations will be described in the baseline HHRA report. 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 according to those criteria. Once data are evaluated for usability as described in Section 2.2, they will be summarized with respect to location and numbers of samples collected. Finally, evaluation of chemical concentrations within the study area with respect to concentrations in background reference areas is discussed in Section 2.3.

2.1 DATA EVALUATION AND SELECTION CRITERIA

Analytical data collected from the Process Areas and background reference areas during previous and planned sample events will be considered relevant for the risk assessment. Analytes selected for these investigations were based on chemicals thought or known to have been associated with historical operations, including metals, petroleum mixtures, polychlorinated biphenyls (PCBs), and others. A comprehensive list of analytes evaluated is provided in the Process Areas RI Work Plan.

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* (U.S. EPA 1992), 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) 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 if differences in sample collection exist between different 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, determine if those deviations were 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 Site QAPP (ESI and Brown and Caldwell 2007).

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, and duplicate and split samples 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 (U.S. EPA 1989).

Data qualifiers are described in detail in the QAPP and are discussed here briefly 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. 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 risk assessment.

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 (U.S. EPA 1989).

There may be exceptions to substitution of one-half the MDL for nondetect concentrations. These exceptions will be based on the frequency of detection of the analyte and the distribution type and skewness of the data. In some cases, statistical methods may be employed (e.g., bootstrap methods) to fill in datasets with nondetect concentrations. EPA guidance (Singh and Singh 2007) will be consulted in this determination, and an explanation of treatment of all nondetect concentrations for all analytes will be provided in the HHRA report.

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 QA/QC 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. 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 remedial investigation sampling event. 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 interlaboratory 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 HHRA is being conducted, a decision framework for evaluating split samples will be developed in consultation with EPA.

2.3 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 (U.S. EPA 2002a). 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, that are present in the environment as a result of human activities, but are 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" (U.S. EPA 2002a). According to the EPA's *Guidance for Comparing Background and Chemical Concentrations in Soil for CERCLA Sites* (2002a), 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 (1989) 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.

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 for metals and radiochemicals. General procedures for evaluating 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 RI Work Plan. Additional discussion of the comparisons between background and Site-related data will be provided in the baseline HHRA report.

3 CHEMICAL SOURCES, RELEASE MECHANISMS, AND TRANSPORT PATHWAYS

This section describes known and potential unconfirmed sources of mine-related chemicals in the Process Areas, chemical release mechanisms, chemical transport pathways for media found within the Process Areas, and the spatial distribution of chemicals of interest in Process Areas. The chemical sources, release mechanisms, transport pathways, and potential routes of human exposure are summarized in the Site-wide CSM (Integral and Brown and Caldwell 2007). A more detailed CSM specific to sources of chemicals in the Process Areas OU and potential transport pathways and exposure routes also is provided in this HHRA work plan.

3.1 POTENTIAL SOURCES AND RELEASE MECHANISMS

Pursuant to the UAO and development of the statement of work, EPA (2007a) has divided the Site into seven OUs. The Process Areas OU (OU-3) is the subject of this HHRA work plan (Figure 1-2). A detailed discussion of historical mining and milling operations, structures and conveyances, and chemical releases associated with past operations is provided in Section 2 of the Process Areas RI Work Plan. A brief summary of potential releases of chemicals to the environment is provided below:

- 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—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—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, and/or the East Stormwater Ditch.

- Leaks or spills from oil and fuel storage tanks—Underground 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 and spills from stored materials—Stored lubricants, oils, solvents, and transformers may have leaked in cases where the integrity of the containers/equipment was compromised.

3.2 POTENTIAL TRANSPORT PATHWAYS

Chemicals resulting from mining and milling activities may originate from the various source areas within the Process Areas OU. General transport mechanisms for chemicals from primary impacted media to secondary and tertiary impacted media are depicted in the physical processes CSM (Figure 3-1) and the addition of human health exposure routes is provided in the Site-wide human health CSM (Figures 3-2 and 3-3). Chemical sources and primary and secondary transport mechanisms as well as exposure routes specific to the Process Areas are provided in Figure 3-4 and discussed below.

3.2.1 Surface and Subsurface Soil

As shown in Figure 3-4, chemicals released directly to surface soils as a result of former mining and milling activities or unplanned releases may be transported by wind and surface water runoff. The presence of natural or artificial physical barriers, such as vegetation or concrete slab pads and foundations, will inhibit or reduce the transport of particles as wind-blown dust. Particulates or fugitive dust transported by wind may be deposited and may accumulate in downwind areas. Areas of dust accumulation may become secondary sources of chemicals to subsurface soil and groundwater via leaching and percolation.

Percolation of process solutions into the soil column, vadose zone, and groundwater is a potential release mechanism that likely ceased when mine operations ended, when such solutions evaporated, and/or when surface mine units dried sufficiently to increase moisture storage capacity. High evaporation rates in the locally arid desert terrain should greatly minimize subsequent leaching or relocation of releases from the former mine units. Geochemical processes such as mobilization and attenuation may modify the concentration of chemicals in percolating process solutions or leachate through soils or the underlying vadose zone. There is the potential for precipitation to leach (mobilize) constituents from mine unit materials. Conversely, some chemicals in meteoric water infiltrating through mine units may be attenuated (e.g., via adsorption).

In addition, horizontal and vertical migration of volatile chemicals (e.g., fuel-related compounds, solvents, degreasers, and radon) that subsequently migrate upwards and are released to ambient air may contribute to attenuation of chemicals in subsurface soil and groundwater. Vapor migration is influenced by chemical and physical properties of the soil and of each individual chemical, and will be considered if volatile chemicals are present in subsurface soil and groundwater within 100 feet below ground surface (bgs) (U.S. EPA 2002c).

3.2.2 Groundwater

Leaching of chemicals from surface mine units within the Process Areas OU into underlying soils, the vadose zone, and groundwater also is identified as a potential release mechanism. Infiltration of meteoric water (as precipitation) containing leached chemicals may provide a link between identified potential sources and the groundwater pathway. Groundwater underlying the Process Areas then may migrate to other areas of the Site. Physical and chemical transport pathways are discussed in more detail in *Site-wide Groundwater Remedial Investigation Work Plan* (Brown and Caldwell and Integral 2007).

3.2.3 Surface Water

Erosion of surface mine units due to surface water runoff (e.g., storm water events or snowmelt) also may result in transfer and deposition of chemicals in exposed surface soil to other, down-gradient areas. Stormwater may potentially accumulate in the north and south low areas and other topographically low areas at the north and southeast portions of the Process Areas. Accumulation of water in topographically low areas may occur where otherwise, during dry times of the year, soil would be exposed. Areas of surface water accumulation may become secondary sources of chemicals to subsurface soil and groundwater via leaching and percolation.

3.2.4 Radiation

In addition to migration of chemicals from their sources to other media, radiation may exist anywhere radiochemicals are or 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 15 cm of soil thickness; radiochemicals found below this level are shielded by the top layer of soil. Geometric attenuation limits the external radiation from materials, including buildings, 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.

4 EXPOSURE ASSESSMENT

One of the purposes of the exposure assessment is to determine which, if any, of the potential routes of human exposure may be complete now or in the future. This determination is made according to whether an exposure pathway contains the following elements (U.S. EPA 1989):

- A source and mechanism for release of constituents
- A transport or retention medium
- A point of potential human 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 human activity patterns and/or the location of potentially exposed individuals relative to the location of an affected exposure medium prevent human contact, or proximity for external radiation sources, then that exposure pathway is not complete. Similarly, if a pathway to human 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 HHRA.

The other purpose of the exposure assessment is to estimate the type and magnitude of human exposure to chemicals identified at a site. To estimate exposure, concentrations and radioactivity at the point of contact are combined with assumptions regarding human activity patterns to calculate chemical intakes and radiation doses for each complete pathway. The intakes are then combined with toxicity criteria for the chemicals to estimate risks in the risk characterization section of the HHRA.

The following sections describe the potential human exposure pathways that are thought to be complete based on a current understanding of the Site (Section 4.1), areas where people may contact mine-related chemicals as part of their routine activities (Section 4.2), the process for selection of chemicals of potential concern (Section 4.3), and the method for estimating intake of and/or exposures (Section 4.4).

4.1 POTENTIAL HUMAN RECEPTORS AND EXPOSURE ROUTES

The media in which mine-related chemicals may be found currently or in the future, the people or populations that may contact mine-related chemicals, and the pathways by which people may contact the chemicals are presented in the Process Areas OU CSM (Figure 3-4) and are discussed in this section. As shown in the Process Areas CSM, potentially relevant exposure media include surface and subsurface soil, particulates and vapors in outdoor air, vapors in indoor air, and stormwater. Potential contact with groundwater is addressed further in *Baseline*

HHRA Work Plan for the Site-Wide Groundwater Operable Unit (Brown and Caldwell and Integral 2007, Appendix A). Populations that may encounter exposure media within the Process Areas are identified as future workers and trespassers.

In Figure 3-4, potentially complete but minor exposure pathways specific to the Process Areas OU are represented by an open circle while other complete pathways that are considered primary exposure routes are represented by a closed circle. Incomplete exposure routes are represented by two short dash symbols. These designations of primary and minor exposure routes are preliminary and do not necessarily correspond to pathways that are intended to be evaluated quantitatively versus qualitatively in the HHRA.

Current workers are not relevant to the Process Areas OU because active mining and other commercial or industrial activities do not currently occur anywhere on the Yerington Mine Site. Two full-time workers currently employed at the Site assist with operations, maintenance, Site security, and other activities. At times, these workers drive through the Process Areas OU to access the Evaporation Ponds and Sulfide Tailings OU and Oxide Tailings OU, and to complete safety patrols. On-site workers take water level measurements monthly and collect groundwater samples quarterly at four active monitoring wells within the Process Areas OU. Although some supplies and tools are stored in the Process Areas, on-site staff avoid dilapidated buildings, exposed foundations, or other areas where physical harm is a risk. All EPA-designated radiological hazard areas are avoided. The workers are trained in hazardous site operations and their activities are conducted in compliance with the Site's health and safety plan. For this reason, a current worker scenario will not be included in the baseline HHRA. No residential areas are located within or adjacent to the Process Areas OU, so there are no current residential exposures.

Future development of the Process Areas is likely to be limited to industrial and commercial use. Future workers within the Process Areas OU may include indoor and outdoor industrial workers and commercial or office workers (MVEC 2007). Future reuse of the Process Areas may result in regrading and construction work prior to redevelopment to accommodate new industrial and commercial uses. Because specific reuse of the Process Areas OU is unknown, several preliminary future worker scenarios are presented:

- Construction worker (short-term employment during redevelopment)
- Trench worker (short-term employment during redevelopment)
- Outdoor worker (employment after redevelopment)
- Indoor worker (employment after redevelopment)

In addition to future workers, trespassers may enter the Process Areas in the future and contact chemicals in environmental media. Potential exposure pathways for the future worker and trespasser populations are discussed below.

