Risk Assessment
Former Reilly Industries
Provo, Utah
UTD009087644

Prepared for:

Vertellus

Vertellus Specialties Inc.

Prepared by:

URS

URS Corporation

June 2013

Vertellus File #2253

URS

June 12, 2013

Mr. Scott T. Anderson, Director
Utah Solid and Hazardous Waste Control Board
Utah Department of Environmental Quality
195 North 1950 West
PO Box 144880
Salt Lake City, UT 84114-4880

Re: Risk Assessment
Former Reilly Industries
Provo, Utah
UTD009087644 ✓

Vertellus File #2253

Dear Mr. Anderson:

On behalf of Vertellus Specialties Inc. (Vertellus), URS Corporation (URS) submits this Risk Assessment in accordance with the Revised Risk Assessment Work Plan, dated December 2012, as approved by the Utah Department of Environmental Quality (UDEQ) on March 14, 2013. We would be happy to meet with you to discuss the results of the Risk Assessment after you have had a chance to review the report. If you would like me to set up a meeting in advance, please let me know.

If you have any questions, please feel free to contact me at 801-904-4016 or John Jones of Vertellus at 317-248-6427.

Very Truly Yours,

Tina Maniatis, PE
Project Manager

cc: Mr. Brad Maulding, UDEQ
Mr. Rolf Johnson, UDEQ

Attachment

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List of Acronyms

µg	microgram
µg/L	microgram per liter
µg/mg	microgram per milligram
µg/m^3	microgram per cubic meter
ABS	dermal absorption fraction
ABS_{GI}	absorbed from the gastrointestinal tract
AC	average concentration
ADD	average daily dose
ADI	average daily intake
amsl	above mean sea level
ATc	averaging time (cancer)
atm-m^3/mole	atmosphere·cubic meter per mole
ATn	averaging time (non-cancer)
ATSDR	Agency for Toxic Substances and Disease Registry
AUF	Area Use Factor
BAF	bioaccumulation factor
BCF	bioconcentration factor
BERA	baseline ERA
bgs	below ground surface
BSAF	biota-sediment accumulation factor
BW	body weight
C	concentration
CalEPA	California Environmental Protection Agency
CCC	Criterion Continuous Concentration
CF	conversion factor
CFR	Code of Federal Regulations
cm	centimeter
cm/hour	centimeters per hour
cm^2	centimeters squared
cm^2/sec	squared centimeters per second
cm^3/cm^3	cubic centimeters per cubic centimeter
cm^3/L	cubic centimeters per liter
COEC	chemical of ecological concern
COPC	chemical of potential concern
COPEC	chemical of potential ecological concern
CR	cancer risk

CS	species receiving special management
CSM	Conceptual Site Model
DSHW	Division of Solid and Hazardous Waste
EA	exposure area
Eco-SSL	Ecological soil screening level
ED	exposure duration
EF	exposure frequency
EPC	exposure point concentration
ERA	ecological risk assessment
ERM	Environmental Resources Management
ESL	ecological screening levels
ETf	Exposure time fraction
EV	number of events
GWIR	Groundwater ingestion rate liters per hour
g/cm^3	grams per cubic centimeter
$g/cm\text{-}second^2$	grams per centimeter seconds squared
g/mole	grams per mole
HHRA	human health risk assessment
HI	hazard index
HPAH	high molecular weight PAH
HQ	hazard quotient
IR	ingestion rate
IRIS	Integrated Risk Information System
J&E	Johnson and Ettinger
kg	kilogram
L/hour	liters per hour
L/m^3	liters per cubic meter
(L)AC	lifetime average concentration
(L)ADI	(Lifetime) Average daily intake
LANL	Los Alamos National Laboratory
LOAEL	lowest observed adverse effect level
LOEC	lowest observed effect concentration
LPAH	low molecular weight PAH
m/sec	meters per second
m^2	squared meter
m^3	cubic meter
m^3/kg	cubic meters per kilogram
$m^3/\mu g$	cubic meters per microgram
mg	milligram

mg/cm^2	milligrams per centimeter squared
mg/day	milligrams per day
mg/kg-day	milligrams per kilogram per day
$(mg/kg\text{-}day)^{-1}$	kilogram-day per milligram
mg/kg bw-day	milligrams per kilograms body weight per day
mg/L	milligrams per liter
mg/m^3	milligrams per cubic meter
MRL	minimum risk level
NOAEL	no observed adverse effects level
NQ	not quantified
OC	organic carbon
ORNL RAIS	Oak Ridge National Laboratory Risk Assessment Information System
ORNL	Oak Ridge National Laboratory
OSHA	Occupational Safety and Health Administration
OSW	Office of Solid Waste
OSWER	Office of Solid Waste and Emergency Response
OUST	Office of Underground Storage Tanks
PAH	polycyclic aromatic hydrocarbon
PEC	probable effect concentration
PEF	particulate emission factor
PPRTV	Provisional Peer-Reviewed Toxicity Values
PSCIPCO	Pacific States Cast Iron Pipe Company
QA/QC	Quality Assurance/Quality Control
RCRA	Resource Conservation & Recovery Act
RfC	reference concentration
RfD	reference dose
RFI	RCRA Facility Investigation
RL	reporting limit
RME	reasonable maximum exposure
ROI	receptor of interest
RSL	Regional Screening Level
SA	surface area
SF	slope factor
SLERA	screening level ERA
SPC	species of concern
SSAF	soil-to-skin-adherence factor
SUF	Seasonality Use Factor
SWIR	Surface water ingestion rate liters per hour
SWMU	solid waste management unit

T&E	Threatened and Endangered
TDM	Tar Derived Materials
TEC	threshold effect concentration
TERA	Toxicology Excellence for Risk Assessment
TGC	target groundwater concentration
TIC	tentatively identified compound
TRV	toxicity reference value
UAC	Utah Administrative Code
UCL	upper confidence limit of the mean
UDEQ	Utah Department of Environmental Quality
UR	unit risk
USEPA	U.S. Environmental Protection Agency
VCP	Voluntary Cleanup Program
VF	volatilization factor
VI	vapor intrusion
VISLs	Vapor Intrusion Screening Levels
VOC	volatile organic compound
WP	Work Plan

EXECUTIVE SUMMARY

A human health risk assessment (HHRA) and an ecological risk assessment (ERA) were conducted as part of the Utah Department of Environmental Quality (UDEQ) Division of Solid and Hazardous Waste (DSHW) Resource Conservation & Recovery Act (RCRA) program for the former Reilly Industries, Inc., coal tar refinery located in Provo, Utah, now owned by Vertellus Specialties Inc. (Vertellus). The risk assessments provide a baseline evaluation of current or potential threats to human health and the environment from chemical releases at the Vertellus property and fenced portion of the canal (Site), and in adjacent off-site properties (off-site) under potential and hypothetical conditions. The risk assessments utilized the data collected from hundreds of locations sampled during the RCRA Facility Investigations (RFIs) that began in 2000 and concluded in 2012.

The risk assessments were conducted in accordance with Utah Administrative Code (UAC) R315-101 and the risk assessment work plan (WP) (URS, 2012) that DSHW approved on March 14, 2013 (UDEQ, 2013). The HHRA evaluated five potential scenarios:

- a potential current child trespasser assumed to be exposed to surface soil, surface sediments, and surface water at the Site;
- a potential future on-site maintenance worker assumed to be exposed to surface soil on the Vertellus property;
- a potential future construction worker assumed to be exposed to surface sediments, subsurface sediments, and surface water while piping the canal;
- a potential future off-site indoor worker assumed to be exposed to volatile organic compounds (VOCs) in indoor air impacted by groundwater on the Pacific States Cast Iron Pipe Company (PSCIPCO) property; and,
- a potential future off-site construction worker assumed to be exposed to subsurface soil and groundwater on the on the PSCIPCO property.

The HHRA also evaluated two hypothetical scenarios for risk management purposes:

- a hypothetical on-site indoor worker exposed to surface soil and indoor air on the Vertellus property and,
- a hypothetical on-site construction worker exposed to surface soil, subsurface soil, and groundwater on the Vertellus property.

Vertellus has no plans for construction or occupation of the Vertellus property by workers. Instead Vertellus plans to maintain the site as a vacant fenced lot for the foreseeable future.

The Vertellus property, fenced portion of the canal, and adjacent off-site PSCIPCO property were divided into ten exposure areas (EA) (See Figure 3-5) for the risk assessments, as discussed in detail in Section 3.1.4. One small exposure area (EA6) and four small surface soil hotpots were specifically separated from the other exposure areas because concentrations of chemicals of potential concern (COPCs) in surface soil were much higher than in other areas of Site. The other exposure areas were selected based on similar sampling locations, similar receptors, and similar media and concentrations of COPCs.

When target organs were considered in the HHRA, non-cancer hazards, expressed as hazard indices (HIs), were 1 or less for all exposure scenarios. Therefore, COPCs in on-site and off-site locations evaluated in the HHRA do not pose an unacceptable threat of non-cancer effects.

Cumulative cancer risks (CR) were less than 1E-06 in EA10 for the future off-site construction worker exposed to groundwater. Cumulative risks were within the UDEQ's risk management range of CRs equal to 1E-06 or greater (but less than 1E-04) for:

- all receptors and media in EA1, EA4, EA5, EA7, and EA9.
- current child trespassers and future on-site maintenance workers exposed to surface soil in EA3.
- hypothetical on-site construction workers exposed to subsurface soil plus groundwater in EA3 and EA4.
- current child trespassers, future on-site maintenance workers, and hypothetical on-site construction workers exposed to surface soil at hotspots 2-SF-2-18, 2-SF-2-19, 2-SF-3-36, and 2-SF-4-23.

Cumulative risks equaled or exceeded the upper end of UDEQ's risk management range of 1E-04 for:

- hypothetical on-site construction workers exposed to subsurface soil in EA2 plus groundwater in EA8.
- hypothetical on-site indoor workers exposed to surface soil in EA3 plus indoor air in EA8.
- all receptors exposed to surface soil in EA6.
- hypothetical on-site indoor workers exposed to surface soil in hotspots 2-SF-2-18, 2-SF-2-19, 2-SF-3-36, and 2-SF-4-23.

The ERA provided a Baseline Ecological Risk Assessment (BERA) for the on-site portions of Vertellus property. The BERA evaluated the following receptors of interest (ROI) exposed to on-site soil in terrestrial areas:

- Plants
- Soil Invertebrates
- Herbivorous Bird (represented by the ring-necked pheasant)
- Invertivorous Bird (represented by the tree swallow)
- Herbivorous Mammal (represented by the mule deer)
- Carnivorous Mammal (represented by the red fox)
- Invertivorous Mammal (represented by the deer mouse)
- Herbivorous Mammal (represented by the meadow vole)

The BERA evaluated the following ROIs exposed to sediments in the Ironton Canal:

- Plants
- Benthic Invertebrates
- Omnivorous Bird (represented by the mallard)
- Invertivorous Bird (represented by the tree swallow)

The BERA also evaluated the Aquatic Community exposed to surface water in the Ironton Canal.

The BERA contemplated the potential for ecological risk to ROIs exposed to soil in EA1, EA2, EA3, EA4, EA6, EA7, and at four hotspot locations. Hazard Quotients (HQs) were developed for each of the EAs to assess the potential for ecological risk. HQs are numbers conservatively derived as indicators of potential risk, not actual calculations of risk. Bioavailability and uptake factors used in the ecological risk calculations were based on conservative literature values that may overestimate risk. Furthermore, the calculations did not take into account habitat quality which is likely unsuitable in the former process areas for ecological receptors.

Using both quantitative HQs and qualitative considerations, potential for ecological risk was characterized in the ERA as "Likely," "Possible," "Unlikely", or "Not at Risk". The results of the BERA indicate:

- Ecological risk may be considered "Likely" for some ROIs exposed to soil in the terrestrial EAs including EA2, EA4, EA3, EA6, and EA7 (in order of highest to lowest risk). However, the gravel cover in EA3 and parts of EA4 and EA2 likely make these areas undesirable as ecological habitat.

- Ecological risk is "Unlikely" for ROIs exposed to surface water in EA1 (Ironton Canal).
- Ecological risk is considered "Likely" for benthic invertebrates and Possible for other ROIs exposed to sediment in the Ironton Canal.

According to Utah Administrative Code (UAC) R315-101, no further action may be requested when the total CR is less than 1E-06 and the total HI is less than 1 based on a residential exposure scenario conducted in accordance with R315-101-5.2(b)(1) and ecological effects are deemed insignificant by the Executive Secretary of DSHW. A Site Management Plan is required if:

(1) the CR is greater than or equal to 1E-06 and/or the HI is greater than 1 based on a residential scenario, or

(2) The Executive Secretary of DSHW determines that ecological effects may be significant.

The Site Management Plan must contain procedures for corrective action if:

(1) the level of risk at the Site is greater than or equal to 1E-04 or the HI is greater than 1 (based on an actual land-use or potential land-use conditions), or

(2) the Executive Secretary concludes that corrective action is required to mitigate ecological effects.

A residential exposure scenario was not evaluated in the HHRA. Therefore, a Site Management Plan will be required for the Site and the off-site areas evaluated in the HHRA.

The HHRA determined that the CRs and HIs were less than 1E-04 and 1, respectively, for potential receptors in exposure areas at most of the Site and off-site, including EA1, EA4, EA5, EA7, EA9 and EA10. Therefore, human health risk will be managed in a Site Management Plan and Environmental Covenant without additional corrective action for these areas.

Cancer risk to all receptors in EA6 exceeded the 1E-04 threshold, and therefore, the Site Management Plan will include procedures for corrective action to mitigate the risks to human health in EA6. Appropriate corrective action determinations will be proposed in a Corrective Action Plan as specified in the 1996 Corrective Action Agreement (UDEQ, 1996) and will incorporate the criteria provided in UAC R315-101-1(b)(4). In order of importance, the criteria include:

(a) The impact or potential impact of the contamination on the human health
(b) The impact or potential impact of the contamination on the environment
(c) The technologies available for use in clean-up
(d) Economic considerations and cost-effectiveness of clean-up options

For the other areas of the Site where risk was estimated to be above unacceptable levels (i.e., CR greater than 1E-04 for human health in EA2, EA3, and the hotspots or where ecological risk may be of concern), risk is localized to only a few locations in each exposure area. For many of the constituents, the range of concentrations is very wide and distribution plots of concentrations show that elevated exposure point concentrations (95% UCLs) are often a result of a limited number of individual high detected concentrations in an EA. Consequently, the distribution of concentrations and risks across an EA are not uniform, and simulating corrective action in these limited areas through what is termed "iterative truncation" can illustrate the reduction in exposure concentrations and risk that result when the highest concentration areas are removed from the 95% UCL calculations. Vertellus suggests that the following iterative truncation process be pursued following the risk assessment:

- Step 1 – Concentrations of constituents that are posing risk are put into rank order (high-to-low).
- Step 2 – High concentrations are iteratively removed from the exposure area data set and the 95% UCL is recalculated to confirm that the number of high concentrations removed would produce a 95% UCL that meets an acceptable risk level for the exposure area.
- Step 3 – Potential areas for removal are defined and anticipated confirmation samples are collected in the field around the areas of assumed removal.
- Step 4 – Confirmation sample results are added to the 95% UCL calculation to confirm that the anticipated removal meets the acceptable risk levels for the exposure area. If the recalculated 95% UCL does not meet the acceptable risk level for the exposure area, the removal area is redefined and additional confirmation samples are collected until the 95% UCL result meets the acceptable risk level.

Iterative truncation will be used to support cost-benefit analysis of instituting corrective actions in place of, or in addition to, doing additional site-specific studies the could be used to further refine the results of the risk assessment.

The Site Management Plan, Environmental Covenant, and Corrective Action Plan(s) will be submitted upon approval of the Risk Assessment in accordance with the procedures and schedule set out in the Corrective Action Agreement (UDEQ, 1996).

1.0 INTRODUCTION

1.1 Purpose and Scope

A human health risk assessment (HHRA) and an ecological risk assessment (ERA) were conducted as part of the Utah Department of Environmental Quality (UDEQ) Division of Solid and Hazardous Waste (DSHW) Resource Conservation & Recovery Act (RCRA) program. The risk assessments provide a baseline evaluation of potential and hypothetical threats to human health and the environment from chemical releases both at the Vertellus property and fenced portion of the canal (Site) and in adjacent off-site properties (off-site) under potential and hypothetical conditions.

1.2 Site Description

The property is located at 2555 South Industrial Parkway in unincorporated Utah County. The property consists of a 31.84-acre empty lot (Figure 1-1). All buildings and structures have been removed, but some remnants such as concrete foundations still remain on the property. The Ironton Canal (canal), which is not owned by Vertellus, runs adjacent to the northern boundary of the property. The northern portion of the property contains the area where plant operations historically took place whereas the southern portion is an undeveloped field. The Site perimeter including the portion of Ironton Canal that is adjacent to the Vertellus property is fenced. Access to the Site is through locked gates from the north by a concrete bridge that spans Ironton Canal or from the northeast corner of the Site. The Site is located at an elevation of approximately 4,500 feet above mean sea level (amsl) and slopes towards the western boundary of the property. Ephemeral ponds may form in the western portion of the Site near Industrial Parkway from surface water draining from the north and south portions of the Site. Surface water in Ironton Canal flows east to west towards Utah Lake located approximately 1.5 miles from the Site. Groundwater at the Site generally flows to the west. Groundwater depths range from less than 1 foot to approximately 9 feet below ground surface (bgs), depending on the location and the time of the year. The average site-wide groundwater depth is approximately 3 feet bgs.

2.0 DATA USABILITY AND ORGANIZATION

Analytical data were evaluated and organized into a form appropriate for baseline risk assessment. A primary purpose of the evaluation of data usability was to select validated analytical results that are of adequate quality for use in quantifying risks.

Three historical sampling phases have been conducted at the Site: Phase I RCRA Facility Investigation (RFI) activities were completed in October 2000. Phase II RFI samples were collected in December 2004 and April 2005. Supplemental Phase II RFI data were collected between October 2008 and January 2010. Analytical data for the Phase I RCRA RFI, Phase II RFI, and Supplemental Phase II RFI sampling events have undergone data usability reviews and have been approved for use by UDEQ. These analytical data are presented in Tables 4-1 to 4-8 in the Phase II RFI Supplemental Investigation Report (Environmental Resources Management [ERM], 2009) and Phase II RFI Supplemental Investigation – Groundwater and Surface Water Monitoring Report (ERM, 2010). Prior to beginning the risk assessment, URS used laboratory analytical data reports to conduct a quality assurance/quality control (QA/QC) evaluation of the analytical results presented in the ERM (2009, 2010) tables. In addition, URS collected sediment samples in February 2012, soil samples in November 2011 and April 2012, and groundwater and surface water samples in November 2011, April 2012, and November 2012. The data collected by URS were validated by a URS chemist.

After review of the combined data set from all sampling events, the results from one location during one sampling event (groundwater sample results collected during the November 2011 sampling event at TW-1) were removed from the data set and not evaluated in the HHRA. Instead, the next highest concentration from the remainder of the four sampling events for TW-1 was used for the calculation of 95% UCLs. The concentrations from TW-1 collected during the November 2011 sampling event were removed because the results were unusually high in comparison with the results from the previous two sampling events and subsequent two sampling events. As an example, benzo(a)pyrene results from all the sampling events at TW-1 are as follows: <6.3 microgram per liter (µg/L) (April 2009), 0.42 µg/L (October 2009), 160 µg/L (November 2011), 6.1 µg/L (April 2012), and 5.5 µg/L (November 2012). In addition, the benzo(a)pyrene concentration from TW-1 collected during the November 2011 sampling event was unusually high in comparison to results at other locations in EA8. There are a total of 95 sample results for benzo(a)pyrene in 25 sampling locations for groundwater in EA8. Excluding the groundwater sampling result collected during the November 2011 sampling event at TW-1, the next highest concentration of benzo(a)pyrene for the other 94 groundwater sample results in EA8 is 6.9 ug/L at TW-2.

For many other detected chemicals, the November 2011 sample concentrations were anomalous to the other four samples collected at TW-1 and to concentrations in other groundwater samples collected throughout EA8. Instead of using the anomalous results from November 2011 which would not be representative of the concentrations of many chemicals in groundwater at that location, the highest concentrations from the other sampling events (e.g., 6.1 µg/L of benzo(a)pyrene from April 2012) were used in the risk assessment.

Additionally, during the Phase II RFI, sediment samples were collected from the former Ironton Steel wastewater pond located on the former Ironton Steel facility, upgradient from the Site. Four samples were collected from different depths at location 2-S-1-1. Results indicated polycyclic aromatic hydrocarbon (PAH) impacts at each depth, but these results were not included in this risk assessment.

In addition, the following steps were conducted to produce the final data set for the risk assessment:

- Where more than one groundwater sample was collected from the same sample location at different points in time, the maximum concentration of each chemical at each well over the five most recent sampling events was used. However, sampling results prior to April, 2009 (i.e., December, 2004, and April, 2005) were not used. Sampling results from December, 2004 and April, 2005 are unlikely to be representative of current conditions at the site; therefore, those sampling results were not used in the risk assessment. For some wells, the maximum concentration used were based on sampling results from less than five sampling events. For example, MW-30 was sampled in April, 2009 and October, 2009, but was not sampled in November, 2011, April, 2012, or November, 2012. Therefore, the concentrations used in the risk assessment were the maximums of the results from April, 2009 and October, 2009 at MW-30. MW-14 was sampled in April 2009, October 2009, November 2011, April 2012, and November 2012. The concentrations used in the risk assessment were the maximum of the results from those five sampling events at MW-14.
- For duplicates for which each sample has detectable quantities of the constituent in question, the higher of the two concentrations was used in the reduced data set. If one sample was a detection and the other a non-detection, the detected value was used. If both sample results were non-detections, the result with the lowest reporting limit (RL) was used.

- Some of the non-detect sampling results have elevated RLs due to matrix interference and sample heterogeneity. These data were classified as non-detect ("U" qualified) and the RL was used in the risk assessment in accordance with current guidance U.S. Environmental Protection Agency [(USEPA), 1989, 2002a]. The potential impact of elevated detection limits on the risk assessment results is discussed in the uncertainty section.
- Tentatively identified compounds (TICs) were not evaluated quantitatively in the HHRA or ERA due to the large uncertainty associated with their chemical identity and concentrations. TICs are evaluated and discussed qualitatively in the uncertainty section.

3.0 HUMAN HEALTH RISK ASSESSMENT

A HHRA was conducted as part of the UDEQ DSHW RCRA program for the Site and impacted off-site areas. The HHRA was conducted in accordance with an approved, detailed risk assessment Work Plan (WP) (URS, 2012; UDEQ, 2013).

3.1 Exposure Assessment

This section describes human exposure scenarios; calculation of exposure point concentrations (EPCs); selection of chemicals of potential concern (COPCs); exposure factors; and calculation of intake for each COPC, exposure pathway, and receptor.

3.1.1 Current and Future On-site Land Use

The Site is currently vacant with no active operations. It is zoned by Utah County as an 1-1 Industrial Zone and is expected to remain zoned for industrial use in the future. Vertellus plans to maintain the Site as a vacant fenced lot for the foreseeable future.

For the Phase II RFI investigations, historical solid waste management units (SWMUs) were consolidated into five SWMU areas, four of which are shown in Figure 1-1:

- SWMU Area 1 – Ironton Canal
- SWMU Area 2 – North and South Impoundments and Evaporation Pan
- SWMU Area 3 – Process Area
- SWMU Area 4 – By-Product Lagoons and Evaporation Areas
- SWMU Area 5 – Site-wide Groundwater (not shown on Figure 1-1)

There is an undeveloped field area in the southern portion of the Site (the south parcel). The majority of the south parcel is not contained in any of the SWMU Areas shown above (Figure 1-1).

3.1.2 Surrounding Land Use

Land use surrounding the Site is also predominantly industrial (Figure 1-1). The Pacific States Cast Iron Pipe Company (PSCIPCO) property adjacent to the west and the Springville Industrial Park adjacent to the south and separated by a railroad line, are industrial facilities on properties zoned for industrial use. A field to the north of the Site (beyond the canal) and owned by PSCIPCO is zoned for industrial use. The Denver and Rio Grande Railroad borders the Site to the east and the former Ironton Steel site is located adjacent to the railroad. The Ironton site was a former steel mill that underwent cleanup under the UDEQ Division of

Environmental Response and Remediation Voluntary Cleanup Program (VCP). It is currently owned and being redeveloped by Provo City as an industrial complex.

Off-site areas that were evaluated in the HHRA include the portion of the Ironton Canal located downstream adjacent to PSCIPCO property and potentially impacted off-site subsurface soil and groundwater located just west of the Industrial Parkway on PSCIPCO property.

3.1.3 Conceptual Site Models

Conceptual Site Models (CSMs) are schematic representations of source areas, release mechanisms, environmental transport media, and potential exposure routes for chemicals that may lead to exposure of human receptors to chemicals. The purpose of the CSM is to identify contaminant sources and exposure pathways that are anticipated to result in the most exposure for the identified receptors.

Potentially complete and significant exposure pathways are quantified by risk assessment. A complete exposure pathway includes all of the following elements:

- A source and mechanism of contaminant release
- A transport or contact medium (e.g., air or soil)
- An exposure point where humans can contact the impacted medium
- An exposure (intake) route (such as ingestion or inhalation)

Four final HHRA CSMs were developed:

1. Ironton Canal (SWMU Area 1 and downstream area) (Figure 3-1);
2. Soil and groundwater for the remainder of the Site (SWMU Areas 2, 3, 4, and 5, south parcel, and offsite) (Figure 3-2);
3. Ironton Canal (SWMU Area 1 and downstream area) (hunting and fishing scenarios only) (Figure 3-3); and
4. Soil and groundwater for the remainder of the Site (SWMU Areas 2, 3, 4, and 5, south parcel, and offsite) (hunting and fishing scenarios only) (Figure 3-4)

The following sections contain information on sources, transport pathways, potential exposure media; human receptors and exposure pathways for the four CSMs.

3.1.3.1 Sources

The risk assessment WP provides detailed descriptions of potential sources of contamination in the Ironton Canal and in soil and groundwater in SWMU Area 2, SWMU Area 3, SWMU Area 4, the south parcel, and off-site locations. A more detailed discussion of the results of

the RFI investigations can be found in the RFI Investigation reports (ERM, 2009 and ERM, 2010). All sampling results were presented in Appendix A in the risk assessment WP and sample locations are shown in Figures 3-6 through 3-9.

Based on the description of sources as described in the risk assessment WP, the following media may have been impacted by historic site activities. Surface water and surface and subsurface sediments have been impacted in the Ironton canal. These media were evaluated in a separate exposure area in the HHRA. Subsurface soil has been impacted in SWMU Area 2. There currently is approximately 6 to 12 inches of organic topsoil over most sampling locations in SWMU Area 2. Therefore, primarily subsurface soil was evaluated in SWMU Area 2. Both surface soil and subsurface soil are impacted in SWMU Area 3. Subsurface soil has been impacted in SWMU Area 4. In SWMU Area 4, there is currently approximately 1 foot or more of crushed stone and slag over on-site sampling locations in the area of the SWMU 11 and 1 to 2 feet of organic top soil over on-site sampling locations in the SWMU 12 area. There is an asphalt parking lot over the off-site area in SWMU Area 4. Therefore, primarily subsurface soil was evaluated in SWMU Area 4. Off-site subsurface soil at PSCIPCO was evaluated in separate exposure areas in the HHRA. Plant operations and wastewater disposal are not known to have occurred in the south parcel; however, some surface soil and subsurface soil locations in this area have minor impacts. These impacts outside of other SWMU Areas were evaluated in a separate exposure area in the risk assessment.

Groundwater has been impacted in SWMU Areas 2, 3, and 4, and to a lesser degree in the south parcel. On-site and off-site groundwater were each evaluated in separate exposure areas in the HHRA.

3.1.3.2 Transport Pathways

Ironton Canal CSM (Figures 3-1 and 3-3): Chemicals in upstream surface water and sediments can be transported to downstream surface water and sediments in the fenced portion of the Ironton Canal (SWMU Area 1). Chemicals may be transported between surface sediments and surface water. Groundwater may transport chemicals into surface water or sediments, depending on the height of groundwater relative to surface water in Ironton Canal (the heights of groundwater and surface water vary throughout the year). Chemicals in surface sediments may leach to subsurface sediments. Chemicals in surface water and sediments can be transported downstream to surface water and sediments in the unfenced portion of the Ironton Canal. Chemicals in those surface sediments may leach to subsurface sediments. Excavation activities in the canal (such as installing a pipe) could expose subsurface sediments. Direct uptake/intake of constituents in surface water and sediments can

occur in aquatic plants and animals (including game fish). Aquatic animals can ingest constituents in plants or other aquatic animals, which in turn may each be ingested by game fish. The canal does not provide good habitat for waterfowl, due to the fast flowing water and steep sides. Therefore, it was assumed that exposure of waterfowl to media in the canal is negligible.

Soil and Groundwater CSM (Figure 3-2 and 3-4): Chemicals in on-site surface soil in SWMU Area 3 (including constituents associated with tar derived materials [TDM] in subsurface soil) could leach into on-site subsurface soil in SWMU Area 3. Chemicals in on-site and off-site subsurface soil (including constituents associated with TDM in surface soil) could leach into on-site and off-site groundwater, respectively. Surface water from Ironton Canal may transport chemicals into groundwater depending on the height of surface water relative to groundwater which varies through the year. On-site groundwater can transport chemicals downgradient to off-site groundwater. Surface water runoff could collect in the ephemeral pond in the area during wet months (winter and spring). Future off-site excavation activities could lead to exposure to off-site subsurface soil and shallow groundwater. Hypothetically, on-site excavation activities could lead to exposure to on-site subsurface soil and shallow groundwater. Volatile organic compounds (VOCs) in groundwater and subsurface soil could enter soil gas both offsite and onsite. Direct uptake/intake of constituents in surface soil can occur in terrestrial plants and terrestrial game. Direct uptake of constituents in subsurface soil can occur in plants. Terrestrial game (e.g., mule deer, pheasants, mourning doves) could ingest constituents in terrestrial plants and in surface water and aquatic plants in the ephemeral pond near Industrial Parkway. Uptake/intake of constituents in surface water in the ephemeral pond near Industrial Parkway can occur in aquatic plants, non-game aquatic animals, and waterfowl (e.g., mallard ducks, geese). Non-game aquatic animals can ingest constituents in aquatic plants or in other non-game aquatic animals. Waterfowl could ingest constituents in soil, aquatic plants, and non-game aquatic animals.

3.1.3.3 Potential Exposure Media

Ironton Canal CSM (Figures 3-1 and 3-3): Potential exposure media in Ironton Canal (both the fenced area in SWMU Area 1 and the unfenced downstream area) include surface and subsurface sediments in the sidewalls of the canal, surface and subsurface sediments in the bottom of the canal, and surface water. Surface sediment is defined as sediment at depths of 0-1 foot bgs. Subsurface sediment is defined as sediment at depths of 1-10 feet bgs. Subsurface sediment samples that are deeper than 10 feet bgs were not evaluated in the HHRA. In addition, exposure media could include game fish consumed by humans.

Soil and Groundwater CSM (Figures 3-2 and 3-4): Shallow groundwater underlying the former Vertellus Facility occurs in unconsolidated soils at depths of less than 10 feet bgs. Shallow groundwater is not currently used at the Site and future use is not anticipated because water is readily available from the Provo City Water Resource Division of Public Works, groundwater in the shallow unconfined aquifer is of limited quantity and low yield due to the soil types, and the shallow groundwater covering most of the site is considered Class IV (Saline Groundwater) and unsuitable for use. However, off-site shallow groundwater could be contacted if there were future intrusive activities. Hypothetical on-site intrusive activities could result in contact with on-site shallow groundwater. No buildings currently exist onsite. If buildings were constructed either onsite or offsite, indoor air could be impacted by vapor intrusion of VOCs in subsurface soil or groundwater. Other potential exposure media include on-site surface soil and on-site and off-site subsurface soil. Surface soil is defined as soil at depths of 0-1 foot bgs. Subsurface soil is defined as soil at depths of 1-10 feet bgs. Subsurface soil samples that are deeper than 10 feet bgs were not evaluated in the HHRA. In addition, exposure media could include terrestrial game and waterfowl consumed by humans.

Off-site impacts are found beneath a parking lot at PSCIPCO, potentially under Industrial Parkway, and in subsurface soil north of the parking lot (adjacent to SWMU Area 4). Off-site surface soil either does not exist (because of the parking lot) or is not impacted. Subsurface soil beneath the parking lot at PSCIPCO and in subsurface soil north of the parking lot (adjacent to SWMU Area 4) was evaluated in the HHRA. Evaluation of on-site surface soil outside of SWMU Area 3 was limited to evaluation of one hot spot sample in SWMU Area 4 (confirmation sample from former surface TDM location), one hot spot sample in SWMU Area 3 (confirmation sample from former surface TDM locations), two hot spot samples in SWMU Area 2 (confirmation samples from former surface TDM locations), and the twelve surface soil samples collected in the south parcel in November, 2011 and April, 2012.

3.1.3.4 Human Receptors

Ironton Canal CSM (Figures 3-1 and 3-3): Based on current and reasonably anticipated future land use scenarios, potential current trespassers (assumed to be children who are 7-18 years of age) playing in Ironton Canal and potential future construction workers piping the canal were evaluated in both the fenced and the unfenced (downstream) portions of the canal. Maintenance workers who take care of the grounds on the Site are a potential future exposure scenario. However, future on-site work at the Site does not include work in Ironton Canal. Hunters and fisherman are potential human receptors that were not evaluated quantitatively in the HHRA, because their exposure to constituents at the site is considered to be negligible (see Section 3.1.3.6).

Hypothetical on-site indoor workers and current/future off-site indoor workers employed at facilities adjacent to the Vertellus property are not potential receptors in Ironton Canal because indoor workers are assumed not to spend time during their workday in a canal.

Soil and Groundwater CSM (Figures 3-2 and 3-4): Current child trespassers and future on-site maintenance workers were evaluated for exposure to on-site surface soil. No buildings currently exist on the Site. However, a hypothetical on-site indoor worker scenario exposed to on-site surface soil and indoor air impacted by VOCs from vapor intrusion from groundwater were evaluated for risk management purposes. A hypothetical on-site construction worker performing intrusive activities on the Vertellus property was also evaluated for risk management purposes. Hunters and fisherman are potential human receptors that were not evaluated quantitatively in the HHRA, because their exposure to constituents at the site is considered to be negligible (see Section 3.1.3.6).

Potential future off-site indoor workers were evaluated for exposure to indoor air impacted by VOCs from vapor intrusion from groundwater. Exposure to indoor air impacted by VOCs from vapor intrusion from soil was not evaluated because USEPA does not currently recommend using the Johnson and Ettinger (J&E) model (USEPA, 2004b) to predict indoor air concentrations from soil concentrations; instead USEPA recommends collecting soil gas samples to evaluate impacts from soil to indoor air. However, soil gas samples cannot be collected at the Site because of the shallow depths to groundwater. The potential impacts to risk estimates of not evaluating indoor air impacted by VOCs from vapor intrusion from soil are discussed in the uncertainty section.

Off-site contamination is found beneath a parking lot at PSCIPCO, potentially under Industrial Parkway, and in subsurface soil north of the parking lot (adjacent to SWMU Area 4). There is no current exposure to off-site subsurface soil or shallow groundwater. A single potential future off-site construction worker scenario was evaluated to account for exposure to subsurface soil and shallow groundwater performing intrusive activities potentially beneath the parking lot, under Industrial Parkway, or in subsurface soil north of the parking lot (adjacent to SWMU Area 4).

3.1.3.5 Potentially Complete and Significant Exposure Pathways

Potentially complete and significant pathways that were evaluated quantitatively in the HHRA are discussed below.

Ironton Canal CSM (Non-Hunting and Non-Fishing Scenarios) (Figure 3-1):

- Current Child Trespasser - Ingestion and dermal exposure to surface sediments and surface water.
- Future Construction Worker (piping the canal) - Ingestion and dermal exposure to surface and subsurface sediments (combined sediments) and surface water.

Soil and Groundwater CSM (Non-Hunting Scenarios) (Figure 3-2):

- Current Child Trespasser - Ingestion, dermal, and inhalation (of particulates) exposure to surface soil.
- Future Onsite Maintenance Worker - Ingestion, dermal, and inhalation (of particulates) exposure to surface soil.
- Hypothetical Onsite Indoor Worker - Ingestion, dermal, and inhalation (of particulates) exposure to surface soil and inhalation of VOCs in indoor air impacted by vapor intrusion from groundwater.
- Hypothetical Onsite Construction Worker - Ingestion, dermal, and inhalation (of particulates) exposure to surface and subsurface soil and ingestion, dermal, and inhalation (of VOCs in air in a trench) exposure to groundwater pooled at the bottom of a trench.
- Future Offsite Indoor Worker - Inhalation of VOCs in indoor air impacted by vapor intrusion from groundwater.
- Future Offsite Construction Worker - Ingestion, dermal, and inhalation (of particulates) exposure to subsurface soil and ingestion, dermal, and inhalation (of VOCs in air in a trench) exposure to groundwater pooled at the bottom of a trench.

3.1.3.6 Potentially Complete, but Negligible Pathways

The USEPA's risk assessment and risk characterization guidance (USEPA, 1989, 1992) does not require that all plausible exposure scenarios and exposure pathways be assessed. Pathways that are incomplete or potentially complete but negligible are not evaluated in risk assessment. A pathway may be potentially complete but negligible if the transport process is considered to be insignificant resulting in negligible concentrations of chemicals in the exposure medium, or if the amount of exposure to the medium is considered to be negligible. Potentially complete but negligible pathways were not evaluated quantitatively in the HHRA because these pathways would be unlikely to measurably impact risk estimates and thus would be unlikely to impact future Site removal action decisions. Potentially complete pathways that are not evaluated quantitatively in the risk characterization are discussed

qualitatively in the uncertainty section of the HHRA. The following pathways are considered to be potentially complete, but negligible:

Ironton Canal CSM (Non-Hunting and Non-Fishing Scenarios) (Figure 3-1):

- Inhalation of VOCs in outdoor air by current trespassers and future construction workers (piping the canal), because concentrations of VOCs that enter outdoor air from wet sediments and surface water will be negligible due to dilution and wind dispersion.
- Dermal absorption of VOCs from sediments by current trespassers and future construction workers (piping the canal), based on USEPA (2004a).

Soil and Groundwater CSM (Non-Hunting Scenarios) (Figure 3-2):

- Inhalation of VOCs in outdoor air above the surface by current on-site trespassers, current off-site trespassers, future off-site indoor workers, hypothetical on-site indoor workers, future on-site maintenance workers, hypothetical on-site construction workers, and future off-site construction workers, because concentrations of VOCs that enter outdoor air from soil and groundwater will be negligible due to dilution and wind dispersion.
- Ingestion and dermal exposure to on-site ephemeral water bodies that form occasionally near Industrial Parkway by current on-site trespassers, future on-site maintenance workers, and hypothetical on-site construction workers, due to limited potential for human exposure.
- Dermal absorption of VOCs from soil by current on-site trespassers, current off-site trespassers, future off-site indoor workers, hypothetical on-site indoor workers, future on-site maintenance workers, hypothetical on-site construction workers, and future off-site construction workers, based on USEPA (2004a).

Ironton Canal CSM (Hunting and Fishing Scenarios) (Figure 3-3):

- All potentially complete pathways associated with fishing in the canal by adult trespassers, due to limited number of fish in the canal and the low potential for fishing in the canal.

Soil and Groundwater CSM (Hunting Scenario) (Figure 3-4):

- All potentially complete pathways associated with hunting on the site by adult trespassers, due to the low potential for game to be exposed to contaminants from soil at the site and the low potential for hunting on the site.

3.1.3.7 Incomplete Pathways

Incomplete pathways were not evaluated in the HHRA because there is no potential risk when there is no potential exposure. The pathways listed below are all considered to be incomplete.

Ironton Canal CSM (Non-Hunting and Non-Fishing Scenarios) (Figure 3-1):

- All pathways for hypothetical on-site indoor workers and current/future off-site indoor workers for exposure to Ironton Canal, because indoor workers are assumed not to spend time during their workday in a canal.
- All pathways for future on-site maintenance workers for exposure to Ironton Canal, because maintenance work at the Site will only occur on the Vertellus property.
- Exposure of current child trespassers to subsurface sediments in the canal, because child trespassers will not perform intrusive activities.
- Inhalation of particulates from sediments by current trespassers and future construction workers (piping the canal), because very few particulates will be emitted from wet sediments.
- Exposure of future construction workers to groundwater in the Ironton Canal, because construction workers piping the canal would only be exposed to surface water impacted by nearby groundwater locations.
- Exposure of future construction workers piping the canal to soil or groundwater on the Vertellus property or on the PSCIPCO property, because construction workers piping a canal would not perform trench work on either of these properties.

Soil and Groundwater CSM (Non-Hunting Scenarios) (Figure 3-2):

- Exposure of child trespassers, indoor workers, and construction workers to chemicals in off-site surface soil, because most of the off-site soil is covered by a parking lot and other off-site surface soil that is not covered is not considered to be impacted.
- Exposure of child trespassers, hypothetical on-site indoor workers, future off-site indoor workers, and future on-site maintenance workers to subsurface soil and groundwater, because those receptors will not perform intrusive activities.

- Exposure of hypothetical on-site construction workers to off-site soil and groundwater.
- Exposure of future off-site construction workers to on-site soil and groundwater.
- Exposure of hypothetical on-site construction workers and future off-site construction workers to media in the canal (instead, future construction workers piping the canal or making repairs to the canal were evaluated in the HHRA).
- Intentional use of on-site or off-site groundwater by all receptors, because water is readily available from the Provo City Water Resource Division of Public Works, groundwater in the shallow unconfined aquifer is of limited quantity and low yield due to the soil types, and the shallow groundwater covering most of the site is considered Class IV (Saline Groundwater) and unsuitable for use.

Ironton Canal CSM (Hunting and Fishing Scenarios) (Figure 3-3):

- All potentially complete pathways associated with hunting in the canal by adult trespassers, due to the low potential for waterfowl to be exposed to contaminants in the canal and the lack of any hunting in the canal.
- Ingestion of waterfowl during fishing by adult trespassers.

3.1.4 Exposure Areas

An exposure area (EA) is defined as a location within which an exposed receptor may reasonably be assumed to move at random and where contact with an environmental medium (e.g., soil) is equally likely at all sub-locations. Exposure areas for evaluation in HHRAs are typically identified based on similarities within the exposure area in (1) geographical location; (2) sources, types, and concentrations of key chemicals; (3) exposure media; (4) potential receptors (based on anticipated patterns of human behavior); and (5) exposure pathways.

Exposure areas for the HHRA were developed primarily based on SWMU Areas, which is consistent with the investigation methodology approved by DSHW and used during RFI Phase II and Phase II Supplemental Investigations. The SWMU Area groupings used during the RFI investigations were based on contamination similar in proximity, nature, release mechanisms, chemicals of concern, media affected, and exposure pathways. The SWMU Areas did take into account potentially significantly different processes, such as SWMU Area 4 which included the waste water from the tar acid/base processing and SWMU Area 1 for the Ironton Canal. Even though some waste materials may be slightly different in physical nature, all waste materials were derived from coal tar, the only raw material processed at the site. Chemical constituents are consistent among the different waste materials and only vary somewhat in concentrations, as confirmed by the RFI investigations. For all these reasons, the

exposure areas for the HHRA basically follow the SWMU Area boundaries with the exception of SWMU Area 5 (groundwater) and SWMU Area 4. SWMU Area 5 and SWMU Area 4 were divided into an on-site exposure area and an off-site exposure area, due to different potential receptors in those two areas. In addition, slight variations were taken into account as noted below where exposure pathways differ or significant concentration differences exist. Final exposure areas are shown in Figure 3-5.

3.1.4.1 Ironton Canal Exposure Area (EA1)

Based on distinct receptors, exposure media, and exposure pathways, the Ironton Canal is a separate exposure area (Figure 3-5). The fenced (SWMU Area 1) and unfenced (downstream) portions of Ironton Canal were combined into a single exposure area (EA1) because the potential receptors (current child trespassers and future construction workers piping the canal) may be exposed to the fenced and unfenced portions of the canal. Exposure media in EA1 include surface water, surface sediments, and subsurface sediments. In contrast to hypothetical on-site construction worker and future off-site construction worker scenarios, future construction workers piping the canal were assumed not to work in soil in trenches (instead future construction workers piping the canal are assumed to work in sediments and surface water in the canal). Therefore, exposure of future construction workers piping the canal to subsurface soil near the canal is incomplete.

3.1.4.2 On-site Surface Soil and Subsurface Soil Exposure Areas (EA2, EA3, and EA4)

The three on-site exposure areas include: EA2 which consists of on-site subsurface soil in SWMU Area 2; EA3 which consists of on-site surface soil and subsurface soil in SWMU Area 3 (with the exception of SWMU 8); and EA4 which includes on-site subsurface soil in the SWMU Area 4 (Figure 3-5).

3.1.4.3 Off-site Subsurface Soil and Groundwater Exposure Area (EA5)

Based on distinct receptors and exposure pathways, a separate exposure area (EA5) has been identified for off-site subsurface soil and groundwater (Figure 3-5). This exposure area contains off-site subsurface soil sampling locations on the PSCIPCO property adjacent to SWMU Area 4. Impacted off-site groundwater sampling locations on PSCIPCO property are also included in this exposure area.

3.1.4.4 On-site Surface Soil Exposure Area for SWMU 8 (EA6)

TDM is present on the surface at SWMU 8. Concentrations of some constituents in surface soil sampling locations 2-SF-3-37, 2-SF-3-39, and 2-SF-3-40 in SWMU 8 are much higher

than in nearby sampling locations in SWMU Area 3. Therefore, surface soil in SWMU 8 was evaluated as EA6, separate from the other sampling locations in SWMU Area 3.

3.1.4.5 On-site Surface Soil and Subsurface Soil Exposure Area in the South Parcel (EA7)

Chemical impacts to surface soil and subsurface soil are generally lower in the south parcel than in adjacent SWMU Areas. Therefore, the south parcel was evaluated separately as EA7 (Figure 3-5).

3.1.4.6 On-site Groundwater Exposure Area (EA8)

On-site groundwater was evaluated as EA8. (Figure 3-9).

3.1.4.7 Off-site Subsurface Soil (EA9)

Based on potential different sources of contamination from locations in EA5, a separate exposure area (EA9) has been identified for off-site subsurface soil that is located north of EA5 (Figure 3-5). This exposure area contains off-site subsurface soil sampling locations on the PSCIPCO property adjacent to SWMU Area 3.

3.1.4.8 Off-site Subsurface soil and Groundwater Exposure Area (EA10)

Off-site subsurface soil and groundwater north of the Ironton Canal were evaluated in EA10 at MW-34 and MW-35 (Figure 3-9).

3.1.4.9 Hotspots at Individual Sampling Locations

Surface soil sampling locations 2-SF-2-18, 2-SF-2-19, 2-SF-3-36, 2-SF-3-38, and 2-SF-4-23 were confirmation samples collected underneath surface TDM that were removed from the Site in November 2010 and November 2011, (with the exception of 2-SF-4-23 which did not require TDM removal in November 2011). Confirmation samples were collected from these locations in November 2011. Because these locations were located directly under TDM, the concentrations of constituents measured at those locations are not necessarily representative of other surface soil locations in SWMU Areas 2, 3, and 4. Therefore, these surface soil sampling locations were evaluated separately (with the exception of 2-SF-3-38) as hotspots in the HHRA (hotpot locations are shown in Figures 3-6, 3-7, and 3-8). Confirmation soil sample 2-SF-3-38 was evaluated in EA3 because its concentrations are consistent with other nearby samples.

3.1.4.10 Summary of Exposure Areas

The following exposure areas and media have been identified for the HHRA (Figure 3-5):

- EA1 – Surface water and surface and subsurface sediments (sampling locations in SWMU Area 1 and the adjacent downstream area)
- EA2 – Subsurface soil (sampling locations in SWMU Area 2)
- EA3 – Surface and subsurface soil (sampling locations in SWMU Area 3, except for SWMU 8)
- EA4 – Subsurface soil (sampling locations in SWMU Area 4)
- EA5 – Subsurface soil and groundwater (off-site sampling locations adjacent to SWMU Area 4)
- EA6 – Surface soil in SWMU 8
- EA7 – Surface soil and subsurface soil (sampling locations in the south parcel)
- EA8 – Groundwater (on-site sampling locations)
- EA9 – Subsurface Soil (off-site sampling locations adjacent to SWMU Area 3)
- EA10 – Subsurface Soil and Groundwater (off-site sampling locations north of the canal)
- Individual surface soil sampling of hotspot locations at 2-SF-2-18, 2-SF-2-19, 2-SF-3-36, and 2-SF-4-23 (Figures 3-6, 3-7, and 3-8)

3.1.5 Sampling Locations

Sampling locations for surface soil, subsurface soil, groundwater, surface water, and sediments are shown in Figures 3-6 to 3-9 and discussed in detail in the risk assessment WP. Some of the sampling locations are not included in exposure areas and were not evaluated in the HHRA. Subsurface soil sampling locations TP-1 and TP-2 which are located in the southernmost portion of the Site were not included in any exposure area because the locations are distant from potential sources and chemical impacts are negligible at those locations (Figure 3-8). Groundwater sampling location MW-36 was not included in any exposure area because it is distant from potential sources and it appears to not be impacted (only cyanide was detected) (Figure 3-8). Off-site surface soil location 2-SF-3-3 was not included in EA9 because off-site surface soil has not been significantly impacted. Off-site groundwater locations MW-19, MW-20, MW-21, and MW-22 were not included in EA9 or EA5 because they are not significantly impacted (Figure 3-7). Instead, a conservative approach was used to evaluate impacts to off-site groundwater by using sampling results from two wells located very close to the boundary of the Site (MW-33 and MW-18) in EA5.