4.1.1 Future Construction Worker

It is possible that temporary workers will be used to redevelop the Process Areas OU in the future. For this baseline HHRA, it will be assumed that the future worker scenario includes a construction worker who works on site temporarily to perform demolition or construction activities within the Process Areas OU. These activities may be conducted throughout the Process Areas, wherever existing structures are located for demolition or where future structures and roads may be built. Activities associated with demolition and construction may result in contact with exposure media via the following primary exposure pathways:

- Inhalation of particulates in air
- Incidental ingestion of and dermal contact with surface soil
- External radiation exposure from surface soil.

Construction workers are assumed to have potential for direct contact with surface soil from 0 to 2 feet bgs during demolition and construction activities. This depth is recommended for the Process Areas OU as the most relevant for activities such as construction, outdoor maintenance, and landscaping (U.S. EPA 2002b). While working, the construction worker also may inhale surface soil that has been resuspended and is entrained by the wind or vehicle movement. Exposure to external radiation from surface soil is evaluated for the upper 15 cm only, due to the shielding effect of this soil horizon over lower depths.

Construction workers may also contact chemicals via other potentially complete but minor exposure pathways:

- Incidental ingestion of, dermal contact with, and external radiation exposure from ephemeral pooled waters
- Inhalation of vapors and radon in outdoor air.

External radiation from stormwater and direct contact with these waters is considered a potentially complete but minor pathway, because these waters are present intermittently and workers are not likely to contact the waters on a regular basis. If volatile chemicals and/or radon are present in subsurface soil and migrate upward to outdoor air, workers may inhale the vapors and/or radon while working outside. However, this exposure pathway is considered a minor pathway, because vapors are expected to be dispersed in ambient air.

It is possible that redevelopment activities will require work in soil at depths below 2 feet bgs. However, activities associated with depths below 2 feet bgs are assumed to be associated with a trench or excavation worker (Section 4.1.2) rather than the construction worker. Based on these assumptions, incomplete exposure routes are assumed for construction worker contact with subsurface soil defined as 2 to 10 feet bgs.

Groundwater within the Process Areas OU lies at or below 100 feet bgs and will not be contacted directly by workers performing construction activities. Potential contact with groundwater is addressed further in *Baseline HHRA Work Plan for the Site-wide Groundwater Operable Unit* (Brown and Caldwell and Integral 2007, Appendix A). The future construction worker is not assumed to work indoors; therefore, inhalation of vapors and radon in indoor air also is considered an incomplete exposure pathway.

4.1.2 Future Trench Worker

As discussed in Section 4.1.1, short-term workers may be hired to assist with future redevelopment of the Process Areas OU. In addition to the demolition and construction activities mentioned above, workers also may work in soil at depths beyond 2 feet bgs to install utilities, pour foundations, or conduct other construction-related activities. For the purposes of this baseline HHRA, future workers who work in subsurface soil will be identified as trench workers. Subsurface soils within the Process Areas OU are defined as 2 to 10 feet bgs (Sickles 2007, pers. comm.). Activities performed by the trench worker may be conducted throughout the Process Areas, wherever existing structures are located for demolition or where future improvements may be built. Potentially complete, primary exposure pathways for trench workers include:

- Inhalation of particulates in air
- Inhalation of vapors and/or radon in trench air
- Incidental ingestion of and dermal contact with surface and subsurface soil
- External radiation exposure from surface and subsurface soil.

While excavating or working in trenches, workers may have direct contact with surface and subsurface soil and may inhale soil as wind-blown dust. Exposure via external radiation from surface and subsurface soil also may be a primary exposure pathway for trench workers. If volatile chemicals are present in soil, inhalation of vapors and/or radon may be a potentially complete, primary exposure pathway. Inhalation of vapors and radon by the trench worker is assumed to be limited to work within a trench or excavation.

Potentially complete but minor exposure pathways for trench workers include:

- Incidental ingestion of, dermal contact with, and external radiation exposure from ephemeral pooled waters
- Inhalation of vapors and/or radon in outdoor air.

External radiation from pooled water following storm events and direct contact with these waters is considered a potentially complete but minor pathway because these standing waters are present intermittently and workers are not likely to contact the waters on a regular basis.

As described above for the future construction worker, incomplete exposure pathways for trench workers include inhalation of vapors and radon indoors. Groundwater within the Process Areas OU lies at or below 100 feet bgs and will not be contacted directly by workers performing excavation activities. Potential contact with groundwater is addressed further in *Baseline HHRA Work Plan for the Site-wide Groundwater Operable Unit* (Brown and Caldwell and Integral 2007, Appendix A).

4.1.3 Future Outdoor Worker

Based on proposals for future Site development, future workers could include both industrial workers and commercial or office workers (MVEC 2007). Under these proposed land use designations, future workers may perform a majority of their duties outdoors. The future outdoor worker is not assumed to perform intensive earth-moving activities, as with the construction and utility workers, but instead may perform lighter intensity work such as building maintenance and skilled or trade labor activities. Potentially complete, primary exposure pathways for future outdoor workers include:

- Inhalation of particulates in outdoor air
- Incidental ingestion of surface and subsurface soil (assumes that subsurface soil is brought to the surface during regrading for redevelopment)
- External radiation from surface and subsurface soil (assumes that subsurface soil is brought to the surface during regrading for redevelopment)

It is assumed that future workers may have direct contact with surface soil and wind-blown dust as well as subsurface soil that has been brought to the surface as a result of regrading activities. External radiation from surface and subsurface soil to a depth of 15 cm bgs also is considered a complete, primary exposure pathway for the Process Areas.

Potentially complete but minor pathways for future outdoor workers include:

- Dermal contact, incidental ingestion, and external radiation exposure from water in ephemeral pooled waters
- Dermal contact with surface and subsurface soil
- Inhalation of vapors and radon in outdoor air.

Dermal absorption of metals, the dominant class of chemicals found in the Process Areas, is low and is likely to be a minor exposure pathway. Also, the future outdoor worker is not expected to have substantial contact with soil, as it is likely that redevelopment will include installation of gravel, pavement, vegetation, and other surface barriers to improve aesthetics and facilitate property reuse.

Contact with ephemeral pooled water following snowmelt or storm events is expected to be a potentially complete but minor pathway because these waters are not present year-round and workers are not likely to contact the waters on a regular basis.

If volatile chemicals and/or radon are present in subsurface soil and migrate upward to outdoor air, workers may inhale the vapors and/or radon while working outside. However, this exposure pathway is considered a minor pathway because vapors are expected to be dispersed in ambient air. Inhalation of vapors and radon in indoor air, if present, are considered incomplete exposure pathways because the outdoor worker is assumed to spend a majority of time outdoors.

4.1.4 Future Indoor Worker

Following redevelopment of the Process Areas, future workers also may include commercial office workers who spend all or most of their time indoors. Potentially complete, primary exposure pathways for future indoor workers include:

- Incidental ingestion of surface and subsurface soil as indoor dust (assumes that subsurface soil is brought to the surface during regrading for redevelopment)
- Inhalation of vapors and radon in indoor air.

The indoor office worker is not likely to perform outdoor activities and have direct contact with soil. Instead, it is assumed that the indoor worker will contact soil that has been tracked or blown indoors and is present on interior surfaces as dust. If volatile chemicals, including radon, are present in subsurface soil, vapors may infiltrate cracks and spaces in building foundations and migrate to indoor air. Therefore, inhalation of vapors and/or radon in indoor air will be considered a potentially complete, primary exposure pathway for indoor workers.

Potentially complete but minor pathways for future indoor workers include:

- Dermal contact with and external radiation from surface and subsurface soil (assumes that subsurface soil is brought to the surface during regrading for redevelopment)
- Dermal contact with, incidental ingestion of, and external radiation exposure from water in ephemeral pooled waters
- Inhalation of particulates in outdoor air
- Inhalation of vapors and/or radon in outdoor air.

The indoor worker is not expected to perform duties outside, and so contact with exterior exposure media will be limited relative to the outdoor worker and redevelopment worker scenarios. Although possible, dermal contact and external radiation from soil, inhalation of particulates, vapors, and radon in outdoor air, and contact with stormwater are assumed to be minor exposure pathways.

4.1.5 Trespasser

Access to the entire Site, including the Process Areas OU, is restricted; however, unauthorized visitors (i.e., trespassers) have entered the Process Areas to unlawfully collect scrap metal and other materials and equipment. Because the Process Areas are not located near or adjacent to a residential area, it is assumed that the trespasser is a young adult or adult. Trespassers may contact chemicals in outdoor environmental media via the following primary exposure pathways:

- Inhalation of particulates in air
- Incidental ingestion of surface soil
- External radiation exposure from surface soil.

While in the Process Areas, trespassers may inhale resuspended surface soil as wind-blown dust. Incidental ingestion of surface soil and external radiation exposure from soil also are potentially complete, primary pathways for the trespasser.

The following exposure pathways are potentially complete but minor relative to those pathways listed above:

- Incidental ingestion of, dermal contact with, and external radiation exposure from ephemeral pools
- Dermal contact with surface soil
- Inhalation of vapors and radon in outdoor air.

Because of the limited time spent in the Process Areas and limited available activities, contact with stormwater and inhalation of vapors and/or radon are expected to be minor exposure pathways as is intensive dermal contact with soil. Trespassers are not expected to have contact with subsurface soil and vapors and/or radon in indoor air. These pathways are assumed to be incomplete.

4.2 EXPOSURE UNITS

An exposure unit is the geographical area in which people are expected to perform activities that result in contact with mine-related chemicals and are often defined by current and/or future land uses. Preliminary designations for the Process Areas OU include industrial, light industrial, and commercial office space area, as shown on Figure 4-1 (MVEC 2007). Based on current zoning and land use proposals for the Site, future workers within the Process Areas OU may include both industrial workers and commercial or office workers (MVEC 2007). Redevelopment of the Site to accommodate new industrial and commercial uses potentially will require regrading and construction work within the 0.43 square km (106 acres) Process Areas.

The land use designations for the Process Areas delineated by MVEC (2007) are proposed as initial exposure units for the baseline HHRA. Selected exposure units may divide the Process Areas into three units for future light industrial, industrial, and commercial office space, but because some anticipated activities may be performed throughout the OU, the entire OU also will be evaluated as an exposure unit. Land use-specific exposure units are proposed to provide risk managers with useful information regarding risks associated with future development plans.

During redevelopment of the Process Areas OU, future trench and construction workers may conduct activities within any of the proposed exposure units, but this work is not expected to occur concurrently. Post-redevelopment indoor and outdoor workers would be expected to work within one of the three exposure units but would not be expected to contact exposure media throughout all three units due to the varied potential activities associated with each land use type. Trespasser activities, however, are not expected to be limited by land and may instead contact media throughout the Process Areas as one exposure unit.