3.1.6 Selection of Chemicals of Potential Concern

The process for selection of COPCs in soil, groundwater, sediments, and surface water in the HHRA is described in detail in the risk assessment WP. Detected chemicals with maximum

detected concentrations or maximum RLs that exceeded risk-based screening levels were selected as COPCs for further evaluation in the HHRA (Tables 3-1 to 3-5).

The risk assessment WP proposed comparing concentrations of detected analytes in groundwater in each exposure area to Target Groundwater Concentrations (TGCs) in Table 2c in USEPA (2002b). However, USEPA (2012b) is a source of updated screening levels for groundwater impacting indoor air (Vapor Intrusion Screening Levels [VISLs]). The VISLs were derived using toxicity values that have been updated since 2002. Therefore, it is appropriate to use the USEPA (2012b) VISLs instead of the USEPA (2002b) TGCs for selecting COPCs for indoor air. Chemicals in groundwater were selected as COPCs for indoor air for further evaluation in the HHRA if (1) the chemical is considered by USEPA (2012b) to be a potential vapor intrusion (VI) COPC, (2) the chemical has inhalation toxicity values, and (3) the maximum detected concentration or maximum RL exceeded the VISL Target Groundwater Concentration (Table 3-3).

No COPCs were selected in subsurface soil in EA10. Therefore, subsurface soil in EA10 was not evaluated further in the HHRA.

3.1.7 Methodology for Estimating Exposure Point Concentrations

EPCs were calculated for each COPC in each medium/exposure area. EPCs for COPCs in surface soil, subsurface soil, surface plus subsurface soil, groundwater, surface water, surface sediment, and surface plus subsurface sediments were calculated using sampling data (Tables 3-1 to 3-9). EPCs for air particulates were calculated by applying a particulate emission factor (PEF) which converts EPCs for chemicals in soil to EPCs for chemicals in air. EPCs for VOCs selected as COPCs for evaluating air in a trench were modeled from EPCs in groundwater using chemical-specific volatilization factors (VFs). The VFs were calculated for VOCs that have inhalation toxicity values. EPCs for VOCs selected as COPCs for evaluating indoor air were modeled from EPCs in groundwater using the J&E model.

EPCs are estimates of the true average concentration of a chemical in media in exposure areas. The 95 percent upper confidence limit of the mean (95% UCL) is recommended by USEPA (2002a) as a reasonable estimate of the true average concentration in an exposure area, given the uncertainty associated with limited sampling. In calculating 95% UCLs, (1) maximum values were used for duplicate samples and (2) multi-depth results (soil or sediment samples obtained from the same location, but at different depths) were treated as independent data points. If the ProUCL-recommended 95% UCL is less than the maximum detected concentration, then the 95% UCL was used as the EPC. When the ProUCL-recommended 95% UCL was greater than the maximum detected concentration, the maximum detected

concentration was used as the EPC. EPCs for exposure areas and media for which 95% UCLs were calculated are shown below and are listed in Tables 3-6 to 3-9.

- Surface water and sediments in EA1
- Soil in EA2, EA3, EA4, EA5, and EA7
- Groundwater in EA8

EPCs for exposure areas and media for which 95% UCLs were not calculated, and therefore maximum detected concentrations were used as the EPCs, (shown below) are listed in Tables 3-1 to 3-5.

- Soil in EA6, EA9, and hotpots 2-SF-2-18, 2-SF-2-19, 2-SF-3-36, 2-SF-4-23
- Groundwater in EA5 and EA10

3.1.7.1 EPCs Derived by Modeling

VOCs in Air in a Trench:

It is unlikely that construction workers would stand in water in a trench, because the Occupational Safety and Health Administration (OSHA) has established requirements for eliminating the accumulation of water in excavations in which workers are present (29 Code of Federal Regulations [CFR] 1926 [OSHA, 2007]). However, for the purposes of the HHRA it was conservatively assumed that construction workers stand in groundwater pooling in a trench and inhale VOCs that volatilize from the groundwater. VOCs in groundwater were identified using the USEPA Regional Screening Level (RSL) tables (USEPA 2012c) which defines VOCs as chemicals with a molecular weight less than 200 grams per mole (g/mole) and a Henry's Law constant greater than or equal to 1E-05 atmosphere cubic meter per mole (atm-m^3/mole). Concentrations of VOCs in trench air were estimated by calculating chemical-specific VF (in liters per cubic meter [L/m^3]) based on chemical-specific parameter values and assumptions about the size of the trench and wind velocity. The VFs were calculated for VOCs that have inhalation toxicity values. The chemical-specific VFs were multiplied by chemical-specific groundwater EPCs calculated for the exposure areas to obtain the EPCs for in air in a trench. The methodology that was used to calculate the VFs is based on a mass transfer approach from USEPA (1993a) guidance for estimating concentrations of VOCs in air in a water-filled lagoon. The mass transfer approach is described in detail in the risk assessment WP. Calculations of VFs are shown in Appendix A.

VOCs in Indoor Air:

Planned Changes to USEPA Guidance on Vapor Intrusion

USEPA is currently in the process of developing new guidance for the evaluation of VOCs in indoor air due to the vapor intrusion pathway, with different offices within USEPA taking the lead depending on the type of site. USEPA recently released two draft vapor intrusion documents for public comments. Office of Solid Waste and Emergency Response (OSWER) Final Guidance for Assessing and Mitigating the Vapor Intrusion Pathway from Subsurface Sources to Indoor Air (External Review Draft) from the USEPA-OSW is intended to replace the USEPA (2002b) vapor intrusion guidance. Guidance For Addressing Petroleum Vapor Intrusion At Leaking Underground Storage Tank Sites (External Review Draft) from USEPA-Office of Underground Storage Tanks (OUST) is intended to address vapor intrusion at petroleum hydrocarbon sites, including addressing significant attenuation of petroleum that can occur under site conditions that favor aerobic biodegradation. Both are "Do Not Cite or Quote" draft documents, and therefore were not used as guidance in this HHRA.

Approach for Evaluating Vapor Intrusion

A conservative approach using the J&E model was used to predict indoor air concentrations at the Site. The approach is very conservative because the J&E model assumes that no biodegradation of petroleum hydrocarbons is occurring, while it is possible that some biodegradation is occurring at the Site. Model inputs used to predict indoor air concentrations for the hypothetical indoor worker scenario were described in the risk assessment WP. J&E model results are shown in Appendix B.

3.1.8 Exposure Factor Values

The reasonable maximum exposure (RME) condition is protective of people at the high end of the exposure distribution (approximately the 95th percentile). Therefore, the RME scenario is intended to assess exposures that are higher than average, but are still within the realistic range of exposure scenarios. Exposure factor values for the RME condition have been identified based on site-specific conditions and various guidance documents. Exposure factor values for receptors and pathways to be evaluated in the HHRA are presented in Tables 3-10 to 3-19. Exposure factor values were either (1) USEPA or UDEQ DSHW default RME values, (2) values derived using information in USEPA's Exposure Factor Handbook (USEPA, 1997b) and dermal guidance (USEPA, 2004a), or (3) values derived using professional judgment and/or based on precedence for prior use at RCRA sites in Utah and/or sites in USEPA Region 8. When professional judgment was used, high-end values were selected that were considered likely to overestimate typical exposure and unlikely to be

exceeded. The specific assumptions and rational used to derive the exposure factor values are listed in footnotes to the tables and discussed in the risk assessment WP.

Absorption factors for evaluating risk from dermal absorption of COPCs from soil and permeability constants for evaluating risk from dermal absorption of COPCs from groundwater were obtained from USEPA (2004a) (Table 3-20). For COPCs that do not have permeability constants in USEPA (2004a), permeability constants were obtained from USEPA (2012c) RSL tables.

3.1.9 Pathway-Specific Intake

For direct contact exposures (i.e., ingestion and dermal contact), two types of intake values were calculated. For non-carcinogenic health effects, the applicable measure of intake for chronic toxicants is referred to as the average daily intake (ADI) and is for a less-than-lifetime exposure. For chemicals that produce carcinogenic effects, intakes are averaged over an entire lifetime and are referred to as the lifetime average daily intake [(L)ADI]. The equation used to estimate (L)ADI for ingestion of soil was:

$$(L)ADI = \frac{EPC \times IR \times ETf \times EF \times ED \times CF}{BW \times AT}$$

where:

(L)ADI	=	(Lifetime) Average daily intake (milligrams per kilogram per day [mg/kg-day])
EPC	=	Exposure point concentration (milligrams per kilogram [mg/kg])
IR	=	Soil ingestion rate (milligrams per day [mg/day])
ETf	=	Exposure time fraction (hours exposed/24 hours) (unitless)
EF	=	Exposure frequency (days/year)
ED	=	Exposure duration (years)
CF	=	Conversion factor (kg/mg)
BW	=	Body weight [kilogram (kg)]
AT	=	Averaging time (days)

The ETf parameter was only used for evaluating current child trespassers exposed to surface soil or surface sediments.

The equation used to estimate (L)ADI for dermal exposure to soil was:

$$(L)ADI = \frac{EPC \times SA \times SSAF \times ABS \times EV \times EF \times ED \times CF}{BW \times AT}$$

where:

(L)ADI	=	(Lifetime) Average daily intake (mg/kg-day)

EPC	=	Exposure point concentration (mg/kg)
SA	=	Skin Surface Area Exposed (centimeters squared [cm^2])
SSAF	=	Soil-to-Skin Adherence Factor (milligrams per centimeters squared [mg/cm^2-event])
ABS	=	Dermal Absorption Fraction (unitless)
EV	=	Number of events (events/day)
EF	=	Exposure frequency (days/year)
ED	=	Exposure duration (years)
CF	=	Conversion factor (kg/mg)
BW	=	Body weight (kg)
AT	=	Averaging time (days)

The equation used to estimate (L)ADI for incidental ingestion of water was:

$$(L)ADI = \frac{EPC \times GWIR / SWIR \times ET \times EF \times ED}{BW \times AT}$$

where:

(L)ADI	=	(Lifetime) Average daily intake (mg/kg-day)
EPC	=	Exposure point concentration (milligrams per liter [mg/L])
GWIR/SWIR	=	Groundwater or surface water ingestion rate (liters per hour [L/hour])
ET	=	Exposure time fraction (hours/day)
EF	=	Exposure frequency (days/year)
ED	=	Exposure duration (years)
BW	=	Body weight (kg)
AT	=	Averaging time (days)

The equation used to estimate (L)ADI for dermal exposure to water was:

$$(L)ADI = \frac{EPC \times SA \times PC \times ET \times EF \times ED}{CF \times BW \times AT}$$

where:

(L)ADI	=	(Lifetime) Average daily intake (mg/kg-day)
EPC	=	Exposure point concentration (mg/L)
SA	=	Skin Surface Area Exposed (cm^2)
PC	=	Permeability constant (centimeters per hour [cm/hour])
ET	=	Exposure time fraction (hours/day)
EF	=	Exposure frequency (days/year)
ED	=	Exposure duration (years)
CF	=	Conversion factor (cubic centimeters per liter [cm^3/L])
BW	=	Body weight (kg)
AT	=	Averaging time (days)

Average concentrations (AC) for non-carcinogens or lifetime average concentrations [(L)AC] for carcinogens for inhalation of particulates are derived using the following equation:

$$(L)AC = \frac{EPC \times ET \times EF \times ED}{AT \times PEF}$$

where:

(L)AC	=	(Lifetime) Average concentration (mg/m^3)
EPC	=	Exposure point concentration (mg/kg)
EF	=	Exposure frequency (days/year)
ED	=	Exposure duration (years)
ET	=	Exposure time (hours/day)
AT	=	Averaging time (hours)
PEF	=	Particulate emission factor (cubic meters per kilogram [m^3/kg])

AC for non-carcinogens or LAC for carcinogens for inhalation of VOCs in air in a trench are derived using the following equation:

$$(L)AC = \frac{EPC \times ET \times EF \times ED \times VF}{AT}$$

where:

(L)AC	=	(Lifetime) Average concentration (milligrams per cubic meter [mg/m^3])
EPC	=	Exposure point concentration (mg/L)
EF	=	Exposure frequency (days/year)
ED	=	Exposure duration (years)
ET	=	Exposure time (hours/day)
AT	=	Averaging time (hours)
VF	=	Volatilization factor (liters per cubic meter [L/m^3])

AC for non-carcinogens or LAC for carcinogens for inhalation of VOCs in indoor air are derived using the following equation:

$$(L)AC = \frac{EPC \times ET \times EF \times ED}{AT}$$

where:

(L)AC	=	(Lifetime) Average concentration (mg/m^3)
EPC	=	Exposure point concentration (milligrams per cubic meter [mg/m^3])
EF	=	Exposure frequency (days/year)
ED	=	Exposure duration (years)
ET	=	Exposure time (hours/day)
AT	=	Averaging time (hours)

3.2 Toxicity Assessment

Toxicity values used for COPCs are shown in Tables 3-21 and 3-22. USEPA has developed many chronic toxicity values to evaluate long-term exposures (7 years to a lifetime). Chronic toxicity values were selected in accordance with USEPA (2003) as outlined below:

- Tier 1 – Integrated Risk Information System (IRIS), available on-line (USEPA, 2013b)
- Tier 2 – USEPA's Provisional Peer-Reviewed Toxicity Values (PPRTVs) or other provisional toxicity values from USEPA RSL tables (USEPA, 2012c)
- Tier 3 – Other toxicity values (e.g., from California Environmental Protection Agency (CalEPA), the Agency for Toxic Substances and Disease Registry, and USEPA's Health Effects Assessment Summary Tables) as provided in USEPA, 2012c.

In addition, subchronic toxicity values are available to evaluate non-cancer effects for exposures of shorter duration (2 weeks to 7 years). Sources of subchronic toxicity values include the PPRTV database (USEPA, 2013c), Agency for Toxic Substances and Disease Registry (ATSDR) Minimum Risk Levels (MRLs) (ATSDR, 2013), and the HEAST (USEPA, 1997c). Subchronic toxicity values were used for some COPCs to evaluate non-cancer effects for the construction worker scenarios; otherwise, chronic toxicity values were used.

3.2.1 Non-Cancer Toxicity Assessment

The reference dose (RfD) is a pathway-specific (i.e., oral or dermal) estimate of a daily chemical intake per unit body weight that is likely to be without deleterious effects (USEPA, 1989). The reference concentration (RfC) used to evaluate non-cancer hazard for the inhalation exposure route is an estimate of a concentration that is likely to be without deleterious effects during a lifetime of continuous exposure. USEPA derives RfDs and RfCs to protect sensitive populations such as children. RfDs are expressed in units of milligram (mg) chemical intake per kilogram (kg) body weight per day, or (mg/kg bw-day). RfCs are expressed in units of mg of chemical per cubic meter (m^3) of air.

3.2.2 Cancer Toxicity Assessment

Most USEPA slope factors (SFs) and unit risks (URs) used for estimating cancer risks (CRs) are upper 95th percentile confidence limits of the probability of response per unit intake of contaminant (by oral or inhalation routes) over a lifetime. SFs and URs are based on mathematical extrapolation from experimental animal data and epidemiological studies, when

available. SFs are expressed in units of risk per mg contaminant intake per kg body weight per day, or $(mg/kg\ bw\text{-}day)^{-1}$. URs are expressed in units of m^3 of air per microgram (µg) of chemical.

3.2.3 Dermal Toxicity Assessment

Per USEPA (2004a) guidance, dermal exposure to soil was not evaluated for VOCs. Dermal exposure to soil was evaluated for non-volatile organics. Dermal exposure was evaluated for all COPCs in groundwater.

The oral toxicity factor (RfD or SF) relates toxic response to an administered dose of chemical, only some of which may be absorbed by the body, whereas chemical intake from dermal contact is estimated as an absorbed dose using chemical-specific permeability constants for absorption from water and dermal absorbed fraction from soil (USEPA, 2004a). So that dermal toxicity is not underestimated, USEPA recommends adjusting oral toxicity factors by the estimated fraction of chemical absorbed from the gastrointestinal tract (ABS_{GI}) to evaluate toxic effects of a dermally absorbed dose (USEPA, 2004a). According to USEPA (2004a), if the ABS_{GI} is greater than 50 percent then no adjustment of the oral toxicity value is needed. Chemical-specific ABS_{GI} values were obtained from USEPA (2012c). None of the COPCs selected for the HHRA have ABS_{GI} values that required adjustment of oral toxicity values. Therefore, unadjusted oral toxicity values were used to calculate risk for dermal exposure routes.

3.2.4 Chemicals Without Toxicity Values

No USEPA toxicity values are available for acenaphthylene, benzo(g,h,i)perylene phenanthrene, or resorcinol. Surrogates with toxicity values were used to evaluate the toxicity of acenaphthylene, benzo(g,h,i)perylene, and phenanthrene. The use of surrogates to evaluate risk for acenaphthylene, benzo(g,h,i)perylene, and phenanthrene is discussed in the uncertainty section.

An oral RfD of 2E+00 mg/kg-day was used for resorcinol (TERA, 2005).

3.3 Risk Characterization

In the risk characterization step, the toxicity factors (RfDs, RfCs, SFs, and URs) were applied in conjunction with intake of COPCs to estimate noncarcinogenic and carcinogenic health risk. This section describes how risk calculations were performed. The risk calculations are presented in detail in Appendix C.

3.3.1 Estimation of Non-Cancer Hazard

For both chronic and subchronic scenarios, the potential for noncarcinogenic effects from ingestion and dermal exposure was characterized by comparing estimated chemical intakes with chemical-specific RfDs. The resulting ratio is called a hazard quotient (HQ). It is derived in the following manner:

$$\text{Non-cancer HQ} = \frac{\text{Chemical Intake (mg/kg-day)}}{\text{RfD (mg/kg-day)}}$$

The potential for noncarcinogenic effects from inhalation exposure was characterized by comparing estimated air concentrations with chemical-specific RfCs. The HQ is derived in the following manner:

$$\text{Non-cancer HQ} = \frac{\text{Exposure Concentration } (m^3/day)}{\text{RfC } (m^3/day)}$$

The non-cancer HQ for each COPC in each scenario and each exposure route was calculated by dividing the chemical intake or exposure concentration by the route- and chemical-specific RfD or RfC, respectively. Oral RfDs were used for oral and dermal routes of exposure and inhalation RfCs were used for inhalation routes of exposure.

Using the RfD or RfC assumes that there is a level of intake or an exposure concentration (the RfD or RfC, respectively) below which it is unlikely that even sensitive individuals such as children will experience adverse health effects over the period of exposure. If the ADI or exposure concentration exceeds the RfD or RfC, respectively, (that is, if the HQ exceeds 1), there may be cause for concern for potential non-cancer effects (USEPA, 1989). However, it should be noted that the level of concern does not increase linearly as the RfD or RfC is approached or exceeded. Since the HQ does not define a dose-response relationship, its numerical value cannot necessarily be construed as a direct estimate of risk (USEPA, 1986). Rather, an HQ above 1 indicates a potential cause for concern for non-cancer health effects for the respective pathway and contaminant.

To assess pathway-specific exposures to multiple chemicals, the HQs for all COPCs are summed to yield a pathway-specific hazard index (HI). If a receptor may be exposed by multiple pathways, the HIs from all identified relevant pathways are summed to obtain the total HI for that receptor. If the total HI is less than or equal to 1, multiple-pathway exposures to COPCs are judged unlikely to result in an adverse effect. A total HI greater than 1 indicates a potential cause for concern for non-cancer health effects.

The assumption of additive effects reflected in the HI is most properly applied to substances that induce the same effect by the same biological mechanism (USEPA, 1986). Consequently, summing HQs for substances that are not expected to induce the same type of toxic effect overestimates the potential for adverse health effects. Therefore, for non-cancer effects it is appropriate to assume that additive effects apply only to constituents that affect the same target organ (USEPA, 1989). Appendix D identifies the critical effect (target organ) for COPCs that significantly contribute to HIs for construction workers exposed to soil in EA2 and EA4. This information was used in evaluating cumulative non-cancer hazards for those two scenarios. USEPA states that the HI should not exceed 1 for groups of chemicals that affect the same target organ (EPA, 1989).

3.3.2 Estimation of Cancer Risk

Potential for carcinogenic effects were characterized in terms of the incremental probability of an individual developing cancer over a lifetime as a result of site-related exposure to a potential carcinogen, for both chronic and subchronic scenarios. Excess individual lifetime CR were estimated from the projected lifetime daily average intake and the cancer SF or UR, which represent upperbound estimates of the dose-response relationship. CR for chemical carcinogens for the oral route and dermal routes of exposure is calculated by multiplying the average daily intake by the cancer SF, as follows:

CR = Chemical Intake (mg/kg-day) x SF (risk per mg/kg-day)

CR for chemical carcinogens for the inhalation routes of exposure is calculated by multiplying the exposure concentration by the UR.

CR = Exposure Concentration (mg/m^3) x UR cubic meter per microgram ($m^3/\mu g$) x conversion factor (1000 micrograms per milligram [µg/mg])

The CR for each COPC in each scenario and each exposure route were calculated by multiplying the chemical intake by the route- and chemical-specific SF or UR. Oral SFs were used for oral and dermal routes of exposure and URs were used for inhalation routes of exposure.

The risks resulting from exposure to multiple carcinogens are assumed to be additive. To assess pathway-specific exposures to multiple chemicals, the CRs for all COPCs are summed to yield a pathway-specific CR. If a receptor may be exposed by multiple pathways, the CRs from all identified relevant pathways are summed to obtain the total CR for that receptor.

3.3.3 Acceptable Risk Levels

According to Utah Administrative Code (UAC) R315-101, no further action may be requested when the total CR is less than 1E-06 and the total HI is less than 1 based on a residential exposure scenario conducted in accordance with R315-101-5.2(b)(1) and ecological effects are deemed insignificant by the Executive Secretary of DSHW. A Site Management Plan is required if:

(1) the CR is greater than or equal to 1E-06 and/or the HI is greater than 1 based on a residential scenario, or

(2) The Executive Secretary of DSHW determines that ecological effects may be significant.

The Site Management Plan must contain procedures for corrective action if:

(1) the level of risk at the Site is greater than or equal to 1E-04 or the HI is greater than 1 (based on an actual land-use or potential land-use conditions), or

(2) the Executive Secretary concludes that corrective action is required to mitigate ecological effects.

3.3.4 Results of the Risk Characterization

This section shows the results of the risk characterization for receptors in each exposure area. Risk drivers are defined as COPCs that contribute to a CR of 1E-04 or greater or to an HI greater than 1.

3.3.4.1 EA1

Current Child Trespasser and Future Construction Worker Piping the Canal (Scenario 1):

Total CRs for current child trespassers and future construction workers piping the canal (Scenario 1) assumed to be exposed to sediments and surface water in EA1 were within UDEQ's risk management range of 1E-06 or greater (but less than 1E-04). HIs were well below 1. There are no chemical risk drivers in EA1.

UDEQ requested that a second scenario be evaluated for construction workers piping the canal (Scenario 2). Scenario 2 uses new UDEQ default exposure factor parameter values for construction workers that are intended to be used consistently throughout Utah involving workers in a trench who construct buildings or repair utility lines. Whereas Scenario 1 uses an exposure duration of 6 months for future construction workers piping the canal, Scenario 2 uses an exposure duration of 1 year. Scenario 1 better represents construction workers piping a canal that is only 930 feet long (see Section 3.3.5.4 for additional discussion). Nevertheless,

the total CR of 2E-05 for future construction workers piping the canal (Scenario 2) was within UDEQ's risk management range of 1E-06 or greater (but less than 1E-04). The total HI of 3E-01 was well below 1.

Table 3-23
Summary of CR and HI for Current Child Trespasser and Future Construction Worker Piping the Canal in EA1

Receptor	Exposure Medium	Cancer Risk	Risk Drivers	Hazard Index	Risk Drivers
Current Child Trespasser	Surface Sediments	1.03E-05	-	1.66E-03	-
	Surface Water	7.74E-08	-	5.31E-04	-
	Total	**1E-05**	**-**	**2E-03**	**-**
Future Construction Worker Piping the Canal (Scenario 1)	Surface Sediments	1.04E-05	-	3.45E-01	-
	Surface Water	2.05E-08	-	1.63E-03	-
	Total	**1E-05**	**-**	**3E-01**	**-**

3.3.4.2 EA2

Hypothetical On-site Construction Worker:

The total CR for hypothetical on-site construction workers assumed to be exposed to subsurface soil plus groundwater in EA2 exceeded the upper end of UDEQ's risk management range of 1E-04. Exposure to subsurface soil accounts for approximately 99% of the total CR for subsurface soil plus groundwater, with carcinogenic polycyclic aromatic hydrocarbons (PAHs) in subsurface soil also accounting for approximately 99% of the total CR. Benzo(a)pyrene, benzo(a)anthracene, and dibenz(a,h)anthracene in subsurface soil contributed approximately 56, 19, and 14% of the total CR, respectively.

The total HI of 1.63 barely exceeded 1 for hypothetical on-site construction workers assumed to be exposed to subsurface soil plus groundwater in EA2. No individual COPC had an HI that exceeded 1 for subsurface soil plus groundwater. The highest total HI for an individual COPC was 0.7. Therefore, HIs were recalculated by grouping COPCs based on target organs (see Appendix D). HIs for individual target organs were less than 1. Therefore, exposure of hypothetical on-site construction workers to subsurface soil plus groundwater would not pose an unacceptable threat of non-cancer health effects.

Table 3-24
Summary of CR and HI for Hypothetical Construction Worker in EA2

Receptor	Exposure Medium	Cancer Risk	Risk Drivers	Hazard Index	Risk Drivers
Hypothetical On-site Construction Worker	Subsurface Soil (EA2)	2.59E-04	cPAH		-
	Groundwater (EA8)	3.18E-06	-		-
	Total	**3E-04**	**cPAH**	**6E-01**[(1)]	**-**

[(1)]Highest HIs for COPCs grouped based on target organs.
cPAH = carcinogenic polycyclic aromatic hydrocarbons

3.3.4.3 EA3

Current Child Trespasser and Future On-site Maintenance Worker:

Total CRs for current child trespassers and future on-site maintenance workers assumed to be exposed to surface soil in EA3 were within UDEQ's risk management range of 1E-06 or greater (but less than 1E-04). HIs were well below 1. There are no chemical risk drivers for current child trespassers or future on-site maintenance workers in EA3.

Table 3-25
Summary of CR and HI for Current Child Trespasser and Maintenance Worker in EA3

Receptor	Exposure Medium	Cancer Risk	Risk Drivers	Hazard Index	Risk Drivers
Current Child Trespasser	Surface Soil	5.95E-05	-	7.98E-03	-
	Total	**6E-05**	**-**	**8E-03**	**-**
Future On-site Maintenance Worker	Surface Soil	4.83E-05	-	5.30E-03	-
	Total	**5E-05**	**-**	**5E-03**	**-**

Hypothetical On-site Indoor Worker:

Total CR for hypothetical on-site indoor workers assumed to be exposed to surface soil (EA3) plus indoor air (EA8) exceeded the upper end of UDEQ's risk management range of 1E-04. Carcinogenic PAHs accounted for approximately 99% of the total CR for surface soil plus indoor air. Benzo(a)pyrene contributed approximately 70% of the total CR. Benzene and naphthalene contributed approximately 98% of the CR for indoor air. However, the CR of 8.85E-06 for indoor air contributed to less than 1% of the total CR for surface soil and indoor air. Therefore, there are no chemical risk drivers for indoor air in EA8. Total HI for hypothetical on-site indoor workers assumed to be exposed to surface soil (EA3) plus indoor air (EA8) was well below 1.

Table 3-26
Summary of CR and HI for Hypothetical On-site Indoor Worker in EA3

Receptor	Exposure Medium	Cancer Risk	Risk Drivers	Hazard Index	Risk Drivers
Hypothetical On-site Indoor Worker	Surface Soil (EA3)	9.57E-04	cPAH	6.90E-02	-
	Indoor air (EA8)	8.85E-06	-	1.95E-01	-
	Total	**1E-03**	**cPAH**	**3E-01**	**-**

cPAH = carcinogenic polycyclic aromatic hydrocarbons

Hypothetical On-site Construction Worker:

Total CR for hypothetical on-site construction workers assumed to be exposed to combined soil plus groundwater in EA3 was within UDEQ's risk management range of 1E-06 or greater (but less than 1E-04). The total HI was well below 1. There are no chemical risk drivers for hypothetical on-site construction workers in EA3.

Table 3-27
Summary of CR and HI for Hypothetical Construction Worker in EA3

Receptor	Exposure Medium	Cancer Risk	Risk Drivers	Hazard Index	Risk Drivers
Hypothetical On-site Construction Worker	Combined Soil (EA3)	8.86E-05	-	3.29E-01	-
	Groundwater (EA8)	3.18E-06	-	3.79E-01	-
	Total	**9E-05**	**-**	**7E-01**	**-**

3.3.4.4 EA4

Hypothetical On-site Construction Worker:

Total CR for hypothetical on-site construction workers assumed to be exposed to combined soil plus groundwater in EA3 was within UDEQ's risk management range of 1E-06 or greater (but less than 1E-04). The total HI of 1.55 barely exceeded 1. No COPCs had an individual HI that exceeded 1 for exposure to subsurface soil plus groundwater. The highest HI for an individual COPC was 0.6. Therefore, HIs were recalculated by grouping COPCs based on target organs (see Appendix D). HIs for individual target organs were equal to or less than 1. Therefore, exposure of hypothetical on-site construction workers to subsurface soil plus groundwater in EA4 would not pose an unacceptable threat of non-cancer health effects.

Table 3-28
Summary of CR and HI for Hypothetical Construction Worker in EA4

Receptor	Exposure Medium	Cancer Risk	Risk Drivers	Hazard Index	Risk Drivers
Hypothetical On-site Construction Worker	Subsurface Soil (EA4)	6.59E-05	-		-
	Groundwater (EA8)	3.18E-06	-		-
	Total	**7E-05**	**cPAHs**	**1E+00[(1)]**	-

[(1)]Highest HIs for COPCs grouped based on target organs.
cPAH = carcinogenic polycyclic aromatic hydrocarbons

3.3.4.5 EA5

Future Off-site Indoor Worker and Future Off-site Construction Worker:

The total CRs for the future off-site indoor workers assumed to be exposed to indoor air and future off-site construction workers assumed to be exposed to subsurface soil and groundwater in EA5 were within UDEQ's risk management range of 1E-06 or greater (but less than 1E-04). The total HIs were below 1. There are no chemical risk drivers for future off-site indoor workers or future off-site construction workers in EA5.

Table 3-29
Summary of CR and HI for Future Offsite Indoor Workers and Construction Worker in EA5

Receptor	Exposure Medium	Cancer Risk	Risk Drivers	Hazard Index	Risk Drivers
Future Off-site Indoor Worker	Indoor Air	9.07E-06	-	2.46E-01	-
	Total	**9E-06**	**-**	**2E-01**	**-**
Future Off-site Construction Worker	Subsurface Soil	4.88E-05	-	2.78E-01	-
	Groundwater	6.01E-07	-	4.71E-01	-
	Total	**5E-05**	**-**	**7E-01**	**-**

3.3.4.6 EA6

Current Child Trespasser, Future On-site Maintenance Worker, Hypothetical On-site Indoor Worker, and Hypothetical On-site Construction Worker:

Total CRs for current child trespassers, future on-site maintenance worker, hypothetical on-site indoor workers, and hypothetical on-site construction workers assumed to be exposed to surface soil in EA6 exceed the upper end of UDEQ's risk management range of 1E-04. For each of the receptors in EA6, carcinogenic PAHs accounted for over 99% of the total CR for surface soil, whereas benzo(a)pyrene alone contributed approximately 69% of the total CR.

Table 3-30
Summary of CR and HI for Current Child Trespassers, Future On-site Maintenance Workers, Hypothetical On-site Indoor Workers, and Hypothetical On-site Construction Workers in EA6

Receptor	Exposure Medium	Cancer Risk	Risk Drivers	Hazard Index	Risk Drivers
Current Child Trespasser	Surface Soil	6.86E-04	-	7.53E-02	-
	Total	**7E-04**	**cPAH**	**8E-02**	**-**
Future On-site Maintenance Worker	Surface Soil	5.57E-04	-	3.59E-02	-
	Total	**6E-04**	**cPAH**	**4E-02**	**-**
Hypothetical On-site Indoor Worker	Surface Soil	1.10E-02	-	6.04E-01	-
	Total	**1E-02**	**cPAH**	**6E-01**	**-**
Hypothetical On-site Construction Worker	Surface Soil	7.51E-04	-	4.11E-01	-
	Total	**8E-04**	**cPAH**	**4E-01**	**-**

cPAH = carcinogenic polycyclic aromatic hydrocarbons

3.3.4.7 EA7

Current Child Trespasser, Future On-site Maintenance Worker, Hypothetical On-site Indoor Worker, and Hypothetical On-site Construction Worker:

Total CRs for current child trespassers and future on-site maintenance worker assumed to be exposed to surface soil, hypothetical on-site indoor workers assumed to be exposed to surface soil and indoor air, and hypothetical on-site construction workers assumed to be exposed to combined soil and groundwater in EA7 were within UDEQ's risk management range of 1E-06 or greater (but less than 1E-04). The total HIs were well below 1. There are no chemical risk drivers for current child trespassers, future on-site maintenance worker, hypothetical on-site indoor workers, or hypothetical on-site construction workers in EA7.

Table 3-31
Summary of CR and HI for Current Child Trespassers, Future On-site Maintenance Workers, Hypothetical On-site Indoor Workers, and Hypothetical On-site Construction Workers in EA7

Receptor	Exposure Medium	Cancer Risk	Risk Drivers	Hazard Index	Risk Drivers
Current Child Trespasser	Surface Soil (EA7)	2.44E-06	-	1.08E-04	-
	Total	**2E-06**	**-**	**1E-04**	**-**
Future On-site Maintenance Worker	Surface Soil (EA7)	1.98E-06	-	2.95E-05	-
	Total	**2E-06**	**-**	**3E-05**	**-**
Hypothetical On-site Indoor Worker	Surface Soil (EA7)	3.93E-05	-	3.08E-04	-
	Groundwater (EA8)	8.85E-06	-	1.95E-01	-
	Total	**5E-05**	**-**	**2E-01**	**-**
Hypothetical On-site Construction Worker	Combined Soil (EA7)	2.76E-06	-	2.77E-04	-
	Groundwater (EA8)	3.18E-06	-	3.79E-01	-
	Total	**6E-06**	**-**	**4E-01**	**-**

3.3.4.8 EA9

Future Off-site Construction Worker:

The total CRs for future off-site construction workers assumed to be exposed to subsurface soil in EA9 was equal to the lower end of UDEQ's risk management range of 1E-06. The total HI was not calculated (none of the COPCs in subsurface soil in EA9 had non-cancer toxicity values). There are no chemical risk drivers for future off-site construction workers in EA9.

Table 3-32
Summary of CR and HI for Future Off-site Construction Worker in EA9

Receptor	Exposure Medium	Cancer Risk	Risk Drivers	Hazard Index	Risk Drivers
Future Off-site Construction Worker	Subsurface soil	1.4E-06	-	NC	-
	Total	**1E-06**	**-**	**NC**	**-**

NC = not calculated

3.3.4.9 EA10

Future Off-site Construction Worker:

Groundwater in EA10 was evaluated in the quantitative HHRA. However, a future off-site indoor worker exposed to VOCs in indoor air was not evaluated in EA10, because EA10 is between the road on the north side of the property and the Ironton Canal. Therefore, no

building would ever be built in this area and there is no reason to evaluate an indoor worker scenario there.

The total CR for future off-site construction workers assumed to be exposed to groundwater in EA10 was less than UDEQ's point of departure of 1E-06 or greater. The total HI was well below 1 for future off-site construction workers. There are no chemical risk drivers for future off-site construction workers in EA10.

Table 3-33
Summary of CR and HI for Future Off-site Construction Worker in EA10

	Exposure Medium	Cancer Risk	Risk Drivers	Hazard Index	Risk Drivers
Future Off-site Construction Worker	Groundwater	1.51E-07	-	1.72E-01	-
	Total	**2E-07**	-	**2E-01**	-

3.3.4.10 Hotspots

Current Trespasser, Future On-site Maintenance Worker, Hypothetical On-site Indoor Worker, and Hypothetical On-site Construction Worker:

Total CRs for current child trespassers, future on-site maintenance workers, and hypothetical on-site construction workers assumed to be exposed to surface soil in hotspots 2-SF-2-18, 2-SF-2-19, 2-SF-3-36, 2-SF-4-23 were within UDEQ's risk management range of 1E-06 or greater (but less than 1E-04). The total HIs were well below 1. There are no chemical risk drivers for current child trespassers, future on-site maintenance workers, or hypothetical on-site construction workers in hotspots 2-SF-2-18, 2-SF-2-19, 2-SF-3-36, 2-SF-4-23.

The total CRs for the hypothetical on-site indoor workers assumed to be exposed to surface soil in hotspots 2-SF-2-18, 2-SF-2-19, 2-SF-3-36, 2-SF-4-23 was equal to or exceeded the upper end of UDEQ's risk management range of 1E-04. Carcinogenic PAHs accounted for nearly 100% of the total CR for surface soil. Benzo(a)pyrene contributed approximately 65 to 69% of the total CR. The total HIs were well below one.

Table 3-34
Summary of CR and HI for Current Child Trespassers, Future On-site Maintenance Workers, Hypothetical On-site Indoor Workers, and Hypothetical On-site Construction Workers Exposed to Hotspots 2-SF-2-18, 2-SF-2-19, 2-SF-3-36, 2-SF-4-23

Receptor	Hotspot	Exposure Medium	Total Cancer Risk	Risk Drivers	Total Hazard Index	Risk Drivers
Current Trespasser	2-SF-2-18	Surface Soil	8E-06	-	NC	-
	2-SF-2-19	Surface Soil	3E-05	-	2E-03	-
	2-SF-3-36	Surface Soil	2E-05	-	4E-03	-
	2-SF-4-23	Surface Soil	7E-05	-	7E-03	-
Future On-site Maintenance Worker	2-SF-2-18	Surface Soil	7E-06	-	NC	-
	2-SF-2-19	Surface Soil	2E-05	-	1E-03	-
	2-SF-3-36	Surface Soil	2E-05	-	3E-03	-
	2-SF-4-23	Surface Soil	5E-05	-	4E-03	-
Hypothetical On-site Indoor Worker	2-SF-2-18	Surface Soil	1E-04	cPAH	NC	-
	2-SF-2-19	Surface Soil	4E-04	cPAH	2E-02	-
	2-SF-3-36	Surface Soil	3E-04	cPAH	3E-02	-
	2-SF-4-23	Surface Soil	1E-03	cPAH	6E-02	-
Hypothetical On-site Construction Worker	2-SF-2-18	Surface Soil	9E-06	-	NC	-
	2-SF-2-19	Surface Soil	3E-05	-	1E-02	-
	2-SF-3-36	Surface Soil	2E-05	-	5E-02	-
	2-SF-4-23	Surface Soil	7E-05	-	4E-02	-

cPAH = carcinogenic polycyclic aromatic hydrocarbons
NC = not calculated

3.3.5 Uncertainty

Uncertainties are inherent in the risk assessment process because of the numerous assumptions that are made in estimating exposure, toxicity, and potential risk. Per USEPA guidance (USEPA, 1989), conservative assumptions were made throughout the risk assessment process so as not to underestimate potential risk. On the other hand, some uncertainties may contribute to underestimating exposure and risk. The HHRA includes an evaluation of uncertainties related to the risk assessment in order to place the risk estimates in perspective and to assist in risk-based decision-making.

3.3.5.1 Data Evaluation and Usability

Validated analytical results that were of adequate quality for use in quantifying risks were used in the HHRA.

Elevated Detection Limits: There were many cases where the highest RL for a chemical in a specific media and exposure area exceeded the highest detected value (Tables 3-1 to 3-5). This issue was addressed in the risk-based screen by selecting COPCs with maximum detected concentrations below screening levels if the maximum RLs exceeded the screening levels. Those COPCs were evaluated quantitatively in the HHRA. In the quantitative risk assessment, detected values and RLs were used to calculate EPCs following current USEPA guidance. When a 95% UCL could not be calculated, the maximum detected concentration (rather than the maximum RL) was used as the EPC. When 95% UCLs were calculated, detected and RL values were processed using USEPA's ProUCL software program (Version 4.1) which reflects the latest USEPA guidance (2002a; Singh et al., 2007; Singh and Singh, 2007) on the calculation of a 95% UCL concentration based on data distribution, data skewness, and sample size.

In some cases, elevated RLs were present in detected samples. In those cases, elevated RLs did not affect calculation of EPCs and risk because the concentration of the chemical (the detected value) was known. In some cases, elevated RLs were present in non-detect samples. Elevated RLs in non-detect samples could affect the calculation of EPCs and risks, if the elevated RLs in non-detects occurred for risk drivers (chemicals which contributed to CRs that were equal to or exceeded 1E-04). Risk drivers in the HHRA were limited to cPAHs. In the data sets used to calculate EPCs, the maximum detected values for cPAHs generally exceeded the maximum RLs in non-detect samples. In those few data sets where the maximum RLs in non-detect samples exceeded the maximum detected values for cPAHs, the exceedance generally occurred in only one sample or the exceedance occurred for only one cPAH or the exceedance was not very much higher than the maximum detected value. Therefore, elevated detection limits probably did not measurably impact the overall risk results.

Tentatively Identified Compounds: TICs were not evaluated quantitatively in the HHRA, but are evaluated qualitatively in this uncertainty section. This is the approach that is generally used for evaluating TICs in HHRAs, because of the large uncertainty associated with evaluating TICs. There are three major concerns associated with trying to evaluate risk to human health from exposure to TICs: (1) there is large uncertainty associated with the chemical identity of each TIC reported by the lab, (2) there is large uncertainty associated

with the concentration of each TIC reported by the lab, (3) there is generally little or no information available regarding the toxicity of each TIC.

Considering the uncertainty involved in correctly identifying a TIC, it would not be appropriate to quantitatively evaluate a chemical that may not even be present at the Site or, if present, is identified incorrectly. Due to the high uncertainty regarding the concentrations of TICs, quantitative evaluation could produce results that are biased too high or too low. Therefore, there would be high uncertainty as to the accuracy of those results. Even in the unlikely event that a quantitative evaluation of TICs was warranted, it would not be possible because most TICs do not have toxicity values. In addition, for most TICs there is very little information in the peer-reviewed literature regarding the toxicity of TICs. Organizations that derive toxicity values for chemicals to be used in HHRAs, such as USEPA, ATSDR, and CalEPA generally prioritize chemicals according to the likelihood for the chemical to be present at contaminated sites at concentrations that might produce toxic effects in humans. The IRIS database, USEPA RSL tables, ATSDR MRLs, and CalEPA toxicity criteria database contain toxicity values for hundreds of chemicals. These sources of toxicity values do not contain toxicity values for TICs because those chemicals are not typically present at contaminated sites at concentrations that would be expected to pose a threat to human health. Therefore, not evaluating TICs in the quantitative risk assessment probably did not measurably impact the overall risk results.

3.3.5.2 Exposure Assessment

Numerous conservative assumptions were made in the exposure assessment so as not to underestimate potential exposure and risk. For example, a conservative approach was used to select COPCs. Maximum detected concentrations and maximum RLs were compared to residential screening levels to select COPCs in soil and sediments. Residential use is not considered to be a reasonably anticipated future land use at the Site. Maximum detected concentrations and maximum RLs were compared to residential screening levels for tap water to select COPCs in surface water and groundwater. Surface water in the canal and on-site and off-site shallow groundwater will never be used as sources of tap water.

Exposure Factor Values: When available, USEPA or UDEQ default reasonable maximum exposure (RME) values were used as exposure parameter values. The RME condition is protective of people at the high end of the exposure distribution (approximately the 95th percentile). In some cases where approved default values were not available, professional judgment was used to identify an exposure factor value. Due to the higher uncertainty in those exposure factor values, the approach used to identify the exposure factors was more conservative than for the RME. Exposure factor values selected using professional judgment

were values that are likely higher than the highest values that would be expected to occur. Therefore the exposure factor values used in the HHRA probably contributed to overestimates of exposure and risk.

A conservative approach was used to estimate EPCs, so as not to underestimate potential exposure and risk. In many cases, the maximum detected value was used as the EPC which assumes that the receptor spends all of their time being exposed at the location of the maximum detected concentration. An exposure area is defined as a location within which an exposed receptor may reasonably be assumed to move at random and where contact with an environmental medium (e.g., soil) is equally likely at all sub-locations. Therefore, using the maximum detected concentration likely contributed to overestimates exposure and risks. In other cases, the 95% UCL was used which is a conservative (high-end estimate) of the EPC.

Potentially Complete, but Negligible Pathways: Potentially complete pathways that were considered to be negligible were not evaluated quantitatively in the risk characterization because these pathways would be unlikely to measurably impact risk estimates and thus would be unlikely to impact future Site decisions.

Hunters and fisherman are potential human receptors that were not evaluated quantitatively in the HHRA, because their exposure to constituents at the Site is considered to be negligible. These scenarios are not realistic for the Site and were added to the risk assessment at the request of UDEQ. All potentially complete pathways associated with fishing in the canal by adult trespassers are considered to be negligible, due to limited number of fish in the canal and the low potential for fishing in the canal. All potentially complete pathways associated with hunting on the Site by adult trespassers are considered to be negligible, due to the low potential for game to be exposed to contaminants from soil at the Site and the low potential for hunting on the Site. Therefore, not evaluating these exposure pathways probably did not measurably impact the overall risk results.

Ingestion and dermal exposure to on-site ephemeral water bodies that form occasionally near Industrial Parkway by current on-site trespassers, future on-site maintenance workers, and hypothetical on-site construction workers were considered to be potentially complete but negligible pathways, due to limited potential for human exposure. Future on-site maintenance workers, and hypothetical on-site construction workers would not be expected to work often (if at all) in a pond. And exposure by child trespassers, if any, would only occur at times when the ephemeral water bodies are present.

Inhalation of VOCs in outdoor air was not evaluated quantitatively in the HHRA, because exposure via that pathway is considered to be negligible. Concentrations of VOCs that enter

outdoor air from soil, groundwater, sediments, and surface water will be negligible due to dilution and wind dispersion. Therefore, not evaluating these exposure pathways probably did not measurably impact the overall risk results.

USEPA (2004a) does not recommend evaluating absorption of VOCs from soil or sediments because in the considered soil exposure scenarios, VOCs would tend to be volatilized from the soil on skin and should be accounted for via inhalation routes in the combined exposure pathway analysis. Therefore, not evaluating this exposure pathway probably did not measurably impact the overall risk results.

Vapor Intrusion Impacts of VOCs in Soil: USEPA does not recommend using the J&E model to evaluate potential risks from VOCs in soil impacted indoor air. Instead, USEPA recommends collecting soil gas or indoor air samples to assess the soil to indoor air exposure pathway. Indoor air samples cannot be collected because there are no enclosed structures on the Site, and even if there were structures, soil gas samples could not be collected because of the shallow depths to groundwater. Impacts of VOCs from groundwater in indoor air were below (EA10) or in the midrange (EA5 and EA8) of UDEQ's risk management range of 1E-06 or greater (but less than 1E-04). It is unlikely that the contribution of VOCs from soil into indoor air would increase the total CR from exposure to indoor air to greater than 1E-04. It should also be noted that Vertellus plans to maintain the Site as a vacant fenced lot for the foreseeable future, which will effectively prevent any indoor air exposure and associated risks.

3.3.5.3 Toxicity Assessment

There is inherent uncertainty in assessing the toxicity of chemicals in humans. However, USEPA's methodology for toxicity assessment was specifically designed to reasonably ensure that estimates of toxicity are protective of human health. Because uncertainties exist in the toxicity assessment process, numerous conservative (health-protective) approaches are used so as not to underestimate toxicity. Conservative approaches used to derive toxicity factors include:

- Assuming humans are more sensitive than the most sensitive laboratory species
- Assuming carcinogens do not have a threshold
- Assuming animal carcinogens also cause cancer in humans

Depending on the chemical, humans can be more or less sensitive than animal species. In addition, there is growing evidence that some carcinogens have threshold doses below which

cancer does not occur. In the HHRA, the conservative assumptions listed above may have contributed to an overestimate of toxicity of COPCs and risk.

Chemicals Without Toxicity Values: As is common practice in HHRA, toxicity values for acenaphthene, pyrene, and anthracene were used as surrogates for acenaphthylene, benzo(g,h,i)perylene, and phenanthrene, respectively. Acenaphthene, pyrene, anthracene, acenaphthylene, benzo(g,h,i)perylene, and phenanthrene are all PAHs. Acenaphthene and acenaphthylene have similar molecular structures, molecular weights (154 and 152 g/mole, respectively), Henry's Law constant (unitless) (7.52E-03 and 4.66E-03, respectively), and log K_{ow} (3.92 and 3.94, respectively). Pyrene and benzo(g,h,i)perylene and have similar molecular weights (202 and 276 g/mole, respectively) and log K_{ow} (4.88 and 6.63, respectively), but dissimilar Henry's Law constant (unitless) (4.87E-04 and 1.35E-05, respectively). Anthracene and Phenanthrene have similar molecular structures, molecular weights (178 and 178 g/mole, respectively), Henry's Law constants (unitless) (2.27E-03 and 1.73E-03), and log K_{ow} (4.45 and 4.46, respectively). Molecular weights, Henry's Law constants (unitless), and K_{ow} were obtained from the Oak Ridge National Laboratory Risk Assessment Information System (ORNL RAIS) database (ORNL, 2013). Using surrogate toxicity values for acenaphthylene, benzo(g,h,i)perylene, and phenanthrene is standard practice in risk assessment and probably did not significantly impact the overall risk results.

Carbazole was not evaluated in the quantitative risk assessment because default toxicity values are not available and a surrogated chemical with toxicity values was not identified. USEPA's PPRTV database (USEPA, 2013c) contains evaluation of carbazole dated July 23, 2008. USEPA concluded that insufficient data were available to derive non-cancer or cancer toxicity values or to assess carcinogenic potential. Not evaluating carbazole in the quantitative risk assessment contributed to a potential underestimation of risk, the magnitude of which depends on the concentrations of carbazole and its (unknown) potential for toxicity.

Use of Chronic Toxicity Values to Evaluate Scenarios with Subchronic Exposure Durations: For many COPCs, chronic toxicity values were used to calculate HIs for construction worker scenarios. Chronic toxicity values are intended to be protective of chronic exposure scenarios defined as scenarios with exposure durations from 7 years to a lifetime of exposure. The construction worker scenarios that were evaluated had exposure duration of 62.5 and 125 days. Therefore, using chronic toxicity values for some COPCs in evaluating construction worker scenarios may have contributed to an overestimation of HIs.

3.3.5.4 Risk Characterization

Assumptions used in the data evaluation and usability, exposure assessment, and toxicity assessment each contribute to risk characterization results. In general, conservative assumptions were used in each step so as not to underestimate potential risk.

A potential future off-site construction worker piping the canal was evaluated in Section 3.3.4.1. A high-end value of 6 months was used as the exposure duration for this scenario. UDEQ requested that a second scenario be evaluated for construction workers piping the canal. The second scenario uses UDEQ default values for construction workers that are to be used consistently throughout Utah for evaluating construction workers exposed to soil in a trench. The second scenario has an exposure duration of 1 year. The total CR was 2E-05 and the total HI was 3E-01 for the second (UDEQ) scenario. The total CR was 1E-05 and the total HI was 3E-01 for the scenario discussed in Section 3.3.4.1.

The scenario discussed in Section 3.3.4.1 is already conservative (overprotective) because it would not take 6 months to pipe a canal that is only 930 feet long. Assuming that it would take an exposure duration of 1 year to pipe that canal is unrealistic and does not represent the intent of the RME (the highest exposure that can be reasonably expected to occur). The second (UDEQ) scenario uses exposure factors intended to be used consistently throughout Utah for scenarios involving workers in a trench who construct buildings or repair utility lines. The site-specific scenario with an exposure duration of 6 months better represents construction workers piping a canal that is 930 feet long. Therefore, the construction worker scenario discussed in Section 3.3.4.1 will be considered in making risk management decisions.

3.3.5.5 Conclusions

Assumptions were made in each step of the HHRA, which introduced uncertainty into the risk characterization results. While this could potentially lead to an underestimation of risk, the use of numerous conservative (i.e., protective of human health) assumptions probably resulted in a net overestimation of potential risk. Therefore, the results of this assessment are likely to be protective of health despite the inherent uncertainties in the process.

3.4 HHRA Conclusions

When target organs were considered, HIs were 1 or less for all exposure scenarios. Therefore, COPCs in on-site and off-site locations evaluated in the HHRA do not pose an unacceptable threat of non-cancer effects.

Cumulative risks were less than 1E-06 in EA10. Cumulative risks were within the UDEQ's risk management range of CRs equal to 1E-06 or greater (but less than 1E-04) for:

- all receptors and media in EA1, EA4, EA5, EA7, and EA9.
- current child trespassers and future on-site maintenance workers exposed to surface soil in EA3.
- hypothetical on-site construction workers exposed to subsurface soil plus groundwater in EA3 and EA4.
- hypothetical on-site construction workers exposed only to groundwater and hypothetical on-site indoor workers exposed only to indoor air in EA8.
- current child trespassers, future on-site maintenance workers, and hypothetical on-site construction workers exposed to surface soil at hotspots 2-SF-2-18, 2-SF-2-19, 2-SF-3-36, 2-SF-4-23.

Cumulative risks equaled or exceeded the upper end of UDEQ's risk management range of 1E-04 for:

- hypothetical on-site construction workers exposed to subsurface soil in EA2 plus groundwater in EA8.
- hypothetical on-site indoor workers exposed to surface soil in EA3 plus indoor air in EA8.
- all receptors exposed to surface soil in EA6.
- hypothetical on-site indoor workers exposed to surface soil in hotspots 2-SF-2-18, 2-SF-2-19, 2-SF-3-36, 2-SF-4-23.

4.0 ECOLOGICAL RISK ASSESSMENT

As described in Section 1.1, a Baseline Ecological Risk Assessment (BERA) has been conducted as part of the UDEQ DSHW RCRA program for the Vertellus Site. The BERA was prepared following the Risk Assessment Work Plan for the Former Reilly Industries Plant that was approved by the UDEQ on March 14, 2013.

The following guidance documents were consulted to help guide methodology for the BERA: *Wildlife Exposure Factors Handbook* (USEPA, 1993b); *Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments* (USEPA, 1997a); *Guidelines for Ecological Risk Assessment* (USEPA, 1998); *The Role of Screening-Level Risk Assessments and Refining Contaminants of Concern in Baseline Ecological Risk Assessments* (USEPA, 2001); *ECO Update/Ground Water Forum Issue Paper* (USEPA, 2008); ProUCL Version 4.1 (USEPA, 2011a); and UAC R315-101-5, Sections 5.2(a) (6 and 7) and 5.3 (8) (UAC, 2011). Site-specific information on habitats and wildlife species present on-site was gathered by Bio/West at the direction of USEPA and DSHW from the *Reilly Site Ecological Assessment* (Bio/West, Inc., 1998).

The BERA incorporates the three primary phases of the standard USEPA ERA framework for a BERA as described in (USEPA, 1997a and 1998):

- Problem Formulation
- Risk Analysis
- Risk Characterization

The methods and results for each of these phases are presented in Sections 4.1 through 4.3. References for the BERA are provided in Section 4.4.

4.1 Problem Formulation

Problem Formulation provides the basis for the approach and methodology used in the BERA. It includes: a general description of the habitats and biota at the Vertellus Site, a brief description of the sampling, selection of assessment endpoints, development of an ecological CSM and identification of exposure pathways, identification of exposure media, development of testable hypotheses and measurement endpoints (i.e., measures of effect), identification of ecological receptors, description of the chemical of potential ecological concern (COPEC) identification process, and identification of COPECs. Many of the elements of the Problem Formulation phase (e.g., creation of a CSM and identification of COPECs) could be considered as elements of a screening-level ERA (SLERA).

4.1.1 Description of the Site

The Site is located at 2555 South Industrial Parkway in unincorporated Utah County between the cities of Provo to the north and Springville to the south. A Site location map is provided as Figure 1-1. The property comprises an area of 31.84 acres and is divided into north and south sections by a fence that runs east to west bisecting the property. The Ironton Canal runs adjacent to the northern boundary of the property, flowing east to west, eventually flowing into Provo Bay and Utah Lake. The northern portion of the property is where plant operations historically took place and the southern portion is an undeveloped field, referred to hereafter as the "south parcel." The Site perimeter is completely fenced. The Site is located at an elevation of approximately 4,500 feet amsl and gently slopes towards the western property boundary. Surface water from the northern portion of the Site drains toward Industrial Parkway and infiltrates into the soil. Site activities from before the 1960s resulted in releases of constituents to on-site and off-site media. Surface water in the south parcel also drains toward Industrial Parkway, where it ponds during wet periods of the year and eventually drains to the northwest corner of the south parcel. A full description of the Site is provided in Section 1 of the Risk Assessment.

4.1.1.1 Natural Terrestrial Habitats

Because the Vertellus Site was an active industrial facility until decommissioning in 2002, only very limited areas of natural habitat exist in the upland areas of the north portion of the property being evaluated in the BERA. The south parcel, which is an undeveloped grassland area bounded by railroad lines on its east and south boundaries, also is evaluated in the BERA.

4.1.1.2 Waters

The Ironton Canal, a permanent man-made water body, runs adjacent to the northern property boundary and is considered part of the Site. Water in the canal eventually drains into wetlands and Provo Bay (Utah Lake). Because the Site slopes gently to the west, any surface runoff moves to the west. No other permanent natural water bodies (ponds or streams) are located onsite. However, an accumulation of water forms seasonally in the north-west corner of the south parcel.

4.1.1.3 Threatened and Endangered/Special Status Plants and Wildlife

According to information from the Utah Division of Wildlife Resources (2011a), seven federally listed species are reported for Utah County. Of these, five are upland species (Ute ladies' tresses [*Spiranthes diluvialis*], deseret milkvetch [*Astragalus desereticus*], clay phacelia [*Phacelia argillacea*], greater sage-grouse [*Centrocercus urophasianus*], and yellow-

billed cuckoo [*Coccyzus americanus*]). It is unlikely that any of these species would inhabit the former industrial area of the Site (i.e., the north section of the property) given the paucity of natural habitat. None of the listed upland species are included as receptors for assessment in the risk assessment as per the approved ERA work plan.

Two other listed species are fish – the least chub (*Iotichthys phlegethontis*) and June sucker (*Chasmistes liorus*). Of these, the June sucker (endangered) is found only in Utah Lake and the Provo River where it spawns. The June Sucker Recovery Implementation Program and the Provo River Delta Restoration Project have been implemented to recover the June sucker population so that it is no longer listed as endangered (June Sucker Recovery Implementation Program, 2010). However, given the distance (approximately 1.5 miles) between Ironton Canal, marshes bordering Provo Bay and Utah Lake, and the highly modified channel (including culverts), it is unlikely that the June sucker is found in Ironton Canal adjacent to the Site.

The least chub (candidate species) historically was found in Utah Lake but now is found only in scattered springs and ponds in western Utah. It is concluded that the least chub has been extirpated from a majority of its original range and appears to be limited to waters in the Snake Valley (Utah Division of Wildlife Resources, 2011b). As such, it is highly unlikely that the least chub is found in Ironton Canal near the Site.

Utah Division of Wildlife Resources (2011a) also provides a listing of state-listed species – wildlife species of concern (SPC) and species receiving special management (CS). A total of 29 birds, mammals, fish, amphibians, reptiles, and gastropods are state-listed. Given the limited habitat in the former industrial area of the Site and in Ironton Canal, it appears unlikely that any state-listed species would be exposed to Site-related contaminants in the north portion of the Site.

Overall, it is highly unlikely that any federally listed species would be exposed to contaminants in on-site soil or in Ironton Canal sediment or surface water.

4.1.2 Ecological Exposure Areas

SWMUs at the Site were initially consolidated into five SWMU areas (see Figure 1-1):

- SWMU Area 1 – Ironton Canal Outfall (SWMU 1)
- SWMU Area 2 – North and South Impoundments and Evaporation Pan (SWMUs 2, 3, and 10)
- SWMU Area 3 – Process Area (SWMUs 4 through 9 and 14)

- SWMU Area 4 – By-Product Lagoons and Evaporation Areas (SWMUs 11 and 12)
- SWMU Area 5 – Sitewide Shallow Groundwater (not depicted on figure)

For the purpose of assessing the potential risk to ecological receptors, ecological exposure areas (EAs) have been established based on the following considerations:

- Exposure media (soil or surface water and sediment)
- Presence of surface soil sample results
- Relative concentrations of contaminants in soil
- SWMU Area boundaries
- Exposure areas set up for the HHRA

Six ecological exposure areas are evaluated in the BERA. These correspond to exposure areas EA1, EA2, EA3, EA4, EA6, and EA7 as described for the HHRA (Figure 3-5). The outline of each exposure area is marked with a purple dashed line in a wider white line. Detailed figures (Figures 3-6, 3-7, and 3-8) show the soil, sediment, and/or surface water sampling locations. EAs 5, 8, 9, and 10 are evaluated in the HHRA but are not evaluated in the BERA for the reasons described below.

4.1.2.1 EA1 – Surface Water and Sediments from SWMU Area 1

Process water was discharged to the Ironton Canal along the north edge of the Site (EA1) from the late 1960s to the early 1970s. Impacted groundwater from the Site also may flow into the canal depending on the height of the groundwater table, which varies through the year, and elevation of water in the canal.

Potential exposure media for ecological receptors in the Ironton Canal include surface sediment (0 to 1 foot bgs) in the sidewalls and bottom of the canal and surface water. Sampling locations are shown in Figure 3-6. Subsurface samples were collected at depths up to 12 feet bgs, but are not representative of sediment to which ecological receptors may be exposed; therefore, subsurface sediments are not evaluated in the BERA. The adjacent and downstream portions of EA1 are combined into a single exposure area because ecological receptors may be exposed in both areas.

4.1.2.2 EA2 – Subsurface Soil from SWMU Area 2

EA2 as shown in Figure 3-8 covers SWMU Area 2, SWMU 10, plus land immediately west of SWMU 2 and SWMU 3. EA2 includes an area covered with gravel that formerly contained a metal evaporation pan (SWMU #10). EA2 has only subsurface soil samples

(except for the two hotspots). No surface soil samples were collected from this portion of the Site because surface soils were not thought to have been directly impacted by Site activities. Only the exposure pathways that are considered to be complete for ecological receptors (1 to 3 feet bgs) are evaluated for EA2. Surface soil confirmation samples were collected after removal of TDM from the ground surface in two hotspot areas (2-SF-2-18 and 2-SF-2-19). The hotspots are evaluated separately from other samples collected in EA2. Ecological receptors may be exposed to subsurface soil through burrowing or ingestion of rooted plants and/or soil invertebrates.

4.1.2.3 EA3 – Surface and Subsurface Soil from SWMU Area 3

EA3 for the BERA covers the same area as EA3 for the HHRA and includes six SWMUs within a majority of the former SWMU Area 3 (Figure 3-6). EA3 also includes several surface soil samples collected just south of the original southern boundary of SWMU Area 3 (the fence line bisecting the property) because these samples (2-SF-3-31, SF-6-2, 2-SF-3-30) have elevated concentrations of soil contaminants similar to concentrations seen in surface soil samples collected in other portions of SWMU Area 3. SWMU Area 3 contained the facility processing area, cooling ponds, and tank farms. Surface soil in the southern half of this exposure area has been impacted by spills and accidental discharges of a variety of organic compounds. A surface soil confirmation sample was collected after removal of TDM in one hotspot area (2-SF-3-36). The hotspot is evaluated separately from other samples collected in EA3.

As seen in Figure 3-6, both surface (0 to 1 foot bgs) and subsurface (1 to 3 feet bgs) samples have been collected in EA3. Terrestrial ecological receptors on the Site are evaluated in the BERA for exposure to both surface soil and subsurface soil. Ecological receptors may be exposed to surface soil through uptake by plants or soil invertebrates or through incidental ingestion during feeding. However, incidental ingestion of surface soil may be restricted by approximately 3 feet of gravel that covers EA3. Exposure to subsurface soil up to 3 feet bgs is possible through burrowing or ingestion of rooted plants or soil invertebrates. However, burrowing through the gravel layer is expected to reduce exposure to surface and subsurface soil.

4.1.2.4 EA4 – Subsurface Soil from SWMU Area 4

EA4 as shown in Figure 3-7 is primarily comprised of SWMU Area #4. It covers a majority of SWMU #12 with the exception of the road and EA5 located west of South Industrial Parkway. EA4 has only subsurface soil samples (except for the hotspot). No surface soil samples were collected from this portion of the Site because surface soils were not thought to have been directly impacted by Site activities. A surface soil confirmation sample was

collected following TDM removal in one hotspot area (2-SF-4-23) and is evaluated separately from other samples collected in EA4.

4.1.2.5 EA6 – Three Surface Soil Samples Collected Beneath TDM

This area corresponds to SWMU #8 as shown in Figure 3-6. Three surface soil samples were collected in the areas in between concrete foundation ribs where elevated concentrations of soil contaminants were suspected. No subsurface samples were collected from these three locations.

4.1.2.6 EA7 – Surface and Subsurface Soil from the South Parcel

EA7 had no processing facilities in it and does not correspond to any former SWMU Area or SWMU. However, it is possible that contamination from SWMU Area 3 north of the fence line bisecting the property migrated south into the south parcel (Figure 3-8). Surface and subsurface soil samples were collected from EA7 in November 2011 and April 2012 to characterize soil concentrations of Site contaminants that may have migrated from SWMU Area 3 onto EA7. These samples, along with previous subsurface samples up to 3 feet bgs, are evaluated in the BERA.

The only terrestrial areas of the Vertellus Site that are not evaluated in the BERA are HHRA EA5 and EA9 located north and west of EA4 and west of South Industrial Parkway (see Figure 3-7). These areas are primarily a paved parking lot for PSCIPCO, and therefore, do not have ecological habitat or complete exposure pathways for ecological receptors. Also, EA8 (Site-wide groundwater) and EA10 (groundwater north of the Ironton Canal) are not evaluated in the BERA.

4.1.3 Conceptual Site Model

CSMs illustrate the movement of chemicals from site-specific activities through various abiotic media, and ultimately, to ecological receptors. CSMs are schematic representations of source areas, release mechanisms, environmental transport media, and potential exposure routes for contaminants that may lead to exposure of ecological receptors to contaminants. The purpose of CSMs is to identify contaminant sources and exposure pathways that are anticipated to result in exposure of identified receptors.

Potentially complete exposure pathways are quantified in the BERA. A complete exposure pathway includes all of the following elements:

- A source and mechanism of contaminant release,
- A transport or contact medium (e.g., soil or water),

- An exposure point where receptors can contact the contaminated medium, and
- An exposure (intake) route (e.g., ingestion or direct contact).

Two ecological CSMs were developed for the BERA:

1. Figure 4-1 – Surface Water and Sediment in the Ironton Canal (EA1) and
2. Figure 4-2 – Soil and Groundwater

The following sections describe the sources, transport pathways, potential exposure media, exposure pathways, and ecological receptors for the two CSMs.

4.1.3.1 Sources

Surface Water and Sediment in the Ironton Canal CSM. Process water was discharged to on-site portions of Ironton Canal from the late 1960s to the early 1970s. The wastewater was a source to on-site surface water and surface and subsurface sediments. Also, impacted groundwater from the Site may flow, via sediments, into surface water in the canal depending on the elevation of the groundwater table that varies through the year relative to water elevation in the canal. Alternatively, surface water in the canal may flow into groundwater if the groundwater elevation is lower than the water elevation in the canal.

Soil and Groundwater CSM. The facility processing area, cooling ponds, and tank farms were located in EA3 and EA4, and the former evaporation pan was located in EA2. SWMUs in EAs 2, 3, and 4 were sources of constituents to surface and subsurface soils in these EAs. Subsurface soil (up to 3 feet bgs) in EAs 2, 3, 4, and 7 and surface soil in EAs 3, 6, and 7 are evaluated in the BERA for exposure of ecological receptors to chemicals in soil. As noted above, surface soil from hotspots located in EAs 2, 3, and 4 are evaluated individually.

4.1.3.2 Transport Pathways

Surface Water and Sediment in the Ironton Canal CSM. Constituents in upstream surface water and sediment in the Ironton Canal can be transported to on-site surface water and sediments directly adjacent to the property or immediately downstream of the Site. Groundwater may transport constituents into on-site surface water through sediments, depending on the elevation of groundwater relative to surface water in the Ironton Canal. Constituents in surface water can become sequestered in sediment, while constituents in sediment can be released to the overlying water. Constituents in surface sediments can migrate to subsurface sediments. Constituents in surface water and sediments can be transported downstream to off-site surface water and sediments. Constituents in off-site surface sediments may migrate to off-site subsurface sediments.

Soil and Groundwater CSM. Constituents in on-site surface soil in EA3 and EA7 could leach into on-site subsurface soil in these EAs. Constituents in on-site and off-site subsurface soil could leach into on-site and off-site groundwater, respectively. Surface water from the Ironton Canal may transport constituents into groundwater depending on the height of the groundwater table which varies through the year. On-site groundwater can transport constituents downgradient to off-site groundwater.

4.1.3.3 Potential Exposure Media

Surface Water and Sediment in the Ironton Canal CSM. Potential exposure media in the Ironton Canal (both within the Site and downstream) include surface sediment in the bottom and sidewalls of the canal and surface water. Also, aquatic plants (food for aquatic-dependent animals) and aquatic animals (prey to invertivores and carnivores) could be exposed to surface sediment and surface water – both within the Site and downstream.

Soil and Groundwater CSM. Shallow groundwater at the Site is not considered an exposure medium for ecological receptors. Abiotic exposure media include surface soil in EA3, EA6, and EA7 and subsurface soil in EA2, EA3, EA4, and EA7. As noted above, surface soil from hotspots located in EAs 2, 3, and 4 are evaluated individually. Subsurface soil may have been impacted by Site activities, but exposure of ecological receptors is limited to contact by vegetation and soil invertebrates and uptake by vegetation. Exposure to subsurface soil by other receptors is either incomplete ("I"), potentially complete but not quantified ("NQ"), or not applicable ("NA"); these exposure pathways are not quantified. Off-site surface soil is not considered impacted and is not evaluated. Additionally, exposure to off-site subsurface soil is not a complete exposure pathway.

Ecological receptor/exposure route combinations in Figures 4-1 and 4-2 with a "**C**" are assumed to be complete and are quantitatively evaluated:

- Surface Soil – Direct Contact – Plants and Soil Invertebrates
- Surface Soil – Ingestion (Incidental) – Herbivores, Invertivores, and Carnivores
- Subsurface Soil – Direct Contact – Plants and Soil Invertebrates
- Subsurface Soil – Uptake – Plants
- Animals (Prey) – Ingestion – Invertivores and Carnivores
- Vegetation – Ingestion – Herbivores
- Surface Sediment – Direct Contact – Plants, Benthic Invertebrates
- Surface Sediment – Ingestion (Incidental) – Herbivores and Invertivores
- Surface Water – Ingestion – Herbivores, Invertivores, and Carnivores

- Surface Water – Direct Contact – Aquatic Organisms

A few receptor/exposure and route/exposure media combinations (e.g., animals [prey] ingested by plants) are not ecologically logical and are shown as "NA." None of these exposure pathways ("I", "NA", or "NQ") are evaluated quantitatively.

As discussed in USEPA (1993b), the inhalation pathway generally is not quantified (NQ) for ecological receptors and is not considered a significant pathway. The inhalation exposure pathway is seldom evaluated because of the lack of appropriate data that are needed for a site and the potentially exposed species. Factors that would be needed include: on-site soil conditions (e.g., depth to groundwater, permeability of the soil); soil gas levels (estimated from groundwater); availability of exposure parameters as applied to potentially exposed receptors (e.g., inhalation rate, burrow temperature, particle size, vapor pressure); and toxicity values for the receptor species exposed to VOCs via the inhalation pathway. Given the absence of exposure and toxicological data for receptors; Vertellus site conditions, including gravel cover over the north parcel and shallow groundwater (2 to 5 feet bgs); and the relative insignificance of the inhalation exposure pathway, this pathway is not quantitatively evaluated in the BERA. The inhalation exposure pathway may be discussed qualitatively for burrowing wildlife.

While direct dermal contact with soil or sediment could potentially occur via digging or probing for food, most soil and sediment does not reach the epidermis of wildlife because of the presence of fur or feathers, and therefore, is not quantified. The dermal exposure pathway may contribute to overall exposure, but its contribution is considered *de minimus*. Plants and soil invertebrates may be in contact with shallow soil moisture (i.e., shallow groundwater), but contact cannot be quantified (NQ) and groundwater is not actively ingested. Also, contact with groundwater by wildlife and aquatic organisms is considered incomplete. Groundwater that "daylights" in the Ironton Canal is considered surface water.

4.1.4 Assessment Endpoints

Assessment endpoints represent specific ecological values to be protected and are the focus of the BERA. USEPA (1998) lists three criteria for selection of assessment endpoints (and receptors): ecological relevance, susceptibility to measured contaminants, and relevance to management goals. The assessment endpoints described below are based on trophic guilds identified as being most relevant to the exposure pathways for the EAs at the Site.

4.1.4.1 Viability and Function of the Plant Community

The plant community transforms inorganic nutrients into biological tissue through photosynthesis. Plant tissue represents the base of the food web by providing forage to

herbivorous and omnivorous invertebrates, birds, and mammals. The plant community also provides habitat for other types of organisms. Plants are found in both terrestrial upland habitats and in aquatic habitats. This assessment endpoint is applicable in EAs 1, 2, 3, 4, 6, and 7. The gravel present in EA2, EA3, EA4, and EA6 substantially reduces the quality of the habitat, but the BERA does not quantitatively account for the degraded ecological habitat in the exposure areas with significant gravel cover.

4.1.4.2 Viability and Function of the Soil Invertebrate Community

Terrestrial invertebrates (e.g., soil microorganisms and earthworms) aid in nutrient cycling, soil aeration, and infiltration by increasing the soil micro- and macro-porosity. Soil microorganisms serve a critical role in nutrient cycling by being the primary consumers of soil organic matter and converting nutrients into plant-available forms. Earthworms have been described as probably the most important soil invertebrate in promoting soil fertility. They break down organic matter and release nutrients, increase soil aeration, and improve water drainage into soil. Microorganisms and earthworms also provide an important food source for many higher trophic level species. This assessment endpoint is applicable in EAs 2, 3, 4, 6, and 7. The gravel present in EA2, EA3, EA4, and EA6 substantially reduces the quality of the habitat, but the BERA does not quantitatively account for the degraded ecological habitat in the exposure areas with significant gravel cover.

4.1.4.3 Viability and Function of the Benthic Invertebrate Community

Benthic invertebrate communities, which can include aquatic insects, worms, and mollusks, comprise a portion of the base of the food web for aquatic ecosystems. Impacts to benthic invertebrate communities may have direct effects (e.g., loss or reduction of forage) and indirect effects (e.g., transfer of bioaccumulative chemicals) on higher trophic level organisms. Benthic invertebrates process organic material in water bodies and are important in nutrient and energy transfer as well as in the overall ecosystem function. This assessment endpoint is applicable in EA1 only.

4.1.4.4 Viability and Function of the Aquatic Community

The aquatic community plays a key role in ecosystem functions such as energy flow, nutrient cycling, and organic matter accumulation. Fish and aquatic invertebrates, which are key components of the aquatic community, are important food resources for higher trophic-level species. This assessment endpoint is applicable in EA1 only.

4.1.4.5 Survival, Growth, and Reproduction of Herbivorous Birds and Mammals

Herbivorous birds and mammals rely primarily on plants as forage. Because these animals feed primarily on plants, they provide the critical pathway between primary productivity of plants to higher levels of the food web. Herbivorous birds and mammals also are the pathway to higher trophic levels for chemicals that have bioaccumulated in plants. Incidental ingestion of soil or sediment also may occur during browsing and burrowing activities. This assessment endpoint is applicable in EAs 1, 2, 3, 4, 6, and 7. The gravel present in EA2, EA3, EA4, and EA6 substantially reduces the quality of the habitat, but the BERA does not quantitatively account for the degraded ecological habitat in the exposure areas with significant gravel cover.

4.1.4.6 Survival, Growth, and Reproduction of Invertivorous Birds and Mammals

One group of carnivorous birds and mammals relies primarily on invertebrates as forage. This group, referred to as invertivores (e.g., insectivores), is important in the population regulation of soil invertebrates, such as earthworms or other soil microorganisms, and benthic and aquatic invertebrates. The foraging behavior of these animals also represents a pathway by which nutrients and energy are transferred from lower to higher levels of the food web. Incidental ingestion of soil or sediment also may occur during burrowing and foraging activities. This assessment endpoint is applicable in EAs 1, 2, 3, 4, 6, and 7. The gravel present in EA2, EA3, EA4, and EA6 substantially reduces the quality of the habitat, but the BERA does not quantitatively account for the degraded ecological habitat in the exposure areas with significant gravel cover.

4.1.4.7 Survival, Growth, and Reproduction of Carnivorous Birds and Mammals

Carnivorous birds and mammals (as referenced in this document) are upper trophic-level organisms that rely primarily on small mammals, birds, or fish as forage. This foraging behavior represents a pathway by which nutrients and energy are transferred from lower to higher levels of the food web. Upper trophic-level predators regulate prey densities, species abundance, and diversity. Impacts to carnivorous birds and mammals could cause detrimental shifts in prey species population densities and community assemblages. Incidental ingestion of soil or sediment also may occur during foraging activities. This assessment endpoint is applicable in EAs 2, 3, 4, 6, and 7. The gravel present in EA2, EA3, EA4, and EA6 substantially reduces the quality of the habitat, but the BERA does not quantitatively account for the degraded ecological habitat in the exposure areas with significant gravel cover.

4.1.5 Risk Questions and Measurement Endpoints

Risk questions are specific questions that are based on assessment values and COPECs. A BERA measurement is selected to evaluate each hypothesis. Measurements, or measures of effect, are measurable ecological characteristics related to the valued characteristic chosen as the assessment value (USEPA, 1998).

To develop a BERA measurement by which risk questions may be answered, an applicable ecological component is identified that is representative of the assessment value. For vertebrates, the generally accepted approach is to select an indicator species to represent the ecological component or feeding guild. These indicator species can also be referred to as ROIs. Although this approach uses one or more species to evaluate a feeding guild in an assessment endpoint, it is important to remember that the ROI is representative of the entire guild as described in the assessment endpoint. Selection of ROIs for the BERA is based on the considerations described in Section 4.1.6.

A summary of the applicable assessment values and associated risk questions and measurements for the identification of chemicals of ecological concern (COECs) at the Site is presented below. (Note: COPECs that present a risk to one or more ecological receptors are termed COECs.)

4.1.5.1 Viability and Function of the Plant Community

Risk Question – Are the concentrations of COPECs in soil sufficient to impair the viability and function of the plant community?

Measurement Endpoint – To evaluate this assessment endpoint in the BERA, representative EPCs of COPECs in soil and sediment are compared with lowest observed effect concentrations (LOECs) for plants.

4.1.5.2 Viability and Function of the Soil Invertebrate Community

Risk Question – Are the concentrations of COPECs in soil sufficient to impair the viability and function of the soil invertebrate community?

Measurement Endpoint – To evaluate this assessment endpoint in the BERA, representative EPCs of COPECs in soil are compared with LOECs for soil invertebrates.

4.1.5.3 Viability and Function of the Benthic Invertebrate Community

Risk Question – Are the concentrations of COPECs in sediment sufficient to impair the viability and function of the benthic invertebrate community?

Measurement Endpoint – To evaluate this assessment endpoint in the ERA, representative EPCs of COPECs in surface sediment are compared with sediment benchmarks from the literature that are protective of the benthic invertebrate community (e.g., probable effect concentrations [PECs] above which harmful effects are likely).

4.1.5.4 Viability and Function of the Aquatic Community

Risk Question – Are the concentrations of COPECs in surface water sufficient to impair the viability and function of the aquatic community?

Measurement Endpoint – To evaluate this assessment endpoint in the BERA, representative EPCs of COPECs in surface water are compared with chronic freshwater water quality criteria in USEPA (2011b), concentrations protective of the aquatic community, or protective of birds and mammals exposed to water (LANL, 2011).

4.1.5.5 Survival, Growth, and Reproduction of Birds and Mammals (Herbivores)

Risk Question – Are the concentrations of COPECs in soil or sediment sufficient to impair the survival, growth, and reproduction of birds and mammals described as herbivores?

Measurement Endpoint – To evaluate this assessment endpoint in the BERA, the dietary dose herbivorous wildlife ROIs receive from soil or sediment, surface water, and plants are compared with toxicity reference values (TRVs) from the literature. TRVs for each soil COPEC representing lowest observed adverse effect level (LOAEL) doses are selected or derived to evaluate potential effects. The ROI representing aquatic omnivorous wildlife evaluated in the BERA is the mallard (*Anas platyrhynchos*) which is assumed to ingest both aquatic plants and benthic invertebrates in the Ironton Canal. Terrestrial herbivorous ROIs are the ring-necked pheasant (*Phasianus colchicus*), mule deer (*Odocoileus hemionus*), and meadow vole (*Microtus pennsylvanicus*). For the purpose of evaluating potential risk to herbivores, all of these herbivores are assumed to have a diet of vegetation (seeds and above-ground plant tissues). Additional descriptions of exposure of the ROIs are provided in Section 4.1.3.

4.1.5.6 Survival, Growth, and Reproduction of Birds and Mammals (Invertivores)

Risk Question – Are the concentrations of COPECs in soil or sediment sufficient to impair the survival, growth, and reproduction of birds and mammals described as invertivores?

Measurement Endpoint – To evaluate this assessment endpoint in the BERA, the dietary dose terrestrial invertivorous wildlife receptors receive from soil or sediment, surface water, and

earthworms, insects, or other invertebrates are compared with TRVs from the literature. Similarly, the dietary dose aquatic-dependent invertivores receive from sediment, surface water, and emergent aquatic invertebrates are compared with TRVs from the literature. TRVs for each soil and sediment COPEC representing LOAEL doses are selected or derived for assessing potential effects. ROIs representing terrestrial invertivorous wildlife evaluated in the BERA are the tree swallow (*Tachycineta bicolor*) and deer mouse (*Peromyscus maniculatus).* The tree swallow may also ingest invertebrates emerging from the Ironton Canal.

4.1.5.7 Survival, Growth, and Reproduction of Birds and Mammals (Carnivores)

Risk Question – Are the concentrations of COPECs in soil or sediment sufficient to impair the survival, growth, and reproduction of birds and mammals described as carnivores?

Measurement Endpoint – To evaluate this assessment endpoint in the BERA, the dietary dose carnivorous wildlife receptors receive from soil or sediment, surface water, and prey (aquatic organisms and/or small mammals) exposed to soil are compared with TRVs from the literature. TRVs for each COPEC representing LOAEL doses are selected or derived from the literature. The ROIs representing terrestrial carnivorous wildlife evaluated in the BERA are the American kestrel (*Falco sparverius*), and red fox (*Vulpes vulpes*).

4.1.6 Ecological Receptors

In order to have ecological relevance, three feeding guilds (herbivore, invertivore, and carnivore) are represented by the selected assessment endpoints and associated wildlife receptors. The selected wildlife ROIs are either prey (e.g., meadow vole) or predators (e.g., red fox) for other components of the greater Site ecosystem. Susceptibility of the receptors to contaminants in soil or sediment is addressed by choosing receptors that live or feed on the ground, have relatively high food and soil ingestion rates (usually associated with small body size), are year-round residents or abundant migrants, and/or have small home ranges. All of the selected ROIs were noted as being present on the Site in Bio/West, Inc. (1998). A complete list of the wildlife observed during three surveys conducted in 1998 is provided in Appendix D of Bio/West, Inc. (1998). The wildlife ROIs selected for the BERA are:

- Terrestrial Herbivores – Ring-necked pheasant, mule deer, and meadow vole
- Terrestrial Invertivores – Tree swallow and deer mouse
- Terrestrial Carnivores – American kestrel and red fox
- Aquatic-Dependent Ominivore – Mallard

- Aquatic-Dependent Invertivore – Tree swallow

As an omnivore, the mallard eats both vegetation (e.g., aquatic plants and seeds) and invertebrates. Therefore, this ROI functions as both an herbivore and an invertivore.

4.1.7 Identification of COPECs

One set of COPECs was selected for each EA and each exposure medium (soil, sediment, and/or surface water), as applicable. For the selection of COPECs in each exposure area and exposure medium, maximum concentrations of chemicals were compared to conservative media-specific ecological screening levels (ESLs). Those analytes exceeding the concentration-based ESLs were retained as COPECs for further evaluation in the BERA.

Detected chemicals considered bioaccumulative, regardless of their exceedance of ESLs, also were selected as COPECs. Bioaccumulative chemicals are those with log K_{ow} values in the range of 5 to 7.5 and a molecular weight of less than 1,100 (ICCA, no date). A list of analytes, their log K_{ow} values, molecular weights, and determination of bioaccumulative status is provided in Table 4-1. (Note: Bioconcentration and bioaccumulation factors for soil COPECs in plants, soil invertebrates, and flesh [i.e., animals] that are applied in the BERA are discussed in Section 4.2.1.3 below.)

4.1.7.1 Selection of ESLs for Each Medium

ESLs were selected for the three exposure media on the Site – soil, sediment, and surface water.

Soil ESLs. Maximum soil concentrations of detected chemicals were compared to soil ESLs. Soil ESLs were compiled from the following sources, as available:

- Ecological soil screening levels (Eco-SSLs) from USEPA (2010) – selected the lowest available Eco-SSL for the protection of plants, soil invertebrates, birds, or mammals.
- Soil ESLs from Los Alamos National Laboratory (LANL, 2011) – selected the lowest available LANL ESL for the protection of plants, soil invertebrates (i.e., earthworms), birds, or mammals.

The selection of soil ESLs from the sources listed above is shown in Table 4-2. These two sources of ESLs document the selection and/or generation of screening levels for soil using the most recent toxicological study results. As seen in Table 4-2, Eco-SSLs from USEPA (2010) for PAHs are available only for soil invertebrates and mammals. Further, only generic

Eco-SSLs are available from USEPA (2010) for low molecular weight PAHs (LPAH) (29,000 µg/kg for soil invertebrates and 100,000 µg/kg for mammals) and high molecular weight PAHs (HPAH) (18,000 µg/kg for soil invertebrates and 1,100 µg/kg for mammals). In contrast, ESLs for individual PAH analytes are available from LANL (2011) for plants, soil invertebrates, birds, and mammals. To address protection of terrestrial ROIs exposed to chemicals in soil and avoid premature exclusion of any detected chemicals as COPECs, the lowest ESL for any terrestrial receptor from either USEPA (2010) or LANL (2011) was selected as the ESL for each detected analyte. The concentrations selected as ESLs are shown in the last column of Table 4-2 and are assumed to be protective of the terrestrial ROIs exposed to chemicals in soil.

Sediment ESLs. Maximum measured sediment concentrations of chemicals were compared to sediment screening levels that were compiled from:

- Consensus threshold effect concentrations (TECs) protective of benthic invertebrates from MacDonald et al. (2000)
- Screening values for the protection of the aquatic community (organisms spending at least part of their life in close association with sediment) from LANL (2011)
- Screening values for the protection of birds and mammals feeding primarily on aquatic insects that have emerged as adults from LANL (2011)

The lowest sediment screening value for each sediment analyte from the three sources listed above was selected for use. The wildlife sediment ESLs from LANL (2011) are based on the lowest chronic no observed adverse effects level (NOAEL) doses available for the violet-green swallow (*Tachycineta thalassina*) and the little brown myotis bat (*Myotis lucifugus occultus*). Both of these wildlife receptors are assumed to feed on aquatic insects that mature and emerge from aquatic habitats (LANL, 2011). By selecting the lowest of the available ESLs, all of the ecological communities potentially exposed to chemicals in sediment are assumed to be protected. The selected sediment ESLs protective of benthic invertebrates and terrestrial and aquatic-dependent wildlife are provided in Table 4-3.

Surface Water ESLs. Maximum surface water concentrations of chemicals were compared to surface water screening levels. Surface water ESLs were compiled from a variety of sources and are protective of ecological ROIs exposed to surface water. The lowest ESLs from the following sources were selected for each surface water analyte:

- Ambient Water Quality Chronic Criteria (USEPA, 2011b)

- Screening values for the protection of the aquatic community (aquatic organisms spending at least part of their life immersed in water) (LANL, 2011)
- Screening values for the protection of birds and mammals drinking water (LANL, 2011)

Surface water ESLs for organics that are protective of aquatic organisms, including the endangered June sucker (if present), and wildlife were selected from the sources listed above and are shown in the last column of Table 4-4. No numeric criteria for the Vertellus surface water analytes are available from Table 2.14.2 of Utah (UAC, 2010).

4.1.7.2 Selected COPECs

In general, chemicals with maximum Site concentrations exceeding selected ESLs are termed COPECs for each exposure medium of concern and are retained for further evaluation in the BERA. Only chemicals identified as COPECs are included in the Risk Analysis and Risk Characterization, and only media with identified COPECs are evaluated.

The selected COPECs for each EA and exposure medium are described below. The higher of the maximum detected concentration or the maximum RL is the exposure concentration used in the selection of COPECs. This concentration is compared to the ESL for the exposure medium, and the analyte is characterized as bioaccumulative or not bioaccumulative. If the maximum exposure concentration (i.e., maximum measured concentration or maximum RL) of the analyte exceeds its ESL or if the analyte is bioaccumulative, it is retained as a COPEC. The COPECs identified for soil are presented in Table 4-5 and are discussed below:

EA2 – Subsurface Soil. In EA2 the only exposure medium with analytical data is subsurface soil. Of the 29 detected soil analytes in EA2, only ethylbenzene does not have an ESL available for the protection of any of the four ecological receptors (plants, soil invertebrates, birds, or mammals). Because ethylbenzene is not bioaccumulative, it is not retained as a COPEC. The remaining 28 soil analytes are retained for further analysis in the BERA as soil COPECs in EA2.

EA3 – Surface and Subsurface Soil. In EA3 both surface and subsurface soil was sampled. Of the 35 analytes, ten analytes are not bioaccumulative and their concentrations do not exceed their ESLs, or no ESL was available. These ten analytes are not retained for further evaluation for this exposure area. The remaining 25 soil analytes are retained for further analysis in the BERA as soil COPECs in EA3.

EA4 – Subsurface Soil. In EA4 the only exposure medium with analytical data is subsurface soil. Of the 33 detected analytes, five analytes are not bioaccumulative and their

concentrations do not exceed their ESLs, or no ESL was available. These five analytes are not retained for further evaluation for this exposure area. The remaining 28 soil analytes are retained for further analysis in the BERA as soil COPECs in EA4.

EA6 – Surface Soil. In EA6 the only exposure medium with analytical data is surface soil. All of the 25 analytes in EA6 were detected in all samples (no maximum RL is reported). Of the 25 analytes, two analytes are not bioaccumulative and their concentrations do not exceed their ESLs, or no ESL was available. These two analytes are not retained for further analysis. The remaining 23 soil analytes are retained for further analysis in the BERA as soil COPECs in EA6.

EA7 – Surface and Subsurface Soil. In EA7 both surface and subsurface soil was sampled. All of the 26 analytes in EA7 have some samples that were non-detect for the analyte. Of the 26 analytes, ten analytes are not bioaccumulative and their concentrations do not exceed their ESLs, or no ESL was available. The remaining 16 soil analytes are retained for further analysis in the BERA as soil COPECs in EA7.

Hotspot 2-SF-2-18 – Surface Soil. In this hotspot the only exposure medium analyzed is surface soil. All of the 22analytes in this hotspot were detected in the sample that was collected. Of the 22 analytes, six analytes are not bioaccumulative and their concentrations do not exceed their ESLs, or no ESL was available. These six analytes are not retained for further analysis. The remaining 16 soil analytes are retained for further analysis in the BERA as soil COPECs in Hotspot 2-SF-2-18.

Hotspot 2-SF-2-19 – Surface Soil. All of the 25 analytes in this hotspot were detected in the one surface soil sample collected. Of the 25 analytes, five analytes are not bioaccumulative and their concentrations do not exceed their ESLs, or no ESL was available. These five analytes are not retained for further analysis. The remaining 20 soil analytes are retained for further analysis in the BERA as soil COPECs in Hotspot 2-SF-2-19.

Hotspot 2-SF-3-36 – Surface Soil. All of the 25 analytes in this hotspot were detected in the one surface soil sample collected. Of the 25 analytes, four analytes are not bioaccumulative and their concentrations do not exceed their ESLs, or no ESL was available. These four analytes are not retained for further analysis. The remaining 21 soil analytes are retained for further analysis in the BERA as soil COPECs in Hotspot 2-SF-3-36.

Hotspot 2-SF-4-23 – Surface Soil. All of the 25 analytes in this hotspot were detected in the one surface soil sample collected. Of the 25 analytes, five analytes are not bioaccumulative and their concentrations do not exceed their ESLs, or no ESL was available. These five

analytes are not retained for further analysis. The remaining 20 soil analytes are retained for further analysis in the BERA as soil COPECs in Hotspot 2-SF-4-23.

Sediment was only sampled in EA1, and the selection process for COPECs in sediment is the same as for selection of COPECs in soil. If the maximum concentration in sediment (i.e., maximum measured concentration or maximum RL) of the analyte exceeds its sediment ESL or if it is bioaccumulative, it is retained as a COPEC for sediment. The COPECs identified for sediment are presented in Table 4-6. As seen in Table 4-6, 32 analytes were detected in shallow sediment (0 to 1 foot) bgs. Of these detected analytes, nine analytes are not bioaccumulative and their concentrations do not exceed their sediment ESL. These analytes are not retained for further analysis. The remaining 23 sediment analytes are retained for further analysis in the BERA as sediment COPECs in EA1.

Surface water was only sampled in EA1, and the selection process for COPECs in this exposure medium is the same as for selection of COPECs in soil and sediment. If the maximum concentration of the analyte in surface water exceeds its chronic water quality criterion (i.e., ESL) (or if a chronic criterion is not available), or if it is bioaccumulative, it is retained as a COPEC. 23 analytes were detected in surface water (Table 4-7). Of these detected analytes, 13 analytes are not bioaccumulative and their concentrations do not exceed their chronic criteria, or no criterion is available. These analytes are not retained for further analysis. The maximum concentrations of the remaining ten surface water analytes exceed chronic criteria or are bioaccumulative and are retained for further analysis in the BERA as surface water COPECs in EA1.

4.2 Risk Analysis

The Risk Analysis component of the BERA includes discussions of ecological receptor exposure pathways and potential ecological effects of the selected COPECs. Descriptions of methods used in the exposure assessment and development/descriptions of potential ecological (toxicological) effects of the contaminants are presented below.

4.2.1 Exposure Assessment

Ecological receptors can be exposed through direct contact with soil, sediment, and/or surface water. Wildlife receptors can also be exposed through ingestion of forage/prey, incidental ingestion of soil or sediment while feeding, and ingestion of water. For both types of exposure (contact and ingestion), the EPC of each COPEC must be estimated. Both direct contact and ingestion exposures are discussed further in the following subsections.

4.2.1.1 Methodology for Estimating Exposure Point Concentrations

Only common species are expected to be present on the Site or in the immediate vicinity of the Site and are the species potentially exposed to the identified COPECs. Therefore, conservative estimates of average EPCs are used in the exposure assessment for all ROIs. The 95% UCL, which represents an upper-bound estimate of the mean concentration of a COPEC in a particular medium, are used as the EPC. EPCs based on 95% UCLs allow for a realistic interpretation of the potential hazards at the community level for common species. If an insufficient number of samples was available to calculate a 95% UCL (typically seven or more sample detections), then the maximum detected concentration was used as the EPC.

USEPA's most recent ProUCL software program (Version 4.1.00 [USEPA, 2011a]) was used to calculate 95% UCL concentrations of COPECs. This software reflects the latest USEPA guidance on the calculation of UCL concentrations, based on data distribution, presence/absence of non-detect data, data skewness, and sample size.

In calculating 95% UCLs, maximum values were used for duplicate samples, and multi-depth results (samples obtained from the same location, but at different depths) were treated as independent data points. If the ProUCL-assessed 95% UCL was less than the maximum detected concentration, then the 95% UCL was used as the EPC. If the ProUCL-assessed UCL was greater than the maximum detected concentration, then the maximum detected concentration was identified as the EPC.

For field duplicates, if one sample result was a detection and the other a non-detection, the detected value was used. If both sample results were non-detections, the result with the lowest RL was used.