4.3 SELECTION OF CHEMICALS OF POTENTIAL CONCERN

This section describes how the total list of analytes measured in the Process Areas remedial investigation is evaluated to determine which chemicals will be selected as COPCs. The purpose of the COPC selection process is to help focus the HHRA on the chemicals that may drive human health risks in the vicinity of the Process Areas, given the knowledge gained from existing data and evaluation of historical operating practices. The COPC selection process involves multiple steps that are outlined in EPA guidance (U.S. EPA 1989). These steps include evaluating the frequency of detection of each analyte, excluding the essential nutrients detected in Site media, selecting risk-based screening levels, and comparing Site concentrations to the screening levels and site-specific background concentrations.

4.3.1 Frequency of Detection

The first step in selecting COPCs involves assessing the frequency of detection for all analytes (U.S. EPA 1989). Analytes that are not detected in any sample will not be carried forward to the COPC screening process. Generally, analytes with a low frequency of detection (for example, 5 percent) in a medium are also eliminated from further consideration because they are likely attributable to laboratory contamination, are an artifact of the sampling methodology, or are not site-related. However, this step will be applied flexibly to ensure that chemicals are not erroneously excluded from consideration and the threshold may vary depending on how many samples were collected (e.g., use of the 5 percent level requires at least 20 samples because 1 detected value in 20 equals 5 percent) and the aerial extent over which the samples were collected.

4.3.2 Evaluation of Essential Nutrients

Some naturally-occurring chemicals in the environment are beneficial to human life. EPA guidance (U.S. EPA 1989) recommends removing chemicals from further consideration if they are generally considered "essential nutrients." These are chemicals that are essential human nutrients toxic only at very high doses and that are present at concentrations that would not be attributable to site activities. The essential nutrients magnesium, calcium, sodium, and potassium will not be included in the COPC selection process.

4.3.3 Selection of Screening Values

As noted above, the COPC selection process may include selecting risk-based screening levels and comparing Process Areas concentrations to the screening levels. This step typically is used when a large number of chemicals have been detected at a site. After evaluating frequency of detection and excluding essential nutrients, the number of remaining COPCs will be evaluated and the following risk-based screening step will only be used if more than 25 chemicals remain listed as COPCs in a given exposure medium. The risk-based screening step also may be used if unforeseen conditions warrant further reduction of COPCs.

Maximum detected chemical concentrations in Process Areas exposure media may be compared to screening levels relevant to current and future land use. Analyte concentrations that exceed screening levels will be retained as COPCs. Recommended screening levels for soil and are discussed below and exposure routes corresponding to each screening level are provided in Table 4-1. Actual screening values, if used, will be provided in the baseline HHRA report.

Soil data will be compared to risk-based values that are protective of exposures expected under proposed future land uses (e.g., commercial/industrial use). EPA's soil screening levels (SSLs) (EPA 2002b) for indoor and outdoor workers are recommended for screening radiochemicals and non-radiochemicals in soils to select COPCs. The SSLs are based on a target cancer risk level of 1 in 1 million and noncancer hazard level of 1.

The indoor worker SSLs are based on the assumption that the indoor worker is present on-site 250 days per year for 25 years and is exposed to soil via incidental ingestion. The outdoor worker is assumed to be present on site 225 days per year for 25 years and is exposed to soil via incidental ingestion and dermal contact. The outdoor worker SSLs can be used to select COPCs for the construction and trench worker scenarios. If volatile chemicals are present in subsurface soils, use of outdoor worker SSLs may not be health-protective for trench workers who inhale vapors while in a trench or excavation space. In this case, EPA Region 9 toxicologists will be consulted for appropriate selection of COPCs for the trench worker.

In addition, outdoor workers are assumed to inhale resuspended soil as wind-blown dust and vapors migrating from subsurface soil to ambient air. Generic SSLs based on inhalation of fugitive dust and vapors may be used to screen soil for the outdoor worker scenarios.

4.4 CALCULATION OF INTAKE

Intakes for each scenario will be calculated using site-specific chemical concentrations and receptor- and scenario-specific exposure assumptions. The intake refers to the amount of a chemical that enters the mouth or lungs, or contacts the skin. For radiochemicals, external exposure pathways are evaluated separately from internal exposure pathways. Chemical-specific intakes for each exposure pathway are estimated using equations that incorporate several factors or variables, which are described below:

- Contact rate—amount of exposure media that a person contacts over a specified time
- Concentration—concentration of a specific chemical in the exposure medium
- Exposure frequency—refers to how often a person could be exposed to the chemical
- Exposure duration—refers to how long a person could be exposed to the chemical
- Relative bioavailability adjustment—accounts for the difference in bioavailability between the exposure medium and the dosing vehicle used in the critical toxicity test that is the basis for the toxicity value
- Body weight—this is the typical mass (in kilograms) for each age group of people who may be exposed
- Exposure averaging time—refers to the time (in days) over which exposure is averaged (e.g., over a lifetime for chemicals that might cause cancer or over a year for other chemicals).

Intake of non-radiochemicals is estimated using each of these variables in the following equation:

$$\text{Intake}\,(\text{mg/kg}\cdot\text{day}) = \frac{\text{CR}\times\text{C}\times\text{EF}\times\text{ED}\times\text{RBA}}{\text{BW}\times\text{AT}}$$

Where,

CR = contact rate (e.g., L/day)

C = chemical-specific exposure point concentration (e.g., μg/L or mg/kg)

EF = exposure frequency (days per year)

ED = exposure duration (year)

RBA = relative bioavailability adjustment (unitless)

BW = body weight (kg)

AT = averaging time (days)

The variables shown in the exposure algorithm above are called exposure factors and vary depending on the receptor population being evaluated. Each receptor population will be characterized by a number of assumptions regarding the frequency of contact with potentially contaminated media, duration of exposure, and other parameters unique to each receptor population. In addition, this equation may vary to some extent, depending on the exposure route being evaluated.

Although the specific exposure scenarios for the Process Areas OU are not yet defined, several exposure parameters that are expected to be utilized in the HHRA are presented in the following sections. The exposure parameters presented in this section are not intended to be a complete list but are presented as a starting point for future discussions of exposure parameters and assumptions that may be used in the HHRA.

For radiochemicals, the following equation will be used to determine intakes:

$$\text{Intake (pCi)} = C \times CR \times EF \times ED \times RBA$$

where the variables are the same as above, except that *C* is expressed in units of pCi/L, based on the radioactivity of a particular radiochemical rather than the mass. In addition, the body mass and averaging time exposure factors are not relevant for radiochemicals. For external exposure to radiochemicals, the exposure pathway is from surface soil from 0 to 15 cm bgs. The exposure is calculated using the following equation:

$$\text{Exposure (pCi - yr/g)} = C \times SH \times EF \times ED$$

where the concentration "C" is in units of pCi/g of surface soil and "SH" is a shielding factor to account for the shielding effect provided by buildings or other structures.

For every exposure pathway, the level of exposure is expected that to vary among individuals due to differences in intake rates, body weights, exposure frequencies, and exposure durations. This results in a wide range of average daily intakes among different members of an exposed population. Typically, risk assessments for non-radiochemicals focus on intakes that are "average" or near the central portion of the range and also on intakes that are near the upper end of the range. These two exposure estimates are called the central tendency exposure (CTE) and the reasonable maximum exposure (RME), respectively. The RME case provides a conservative estimate of exposure that is plausible but still well above the average exposure level. Evaluating two exposure conditions provides more complete risk characterization information for risk evaluation and risk management decision-making. For radiochemicals, a CTE exposure scenario is typically evaluated.

4.4.1 Exposure Point Concentrations

To estimate the magnitude of exposure from each exposure medium, a representative concentration of each COPC for each exposure unit will be calculated and applied to the intake equation described in Section 4.4. Exposure units are described in Section 4.2 and will be selected in consultation with EPA.

The representative chemical concentration is commonly called the exposure point concentration (EPC). An EPC is a conservative estimate of the average chemical concentration in a medium that someone is likely to contact over a long period of time (U.S. EPA 1989; Singh et al. 2007). EPCs for radiochemicals are expressed as an activity level in a medium rather than a concentration. EPCs may be derived in several ways using a variety of statistical analyses. An EPC will be calculated for each medium within each exposure unit following selection of exposure units in consultation with EPA.

4.4.1.1 Soil EPCs

As mentioned above, statistical analyses will be used to identify soil EPCs. Because of the uncertainty associated with estimating a true average concentration, EPA (1992) recommends using the 95th percentile upper confidence limit (UCL) of the arithmetic mean concentration. Methods for calculating UCLs will vary depending on the frequency of detection and distribution of skewness[1] of the data. The distribution of COPCs in exposure media will be evaluated by performing a Goodness-of-Fit test, which will test if the data follow a normal, gamma, lognormal, or indeterminate distribution. The various methods for distribution testing and calculation of an appropriate UCL are provided in the updated *ProUCL User's Guide* (Singh et al. 2007) and *ProUCL Technical Guide* (Singh and Singh 2007). The baseline HHRA report will provide the results of statistical analyses conducted to determine the distribution of the data and the recommended UCL.

4.4.1.2 Airborne Particulate EPCs

Active ambient air monitors are located to the southwest (AM-1) and east (AM-3) of the Process Areas OU; no monitors are located within the Process Areas OU. PM10 (particulate matter smaller than 10 µm), metals, and radiochemical analytical data collected from February 2005

[1] Normally distributed datasets are symmetrical; however, nonsymmetrical datasets are said to be "skewed." Skewed datasets may be left- (negatively) or right- (positively) skewed, indicating that data points tend to fall farther below or above the median, respectively. Environmental datasets with nondetect values are negatively skewed.

through 2007 are available for each monitoring location. More recently in spring 2007, continuous monitors also were installed at these locations. With a predominant wind direction blowing toward the northeast, data from AM-1 will most often represent dust concentrations blowing to the Site from off-site areas, including Weed Heights, and AM-3 data will most often represent dust from on-site areas south of the Process Areas.

Due to the uncertainty in determining if air monitors represent ambient air concentrations of metals and radiochemicals specifically within the Process Areas OU, particularly during earthmoving activities that are likely to occur during redevelopment, fugitive dust concentrations will be estimated from chemical concentrations in surface soil. A particulate emission factor (PEF) will be used to relate the chemical concentration in soil to an estimated chemical concentration associated with respirable particles in air due to dust emissions from contaminated soil.

EPA (2002b) recommends using a default PEF value of 1.36×10^9 m^3/kg, which is based on a half-acre site with 50 percent ground cover and an annual average wind speed of 4.69 m/s. The default factor is based on a dispersion modeling study conducted by EPA to estimate fugitive dust emission at various sites (U.S. EPA 1996, 2002b). Factors influencing the particulate emission factor include the amount of ground cover present, soil type, and wind speed. The area, fraction of ground cover, and wind speeds associated with the Process Areas are inconsistent with the EPA default value and so a site-specific PEF will be calculated, following EPA (2002b) guidance. The site-specific value will be based on meteorological data, soil characteristics, and other physical attributes of the Process Areas and will consider redevelopment activities that may contribute to dust resuspension (e.g., vehicle traffic, excavating activities).