Results of the calculation of EPCs (primarily 95% UCLs) for surface soil and subsurface soil in the EAs evaluated in the BERA (EA2, EA3, EA4, EA6, and EA7) are presented in Table 4-8. EPCs (primarily 95% UCLs) for sediment in EA1 are presented in Table 4-9. EPCs (primarily 95% UCLs) for surface water in EA1 are presented in Table 4-10. As seen in these tables, summary statistics for each EA, soil depth (surface, subsurface, or both), sediment (surface only), or surface water and the detected analytes are provided in addition to the calculated 95% UCL and selected EPC (95% UCL or maximum).

4.2.1.2 Direct Exposure

As seen by the "C" symbols in the ecological CSMs (Figures 4-1 and 4-2), plants and soil invertebrates are assumed to be in direct contact with COPECs in soils. Rooted aquatic plants and benthic invertebrates are in direct contact with COPECs in sediment. Aquatic organisms

are in direct contact with surface water. All direct contact exposures indicated with a "C" are quantitatively evaluated in the BERA (for each COPEC identified for a given medium). Wildlife (birds and mammals) may be in direct contact with soil, sediment, and/or surface water, but those exposure pathways are assumed to be *de minimus* because of coverings of fur or feathers and are not evaluated (indicated by "NQ").

4.2.1.3 Exposure of Wildlife Receptors Through Ingestion

Concentrations of COPECs in soil, sediment, and surface water are used directly in estimating direct exposure of receptors and also are necessary to estimate ingestion exposure concentrations for wildlife receptors. Meaningful inferences about the potential hazards of ingesting COPECs require an understanding of the relationship between exposures, expressed as concentrations (µg/kg or micrograms per liter [µg/L]) or doses (mass of COPEC/unit of receptor body weight/unit of time [mg/kg bw-day]) and responses. Doses were estimated using:

- The measured concentration of each COPEC in media known or assumed to be ingested (mg/kg in food and in soil/sediment)
- Estimates of the mass of each medium ingested on average per day
- Estimates of the mass of each COPEC consumed per day, obtained by multiplying the concentration (µg/kg or µg/L) in each medium by the amount of that medium (kg or L) ingested by an individual in the population of the receptor species and expressed in terms of the mass (BW) of the receptor (mg/kg bw-day)

Ingestion-pathway exposures for each wildlife ROI were estimated as average daily doses (ADDs) using the approach outlined in USEPA (1993b) as follows:

For food, soil (or sediment), and water:

$$ADD = ([IR_f x C_f] + [IR_s x C_s] + [IR_w x C_w]) \times BA x AUF x SUF / BW$$

Where:

IR_f	=	Ingestion rate of food (kg/day)
IR_s	=	Ingestion rate (incidental) of soil or sediment (kg/day)
IR_w	=	Ingestion rate of water (L/day)
C_f	=	Concentration of COPEC in food (mg/kg; estimated)
C_s	=	Concentration of COPEC in soil or sediment (mg/kg; measured)
C_w	=	Concentration of COPEC in water (mg/L; measured)
BA	=	Bioavailability of COPEC in soil/sediment and food (assumed to be 1.0)

AUF = Area use factor (decimal fraction)
SUF = Seasonality use factor (conservatively assumed to be 1.0)
BW = Body weight of the receptor (kg)

As seen in the CSMs (Figures 4-1 and 4-2), wildlife are assumed to ingest soil or sediment and surface water containing COPECs in addition to COPECs in food (plants or prey). Exposure of wildlife to COPECs in soil/sediment and surface water was evaluated as part of the ingestion pathway that includes food intake.

Relatively few empirical measurements of these attributes in wildlife species are available, and those that are available are often based on captive specimens. For these and many other reasons, assumed values for these parameters are uncertain. Uncertainty can never be totally eliminated, but prudent application of well-documented information about the behavior and physiology of the ROIs minimizes uncertainty. The assumptions used in this analysis are based on formally published information for the ROIs or plausible surrogate species. Generally accepted principles and qualified professional judgment are used to derive assumptions from relevant literature (including USEPA 1993b, and primary sources cited therein). Exposure factors (e.g., BW, IR_f) specific for each wildlife ROI to be evaluated are presented in Table 4-11.

Ingestion Rate of Food (IR_f). There are three general sources of IR_f values for wildlife:

- Expressions based on a percentage of body weight, derived from collective experience (including some empirical measurements) of researchers familiar with the types of animals in question (e.g., Nagy, 2001)
- Empirical measurements, usually obtained from a relatively small "sample" of animals fed *ad libitum* in captivity
- Allometric equations based on a combination of empirical measurements from a wide variety of representatives of categories of animals and bioenergetic principles and theory (e.g., Nagy, 2001; also see USEPA, 1993b)

Most of the IR_f values in Table 4-11 are based on allometric relationships provided in USEPA (1993). In the absence of empirical measurements specific to the selected ROIs, use of the allometric equations is appropriate because these are widely accepted, empirically-derived relationships. IR_f values are calculated in units of dry weight.

Dietary Composition. In general, there is a paucity of detailed quantitative dietary studies, and these relate primarily to localized populations of only a few species (USEPA, 1993b). In nature, the diets of most vertebrates vary considerably with season and availability of food

items (Allee et al., 1951; Martin et al., 1951). However, some animals have morphological, physiological, or behavioral adaptations that limit their ability to use certain broad categories of food.

Diets identified for the ROIs in Table 4-11 are based on available literature and consider feeding patterns and the way food habits are commonly described. For the purpose of this BERA, the typical diets are conservatively modified so that each ROI, except for the mallard which is an omnivore, is described as strictly being an herbivore, invertivore, or carnivore.

Ingestion Rates of Soil/Sediment (IR_s). Many higher vertebrates are known to ingest soil or sediment incidental to feeding or grooming (USEPA, 1993, 2005; Beyer et al., 1994). The quantities are often a function of the animal's feeding habits; for example, some small mammals that feed extensively on roots ingest relatively high amounts of soil. In some cases, professional judgment has been used in interpreting reported rates, or extrapolating from surrogate species. The IR_s is normally estimated as a percentage of the overall diet, and then converted to kg/day (dry weight).

Ingestion Rates of Water (IR_w). It is assumed that wildlife exposed to soil or sediment would also ingest water in the Ironton Canal. This is a conservative assumption in that wildlife could be ingesting water from other nearby sources not affected by Site contamination. Water ingestion rates for the individual wildlife ROIs are primarily from Sample et al. (1997) or USEPA (1993b).

Area Use Factor (AUF). An AUF is the fraction of the exposure area over which a receptor may forage (AUF = Exposure Area / Home Range). To account for the fraction of ingested media derived from each exposure area, behavioral information from the literature (such as home ranges or feeding territories) is considered in light of the relevant exposure area dimensions. For example, if a receptor is known to forage over a greater area than is available for an exposure area, then its exposure potential is less than that of an alternate species that forages over the same exposure area but has a smaller home range. Home ranges (acres) of the wildlife ROIs are provided in Table 4-11. The unitless AUF can range from near 0.0 to 1.0 (100% site use). AUFs may be equal to 1.0 for small mammals with small home ranges (e.g., meadow vole – 0.1 acre). Conversely, AUFs for birds or mammals with large home ranges (e.g., mallard – 274 acres) can be small. Calculated AUFs are provided in Table 4-12 for each ecological ROI and ecological exposure area where the ROI may be exposed. Hotspots, which are an estimated area of only 1.0 square foot, are not included as exposure areas for wide-ranging wildlife because of the extremely small AUFs for these wildlife. Only

the deer mouse and meadow vole, in addition to plants and soil invertebrates, are included as exposed ecological receptors for the hotspots.

Seasonality Use Factor (SUF). An SUF is the fraction of time during which a receptor may forage in an exposure area. To account for the fraction of ingested media derived from each exposure area, behavioral information from the literature (e.g., migration patterns and wintering areas) is considered in light of the location of the Site. Because most of the ROIs are resident species and are expected or known to be found in the vicinity of the Site throughout most of the year, the SUF is assumed to be 1.0 (100%) for the purpose of calculating exposure for all ROIs.

Body Weight (BW). Body weight is an important factor because it is often used in calculating other exposure parameters when realistic direct measurements are not available (e.g., IR_f and IR_w). Estimated or reported body weights for the wildlife ROIs are presented in Table 4-11.

Concentration of COPEC in Environmental Media (C_s or C_w). Measured concentrations of COPECs in each environmental medium (soil, sediment, and/or surface water) that receptors may contact were used to calculate EPCs. See Section 4.2.1.1 for the methodology to be used in estimating EPCs of COPECs for each exposure medium.

As shown it Table 4-11, wildlife incidentally ingest some surface soil (or sediment) while feeding. Therefore, in EA3 and EA7, where both surface and subsurface soil sample data are available, concentrations of contaminants in ingested soil are based on surface soil concentrations. However, because of its burrowing habits, the meadow vole is assumed to incidentally ingest soil from both surface and subsurface soil. For this exposure pathway in EA3 and EA7, it was assumed that the meadow vole ingested soil with the higher concentrations (surface or subsurface soil).

In EA2 and EA4, only subsurface soil samples were collected because based on Site history, surface soil is not believed to have been impacted by contamination from the Site. Therefore, for these two EAs, the concentrations of COPECs in the incidentally ingested surface soil were assumed to be zero. However, because the meadow vole is assumed to incidentally ingest soil from both surface and subsurface soil and no data are available for surface soil, it was assumed that the meadow vole ingested only subsurface soil.

For EA2 and EA4 where only subsurface soil samples were collected, uptake of contaminants by plants, soil invertebrates, or small mammals (i.e., food for higher-level organisms) is based

on concentrations in the subsurface soil through the application of bioconcentration or bioaccumulation factors (BCFs or BAFs).

Concentration of COPEC in Food (C_f). Concentrations of COPECs in food and prey organisms ingested by wildlife are estimated by the application of a BCF or BAF to the soil EPC (C_s) for the COPEC. BCFs are applied to the relationship between COPEC concentrations in soil and in plants or invertebrate tissues that are in direct contact with soil. BAFs are applied to the relationship between concentrations in soil and in small mammals and take into account dietary exposure pathways.

BCF and BAF models are used to estimate the concentrations of COPECs in plant or prey tissue based on the concentrations of COPECs in soil because site-specific tissue data are not available for use in the dose calculation described above. Soil-to-biota BCF models for plants and invertebrates, and BAF models for small mammals selected for use are either simple BCFs/BAFs that can be multiplied by the concentration in Site media ($C_f = BAF x C_s$) or regression models that incorporate the soil or sediment concentration to estimate the COPEC concentration in food items. Regression equations are usually presented in the general form:

$$ln(C_f) = B1 x (ln[C_s]) + B0$$

where:

B0 = log-transformed y intercept

B1 = slope

The updated Eco-SSL regression model BCFs/BAFs for soil from USEPA (2005) were used where available. In the absence of Eco-SSL BCFs for plants and invertebrates, alternative regression models or BCFs from LANL (2011) were used. For EAs having both surface and subsurface soil results, uptake to plants, soil invertebrates, and/or small mammalian prey was based on the higher of surface or subsurface soil results. If only surface or subsurface soil samples were collected, uptake was based on the available data. As recommended in USEPA (2005), BAFs for uptake of PAHs into small mammals are equal to zero because of the rapid metabolism of PAHs after ingestion. BCFs/BAFs for soil are shown in Table 4-13.

The uptake of COPECs from canal sediment to plants was based on uptake from soil to plants from USEPA (2005) or LANL (2011). For uptake from sediment to benthic invertebrates, biota-sediment accumulation factors (BSAFs) from USACE (2009) (Table 4-14) were used. As described in USACE (2009):

"A ...BSAF expresses the steady-state difference between the concentration of a bioaccumulating neutral (nonpolar) organic chemical normalized on the organic carbon content of a sediment [OC], and the concentration measured in the total extractable lipids of an organism [C_{Inv}] for which that sediment represents the source of contamination in its habitat."

$$C_{Inv}x\%\ lipid = BASFx(C_{Sed})x\%OC$$

As seen in Tables 4-13 and 4-14, estimates of tissue concentrations in invertebrates cannot be calculated without site-specific chemical concentration data. Therefore, after EPCs in soil and sediment were calculated, invertebrate tissue concentrations of COPECs were calculated. For the calculation of COPECs in benthic invertebrates, it was conservatively assumed that the percent lipids in invertebrates was 3.5% based on the 90th percentile of lipid data for a freshwater worm USEPA (2012a), and the percent organic carbon in sediment was conservatively assumed to be 1%. Concentrations of COPECs in rooted aquatic plants were estimated using the plant BCFs in Table 4-13.

4.2.2 Ecological Effects of Contaminants

The effects of chemicals on ecological receptors can be based on direct comparisons of concentration-based benchmarks with measured concentrations in the abiotic exposure media (soil, sediment, or surface water) expressed as mg/kg or mg/L, or effects can be based on comparisons of dose-based TRVs with estimated doses that a wildlife receptor receives from the environment. As described previously (see Section 4.2.1.3), doses are expressed as mg/kg bw-day.

4.2.2.1 Direct Exposure TRVs

To evaluate potential risks to plants, soil invertebrates, benthic invertebrates, and aquatic organisms, EPCs of COPECs in soil, sediment, and surface water were compared directly with low-effect benchmarks from the literature.

ESLs used in the screening for plants and soil invertebrates exposed to chemicals in soil were compiled as described in Section 4.1.7.1. To evaluate potential risks to plants and soil invertebrates from identified soil COPECs, comparisons with EPCs were made with LOECs. If a LOEC is not available for a COPEC but a (no observed effect concentration (NOEC) is available, the NOEC was multiplied by a factor of 5 to adjust from a no-effect concentration to low-effect concentration (i.e., the LOEC). Therefore, for COPECs without LOECs in the literature, LOECs were estimated as 5 times the plant and invertebrate ESLs (i.e., NOECs) listed in Table 4-2. The lower of the ESLs from USEPA (2010) or LANL (2011) were selected as the basis for the LOECs. The plant and soil invertebrate ESLs multiplied by 5 serve as estimates of the LOECs. The NOEC-to-LOEC estimation process is parallel to that

for NOAEL-to-LOAEL estimations described below in Section 4.2.2.2 for wildlife ingestion pathway TRVs. The estimated LOECs for the COPECs to which plants and soil invertebrates may be exposed are shown in Table 4-15.

ESLs used in the screening for benthic invertebrates and riparian and rooted aquatic plants exposed to chemicals in sediment were compiled as described in Section 4.1.7.1. To evaluate potential risks to benthic invertebrates from identified sediment COPECs, comparisons of sediment EPCs were made with the lower of two thresholds: 1) LOECs estimated from Protection of the Aquatic Community thresholds (LANL, 2011) or 2) PECs (concentrations above which harmful effects are likely) from MacDonald et al. (2000). To evaluate potential risks to riparian and aquatic plants, sediment EPCs were compared with soil LOECs because of the absence of sediment-based LOECs for plants. LOECs were estimated as 5 times the plant NOECs from LANL (2011). LOECs for benthic invertebrates and riparian and aquatic plants are shown in Table 4-16.

To evaluate potential risks to aquatic organisms from identified surface water COPECs, comparisons with EPCs were made with chronic freshwater water quality criteria in USEPA (2011b) or with water concentrations protective of the aquatic community or protective of birds or mammals from LANL (2011) (see Table 4-4). Comparisons of COPECs in surface waters were made with chronic or protective criteria only. The ambient water quality criteria (USEPA, 2011b) are protective of 95% of all aquatic taxa, which often encompasses highly sensitive species that may or may not exist at a particular site.

4.2.2.2 *Ingestion Pathway TRVs*

In accordance with assessment endpoints involving survival, growth, and reproduction for terrestrial wildlife (birds and mammals), appropriate dietary toxicological endpoints for COPECs were reviewed for application in the BERA. These endpoints may include the NOAEL or LOAEL dose. The NOAEL is the highest dose where there is no statistically significant difference from the control response. The LOAEL is the lowest dose that results in a statistically significant effect compared to a control.

Primary sources for the wildlife ingestion pathway TRVs are LANL (2011) and USEPA (1999 and 2010). The general strategy for selecting (or deriving) a single LOAEL value as a TRV from among the values reported in the literature is as follows:

- Preference is given to studies that are chronic or subchronic exposures versus single event or acute exposures. Where data are available for more than one dosing regimen, chronic is selected first, subchronic second, and acute only if no other data are available. If data for a chemical is available only for acute exposure, the dose is

adjusted to approximate a LOAEL dose. Critical life-stage tests also carry significant weight.

- Studies are considered based on the dosing regimen. Intraperitoneal or intravenous studies are not used. Studies using gavage or oral intubation are not used when food studies are available.
- Where literature values are identified for the specific ROI, the lowest LOAEL representing the assessment endpoint (survival, growth, or reproduction) is selected, if available.
- Where values are not available for a specific ROI (which is characteristic of the vast majority of literature values), values from taxonomically close surrogate receptors are selected.
- Where only a NOAEL value is available for a COPEC, the LOAEL is based on 5 times the NOAEL. The ratio of 1:5 (NOAEL to LOAEL) is based on the NOAEL: LOAEL ratio of uncertainty factors presented in the U.S. Army's Standard Practice for Wildlife Toxicity Reference Values (USACHPPM, 2000). Also, the 1:5 ratio is near the average of bounded NOAEL-LOAEL ratios compiled from data summaries for metal toxicity to birds and mammals included in the Eco-SSLs (USEPA, 2010) and in data summaries for 16 organic compounds including PAHs, phthalates, pesticides, energetics, and xylene. By applying this uncertainty factor, some level of uncertainty is added to the estimated LOAEL, but the estimated dose is not expected to be overestimated. Consequently, resulting risk estimates are not expected to be underestimated.

Measures of effect considered include survival, growth, and/or reproduction. Endpoints specifically related to survival, growth, and reproduction such as fetotoxicity or infertility are considered. Effects such as carcinogenesis, liver damage, kidney function, enzyme induction, and blood pressure are generally not considered appropriate endpoints for use in assessing the potential for ecologically significant effects. However, due to a paucity of toxicity data for some PAHs, carcinogenic endpoints were used.

The chronic NOAEL and LOAEL TRVs for wildlife exposed to COPECs in soil are found in Tables 4-17 and 4-18 for birds and mammals, respectively. The LOAEL TRVs were used in the BERA to assess risk to the ROIs potentially exposed to COPECs in soil. Accompanying NOAELs are shown in the tables when the LOAEL has been estimated from the NOAEL that is reported in USEPA (1999 and 2010) or LANL (2011).

4.3 Risk Characterization

The final component of the BERA, Risk Characterization, includes the Risk Estimation and Risk Description. It is the culmination of problem formulation and is the interpretation of potential ecological effects related to the assessment endpoints (USEPA, 1998).

4.3.1 Risk Estimation

Risk estimation uses results from the exposure and effects characterization to develop an "estimate" of the risks posed to receptors representing specific ecological values to be protected (i.e., assessment endpoints [see Section 4.1.3]). Risk estimates, expressed in terms of HQs based on LOECs (for plants, soil invertebrates, benthic invertebrates, and/or aquatic organisms) and LOAEL TRVs (for wildlife species), are calculated for each of the appropriate receptor groups. HQs were generated for each ROI with a complete exposure route ("C") as shown in the two CSMs (Figures 4-1 and 4-2). The HQ is calculated as follows:

HQ = (EPC or Dose) / (LOEC or LOAEL TRV)

The HQs are interpreted as follows:

- HQ <1 indicates no risk in view of the conservative approach used
- HQ >1 suggests possible risk to the ROI, and the uncertainties associated with this conclusion should be considered further

When the HQ is less than or equal to one (≤1.0), the estimated potential exposure (EPC or Dose) is less than or equal to the TRV, indicating that significant adverse effects to the common species evaluated likely do not exist given the conservative assumptions inherent in the process. HQ values above 1.0 suggest the ROI is potentially at risk of adverse effects. Effects are evaluated at the population level for common species. HQ values greater than 1.0 must be interpreted in the context of uncertainties inherent in the risk assessment process and may suggest the need for additional risk refinement and evaluation.

Although the HQ is not a definitive measure, it can be used to estimate the potential level at which the measured or predicted exposure (EPC or Dose) relates to known levels where adverse effects have been observed in laboratory toxicological studies or found to not be statistically significant. HQs constitute the first "line-of-evidence" for interpreting the potential for ecological risks. The HQ tool as applied in the BERA should not be construed as an accurate "measure" of risk, but rather as an "indication" of the potential for risk. The magnitude of the HQ is also commonly considered in the interpretation of the potential for adverse effects to occur at a site.

Risk results for plants, soil invertebrates, birds, and mammals from exposure to chemicals in soil in upland habitats, water, and ingested food are described below. Next, risk to aquatic plants, benthic invertebrates, and two birds (mallard and tree swallow) from exposure to sediment and surface water in Ironton Canal are described. Risk to the aquatic community exposed to surface water in the canal also is described. Risk calculations for plants and soil invertebrates are provided in Appendix E. Risk calculations for wildlife (birds and mammals) exposed to COPECs in each EA are provided in Appendix F.

4.3.1.1 Risk to Plants, Soil Invertebrates, and Wildlife in EA2

The calculated HQs to terrestrial ROIs (plants, soil invertebrates, birds, and mammals) in EA2 are shown in Table 4-19. Only subsurface soil samples were collected in EA2. A total of 29 COPECs were identified for EA2. Of these, 23 chemicals have one or more HQs greater than 1.0 (shown in bold print in Table 4-19) for at least one receptor and are considered COECs. Several COPECs do not have TRVs for plants, soil invertebrates, or birds as shown with "NC" (not calculated) in the table.

4.3.1.2 Risk to Plants, Soil Invertebrates, and Wildlife in EA3

The calculated HQs to terrestrial ROIs (plants, soil invertebrates, birds, and mammals) in EA3 are shown in Table 4-20. Both surface and subsurface soil samples were collected in EA3. A total of 25 COPECs were identified for EA3. Of these, 16 chemicals have one or more HQs greater than 1.0 for at least one receptor and are considered COECs. Several COPECs do not have TRVs for plants, soil invertebrates, or birds as shown with "NC" in the table.

4.3.1.3 Risk to Plants, Soil Invertebrates, and Wildlife in EA4

The calculated HQs to terrestrial ROIs (plants, soil invertebrates, birds, and mammals) in EA4 are shown in Table 4-21. Only subsurface soil samples were collected in EA4. A total of 29 COPECs were identified for EA4. Of these, 24 chemicals have one or more HQs greater than 1.0 for at least one receptor and are considered COECs. Several COPECs do not have TRVs for plants, soil invertebrates, or birds as shown with "NC" in the table.

4.3.1.4 Risk to Plants, Soil Invertebrates, and Wildlife in EA6

The calculated HQs to terrestrial ROIs (plants, soil invertebrates, birds, and mammals) in EA6 are shown in Table 4-22. Only surface soil samples were collected in EA6 which is a small (0.164 acre) located within EA3. A total of 24 COPECs were identified for EA6. Of these, 22 chemicals have one or more HQs greater than 1.0 for at least one receptor and are considered COECs. Several COPECs do not have TRVs for plants, soil invertebrates, or birds as shown with "NC" in the table.

4.3.1.5 Risk to Plants, Soil Invertebrates, and Wildlife in EA7

The calculated HQs to terrestrial ROIs (plants, soil invertebrates, birds, and mammals) in EA7 are shown in Table 4-23. Both surface and subsurface soil samples were collected in EA7. A total of 17 COPECs were identified for EA7. Of these, six chemicals have one or more HQs greater than 1.0 for at least one receptor and are considered COECs. Several COPECs do not have TRVs for plants, soil invertebrates, or birds as shown with "NC" in the table.

4.3.1.6 Risk to Plants, Soil Invertebrates, and Small Mammals in Hotspot 2-SF-2-18

The calculated HQs to terrestrial ROIs (plants, soil invertebrates, and small mammalian invertivores and herbivores [represented by deer mouse and meadow vole, respectively]) in hotspot 2-SF-2-18 are shown in Table 4-24. It was assumed that exposure of wide-ranging birds and mammals would be *de minimus* at hotspots which have an estimated area of only 1.0 square foot. Only one surface soil sample was collected in this hotspot which is located in the northern portion of EA2. A total of 16 COPECs were identified for this hotspot. Of these, two chemicals have one or more HQs greater than 1.0 for plants or soil invertebrates and are considered COECs. No risk was shown for small mammals.

4.3.1.7 Risk to Plants, Soil Invertebrates, and Small Mammals in Hotspot 2-SF-2-19

The calculated HQs to terrestrial ROIs (plants, soil invertebrates, and small mammals) in Hotspot 2-SF-2-19 are shown in Table 4-25. Only one surface soil sample was collected in this hotspot which is located in the northern portion of EA2. A total of 20 COPECs were identified for this hotspot. Of these, 10 chemicals have one or more HQs greater than 1.0 for plants or soil invertebrates and are considered COECs. No risk was shown for small mammals.

4.3.1.8 Risk to Plants, Soil Invertebrates, and Small Mammals in Hotspot 2-SF-3-36

The calculated HQs to terrestrial ROIs (plants, soil invertebrates, and small mammals) in Hotspot 2-SF-3-36 are shown in Table 4-26. Only one surface soil sample was collected in this hotspot which is located in the north-west corner of EA3. A total of 21 COPECs were identified for this hotspot. Of these, 12 chemicals have one or more HQs greater than 1.0 for plants or soil invertebrates and are considered COECs. No risk was shown for small mammals.

4.3.1.9 Risk to Plants, Soil Invertebrates, and Small Mammals in Hotspot 2-SF-4-23

The calculated HQs to terrestrial ROIs (plants, soil invertebrates, and small mammals) in Hotspot 2-SF-4-23 are shown in Table 4-27. Only one surface soil sample was collected in this hotspot which is located in the northern portion of EA4. A total of 20 COPECs were identified for this hotspot. Of these, 12 chemicals have one or more HQs greater than 1.0 for plants or soil invertebrates and are considered COECs. No risk was shown for small mammals.

4.3.1.10 Risk to Aquatic Plants, Benthic Invertebrates, and Birds in EA1

The calculated HQs to aquatic and riparian plants, benthic invertebrates, and two aquatic-related birds (omnivorous birds [mallard] and invertivorous birds [tree swallow]) are shown in Table 4-28. It was assumed that all of these ROIs are primarily exposed to chemicals in sediment in the Ironton Canal. The mallard (an omnivore) may ingest aquatic plants and benthic invertebrates, and the tree swallow (an invertivore) may ingest emerging aquatic invertebrates. They also are assumed to ingest water and sediment in the canal. A total of 24 COPECs were identified for sediment. Of these, 17 chemicals have one or more HQs greater than 1.0 and are considered to be sediment COECs for at least one receptor. Benthic invertebrates are at risk from exposure to all COECs in sediment. No risk was shown for invertivorous birds. Several COPECs do not have TRVs for plants or birds as shown with "NC" in the table.

4.3.1.11 Risk to the Aquatic Community in EA1

The calculated HQ to the aquatic community (defined as organisms that spend a significant portion of their lifetime in water) is shown in Table 4-29. A total of 10 COPECs were identified for surface water. Of these, two chemicals (benzo(a)pyrene and total cyanide) have HQs greater than 1.0 and are considered surface water COECs.

4.3.2 Uncertainty

ERAs, including the SLERA and BERA, employ conservative assumptions at several steps of the process where data may be lacking so as to complete the assessments while not underestimating exposure and risk. As a result, the multiple conservative assumptions generally result in risk estimates for ecological ROIs that may be overestimated. On the other hand, some uncertainties may result in underestimating exposure and risk. The sources of uncertainty and their effect on the assessment of risk are discussed in the following sections in order to place the risk estimates in perspective and to support risk-based decision-making. The principal sources of uncertainty applicable to the ERA – exposure, ecological effect of

chemicals, and risk characterization – are described below together with their estimated effect on the risk assessment.

4.3.2.1 Exposure

- Exposure concentrations are based on 95% UCL concentrations in soil and sediment for analytes having seven or more analytical results. For many of the COECs, the range of concentrations is very wide (see Table 4-8), and a statistical distribution of concentrations shows that high 95% UCL exposure concentrations are often driven by a limited number (often fewer than five) of very high individual detected concentrations in an EA. Consequently, the distribution of concentrations across an EA and the localized risks are not uniform – *May overestimate exposure of ecological receptors across EAs.*

- It is understood that actual bioavailability of chemicals varies with site conditions (e.g., Eh, pH, and organic matter of the exposure matrix) and is probably less than 100%, as suggested in the scientific literature (USEPA, 2001, 2013a; Gustafsson et al., 2003). For the SLERA and BERA, bioavailability was conservatively assumed to be 100% – *Likely overestimates bioavailability of most chemicals.*

- AUFs for wide-ranging wildlife were based on home range divided by acreage in EAs for estimating exposure to COPECs. None of the AUFs incorporates site-specific habitat quality. In EAs 2, 3, and 6, the overall habitat is physically degraded and substantial areas of EA2 and EA3 are covered with up to five feet of gravel. EA7 has terrestrial habitat that has been minimally altered by past industrial activities and resembles habitats in nearby natural areas. Also, the northern portion of EA4 has been physically altered and is also overlain with gravel. *Exposure of wildlife receptors in EAs 2, 3, 4, and 6 is likely overestimated when exposure is based on AUFs alone and habitat quality (gravel cover) is not considered.*

- Physical quality of the habitats in the EAs also affects the plant and soil invertebrate communities. The gravel cover over large portions of EAs 2, 3, 4, and 6 severely restricts areas where viable communities of plants and soil invertebrates can be established – *Exposure of plants and soil invertebrates in EAs 2, 3, 4, and 6 is likely overestimated when the degraded habitat quality (gravel cover) is not considered.*

- Uptake factors for prey items – An uptake factor typically derived using literature-derived equilibrium assumptions presumes that the measured concentrations of contaminants are constantly available to the ROIs. It does not consider that only a finite mass of each contaminant is available in the contact area for each receptor (e.g., soils in the immediate root zone of plants) – *May overestimate exposure and risk.*

- A number of exposure pathways for various receptors cannot be quantified (e.g., NQs in Figure 4-2 for surface soil inhalation and contact by wildlife) – *May underestimate total exposure and risk for wildlife.*
- The SUF is conservatively assumed to be 1 (100%) in the calculation of exposure of wildlife receptors. While some species may be on the site year-round, others migrate seasonally and therefore are not exposed over the full year – *Overestimates exposure and risk for several wildlife receptors.*

4.3.2.2 Ecological Effect of Chemicals

- Lack of ESLs for plants, soil invertebrates, birds, and mammals exposed to detected chemicals in soil. As seen in Table 4-5, ESLs are not available for three detected chemicals (2,4-dimethylphenol, 2-methylnaphthalene, and ethylbenzene) and therefore are not screened/retained as COPECs – *May underestimate possible risks to ROIs from exposure to these chemicals in soil.*
- Lack of TRVs for plants, soil invertebrates, birds, and mammals exposed to COPECs in soil. The numbers of COPECs without TRVs are: 22 for plants, 28 for soil invertebrates, 19 for birds, and 17 for mammals – *May underestimate possible risks to ROIs from exposure to COPECs in soil.*
- Extrapolation of toxicological data from laboratory test species to wildlife receptor species – Species differ with respect to absorption, metabolism, distribution, and excretion of chemicals – *Overall effect unknown: may overestimate or underestimate risk to wildlife species.*

4.3.2.3 Risk Characterization

- Background chemical levels – Some portion of the concentrations of PAHs measured onsite are ubiquitous in the natural environment. According to a study by the USEPA (2007), predominant sources of emissions of PAH compounds nationally are related to vehicular traffic, coal combustion, jet exhaust, and natural gas combustion. The distribution of sources and soil concentrations vary by region. The portion of the total levels of PAHs in soil, sediment, and surface water that are attributable to background levels is not factored out in the calculation of site-related exposure and risk – *May overestimate site-related risk from PAHs.*
- The USEPA (2010) provides only Eco-SSLs for the groups of LPAH and HPAH compounds. This was done because each of these groups likely has the same mode of

toxic action and toxicity information for some of the individual PAHs are scarce. Individual PAHs were chosen to represent the toxicity for each group of PAHs (e.g., toxicity of HPAH to mammals is based on toxicity data for benzo(a)anthracene) – *May over-or under-estimate toxicity and risk from LPAH and HPAH.*

4.3.3 Risk Description

The Risk Description provides an interpretation (i.e., description) of the quantitative risk estimates in the context of ecological significance (relevance) and uncertainties inherent in the risk assessment process for ecological receptors.

To better understand which EAs may pose the greatest ecological risk, which chemicals may pose the greatest risk, and which ecological receptors may be at the greatest risk, the risk description for the five principal terrestrial EAs is organized by EA, COEC, and ROI. Risk posed by the hotspots is discussed next, followed by discussions of risk from exposure to sediment and surface water in the Ironton Canal. Using professional judgment, the potential for ecological risk for ROIs in each EA is characterized as "Likely," "Possible," "Unlikely", or "Not at Risk" after considering the quantitative results and qualitative factors that may affect the results.

4.3.3.1 Risk for the Five Exposure Areas

In general, the order of upland (terrestrial) EAs, where the primary exposure medium is soil, from highest potential risk to least potential risk is EA2, EA4, EA3, EA6, and EA7. This ranking is based on the overall highest HQ for any receptor and the highest HQs for the most sensitive ROI, invertivorous birds (represented by the tree swallow). For EA2, the highest HQ is 20,000 for invertivorous birds exposed to HPAH. For EA4, the highest HQ is 6,500 for invertivorous birds exposed to HPAH. If the average number of COECs (with HQs greater than 1.0) for each of the terrestrial ROIs was the primary parameter used to identify the highest-to-lowest order of exposure areas, EA2 would still be the EA posing the greatest risk to ecological receptors, followed by EA4, EA6, EA3, and EA7. EA2 has an average of 7.3 COECs for the nine terrestrial ROIs considered. EA4 and EA6 have an average of 6.0 COECs (chemicals with HQs greater than 1.0) for the nine terrestrial ROIs.

The habitat quality of most EAs has been physically altered by past industrial activities. When the physical habitat quality of each EA is considered, the effective AUFs (i.e., usability) for ROIs exposed in EAs 2, 3, 4, and 6 is substantially decreased. Specifically, EA3 has substantial areas covered with up to 5 feet of gravel over the soil. The southern third of EA3 has 3 to 5 feet of gravel over a subsurface concrete pad located approximately 3 feet below ground surface. In EA2 the area under the former evaporation pan has two or

more feet of gravel over subsurface soil. Additionally, the exposure area of EA6 is very small (less than 0.2 acre) and any risk (i.e., impacts) at the population level for a ROI would likely be insignificant. As a result of the reduced physical quality of the habitats in EAs 2, 3, 4, and 6, estimated exposure and risks to the terrestrial ROIs are reduced. Finally, because the Site is located in an industrial area and the future use of the Site is to maintain the Site as a vacant fenced lot, the Site is not appropriate for use as a natural reserve.

In EA2 and EA4, risk is driven primarily by only a handful of locations. For instance, in EA2 four or five locations (depending on the PAH) have the highest concentrations in soil and likely drive the risk for that EA (locations 2-SS-2-9, MW-28, 2-SS-2-17, and SS-23-6). In EA4, risk is driven primarily by one location, 2-SS-4-4. As a result, it is likely that only small areas in each of these two EAs constitute the potentially unacceptable ecological risk while risk for the overall EA is overestimated.

4.3.3.2 Risk for Chemicals of Ecological Concern

Five of the nine ROIs have HQs greater than 1.0 for each of three COECs – benzo(a)anthracene, benzo(b)fluoranthene, and HPAH. The five ROIs are herbivorous birds (ring-necked pheasant), invertivorous birds (tree swallow), small invertivorous mammals (deer mouse), small herbivorous mammals (meadow vole), and plants or soil invertebrates. The three COECs listed pose possible risks to the highest number of ROIs exposed in the five terrestrial EAs. However, cyanide poses a possible risk in only one terrestrial exposure area (EA2). Three other chemicals (benzo(a)pyrene, chrysene, and dibenz(a,h)anthracene) pose possible risk to four of the nine ROIs – herbivorous birds, invertivorous birds, small invertivorous mammals, and small herbivorous mammals. The remaining chemicals are COECs for fewer ROIs.

4.3.3.3 Risk for Ecological Receptors

Among the nine terrestrial ROIs, some receptors are at more risk from exposure to chemicals than others. Within the context of an ERA, this is due to several factors, including the toxicity of chemicals to different categories of receptors and anticipated exposure of each ROI to the chemicals in the five terrestrial EAs. Overall, invertivorous mammals (deer mouse) and invertivorous birds (tree swallow) are the most sensitive ROIs. Invertivorous mammals have the highest average number of COECs with HQs greater than 1.0 (13) versus 7.4 COECs for invertivorous birds. However, invertivorous birds have the highest HQ among the five terrestrial EAs (HQ = 20,000 at EA2) versus HQ = 4,700 at EA2 for small invertivorous mammals. Small herbivorous mammals (meadow vole) are the third most sensitive receptors and have a maximum HQ of 730 at EA2. Large herbivorous mammals (mule deer),

carnivorous mammals (red fox), and carnivorous birds (American kestrel) are at the least risk. Each of these three ROIs has a large home range which limits their exposure to PAHs in soil.

Overall, the order of terrestrial EAs that may pose the most to the least ecological risk is: EA2, EA4, EA3, EA6, and EA7. The chemicals posing the greatest ecological risk in the five EAs are benzo(a)anthracene, benzo(b)fluoranthene, and HPAH. Six ROIs (plants, soil invertebrates, herbivorous birds, invertivorous birds, small invertivorous mammals, and small herbivorous mammals) are at Likely Risk from exposure to COECs in three of the five terrestrial EAs (EA2, EA4, and EA3). In EA7, invertivorous birds are at Likely Risk, herbivorous birds and small invertivorous mammals are at Possible Risk, and plants and small herbivorous mammals are at Unlikely Risk. Soil invertebrates are Not at Risk in EA7. Because of its small size, EA6 poses only localized risk to the ROIs. Carnivorous birds are Not at Risk in EA7 and are at Unlikely Risk in only one EA (EA2). Large herbivorous mammals (mule deer) and carnivorous mammals (red fox) are Not at Risk in any EAs (i.e., no COPECs pose a risk to either ROI).

4.3.3.4 Risk in Hotspots

Four hotspots were evaluated separately from the larger terrestrial EAs. Hotspot 2-SF-2-18 is located in the northern corner of EA2. Based on the surface soil sample collected, only two COECs were identified for this hotspot – acenaphthalene and HPAH. Because the two small mammals evaluated for hotspots (invertivorous and herbivorous mammals) have no HQs greater than 1.0, and the HQs for plants and soil invertebrates are only slightly greater than 1.0, it is concluded that the overall risk at 2-SF-2-18 is Unlikely for the four ROIs.

Hotspot 2-SF-2-19 also is located in the northern portion of EA2. Based on the surface soil sample collected, 10 COECs were identified with HQs greater than 1.0 for exposure of plants or soil invertebrates. HQs range from 1.1 to 34 for plants and 1.9 to 7.3 for soil invertebrates. Overall, risk at 2-SF-2-19 is Likely for plants and Possible for soil invertebrates. Small mammals are Not at Risk at 2-SF-2-19.

Hotspot 2-SF-3-36 is located in the north-west corner of EA3. Based on the surface soil sample collected, 12 COECs were identified with HQs greater than 1.0 for exposure of plants or soil invertebrates. HQs range from 1.4 to 44 for plants and 1.1 to 9.8 for soil invertebrates. Overall, risk at 2-SF-3-36 is Likely for plants and Possible for soil invertebrates. Small mammals are Not at Risk at 2-SF-3-36.

Hotspot 2-SF-4-23 is located in the northern portion of EA4. Based on the surface soil sample collected, 12 COECs were identified with HQs greater than 1.0 for exposure of plants or soil invertebrates. HQs range from 1.3 to 66 for plants and 3.0 to 21 for soil invertebrates.

Overall, risk at 2-SF-4-23 is Likely for plants and Possible for soil invertebrates. Small mammals are Not at Risk at 2-SF-4-23.

These risk estimates for small mammals exposed to hotspots incorporate the fact that each of the hotspots has an area of only 1 square foot in the estimation of their AUFs. However, the small area of each hotspot is not considered in the estimates of risk to plants and soil invertebrates. Consequently, estimates of risk to plants and soil invertebrates are overly conservative in that plant and soil invertebrate communities would not be adversely affected by exposure at the hotspots.

4.3.3.5 Risk for Aquatic-Related Receptors

Four ROIs are exposed primarily to sediment in the Ironton Canal (EA1): aquatic plants, benthic invertebrates, omnivorous birds (mallard), and invertivorous birds (tree swallow). The aquatic community, which includes aquatic invertebrates, and possibly fish, is exposed primarily to surface water.

Seventeen chemicals have one or more HQs greater than 1.0 and are considered COECs for sediment in EA1. Benthic invertebrates are at risk from exposure to all COECs in sediment, and aquatic plants are at risk from three COECs. Omnivorous birds may be at risk from one PAH. No risk was shown for invertivorous birds exposed to sediment. Several COPECs do not have TRVs for plants or birds as shown with "NC" (not calculated) in Table 4-28. Overall, benthic invertebrates are at Likely Risk, plants are at Possible Risk, omnivorous birds are at Unlikely Risk, and invertivorous birds are Not at Risk from exposure to sediment in EA1.

A closer examination of the results for EA1 reveals the following: One location in EA1 (2-S-1-7) contributes the most to the potential risk of exposure from sediments to benthic invertebrates, and therefore, risk is likely overestimated for the entire EA. Although the highest HQ (HQ = 51,000) for benthic invertebrates is for anthracene, it is conservatively based on a LOEC of 1.95 µg/kg estimated as five times the screening value from LANL (2011) (Table 4-16). If the LOEC were based on the consensus PEC from MacDonald et al. (2000) (845 µg/kg), the HQ would be two orders of magnitude lower.

A total of 10 COPECs were identified for exposure of the aquatic community to surface water in the Ironton Canal (EA1). Of these, only two chemicals (benzo(a)pyrene and total cyanide) have HQs slightly higher than 1.0 and are considered to be COECs for surface water. No other surface water COPECs have HQs greater than 1.0. Overall, the aquatic community in EA1 is at Unlikely Risk from exposure to COECs in surface water.

5.0 OVERALL SUMMARY AND CONCLUSIONS

Investigation of the former Reilly Industries, Inc., coal tar refinery located in Provo, Utah began in 2000 under an approved RCRA RFI work plan. During the 12 years of investigation, soil, groundwater, surface water, and sediment samples have been collected from hundreds of locations at the Site. In 2012, UDEQ approved a risk assessment work plan following conclusion of the investigations. Vertellus conducted the HHRA and ERA per the approved work plan and UAC R315-101 as described herein.

A residential exposure scenario was not evaluated in the HHRA. Therefore, a Site Management Plan will be required for the Site and the off-site areas evaluated in the HHRA.

The HHRA determined that the CRs and HIs were less than 1E-04 and 1, respectively, for potential receptors in exposure areas at most of the Site and off-site, including EA1, EA4, EA5, EA7, EA9 and EA10. Therefore, human health risk will be managed in a Site Management Plan and Environmental Covenant without additional corrective action for these areas.

Cancer risk to all receptors in EA6 exceeded the 1E-04 threshold, and therefore, the Site Management Plan will include procedures for corrective action to mitigate the risks to human health in EA6. Appropriate corrective action determinations will be proposed in a Corrective Action Plan as specified in the 1996 Corrective Action Agreement (UDEQ, 1996) and will incorporate the criteria provided in UAC R315-101-1(b)(4). In order of importance, the criteria include:

(a) The impact or potential impact of the contamination on the human health
(b) The impact or potential impact of the contamination on the environment
(c) The technologies available for use in clean-up
(d) Economic considerations and cost-effectiveness of clean-up options

For the other areas of the Site where risk was estimated to be above unacceptable levels (i.e., CR greater than 1E-04 for human health in EA2, EA3, and the hotspots or where ecological risk may be of concern), risk is localized to only a few locations in each exposure area. For many of the constituents, the range of concentrations is very wide and distribution plots of concentrations show that elevated exposure point concentrations (95% UCLs) are often a result of a limited number of individual high detected concentrations in an EA. Consequently, the distribution of concentrations and risks across an EA are not uniform, and simulating corrective action in these limited areas through what is termed "iterative truncation" can illustrate the reduction in exposure concentrations and risk that result when the highest concentration areas are removed from the 95% UCL calculations. Vertellus suggests that the following iterative truncation process be pursued following the risk assessment:

- Step 1 – Concentrations of constituents that are posing risk are put into rank order (high-to-low).
- Step 2 – High concentrations are iteratively removed from the exposure area data set and the 95% UCL is recalculated to confirm that the number of high concentrations removed would produce a 95% UCL that meets an acceptable risk level for the exposure area.
- Step 3 – Potential areas for removal are defined and anticipated confirmation samples are collected in the field around the areas of assumed removal.
- Step 4 – Confirmation sample results are added to the 95% UCL calculation to confirm that the anticipated removal meets the acceptable risk levels for the exposure area. If the recalculated 95% UCL does not meet the acceptable risk level for the exposure area, the removal area is redefined and additional confirmation samples are collected until the 95% UCL result meets the acceptable risk level.

Iterative truncation will be used to support cost-benefit analysis of instituting corrective actions in place of, or in addition to, doing additional site-specific studies the could be used to further refine the results of the risk assessment.

The Site Management Plan, Environmental Covenant, and Corrective Action Plan(s) will be submitted upon approval of the Risk Assessment in accordance with the procedures and schedule set out in the Corrective Action Agreement (UDEQ, 1996).

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Tables

Table 3-1
Selection of COPCs
Soil
EA2, EA3, EA4, EA5, EA6, EA7, EA9, EA10, Hotspots
Vertellus - Provo, Utah

Detected Analytes	Maximum Detection (µg/kg)[1]	Maximum RL (µg/kg)[1]	Selected Maximum (µg/kg)[2]	Adjusted Regional Screening Level (Residential Soil) (µg/kg)[3]	Selected Maximum Greater than Screening Level?	Retained for Further Evaluation in the HHRA?
Exposure Area 2						
Acetone	620	5,000,000	5,000,000	6,100,000	No	No
Methyl ethyl ketone	60	2,000,000	2,000,000	2,800,000	No	No
3&4-Methylphenol	1,060,000	7,000,000	7,000,000	310,000	Yes	Yes
Acenaphthene	7,690,000	700	7,690,000	340,000	Yes	Yes
Acenaphthylene	1,880,000	7,000,000	7,000,000	340,000	Yes	Yes
Anthracene	19,800,000	3,000	19,800,000	1,700,000	Yes	Yes
Benzene	780,000	500	780,000	1,100	Yes	Yes
Benzo(a)anthracene	3,470,000	7,000,000	7,000,000	150	Yes	Yes
Benzo(a)pyrene	2,650,000	7,000,000	7,000,000	15	Yes	Yes
Benzo(b)fluoranthene	3,150,000	7,000,000	7,000,000	150	Yes	Yes
Benzo(k)fluoranthene	1,600,000	7,000,000	7,000,000	1,500	Yes	Yes
Carbon disulfide	15	200,000	200,000	82,000	Yes	Yes
Chloroform	12	200,000	200,000	290	Yes	Yes
Chrysene	4,120,000	7,000,000	7,000,000	15,000	Yes	Yes
Cyanide, Total	6,500,000	70	6,500,000	2,200	Yes	Yes
Dibenz(a,h)anthracene	1,140,000	7,000,000	7,000,000	15	Yes	Yes
Ethylbenzene	11,800	200,000	200,000	5,400	Yes	Yes
Fluoranthene	14,400,000	300	14,400,000	230,000	Yes	Yes
Fluorene	3,770,000	7,000,000	7,000,000	230,000	Yes	Yes
Indeno(1,2,3-c,d)pyrene	1,760,000	7,000,000	7,000,000	150	Yes	Yes
Methylene chloride	160	500,000	500,000	56,000	Yes	Yes
Naphthalene	58,700,000	21,000	58,700,000	3,600	Yes	Yes
Phenanthrene	21,900,000	300	21,900,000	1,700,000	Yes	Yes
Phenol	916,000	7,000,000	7,000,000	1,800,000	Yes	Yes
Pyrene	9,240,000	700	9,240,000	170,000	Yes	Yes
Toluene	1,260,000	4,000	1,260,000	500,000	Yes	Yes
Xylenes (Total)	1,500,000	21	1,500,000	63,000	Yes	Yes
Exposure Area 3						
2-Methylphenol	13,800	200,000	200,000	310,000	No	No
3&4-Methylphenol	63,600	200,000	200,000	310,000	No	No
Acetone	20,000	410,000	410,000	6,100,000	No	No
Anthracene	980,000	200,000	980,000	1,700,000	No	No
Benzo(g,h,i)perylene	110,000	-	110,000	170,000	No	No
bis(2-Ethylhexyl)phthalate	1,600	-	1,600	35,000	No	No
Carbon disulfide	1,000	82,000	82,000	82,000	No	No
m,p-Xylene	1,400	16	1,400	59,000	No	No
Methyl ethyl ketone	10,000	410,000	410,000	2,800,000	No	No
o-Xylene	930	-	930	69,000	No	No
Phenol	92,500	200,000	200,000	1,800,000	No	No
Toluene	188,000	27,000	188,000	500,000	No	No
2,4-Dimethylphenol	37,100	200,000	200,000	120,000	Yes	Yes
2-Methylnaphthalene	330,000	-	330,000	23,000	Yes	Yes
Acenaphthene	2,180,000	30,000	2,180,000	340,000	Yes	Yes
Acenaphthylene	564,000	200,000	564,000	340,000	Yes	Yes
Benzene	127,000	27,000	127,000	1,100	Yes	Yes
Benzenethiol	15,000	2,000,000	2,000,000	7,800	Yes	Yes
Benzo(a)anthracene	1,090,000	20,000	1,090,000	150	Yes	Yes
Benzo(a)pyrene	1,500,000	10,000	1,500,000	15	Yes	Yes
Benzo(b)fluoranthene	1,380,000	20,000	1,380,000	150	Yes	Yes

Table 3-1
Selection of COPCs
Soil
EA2, EA3, EA4, EA5, EA6, EA7, EA9, EA10, Hotspots
Vertellus - Provo, Utah

Detected Analytes	Maximum Detection (µg/kg)[1]	Maximum RL (µg/kg)[1]	Selected Maximum (µg/kg)[2]	Adjusted Regional Screening Level (Residential Soil) (µg/kg)[3]	Selected Maximum Greater than Screening Level?	Retained for Further Evaluation in the HHRA?
Benzo(k)fluoranthene	584,000	20,000	584,000	1,500	Yes	Yes
Carbazole	17,000	-	17,000	NV	NA	Yes[4]
Chloroform	1,000	41,000	41,000	290	Yes	Yes
Chrysene	1,350,000	10,000	1,350,000	15,000	Yes	Yes
Cyanide, Total	45,000	70	45,000	2,200	Yes	Yes
Dibenz(a,h)anthracene	285,000	200,000	285,000	15	Yes	Yes
Dibenzofuran	290,000	-	290,000	7,800	Yes	Yes
Ethylbenzene	24,800	27,000	27,000	5,400	Yes	Yes
Fluoranthene	2,690,000	310	2,690,000	230,000	Yes	Yes
Fluorene	1,380,000	200,000	1,380,000	230,000	Yes	Yes
Indeno(1,2,3-c,d)pyrene	1,030,000	190,000	1,030,000	150	Yes	Yes
Methylene bromide	1,000	41,000	41,000	730	Yes	Yes
Methylene chloride	14,000	82,000	82,000	56,000	Yes	Yes
Naphthalene	5,980,000	200,000	5,980,000	3,600	Yes	Yes
Phenanthrene	4,410,000	20,000	4,410,000	1,700,000	Yes	Yes
Pyrene	2,210,000	310	2,210,000	170,000	Yes	Yes
Resorcinol	15,000	2,000,000	2,000,000	122,200	Yes	Yes
Xylenes (Total)	182,000	81,000	182,000	63,000	Yes	Yes
Exposure Area 4						
2,4-Dimethylphenol	110,000	92,000	110,000	120,000	No	No
2-Methylphenol	150,000	92,000	150,000	310,000	No	No
Acenaphthylene	169,000	53,000	169,000	340,000	No	No
Acetone	792	88,000	88,000	6,100,000	No	No
Anthracene	790,000	20,000	790,000	1,700,000	No	No
Carbon disulfide	940	18,000	18,000	82,000	No	No
Ethylbenzene	2,620	1,600	2,620	5,400	No	No
m,p-Xylene	3,900	-	3,900	59,000	No	No
Methyl ethyl ketone	21	88,000	88,000	2,800,000	No	No
Methylene chloride	250	18,000	18,000	56,000	No	No
o-Xylene	2,000	-	2,000	69,000	No	No
Phenanthrene	1,300,000	20,000	1,300,000	1,700,000	No	No
Phenol	820,000	92,000	820,000	1,800,000	No	No
Toluene	22,500	8,800	22,500	500,000	No	No
Xylenes (Total)	38,000	26,000	38,000	63,000	No	No
2-Methylnaphthalene	1,400,000	10,000	1,400,000	23,000	Yes	Yes
3&4-Methylphenol	470,000	92,000	470,000	310,000	Yes	Yes
Acenaphthene	2,200,000	20,000	2,200,000	340,000	Yes	Yes
Benzene	11,500	1,600	11,500	1,100	Yes	Yes
Benzo(a)anthracene	3,700,000	20,000	3,700,000	150	Yes	Yes
Benzo(a)pyrene	190,000	30,000	190,000	15	Yes	Yes
Benzo(b)fluoranthene	190,000	30,000	190,000	150	Yes	Yes
Benzo(k)fluoranthene	84,000	30,000	84,000	1,500	Yes	Yes
Chrysene	3,700,000	20,000	3,700,000	15,000	Yes	Yes
Cyanide, Total	90,000	60	90,000	2,200	Yes	Yes
Dibenz(a,h)anthracene	35,000	53,000	53,000	15	Yes	Yes
Dibenzofuran	1,000,000	10,000	1,000,000	7,800	Yes	Yes
Fluoranthene	2,200,000	20,000	2,200,000	230,000	Yes	Yes
Fluorene	1,400,000	20,000	1,400,000	230,000	Yes	Yes
Indeno(1,2,3-c,d)pyrene	130,000	53,000	130,000	150	Yes	Yes
Naphthalene	6,500,000	20,000	6,500,000	3,600	Yes	Yes

Table 3-1
Selection of COPCs
Soil
EA2, EA3, EA4, EA5, EA6, EA7, EA9, EA10, Hotspots
Vertellus - Provo, Utah

Detected Analytes	Maximum Detection (µg/kg)[1]	Maximum RL (µg/kg)[1]	Selected Maximum (µg/kg)[2]	Adjusted Regional Screening Level (Residential Soil) (µg/kg)[3]	Selected Maximum Greater than Screening Level?	Retained for Further Evaluation in the HHRA?
Pyrene	1,900,000	20,000	1,900,000	170,000	Yes	Yes
Resorcinol	2,160	680,000	680,000	122,200	Yes	Yes
Exposure Area 5						
2,4-Dimethylphenol	92,300	2,000	92,300	120,000	No	No
2-Methylnaphthalene	1,200	-	1,200	23,000	No	No
2-Methylphenol	98,500	2,000	98,500	310,000	No	No
Acenaphthylene	162,000	270	162,000	340,000	No	No
Acetone	330	4,100	4,100	6,100,000	No	No
Anthracene	1,300,000	240	1,300,000	1,700,000	No	No
Benzene	270	410	410	1,100	No	No
Carbon disulfide	239	13	239	82,000	No	No
Cyanide, Total	310	-	310	2,200	No	No
Dibenzofuran	530	-	530	7,800	No	No
Ethylbenzene	590	7	590	5,400	No	No
m,p-Xylene	640	-	640	59,000	No	No
Methyl ethyl ketone	2,980	58	2,980	2,800,000	No	No
Methylene chloride	58	820	820	56,000	No	No
o-Xylene	410	-	410	69,000	No	No
Phenol	495,000	270	495,000	1,800,000	No	No
Toluene	700	410	700	500,000	No	No
Xylenes (Total)	1,070	20	1,070	63,000	No	No
3&4-Methylphenol	443,000	2,000	443,000	310,000	Yes	Yes
Acenaphthene	1,960,000	240	1,960,000	340,000	Yes	Yes
Benzo(a)anthracene	747,000	240	747,000	150	Yes	Yes
Benzo(a)pyrene	374,000	240	374,000	15	Yes	Yes
Benzo(b)fluoranthene	465,000	240	465,000	150	Yes	Yes
Benzo(k)fluoranthene	167,000	240	167,000	1,500	Yes	Yes
Chrysene	844,000	240	844,000	15,000	Yes	Yes
Dibenz(a,h)anthracene	1,370	80,000	80,000	15	Yes	Yes
Fluoranthene	4,170,000	240	4,170,000	230,000	Yes	Yes
Fluorene	1,860,000	240	1,860,000	230,000	Yes	Yes
Indeno(1,2,3-c,d)pyrene	161,000	2,000	161,000	150	Yes	Yes
Naphthalene	1,470,000	240	1,470,000	3,600	Yes	Yes
Phenanthrene	7,810,000	240	7,810,000	1,700,000	Yes	Yes
Pyrene	4,470,000	240	4,470,000	170,000	Yes	Yes
Exposure Area 6						
2,4-Dimethylphenol	4,200	-	4,200	120,000	No	No
2-Methylphenol	4,100	-	4,100	310,000	No	No
3&4-Methylphenol	11,000	-	11,000	310,000	No	No
Acenaphthylene	140,000	-	140,000	340,000	No	No
Anthracene	860,000	-	860,000	1,700,000	No	No
Phenol	6,700	-	6,700	1,800,000	No	No
2-Methylnaphthalene	82,000	-	82,000	23,000	Yes	Yes
Acenaphthene	550,000	-	550,000	340,000	Yes	Yes
Benzo(a)anthracene	2,400,000	-	2,400,000	150	Yes	Yes
Benzo(a)pyrene	2,200,000	-	2,200,000	15	Yes	Yes
Benzo(b)fluoranthene	2,500,000	-	2,500,000	150	Yes	Yes
Benzo(g,h,i)perylene	1,100,000	-	1,100,000	170,000	Yes	Yes
Benzo(k)fluoranthene	1,000,000	-	1,000,000	1,500	Yes	Yes
Carbazole	650,000	-	650,000	NV	NA	Yes[4]

Table 3-1
Selection of COPCs
Soil
EA2, EA3, EA4, EA5, EA6, EA7, EA9, EA10, Hotspots
Vertellus - Provo, Utah

Detected Analytes	Maximum Detection (µg/kg)[1]	Maximum RL (µg/kg)[1]	Selected Maximum (µg/kg)[2]	Adjusted Regional Screening Level (Residential Soil) (µg/kg)[3]	Selected Maximum Greater than Screening Level?	Retained for Further Evaluation in the HHRA?
Chrysene	2,500,000	-	2,500,000	15,000	Yes	Yes
Dibenz(a,h)anthracene	370,000	-	370,000	15	Yes	Yes
Dibenzofuran	200,000	-	200,000	7,800	Yes	Yes
Fluoranthene	5,300,000	-	5,300,000	230,000	Yes	Yes
Fluorene	470,000	-	470,000	230,000	Yes	Yes
Indeno(1,2,3-c,d)pyrene	1,100,000	-	1,100,000	150	Yes	Yes
Naphthalene	450,000	-	450,000	3,600	Yes	Yes
Phenanthrene	4,400,000	-	4,400,000	1,700,000	Yes	Yes
Pyrene	4,800,000	-	4,800,000	170,000	Yes	Yes
Exposure Area 7						
2-Methylnaphthalene	2,700	17	2,700	23,000	No	No
2-Methylphenol	75	530	530	310,000	No	No
3&4-Methylphenol	120	530	530	310,000	No	No
Acenaphthene	30,000	280	30,000	340,000	No	No
Acenaphthylene	5,000	280	5,000	340,000	No	No
Acetone	447	80	447	6,100,000	No	No
Anthracene	38,000	280	38,000	1,700,000	No	No
Benzene	14	8	14	1,100	No	No
Benzo(g,h,i)perylene	8,000	17	8,000	170,000	No	No
Carbon disulfide	4	16	16	82,000	No	No
Cyanide, Total	73	-	73	2,200	No	No
Dibenzofuran	900	330	900	7,800	No	No
Ethylbenzene	8	8	8	5,400	No	No
Fluoranthene	54,000	280	54,000	230,000	No	No
Fluorene	25,000	280	25,000	230,000	No	No
Methyl ethyl ketone	107	80	107	2,800,000	No	No
Methylene chloride	4	16	16	56,000	No	No
Phenanthrene	27,000	280	27,000	1,700,000	No	No
Phenol	264	530	530	1,800,000	No	No
Pyrene	60,000	280	60,000	170,000	No	No
Toluene	1	8	8	500,000	No	No
Benzo(a)anthracene	22,000	280	22,000	150	Yes	Yes
Benzo(a)pyrene	19,000	280	19,000	15	Yes	Yes
Benzo(b)fluoranthene	19,000	280	19,000	150	Yes	Yes
Benzo(k)fluoranthene	7,300	280	7,300	1,500	Yes	Yes
Carbazole	1,500	330	1,500	NV	NA	Yes[4]
Chrysene	22,000	280	22,000	15,000	Yes	Yes
Dibenz(a,h)anthracene	2,700	280	2,700	15	Yes	Yes
Indeno(1,2,3-c,d)pyrene	9,300	280	9,300	150	Yes	Yes
Naphthalene	24,000	250	24,000	3,600	Yes	Yes
Exposure Area 9						
2-Methylnaphthalene	220	-	220	23,000	No	No
Acenaphthene	200	220	220	340,000	No	No
Acenaphthylene	420	220	420	340,000	No	No
Acetone	34	54	54	6,100,000	No	No
Anthracene	860	220	860	1,700,000	No	No
Benzene	30	6	30	1,100	No	No
Chrysene	4,400	220	4,400	15,000	No	No
Dibenzofuran	210	-	210	7,800	No	No
Ethylbenzene	4	6	6	5,400	No	No

Table 3-1
Selection of COPCs
Soil
EA2, EA3, EA4, EA5, EA6, EA7, EA9, EA10, Hotspots
Vertellus - Provo, Utah

Detected Analytes	Maximum Detection (µg/kg)[1]	Maximum RL (µg/kg)[1]	Selected Maximum (µg/kg)[2]	Adjusted Regional Screening Level (Residential Soil) (µg/kg)[3]	Selected Maximum Greater than Screening Level?	Retained for Further Evaluation in the HHRA?
Fluoranthene	5,700	190	5,700	230,000	No	No
Fluorene	210	220	220	230,000	No	No
m,p-Xylene	1	-	1	59,000	No	No
Methyl ethyl ketone	9	64	64	2,800,000	No	No
Methylene chloride	15	13	15	56,000	No	No
Naphthalene	1,000	190	1,000	3,600	No	No
Phenanthrene	2,800	220	2,800	1,700,000	No	No
Pyrene	6,000	190	6,000	170,000	No	No
Toluene	14	6	14	500,000	No	No
Xylenes (Total)	16	19	19	63,000	No	No
Benzo(a)anthracene	3,400	220	3,400	150	Yes	Yes
Benzo(a)pyrene	4,100	220	4,100	15	Yes	Yes
Benzo(b)fluoranthene	4,700	220	4,700	150	Yes	Yes
Benzo(k)fluoranthene	1,600	220	1,600	1,500	Yes	Yes
Dibenz(a,h)anthracene	730	220	730	15	Yes	Yes
Indeno(1,2,3-c,d)pyrene	2,800	220	2,800	150	Yes	Yes
Exposure Area 10						
2,4-Dimethylphenol	1,520	250	1,520	120,000	No	No
2-Methylphenol	1,520	250	1,520	310,000	No	No
3&4-Methylphenol	100	250	250	310,000	No	No
Acenaphthene	137	250	250	340,000	No	No
Acetone	25	75	75	6,100,000	No	No
Benzene	3	8	8	1,100	No	No
Carbon disulfide	8	15	15	82,000	No	No
Ethylbenzene	9	8	9	5,400	No	No
Methylene chloride	3	15	15	56,000	No	No
Naphthalene	529	250	529	3,600	No	No
Toluene	6	8	8	500,000	No	No
Xylenes (Total)	20	23	23	63,000	No	No
Hotspot 2-SF-2-18						
2-Methylnaphthalene	780	-	780	23,000	No	No
Acenaphthene	2,000	-	2,000	340,000	No	No
Acenaphthylene	3,000	-	3,000	340,000	No	No
Anthracene	6,300	-	6,300	1,700,000	No	No
Benzo(g,h,i)perylene	15,000	-	15,000	170,000	No	No
bis(2-Ethylhexyl)phthalate	930	-	930	35,000	No	No
Dibenzofuran	1,900	-	1,900	7,800	No	No
Fluoranthene	41,000	-	41,000	230,000	No	No
Fluorene	3,200	-	3,200	230,000	No	No
Naphthalene	1,400	-	1,400	3,600	No	No
Phenanthrene	28,000	-	28,000	1,700,000	No	No
Pyrene	39,000	-	39,000	170,000	No	No
Benzo(a)anthracene	22,000	-	22,000	150	Yes	Yes
Benzo(a)pyrene	26,000	-	26,000	15	Yes	Yes
Benzo(b)fluoranthene	28,000	-	28,000	150	Yes	Yes
Benzo(k)fluoranthene	13,000	-	13,000	1,500	Yes	Yes
Carbazole	2,600	-	2,600	NV	NA	Yes(4)
Chrysene	26,000	-	26,000	15,000	Yes	Yes
Dibenz(a,h)anthracene	4,900	-	4,900	15	Yes	Yes
Indeno(1,2,3-c,d)pyrene	15,000	-	15,000	150	Yes	Yes

Table 3-1
Selection of COPCs
Soil
EA2, EA3, EA4, EA5, EA6, EA7, EA9, EA10, Hotspots
Vertellus - Provo, Utah

Detected Analytes	Maximum Detection (µg/kg)[1]	Maximum RL (µg/kg)[1]	Selected Maximum (µg/kg)[2]	Adjusted Regional Screening Level (Residential Soil) (µg/kg)[3]	Selected Maximum Greater than Screening Level?	Retained for Further Evaluation in the HHRA?
Hotspot 2-SF-2-19						
2,4-Dimethylphenol	350	-	350	120,000	No	No
2-Methylnaphthalene	15,000	-	15,000	23,000	No	No
2-Methylphenol	330	-	330	310,000	No	No
3&4-Methylphenol	1,200	-	1,200	310,000	No	No
Acenaphthene	43,000	-	43,000	340,000	No	No
Acenaphthylene	8,600	-	8,600	340,000	No	No
Anthracene	73,000	-	73,000	1,700,000	No	No
Benzo(g,h,i)perylene	48,000	-	48,000	170,000	No	No
Fluoranthene	220,000	-	220,000	230,000	No	No
Fluorene	35,000	-	35,000	230,000	No	No
Phenanthrene	200,000	-	200,000	1,700,000	No	No
Phenol	1,200	-	1,200	1,800,000	No	No
Benzo(a)anthracene	89,000	-	89,000	150	Yes	Yes
Benzo(a)pyrene	80,000	-	80,000	15	Yes	Yes
Benzo(b)fluoranthene	100,000	-	100,000	150	Yes	Yes
Benzo(k)fluoranthene	43,000	-	43,000	1,500	Yes	Yes
Carbazole	30,000	-	30,000	NV	NA	Yes(4)
Chrysene	100,000	-	100,000	15,000	Yes	Yes
Dibenz(a,h)anthracene	15,000	-	15,000	15	Yes	Yes
Dibenzofuran	20,000	-	20,000	7,800	Yes	Yes
Indeno(1,2,3-c,d)pyrene	45,000	-	45,000	150	Yes	Yes
Naphthalene	44,000	-	44,000	3,600	Yes	Yes
Pyrene	190,000	-	190,000	170,000	Yes	Yes
Hotspot 2-SF-3-36						
2,4-Dimethylphenol	1,900	-	1,900	120,000	No	No
2-Methylphenol	2,400	-	2,400	310,000	No	No
3&4-Methylphenol	8,500	-	8,500	310,000	No	No
Acenaphthene	10,000	-	10,000	340,000	No	No
Acenaphthylene	63,000	-	63,000	340,000	No	No
Anthracene	59,000	-	59,000	1,700,000	No	No
Benzo(g,h,i)perylene	35,000	-	35,000	170,000	No	No
Fluoranthene	210,000	-	210,000	230,000	No	No
Fluorene	72,000	-	72,000	230,000	No	No
Phenanthrene	270,000	-	270,000	1,700,000	No	No
Phenol	10,000	-	10,000	1,800,000	No	No
Pyrene	160,000	-	160,000	170,000	No	No
2-Methylnaphthalene	49,000	-	49,000	23,000	Yes	Yes
Benzo(a)anthracene	79,000	-	79,000	150	Yes	Yes
Benzo(a)pyrene	63,000	-	63,000	15	Yes	Yes
Benzo(b)fluoranthene	73,000	-	73,000	150	Yes	Yes
Benzo(k)fluoranthene	27,000	-	27,000	1,500	Yes	Yes
Carbazole	30,000	-	30,000	NV	NA	Yes(4)
Chrysene	80,000	-	80,000	15,000	Yes	Yes
Dibenz(a,h)anthracene	12,000	-	12,000	15	Yes	Yes
Dibenzofuran	45,000	-	45,000	7,800	Yes	Yes
Indeno(1,2,3-c,d)pyrene	39,000	-	39,000	150	Yes	Yes
Naphthalene	220,000	-	220,000	3,600	Yes	Yes
Hotspot 2-SF-4-23						
2,4-Dimethylphenol	640	-	640	120,000	No	No

Table 3-1
Selection of COPCs
Soil
EA2, EA3, EA4, EA5, EA6, EA7, EA9, EA10, Hotspots
Vertellus - Provo, Utah

Detected Analytes	Maximum Detection (µg/kg)[1]	Maximum RL (µg/kg)[1]	Selected Maximum (µg/kg)[2]	Adjusted Regional Screening Level (Residential Soil) (µg/kg)[3]	Selected Maximum Greater than Screening Level?	Retained for Further Evaluation in the HHRA?
2-Methylnaphthalene	23,000	-	23,000	23,000	No	No
2-Methylphenol	460	-	460	310,000	No	No
3&4-Methylphenol	1,500	-	1,500	310,000	No	No
Acenaphthene	82,000	-	82,000	340,000	No	No
Acenaphthylene	17,000	-	17,000	340,000	No	No
Anthracene	130,000	-	130,000	1,700,000	No	No
Benzo(g,h,i)perylene	100,000	-	100,000	170,000	No	No
Fluorene	56,000	-	56,000	230,000	No	No
Phenanthrene	310,000	-	310,000	1,700,000	No	No
Phenol	1,600	-	1,600	1,800,000	No	No
Benzo(a)anthracene	250,000	-	250,000	150	Yes	Yes
Benzo(a)pyrene	200,000	-	200,000	15	Yes	Yes
Benzo(b)fluoranthene	310,000	-	310,000	150	Yes	Yes
Benzo(k)fluoranthene	100,000	-	100,000	1,500	Yes	Yes
Carbazole	24,000	-	24,000	NV	NA	Yes(4)
Chrysene	310,000	-	310,000	15,000	Yes	Yes
Dibenz(a,h)anthracene	39,000	-	39,000	15	Yes	Yes
Dibenzofuran	40,000	-	40,000	7,800	Yes	Yes
Fluoranthene	580,000	-	580,000	230,000	Yes	Yes
Indeno(1,2,3-c,d)pyrene	110,000	-	110,000	150	Yes	Yes
Naphthalene	81,000	-	81,000	3,600	Yes	Yes
Pyrene	470,000	-	470,000	170,000	Yes	Yes

Notes:

[1] Results are for soil at depths of 0-1 foot (EA6, Hotspot 2-SF-2-18, Hotspot 2-SF-2-19, Hotspot 2-SF-3-36, and Hotspot 2-SF-4-23), 1-10 feet (EA2, EA4, EA5, EA9, and EA10), and 0-10 feet (EA3 and EA7).

[2] The selected maximum is the higher of the maximum detection and maximum RL.

[3] The screening level is the lower of the RSLs for non-cancer and cancer effects (USEPA 2012). Screening levels based on non-cancer effects were adjusted by multiplying the RSL by 0.1.

[4] Carbozole was not evaluated in the quantitative HHRA, because no toxicity values were identified.

Bolded analytes indicated COPCs

- = Since no RL is provided for detected results, no maximum RL is provided where all results are detects (or where no RL was reported).

HHRA = Human Health Risk Assessment

NA= Not applicable

NV = The chemical does not have a screening level

RL = reporting limit

RSL = Regional screening level

µg/kg = micrograms per kilogram

Source:

U.S. Environmental Protection Agency (USEPA). 2012. USEPA Master Regional Screening Level (RSL) Table. November.

Table 3-2
Selection of COPCs
Direct Contact with Groundwater
EA5, EA8, and EA10
Vertellus - Provo, Utah

Detected Analytes	Maximum Detection (µg/L)	Maximum RL (µg/L)	Selected Maximum (µg/L)[1]	Adjusted Regional Screening Level (Tap Water) (µg/L)[2]	Selected Maximum Greater than Screening Level?	Retained for Further Evaluation in the HHRA?
Exposure Area 5						
Acetone	106	200	200	1,200	No	No
Fluoranthene	13	--	13	63	No	No
Methyl ethyl ketone	8	100	100	490	No	No
Styrene	3	50	50	110	No	No
Toluene	20	7	20	86	No	No
2,4-Dimethylphenol	1,900	--	1,900	27	Yes	Yes
2-Methylnaphthalene	520	--	520	2.7	Yes	Yes
2-Methylphenol	1,500	--	1,500	72	Yes	Yes
3&4-Methylphenol	13,000	--	13,000	72	Yes	Yes
Acenaphthene	610	--	610	40	Yes	Yes
Acenaphthylene	65	19	65	40	Yes	Yes
Anthracene	170	--	170	130	Yes	Yes
Benzene	57	5	57	0.39	Yes	Yes
Benzo(a)anthracene	0.98	19	19	0.029	Yes	Yes
Benzo(a)pyrene	0.19	19	19	0.0029	Yes	Yes
Benzo(b)fluoranthene	0.35	19	19	0.029	Yes	Yes
Benzo(k)fluoranthene	0.017	19	19	0 29	Yes	Yes
Carbazole	380	--	380	NV	NA	Yes[3]
Chrysene	0 64	19	19	2 9	Yes	Yes
Cyanide, Total	380	--	380	0.14	Yes	Yes
Dibenz(a,h)anthracene	0.011	19	19	0.0029	Yes	Yes
Dibenzofuran	230	--	230	0.58	Yes	Yes
Ethylbenzene	6	50	50	1.3	Yes	Yes
Fluorene	210	--	210	22	Yes	Yes
Naphthalene	7,800	--	7,800	0.14	Yes	Yes
Phenanthrene	210	--	210	130	Yes	Yes
Phenol	26,000	--	26,000	450	Yes	Yes
Pyrene	13	--	13	8.7	Yes	Yes
Xylenes (Total)	34 7	50	50	19	Yes	Yes
Exposure Area 8						
Styrene	95	25	95	110	No	No
2,4-Dimethylphenol	14,600	6.3	14,600	27	Yes	Yes
2-Chlorophenol	5	10	10	7.1	Yes	Yes
2-Methylnaphthalene	840	0.5	840	2 7	Yes	Yes
2-Methylphenol	29,000	6 3	29,000	72	Yes	Yes
3&4-Methylphenol	96,000	10	96,000	72	Yes	Yes
Acenaphthene	491	5	491	40	Yes	Yes

Table 3-2
Selection of COPCs
Direct Contact with Groundwater
EA5, EA8, and EA10
Vertellus - Provo, Utah

Detected Analytes	Maximum Detection (µg/L)	Maximum RL (µg/L)	Selected Maximum (µg/L)[1]	Adjusted Regional Screening Level (Tap Water) (µg/L)[2]	Selected Maximum Greater than Screening Level?	Retained for Further Evaluation in the HHRA?
Acenaphthylene	76	6.3	76	40	Yes	Yes
Acetone	275	2,500	2,500	1,200	Yes	Yes
Anthracene	270	190	270	130	Yes	Yes
Benzene	6,950	5	6,950	0.39	Yes	Yes
Benzenethiol	120	400	400	1.3	Yes	Yes
Benzo(a)anthracene	230	190	230	0.029	Yes	Yes
Benzo(a)pyrene	160	190	190	0.0029	Yes	Yes
Benzo(b)fluoranthene	230	190	230	0.029	Yes	Yes
Benzo(g,h,i)perylene	67	2.4	67	8.7	Yes	Yes
Benzo(k)fiuoranthene	90	190	190	0.29	Yes	Yes
Carbazole	330	1	330	NV	NA	Yes[3]
Carbon disulfide	7	100	100	72	Yes	Yes
Chrysene	290	190	290	2 9	Yes	Yes
Cyanide, Total	880	10	880	0.14	Yes	Yes
Dibenz(a,h)anthracene	21	190	190	0.0029	Yes	Yes
Dibenzofuran	290	10	290	0.58	Yes	Yes
Ethylbenzene	530	5	530	1.3	Yes	Yes
Fluoranthene	820	190	820	63	Yes	Yes
Fluorene	190	190	190	22	Yes	Yes
Indeno(1,2,3-c,d)pyrene	69	190	190	0.029	Yes	Yes
Methyl ethyl ketone	28.4	500	500	490	Yes	Yes
Methylene chloride	6.8	250	250	9.9	Yes	Yes
Naphthalene	13,000	6.3	13,000	0.14	Yes	Yes
Phenanthrene	180	190	190	130	Yes	Yes
Phenol	200,000	9	200,000	450	Yes	Yes
Pyrene	690	190	690	8.7	Yes	Yes
Toluene	3,600	5	3,600	86	Yes	Yes
Xylenes (Total)	1,620	6	1,620	19	Yes	Yes
Exposure Area 10						
Acenaphthylene	4.1	4 8	4.8	40	No	No
Acetone	7.8	60	60	1,200	No	No
Anthracene	2.1	4.8	4.8	130	No	No
Carbon disulfide	14	10	14	72	No	No
Fluoranthene	1.6	4.8	4.8	63	No	No
Phenanthrene	22 6	4.8	22.6	130	No	No
Pyrene	1.1	4.8	4.8	8.7	No	No
Styrene	1	10	10	110	No	No
2,4-Dimethylphenol	4,800	5	4,800	27	Yes	Yes

Table 3-2
Selection of COPCs
Direct Contact with Groundwater
EA5, EA8, and EA10
Vertellus - Provo, Utah

Detected Analytes	Maximum Detection (µg/L)	Maximum RL (µg/L)	Selected Maximum (µg/L)[1]	Adjusted Regional Screening Level (Tap Water) (µg/L)[2]	Selected Maximum Greater than Screening Level?	Retained for Further Evaluation in the HHRA?
2-Methylnaphthalene	68	--	68	2.7	Yes	Yes
2-Methylphenol	1,550	5	1,550	72	Yes	Yes
3&4-Methylphenol	1,660	5	1,660	72	Yes	Yes
Acenaphthene	120	--	120	40	Yes	Yes
Benzene	95.3	2	95.3	0 39	Yes	Yes
Benzenethiol	7	100	100	1.3	Yes	Yes
Benzo(a)anthracene	0.035	4.8	4.8	0.029	Yes	Yes
Benzo(a)pyrene	0.015	4.8	4.8	0.0029	Yes	Yes
Benzo(b)fluoranthene	0.018	4.8	4.8	0 029	Yes	Yes
Benzo(k)fluoranthene	0.011	4.8	4.8	0.29	Yes	Yes
Carbazole	30	--	30	NV	NA	Yes[3]
Chrysene	0.032	4.8	4.8	2 9	Yes	Yes
Cyanide, Total	85	--	85	0.14	Yes	Yes
Dibenzofuran	24	--	24	0 58	Yes	Yes
Ethylbenzene	70.1	2	70.1	1.3	Yes	Yes
Fluorene	23	4 8	23	22	Yes	Yes
Naphthalene	2,200	--	2,200	0.14	Yes	Yes
Phenol	480	50	480	450	Yes	Yes
Toluene	111	2	111	86	Yes	Yes
Xylenes (Total)	130	6	130	19	Yes	Yes

Notes:

[1] The selected maximum is the higher of the maximum detection and maximum RL.

[2] The screening level is the lower of the RSLs for non-cancer and cancer effects (USEPA 2012). Screening levels based on non-cancer effects were adjusted by multiplying the RSL by 0.1.

[3] Carbozole was not evaluated in the quantitative HHRA, because no toxicity values were identified.

Bolded analytes indicate COPCs.

- = Since no RL was reported for detected results, no maximum RL is provided where all results are detects (or where no RL was reported)

HHRA = Human Health Risk Assessment

NA= Not applicable

NV = The chemical does not have a screening level

RL = reporting limit

RSL = Regional screening level

µg/L = micrograms per liter

Source:

U.S Environmental Protection Agency (USEPA). 2012. USEPA Master Regional Screening Level (RSL) Table. November.

Table 3-3
Selection of COPCs
Vapor Intrusion from Groundwater to Indoor Air
EA5 and EA8
Vertellus - Provo, Utah

Detected Analytes	Maximum Detection (µg/L)	Maximum RL (µg/L)	Selected Maximum (µg/L)[1]	Vapor Intrusion Screening Level (µg/L)[2]	Selected Maximum Greater than Screening Level?	Retained for Further Evaluation in the HHRA?
Exposure Area 5						
2,4-Dimethylphenol	1,900	--	1,900	Not a VI COPC	NA	No
2-Methylphenol	1,500	--	1,500	Not a VI COPC	NA	No
3&4-Methylphenol	13,000	--	13,000	Not a VI COPC	NA	No
Acetone	106	200	200	2 26E+07	No	No
Benzo(a)anthracene	1	19	19	Not a VI COPC	NA	No
Benzo(a)pyrene	0	19	19	Not a VI COPC	NA	No
Benzo(b)fluoranthene	0	19	19	Not a VI COPC	NA	No
Benzo(k)fluoranthene	0	19	19	Not a VI COPC	NA	No
Carbazole	380	--	380	Not a VI COPC	NA	No
Chrysene	1	19	19	Not a VI COPC	NA	No
Cyanide, Total	380	--	380	Not a VI COPC	NA	No
Dibenz(a,h)anthracene	0	19	19	Not a VI COPC	NA	No
Fluoranthene	13	--	13	Not a VI COPC	NA	No
Methyl ethyl ketone	8	100	100	2 24E+06	No	No
Phenol	26,000	--	26,000	Not a VI COPC	NA	No
Styrene	3	50	50	9 28E+03	No	No
Toluene	20	7	20	1.92E+04	No	No
Xylenes (Total)	35	50	50	4 93E+02	No	No
2-Methylnaphthalene	520	--	520	NV	NA	Yes[3]
Acenaphthene	610	--	610	NV	NA	Yes[3]
Acenaphthylene	65	19	65	NV	NA	Yes[3]
Anthracene	170	--	170	NV	NA	Yes[3]
Benzene	57	5	57	1 38E+00	Yes	Yes
Dibenzofuran	230	--	230	NV	NA	Yes[3]
Ethylbenzene	6	50	50	3 02E+00	Yes	Yes
Fluorene	210	--	210	NV	NA	Yes[3]
Naphthalene	7,800	--	7,800	3 98E+00	Yes	Yes
Phenanthrene	210	--	210	NV	NA	Yes[3]
Pyrene	13	--	13	NV	NA	Yes[3]
Exposure Area 8						
2,4-Dimethylphenol	14,600	6	14,600	Not a VI COPC	NA	No
2-Methylphenol	29,000	6	29,000	Not a VI COPC	NA	No
3&4-Methylphenol	96,000	10	96,000	Not a VI COPC	NA	No
Acetone	275	2,500	2,500	2 26E+07	No	No
Benzo(a)anthracene	230	190	230	Not a VI COPC	NA	No
Benzo(a)pyrene	160	190	190	Not a VI COPC	NA	No
Benzo(b)fluoranthene	230	190	230	Not a VI COPC	NA	No
Benzo(k)fluoranthene	90	190	190	Not a VI COPC	NA	No
Carbazole	330	1	330	Not a VI COPC	NA	No
Carbon disulfide	7	100	100	1 24E+03	No	No
Chrysene	290	190	290	Not a VI COPC	NA	No

Table 3-3
Selection of COPCs
Vapor Intrusion from Groundwater to Indoor Air
EA5 and EA8
Vertellus - Provo, Utah

Detected Analytes	Maximum Detection (µg/L)	Maximum RL (µg/L)	Selected Maximum (µg/L)[1]	Vapor Intrusion Screening Level (µg/L)[2]	Selected Maximum Greater than Screening Level?	Retained for Further Evaluation in the HHRA?
Cyanide, Total	880	10	880	Not a VI COPC	NA	No
Dibenz(a,h)anthracene	21	190	190	Not a VI COPC	NA	No
Fluoranthene	820	190	820	Not a VI COPC	NA	No
Indeno(1,2,3-c,d)pyrene	69	190	190	Not a VI COPC	NA	No
Methyl ethyl ketone	28	500	500	2 24E+06	No	No
Methylene chloride	7	250	250	7 23E+02	No	No
Phenol	200,000	9	200,000	Not a VI COPC	NA	No
Styrene	95	25	95	9 28E+03	No	No
Toluene	3,600	5	3,600	1.92E+04	No	No
2-Chlorophenol	5	10	10	NV	NA	Yes[3]
2-Methylnaphthalene	840	1	840	NV	NA	Yes[3]
Acenaphthene	491	5	491	NV	NA	Yes[3]
Acenaphthylene	76	6	76	NV	NA	Yes[3]
Anthracene	270	190	270	NV	NA	Yes[3]
Benzene	6,950	5	6,950	1 38E+00	Yes	Yes
Benzenethiol	120	400	400	NV	NA	Yes[3]
Benzo(g,h,i)perylene	67	2	67	NV	NA	Yes[3]
Dibenzofuran	290	10	290	NV	NA	Yes[3]
Ethylbenzene	530	5	530	3 02E+00	Yes	Yes
Fluorene	190	190	190	NV	NA	Yes[3]
Naphthalene	13,000	6	13,000	3 98E+00	Yes	Yes
Phenanthrene	180	190	190	NV	NA	Yes[3]
Pyrene	690	190	690	NV	NA	Yes[3]
Xylenes (Total)	1,620	6	1,620	4 93E+02	Yes	Yes

Notes:

[1] The selected maximum is the higher of the maximum detection and maximum RL

[2] The screening level is the lower of the VISL Target Groundwater Concentrations for non-cancer and cancer effects (USEPA 2012)

[3] COPC will not be evaluated quantitatively in the HHRA because there is no inhalation toxicity value

Bolded analytes indicate COPCs

- = Since no RL is provided for detected results, no maximum RL is provided where all results are detects (or where no RL was reported)

COPC = Chemical of potential concern

HHRA = Human Health Risk Assessment

NA= Not applicable

NV = The chemical does not have inhalation toxicity values

RL = reporting limit

µg/L = micrograms per liter

VI = Vapor intrusion

VISL = Vapor intrusion screening level

USEPA 2012 OSWER Vapor Intrusion Assessment. Vapor Intrusion Screening Level Calculator Version 3 0, November 2012 RSLs

Table 3-4
Selection of COPCs
Sediments
EA1
Vertellus - Provo, Utah

Detected Analytes	Maximum Detection (µg/kg)[1]	Maximum RL (µg/kg)[1]	Selected Maximum (µg/kg)[2]	Adjusted Regional Screening Level (Residential Soil) (µg/kg)[3]	Selected Maximum Greater than Screening Level?	Retained for Further Evaluation in the HHRA?
Exposure Area 1						
2-Methylphenol	2,400	200,000	200,000	310,000	No	No
3&4-Methylphenol	3,100	200,000	200,000	310,000	No	No
Acenaphthylene	264,000	200,000	264,000	340,000	No	No
Acetone	4,170	6,400	6,400	6,100,000	No	No
Anthracene	860,000	1,400	860,000	1,700,000	No	No
Carbon disulfide	83	1,600	1,600	82,000	No	No
Dibenzofuran	750	230	750	7,800	No	No
m,p-Xylene	2	120	120	59,000	No	No
Methyl ethyl ketone	5,570	6,400	6,400	2,800,000	No	No
Methylene chloride	3	1,600	1,600	56,000	No	No
o-Xylene	6	62	62	69,000	No	No
Phenol	4,000	200,000	200,000	1,800,000	No	No
Toluene	5,250	640	5,250	500,000	No	No
Xylenes (Total)	43,000	640	43,000	63,000	No	No
2,4-Dimethylphenol	4,520	200,000	200,000	120,000	Yes	Yes
2-Methylnaphthalene	1,080,000	1,400	1,080,000	23,000	Yes	Yes
Acenaphthene	2,830,000	2,000	2,830,000	340,000	Yes	Yes
Benzene	7,510	320	7,510	1,100	Yes	Yes
Benzenethiol	47	2,000,000	2,000,000	7,800	Yes	Yes
Benzo(a)anthracene	420,000	20,000	420,000	150	Yes	Yes
Benzo(a)pyrene	360,000	200,000	360,000	15	Yes	Yes
Benzo(b)fluoranthene	316,000	200,000	316,000	150	Yes	Yes
Benzo(k)fluoranthene	317,000	200,000	317,000	1,500	Yes	Yes
Chrysene	499,000	20,000	499,000	15,000	Yes	Yes
Cyanide, Total	3,900	1,000	3,900	2,200	Yes	Yes
Dibenz(a,h)anthracene	89,100	200,000	200,000	15	Yes	Yes
Ethylbenzene	45,900	640	45,900	5,400	Yes	Yes
Fluoranthene	2,410,000	2,600	2,410,000	230,000	Yes	Yes
Fluorene	1,760,000	2,000	1,760,000	230,000	Yes	Yes
Indeno(1,2,3-c,d)pyrene	168,000	200,000	200,000	150	Yes	Yes
Naphthalene	4,650,000	200,000	4,650,000	3,600	Yes	Yes
Phenanthrene	5,160,000	2,600	5,160,000	1,700,000	Yes	Yes
Pyrene	1,770,000	1,500	1,770,000	170,000	Yes	Yes

Notes:

[1] Results are for sediments at depths of 0-10 feet

[2] The selected maximum is the higher of the maximum detection and maximum RL

[3] The screening level is the lower of the RSLs for non-cancer and cancer effects (USEPA 2012) Screening levels based on non- cancer effects were adjusted by multiplying the RSL by 0 1

Bolded analytes indicate COPCs

HHRA = Human Health Risk Assessment

NA= Not applicable

NV = The chemical does not have a screening level

RL = reporting limit

RSL = Regional screening level

µg/kg = micrograms per kilogram

Source:

U S Environmental Protection Agency (USEPA) 2012 USEPA Master Regional Screening Level (RSL) Table November

Table 3-5
Selection of COPCs
Surface Water
EA1
Vertellus - Provo, Utah

Detected Analytes	Maximum Detection (µg/L)	Maximum RL (µg/L)	Selected Maximum (µg/L)[1]	Adjusted Regional Screening Level (Tap Water) (µg/L)[2]	Selected Maximum Greater than Screening Level?	Retained for Further Evaluation in the HHRA?
Exposure Area 1						
2,4-Dimethylphenol	10 4	5.2	10 4	27	No	No
2-Methylphenol	13 6	5.2	13 6	72	No	No
Acenaphthene	0.013	5	5	40	No	No
Acetone	4.3	50	50	1200	No	No
Benzo(g,h,i)perylene	0.025	0.048	0.048	8 7	No	No
Fluoranthene	0.45	5	5	63	No	No
Fluorene	0.25	5	5	22	No	No
Phenanthrene	0.32	5	5	130	No	No
Phenol	4.9	5.2	5.2	450	No	No
Pyrene	0.04	5	5	8.7	No	No
Toluene	4.3	5	5	86	No	No
Xylenes (Total)	1.8	6	6	19	No	No
3&4-Methylphenol	384	5.2	384	72	Yes	Yes
Benzene	17.8	5	17.8	0 39	Yes	Yes
Benzo(a)anthracene	0.022	5	5	0.029	Yes	Yes
Benzo(a)pyrene	0 029	5	5	0.0029	Yes	Yes
Benzo(b)fluoranthene	0 037	5	5	0.029	Yes	Yes
Benzo(k)fluoranthene	0.02	5	5	0.29	Yes	Yes
Chrysene	0.033	5	5	2.9	Yes	Yes
Cyanide, Total	29	10	29	0.14	Yes	Yes
Ethylbenzene	1	5	5	1.3	Yes	Yes
Indeno(1,2,3-c,d)pyrene	0.02	5	5	0.029	Yes	Yes
Naphthalene	21 8	5	21.8	0.14	Yes	Yes

Notes:

[1] The selected maximum is the higher of the maximum detection and maximum RL

[2] The screening level is the lower of the RSLs for non-cancer and cancer effects (USEPA 2012). Screening levels based on non-cancer effects were adjusted by multiplying the RSL by 0.1.

Bolded analytes indicate COPCs.

HHRA = Human Health Risk Assessment

RL = reporting limit

RSL = Regional screening level

µg/L = micrograms per liter

Source:

U.S. Environmental Protection Agency (USEPA) 2012. USEPA Master Regional Screening Level (RSL) Table. November.