The PEF will be applied in the following equation to calculate EPCs resulting from fugitive dust:

$$C_f = C_s / PEF$$

Where,

C_f = Steady-state chemical concentration in outdoor air (mg chemical/m^3 air)

Cs = Soil concentration of chemical (mg chemical/kg soil)

PEF = Site-specific particulate emission factor (m^3 air/kg particulate)

The chemical-specific soil concentration will be based on soil EPCs described in Section 4.4.1.1.

4.4.1.3 Outdoor Vapor EPCs

Volatile chemicals (fuel-related compounds) will be sampled in soils, but ambient vapor concentrations will not be monitored. If volatile chemicals are present in soil, soil gas associated with those chemicals may migrate upward to ambient air. If necessary, EPCs for vapors in ambient air will be estimated from the soil EPCs using a chemical-specific volatilization factor (VF). The VF accounts for the rate at which a chemical volatilizes from soil and how well it is dispersed in ambient air. EPCs generated for ambient air may not be protective of vapor concentrations found in trenches or excavations. Methods for evaluating vapor concentrations for a trench worker scenario will be developed in consultation with EPA toxicologists.

To estimate a VF for soil, EPA (1996, 2002b) relies on the Jury model to calculate the flux of a chemical from soil. This model is based on the assumption that the source of contamination is infinite and that vapor phase diffusion is the only transport mechanism. EPA's soil-to-air VFs will be used to estimate the concentrations of vapors in ambient air according to the following equation:

$$C_v = C_s \times VF$$

Where,

C_v = Chemical concentration in outdoor air (mg chemical/m^3 air)

C_s = Chemical concentration in soil (mg chemical/kg soil)

VF = Chemical-specific volatilization factor (kg/m^3)

Selected chemical-specific soil concentrations will be selected for input into the model based on chemical concentration and sample location. VFs used to estimate outdoor vapor EPCs will be provided in the baseline HHRA report.

4.4.1.4 Indoor Vapor EPCs

As noted in the previous section, some volatile chemicals will be measured in Process Areas soils. If present, the chemicals may volatilize and migrate upward through soil and infiltrate indoor air spaces. Volatile chemicals in groundwater also may migrate to indoor air, but EPA guidance (2004) recommends evaluation of groundwater as a source only if impacted groundwater is present at depths less than 100 feet bgs. In the Process Areas, the depth to groundwater exceeds this depth and will not be considered as a potential source of vapors in indoor air. Vapor migration from groundwater also is discussed in *Baseline HHRA Work Plan for the Site-wide Groundwater Operable Unit* (Brown and Caldwell and Integral 2007, Appendix A).

If necessary, a building infiltration model will be used to calculate chemical concentrations in indoor air resulting from volatilization of chemicals from soil and migration through cracks in the building foundation into indoor air. The model is based on an indoor infiltration model developed by Johnson and Ettinger (1991) and modified by EPA (2004). The model couples both advective and diffusive flow of soil gases and considers the resistance caused by the foundation on the infiltration rate into a building. Soil analytical data selected based on chemical concentration and location will be entered into the model to estimate vapor concentrations in indoor air.

The amount of building infiltration from soil gas can be determined from the ratio of the chemical concentration in the indoor air to the soil gas concentration at the source (Johnson and Ettinger 1991; U.S. EPA 2004):

$$\frac{C_b}{C_a} = \frac{\left[\dfrac{D_{eff}\,A_b}{Q_b\,L_T}\right] \times \exp\left(\dfrac{Q_s\,L_{crack}}{D_{crack}\,A_{crack}}\right)}{\exp\left(\dfrac{Q_s\,L_{crack}}{D_{crack}\,A_{crack}}\right) + \left[\dfrac{D_{eff}\,A_b}{Q_b\,L_T}\right] + \left[\dfrac{D_{eff}\,A_b}{Q_s\,L_T}\right] \times \left[\exp\left(\dfrac{Q_s\,L_{crack}}{D_{crack}\,A_{crack}}\right) - 1\right]}$$

Where,

C_b = Chemical concentration in indoor air (g/m^3)

C_a = Chemical concentration in soil gas (g/m^3)

D_{eff} = Effective diffusion coefficient through soil (cm^2/sec)

A_b = Area of building foundation and below grade walls (cm^2)

Q_b = Building ventilation rate (cm^3/sec)

LT = Distance from contaminant source to building foundation (distance between the building foundation and the water table or contamination source) (cm)

Q_s = Soil gas emission rate into building (cm^3/sec)

L_{crack} = Thickness of foundation (cm)

D_{crack} = Effective diffusion coefficient through crack (cm^2/sec)

A_{crack} = Area of cracks in foundation through which vapors can pass (cm^2).

The method for calculation of effective diffusivity, D_{eff}, and soil gas emission rate into the building, Q_s, are provided in EPA (2004) guidance. Building infiltration and soil type input parameters will be provided in the baseline HHRA report if the vapor intrusion pathway is quantified.

4.4.2 Exposure Duration

Exposure duration (ED) is the length of time during which someone may be exposed through a specific exposure pathway. It varies depending on the receptor population and the activity and often involves consideration of the length of residence in an area. Assumptions for the short-term, redevelopment construction and trench workers, long-term post-redevelopment indoor and outdoor workers, and a trespasser are provided below.

The trench and construction workers are assumed to work on a short-term redevelopment project that lasts less than 1 year (e.g., building demolition, digging trenches to lay utility lines, pour foundations). If multiple construction projects occur on the Site, it will be assumed that different workers will participate on each project. The recommended exposure duration for the trench and construction worker is 1 year for both the RME and CTE.

EPA (1991, 2002b) recommends an RME exposure duration of 25 years for a typical worker. This value is based on U.S. Census data. It represents the upper-bound estimate for the amount of time a person works at the same location. The worker CTE exposure duration may be the same or less than a CTE exposure duration that would be suitable for a resident. The 50^{th} percentile for years lived at the same house is 9 years (U.S. EPA 1997). Therefore, it will be assumed that the exposure duration for a worker is the same value. These values are recommended for the post-redevelopment indoor and outdoor worker scenarios.

The trespasser scenario assumes that a young adult or adult from the surrounding community accesses the Site without permission. As a conservative estimate, the recommended exposure duration for the trespasser is equal to that of a nearby resident. Therefore, the RME and CTE exposure durations for the trespasser are 30 years and 9 years, respectively (U.S. EPA 1997). These values represent the 95^{th} and 50^{th} percentile values for years lived in the same house (U.S. EPA 1997).

4.4.3 Exposure Frequency

Exposure frequency describes how many days someone may have contact with exposure media in a typical 1year period. Values for exposure frequency vary for each scenario. The exposure frequency assumption for each scenario will be selected in consultation with EPA Region 9 toxicologists. However, some recommended assumptions are provided below.

EPA does not provide guidance for selection of exposure frequency for a trench or construction worker scenario. For this baseline HHRA, it is assumed that a trench or construction worker will work a total of 3 months, or 65 days/year, onsite. This value is recommended as an RME value. For the CTE value, it is assumed that a trench or construction worker is hired for one short-term project lasting 1 month, or 20 days/year.

An RME exposure frequency value of 225 days/year for outdoor workers is recommended (U.S. EPA 2002b). Based on professional judgment, an additional 10 days is subtracted to account for illness and holidays, for an RME value for 215 days/year for future, post-redevelopment outdoor workers. An exposure frequency of 155 days/year will be used for the CTE value, assuming the outdoor worker cannot work 3 months or 60 days/year due to inclement weather and other responsibilities.

EPA (2002b) recommends an exposure frequency of 250 days/year for indoor workers. This value is based on an average 5-day work week, with 10 days off for vacation. Based on professional judgment, an additional 10 days is subtracted to account for illness and holidays, for an RME value for 240 days/year for indoor workers. An exposure frequency of 240 days/year also will be used for the CTE value.

Guidance is not available for the number of days that trespassers could be assumed to enter a site. For this baseline HHRA, it will be assumed that the trespasser accesses the Process Areas one time per month for 6 months of the year and two times per month during the other 6 months of the year, or 18 days/year. This value of 18 days/year is recommended for the RME value. For the CTE value, it is assumed that the trespasser enters the Process Areas one time per month for half of the year, or 6 days/year.

4.4.4 Contact Rate

The contact rate describes how much of the exposure media someone may contact in a typical year. Contact rates will vary depending on the receptor and route of exposure. A discussion of recommended contact rates for each exposure medium (e.g., ingestion rate, inhalation rate) will be provided upon selection of complete exposure routes in consultation with EPA Region 9 toxicologists.

4.4.5 Relative Bioavailability Adjustment

For evaluation of incidental ingestion of soil, a relative bioavailability adjustment (RBA) will be used to account for the difference in chemical bioavailability in the exposure medium, versus the dosing vehicle used in the critical toxicity study that is the basis for the toxicity value.

For practical reasons, toxicity tests are usually designed using dosing media with high bioavailability, often corn oil or diet for organic chemicals and water for metals. The bioavailability of chemicals in soil, on the other hand, can vary depending on such factors as the following:

- Form of the chemical present (e.g., oxidation state or molecular composition)
- Physical form in the soil (e.g., sequestration of organic compounds in soil pore spaces)
- Length of time the chemical has been present in soil (aging or weathering)
- Soil characteristics (e.g., fraction organic carbon, pore size).

For many organic chemicals, fasting vs. nonfasting conditions, or the presence of protein or lipids in the gastrointestinal tract, affect the degree of absorption. In some cases, the concentration of the chemical in soil also affects bioavailability.

The RBA accounts for differences in the bioavailability of a chemical in soil relative to the dosing medium used in the critical toxicity study. It can be calculated as follows:

$$RBA = \frac{\text{absorbed fraction from soil}}{\text{absorbed fraction from dosing medium used in toxicity study}} \times 100$$

The RBA is typically less than 1.0 because the most bioavailable form of a chemical is commonly used in toxicity studies.

A literature search will be conducted for each COPC to identify appropriate RBA values for the soil ingestion pathway. In particular, RBA values obtained from other mine-related sites will be reviewed in addition to reviewing peer-reviewed literature sources. The values identified for use will be provided in the baseline HHRA report.

4.4.6 Body Weight

A value of 70 kilograms (154 pounds) represents the body weight (BW) for adults, based on an average of male and female adult body weights (U.S. EPA 1989). This parameter is not included in dose estimation for radiochemicals (U.S. EPA 1989).

4.4.7 Averaging Time

The averaging time (AT) is the time period over which an exposure is averaged. The averaging times for evaluating carcinogenic and noncarcinogenic effects are different. For evaluating carcinogenic effects, chemical intakes are averaged over the full 70-year lifetime (25,550 days) to be consistent with the way carcinogenic slope factors are derived (U.S. EPA 1989). When evaluating noncarcinogenic effects, however, chemical intakes are averaged over the exposure duration (U.S. EPA 1989). For noncarcinogenic effects, the exposure duration (typically expressed in years) is converted to days and used as the averaging time. For example, the averaging time for evaluating noncarcinogenic effects for a worker is 25 years (9,125 days). This parameter is not included in dose estimation for radiochemicals (U.S. EPA 1989).