Table 3-6
Summary Statistics and EPC Results
Soil in EA2, EA3, EA4, EA5, EA7
Vertellus - Provo, Utah

Exposure Area	Depth Group	Analyte	Unit	No. of Samples	Detection Rate	Summary Statistics		Non-detect Reporting Limit (RL)		Detected Values		Goodness-of-Fit Test	Upper Confidence Limit (UCL)	Assessed 95% UCL	EPC used in Risk Calculations
						Mean	Std Dev	Min RL	Max RL	Min Detected	Max Detected	Distribution	Method of UCL Calculation		
EA2	1 -10 ft bgs	3&4-Methylphenol	µg/kg	26	8%	43,696	207,452	180	7,000,000	1,350	1,060,000	Non-parametnc	99% KM (Chebyshev) UCL	627,518	**627,518**
EA2	1 -10 ft bgs	Acenaphthene	µg/kg	26	62%	463,686	1,498,218	200	700	251	7,690,000	Gamma	95% KM (BCA) UCL	1,077,645	**1,077,645**
EA2	1 -10 ft bgs	Acenaphthylene	µg/kg	26	19%	109,102	386,462	200	7,000,000	2,970	1,880,000	Normal	95% KM (t) UCL	256,719	**256,719**
EA2	1 -10 ft bgs	Anthracene	µg/kg	26	62%	1,062,877	3,829,575	200	3,000	264	19,800,000	Gamma	95% KM (BCA) UCL	2,602,536	**2,602,536**
EA2	1 -10 ft bgs	Benzene	µg/kg	26	31%	38,650	153,744	2	500	10	780,000	Gamma	95% KM (t) UCL	93,709	**93,709**
EA2	1 -10 ft bgs	Benzo(a)anthracene	µg/kg	26	58%	364,093	853,988	200	7,000,000	660	3,470,000	Lognormal	99% KM (Chebyshev) UCL	2,123,154	**2,123,154**
EA2	1 -10 ft bgs	Benzo(a)pyrene	µg/kg	26	50%	351,393	770,324	200	7,000,000	730	2,650,000	Gamma	95% KM (t) UCL	625,303	**625,303**
EA2	1 -10 ft bgs	Benzo(b)fluoranthene	µg/kg	26	50%	370,481	832,966	200	7,000,000	528	3,150,000	Gamma	95% KM (t) UCL	666,666	**666,666**
EA2	1 -10 ft bgs	Benzo(k)fluoranthene	µg/kg	26	50%	206,700	465,056	200	7,000,000	660	1,600,000	Gamma	95% KM (t) UCL	372,064	**372,064**
EA2	1 -10 ft bgs	Carbon disulfide	µg/kg	26	35%	6 01	2 83	6 6	200,000	4	15	Normal	95% KM (t) UCL	7 20	**7.20**
EA2	1 -10 ft bgs	Chloroform	µg/kg	26	4%	-	-	5	200,000	12	12	-	-	-	**12.0**
EA2	1 -10 ft bgs	Chrysene	µg/kg	26	58%	408,920	972,432	200	7,000,000	1,020	4,120,000	Lognormal	99% KM (Chebyshev) UCL	2,411,955	**2,411,955**
EA2	1 -10 ft bgs	Cyanide, Total	µg/kg	17	65%	407,162	1,523,797	50	70	50	6,500,000	Lognormal	99% KM (Chebyshev) UCL	4,263,868	**4,263,868**
EA2	1 -10 ft bgs	Dibenz(a,h)anthracene	µg/kg	26	27%	68,831	226,008	200	7,000,000	4,400	1,140,000	Gamma	95% KM (t) UCL	152,346	**152,346**
EA2	1 -10 ft bgs	Ethylbenzene	µg/kg	26	35%	1,144	3,162	6	200,000	6	11,800	Gamma	95% KM (t) UCL	2,290	**2,290**
EA2	1 -10 ft bgs	Fluoranthene	µg/kg	26	69%	1,257,403	3,116,066	200	300	264	14,400,000	Gamma	95% KM (BCA) UCL	2,530,491	**2,530,491**
EA2	1 -10 ft bgs	Fluorene	µg/kg	26	46%	315,727	853,670	200	7,000,000	627	3,770,000	Gamma	95% KM (t) UCL	620,333	**620,333**
EA2	1 -10 ft bgs	Indeno(1,2,3-c,d)pyrene	µg/kg	26	50%	174,597	413,804	200	7,000,000	297	1,760,000	Gamma	95% KM (t) UCL	321,737	**321,737**
EA2	1 -10 ft bgs	Methylene chlonde	µg/kg	26	12%	12 4	36 0	11	500,000	1 6	160	Normal	95% KM (t) UCL	28 8	**28.8**
EA2	1 -10 ft bgs	Naphthalene	µg/kg	26	58%	3,585,913	12,257,242	200	21,000	231	58,700,000	Gamma	95% KM (BCA) UCL	7,948,537	**7,948,537**
EA2	1 -10 ft bgs	Phenanthrene	µg/kg	26	69%	1,761,452	4,707,152	200	300	297	21,900,000	Gamma	95% KM (BCA) UCL	3,586,521	**3,586,521**
EA2	1 -10 ft bgs	Phenol	µg/kg	26	12%	38,418	179,139	200	7,000,000	1,580	916,000	Lognormal	99% KM (Chebyshev) UCL	475,021	**475,021**
EA2	1 -10 ft bgs	Pyrene	µg/kg	26	65%	1,018,759	2,247,121	200	700	231	9,240,000	Gamma	95% KM (BCA) UCL	1,853,473	**1,853,473**
EA2	1 -10 ft bgs	Toluene	µg/kg	26	27%	56,725	242,935	6	4,000	12	1,260,000	Gamma	95% KM (t) UCL	144,628	**144,628**
EA2	1 -10 ft bgs	Xylenes (Total)	µg/kg	26	42%	66,441	288,569	0 46	21	6	1,500,000	Gamma	95% KM (t) UCL	167,829	**167,829**
EA3	0 - 1 ft bgs	2,4-Dimethylphenol	µg/kg	32	9%	353	778	180	70,000	7 9	2,400	Normal	95% KM (t) UCL	927	**927**
EA3	0 - 1 ft bgs	2-Methylnaphthalene	µg/kg	4	100%	-	-	-	-	72	9,400	-	-	-	**9,400**
EA3	0 - 1 ft bgs	Acenaphthene	µg/kg	32	59%	14,313	30,308	200	20,000	150	170,000	Gamma	95% KM (BCA) UCL	24,865	**24,865**
EA3	0 - 1 ft bgs	Acenaphthylene	µg/kg	32	13%	1,794	4,447	180	70,000	12	15,000	Gamma	95% KM (t) UCL	4,561	**4,561**
EA3	0 - 1 ft bgs	Benzo(a)anthracene	µg/kg	32	84%	79,138	101,154	180	20,000	51	486,000	Gamma	95% KM (Chebyshev) UCL	158,594	**158,594**
EA3	0 - 1 ft bgs	Benzo(a)pyrene	µg/kg	32	94%	104,034	114,754	180	200	23	530,000	Gamma	95% KM (Chebyshev) UCL	193,969	**193,969**
EA3	0 - 1 ft bgs	Benzo(b)fluoranthene	µg/kg	32	81%	106,945	134,328	180	20,000	30	606,000	Gamma	95% KM (Chebyshev) UCL	212,507	**212,507**
EA3	0 - 1 ft bgs	Benzo(k)fluoranthene	µg/kg	32	91%	54,637	51,717	180	20,000	7 1	241,000	Non-parametnc	99% KM (Chebyshev) UCL	147,228	**147,228**
EA3	0 - 1 ft bgs	Carbazole	µg/kg	1	100%	-	-	-	-	17,000	17,000	-	-	-	**17,000**
EA3	0 - 1 ft bgs	Chrysene	µg/kg	32	94%	105,358	125,082	180	200	46	604,000	Gamma	95% KM (Chebyshev) UCL	203,388	**203,388**
EA3	0 - 1 ft bgs	Cyanide, Total	µg/kg	13	92%	4,535	11,787	50	50	30	45,000	Lognormal	99% KM (Chebyshev) UCL	38,507	**38,507**
EA3	0 - 1 ft bgs	Dibenz(a,h)anthracene	µg/kg	32	34%	19,215	35,102	180	20,000	29	147,000	Normal	95% KM (t) UCL	30,443	**30,443**
EA3	0 - 1 ft bgs	Dibenzofuran	µg/kg	4	100%	-	-	-	-	73	11,000	-	-	-	**11,000**
EA3	0 - 1 ft bgs	Ethylbenzene	µg/kg	11	9%	-	-	5	260	4	4	-	-	-	**4.00**
EA3	0 - 1 ft bgs	Fluoranthene	µg/kg	32	97%	143,938	167,799	200	200	13	825,000	Gamma	95% KM (Chebyshev) UCL	275,373	**275,373**
EA3	0 - 1 ft bgs	Fluorene	µg/kg	32	50%	12,930	29,459	200	20,000	23	169,000	Gamma	95% KM (t) UCL	22,185	**22,185**
EA3	0 - 1 ft bgs	Indeno(1,2,3-c,d)pyrene	µg/kg	32	81%	67,275	79,709	180	20,000	100	346,000	Gamma	95% KM (Chebyshev) UCL	129,935	**129,935**
EA3	0 - 1 ft bgs	Methylene chloride	µg/kg	11	82%	615	831	20	20	22	2,760	Gamma	95% KM (Chebyshev) UCL	1,774	**1,774**
EA3	0 - 1 ft bgs	Naphthalene	µg/kg	32	44%	15,797	48,730	200	20,000	340	282,000	Lognormal	97 5% KM (Chebyshev) UCL	71,917	**71,917**
EA3	0 - 1 ft bgs	Phenanthrene	µg/kg	32	91%	99,460	165,720	200	20,000	28	860,000	Gamma	95% KM (Chebyshev) UCL	229,423	**229,423**
EA3	0 - 1 ft bgs	Pyrene	µg/kg	32	97%	174,366	283,442	200	200	14	1,590,000	Gamma	95% KM (Chebyshev) UCL	396,383	**396,383**
EA3	0 - 1 ft bgs	Xylenes (Total)	µg/kg	11	18%	37 9	91 4	6	17	9	327	Non-parametnc	99% KM (Chebyshev) UCL	426	**327**
EA3	0 -10 ft bgs	2,4-Dimethylphenol	µg/kg	68	21%	1,691	6,069	180	200,000	7 9	37,100	Gamma	95% KM (t) UCL	3,054	**3,054**

Table 3-6
Summary Statistics and EPC Results
Soil in EA2, EA3, EA4, EA5, EA7
Vertellus - Provo, Utah

Exposure Area	Depth Group	Analyte	Unit	No. of Samples	Detection Rate	Summary Statistics		Non-detect Reporting Limit (RL)		Detected Values		Goodness-of-Fit Test	Upper Confidence Limit (UCL)	Assessed 95% UCL	EPC used in Risk Calculations
						Mean	Std Dev	Min RL	Max RL	Min Detected	Max Detected	Distribution	Method of UCL Calculation		
EA3	0 -10 ft bgs	2-Methylnaphthalene	µg/kg	7	100%	49,222	123,856	-	-	72	330,000	Gamma	95% Adjusted Gamma UCL	752,538	**330,000**
EA3	0 -10 ft bgs	Acenaphthene	µg/kg	68	66%	87,530	296,695	200	30,000	126	2,180,000	Lognormal	97 5% KM (Chebyshev) UCL	314,770	**314,770**
EA3	0 -10 ft bgs	Acenaphthylene	µg/kg	68	18%	15,697	77,088	180	200,000	12	564,000	Gamma	95% KM (t) UCL	32,004	**32,004**
EA3	0 -10 ft bgs	Benzene	µg/kg	47	38%	2,849	18,315	2	27,000	0 54	127,000	Lognormal	99% KM (Chebyshev) UCL	30,203	**30,203**
EA3	0 -10 ft bgs	Benzenethiol	µg/kg	68	1%	-	-	180	2,000,000	15,000	15,000	-	-	-	**15,000**
EA3	0 -10 ft bgs	Benzo(a)anthracene	µg/kg	68	82%	108,525	194,738	180	20,000	51	1,090,000	Gamma	95% KM (Chebyshev) UCL	212,396	**212,396**
EA3	0 -10 ft bgs	Benzo(a)pyrene	µg/kg	68	85%	141,767	261,211	180	10,000	23	1,500,000	Gamma	95% KM (Chebyshev) UCL	281,048	**281,048**
EA3	0 -10 ft bgs	Benzo(b)fluoranthene	µg/kg	68	79%	132,557	253,682	180	20,000	30	1,380,000	Gamma	95% KM (Chebyshev) UCL	267,912	**267,912**
EA3	0 -10 ft bgs	Benzo(k)fluoranthene	µg/kg	68	84%	73,554	116,699	180	20,000	7 1	584,000	Gamma	95% KM (Chebyshev) UCL	135,790	**135,790**
EA3	0 -10 ft bgs	Carbazole	µg/kg	1	100%	-	-	-	-	17,000	17,000	-	-	-	**17,000**
EA3	0 -10 ft bgs	Chloroform	µg/kg	47	6%	31 3	153 2	5	41,000	7	1,000	Lognormal	99% KM (Chebyshev) UCL	323	**322.8**
EA3	0 -10 ft bgs	Chrysene	µg/kg	68	87%	130,814	221,561	180	10,000	46	1,350,000	Gamma	95% KM (Chebyshev) UCL	248,935	**248,935**
EA3	0 -10 ft bgs	Cyanide, Total	µg/kg	24	63%	3,433	9,737	2	70	30	45,000	Lognormal	99% KM (Chebyshev) UCL	23,903	**23,903**
EA3	0 -10 ft bgs	Dibenz(a,h)anthracene	µg/kg	68	40%	18,631	43,778	180	200,000	29	285,000	Gamma	95% KM (t) UCL	27,774	**27,774**
EA3	0 -10 ft bgs	Dibenzofuran	µg/kg	7	100%	43,520	108,758	-	-	73	290,000	Gamma	95% Adjusted Gamma UCL	663,244	**290,000**
EA3	0 -10 ft bgs	Ethylbenzene	µg/kg	47	38%	1,323	4,846	5	27,000	2	24,800	Gamma	95% KM (t) UCL	2,558	**2,568**
EA3	0 -10 ft bgs	Fluoranthene	µg/kg	68	91%	243,045	476,351	200	310	13	2,690,000	Gamma	95% KM (Chebyshev) UCL	496,897	**496,897**
EA3	0 -10 ft bgs	Fluorene	µg/kg	68	54%	71,518	219,698	200	200,000	23	1,380,000	Lognormal	97 5% KM (Chebyshev) UCL	240,241	**240,241**
EA3	0 -10 ft bgs	Indeno(1,2,3-c,d)pyrene	µg/kg	68	75%	82,719	158,436	180	190,000	100	1,030,000	Gamma	95% KM (Chebyshev) UCL	167,348	**167,348**
EA3	0 -10 ft bgs	Methylene bromide	µg/kg	47	2%	-	-	0 32	41,000	1,000	1,000	-	-	-	**1,000**
EA3	0 -10 ft bgs	Methylene chloride	µg/kg	47	68%	1,038	2,583	11	82,000	5 2	14,000	Lognormal	97 5% KM (Chebyshev) UCL	3,485	**3,486**
EA3	0 -10 ft bgs	Naphthalene	µg/kg	68	54%	230,136	945,707	200	200,000	91	5,980,000	Lognormal	97 5% KM (Chebyshev) UCL	956,229	**956,229**
EA3	0 -10 ft bgs	Phenanthrene	µg/kg	68	88%	276,656	693,999	200	20,000	28	4,410,000	Lognormal	97 5% KM (Chebyshev) UCL	806,670	**806,670**
EA3	0 -10 ft bgs	Pyrene	µg/kg	68	91%	244,043	450,150	200	310	14	2,210,000	Gamma	95% KM (Chebyshev) UCL	483,932	**483,932**
EA3	0 -10 ft bgs	Resorcinol	µg/kg	67	1%	-	-	180	2,000,000	15,000	15,000	-	-	-	**15,000**
EA3	0 -10 ft bgs	Xylenes (Total)	µg/kg	47	43%	6,473	28,977	6	81,000	0 27	182,000	Gamma	95% KM (t) UCL	13,754	**13,754**
EA4	1 -10 ft bgs	2-Methylnaphthalene	µg/kg	4	75%	-	-	10,000	10,000	100	1,400,000	-	-	-	**1,400,000**
EA4	1 -10 ft bgs	3&4-Methylphenol	µg/kg	20	50%	48,944	109,808	240	92,000	65	470,000	Gamma	95% KM (t) UCL	93,727	**93,727**
EA4	1 -10 ft bgs	Acenaphthene	µg/kg	20	80%	179,633	483,852	300	20,000	64	2,200,000	Gamma	95% KM (Chebyshev) UCL	666,701	**666,701**
EA4	1 -10 ft bgs	Benzene	µg/kg	20	85%	1,680	3,438	6	1,600	3	11,500	Lognormal	99% KM (Chebyshev) UCL	9,565	**9,565**
EA4	1 -10 ft bgs	Benzo(a)anthracene	µg/kg	20	70%	213,457	801,236	240	20,000	154	3,700,000	Lognormal	99% KM (Chebyshev) UCL	2,063,390	**2,063,390**
EA4	1 -10 ft bgs	Benzo(a)pyrene	µg/kg	20	65%	30,416	54,276	240	30,000	102	190,000	Gamma	95% KM (BCA) UCL	53,990	**53,990**
EA4	1 -10 ft bgs	Benzo(b)fluoranthene	µg/kg	20	60%	30,354	57,242	240	30,000	112	190,000	Gamma	95% KM (BCA) UCL	53,022	**53,022**
EA4	1 -10 ft bgs	Benzo(k)fluoranthene	µg/kg	20	60%	15,508	24,605	220	30,000	130	84,000	Gamma	95% KM (BCA) UCL	26,267	**26,267**
EA4	1 -10 ft bgs	Chrysene	µg/kg	20	75%	222,989	799,917	240	20,000	183	3,700,000	Lognormal	99% KM (Chebyshev) UCL	2,065,158	**2,065,168**
EA4	1 -10 ft bgs	Cyanide, Total	µg/kg	12	83%	10,926	25,466	60	60	110	90,000	Lognormal	99% KM (Chebyshev) UCL	88,028	**88,028**
EA4	1 -10 ft bgs	Dibenz(a,h)anthracene	µg/kg	20	20%	3,593	8,995	220	53,000	54	35,000	Normal	95% KM (t) UCL	7,865	**7,865**
EA4	1 -10 ft bgs	Dibenzofuran	µg/kg	4	75%	-	-	10,000	10,000	210	1,000,000	-	-	-	**1,000,000**
EA4	1 -10 ft bgs	Fluoranthene	µg/kg	20	75%	220,387	492,568	240	20,000	31	2,200,000	Gamma	95% KM (Chebyshev) UCL	717,336	**717,336**
EA4	1 -10 ft bgs	Fluorene	µg/kg	20	75%	130,769	311,776	240	20,000	210	1,400,000	Gamma	95% KM (Chebyshev) UCL	445,316	**445,316**
EA4	1 -10 ft bgs	Indeno(1,2,3-c,d)pyrene	µg/kg	20	35%	12,087	31,486	220	53,000	200	130,000	Gamma	95% KM (t) UCL	25,277	**25,277**
EA4	1 -10 ft bgs	Naphthalene	µg/kg	20	95%	452,558	1,405,368	20,000	20,000	343	6,500,000	Lognormal	99% KM (Chebyshev) UCL	3,664,988	**3,664,988**
EA4	1 -10 ft bgs	Pyrene	µg/kg	20	75%	186,785	417,982	240	20,000	35	1,900,000	Gamma	95% KM (Chebyshev) UCL	608,485	**608,485**
EA4	1 -10 ft bgs	Resorcinol	µg/kg	20	10%	1,840	160	220	680,000	1,760	2,160	Non-parametnc	95% KM (t) UCL	2,015	**2,015**
EA5	1 -10 ft bgs	3&4-Methylphenol	µg/kg	11	36%	51,361	127,711	180	2,000	386	443,000	Normal	95% KM (t) UCL	131,949	**131,949**
EA5	1 -10 ft bgs	Acenaphthene	µg/kg	11	91%	236,343	572,628	240	240	126	1,960,000	Non-parametnc	99% KM (Chebyshev) UCL	2,047,152	**1,960,000**
EA5	1 -10 ft bgs	Benzo(a)anthracene	µg/kg	11	64%	86,340	215,773	200	240	621	747,000	Lognormal	99% KM (Chebyshev) UCL	785,525	**747,000**
EA5	1 -10 ft bgs	Benzo(a)pyrene	µg/kg	11	64%	43,280	107,387	200	240	620	374,000	Gamma	95% KM (BCA) UCL	111,076	**111,076**

Table 3-6
Summary Statistics and EPC Results
Soil in EA2, EA3, EA4, EA5, EA7
Vertellus - Provo, Utah

Exposure Area	Depth Group	Analyte	Unit	No. of Samples	Detection Rate	Summary Statistics		Non-detect Reporting Limit (RL)		Detected Values		Goodness-of-Fit Test	Upper Confidence Limit (UCL)	Assessed 95% UCL	EPC used in Risk Calculations
						Mean	Std Dev	Min RL	Max RL	Min Detected	Max Detected	Distribution	Method of UCL Calculation		
EA5	1 -10 ft bgs	Benzo(b)fluoranthene	µg/kg	11	64%	53,536	133,560	200	240	600	465,000	Gamma	95% KM (BCA) UCL	137,563	**137,563**
EA5	1 -10 ft bgs	Benzo(k)fluoranthene	µg/kg	11	64%	19,759	48,201	200	240	260	167,000	Gamma	95% KM (BCA) UCL	49,921	**49,921**
EA5	1 -10 ft bgs	Chrysene	µg/kg	11	64%	96,997	243,564	200	240	650	844,000	Lognormal	99% KM (Chebyshev) UCL	886,236	**844,000**
EA5	1 -10 ft bgs	Dibenz(a,h)anthracene	µg/kg	11	18%	528	318	200	80,000	408	1,370	Non-parametnc	95% KM (t) UCL	817	**816.6**
EA5	1 -10 ft bgs	Fluoranthene	µg/kg	11	73%	468,264	1,201,718	220	240	329	4,170,000	Lognormal	99% KM (Chebyshev) UCL	4,322,334	**4,170,000**
EA5	1 -10 ft bgs	Fluorene	µg/kg	11	73%	223,088	543,444	220	240	227	1,860,000	Gamma	95% KM (Chebyshev) UCL	986,628	**986,628**
EA5	1 -10 ft bgs	Indeno(1,2,3-c,d)pyrene	µg/kg	11	55%	18,779	46,033	200	2,000	333	161,000	Gamma	95% KM (BCA) UCL	47,555	**47,555**
EA5	1 -10 ft bgs	Naphthalene	µg/kg	11	91%	160,033	419,041	240	240	127	1,470,000	Lognormal	99% KM (Chebyshev) UCL	1,485,158	**1,470,000**
EA5	1 -10 ft bgs	Phenanthrene	µg/kg	11	73%	877,264	2,250,975	220	240	814	7,810,000	Lognormal	99% KM (Chebyshev) UCL	8,096,443	**7,810,000**
EA5	1 -10 ft bgs	Pyrene	µg/kg	11	73%	498,514	1,286,505	220	240	248	4,470,000	Lognormal	99% KM (Chebyshev) UCL	4,624,508	**4,470,000**
EA7	0 - 1 ft bgs	Benzo(a)anthracene	µg/kg	12	100%	4,777	3,762	-	-	200	12,000	Normal	95% Student's-t UCL	6,727	**6,727**
EA7	0 - 1 ft bgs	Benzo(a)pyrene	µg/kg	12	100%	5,563	4,222	-	-	290	13,000	Normal	95% Student's-t UCL	7,752	**7,752**
EA7	0 - 1 ft bgs	Benzo(b)fluoranthene	µg/kg	12	100%	6,229	4,609	-	-	320	13,000	Normal	95% Student's-t UCL	8,618	**8,618**
EA7	0 - 1 ft bgs	Benzo(k)fluoranthene	µg/kg	12	100%	2,893	2,280	-	-	150	7,300	Normal	95% Student's-t UCL	4,075	**4,075**
EA7	0 - 1 ft bgs	Carbazole	µg/kg	12	100%	620	481	-	-	29	1,500	Normal	95% Student's-t UCL	869	**869.3**
EA7	0 - 1 ft bgs	Chrysene	µg/kg	12	100%	6,240	4,925	-	-	260	14,000	Normal	95% Student's-t UCL	8,793	**8,793**
EA7	0 - 1 ft bgs	Dibenz(a,h)anthracene	µg/kg	12	100%	1,067	859	-	-	59	2,700	Normal	95% Student's-t UCL	1,512	**1,512**
EA7	0 - 1 ft bgs	Indeno(1,2,3-c,d)pyrene	µg/kg	12	100%	3,521	2,630	-	-	180	7,900	Normal	95% Student's-t UCL	4,884	**4,884**
EA7	0 - 1 ft bgs	Naphthalene	µg/kg	12	100%	3,674	6,869	-	-	27	24,000	Gamma	95% Adjusted Gamma UCL	12,555	**12,555**
EA7	0 -10 ft bgs	Benzo(a)anthracene	µg/kg	25	84%	3,400	5,055	17	280	5 2	22,000	Gamma	95% KM (Chebyshev) UCL	7,917	**7,917**
EA7	0 -10 ft bgs	Benzo(a)pyrene	µg/kg	25	84%	3,683	4,926	17	280	7 4	19,000	Gamma	95% KM (Chebyshev) UCL	8,084	**8,084**
EA7	0 -10 tt bgs	Benzo(b)fluoranthene	µg/kg	25	84%	4,049	5,200	17	280	8 6	19,000	Gamma	95% KM (Chebyshev) UCL	8,695	**8,695**
EA7	0 -10 ft bgs	Benzo(k)fluoranthene	µg/kg	25	80%	1,807	2,253	17	280	4 6	7,300	Gamma	95% KM (Chebyshev) UCL	3,822	**3,822**
EA7	0 -10 ft bgs	Carbazole	µg/kg	19	68%	407	460	33	330	29	1,500	Normal	95% KM (t) UCL	598	**597.9**
EA7	0 -10 ft bgs	Chrysene	µg/kg	25	84%	4,149	5,684	17	280	8 2	22,000	Gamma	95% KM (Chebyshev) UCL	9,226	**9,226**
EA7	0 -10 ft bgs	Dibenz(a,h)anthracene	µg/kg	25	72%	660	848	17	280	3 4	2,700	Gamma	95% KM (Chebyshev) UCL	1,421	**1,421**
EA7	0 -10 ft bgs	Indeno(1,2,3-c,d)pyrene	µg/kg	25	80%	2,193	2,793	17	280	3 9	9,300	Gamma	95% KM (Chebyshev) UCL	4,692	**4,692**
EA7	0 -10 ft bgs	Naphthalene	µg/kg	25	76%	2,306	5,017	17	250	3 5	24,000	Gamma	95% KM (Chebyshev) UCL	6,800	**6,800**

Notes:

1 - If the dataset contains nondetects, summary statistics and UCLs are estimated by the Kaplan-Meier (KM) method

2 - Goodness-of-Fit Test at 5% significance level is used to test for distnbutional assumption

3 - The distnbutional assumption from (2) is used to select the appropnate UCL calculation method For normal distnbution, the UCL is based on the t-statistics For lognormal distnbution, gamma distnbution, and non-parametnc assumption, the UCL is based on the recommendations from USEPA (2002) and Singh (2010a and 2010b)

Sources:

USEPA 2002 Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites Office of Emergency and Remedial Response, U.S Environmental Protection Agency, Report No OSWER 9285 6-10
Singh, A , R Maichle, and N Armbya 2010a *ProUCL Version 4 1 User Guide.* Office of Research and Development, U S Environmental Protection Agency, Report No EPA/600/R-07/038
Singh, A , N Armbya, and A K Singh 2010b *ProUCL Version 4 1 Technical Guide* Office of Research and Development, U S Environmental Protection Agency, Report No EPA/600/R-07/041

bgs = below ground surface
EA2 = Exposure Area 2
EA3 = Exposure Area 3
EA4 = Exposure Area 4
EA5 = Exposure Area 5
EA7 = Exposure Area 7

Max RL = maximum reporting limit
Min RL = minimum reporting limit
Std Dev = standard deviation
UCL = upper confidence limie
µg/kg = micrograms per kilogram

Table 3-7
Summary Statistics and EPC Results
Groundwater in EA8
Vertellus - Provo, Utah

Exposure Area	Depth Group	Analyte	Unit	No. of Samples	Detection Rate	Summary Statistics		Non-detect Reporting Limit (RL)		Detected Values		Goodness-of-Fit Test	Upper Confidence Limit (UCL)	Assessed 95% UCL	EPC used in Risk Calculations
						Mean	Std Dev	Min RL	Max RL	Min Detected	Max Detected	Distribution	Method of UCL Calculation		
EA8	0 - 0 ft bgs	2,4-Dimethylphenol	µg/L	23	61%	1,716	3,468	5	5	3	14,600	Gamma	95% KM (BCA) UCL	2,985	**2,985**
EA8	0 - 0 ft bgs	2-Chlorophenol	µg/L	14	7%	-	-	0 9	10	5	5	-	-	-	**5.00**
EA8	0 - 0 ft bgs	2-Methylnaphthalene	µg/L	14	79%	156	258	0 5	0 5	0 5	840	Gamma	95% KM (Chebyshev) UCL	471	**471**
EA8	0 - 0 ft bgs	2-Methylphenol	µg/L	23	61%	2,967	7,894	5	5	1 8	29,000	Gamma	95% KM (BCA) UCL	6,232	**6,232**
EA8	0 - 0 ft bgs	3&4-Methylphenol	µg/L	23	57%	8,265	23,163	5	5	3.8	96,000	Gamma	95% KM (BCA) UCL	17,036	**17,036**
EA8	0 - 0 ft bgs	Acenaphthene	µg/L	23	91%	189	167	4 6	5	0.16	491	Normal	95% KM (t) UCL	250	**250**
EA8	0 - 0 ft bgs	Acenaphthylene	µg/L	23	78%	16 9	24 1	4 6	5	0 012	76	Gamma	95% KM (Chebyshev) UCL	39 4	**39.4**
EA8	0 - 0 ft bgs	Acetone	µg/L	23	39%	31 9	60 6	50	500	3 4	275	Gamma	95% KM (t) UCL	55 8	**55.8**
EA8	0 - 0 ft bgs	Anthracene	µg/L	23	87%	25 1	56 5	4 6	5	0 045	270	Gamma	95% KM (Chebyshev) UCL	77 8	**77.8**
EA8	0 - 0 ft bgs	Benzene	µg/L	23	70%	586	1,520	2	5	1 5	6,950	Gamma	95% KM (BCA) UCL	1,152	**1,152**
EA8	0 - 0 ft bgs	Benzenethiol	µg/L	23	22%	22 3	28 6	10	400	11 4	120	Normal	95% KM (t) UCL	34 3	**34.3**
EA8	0 - 0 ft bgs	Benzo(a)anthracene	µg/L	23	83%	11 5	46 7	4 6	5	0 022	230	Lognormal	99% KM (Chebyshev) UCL	111	**111**
EA8	0 - 0 ft bgs	Benzo(a)pyrene	µg/L	23	61%	7 78	32 50	4 6	5	0 072	160	Non-parametric	99% KM (Chebyshev) UCL	77 7	**77.7**
EA8	0 - 0 ft bgs	Benzo(b)fluoranthene	µg/L	23	65%	11 1	46 7	4 6	5	0 013	230	Lognormal	99% KM (Chebyshev) UCL	112	**112**
EA8	0 - 0 ft bgs	Benzo(g,h,i)perylene	µg/L	14	71%	5 11	17 17	0 048	0 96	0 011	67	Lognormal	99% KM (Chebyshev) UCL	53 3	**53.3**
EA8	0 - 0 ft bgs	Benzo(k)fluoranthene	µg/L	23	52%	4 62	18 24	2 4	5	0 038	90	Non-parametric	99% KM (Chebyshev) UCL	44 2	**44.2**
EA8	0 - 0 ft bgs	Carbon disulfide	µg/L	23	13%	1 51	1.77	2	100	0 89	7	Normal	95% KM (t) UCL	2 39	**2.39**
EA8	0 - 0 ft bgs	Chrysene	µg/L	23	83%	14 1	58 9	4 6	5	0 016	290	Non-parametnc	99% KM (Chebyshev) UCL	140	**140**
EA8	0 - 0 ft bgs	Cyanide, Total	µg/L	23	100%	145	217	-	-	4	880	Lognormal	95% Chebyshev (Mean, Sd) UCL	343	**343**
EA8	0 - 0 ft bgs	Dibenz(a,h)anthracene	µg/L	23	30%	1 21	4 33	0 47	190	0 028	21	Lognormal	99% KM (Chebyshev) UCL	11 2	**11.2**
EA8	0 - 0 ft bgs	Dibenzofuran	µg/L	14	86%	81 4	81 9	0 9	1	3	290	Normal	95% KM (t) UCL	122	**122**
EA8	0 - 0 ft bgs	Ethylbenzene	µg/L	23	74%	60 4	115 5	2	5	0 49	530	Gamma	95% KM (Chebyshev) UCL	169	**169**
EA8	0 - 0 ft bgs	Fluoranthene	µg/L	23	91%	48 0	165 5	4 6	5	0 13	820	Lognormal	99% KM (Chebyshev) UCL	400	**400**
EA8	0 - 0 ft bgs	Fluorene	µg/L	23	87%	50 3	53 5	4 6	5	0 084	190	Non-parametnc	99% KM (Chebyshev) UCL	164	**164**
EA8	0 - 0 ft bgs	Indeno(1,2,3-c,d)pyrene	µg/L	23	43%	3 81	14 28	0 47	190	0 017	69	Gamma	95% KM (t) UCL	9 34	**9.34**
EA8	0 - 0 ft bgs	Methyl ethyl ketone	µg/L	23	4%	-	-	10	500	28 4	28 4	-	-	-	**28.4**
EA8	0 - 0 ft bgs	Methylene chloride	µg/L	23	4%	-	-	5	250	6 8	6 8	-	-	-	**6.80**
EA8	0 - 0 ft bgs	Naphthalene	µg/L	23	91%	1,834	3,199	4 6	4 8	0 19	13,000	Gamma	95% KM (Chebyshev) UCL	4,813	**4,813**
EA8	0 - 0 ft bgs	Phenanthrene	µg/L	23	83%	51 0	53 9	4 6	5	0 2	180	Normal	95% KM (t) UCL	70 9	**70.9**
EA8	0 - 0 ft bgs	Phenol	µg/L	23	74%	14,269	43,619	5	5	2 6	200,000	Non-parametnc	99% KM (Chebyshev) UCL	107,551	**107,551**
EA8	0 - 0 ft bgs	Pyrene	µg/L	23	91%	39 1	139 3	4 6	5	0 1	690	Lognormal	99% KM (Chebyshev) UCL	335	**335**
EA8	0 - 0 ft bgs	Toluene	µg/L	23	65%	282	771	2	5	1	3,600	Gamma	95% KM (BCA) UCL	587	**587**
EA8	0 - 0 ft bgs	Xylenes (Total)	µg/L	23	65%	164	347	6	6	15 6	1,620	Lognormal	97 5% KM (Chebyshev) UCL	632	**632**

Notes:

1 - If the dataset contains nondetects, summary statistics and UCLs are estimated by the Kaplan-Meier (KM) method

2 - Goodness-of-Fit Test at 5% significance level is used to test for distributional assumption

3 - The distributional assumption from (2) is used to select the appropriate UCL calculation method For normal distribution, the UCL is based on the t-statistics For lognormal distribution, gamma distribution, and non-parametnc assumption, the UCL is based on the recommendations from USEPA (2002) and Singh (2010a and 2010b)

Sources:

USEPA 2002 Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites Office of Emergency and Remedial Response, U S Environmental Protection Agency, Report No OSWER 9285 6-10
Singh, A , R Maichle, and N Armbya 2010a *ProUCL Version 4 1 User Guide* Office of Research and Development, U S Environmental Protection Agency, Report No EPA/600/R-07/038
Singh, A , N Armbya, and A K Singh 2010b *ProUCL Version 4 1 Technical Guide* Office of Research and Development, U S Environmental Protection Agency, Report No EPA/600/R-07/041

bgs = below ground surface
EA8 = Exposure Area 8
Max RL = maximum reporting limit
Min RL = minimum reporting limit
Std Dev = standard deviation
UCL = upper confidence limie
µg/L = micrograms per liter

Table 3-8
Summary Statistics and EPC Results
Sediments in EA1
Vertellus - Provo, Utah

Exposure Area	Depth Group	Analyte	Unit	No. of Samples	Detection Rate	Summary Statistics		Non-detect Reporting Limit (RL)		Detected Values		Goodness-of-Fit Test	Upper Confidence Limit (UCL)	Assessed 95% UCL	EPC used in Risk Calculations
						Mean	Std Dev	Min RL	Max RL	Min Detected	Max Detected	Distribution	Method of UCL Calculation		
EA1	0 - 1 ft bgs	2-Methylnaphthalene	µg/kg	5	40%	16 0	4 0	230	1,400	12	20	Non-parametnc	95% KM (t) UCL	24 5	**20**
EA1	0 - 1 ft bgs	Acenaphthene	µg/kg	9	56%	48,430	125,047	230	2,000	13	401,000	Gamma	95% KM (BCA) UCL	137,242	**137242**
EA1	0 - 1 ft bgs	Benzene	µg/kg	9	44%	4 73	4 01	2	320	2 2	14	Normal	95% KM (t) UCL	8 02	**8.018**
EA1	0 - 1 ft bgs	Benzo(a)anthracene	µg/kg	9	67%	30,405	49,006	230	1,400	84	136,000	Gamma	95% KM (BCA) UCL	64,111	**64111**
EA1	0 - 1 ft bgs	Benzo(a)pyrene	µg/kg	9	67%	25,732	42,184	230	1,400	110	128,000	Normal	95% KM (t) UCL	54,376	**54376**
EA1	0 - 1 ft bgs	Benzo(b)fluoranthene	µg/kg	9	67%	28,551	47,004	230	1,500	120	142,000	Normal	95% KM (t) UCL	60,467	**60467**
EA1	0 - 1 ft bgs	Benzo(k)fluoranthene	µg/kg	9	67%	11,012	15,110	230	1,700	54	40,200	Normal	95% KM (t) UCL	21,272	**21272**
EA1	0 - 1 ft bgs	Chrysene	µg/kg	9	67%	41,110	66,983	230	1,700	100	197,000	Normal	95% KM (t) UCL	86,592	**86592**
EA1	0 - 1 ft bgs	Cyanide, Total	µg/kg	6	83%	927	590	1,000	1,000	130	1,600	Normal	95% KM (t) UCL	1,470	**1470**
EA1	0 - 1 ft bgs	Dibenz(a,h)anthracene	µg/kg	9	44%	2,750	4,666	230	2,000	22	13,900	Normal	95% KM (t) UCL	6,090	**6090**
EA1	0 - 1 ft bgs	Ethylbenzene	µg/kg	9	44%	9 50	10.00	1 8	640	1 5	26 9	Normal	95% KM (t) UCL	17 6	**17.6**
EA1	0 - 1 ft bgs	Fluoranthene	µg/kg	9	67%	73,573	127,831	230	2,600	110	365,000	Gamma	95% KM (BCA) UCL	165,404	**165404**
EA1	0 - 1 ft bgs	Fluorene	µg/kg	9	44%	34,875	89,757	230	2,000	7 9	288,000	Gamma	95% KM (t) UCL	99,118	**99118**
EA1	0 - 1 ft bgs	Indeno(1,2,3-c,d)pyrene	µg/kg	9	67%	9,831	15,895	230	1,400	76	49,500	Normal	95% KM (t) UCL	20,624	**20624**
EA1	0 - 1 ft bgs	Naphthalene	µg/kg	9	67%	4,136	7,627	820	2,600	6 6	22,400	Gamma	95% KM (BCA) UCL	9,089	**9089**
EA1	0 - 1 ft bgs	Phenanthrene	µg/kg	9	67%	65,397	125,083	230	2,600	76	388,000	Gamma	95% KM (BCA) UCL	145,545	**145545**
EA1	0 - 1 ft bgs	Pyrene	µg/kg	9	67%	73,020	121,806	230	1,500	120	331,000	Gamma	95% KM (BCA) UCL	153,218	**153218**
EA1	0 -10 ft bgs	2,4-Dimethylphenol	µg/kg	32	9%	256	876	51	200,000	33	4,520	Normal	95% KM (t) UCL	603	**603**
EA1	0 -10 ft bgs	2-Methylnaphthalene	µg/kg	16	44%	67,565	261,410	47	1,400	12	1,080,000	Non-parametnc	99% KM (Chebyshev) UCL	769,913	**769913**
EA1	0 -10 ft bgs	Acenaphthene	µg/kg	32	66%	173,722	534,197	52	2,000	5 4	2,830,000	Lognormal	99% KM (Chebyshev) UCL	1,136,528	**1136528**
EA1	0 -10 ft bgs	Benzene	µg/kg	32	41%	257	1,304	1 5	320	1 6	7,510	Non-parametnc	99% KM (Chebyshev) UCL	2,645	**2645**
EA1	0 -10 ft bgs	Benzenethiol	µg/kg	25	4%	-	-	210	2,000,000	47	47	-	-	-	**47.0**
EA1	0 -10 ft bgs	Benzo(a)anthracene	µg/kg	32	56%	54,704	119,805	47	20,000	22	420,000	Gamma	95% KM (BCA) UCL	96,347	**96347**
EA1	0 -10 ft bgs	Benzo(a)pyrene	µg/kg	32	53%	33,335	81,497	47	200,000	18	360,000	Gamma	95% KM (BCA) UCL	60,053	**60053**
EA1	0 -10 ft bgs	Benzo(b)fluoranthene	µg/kg	32	53%	32,714	76,657	51	200,000	19	316,000	Gamma	95% KM (BCA) UCL	58,873	**58873**
EA1	0 -10 ft bgs	Benzo(k)fluoranthene	µg/kg	32	53%	25,391	68,313	60	200,000	8 3	317,000	Gamma	95% KM (BCA) UCL	48,862	**48862**
EA1	0 -10 ft bgs	Chrysene	µg/kg	32	56%	58,792	125,336	60	20,000	21	499,000	Gamma	95% KM (BCA) UCL	100,568	**100568**
EA1	0 -10 ft bgs	Cyanide, Total	µg/kg	23	65%	838	1,051	50	1,000	60	3,900	Gamma	95% KM (BCA) UCL	1,222	**1222**
EA1	0 -10 ft bgs	Dibenz(a,h)anthracene	µg/kg	32	28%	4,897	16,474	51	200,000	22	89,100	Gamma	95% KM (t) UCL	10,233	**10233**
EA1	0 -10 ft bgs	Ethylbenzene	µg/kg	32	44%	1,912	8,070	1 4	640	1 2	45,900	Lognormal	99% KM (Chebyshev) UCL	16,642	**16642**
EA1	0 -10 ft bgs	Fluoranthene	µg/kg	32	59%	194,281	492,075	89	2,600	40	2,410,000	Gamma	95% KM (BCA) UCL	348,740	**348740**
EA1	0 -10 ft bgs	Fluorene	µg/kg	32	44%	124,414	356,416	51	2,000	7 9	1,760,000	Gamma	95% KM (t) UCL	235,274	**235274**
EA1	0 -10 ft bgs	Indeno(1,2,3-c,d)pyrene	µg/kg	32	47%	14,427	36,008	47	200,000	76	168,000	Gamma	95% KM (t) UCL	25,779	**25779**
EA1	0 -10 ft bgs	Naphthalene	µg/kg	32	44%	197,725	838,154	51	200,000	6 6	4,650,000	Lognormal	99% KM (Chebyshev) UCL	1,727,650	**1727650**
EA1	0 -10 ft bgs	Phenanthrene	µg/kg	32	63%	319,534	986,096	79	2,600	65	5,160,000	Gamma	95% KM (BCA) UCL	637,990	**637990**
EA1	0 -10 ft bgs	Pyrene	µg/kg	32	59%	167,091	389,309	51	1,500	40	1,770,000	Gamma	95% KM (BCA) UCL	299,797	**299797**

Notes:

1 - If the dataset contains nondetects, summary statistics and UCLs are estimated by the Kaplan-Meier (KM) method

2 - Goodness-of-Fit Test at 5% significance level is used to test for distnbutional assumption

3 - The distnbutional assumption from (2) is used to select the appropnate UCL calculation method For normal distnbution, the UCL is based on the t-statistics For lognormal distnbution, gamma distnbution, and non-parametnc assumption, the UCL is based on the recommendations from USEPA (2002) and Singh (2010a and 2010b)

Sources:

USEPA 2002 Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites Office of Emergency and Remedial Response, U S Environmental Protection Agency, Report No OSWER 9285 6-10
Singh, A , R Maichle, and N Armbya 2010a *ProUCL Version 4 1 User Guide* Office of Research and Development, U S Environmental Protection Agency, Report No EPA/600/R-07/038
Singh, A , N Armbya, and A K Singh 2010b *ProUCL Version 4 1 Technical Guide* Office of Research and Development, U S Environmental Protection Agency, Report No EPA/600/R-07/041

bgs = below ground surface
EA1 = Exposure Area 1
Max RL = maximum reporting limit
Min RL = minimum reporting limit
Std Dev = standard deviation
UCL = upper confidence limie
µg/kg = micrograms per kilogram

Table 3-9
Summary Statistics and EPC Results
Surface Water in EA1
Vertellus - Provo, Utah

Exposure Area	Depth Group	Analyte	Unit	No. of Samples	Detection Rate	Summary Statistics		Non-detect Reporting Limit (RL)		Detected Values		Goodness-of-Fit Test	Upper Confidence Limit (UCL)	Assessed 95% UCL	EPC used in Risk Calculations
						Mean	Std Dev	Min RL	Max RL	Min Detected	Max Detected	Distribution	Method of UCL Calculation		
EA1	0 - 0 ft bgs	3&4-Methylphenol	µg/L	15	13%	28.6	95 0	0 9	5 2	3 2	384	Non-parametnc	99% KM (Chebyshev) UCL	373 7	**374**
EA1	0 - 0 ft bgs	Benzene	µg/L	21	10%	4 09	3 07	0 5	5	3 4	17.8	Non-parametnc	95% KM (BCA) UCL	17 8	**17.8**
EA1	0 - 0 ft bgs	Benzo(a)anthracene	µg/L	21	19%	0 0168	0 0033	0 047	5	0.014	0 022	Normal	95% KM (t) UCL	0 0200	**0.0200**
EA1	0 - 0 ft bgs	Benzo(a)pyrene	µg/L	21	19%	0 0178	0 0068	0 047	5	0 012	0 029	Normal	95% KM (t) UCL	0 0245	**0.0245**
EA1	0 - 0 ft bgs	Benzo(b)fluoranthene	µg/L	21	29%	0 0185	0 0089	0 047	5	0.011	0 037	Normal	95% KM (t) UCL	0 0253	**0.0253**
EA1	0 - 0 ft bgs	Benzo(k)fluoranthene	µg/L	21	10%	0 0125	0 0043	0 0095	5	0 01	0 02	Non-parametnc	95% KM (t) UCL	0 0178	**0.0178**
EA1	0 - 0 ft bgs	Chrysene	µg/L	21	24%	0 0186	0 0078	0 047	5	0 01	0 033	Normal	95% KM (t) UCL	0 0253	**0.0253**
EA1	0 - 0 ft bgs	Cyanide, Total	µg/L	12	42%	6 93	6 98	10	10	2.2	29	Gamma	95% KM (t) UCL	11.3	**11.3**
EA1	0 - 0 ft bgs	Ethylbenzene	µg/L	21	5%	-	-	0 8	5	1	1	-	-	-	**1.00**
EA1	0 - 0 ft bgs	Indeno(1,2,3-c,d)pyrene	µg/L	21	5%	-	-	0 0095	5	0 02	0 02	-	-	-	**0.0200**
EA1	0 - 0 ft bgs	Naphthalene	µg/L	21	48%	1.35	4 63	0.047	5	0 029	21 8	Lognormal	99% KM (Chebyshev) UCL	12 0	**12.0**

Notes:

1 - If the dataset contains nondetects, summary statistics and UCLs are estimated by the Kaplan-Meier (KM) method

2 - Goodness-of-Fit Test at 5% significance level is used to test for distnbutional assumption

3 - The distributional assumption from (2) is used to select the appropnate UCL calculation method For normal distribution, the UCL is based on the t-statistics For lognormal distnbution, gamma distnbution, and non-parametnc assumption, the UCL is based on the recommendations from USEPA (2002) and Singh (2010a and 2010b).

Sources:

USEPA 2002 Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites Office of Emergency and Remedial Response, U S Environmental Protection Agency, Report No OSWER 9285 6-10

Singh, A , R Maichle, and N Armbya. 2010a *ProUCL Version 4.1 User Guide* Office of Research and Development, U S Environmental Protection Agency, Report No. EPA/600/R-07/038

Singh, A , N Armbya, and A K Singh. 2010b *ProUCL Version 4 1 Technical Guide* Office of Research and Development, U S Environmental Protection Agency, Report No EPA/600/R-07/041.

bgs = below ground surface

EA1 = Exposure Area 1

Max RL = maximum reporting limit

Min RL = minimum reporting limit

Std Dev = standard deviation

UCL = upper confidence limie

µg/L = micrograms per liter

Table 3-10
Exposure Factors
Child Trespasser Exposed to Surface Soil
Vertellus - Provo, Utah

Exposure Pathway	Parameter	Description	Exposure Parameters	
			RME	Source
Incidental Soil Ingestion	SIR	Soil Ingestion Rate (mg/day)	100	(a)
	ETf	Exposure time fraction (unitless)	0 17	(n)
	EF	Exposure Frequency (days/year)	52	(b)
	ED	Exposure Duration (years)	12	(c)
	BW	Body Weight (kg)	47	(d)
	ATnc	Averaging Time for Noncarcinogenic Effects (days)	4,380	(e)
	ATc	Averaging Time for Carcinogenic Effects (days)	25,550	(f)
	CF	Unit Conversion Factor (kg/mg)	1E-06	--
Dermal Contact with Soil	SA	Skin Surface Area Exposed (cm^2)	4,373	(g)
	SSAF	Soil-to-Skin Adherence Factor (mg/cm^2-event)	0 07	(h)
	ABS	Dermal Absorption Fraction (unitless)	chemical-specific	(i)
	EV	Number of events (events/day)	1	(o)
	EF	Exposure Frequency (days/year)	52	(b)
	ED	Exposure Duration (years)	12	(c)
	BW	Body Weight (kg)	47	(d)
	ATnc	Averaging Time for Noncarcinogenic Effects (days)	4,380	(e)
	ATc	Averaging Time for Carcinogen Effects (days)	25,550	(f)
	CF	Unit Conversion Factor (kg/mg)	1E-06	--
Inhalation of Soil-derived Chemicals	ET	Exposure Time (hour/day)	4	(j)
	EF	Exposure Frequency (days/year)	52	(b)
	ED	Exposure Duration (years)	12	(c)
	PEF	Particulate Emission Factor (m^3/kg)	1.32E+09	(k)
	VF	Volatilization Factor (m^3/kg)	Calculated	
	ATnc	Averaging Time for Noncarcinogenic Effects (hours)	105,120	(l)
	ATc	Averaging Time for Carcinogen Effects (hours)	613,200	(m)

Notes:

(a) The USEPA default value for soil ingestion by older child and adult residents based on 24 hour/day exposure (USEPA 1991) was used.

(b) Conservative assumption (3 days/week during June, July, and August and 1 day/week during April, May, September, and October) UDEQ DSHW has accepted the use of this value for adolescent recreators at other RCRA sites in Utah.

(c) Child trespassers are assumed to range in age from 7 to 18 Therefore, the total exposure duration is 12 years.

(d) Body weight is the average of males and females aged 7 to 18 (USEPA 1997). UDEQ DSHW has accepted the use of this value for adolescent recreators (age 7-18) exposed to soil at other RCRA sites in Utah.

(e) The USEPA (1989) default approach for averaging time for noncarcinogens (ATn) is the exposure duration expressed in days.

(f) The USEPA (1989) default approach for averaging time for carcinogens (ATc) is the exposure duration expressed in days.

(g) Sum of the average surface area of head, hands, forearms, and lower legs for ages 7-18 (male and female) (Exhibit C-1; USEPA, 2004). UDEQ DSHW has accepted the use of this value for adolescent recreators (age 7-18) exposed to soil at other RCRA sites in Utah.

(h) Recommended soil-to-skin adherence factor for ages 7-31 (Exhibit 3-5; USEPA, 2004).

(i) Chemical-specific default values for ABSd will be obtained from Exhibit 3-4 in USEPA (2004).

(j) Professional judgement was used to derive this value, which is considered to be a high-end value that is unlikley to be exceeded. Assumes child trespassers will spend 4 hours each day playing on the site.

(k) This is the USEPA (1996) default value (Equation 5, p. 23).

(l) The USEPA (2009) default approach for averaging time for noncarcinogens (ATn) is the exposure duration expressed in hours.

(m) The USEPA (2009) default approach for averaging time for carcinogens (ATc) is the exposure duration expressed in hours.

(n) Child trespassers are assumed to be exposed to soil for 4 hours each day. Because the soil ingestion rate of 100 mg/day for older child and adult residents is based on a 24 hour/day exposure, ETf was calculated as 4 hours/24 hours = 0 17

(o) This is the USEPA (2004) default value (Exhibit 3-5)

cm^2 = centimeters squared

kg = kilogram

kg/mg = kilogram per milligram

m3/kg = meters cubed per kilogram

mg/cm^2 = milligrams per centimeter squared

Table 3-10
Exposure Factors
Child Trespasser Exposed to Surface Soil
Vertellus - Provo, Utah

mg/day = milligrams per day
RCRA = Resource Conservation and Recovery Act
RME = Reasonable Maximum Exposure.