5 TOXICITY ASSESSMENT

The purpose of the toxicity assessment is to summarize health effects that may be associated with exposure to the chemicals included in the risk assessment and to identify doses that may be associated with those effects. The focus is on effects associated with long-term, repeated exposures and on effects that could be associated with the chemical concentrations and pathways of exposure that are relevant in environmental settings. Toxicity values developed based on dose-response assessments for these relevant adverse effects are identified. These toxicity values are numerical expressions of chemical dose and response and vary based on factors such as the route of exposure and duration of exposure.

Toxicity values for carcinogenic and noncarcinogenic health effects have been developed for many chemicals by government agencies, including EPA, the U.S. Agency for Toxic Substances and Disease Registry (ATSDR), and the World Health Organization. As recommended by EPA in *Human Health Toxicity Values in Superfund Risk Assessments* (U.S. EPA 2003), the primary sources that will be consulted for selection of toxicity values are, in order of priority, EPA's Integrated Risk Information System (IRIS) and EPA's Provisional Peer Reviewed Toxicity Values (PPRTVs) from the National Center for Environmental Assessment/Superfund Health Risk Technical Support Center. If neither IRIS toxicity values nor PPRTVs are available, then EPA Region 9 toxicologists will be consulted. For radiochemicals, EPA's Health Effects Assessment Summary Tables (HEAST) will be used to obtain toxicity values (U.S. EPA 2001).

Duration of exposure is an important factor to consider when selecting appropriate toxicity values for the HHRA. This is because the exposure levels that cause toxic effects vary depending on how long the exposure occurs. For example, with regular, repeated exposure to a chemical over many years (typically referred to as chronic exposure), much lower concentrations (and resulting doses) of a chemical could be associated with toxic effects, compared with concentrations that would be identified as causing toxic effects in a person who is exposed to a chemical for only 1 day (referred to as an acute exposure). Intermediate duration exposures (referred to as subchronic exposures) are more likely to lead to toxic effects at intermediate concentrations. This baseline HHRA will evaluate risks associated with scenarios involving subchronic and chronic exposures to COPCs on and around the Process Areas OU.

5.1 NONCANCER EFFECTS

The potential for noncancer health effects from chronic exposures (i.e., exposure duration greater than 7 years) is evaluated by comparing the estimated daily intake with a reference dose (RfD) for oral exposure routes or reference concentration (RfC) for inhalation exposure routes. The toxicity values represent average daily exposure levels at which no adverse effects are expected to occur with chronic exposures. Subchronic RfDs or RfCs are applied when exposures are less than 7 years, as is the case with children (i.e., 0 to 6 years) or trench workers (i.e., ≤ 1 year).

The RfDs for many noncarcinogenic effects are generally based on laboratory animal studies or epidemiological studies in humans. In such studies, the RfD is typically calculated by first identifying the highest concentration or dose that does not cause observable adverse effects (the no-observed-adverse-effect level, or NOAEL) in the study subject. If a NOAEL cannot be identified from the study, a lowest-observed-adverse-effect level (LOAEL) may be used. This dose or concentration is then divided by uncertainty factors to calculate a reference dose.

The uncertainty factors are applied to account for limitations in the underlying data and are intended to ensure that the toxicity value calculated based on the data will be unlikely to result in adverse health effects in exposed human populations. For example, an uncertainty factor of 10 may be used to account for interspecies differences (if animal studies were used as the basis for the calculation), and another factor of up to 10 may be used to address the potential that human subpopulations such as children or the elderly may have increased sensitivity to the chemical's adverse effects (if these populations were not adequately evaluated). Thus, variations in the strength of the underlying data are reflected in the uncertainty factors used to calculate the toxicity values and in the low, medium, or high confidence ratings assigned to those values (U.S. EPA 2007b).

5.2 CARCINOGENIC EFFECTS

A component of assessing carcinogenic health effects is a qualitative evaluation of the extent to which a chemical is a human carcinogen. For most chemicals listed in IRIS, this evaluation was conducted by EPA using a classification system called weight-of-evidence (WOE) determination.[2] A chemical is assigned a WOE classification based on data obtained from both human and animal studies. Once a WOE is assigned to a chemical, a quantitative estimate of carcinogenic potential for the chemical is derived. Chemicals for which EPA considers adequate human data indicating carcinogenicity are available are categorized as "known human carcinogens" (WOE class A), while other chemicals with various levels of supporting data may be classified as "probable human carcinogens" (WOE class B1 or B2), or "possible human carcinogens" (WOE class C). Where EPA considers that data are inadequate for determining carcinogenicity, the chemical is "not classifiable as to human carcinogenicity" (WOE class D). When studies provide evidence of noncarcinogenicity, a chemical is assigned a WOE class E (U.S. EPA 2005).

[2] The WOE categories described in the final *Guidelines for Carcinogen Risk Assessment* (U.S. EPA 2005) as "standard hazard descriptors" differ from and may eventually supersede those used in IRIS (U.S. EPA 2007b). These descriptors include "carcinogenic to humans," "likely to be carcinogenic to humans," "suggestive evidence of carcinogenic potential," "inadequate information to assess carcinogenic potential," and "not likely to be carcinogenic to humans."

To assess carcinogenic health effects, cancer slope factors (CSFs) are used for oral or dermal exposures and unit risk factors (URFs) are used for inhalation exposures. CSFs and URFs are upper-bound estimates of the carcinogenic potency of chemicals. They are used to estimate the incremental risk of developing cancer, corresponding to a lifetime of exposure at the levels described in the exposure assessment. In standard risk assessment procedures, estimates of carcinogenic potency reflect the conservative assumption that no threshold exists for carcinogenic effects (i.e., that any exposure to a carcinogenic chemical will contribute an incremental amount to an individual's overall risk of developing cancer).

5.3 RADIOLOGICAL EFFECTS

The primary effects of chronic exposure to radioactive chemicals are carcinogenicity (ability to cause cancer), mutagenicity (ability to induce genetic mutations), and teratogenicity (ability to induce birth defects). Mutagenicity may occur in either somatic (body) or germ (reproductive) cells; the latter resulting in genetic or inherited defects.

As with toxicity assessments of non-radiochemicals, more is known regarding the effects of exposure to high doses of radiation resulting from industrial accidents rather than low doses typically observed in the environment. For this reason, the effects of low dose and low frequency exposures are usually extrapolated from studies of high dose-response effects. The most important dose-response effect for environmental exposures is carcinogenicity, followed by mutagenicity (U.S. EPA 1989, 2001). For these two effects, it is assumed that there is no threshold or level below which no effect is expected. There may be a threshold for teratogenic effects which, combined with a limited duration for exposure (9 months) and importance of timing to induce effects, shifts the greatest relative risk to carcinogenicity and mutagenicity. Risk of cancer is potentially greater than risk of genetic mutations, because mutations may be induced only during the reproductive lifetime of an individual, whereas cancer may be induced at any point during the life span. Furthermore, mutagenic effects resulting from exposure to radiation have been observed only in laboratory animals. If mutagenic effects were to occur, the risks would be distributed over several generations. For these reasons, only carcinogenicity resulting from exposure to radiochemicals is evaluated in risk assessment (U.S. EPA 1989, 2001). EPA classifies all radiochemicals as a WOE class A, known human carcinogens (U.S. EPA 2001).

CSFs for radiochemicals are provided in EPA's HEAST tables (U.S. EPA 2001). The CSFs represent central estimates of age-averaged, excess lifetime cancer incidence per unit of activity.

5.4 TOXICITY PROFILES

A profile of the toxicity for COPCs will be included in the baseline HHRA report. These profiles will include a description of the basis for the relevant RfD, RfC, CSF, and/or URF for each COPC, the confidence level in the toxicity estimate, target organ, and uncertainties in the toxicity assessment.

6 RISK CHARACTERIZATION

To characterize risks, quantitative estimates of exposure and toxicity are combined to yield numerical estimates of potential health risk for noncarcinogenic and carcinogenic COPCs. This phase of a risk assessment also involves interpreting and qualifying the derived risk estimates and the uncertainty associated with them.

6.1 NONCANCER RISKS

Health risks other than cancer are characterized as the increased likelihood that an individual will suffer adverse health effects as a result of chemical exposure. To evaluate noncancer risks, the ratio of the average daily intake to the RfD or RfC is calculated. This ratio is referred to as the hazard quotient. If the calculated value of the hazard quotient is less than or equal to 1.0, no adverse health effects are expected. If the calculated value of the hazard quotient is greater than 1.0, then further risk evaluation is needed. The hazard quotient will be calculated using the following equation:

$$HQ = \frac{Intake}{RfX}$$

Where,

HQ = Hazard quotient associated with exposure to the chemical *via* the specified exposure route (dimensionless)

Intake = Estimated average daily intake of the chemical *via* the specified exposure route (mg/kg-day)

RfX = Reference dose (RfD) or reference concentration (RfC) for the COPC (mg/kg-day)

To evaluate the effect of exposure to multiple chemicals that act on the body in a similar manner, the hazard quotients for each exposure pathway for individual chemicals are typically summed to determine a noncancer hazard index using the following formula:

$$HI = \frac{Intake_1}{RfX_1} + \frac{Intake_2}{RfX_2} + \ldots + \frac{Intake_i}{RfX_i}$$

Where,

HI = hazard index

$Intake_i$ = Intake for chemical *i* (mg/kg-day)

RfX_i = Reference dose or concentration for the i^{th} chemical (mg/kg-day)

Hazard indices for multiple chemicals are generally not summed if the reference doses for the chemicals are based on effects on different target organs. This is because the noncancer health risks associated with chemicals that affect different target organs are unlikely to be additive.

6.2 CANCER RISKS

The cancer risk estimates derived using standard risk assessment methods are characterized as the incremental probability that an individual will develop cancer during his or her lifetime due to exposure to site-related chemicals resulting from the specific exposure scenarios that are going to be evaluated. The term "incremental" reflects the fact that the calculated risk associated with site-related exposure is in addition to the background risk of cancer experienced by all individuals in the course of daily life.

Excess incremental lifetime cancer risks will be calculated using the following equation:

$$Cancer\ Risk = Intake\left(\frac{mg}{kg \cdot day}\right) \times CSF\left(\frac{mg}{kg \cdot day}\right)^{-1}$$

Because cancer risks are assumed to be additive, risks associated with simultaneous exposure to more than one carcinogen in a given medium are typically combined to estimate the total cancer risk associated with each exposure pathway (U.S. EPA 1989). Where exposures may occur via multiple exposure routes, total cancer risks for each exposure pathway may be summed for reasonable combinations of exposure pathways to determine the total cancer risk for the population of concern.

6.3 RADIOLOGICAL RISKS

Cancer risks resulting from intakes of radiochemicals will be calculated as described in Section 6.2, by multiplying the estimated activity intake by the CSF:

$$Cancer\ Risk = Intake\ (pCi) \times CSF\ (pCi)^{-1}$$

For external exposure, the integrated exposure concentration is multiplied by the CSF:

$$Cancer\ \ Risk = IntegratedExposure\left(\frac{pCi \cdot yr}{g}\right) \times CSF\left(\frac{pCi \cdot yr}{g}\right)^{-1}$$

Cancer risks for non-radiochemical and radiochemical exposures will be summed to obtain an estimate of total lifetime cancer risk.

6.4 UNCERTAINTY EVALUATION

An evaluation of uncertainties will be provided in the baseline HHRA report, including a table identifying specific factors that may result in an over- or underestimation of risks. In addition, a sensitivity analysis may be warranted to quantify the magnitude of uncertainty associated with specific exposure parameters. In some cases, a probabilistic analysis of specific exposure pathways or scenarios may be performed to gain a greater understanding of uncertainty and variability in risk assessment assumptions.

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FIGURES

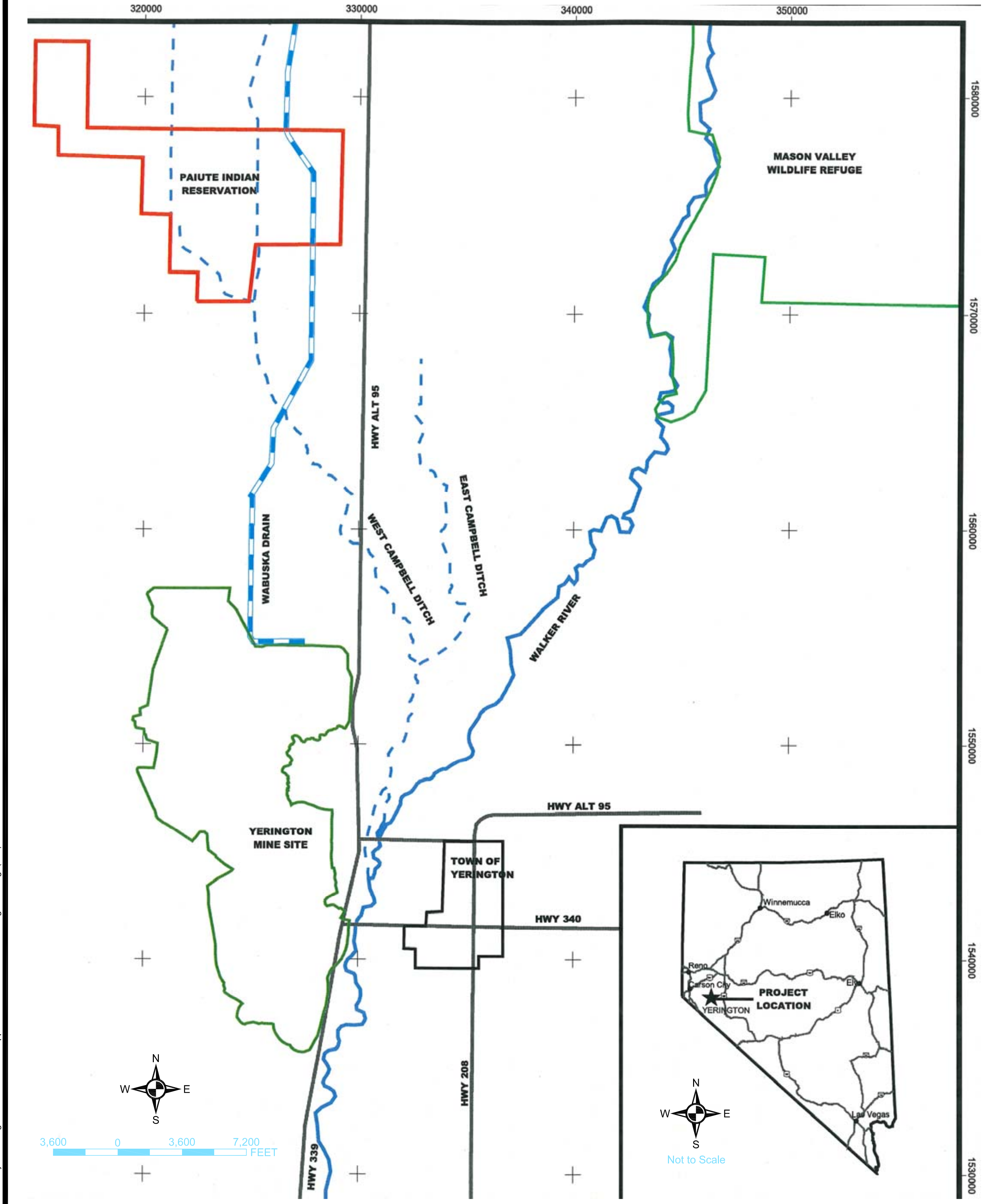

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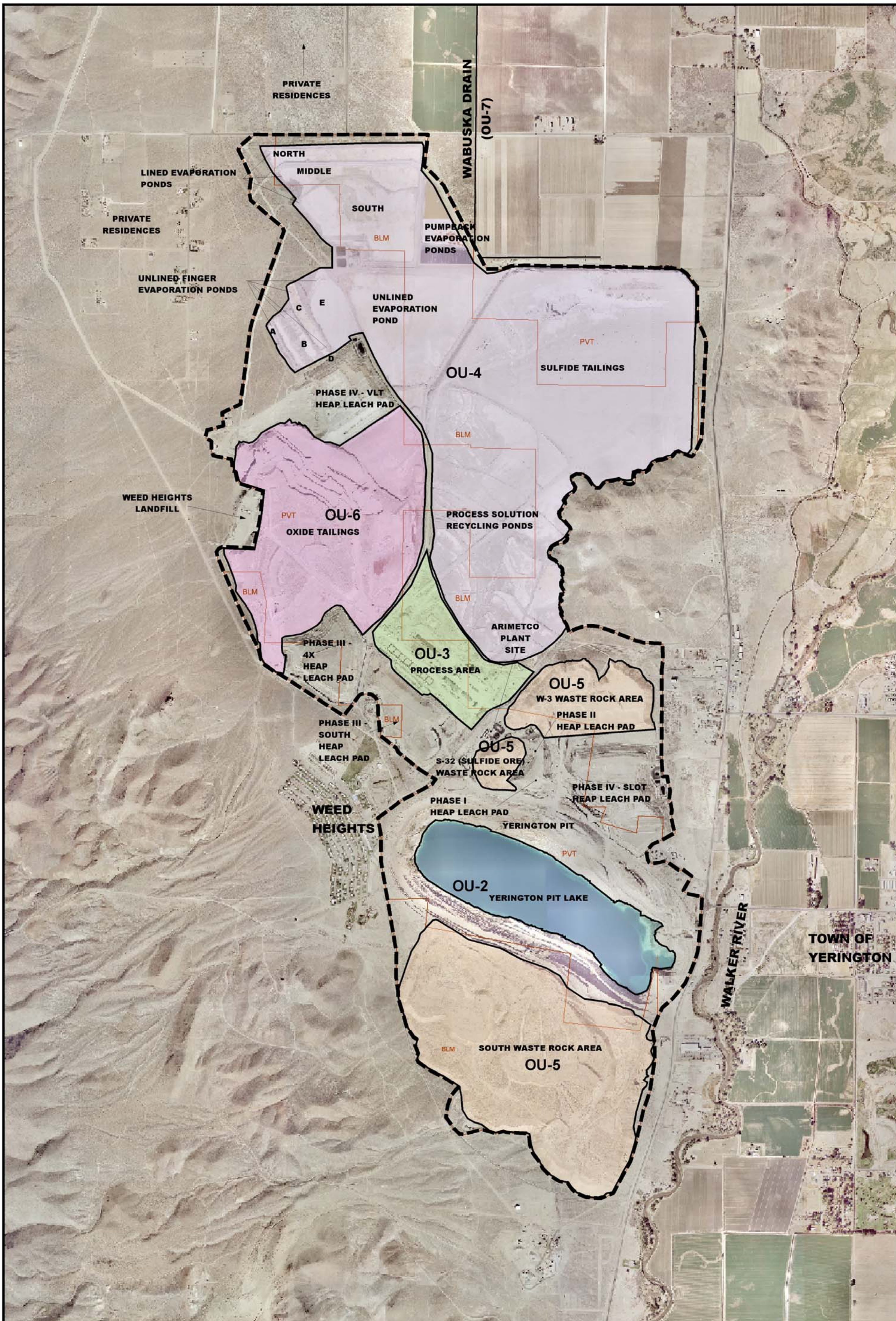
Figure 1-1

Project Location



NOTES:
1.) PROJECTION: NEVADA STATE PLANE, WEST ZONE
1927 NORTH AMERICAN DATUM (FEET)
2.) BASE PHOTO TAKEN OCTOBER 2001

EXPLANATION

- MINE SITE BOUNDARY
- MINE UNIT
- BLM - PRIVATE LAND BOUNDARY

Note: Preliminary designations subject to EPA revisions

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N W E S

3,000 0 3,000 6,000 FEET

Figure 1-2

Operable Units Yerington Mine Site

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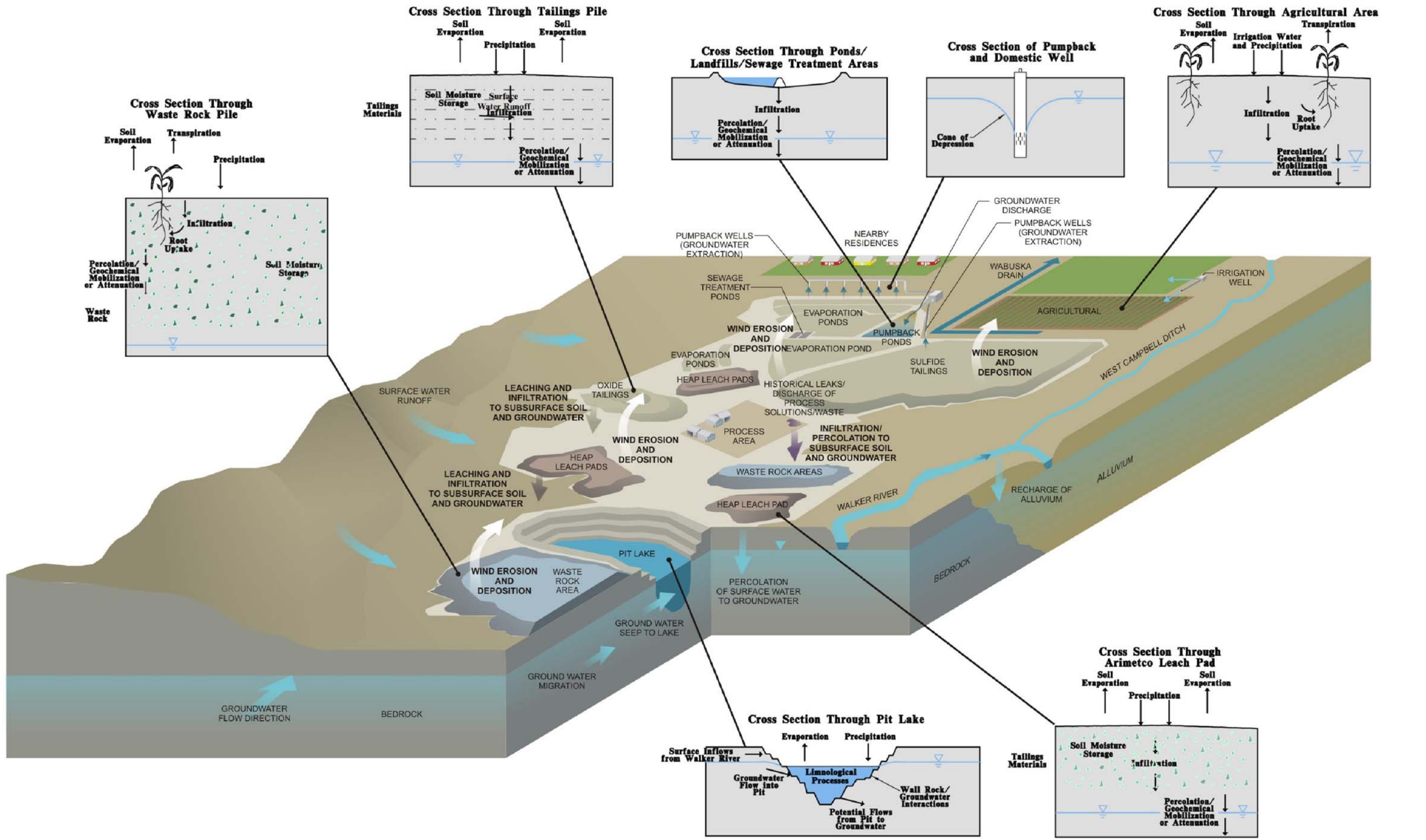