Sources:

U.S Environmental Protection Agency (USEPA). 1989. Risk Assessment Guidance for Superfund: Volume I - Human Health Evaluation Manual. Part A. Interim Final. Office of Emergency and Remedial Response, Washington, D.C. December.
USEPA. 1991. Human Health Evaluation Manuel. Supplemental Guidance. Standard Default Exposure Factors. Office of Emergency and Remedial Response Washington, D.C March.
USEPA 1996. Soil Screening Guidance. User's Guide Publication 9355.4-23. July.
USEPA 1997. Exposure Factors Handbook. Office of Research and Development, Washington, DC. EPA/600/P-95/002Fa August.
USEPA. 2004. Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual, Part E, Supplemental Guidance for Dermal Risk Assessment. EPA/540/R/99/005, OSWER 9285.7-02EP, PB99-963312. July.
USEPA. 2009. Risk Assessment Guidance for Superfund. Volume I: Human Health Evaluation Manual (Part F, Supplemental Guidance for Inhalation Risk Assessment). USEPA-540-R-070-002. January.

Table 3-11
Exposure Factors
Child Trespasser Exposed to Surface Water
Vertellus - Provo, Utah

Exposure Pathway	Parameter	Description	Exposure Parameters	
			RME	Source
Incidental Surface Water Ingestion	SWIR	Surface Water Ingestion Rate (L/hour)	0.005	(a)
	BW	Body Weight (kg)	47	(b)
	ED	Exposure Duration (years)	12	(c)
	EF	Exposure Frequency (days/year)	10	(d)
	ET	Exposure Time (hour/day)	1	(e)
	AT_{nc}	Averaging Time for Noncarcinogens (days)	4,380	(f)
	AT_c	Averaging Time for Carcinogens (days)	25,550	(g)
Dermal Contact with Surface Water	SA	Skin Surface Area Exposed (cm^2)	4,373	(h)
	BW	Body Weight (kg)	47	(b)
	CF	Conversion Factor (cm^3/L)	1000	-
	PC	Permeability Constanct (cm/hour)	chemical-specific	(i)
	ED	Exposure Duration (years)	12	(c)
	EF	Exposure Frequency (days/year)	10	(d)
	ET	Exposure Time (hours/day)	1	(e)
	AT_{nc}	Averaging Time for Noncarcinogens (days)	4,380	(f)
	AT_c	Averaging Time for Carcinogens (days)	25,550	(g)

Notes:

(a) Professional judgement was used to derive this value, which is considered to be a high-end value that is unlikley to be exceeded. Assuming that incidental ingestion of surface water from accidental splashing or hand-to-face contact while working might result in a very small amount of water in or near the mouth, but that most would be removed by wiping or spitting, 5 mL/hour was assumed for the remaining amount actually ingested. UDEQ DSHW has accepted the use of this value for trespassers exposed to surface water at other RCRA sites in Utah. See Section 3.1.8 for additional discussion of the derivation and use of this value.

(b) Body weight is the average of males and females aged 7 to 18 (USEPA 1997). UDEQ DSHW has accepted the use of this value for adolescent recreators (age 7-18) at other RCRA sites in Utah

(c) Child trespassers are assumed to range in age from 7 to 18 Therefore, the total exposure duration is 12 years.

(d) Professional judgement was used to derive this value, which is considered to be a high-end value that is unlikley to be exceeded. Wading is assumed to occur 2 days/month during the period from May through September. UDEQ DSHW has accepted the use of this value for adolescent recreators exposed to surface water at other RCRA sites in Utah.

(e) Professional judgement was used to derive this value, which is considered to be a high-end value that is unlikley to be exceeded Assumes that child trespassers spend 1 hour each day in contact with surface water. UDEQ DSHW has accepted the use of this value for adolescent recreators exposed to surface water at other RCRA sites in Utah.

(f) The USEPA (1989) default approach for averaging time for noncarcinogens (ATn) is the exposure duration expressed in days.

(g) The USEPA (1989) default approach for averaging time for carcinogens (ATc) is the exposure duration expressed in days.

(h) Sum of the average surface area of head, hands, forearms, and lower legs for ages 7-18 (male and female) (Exhibit C-1; USEPA, 2004). UDEQ DSHW has accepted the use of this value for adolescent recreators (age 7-18) exposed to soil at other RCRA sites in Utah

(i) Chemical-specific default values for PC will be obtained from Exhibit B-2 in USEPA (2004).

cm^2 = squared centimeters
cm^3/L = cubed centimeters per liter
cm/hour = centimeters per hour
kg = kilograms
L/hour = Liters per hour
ml/hour = milliliters per hour
RCRA = Resource Conservation and Recovery Act
RME = Reasonable Maximum Exposure

Sources:

U.S Environmental Protection Agency (USEPA). 1989. Risk Assessment Guidance for Superfund. Volume I - Human Health Evaluation Manual. Part A Interim Final. Office of Emergency and Remedial Response, Washington, D C. December.

USEPA. 1997 Exposure Factors Handbook. Office of Research and Development, Washington, DC. EPA/600/P-95/002Fa. August

USEPA 2004. Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual, Part E, Supplemental Guidance for Dermal Risk Assessment. EPA/540/R/99/005, OSWER 9285.7-02EP, PB99-963312 July

Table 3-12
Exposure Factors
Child Trespasser Exposed to Surface Sediments
Vertellus - Provo, Utah

Exposure Pathway	Parameter	Description	Exposure Parameters	
			RME	Source
Incidental Sediment Ingestion	SIR	Sediment Ingestion Rate (mg/day)	100	(a)
	ETf	Exposure time fraction (unitless)	0.17	(j)
	EF	Exposure Frequency (days/year)	10	(b)
	ED	Exposure Duration (years)	12	(c)
	BW	Body Weight (kg)	47	(d)
	ATnc	Averaging Time for Noncarcinogenic Effects (days)	4,380	(e)
	ATc	Averaging Time for Carcinogenic Effects (days)	25,550	(f)
	CF	Unit Conversion Factor (kg/mg)	1E-06	--
Dermal Contact with Sediment	SA	Skin Surface Area Exposed (cm^2)	4,373	(g)
	SSAF	Soil-to-Skin Adherence Factor (mg/cm^2-event)	0.3	(h)
	ABS	Dermal Absorption Fraction (unitless)	chemical-specific	(i)
	EV	Number of events (events/day)	1	(k)
	EF	Exposure Frequency (days/year)	10	(b)
	ED	Exposure Duration (years)	12	(c)
	BW	Body Weight (kg)	47	(d)
	ATnc	Averaging Time for Noncarcinogenic Effects (days)	4,380	(e)
	ATc	Averaging Time for Carcinogen Effects (days)	25,550	(f)
	CF	Unit Conversion Factor (kg/mg)	1E-06	--

Notes:

(a) There are no USEPA default values for sediment ingestion by child trespassers. Therefore the USEPA default value for soil ingestion by older child and adult residents based on 24 hour/day exposure (USEPA 1991) was used

(b) Professional judgement was used to derive this value, which is considered to be a high-end value that is unlikley to be exceeded. Wading is assumed to occur 2 days/month during the period from May through September. UDEQ DSHW has accepted the use of this value for evaluating adolescent recreators exposed to wet sediments at other RCRA sites in Utah.

(c) Child trespassers are assumed to range in age from 7 to 18. Therefore, the total exposure duration is 12 years.

(d) Body weight is the average of males and females aged 7 to 18 (USEPA 1997). UDEQ DSHW has accepted the use of this value for adolescent recreators (age 7-18) at other RCRA sites in Utah.

(e) The USEPA (1989) default approach for averaging time for noncarcinogens (ATn) is the exposure duration expressed in days.

(f) The USEPA (1989) default approach for averaging time for carcinogens (ATc) is the exposure duration expressed in days.

(g) Sum of the average surface area of head, hands, forearms, and lower legs for ages 7-18 (male and female) (Exhibit C-1; USEPA, 2004) UDEQ DSHW has accepted the use of this value for adolescent recreators (age 7-18) exposed to soil at other RCRA sites in Utah.

(h) Soil-to-skin adherence factor for the irrigation installer (Exhibit 3-3, USEPA 2004). UDEQ DSHW has accepted the use of this value for evaluating adolescent recreators exposed to wet sediments at other RCRA sites in Utah.

(i) Chemical-specific default values for ABSd will be obtained from Exhibit 3-4 in USEPA (2004).

(j) Professional judgement was used to derive this value, which is considered to be a high-end value that is unlikley to be exceeded. Child trespassers are assumed to be exposed to sediments (including sidewall sediments) for 4 hours each day Because the soil ingestion rate of 100 mg/day for older child and adult residents is based on a 24 hour/day exposure, ETf was calculated as 4 hours/24 hours = 0.17.

(k) This is the USEPA (2004) default value (Exhibit 3-5).

cm^2 = centimeters squared
kg = kilogram
kg/mg = kilogram per milligram
mg/cm^2 = milligrams per centimeter squared
mg/day = milligrams per day
RCRA = Resource Conservation & Recovery Act
RME = Reasonable Maximum Exposure.

Sources:

U S Environmental Protection Agency (USEPA). 1989. Risk Assessment Guidance for Superfund: Volume I - Human Health Evaluation Manual Part A Interim Final. Office of Emergency and Remedial Response, Washington, D.C December

USEPA. 1991. Human Health Evaluation Manuel. Supplemental Guidance. Standard Default Exposure Factors. Office of Emergency and Remedial Response. Washington, D.C. March.

USEPA. 1997 Exposure Factors Handbook, Volumes I through III, EPA\600\P-95\002F.

USEPA. 2004. Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual, Part E, Supplemental Guidance for Dermal Risk Assessment. EPA/540/R/99/005, OSWER 9285 7-02EP, PB99-963312. July.

Table 3-13
Exposure Factors
Future Construction Worker Exposed to Combined Sediments
Vertellus - Provo, Utah

Exposure Pathway	Parameter	Description	Exposure Parameters	
			RME	Source
Incidental Sediment Ingestion	SIR	Sediment Ingestion Rate (mg/day)	330	(a)
	ETf	Exposure time fraction (unitless)	-	(g)
	EF	Exposure Frequency (days/year)	125	(b)
	ED	Exposure Duration (years)	0.5/1	(c)
	BW	Body Weight (kg)	70	(j)
	AT_{nc}	Averaging Time for Noncarcinogens (days)	183/365	(d)
	AT_c	Averaging Time for Carcinogens (days)	25,550	(e)
	CF	Unit Conversion Factor (kg/mg)	1E-06	-
Dermal Contact with Sediment	SA	Skin Surface Area Exposed (cm^2)	3,300	(f)
	SSAF	Soil-to-Skin Adherence Factor (mg/cm^2-event)	0 3	(a)
	ABSd	Dermal absorption fraction (unitless)	chemical-specific	(i)
	EV	Number of events (events/day)	1	(h)
	EF	Exposure Frequency (days/year)	125	(b)
	ED	Exposure Duration (years)	0 5/1	(c)
	BW	Body Weight (kg)	70	(j)
	AT_{nc}	Averaging Time for Noncarcinogens (days)	183/365	(d)
	AT_c	Averaging Time for Carcinogens (days)	25,550	(e)
	CF	Unit Conversion Factor (kg/mg)	1E-06	-

Notes:

(a) There are no USEPA default values for exposure to sediments by construction workers. Therefore, the USEPA (2002) default values for soil ingestion and soil-to-skin adherence factor for construction workers (Equation 5-1) will be used UDEQ DSHW has accepted the use of these values for construction workers exposed to sediments at other RCRA sites in Utah.

(b) This is the UDEQ (2008) default value.

(c) Risks for construction workers piping the canal will be calculated twice, using two different exposure durations. An ED of 6 months is the UDEQ (2005) default value, which overestimates the duration that will be required to pipe the 930-foot long portion of the canal. An ED of 1 year is the UDEQ (2012) default value.

(d) The USEPA (1989) default approach for averaging time for noncarcinogens (ATn) is the exposure duration expressed in days.

(e) The USEPA (1989) default approach for averaging time for carcinogens (ATc) is the exposure duration expressed in days.

(f) There are no USEPA default values for exposure to sediments by construction workers. Therefore, the USEPA (2002) default value for skin surface area for exposure of construction workers to soil (Equation 5-1) will be used, which assumes that the face, forearms, and hands are exposed. UDEQ DSHW has accepted the use of this value for construction workers exposed to sediments at other RCRA sites in Utah.

(g) An ETf value is not needed to calculate intake for the construction worker scenario because the units for sediment ingestion rate are milligrams of sediment ingested per work day (330 mg/day).

(h) This is the USEPA (2004) default value for soil (Exhibit 3-5).

(i) Chemical-specific default values for ABSd will be obtained from Exhibit 3-4 in USEPA (2004) .

(j) This is the USEPA (2002) default value (Equation 5-1)

cm^2 = centimeters squared
kg = kilogram
kg/mg = kilogram per milligram
mg/cm^2 = milligrams per centimeter squared
mg/day = milligrams per day
RME = Reasonable Maximum Exposure.
USEPA = U.S. Environmental Protection Agency
UDEQ = Utah Department of Environmental Quality

Sources:

Utah Department of Environmental Quality (UDEQ). 2005. Correspondence from Chris Bittner (UDEQ risk assessor) to William Ruoff (URS Corporation risk assessor) in May 2005.

UDEQ 2008. Correspondence from Chris Bittner (UDEQ risk assessor) to William Ruoff (URS Corporation risk assessor) on January 17, 2008

UDEQ 2012. Value provided by UDEQ (personal communication between Eric Baiden, UDEQ risk assessor and William Ruoff, URS Corporation risk assessor, March 2012.

U.S. Environmental Protection Agency (USEPA). 1989. Risk Assessment Guidance for Superfund. Volume I - Human Health Evaluation Manual. Part A. Interim Final. Office of Emergency and Remedial Response, Washington, D.C. December.

USEPA 2002. Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites OSWER 9355.4-24 March.

USEPA 2004. Risk Assessment Guidance for Superfund. Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment). Final. July.

Table 3-14
Exposure Factors
Future Construction Worker Exposed to Surface Water
Vertellus - Provo, Utah

Exposure Pathway	Parameter	Description	Exposure Parameters	
			RME	Source
Incidental Surface Water Ingestion	SWIR	Surface Water Ingestion Rate (L/hour)	0.005	(a)
	ET	Exposure Time (hour/day)	1	(b)
	EF	Exposure Frequency (days/year)	125	(c)
	ED	Exposure Duration (years)	0 5/1	(d)
	BW	Body Weight (kg)	70	(e)
	AT_{nc}	Averaging Time for Noncarcinogens (days)	183/365	(f)
	AT_c	Averaging Time for Carcinogens (days)	25,550	(g)
Dermal Contact with Surface Water	SA	Skin Surface Area Exposed (cm^2)	3,300	(i)
	ET	Exposure Time (hour/day)	1	(b)
	PC	Permeability Constanct (cm/hour)	chemical-specific	(h)
	CF	Conversion Factor (cm^3/L)	1000	-
	EF	Exposure Frequency (days/year)	125	(c)
	ED	Exposure Duration (years)	0 5/1	(d)
	BW	Body Weight (kg)	70	(e)
	AT_{nc}	Averaging Time for Noncarcinogens (days)	183/365	(f)
	AT_c	Averaging Time for Carcinogens (days)	25,550	(g)

Notes:

(a) Professional judgement was used to derive this value, which is considered to be a high-end value that is unlikley to be exceeded. Assuming that incidental ingestion of groundwater from accidental splashing or hand-to-face contact while working might result in a very small amount of water in or near the mouth, but that most would be removed by wiping or spitting, 5 mL/hour was assumed for the remaining amount actually ingested UDEQ DSHW has accepted the use of this value for construction workers piping a canal at other RCRA sites in Utah USEPA Region 8 has used this value for construction workers exposed to surface water See additional discussion in Section 3 1.8

(b) Professional judgement was used to derive this value, which is considered to be a high-end value that is unlikley to be exceeded Assumes that construction workers will be in contact with surface water in the canal for approximately 1 hour/day UDEQ DSHW has accepted the use of this value for construction workers piping a canal at other RCRA sites in Utah

(c) This is the UDEQ (2008) default value

(d) Risks for construction workers piping the canal will be calculated twice, using two different exposure durations An ED of 6 months is the UDEQ (2005) default value, which overestimates the duration that will be required to pipe the 930-foot long portion of the canal An ED of 1 year is the UDEQ (2012) default.

(e) This is the USEPA (2002) default value (Equation 5-1).

(f) The USEPA (1989) default approach for averaging time for noncarcinogens (ATn) is the exposure duration expressed in days

(g) The USEPA (1989) default approach for averaging time for carcinogens (ATc) is the exposure duration expressed in days.

(h) Chemical-specific default values for PC will be obtained from Exhibit B-2 in USEPA (2004)

(i) There are no USEPA default values for exposure to surface water by construction workers Therefore, the USEPA (2002) default value for skin surface area for exposure of construction workers to soil (Equation 5-1) will be used, which assumes that the face, forearms, and hands are exposed UDEQ DSHW has accepted the use of this value for construction workers piping a canal at other RCRA sites in Utah

cm^2 = squared centimeters
cm^3/L = cubed centimeters per liter
cm/hour = centimeters per hour
DSHW = Department of Solid and Hazardous Waste
kg = kilograms
L/hour = Liters per hour
mL/hour = milliliters per hour
RCRA = Resource Conservation and Recovery Act
RME = Reasonable Maximum Exposure
USEPA = U S Environmental Protection Agency
UDEQ = Utah Department of Environmental Quality

Sources:

Utah Department of Environmental Quality (UDEQ). 2005 Correspondence from Chris Bittner (UDEQ risk assessor) to William Ruoff (URS Corporation risk assessor) in May 2005

UDEQ. 2008 Correspondence from Chris Bittner (UDEQ risk assessor) to William Ruoff (URS Corporation risk assessor) on January 17,

UDEQ 2012 Value provided by UDEQ (personal communication between Eric Baiden, UDEQ risk assessor and William Ruoff, URS Corporation risk assessor, March 2012).

U S Environmental Protection Agency (USEPA) 1989 Risk Assessment Guidance for Superfund Volume I - Human Health Evaluation Manual Part A. Interim Final Office of Emergency and Remedial Response, Washington, D C December

USEPA. 2002 Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites OSWER 9355 4-24 March

USEPA 2004 Risk Assessment Guidance for Superfund Volume I Human Health Evaluation Manual, Part E, Supplemental Guidance for Dermal Risk Assessment. EPA/540/R/99/005, OSWER 9285.7-02EP, PB99-963312 July.

Table 3-15
Exposure Factors
Construction Worker Exposed to Soil
Vertellus - Provo, Utah

Exposure Pathway	Parameter	Description	Exposure Parameters	
			RME	Source
Incidental Soil Ingestion	SIR	Soil Ingestion Rate (mg/day)	330	(a)
	ETf	Exposure time fraction (unitless)	-	(j)
	EF	Exposure Frequency (days/year)	125	(b)
	ED	Exposure Duration (years)	1	(c)
	BW	Body Weight (kg)	70	(a)
	AT_{nc}	Averaging Time for Noncarcinogens (days)	365	(d)
	AT_c	Averaging Time for Carcinogens (days)	25,550	(e)
	CF	Unit Conversion Factor (kg/mg)	1E-06	-
Dermal Contact with Soil	SA	Skin Surface Area Exposed (cm^2)	3,300	(g)
	SSAF	Soil-to-Skin Adherence Factor (mg/cm^2-event)	0.3	(a)
	ABSd	Dermal absorption fraction (unitless)	chemical-specific	(l)
	EV	Number of events (events/day)	1	(k)
	EF	Exposure Frequency (days/year)	125	(b)
	ED	Exposure Duration (years)	1	(c)
	BW	Body Weight (kg)	70	(a)
	AT_{nc}	Averaging Time for Noncarcinogens (days)	365	(d)
	AT_c	Averaging Time for Carcinogens (days)	25,550	(e)
	CF	Unit Conversion Factor (kg/mg)	1E-06	-
Inhalation of Particulates	ET	Exposure Time (hour/day)	8	(m)
	EF	Exposure Frequency (days/year)	125	(b)
	ED	Exposure Duration (years)	1	(c)
	PEF	Particulate Emission Factor (m^3/kg)	1.00E+06	(f)
	AT_{nc}	Averaging Time for Noncarcinogens (hours)	8,760	(h)
	AT_c	Averaging Time for Carcinogens (hours)	613,200	(i)

Notes:

(a) This is the USEPA (2002) default value (Equation 5-1).

(b) This is the UDEQ (2008) default value.

(c) This is the UDEQ (2012) default value

(d) The USEPA (1989) default approach for averaging time for noncarcinogens (ATn) is the exposure duration expressed in days.

(e) The USEPA (1989) default approach for averaging time for carcinogens (ATc) is the exposure duration expressed in days.

(f) PEF associated with the approximate air concentration of visible dust (1 ug/m^3). UDEQ DSHW has accepted the use of this PEF value at other RCRA sites in Utah. It is also the CalEPA (2011) default PEF value for construction worker scenarios

(g) This is the USEPA (2002) default value (Equation 5-1), which assumes that the face, forearms, and hands are exposed.

(h) The USEPA (2009) default approach for averaging time for noncarcinogens (ATn) is the exposure duration expressed in hours.

(i) The USEPA (2009) default approach for averaging time for carcinogens (ATc) is the exposure duration expressed in hours.

(j) An ETf value is not needed to calculate intake for the construction worker scenario because the units for soil ingestion rate are milligrams of soil ingested per work day (330 mg/day).

(k) This is the USEPA (2004) default value (Exhibit 3-5).

(l) Chemical-specific default values for ABSd will be obtained from Exhibit 3-4 in USEPA (2004).

(m) Typical exposure time used for construction workers. Also recommended in Section 6.3 of USEPA (2009).

CalEPA = California Environmental Protection Agency

cm^2 = centimeters squared

DSHW = Division of Solid and Hazardous Waste

kg = kilogram

kg/mg = kilogram per milligram

m3/kg = meters cubed per kilogram

mg/cm^2 = milligrams per centimeter squared

mg/day = milligrams per day

PEF = Particulate emission factor

RCRA = Resource Conservation and Recovery Act

RME = Reasonable Maximum Exposure.

UDEQ = Utah Department of Environmental Quality

USEPA = U.S. Environmental Protection Agency

Table 3-15
Exposure Factors
Construction Worker Exposed to Soil
Vertellus - Provo, Utah

Sources:

California Environmental Protection Agency (CalEPA). 2011 Human Health Risk Assessment (HHRA) Note HERO HHRA Note Number · 1. Recommended DTSC Default Exposure Factors for Use in Risk Assessment at California Hazardous Waste Sites and Permitted Facilities. May 20

Utah Department of Environmental Quality (UDEQ) 2008 Correspondence from Chris Bittner (UDEQ risk assessor) to William Ruoff (URS Corporation risk assessor) on January 17, 2008

UDEQ. 2012. Value provided by UDEQ (personal communication between Eric Baiden, UDEQ risk assessor and William Ruoff, URS Corporation risk assessor, March 2012).

U.S. Environmental Protection Agency (USEPA). 1989. Risk Assessment Guidance for Superfund: Volume I - Human Health Evaluation Manual. Part A. Interim Final. Office of Emergency and Remedial Response, Washington, D.C. December.

USEPA. 2002. Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites. OSWER 9355.4-24. March.

USEPA. 2004. Risk Assessment Guidance for Superfund Volume I· Human Health Evaluation Manual, Part E, Supplemental Guidance for Dermal Risk Assessment. EPA/540/R/99/005, OSWER 9285.7-02EP, PB99-963312. July.

USEPA. 2009. Risk Assessment Guidance for Superfund. Volume I: Human Health Evaluation Manual. (Part F, Supplemental Guidance for Inhalation Risk Assessment). USEPA-540-R-070-002 January.

Table 3-16
Exposure Factors
Construction Worker Exposed to Groundwater
Vertellus - Provo, Utah

Exposure Pathway	Parameter	Description	Exposure Parameters	
			RME	Source
Incidental Groundwater Ingestion	GWIR	Groundwater Ingestion Rate (L/hour)	0.005	(a)
	ET	Exposure Time (hour/day)	1	(b)
	EF	Exposure Frequency (days/year)	45	(c)
	ED	Exposure Duration (years)	1	(d)
	BW	Body Weight (kg)	70	(e)
	AT_{nc}	Averaging Time for Noncarcinogens (days)	365	(f)
	AT_c	Averaging Time for Carcinogens (days)	25,550	(g)
Dermal Contact with Groundwater	SA	Skin Surface Area Exposed (cm^2)	3,300	(k)
	ET	Exposure Time (hour/day)	1	(b)
	PC	Permeability Constanct (cm/hour)	chemical-specific	(h)
	CF	Conversion Factor (cm^3/L)	1000	-
	EF	Exposure Frequency (days/year)	45	(c)
	ED	Exposure Duration (years)	1	(d)
	BW	Body Weight (kg)	70	(e)
	AT_{nc}	Averaging Time for Noncarcinogens (days)	365	(f)
	AT_c	Averaging Time for Carcinogens (days)	25,550	(g)
Inhalation of VOCs from Groundwater	ET	Exposure Time (hour/day)	1	(b)
	EF	Exposure Frequency (days/year)	45	(c)
	ED	Exposure Duration (years)	1	(d)
	VF	Volatilization Factor (L/m^3)	chemical-specific	Calculated
	AT_{nc}	Averaging Time for Noncarcinogens (hours)	8,760	(i)
	AT_c	Averaging Time for Carcinogens (hours)	613,200	(j)

Notes:

(a) Professional judgement was used to derive this value, which is considered to be a high-end value that is unlikley to be exceeded. Assuming that incidental ingestion of groundwater from accidental splashing or hand-to-face contact while working might result in a very small amount of water in or near the mouth, but that most would be removed by wiping or spitting, 5 mL/hour was assumed for the remaining amount actually ingested. UDEQ DSHW has accepted the use of this value for trench worker scenarios at other RCRA sites in Utah. See Section 3 1 8 for additional discussion of the derivation and use of this value

(b) Professional judgement was used to derive this value, which is considered to be a high-end value that is unlikley to be exceeded. Assumes that construction workers will be in contact with groundwater in a trench for about 1 hour/day UDEQ DSHW has accepted the use of this value for trench worker scenarios at other RCRA sites in Utah

(c) This value has been adopted by the Indiana Department of Environmental Quality and used in the USEPA Region 5 RCRA Program. The specific rational for the derivation of this value was not determined. UDEQ DSHW has accepted the use of this value for trench worker scenarios at other RCRA sites in Utah.

(d) This is the UDEQ (2012) default value Construction activities are assumed to occur over a 1 year period

(e) This is the USEPA (2002) default value (Equation 5-1).

(f) The USEPA (1989) default approach for averaging time for noncarcinogens (ATn) is the exposure duration expressed in days.

(g) The USEPA (1989) default approach for averaging time for carcinogens (ATc) is the exposure duration expressed in days.

(h) Chemical-specific default values for PC will be obtained from Exhibit B-2 in USEPA (2004).

(i) The USEPA (2009) default approach for averaging time for noncarcinogens (ATn) is the exposure duration expressed in hours.

(j) The USEPA (2009) default approach for averaging time for carcinogens (ATc) is the exposure duration expressed in hours.

(k) There are no USEPA default values for exposure to groundwater by construction workers Therefore, the USEPA (2002) default value for skin surface area for exposure of construction workers to soil (Equation 5-1) will be used, which assumes that the face, forearms, and hands are exposed. UDEQ DSHW has accepted the use of this value for trench workers at other RCRA sites in Utah.

cm^2 = squared centimeters

cm^3/L = cubed centimeters per liter

cm/hour - centimeters per hour

DSHW = Division of Solid and Hazardous Waste

kg = kilograms

L/hour = liters per hour

L/m^3 = liters per cubed meter

mL/hour = milliliters per hour

RCRA = Resource Conservation and Recovery Act

RME = Reasonable Maximum Exposure

UDEQ = Utah Department of Environmental Quality

USEPA = U.S. Environmental Protection Agency

VOC = Volatile organic compound

Table 3-16
Exposure Factors
Construction Worker Exposed to Groundwater
Vertellus - Provo, Utah

Sources:

Utah Department of Environmental Quality (UDEQ). 2012. Value provided by UDEQ (personal communication between Eric Baiden, UDEQ risk assessor and William Ruoff, URS Corporation risk assessor, March 2012).

U S. Environmental Protection Agency (USEPA). 1989. Risk Assessment Guidance for Superfund: Volume I - Human Health Evaluation Manual. Part A. Interim Final. Office of Emergency and Remedial Response, Washington, D.C. December.

USEPA. 2002 Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites. OSWER 9355.4-24 March.

USEPA. 2004. Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual, Part E, Supplemental Guidance for Dermal Risk Assessment. EPA/540/R/99/005, OSWER 9285.7-02EP, PB99-963312. July.

USEPA. 2009. Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part F, Supplemental Guidance for Inhalation Risk Assessment). USEPA-540-R-070-002 January

Table 3-17
Exposure Factors
Indoor Worker Exposed to Surface Soil
Vertellus - Provo, Utah

Exposure Pathway	Parameter	Description	Exposure Parameters	
			RME	Source
Incidental Soil Ingestion	SIR	Soil Ingestion Rate (mg/day)	50	(a)
	ETf	Exposure time fraction (unitless)	-	(j)
	EF	Exposure Frequency (days/year)	250	(a)
	ED	Exposure Duration (years)	25	(a)
	BW	Body Weight (kg)	70	(a)
	AT_{nc}	Averaging Time for Noncarcinogens (days)	9,125	(b)
	AT_c	Averaging Time for Carcinogens (days)	25,550	(c)
	CF	Unit Conversion Factor (kg/mg)	1E-06	-
Dermal Contact with Soil	SA	Skin Surface Area Exposed (cm^2)	3,300	(d)
	SSAF	Soil-to-Skin Adherence Factor (mg/cm^2-event)	0 2	(e)
	ABSd	Dermal absorption fraction (unitless)	chemical-specific	(l)
	EV	Number of events (events/day)	1	(k)
	EF	Exposure Frequency (days/year)	250	(a)
	ED	Exposure Duration (years)	25	(a)
	BW	Body Weight (kg)	70	(a)
	AT_{nc}	Averaging Time for Noncarcinogens (days)	9,125	(b)
	AT_c	Averaging Time for Carcinogens (days)	25,550	(c)
	CF	Unit Conversion Factor (kg/mg)	1E-06	-
Inhalation of Particulates	ET	Exposure Time (hour/day)	8	(f)
	EF	Exposure Frequency (days/year)	250	(a)
	ED	Exposure Duration (years)	25	(a)
	PEF	Particulate Emission Factor (m^3/kg)	1.32E+09	(g)
	AT_{nc}	Averaging Time for Noncarcinogens (hours)	219,000	(h)
	AT_c	Averaging Time for Carcinogens (hours)	613,200	(i)

Notes:

(a) This is the USEPA (1991) default value (Summary of Standard Default Exposure Factor Tables, p.15)

(b) The USEPA (1989) default approach for averaging time for noncarcinogens (ATn) is the exposure duration expressed in days.

(c) The USEPA (1989) default approach for averaging time for carcinogens (ATc) is the exposure duration expressed in days.

(d) This is the USEPA (2004) default value (Exhibit 3-5), which assumes that the face, forearms, and hands are exposed.

(e) This is the USEPA (2004) default value (Exhibit 3-5)

(f) Typical exposure time used for indoor workers. Also recommended in Section 6.2 of USEPA (2009).

(g) This is the USEPA (1996) default value (Equation 5, p 23)

(h) The USEPA (2009) default approach for averaging time for noncarcinogens (ATn) is the exposure duration expressed in hours.

(i) The USEPA (2009) default approach for averaging time for carcinogens (ATc) is the exposure duration expressed in hours.

(j) An ETf value is not needed to calculate intake for the indoor worker scenario because the units for soil ingestion rate are milligrams of soil ingested per work day (50 mg/day).

(k)This is the USEPA (2004) default value (Exhibit 3-5).

(l) Chemical-specific default values for ABSd will be obtained from Exhibit 3-4 in USEPA (2004).

cm^2 = centimeters squared

kg = kilogram

kg/mg = kilogram per milligram

m3/kg = meters cubed per kilogram

mg/cm^2 = milligrams per centimeter squared

mg/day = milligrams per day

RME = Reasonable Maximum Exposure.

Sources:

U.S. Environmental Protection Agency (USEPA). 1989. Risk Assessment Guidance for Superfund. Volume I - Human Health Evaluation Manual. Part A. Interim Final. Office of Emergency and Remedial Response, Washington, D.C December

USEPA 1991 Human Health Evaluation Manual, Supplemental Guidance, Standard Default Exposure Factors. Office of Emergency and Remedial Response, Washington, DC. March.

USEPA. 1996. Soil Screening Guidance. User's Guide. Publication 9355.4-23 July

USEPA 2004. Risk Assessment Guidance for Superfund Volume I· Human Health Evaluation Manual, Part E, Supplemental Guidance for Dermal Risk Assessment. EPA/540/R/99/005, OSWER 9285.7-02EP, PB99-963312. July.

USEPA 2009. Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual. (Part F, Supplemental Guidance for Inhalation Risk Assessment). USEPA-540-R-070-002. January.

Table 3-18
Exposure Factors
Indoor Worker Exposed to Indoor Air
Vertellus - Provo, Utah

Exposure Pathway	Parameter	Description	Exposure Parameters	
			RME	Source
Inhalation of VOCs from Groundwater	ET	Exposure Time (hour/day)	8	(a)
	EF	Exposure Frequency (days/year)	250	(b)
	ED	Exposure Duration (years)	25	(b)
	AT_{nc}	Averaging Time for Noncarcinogens (hours)	219,000	(c)
	AT_c	Averaging Time for Carcinogens (hours)	613,200	(d)

Notes:

(a) Typical exposure time used for indoor workers. Also recommended in Section 6.2 of USEPA (2009).

(b) This is the USEPA (1991) default value (Summary of Standard Default Exposure Factor Tables, p.15).

(c) The USEPA (2009) default approach for averaging time for noncarcinogens (ATn) is the exposure duration expressed in hours.

(d) The USEPA (2009) default approach for averaging time for carcinogens (ATc) is the exposure duration expressed in hours.

RME = Reasonable Maximum Exposure
VOC = Volatile organic compound

Sources:

U.S. Environmental Protection Agency (USEPA). 1991. Human Health Evaluation Manual, Supplemental Guidance, Standard Default Exposure Factors. Office of Emergency and Remedial Response, Washington, DC March.

USEPA 2009. Risk Assessment Guidance for Superfund. Volume I: Human Health Evaluation Manual. (Part F, Supplemental Guidance for Inhalation Risk Assessment). USEPA-540-R-070-002. January.

Table 3-19
Exposure Factors
Maintenance Worker Exposed to Surface Soil
Vertellus - Provo, Utah

Exposure Pathway	Parameter	Description	Exposure Parameters	
			RME	Source
Incidental Soil Ingestion	SIR	Soil Ingestion Rate (mg/day)	100	(a)
	ETf	Exposure time fraction (unitless)	-	(k)
	EF	Exposure Frequency (days/year)	12	(b)
	ED	Exposure Duration (years)	25	(c)
	BW	Body Weight (kg)	70	(c)
	AT_{nc}	Averaging Time for Noncarcinogens (days)	9,125	(d)
	AT_c	Averaging Time for Carcinogens (days)	25,550	(e)
	CF	Unit Conversion Factor (kg/mg)	1E-06	-
Dermal Contact with Soil	SA	Skin Surface Area Exposed (cm^2)	3,300	(c)
	SSAF	Soil-to-Skin Adherence Factor (mg/cm^2-event)	0 1	(g)
	ABSd	Dermal absorption fraction (unitless)	chemical-specific	(m)
	EV	Number of events (events/day)	1	(l)
	EF	Exposure Frequency (days/year)	12	(b)
	ED	Exposure Duration (years)	25	(c)
	BW	Body Weight (kg)	70	(c)
	AT_{nc}	Averaging Time for Noncarcinogens (days)	9,125	(d)
	AT_c	Averaging Time for Carcinogens (days)	25,550	(e)
	CF	Unit Conversion Factor (kg/mg)	1E-06	-
Inhalation of Particulates	ET	Exposure Time (hour/day)	8	(f)
	EF	Exposure Frequency (days/year)	12	(b)
	ED	Exposure Duration (years)	25	(c)
	BW	Body Weight (kg)	70	(c)
	PEF	Particulate Emission Factor (m^3/kg)	1.32E+09	(h)
	AT_{nc}	Averaging Time for Noncarcinogens (days)	219,000	(i)
	AT_c	Averaging Time for Carcinogens (days)	613,200	(j)

Notes:

(a) This is the USEPA default value for outdoor workers (USEPA 2012). Table 1. Standard Default Values

(b) Professional judgement was used to derive this value, which is considered to be a high-end value that is unlikley to be exceeded. Based on a conservative assumption of 1 day/month which was previously approved by UDEQ for U.S. Steel's Ironton facility and other RCRA sites in Utah.

(c) USEPA (2002) default values for outdoor workers (Exhibit 1-2).

(d) The USEPA (1989) default approach for averaging time for noncarcinogens (ATn) is the exposure duration expressed in days.

(e) The USEPA (1989) default approach for averaging time for carcinogens (ATc) is the exposure duration expressed in days.

(f) Typical exposure time used for workers.

(g) 95th percentile value for a groundskeeper (Exhibit 3-3, USEPA 2004). UDEQ DSHW has accepted the use of this value for maintenance workers exposed to soil at other RCRA sites in Utah

(h) This is the USEPA (1996) default value (Equation 5, p. 23).

(i) The USEPA (2009) default approach for averaging time for noncarcinogens (ATn) is the exposure duration expressed in hours.

(j) The USEPA (2009) default approach for averaging time for carcinogens (ATc) is the exposure duration expressed in hours.

(k) An ETf value is not needed to calculate intake for the maintenance worker scenario because the units for soil ingestion rate are milligrams of soil ingested per work day (100 mg/day)

(l) This is the USEPA (2004) default value (Exhibit 3-5).

(m) Chemical-specific default values for ABSd will be obtained from Exhibit 3-4 in USEPA (2004) .

cm^2 = centimeters squared
DSHW = Division of Solid and Hazardous Waste
kg = kilogram
kg/mg = kilogram per milligram
m3/kg = meters cubed per kilogram
mg/cm^2 = milligrams per centimeter squared
mg/day = milligrams per day
RCRA = Resource and Conservation Recovery Act
RME = Reasonable Maximum Exposure.
UDEQ = Utah Department of Environmental Quality
USEPA = U.S. Environmental Protection Agency

Table 3-19
Exposure Factors
Maintenance Worker Exposed to Surface Soil
Vertellus - Provo, Utah

Sources:

U S Environmental Protection Agency (USEPA). 1989. Risk Assessment Guidance for Superfund: Volume I - Human Health Evaluation Manual. Part A. Interim Final Office of Emergency and Remedial Response, Washington, D C. December.

USEPA. 1996. Soil Screening Guidance. User's Guide Publication 9355.4-23 July.

USEPA 2002. Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites. OSWER 9355.4-24. March

USEPA. 2004 Risk Assessment Guidance for Superfund Volume I Human Health Evaluation Manual, Part E, Supplemental Guidance for Dermal Risk Assessment EPA/540/R/99/005, OSWER 9285.7-02EP, PB99-963312 July.

USEPA. 2009. Risk Assessment Guidance for Superfund. Volume I: Human Health Evaluation Manual. (Part F, Supplemental Guidance for Inhalation Risk Assessment). USEPA-540-R-070-002 January.

USEPA. 2012. Regional Screening Level Table. Users Guide May

Table 3-20
Parameter Values for Dermal Exposure
Vertellus - Provo, Utah

COPC	ABSd	Source	PC	Primary Source[5]	Secondary Source[5]
	unitless		cm/hour		
2,4-Dimethylphenol	1.00E-01	(1)	1.10E-01	RAGs E	NA
2-Chlorophenol		(2)	8.00E-03	RAGs E	NA
2-Methylnaphthalene		(2)	9.17E-02	EPI	EPA RSL
2-Methylphenol	1.00E-01	(1)	7.70E-03	RAGs E	NA
3&4-Methylphenol	1.00E-01	(1)	7.80E-03	RAGs E	NA
Acenaphthene	1.30E-01	(3)	8.60E-02	EPI	EPA RSL
Acenaphthylene	1.30E-01	(3)	9.11E-02	EPI	ORNL RAIS
Acetone		(2)	5.12E-04	EPI	EPA RSL
Anthracene	1.30E-01	(3)	1.42E-01	EPI	EPA RSL
Benzene		(2)	1.50E-02	RAGs E	NA
Benzenethiol		(2)	1.78E-02	EPI	EPA RSL
Benzo(a)anthracene	1.30E-01	(3)	4.70E-01	RAGs E	NA
Benzo(a)pyrene	1.30E-01	(3)	7.00E-01	RAGs E	NA
Benzo(b)fluoranthene	1.30E-01	(3)	7.00E-01	RAGs E	NA
Benzo(g,h,i)perylene	1.30E-01	(3)	1.12E+00	EPI	ORNL RAIS
Benzo(k)fluoranthene	1 30E-01	(3)	6.91E-01	EPI	EPA RSL
Carbazole	1 30E-01	NV	-	NA	NA
Carbon disulfide		(2)	1 70E-02	RAGs E	NA
Chloroform		(2)	-	NA	NA
Chrysene	1.30E-01	(3)	4 70E-01	RAGs E	NA
Cyanide, Total		(4)	1.00E-03	RAGs E	Default value for inorganics
Dibenz(a,h)anthracene	1.30E-01	(3)	1 50E+00	RAGs E	NA
Dibenzofuran		(2)	9.75E-02	EPI	ORNL RAIS
Ethylbenzene		(2)	4.90E-02	RAGs E	NA
Fluoranthene	1 30E-01	(3)	2.20E-01	RAGs E	NA
Fluorene	1.30E-01	(3)	1.10E-01	EPI	EPA RSL
Indeno(1,2,3-c,d)pyrene	1.30E-01	(3)	1.00E+00	RAGs E	NA
Methyl ethyl ketone		(2)	9.60E-04	RAGs E	NA
Methylene bromide		(2)	-	NA	NA
Methylene chloride		(2)	3 50E-03	RAGS E	NA
Naphthalene		(2)	4.70E-02	RAGs E	NA
Phenanthrene	1.30E-01	(3)	1.40E-01	RAGs E	NA
Phenol	1.00E-01	(1)	4.30E-03	RAGs E	NA
Pyrene	1.30E-01	(3)	2.01E-01	EPI	EPA RSL
Resorcinol	1.00E-01	(1)	-	NA	NA
Toluene		(2)	3.10E-02	RAGs E	NA
Xylenes (Total)		(2)	5.00E-02	EPI	EPA RSL

Notes:

[1] USEPA (2004) default value for SVOCs

[2] USEPA (2004) does not recommend calculating risk for absorption on VOCs from soil

[3] USEPA (2004) default value for PAHs

[4] USEPA (2004) does not recommend calculating risk from absorption of inorganics from soil (except for arsenic and cadmium which are not COPCs)

[5] PC values were obtained from USEPA (2004), USEPA (2012), or ORNL (2013). USEPA (2012) and ORNL (2013) PC values were from USEPA (2013)

- = Chemical is not a COPC in groundwater or surface water
ABSd = Dermal absorption fraction
cm/hour = Centimeters per hour
COPC = Chemical of potential concern
EPA RSL = PC value from EPI was obtained from USEPA (2012)
EPI = Estimation Programs Interface (USEPA 2013)
NA = Not applicable
ORNL RAIS = PC value from EPI was obtained from ORNL (2013)
PAH = Polyaromatic hydrocarbons

Table 3-20
Parameter Values for Dermal Exposure
Vertellus - Provo, Utah

PC = Permeability constant
RAGs E = PC value was obtained from Table B-2 in USEPA (2004)
SVOC = Semivolatile organic compounds
VOC = Volatile organic compounds

Oak Ridge National Laboratories (ORNL). 2013. The Risk Assessment Information System (RAIS) Online database: http://rais.ornl.gov/

U.S Environmental Protection Agency (USEPA). 2004. Risk Assessment Guidance for Superfund. Volume I. Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment). Final July.

U.S. Environmental Protection Agency (USEPA). 2012 USEPA Master Regional Screening Level (RSL) Table. November. Online at: http://www epa gov/region9/superfund/prg/.

U S. Environmental Protection Agency (USEPA). 2013. Exposure Assessment Tools and Models. Estimation Program Interface (EPI) Suite. Online at. http.//www.epa.gov/oppt/exposure/pubs/episuite.htm

Table 3-21
Oral and Dermal Toxicity Values[1]
Vertellus - Provo, Utah

COPC	Chronic RfD_o/RfD_{abs}	Source[2]	Subchronic RfD_o/RfD_{abs}	Source[3]	SF_o/SF_{abs}	Source[2]
	mg/kg-day		mg/kg-day		kg-day/mg	
2,4-Dimethylphenol	2.00E-02	I	5.00E-02	P		
2-Chlorophenol	5.00E-03	I				
2-Methylnaphthalene	4.00E-03	I	4 00E-03	P		
2-Methylphenol	5.00E-02	I				
3&4-Methylphenol	5.00E-02	I(4)				
Acenaphthene	6 00E-02	I	2 00E-01	P		
Acenaphthylene	6.00E-02	S				
Acetone	9.00E-01	I				
Anthracene	3.00E-01	I				
Benzene	4.00E-03	I	1.00E-02	P	5.50E-02	I
Benzenethiol	1.00E-03	P	1 00E-02	P		
Benzo(a)anthracene					7.30E-01	E
Benzo(a)pyrene					7.30E+00	I
Benzo(b)fluoranthene					7.30E-01	E
Benzo(g,h,i)perylene	3 00E-02	S				
Benzo(k)fluoranthene					7.30E-02	E
Carbazole						
Carbon disulfide	1.00E-01	I				
Chloroform	1.00E-02	I			3.10E-02	C
Chrysene					7.30E-03	E
Cyanide, Total	6 00E-04	I	5.00E-02	A		
Dibenz(a,h)anthracene					7.30E+00	E
Dibenzofuran	1.00E-03	X	4.00E-03	P		
Ethylbenzene	1.00E-01	I			1.10E-02	C
Fluoranthene	4 00E-02	I	1 00E-01	P		
Fluorene	4.00E-02	I	4.00E-01	H		
Indeno(1,2,3-c,d)pyrene					7.30E-01	E
Methyl ethyl ketone	6 00E-01	I				
Methylene bromide	1 00E-02	H				
Methylene chloride	6.00E-03	I			2 00E-03	I
Naphthalene	2.00E-02	I	6.00E-01	A		
Phenanthrene	3.00E-01	S				
Phenol	3.00E-01	I				
Pyrene	3.00E-02	I	3.00E-01	P		
Resorcinol	2 00E+00	T				
Toluene	8.00E-02	I				
Xylenes (Total)	2 00E-01	I				

Notes:

[1]COPCs at the site do not require adjustment of oral toxicity values to derive dermal toxicity values. Therefore, $RfD_o = RfD_{abs}$ and $SF_o = SF_{abs}$

[2]Secondary source for all chronic RfDs and SFs (except for resorcinol) was the USEPA (2012) RSL tables. Primary sources are listed in the Source columns in the table.

[3]Primary sources for subchronic RfDs were the provisional peer reviewed toxicity value database (USEPA 2013a), Agency for Toxic Substances and Disease Registry Minimum Risk Levels (ATSDR 2013), and the Health Effects Assessment Summary Tables (USEPA 1997)

[4]The RfD for 3-methylphenol was used to evaluate 3,4-methylphenol

C = California Environmental Protection Agency Toxicity Criteria (Cal/EPA 2013)
COPC = Chemical of potential concern
E = Environmental Criteria and Assessment Office toxicity value
H = Health Effects Assessment Summary Tables toxicity value (USEPA 1997)
I = Integrated Risk Information System toxicity value (USEPA 2013b)
kg-day/mg = kilogram-day per milligram
mg/kg-day = milligram per kilogram-day
P = Provisional peer reviewed toxicity value
RfD = Oral and dermal reference dose

Table 3-21
Oral and Dermal Toxicity Values[1]
Vertellus - Provo, Utah

S = Surrogate: RfDs for acenaphthene, pyrene, and anthracene were used as RfDs for acenaphthylene, benzo(g,h,i)perylene, and phenanathrene, respectively
SF = Oral and dermal slope factor
T = TERA
X = Provisional peer reviewed toxicity value appendix (USEPA 2013a)

Agency for Toxic Substances and Disease Registry (ATSDR) 2013 Minimum Risk Levels (MRLs) for Hazardous Substances December. Online at: http://www.atsdr.cdc.gov/mrls/index.asp.
California Environmental Protection Agency (CalEPA). 2013. Toxicity Criteria Database.
Office of Environmental Health Hazard Assessment. Online at. http://www.oehha.ca.gov/risk/ChemicalDB/index.asp
Toxicology Excellence for Risk Assessment (TERA). 2005 Description of a Proposed Reference Dose. Resorcinol. Prepared for Review by the Resorcinol Peer Review Panel Toxicology Excellence for Risk Assessment Prepared by AMEC Earth and Environmental, Inc. March 2005. Available online at: http://www.tera org/iter/Revised_Resorcinol%20RfD_032805.pdf
U S. Environmental Protection Agency (USEPA). 1997. Health Effects Assessment Summary Table (HEAST) - FY 1997 Update. Office of Research and Development, Washington, DC July
U.S Environmental Protection Agency (USEPA) 2012 USEPA Master Regional Screening Level (RSL) Table. November Online at: http://www.epa.gov/region9/superfund/prg/.
U.S. Environmental Protection Agency (USEPA) 2013a. Provisional Peer Reviewed Toxicity Values for Superfund (PPRTV). PPRTV Assessments Electronic Library. Online at: http://hhpprtv.ornl gov/index.html
U.S. Environmental Protection Agency (USEPA). 2013b Integrated Risk Information System (IRIS). On-line database at http://www epa gov/iris.