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Conceptual Site Model
Yerington Mine Site

Figure 3-1

Schematic Diagram of Physical and Chemical Processes

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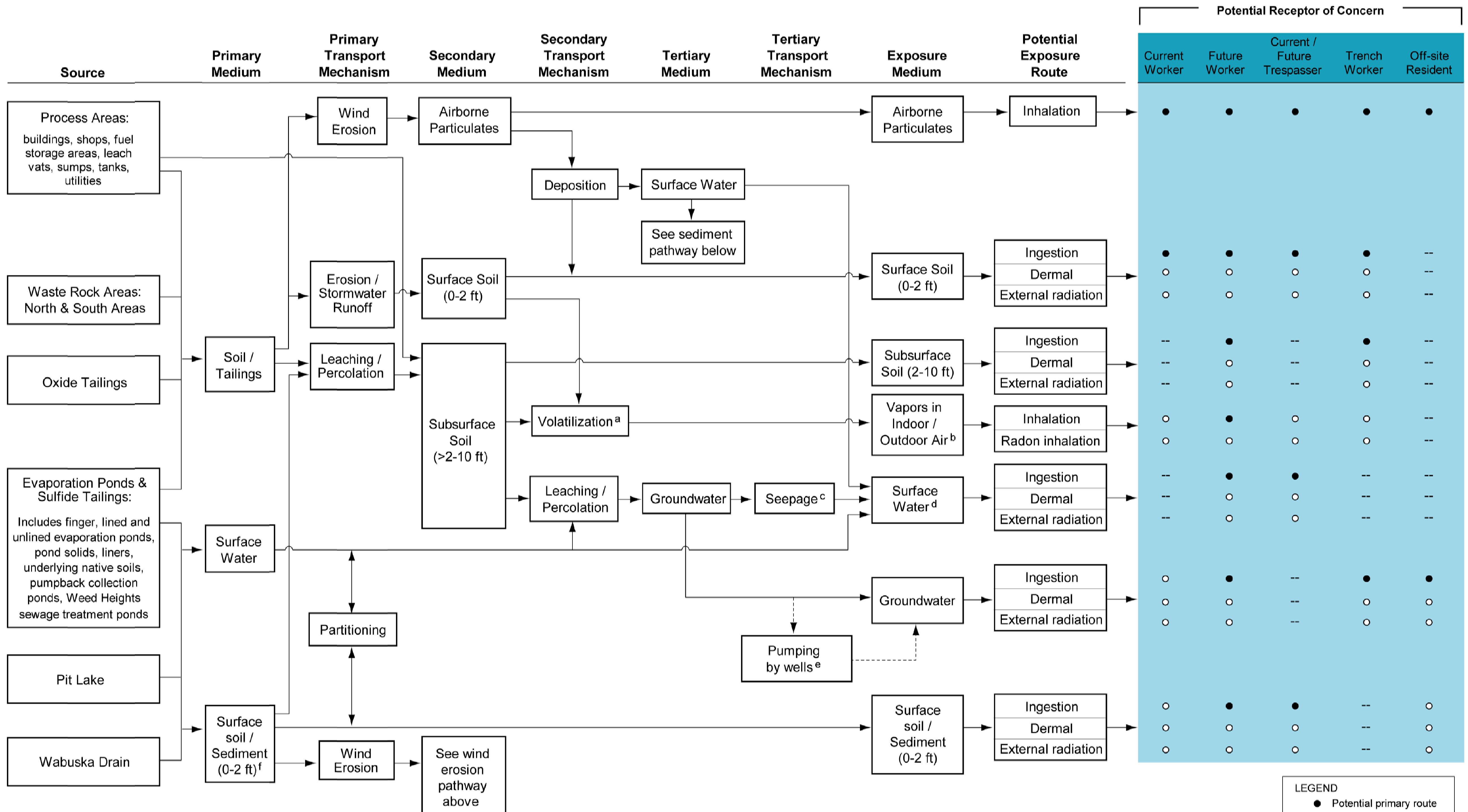

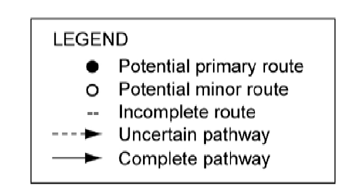

Notes:

[a] Volatilization of chemicals from soil is a complete pathway for chemicals in soil to a maximum depth of 100 ft bgs (EPA 2002).

[b] Current worker, current/future trespasser, and trench worker are assumed to have contact with vapors in outdoor air only. Future worker is assumed to have contact with vapors in both indoor and outdoor air.

[c] Seepage of groundwater to surface water pathway is complete for Wabuska Drain and Pit Lake but is incomplete for pond areas.

[d] Surface water includes ephemeral ponds and Wabuska Drain as well as Pit Lake waters.

[e] Pumping of groundwater by offsite irrigation wells occurs to the north and east of the Site; it has not been confirmed that this groundwater has been impacted by Site-related chemicals. Groundwater movement via the pumpback system and offsite irrigation and drinking water wells will be depicted in more detail in the Groundwater Operable Unit Remedial Investigation Work Plan.

[f] The Wabuska Drain and various pond areas are ephemeral. When these areas are dry, solid media is considered a "soil" whereas when water overlies the ponds or fills the Drain, solid media is considered a "sediment."

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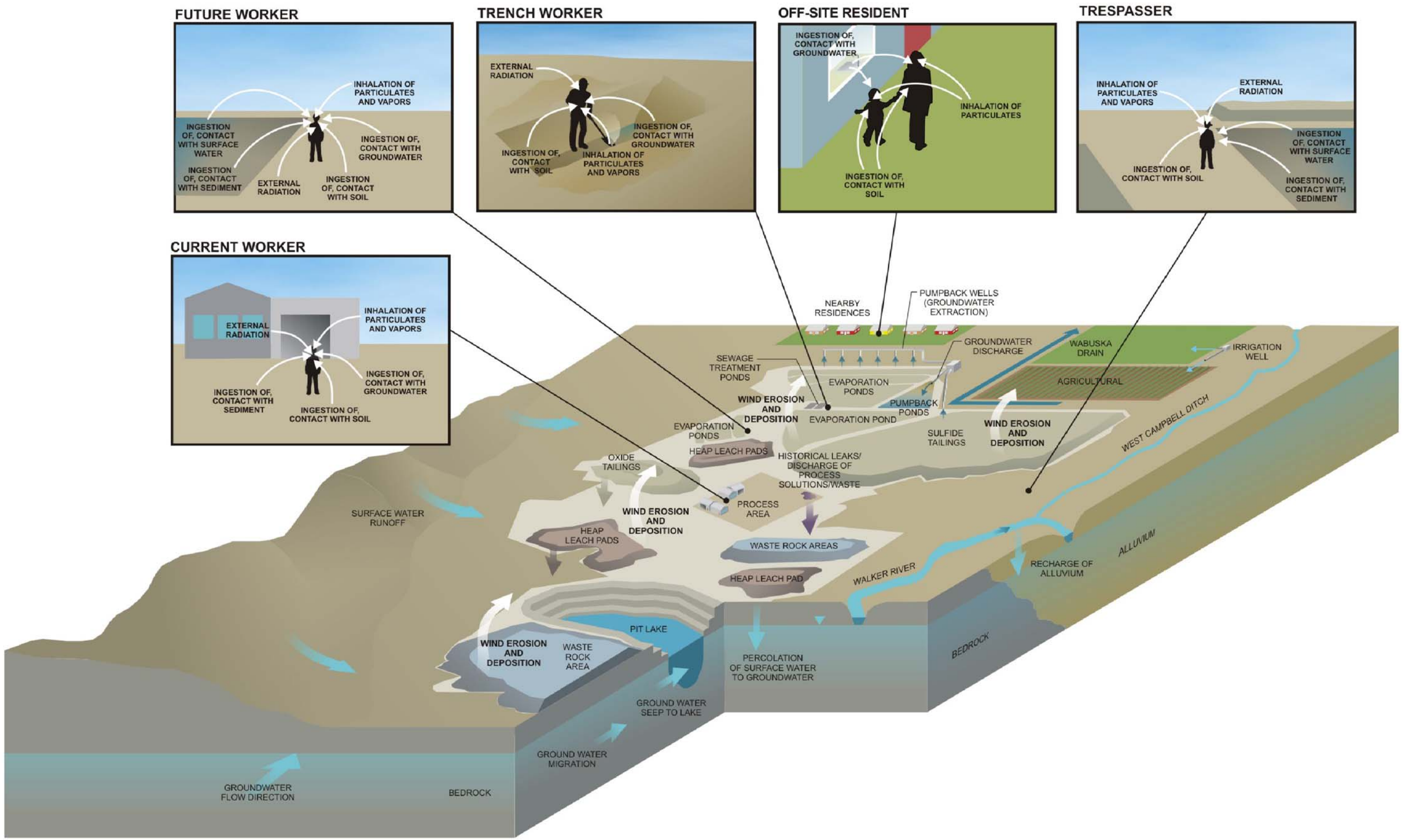
Conceptual Site Model Yerington Mine Site

Figure 3-2

Conceptual Site Model for Human Health Receptors



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Conceptual Site Model
Yerington Mine Site

Figure 3-3

Schematic Diagram for Human Health Receptors

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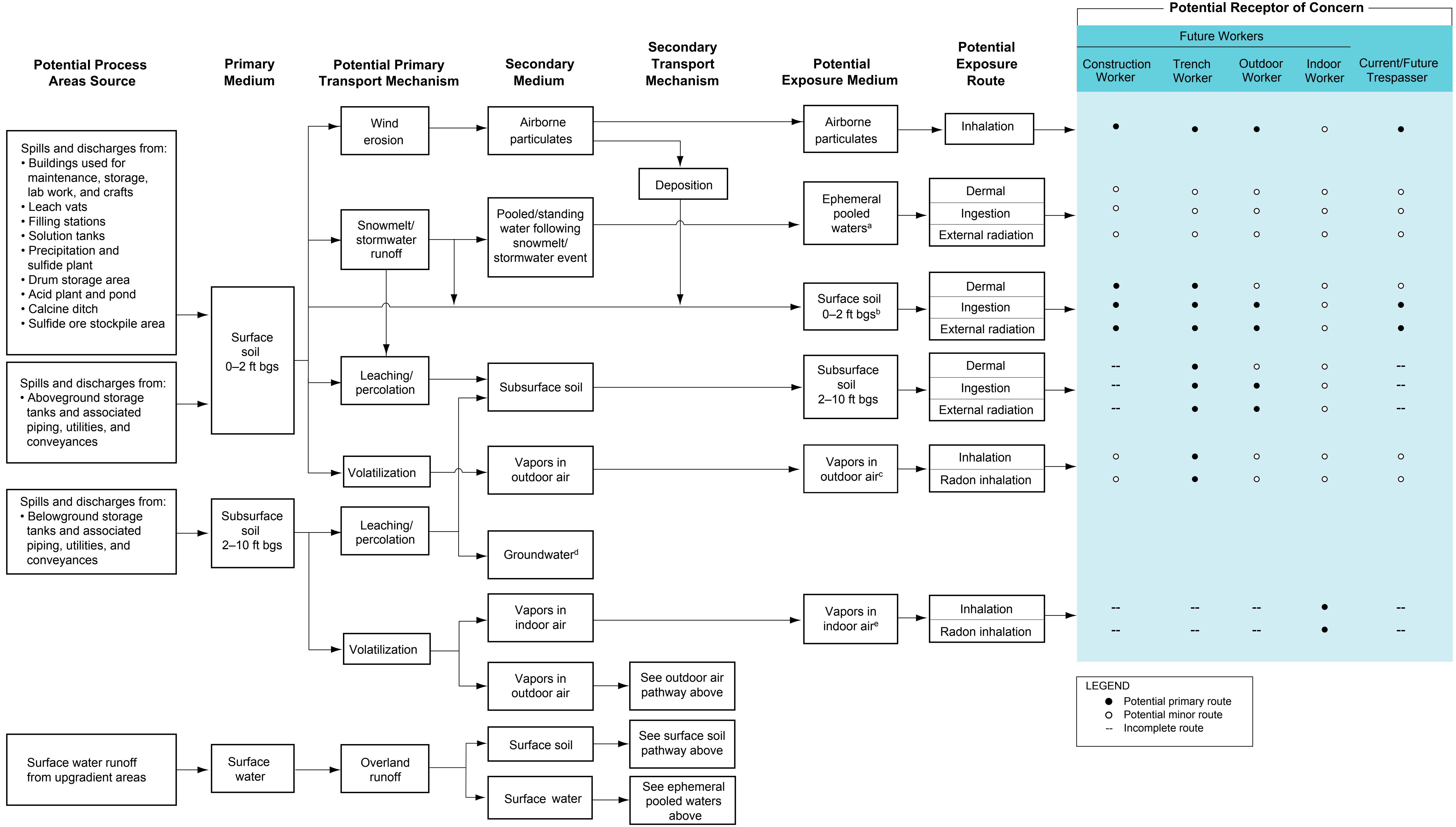

Potential Exposure Medium	Potential Exposure Route	Construction Worker	Trench Worker	Outdoor Worker	Indoor Worker	Current/Future Trespasser
Airborne particulates	Inhalation	●	●	●	○	●
Ephemeral pooled waters[a]	Dermal	○	○	○	○	○
	Ingestion	○	○	○	○	○
	External radiation	○	○	○	○	○
Surface soil 0–2 ft bgs[b]	Dermal	●	●	○	○	○
	Ingestion	●	●	●	○	●
	External radiation	●	●	●	○	●
Subsurface soil 2–10 ft bgs	Dermal	--	●	○	○	--
	Ingestion	--	●	●	○	--
	External radiation	--	●	●	○	--
Vapors in outdoor air[c]	Inhalation	○	●	○	○	○
	Radon inhalation	○	●	○	○	○
Vapors in indoor air[e]	Inhalation	--	--	--	●	--
	Radon inhalation	--	--	--	●	--

Notes:

[a] Snowmelt and rain events can lead to temporary pools of water in low-lying areas of the process areas operable unit.
[b] For external radiation, surface soil is defined as 0–15 cm bgs.
[c] Vapor migration to outdoor air will be evaluated when chemicals are found in soil at depths of <100 ft bgs.
[d] This exposure medium is evaluated in the *Site-wide Groundwater Operable Unit, Human Health Risk Assessment Work Plan* (Integral, Foxfire, Brown and Caldwell 2007).
[e] Vapor migration to indoor air is evaluated when chemicals are found in soil within 100 vertical or horizontal feet of a building.

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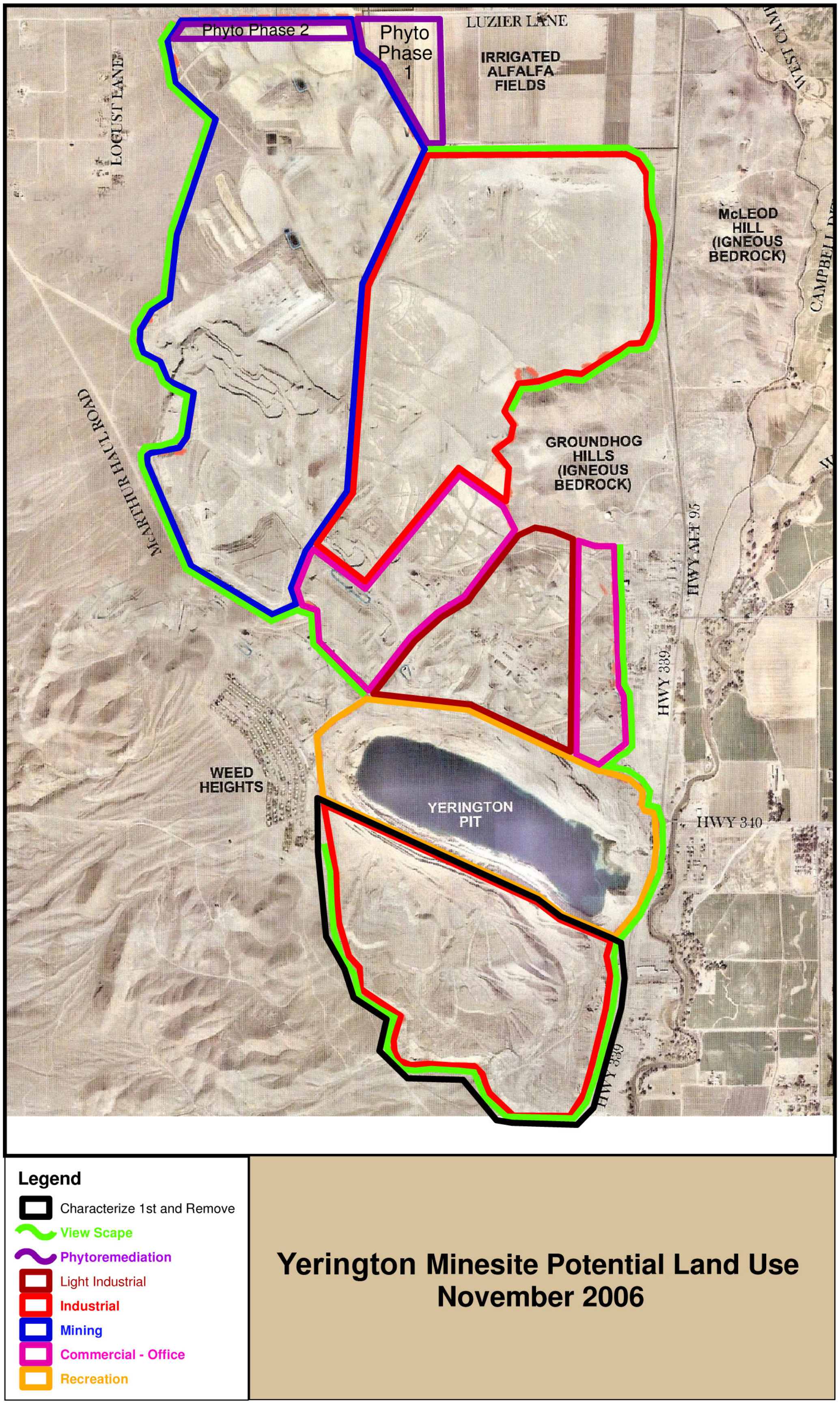
Conceptual Site Model
Yerington Mine Site

Figure 3-4

Human Health Receptor Scenarios at the Process Areas Operable Unit



Yerington Minesite Potential Land Use
November 2006

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Date: August 2007

Atlantic Richfield Company

Project Number: 132034

Figure 4-1
Yerington Minesite Potential Land Use
November 2006

TABLES

Table 4-1. Exposure Route Basis for Screening Levels

Scenarios	Exposure Routes	Source
Surface soil (0-2 ft bgs)		
Outdoor Worker	Incidental ingestion/dermal contact	EPA 2002 (SSLs)
	Inhalation of particulates in outdoor air	EPA 2002 (SSLs)
	Inhalation of vapors in outdoor air	EPA 2002 (SSLs)
	Inahaltion of radon (0-15 cm bgs)	5 pCi/g Ra-226
	Inhalation of radon in indoor air (> 15 cm bgs)	15 pCi/g Ra-226
	External radiation	EPA 2000 (SSG for Radionuclides)
Indoor Worker	Incidental ingestion	EPA 2002 (SSLs)
Subsurface soil (2-10 ft bgs)		
Outdoor Worker	Incidental ingestion/dermal contact	EPA 2002 (SSLs)
	Inhalation of particulates in outdoor air	EPA 2002 (SSLs)
	Inhalation of vapors in outdoor air	EPA 2002 (SSLs)
	External radiation	EPA 2000 (SSG for Radionuclides)
Indoor Worker	Incidental ingestion[a]	EPA 2002 (SSLs)
	Inhalation of vapors in indoor air	EPA 2004 (J&E SoilSCREEN.xls)

Notes:
a Applies to future worker scenario only
bgs = below ground surface
J&E = Johnson & Ettinger (1991)
SSL = Soil screening level