Table 3-22
Inhalation Toxicity Values
Vertellus - Provo, Utah

COPC	RfC mg/m^3	Source[1]	Unit risk m^3/µg	Source[1]
2,4-Dimethylphenol				
2-Chlorophenol				
2-Methylnaphthalene				
2-Methylphenol	6 00E-01	C		
3&4-Methylphenol	6.00E-01	C		
Acenaphthene				
Acenaphthylene				
Acetone	3.10E+01	A		
Anthracene				
Benzene	3.00E-02	I	7 80E-06	I
Benzenethiol				
Benzo(a)anthracene			1.10E-04	C
Benzo(a)pyrene			1 10E-03	C
Benzo(b)fluoranthene			1 10E-04	C
Benzo(g,h,i)perylene				
Benzo(k)fluoranthene			1.10E-04	C
Carbazole				
Carbon disulfide	7 00E-01	I		
Chloroform	9 80E-02	A	2.30E-05	I
Chrysene			1.10E-05	C
Cyanide, Total	8.00E-04	S		
Dibenz(a,h)anthracene			1.20E-03	C
Dibenzofuran				
Ethylbenzene	1.00E+00	I	2.50E-06	C
Fluoranthene				
Fluorene				
Indeno(1,2,3-c,d)pyrene			1.10E-04	C
Methyl ethyl ketone	5.00E+00	I		
Methylene bromide	4.00E-03	X		
Methylene chloride	6.00E-01	I	1.00E-08	I
Naphthalene	3.00E-03	I	3.40E-05	C
Phenanthrene				
Phenol	2 00E-01	C		
Pyrene				
Resorcinol				
Toluene	5.00E+00	I		
Xylenes (Total)	1.00E-01	I		

Notes:

[1]Secondary source for all chronic RfDs and SFs was the USEPA (2012) RSL tables

Primary sources are listed in the Source columns in the table.

A = Agency for Toxic Substances and Disease Registry Minimum Risk Level (ATSDR 2013)

C = California Environmental Protection Agency Toxicity Criteria (Cal/EPA 2013)

COPC = Chemical of potential concern

I = Integrated Risk Information System toxicity value (USEPA 2013b)

m^3/µg = Cubic meter per microgram

mg/m^3 = Milligrams percubic meter

RfC = Reference concentration

S = RSL User Guide Section 5 (USEPA 2012)

X = Provisional peer reviewed toxicity value appendix (USEPA 2013a)

Table 3-22
Inhalation Toxicity Values
Vertellus - Provo, Utah

Agency for Toxic Substances and Disease Registry (ATSDR). 2013 Minimum Risk Levels (MRLs) for Hazardous Substances. December. Online at: http://www atsdr.cdc.gov/mrls/index.asp.
California Environmental Protection Agency (CalEPA). 2013 Toxicity Criteria Database Office of Environmental Health Hazard Assessment. Online at: http://www oehha ca.gov/risk/ChemicalDB/index.asp.
U S. Environmental Protection Agency (USEPA). 2012. USEPA Master Regional Screening Level (RSL) Table November. Online at: http://www.epa.gov/region9/superfund/prg/
U.S. Environmental Protection Agency (USEPA). 2013a. Provisional Peer Reviewed Toxicity Values for Superfund (PPRTV) PPRTV Assessments Electronic Library. Online at. http://hhpprtv ornl.gov/index.html
U.S. Environmental Protection Agency (USEPA). 2013b. Integrated Risk Information System (IRIS). On-line database at http://www epa.gov/iris.

Table 4-1
Identification of Bioaccumulative Chemicals
Vertellus - Provo, Utah

Analyte	Octanol-Water Partition Coefficient (Log Kow)[1]	Molecular Weight (grams/mole)[1]	Bioaccumulative?[2]
2,4-Dimethylphenol	2 30	2.3	No
2-Methylnaphthalene	3 86	142	No
2-Methylphenol	1 95	108	No
3&4-Methylphenol			No
3-Methylphenol (m-cresol)	1.96	108	No
4-Methylphenol (p-cresol)	1 94	108	No
4-Methylphenol	1 94	108	No
Acenaphthene	3 92	154	No
Acenaphthylene	3 94	152	No
Acetone	-0.24	58 1	No
Anthracene	4 45	178	No
Benzene	2 13	78 1	No
Benzo(a)anthracene	5 76	228	Yes
Benzo(a)pyrene	6 13	252	Yes
Benzo(b)fluoranthene	5 78	252	Yes
Benzo(g,h,i)perylene	6.63	276	Yes
Benzo(k)fluoranthene	6 11	252	Yes
bis(2-Ethylhexyl)phthalate	7.60	391	No
Carbazole	3 72	167	No
Carbon disulfide	1.94	76 1	No
Chloroform	1.97	119	No
Chrysene	5 81	228	Yes
Cyanide, Total	-0 25	27	No
Dibenz(a,h)anthracene	6 75	278	Yes
Dibenzofuran	4 12	168	No
Ethylbenzene	3 15	106	No
Fluoranthene	5.16	202	Yes
Fluorene	4 18	166	No
HPAH			Yes
Indeno(1,2,3-c,d)pyrene	6.70	276	Yes
LPAH			Yes
Methyl ethyl ketone	0 29	72 1	No
Methylene chloride	1 25	84 9	No
Naphthalene	3.30	128	No
PAH (Total)			Yes
Phenanthrene	4.46	178	No
Phenol	1 46	94 1	No
Pyrene	4.88	202	No
Xylenes (Total)	3.16	106	No
m-Xylene	3 20	106	No
p-Xylene	3 15	106	No
m,p-Xylene			No
o-Xylene	3.12	106	No
Toluene	2 73	92 1	No

Notes:

1 - Log Kow and molecular weights from http //rais ornl gov/cgi-bin/tools/, EPI (Estimation Programs Interface) SuiteTM, a Windows-based suite of physical/chemical property and environmental fate estimation programs developed by USEPA's Office of Pollution Prevention Toxics and Syracuse Research Corporation (SRC)

2 - Bioaccumulative chemicals are those with log Kow values in the range of 5 to 7 5 and a molecular weight of less than 1,100 (ICCA, no date) 3&4-Methylphenol and m,p-Xylene are not considered bioaccumulative because 3-Methylphenol and 4-Methylphyenol as well as m-Xylene and p-Xylene are not bioaccumulative PAH (Total) is considered bioaccumulative because at least one of the individual PAHs is bioaccumulative. Similarly, HPAH and LPAH are considere bioaccumulative because at least one of the individual PAHs included in their calcualtion is bioaccumulative

Cyanide, Total as CN-

HPAH = high molecular weight PAH, includes Benz(a)anthracene, Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(g,h,i)perylene, Benzo(k)fluoranthene, Chrysene, Dibenz(a,h)anthracene, Indeno(1,2,3-cd)pyrene, and Pyrene.

Kow = Octanol-Water Partition Coefficient

LPAH = low molecular weigth PAH, includes 2-Methylnaphthalene, Acenaphthene, Acenaphthylene, Anthracene, Fluoranthene, Fluorene, Naphthalene, and Phenanthrene.

PAH = polycyclic aromatic hydrocarbon

USEPA = U S Environmental Protection Agency

Source:

International Council of Chemical Associations (ICCA) No Date ICCA Bnefing Paper: Log Kow Criteria of 5 is Equivalent to BCF Cntena of 5,000 Accessed at www icca-chem org

Table 4-2
Ecological Screening Levels for Soil
Vertellus - Provo, Utah

Detected Soil Analytes[1]	Plants		Invertebrates[2]		Birds		Mammals		Selected ESL[3]
	USEPA	LANL	USEPA	LANL	USEPA	LANL	USEPA	LANL	
2,4-Dimethylphenol	-	-	-	-	-	-	-	-	NV
2-Methylnaphthalene	-	-	LPAH	-	-	-	LPAH	-	NV
2-Methylphenol	-	670	-	-	-	-	-	590,000	670
3&4-Methylphenol	-	690	-	-	-	-	-	-	690
Acenaphthene	-	250	LPAH	-	-	-	LPAH	-	250
Acenaphthylene	-	-	LPAH	-	-	-	LPAH	120,000	120,000
Acetone	-	-	-	-	-	7,500	-	1,200	1,200
Anthracene	-	6,800	LPAH	-	-	-	LPAH	210,000	6,800
Benzene	-	-	-	-	-	-	-	24,000	24,000
Benzo(a)anthracene	-	18,000	HPAH	-	-	800	HPAH	3,000	800
Benzo(a)pyrene	-	-	HPAH	-	-	-	HPAH	53,000	53,000
Benzo(b)fluoranthene	-	18,000	HPAH	-	-	-	HPAH	38,000	18,000
Benzo(g,h,i)perylene	-	-	HPAH	-	-	-	HPAH	24,000	24,000
Benzo(k)fluoranthene	-	-	HPAH	-	-	-	HPAH	62,000	62,000
bis(2-Ethylhexyl)phthalate	-	-	-	-	-	20	-	590	20
Carbazole	-	-	-	-	-	-	-	80,000	80,000
Carbon Disulfide	-	-	-	-	-	-	-	820	820
Chloroform	-	-	-	-	-	-	-	8,000	8,000
Chrysene	-	-	HPAH	-	-	-	HPAH	2,400	2,400
Cyanide, Total	-	-	-	-	-	100	-	310,000	100
Dibenz(a,h)anthracene	-	-	HPAH	-	-	-	HPAH	12,000	12,000
Dibenzofuran	-	6,100	-	-	-	-	-	-	6,100
Ethylbenzene	-	-	-	-	-	-	-	-	NV
Fluoranthene	-	-	LPAH	10,000	-	-	LPAH	22,000	10,000
Fluorene	-	-	LPAH	3,700	-	-	LPAH	250,000	3,700
Indeno(1,2,3-c,d)pyrene	-	-	HPAH	-	-	-	HPAH	62,000	62,000
m,p-Xylene	-	100,000	-	-	-	41,000	-	1,400	1,400
Methyl ethyl ketone	-	-	-	-	-	-	-	360,000	360,000
Methylene chloride	-	1,600,000	-	-	-	-	-	2,600	2,600
Naphthalene	-	1,000	LPAH	-	-	3,400	LPAH	9,700	1,000
o-Xylene	-	100,000	-	-	-	41,000	-	1,400	1,400
Phenanthrene	-	-	LPAH	5,500	-	-	LPAH	10,000	5,500
Phenol	-	790	-	1,800	-	-	-	38,000	790
Pyrene	-	-	HPAH	10,000	-	34,000	HPAH	22,000	10,000
Toluene	-	200,000	-	-	-	-	-	23,000	23,000
Xylenes (Total)	-	100,000	-	-	-	41,000	-	1,400	1,400
HPAH	-	-	18,000	-	-	-	1,100	-	1,100
LPAH	-	-	29,000	-	-	-	100,000	-	29,000

Notes:

All units are µg/kg

1 - Xylenes (Total) ESLs are used for m,p-Xylene and o-Xylene

2 - The LANL (2011) invertebrate values are based on earthworm data

3 - Lowest of available soil Eco-SSLs (USEPA 2010) or ESLs (LANL 2011)

4 - PAHs are evaluated individually (based on LANL 2011 as available) as well as grouped as HPAHs and LPAHs (based on USEPA 2010 as available)

Eco-SSL = Ecological Soil Screening Level

ESL = Ecological Screening Level

HPAH = high molecular weight PAH, calculated from individual PAH results, includes Benz(a)anthracene, Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(g,h,i)perylene, Benzo(k)fluoranthene, Chrysene, Dibenz(a,h)anthracene, Indeno(1,2,3-cd)pyrene, and Pyrene The selected (lower) soil ESL is 1,100 µg/kg

LPAH = low molecular weigth PAH, calculated from individual PAH results, includes 2-Methylnaphthalene, Acenaphthene, Acenaphthylene, Anthracene, Fluoranthene, Fluorene, Naphthalene, and Phenanthrene The selected (lower) soil ESL is 29,000 µg/kg

LANL = Los Alamos National Laboratory (source of ESLs)

NA = not applicable, PAHs will be evaluated based on the USEPA (2010) Eco-SSLs for HPAHs and LPAHs

NV = no value available for the individual PAH is from USEPA (2010) or LANL (2011)

PAH = polycyclic aromatic hydrocarbon

µg/kg = micrograms per kilogram

USEPA = U S. Environmental Protection Agency (source of Eco-SSLs)

Sources:

Los Alamos National Laboratory (LANL) 2011 ECORISK Database (Release 3 0) Environmental Programs Directorate LA-UR-11-5460. Los Alamos, New Mexico. Issued October 1 Accessed online at http://www lanl gov/environment/cleanup/econsk shtml

U S Environmental Protection Agency (USEPA). 2010 Ecological Soil Screening Levels (Eco-SSLs) Office of Solid Waste and Emergency Response http.//www.epa gov/ecotox/ecossl/ Latest update: October 20. Accessed online on January 30, 2012

Table 4-3
Ecological Screening Values for Sediment
Vertellus - Provo, Utah

Detected Sediment Analytes[1]	Consensus Sediment Quality Guidelines (TEC) (MacDonald et al. 2000)	Protection of Aquatic Community (LANL 2011)	Protection of Birds and Mammals (LANL 2011)[2]	Selected Sediment Screening Value[3]
2,4-Dimethylphenol	-	-	-	NV
2-Methylnaphthalene	-	180	3,100	180
2-Methylphenol	-	-	1,900,000	1,900,000
3&4-Methylphenol	-	-	-	NV
Acenaphthene	-	620	160,000	620
Acenaphthylene	-	44	150,000	44
Acetone	-	65	19,000	65
Anthracene	57.2	0.39	270,000	0.39
Benzene	-	57	61,000	57
Benzo(a)anthracene	108	110	5,900	108
Benzo(a)pyrene	150	350	83,000	150
Benzo(b)fluoranthene	-	240	59,000	240
Benzo(k)fluoranthene	-	240	93,000	240
Carbon disulfide	-	-	1,500	1 5
Chrysene	166	500	4,400	166
Cyanide, Total	-	100	140	100
Dibenz(a,h)anthracene	33	15	19,000	15
Dibenzofuran	-	2300	-	2,300
Ethylbenzene	-	-	-	NV
Fluoranthene	423	2900	28,000	423
Fluorene	77.4	540	320,000	77.4
Indeno(1,2,3-c,d)pyrene	-	78	93,000	78
m,p-Xylene	-	1100	1,800	1,100
Methyl ethyl ketone	-	-	3,300,000	3,300
Methylene chloride	-	380	11,000	380
Naphthalene	176	470	22,000	176
o-Xylene	-	1100	1,800	1,100
Phenanthrene	204	850	14,000	204
Phenol	-	-	840,000	840,000
Pyrene	195	570	29,000	195
Toluene	-	670	29,000	670
Xylenes (Total)	-	1100	1,800	1,100
PAH (Total)	1610000	-	-	1,610,000

Notes:

All units are µg/kg.

1 - Xylenes (Total) ecological sediment screening values are used for m,p-Xylene and o-Xylene.

2 - Lower of available bird or mammal sediment screening values

3 - Lowest available sediment screening value

NV = no value availabe from MacDonald et al (2000) or LANL (2011)

PAH = polycyclic aromatic hydrocarbon; PAH (Total) calculated from individual PAH results

TEC = threshold effect concentration

µg/kg = micrograms per kilogram

Sources:

Los Alamos National Laboratory (LANL). 2011. ECORISK Database (Release 3 0). Environmental Programs Directorate LA-UR-11-5460. Los Alamos, New Mexico. Issued October 1 Accessed online at http //www.lanl gov/environment/cleanup/ecorisk.shtml.

MacDonald, D.D., C G. Ingersoll and T.A. Berger. 2000. Development and evaluation of consensus-based sediment quality guidelines for freshwater ecosystems. Arch. Environ. Contam. Toxicol. 39.20-31

Table 4-4
Ecological Screening Values for Surface Water
Vertellus - Provo, Utah

Detected Surface Water Analytes	Ambient Water Quality Criteria (Chronic Freshwater) (USEPA 2011)	Protection of Aquatic Community (LANL 2011)	Protection of Birds and Mammals[1] (LANL 2011)	Selected Surface Water Screening Value[2]
2,4-Dimethylphenol	-	-	-	NV
2-Methylphenol	-	-	-	NV
3&4-Methylphenol	-	-	-	NV
Acenaphthene	-	23	310,000	23
Acetone	-	11,000	44,000	11,000
Benzene	-	45	110,000	45
Benzo(a)anthracene	-	0.027	760	0.027
Benzo(a)pyrene	-	0.014	4,400	0.014
Benzo(b)fluoranthene	-	30	17,000	30
Benzo(g,h,i)perylene	-	30	32,000	30
Benzo(k)fluoranthene	-	30	32,000	30
Chrysene	-	30	760	30
Cyanide, Total	5.2	5.2	130	5.2
Ethylbenzene	-	-	-	NV
Fluoranthene	-	6.1	56,000	6.1
Fluorene	-	3.9	560,000	3.9
Indeno(1,2,3-c,d)pyrene	-	30	32,000	30
Naphthalene	-	23	57	23
Phenanthrene	-	6.3	23,000	6.3
Phenol	-	110	260,000	110
Pyrene	-	30	33,000	30
Toluene	-	130	110,000	130
Xylenes (Total)	-	86	9,400	86

Notes:

All units are µg/L.

1 - Lower of available bird or mammal surface water screening values

2 - Lowest of available surface water screening values

USEPA (2011) chronic criteria for cyanide is based on free cyanide.

LANL (2011) screening values for cyanide is based on total cyanide.

µg/L = micrograms per liter

NV = no value availabe from USEPA (2011) or LANL (2011)

Sources:

Los Alamos National Laboratory (LANL) 2011 ECORISK Database (Release 3.0). Environmental Programs Directorate LA-UR-11-5460. Los Alamos, New Mexico. Issued October 1. Accessed online at http://www.lanl.gov/environment/cleanup/ecorisk shtml.

U.S Environmental Protection Agency (USEPA). 2011. National Recommended Water Quality Criteria. Update: March 22. Available at http://www.epa.gov/scitech/swguidance/standards/current/index.cfm. Accessed June 11, 2012.

Table 4-5
Identification of COPECs for Soil
Vertellus - Provo, Utah

Detected Soil Analyte[1]	Maximum Detected Concentration (µg/kg)[2]	Maximum Reporting Limit (µg/kg)	Selected Maximum (µg/kg)[3]	Ecological Screening Level for Soil (µg/kg)	Maximum Is Greater than Screening Level?	Analyte Is Bioaccumulative?	Analyte is Retained as a COPEC for Further Evaluation?
EA2 – Subsurface Soil							
3&4-Methylpheno	1,060,000	7,000,000	7,000,000	690	Yes	No	Yes
Acenaphthene	7,690,000	700	7,690,000	250	Yes	No	Yes
Acenaphthylene	1,880,000	7,000,000	7,000,000	120,000	Yes	No	Yes
Acetone	620	5,000,000	5,000,000	1,200	Yes	No	Yes
Anthracene	19,800,000	200	19,800,000	6,800	Yes	No	Yes
Benzene	780,000	6	780,000	24,000	Yes	No	Yes
Benzo(a)anthracene	3,470,000	7,000,000	7,000,000	800	Yes	Yes	Yes
Benzo(a)pyrene	2,650,000	7,000,000	7,000,000	53,000	Yes	Yes	Yes
Benzo(b)fluoranthene	3,150,000	7,000,000	7,000,000	18,000	Yes	Yes	Yes
Benzo(k)fluoranthene	1,600,000	7,000,000	7,000,000	62,000	Yes	Yes	Yes
Carbon disulfide	15	200,000	200,000	820	Yes	No	Yes
Chloroform	12	200,000	200,000	8,000	Yes	No	Yes
Chrysene	4,120,000	7,000,000	7,000,000	2,400	Yes	Yes	Yes
Cyanide, Total	6,500,000	70	6,500,000	100	Yes	No	Yes
Dibenz(a,h)anthracene	1,140,000	7,000,000	7,000,000	12,000	Yes	Yes	Yes
Ethylbenzene	11,400	200,000	200,000	NV	NA	No	No
Fluoranthene	14,400,000	200	14,400,000	10,000	Yes	Yes	Yes
Fluorene	3,770,000	7,000,000	7,000,000	3,700	Yes	No	Yes
HPAH	58,240,000	1,600	58,240,000	1,100	Yes	Yes	Yes
LPAH	136,489,997	1,400	136,489,997	29,000	Yes	Yes	Yes
Indeno(1,2,3-c,d)pyrene	1,760,000	7,000,000	7,000,000	62,000	Yes	Yes	Yes
Methyl ethyl ketone	60	2,000,000	2,000,000	360,000	Yes	No	Yes
Methylene chloride	160	500,000	500,000	2,600	Yes	No	Yes
Naphthalene	58,700,000	10,000	58,700,000	1,000	Yes	No	Yes
Phenanthrene	21,900,000	200	21,900,000	5,500	Yes	No	Yes
Phenol	916,000	7,000,000	7,000,000	790	Yes	No	Yes
Pyrene	9,240,000	200	9,240,000	10,000	Yes	No	Yes
Toluene	1,260,000	4,000	1,260,000	23,000	Yes	No	Yes
Xylenes (Total)	1,500,000	18	1,500,000	1,400	Yes	No	Yes
EA3 – Surface and Subsurface Soil							
2,4-Dimethylpheno	2,400	200,000	200,000	NV	NA	No	No
2-Methylnaphthalene	9,400	-	9,400	NV	NA	No	No
2-Methylpheno	2,100	200,000	200,000	670	Yes	No	Yes
3&4-Methylpheno	1,200	200,000	200,000	690	Yes	No	Yes
Acenaphthene	202,000	30,000	202,000	250	Yes	No	Yes
Acenaphthylene	15,000	200,000	200,000	120,000	Yes	No	Yes
Acetone	640	200	640	1,200	No	No	No
Anthracene	209,000	200,000	209,000	6,800	Yes	No	Yes
Benzene	84	260	260	24,000	No	No	No
Benzo(a)anthracene	486,000	20,000	486,000	800	Yes	Yes	Yes
Benzo(a)pyrene	860,000	10,000	860,000	53,000	Yes	Yes	Yes
Benzo(b)fluoranthene	606,000	20,000	606,000	18,000	Yes	Yes	Yes
Benzo(g,h,i)perylene	110,000	-	110,000	24,000	Yes	Yes	Yes
Benzo(k)fluoranthene	584,000	20,000	584,000	62,000	Yes	Yes	Yes
bis(2-Ethylhexyl)phthalate	1,600	-	1,600	20	Yes	No	Yes
Carbazole	17,000	-	17,000	80,000	No	No	No
Chloroform	7	260	260	8,000	No	No	No
Chrysene	604,000	10,000	604,000	2,400	Yes	Yes	Yes
Cyanide, Total	45,000	60	45,000	100	Yes	No	Yes
Dibenz(a,h)anthracene	147,000	200,000	200,000	12,000	Yes	Yes	Yes
Dibenzofuran	11,000	-	11,000	6,100	Yes	No	Yes
Ethylbenzene	4	260	260	NV	NA	No	No
Fluoranthene	825,000	200	825,000	10,000	Yes	Yes	Yes
Fluorene	169,000	200,000	200,000	3,700	Yes	No	Yes
HPAH	4,550,000	1,600	4,550,000	1,100	Yes	Yes	Yes
LPAH	2,585,000	1,400	2,585,000	29,000	Yes	Yes	Yes
Indeno(1,2,3-c,d)pyrene	419,000	20,000	419,000	62,000	Yes	Yes	Yes
Methyl ethyl ketone	8	2,600	2,600	360,000	No	No	No
Methylene chloride	2,760	20	2,760	2,600	Yes	No	Yes
Naphthalene	282,000	200,000	282,000	1,000	Yes	No	Yes
Phenanthrene	860,000	20,000	860,000	5,500	Yes	No	Yes
Phenol	900	200,000	200,000	790	Yes	No	Yes
Pyrene	1,590,000	200	1,590,000	10,000	Yes	No	Yes
Toluene	25	260	260	23,000	No	No	No
Xylenes (Total)	327	17	327	1,400	No	No	No
EA4 – Subsurface Soil							
2,4-Dimethylpheno	110,000	30,000	110,000	NV	NA	No	No
2-Methylnaphthalene	1,400,000	10,000	1,400,000	NV	NA	No	No
2-Methylpheno	150,000	30,000	150,000	670	Yes	No	Yes
3&4-Methylpheno	470,000	30,000	470,000	690	Yes	No	Yes
Acenaphthene	2,200,000	3,000	2,200,000	250	Yes	No	Yes
Acenaphthylene	140,000	10,000	140,000	120,000	Yes	No	Yes
Acetone	792	88,000	88,000	1,200	Yes	No	Yes
Anthracene	790,000	3,000	790,000	6,800	Yes	No	Yes
Benzene	4,600	-	4,600	24,000	No	No	No
Benzo(a)anthracene	3,700,000	3,000	3,700,000	800	Yes	Yes	Yes
Benzo(a)pyrene	190,000	3,000	190,000	53,000	Yes	Yes	Yes
Benzo(b)fluoranthene	190,000	30,000	190,000	18,000	Yes	Yes	Yes
Benzo(k)fluoranthene	84,000	3,000	84,000	62,000	Yes	Yes	Yes

Table 4-5
Identification of COPECs for Soil
Vertellus - Provo, Utah

Detected Soil Analyte[1]	Maximum Detected Concentration (µg/kg)[2]	Maximum Reporting Limit (µg/kg)	Selected Maximum (µg/kg)[3]	Ecological Screening Level for Soil (µg/kg)	Maximum is Greater than Screening Level?	Analyte is Bioaccumulative?	Analyte is Retained as a COPEC for Further Evaluation?
Carbon disulfide	940	18,000	18,000	820	Yes	No	Yes
Chrysene	3,700,000	3,000	3,700,000	2,400	Yes	Yes	Yes
Cyanide, Total	33,000	60	33,000	100	Yes	No	Yes
Dibenz(a,h)anthracene	21,000	30,000	30,000	12,000	Yes	Yes	Yes
Dibenzofuran	1,000,000	10,000	1,000,000	6,100	Yes	No	Yes
Ethylbenzene	2,520	440	2,520	NV	NA	No	No
Fluoranthene	2,200,000	3,000	2,200,000	10,000	Yes	Yes	Yes
Fluorene	1,400,000	3,000	1,400,000	3,700	Yes	No	Yes
HPAH	9,859,000	24,000	9,859,000	1,100	Yes	Yes	Yes
LPAH	14,630,000	-	14,630,000	29,000	Yes	Yes	Yes
Indeno(1,2,3-c,d)pyrene	74,000	30,000	74,000	62,000	Yes	Yes	Yes
m,p-Xylene	3,900	-	3,900	1,400	Yes	No	Yes
Methylene chloride	250	18,000	18,000	2,600	Yes	No	Yes
Naphthalene	6,500,000	-	6,500,000	1,000	Yes	No	Yes
o-Xylene	2,000	-	2,000	1,400	Yes	No	Yes
Phenanthrene	337,000	3,000	337,000	5,500	Yes	No	Yes
Phenol	820,000	30,000	820,000	790	Yes	No	Yes
Pyrene	1,900,000	3,000	1,900,000	10,000	Yes	No	Yes
Toluene	7,200	8,800	8,800	23,000	No	No	No
Xylenes (Total)	5,900	26,000	26,000	1,400	Yes	No	Yes
EA6 – Surface Soil							
2,4-Dimethylpheno	4,200	-	4,200	NV	NA	No	No
2-Methylnaphthalene	82,000	-	82,000	NV	NA	No	No
2-Methylpheno	4,100	-	4,100	670	Yes	No	Yes
3&4-Methylpheno	11,000	-	11,000	690	Yes	No	Yes
Acenaphthene	550,000	-	550,000	250	Yes	No	Yes
Acenaphthylene	140,000	-	140,000	120,000	Yes	No	Yes
Anthracene	860,000	-	860,000	6,800	Yes	No	Yes
Benzo(a)anthracene	2,400,000	-	2,400,000	800	Yes	Yes	Yes
Benzo(a)pyrene	2,200,000	-	2,200,000	53,000	Yes	Yes	Yes
Benzo(b)fluoranthene	2,500,000	-	2,500,000	18,000	Yes	Yes	Yes
Benzo(g,h,i)perylene	1,100,000	-	1,100,000	24,000	Yes	Yes	Yes
Benzo(k)fluoranthene	1,000,000	-	1,000,000	62,000	Yes	Yes	Yes
Carbazole	650,000	-	650,000	80,000	Yes	No	Yes
Chrysene	2,500,000	-	2,500,000	2,400	Yes	Yes	Yes
Dibenz(a,h)anthracene	370,000	-	370,000	12,000	Yes	Yes	Yes
Dibenzofuran	200,000	-	200,000	6,100	Yes	No	Yes
Fluoranthene	5,300,000	-	5,300,000	10,000	Yes	Yes	Yes
Fluorene	470,000	-	470,000	3,700	Yes	No	Yes
HPAH	17,970,000	-	17,970,000	1,100	Yes	Yes	Yes
LPAH	11,776,200	-	11,776,200	29,000	Yes	Yes	Yes
Indeno(1,2,3-c,d)pyrene	1,100,000	-	1,100,000	62,000	Yes	Yes	Yes
Naphthalene	450,000	-	450,000	1,000	Yes	No	Yes
Phenanthrene	4,400,000	-	4,400,000	5,500	Yes	No	Yes
Phenol	6,700	-	6,700	790	Yes	No	Yes
Pyrene	4,800,000	-	4,800,000	10,000	Yes	No	Yes
EA7 – Surface and Subsurface Soil							
2-Methylnaphthalene	2,700	17	2,700	NV	NA	No	No
Acenaphthene	1,400	280	1,400	250	Yes	No	Yes
Acenaphthylene	1,500	280	1,500	120,000	No	No	No
Acetone	447	80	447	1,200	No	No	No
Anthracene	8,900	280	8,900	6,800	Yes	No	Yes
Benzene	14	8	14	24,000	No	No	No
Benzo(a)anthracene	12,000	280	12,000	800	Yes	Yes	Yes
Benzo(a)pyrene	13,000	280	13,000	53,000	No	Yes	Yes
Benzo(b)fluoranthene	13,000	280	13,000	18,000	No	Yes	Yes
Benzo(g,h,i)perylene	8,000	17	8,000	24,000	No	Yes	Yes
Benzo(k)fluoranthene	7,300	280	7,300	62,000	No	Yes	Yes
Carbazole	1,500	330	1,500	80,000	No	No	No
Carbon disulfide	4	16	16	820	No	No	No
Chrysene	14,000	280	14,000	2,400	Yes	Yes	Yes
Dibenz(a,h)anthracene	2,700	280	2,700	12,000	No	Yes	Yes
Dibenzofuran	900	330	900	6,100	No	No	No
Ethylbenzene	8	8	8	NV	NA	No	No
Fluoranthene	23,000	280	23,000	10,000	Yes	Yes	Yes
Fluorene	1,300	280	1,300	3,700	No	No	No
HPAH	99,100	2,240	99,100	1,100	Yes	Yes	Yes
LPAH	53,070	136	53,070	29,000	Yes	Yes	Yes
Indeno(1,2,3-c,d)pyrene	7,900	280	7,900	62,000	No	Yes	Yes
Methyl ethyl ketone	107	80	107	360,000	No	No	No
Naphthalene	24,000	250	24,000	1,000	Yes	No	Yes
Phenanthrene	10,000	280	10,000	5,500	Yes	No	Yes
Pyrene	22,000	280	22,000	10,000	Yes	No	Yes
Hotspot 2-SF-2-18 – Surface Soil							
2-Methylnaphthalene	780	-	780	NV	NA	No	No
Acenaphthene	2,000	-	2,000	250	Yes	No	Yes
Acenaphthylene	3,000	-	3,000	120,000	No	No	No
Anthracene	6,300	-	6,300	6,800	No	No	No
Benzo(a)anthracene	22,000	-	22,000	800	Yes	Yes	Yes

Table 4-5
Identification of COPECs for Soil
Vertellus - Provo, Utah

Detected Soil Analyte[1]	Maximum Detected Concentration (µg/kg)[2]	Maximum Reporting Limit (µg/kg)	Selected Maximum (µg/kg)[3]	Ecological Screening Level for Soil (µg/kg)	Maximum Is Greater than Screening Level?	Analyte Is Bioaccumulative?	Analyte is Retained as a COPEC for Further Evaluation?
Benzo(a)pyrene	26,000	-	26,000	53,000	No	Yes	Yes
Benzo(b)fluoranthene	28,000	-	28,000	18,000	Yes	Yes	Yes
Benzo(g,h,i)perylene	15,000	-	15,000	24,000	No	Yes	Yes
Benzo(k)fluoranthene	13,000	-	13,000	62,000	No	Yes	Yes
bis(2-Ethylhexyl)phthalate	930	-	930	20	Yes	No	Yes
Carbazole	2,600	-	2,600	80,000	No	No	No
Chrysene	26,000	-	26,000	2,400	Yes	Yes	Yes
Dibenz(a,h)anthracene	4,900	-	4,900	12,000	No	Yes	Yes
Dibenzofuran	1,900	-	1,900	6,100	No	No	No
Fluoranthene	41,000	-	41,000	10,000	Yes	Yes	Yes
Fluorene	3,200	-	3,200	3,700	No	No	No
HPAH	188,900	-	188,900	1,100	Yes	Yes	Yes
LPAH	85,680	-	85,680	29,000	Yes	Yes	Yes
Indeno(1,2,3-c,d)pyrene	15,000	-	15,000	62,000	No	Yes	Yes
Naphthalene	1,400	-	1,400	1,000	Yes	No	Yes
Phenanthrene	28,000	-	28,000	5,500	Yes	No	Yes
Pyrene	39,000	-	39,000	10,000	Yes	No	Yes
Hotspot 2-SF-2-19 -- Surface Soil							
2,4-Dimethylpheno	350	-	350	NV	NA	No	No
2-Methylnaphthalene	15,000	-	15,000	NV	NA	No	No
2-Methylpheno	330	-	330	670	No	No	No
3&4-Methylpheno	1,200	-	1,200	690	Yes	No	Yes
Acenaphthene	43,000	-	43,000	250	Yes	No	Yes
Acenaphthylene	8,600	-	8,600	120,000	No	No	No
Anthracene	73,000	-	73,000	6,800	Yes	No	Yes
Benzo(a)anthracene	89,000	-	89,000	800	Yes	Yes	Yes
Benzo(a)pyrene	80,000	-	80,000	53,000	Yes	Yes	Yes
Benzo(b)fluoranthene	100,000	-	100,000	18,000	Yes	Yes	Yes
Benzo(g,h,i)perylene	48,000	-	48,000	24,000	Yes	Yes	Yes
Benzo(k)fluoranthene	43,000	-	43,000	62,000	No	Yes	Yes
Carbazole	30,000	-	30,000	80,000	No	No	No
Chrysene	100,000	-	100,000	2,400	Yes	Yes	Yes
Dibenz(a,h)anthracene	15,000	-	15,000	12,000	Yes	Yes	Yes
Dibenzofuran	20,000	-	20,000	6,100	Yes	No	Yes
Fluoranthene	220,000	-	220,000	10,000	Yes	Yes	Yes
Fluorene	35,000	-	35,000	3,700	Yes	No	Yes
HPAH	710,000	-	710,000	1,100	Yes	Yes	Yes
LPAH	638,600	-	638,600	29,000	Yes	Yes	Yes
Indeno(1,2,3-c,d)pyrene	45,000	-	45,000	62,000	No	Yes	Yes
Naphthalene	44,000	-	44,000	1,000	Yes	No	Yes
Phenanthrene	200,000	-	200,000	5,500	Yes	No	Yes
Phenol	1,200	-	1,200	790	Yes	No	Yes
Pyrene	190,000	-	190,000	10,000	Yes	No	Yes
Hotspot 2-SF-3-36 -- Surface Soil							
2,4-Dimethylpheno	1,900	-	1,900	NV	NA	No	No
2-Methylnaphthalene	49,000	-	49,000	NV	NA	No	No
2-Methylpheno	2,400	-	2,400	670	Yes	No	Yes
3&4-Methylpheno	8,500	-	8,500	690	Yes	No	Yes
Acenaphthene	10,000	-	10,000	250	Yes	No	Yes
Acenaphthylene	63,000	-	63,000	120,000	No	No	No
Anthracene	59,000	-	59,000	6,800	Yes	No	Yes
Benzo(a)anthracene	79,000	-	79,000	800	Yes	Yes	Yes
Benzo(a)pyrene	63,000	-	63,000	53,000	Yes	Yes	Yes
Benzo(b)fluoranthene	73,000	-	73,000	18,000	Yes	Yes	Yes
Benzo(g,h,i)perylene	35,000	-	35,000	24,000	Yes	Yes	Yes
Benzo(k)fluoranthene	27,000	-	27,000	62,000	No	Yes	Yes
Carbazole	30,000	-	30,000	80,000	No	No	No
Chrysene	80,000	-	80,000	2,400	Yes	Yes	Yes
Dibenz(a,h)anthracene	12,000	-	12,000	12,000	No	Yes	Yes
Dibenzofuran	45,000	-	45,000	6,100	Yes	No	Yes
Fluoranthene	210,000	-	210,000	10,000	Yes	Yes	Yes
Fluorene	72,000	-	72,000	3,700	Yes	No	Yes
HPAH	568,000	-	568,000	1,100	Yes	Yes	Yes
LPAH	953,000	-	953,000	29,000	Yes	Yes	Yes
Indeno(1,2,3-c,d)pyrene	39,000	-	39,000	62,000	No	Yes	Yes
Naphthalene	220,000	-	220,000	1,000	Yes	No	Yes
Phenanthrene	270,000	-	270,000	5,500	Yes	No	Yes
Phenol	10,000	-	10,000	790	Yes	No	Yes
Pyrene	160,000	-	160,000	10,000	Yes	No	Yes
Hotspot 2-SF-4-23 -- Surface Soil							
2,4-Dimethylpheno	640	-	640	NV	NA	No	No
2-Methylnaphthalene	23,000	-	23,000	NV	NA	No	No
2-Methylpheno	460	-	460	670	No	No	No
3&4-Methylpheno	1,500	-	1,500	690	Yes	No	Yes
Acenaphthene	82,000	-	82,000	250	Yes	No	Yes
Acenaphthylene	17,000	-	17,000	120,000	No	No	No
Anthracene	130,000	-	130,000	6,800	Yes	No	Yes
Benzo(a)anthracene	250,000	-	250,000	800	Yes	Yes	Yes
Benzo(a)pyrene	200,000	-	200,000	53,000	Yes	Yes	Yes

Table 4-5
Identification of COPECs for Soil
Vertellus - Provo, Utah

Detected Soil Analyte[1]	Maximum Detected Concentration (µg/kg)[2]	Maximum Reporting Limit (µg/kg)	Selected Maximum (µg/kg)[3]	Ecological Screening Level for Soil (µg/kg)	Maximum Is Greater than Screening Level?	Analyte Is Bioaccumulative?	Analyte is Retained as a COPEC for Further Evaluation?
Benzo(b)fluoranthene	310,000	-	310,000	18,000	Yes	Yes	Yes
Benzo(g,h,i)perylene	100,000	-	100,000	24,000	Yes	Yes	Yes
Benzo(k)fluoranthene	100,000	-	100,000	62,000	Yes	Yes	Yes
Carbazole	24,000	-	24,000	80,000	No	No	No
Chrysene	310,000	-	310,000	2,400	Yes	Yes	Yes
Dibenz(a,h)anthracene	39,000	-	39,000	12,000	Yes	Yes	Yes
Dibenzofuran	40,000	-	40,000	6,100	Yes	No	Yes
Fluoranthene	580,000	-	580,000	10,000	Yes	Yes	Yes
Fluorene	56,000	-	56,000	3,700	Yes	No	Yes
HPAH	1,889,000	-	1,889,000	1,100	Yes	Yes	Yes
LPAH	1,279,000	-	1,279,000	29,000	Yes	Yes	Yes
Indeno(1,2,3-c,d)pyrene	110,000	-	110,000	62,000	Yes	Yes	Yes
Naphthalene	81,000	-	81,000	1,000	Yes	No	Yes
Phenanthrene	310,000	-	310,000	5,500	Yes	No	Yes
Phenol	1,600	-	1,600	790	Yes	No	Yes
Pyrene	470,000	-	470,000	10,000	Yes	No	Yes

Notes:

1 - For the calculation of HPAH and LPAH, Kaplan-Meir method was applied for summing detects and non-detects of PAHs at individual sample locations. For sample locations where no individual PAHs were detected, the resulting calculated concentration is treated as a non-detect and the calculated RL is reported.

2 - Maximum Detected Concetration is the higher of the maximum surface soil (0 to 1 foot) or subsurface soil (1 to 3 feet) concentrations, as available for the EA

3 - Selected maximum is the higher of the detected concentration or the RL.

Dash (-) = No Maximum Reporting Limit is shown for an analyte because all results for the analyte were detects.

COPEC = chemical of potential ecological concern

EA = exposure area

HPAH = high molecular weight PAH, calculated from individual PAH results, includes Benz(a)anthracene, Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(g,h,i)perylene, Benzo(k)fluoranthene, Chrysene, Dibenz(a,h)anthracene, Indeno(1,2,3-cd)pyrene, and Pyrene

LPAH = low molecular weigth PAH; calculated from individual PAH results, includes 2-Methylnaphthalene, Acenaphthene, Acenaphthylene, Anthracene, Fluoranthene, Fluorene, Naphthalene, and Phenanthrene

NA = not applicable

NV = no screening value
available

µg/kg = micrograms per kilogram

PAH = polycyclic aromatic hydrocarbon

Table 4-6
Identification of COPECs for Sediment
Vertellus - Provo, Utah

Detected Sediment Analyte	Maximum Detection (µg/kg)	Maxmimum Reporting Limit (µg/kg)	Selected Maximum (µg/kg)[2]	Sediment Ecological Screening Level	Selected Maximum Greater than Screening Level?	Bioaccumulative ?	Retained for Further Evaluation in the ERA?
EA1 - Surface Sediment[1]							
2-Methylnaphthalene	20	1,400	1,400	180	Yes	No	Yes
2-Methylphenol	6.5	2,000	2,000	1,900,000	No	No	No
3&4-Methylphenol	908	2,300	2,300	NV	NA	No	No
Acenaphthene	401,000	2,000	401,000	620	Yes	No	Yes
Acenaphthylene	10,500	2,000	10,500	44	Yes	No	Yes
Acetone	143	6,400	6,400	65	Yes	No	Yes
Anthracene	261,000	1,400	261,000	0 39	Yes	No	Yes
Benzene	14	320	320	57	Yes	No	Yes
Benzo(a)anthracene	136,000	1,400	136,000	108	Yes	Yes	Yes
Benzo(a)pyrene	128,000	1,400	128,000	150	Yes	Yes	Yes
Benzo(b)fluoranthene	142,000	1,500	142,000	240	Yes	Yes	Yes
Benzo(k)fluoranthene	40,200	1,700	40,200	240	Yes	Yes	Yes
Carbon disulfide	8.1	1,600	1,600	1.5	Yes	No	Yes
Chrysene	197,000	1,700	197,000	166	Yes	Yes	Yes
Cyanide, Total	1,600	1,000	1,600	100	Yes	No	Yes
Dibenz(a,h)anthracene	13,900	2,000	13,900	15	Yes	Yes	Yes
Dibenzofuran	11	230	230	2,300	No	No	No
Ethylbenzene	26.9	640	640	NV	NA	No	No
Fluoranthene	365,000	2,600	365,000	423	Yes	Yes	Yes
Fluorene	288,000	2,000	288,000	77.4	Yes	No	Yes
Indeno(1,2,3-c,d)pyrene	49,500	1,400	49,500	78	Yes	Yes	Yes
m,p-Xylene	1 5	14	14	1,100	No	No	No
Methyl ethyl ketone	16.7	6,400	6,400	3,300	Yes	No	Yes
Methylene chloride	3	1,600	1,600	380	Yes	No	Yes
Naphthalene	22,400	2,600	22,400	176	Yes	No	Yes
o-Xylene	5 8	6 8	6.8	1,100	No	No	No
PAH (Total)	2,515,840	27,000	2,515,840	1,610,000	Yes	Yes	Yes
Phenanthrene	388,000	2,600	388,000	204	Yes	No	Yes
Phenol	20	2,800	2,800	840,000	No	No	No
Pyrene	331,000	1,500	331,000	195	Yes	No	Yes
Toluene	10.5	640	640	670	No	No	No
Xylenes (Total)	57.9	640	640	1,100	No	No	No

Notes:
1 - ERA screening based on sediment resutls from 0 to1 foot
2 - Selected maximum is the higher of the detected concentratio or the RL

COPEC = chemical of potential ecological concern
EA = exposure area
ERA = Ecological Risk Assessment
µg/kg = micrograms per kilogram
Na = not applicable
NV = no screening value available
PAH (Total) is not an analytically measured value. It is calcualted from the analytical measured values of individual PAHs
PAH = polycyclic aromatic hydrocarbor
RL = reporting limit

Table 4-7
Identification of COPECs for Surface Water
Vertellus - Provo, Utah

Detected Analytes	Maximum Detection (µg/L)	Maximum Reporting Limit (µg/L)	Selected Maximum (µg/L)	Surface Water Ecological Screening Level (µg/L)	Selected Maximum Greater than Screening Level?	Bioaccumulative Chemical?	Retained for Further Evaluation in the ERA?
EA 1							
2,4-Dimethylphenol	10.4	5.2	10.4	NV	NA	No	No
2-Methylphenol	13.6	5.2	13.6	NV	NA	No	No
3&4-Methylphenol	384	5.2	384	NV	NA	No	No
Acenaphthene	0.013	5	5	23	No	No	No
Acetone	4.3	50	50	11,000	No	No	No
Benzene	17.8	5	17.8	45	No	No	No
Benzo(a)anthracene	0.022	5	5	0.027	Yes	Yes	Yes
Benzo(a)pyrene	0.029	5	5	0.014	Yes	Yes	Yes
Benzo(b)fluoranthene	0.037	5	5	30	No	Yes	Yes
Benzo(g,h,i)perylene	0.025	0.048	0.048	30	No	Yes	Yes
Benzo(k)fluoranthene	0.02	5	5	30	No	Yes	Yes
Chrysene	0.033	5	5	30	No	Yes	Yes
Cyanide, Total	29	10	29	5.2	Yes	No	Yes
Ethylbenzene	1	5	5	NV	NA	No	No
Fluoranthene	0.45	5	5	6.1	No	Yes	Yes
Fluorene	0.25	5	5	3.9	Yes	No	Yes
Indeno(1,2,3-c,d)pyrene	0.02	5	5	30	No	Yes	Yes
Naphthalene	21.8	5	21.8	23	No	No	No
Phenanthrene	0.32	5	5	6.3	No	No	No
Phenol	4.9	5.2	5.2	110	No	No	No
Pyrene	0.04	5	5	30	No	No	No
Toluene	4.3	5	5	130	No	No	No
Xylenes (Total)	1.8	6	6	86	No	No	No

Notes:
COPEC = chemical of potential ecological concern
EA = exposure area
ERA = Ecological Risk Assessment
µg/L = micrograms per liter
NA = not applicable
NV = no screening value available

Table 4-8
Exposure Point Concentrations in Soil
Vertellus - Provo, Utah

Exposure Area	Depth Group	COPEC	No. of Samples	Detection Rate	Summary Statistics		Non-detect Reporting Limit (RL)		Detected Values		Goodness-of-Fit Test	Upper Confidence Limit (UCL)		Selected EPC
					Mean	Std Dev	Min RL	Max RL	Min Detected	Max Detected	Distribution	Method of UCL Calculation	Assessed 95% UCL	
EA2	1 - 3 ft bgs	3&4-Methylphenol	15	13%	76,968	272,644	200	7,000,000	1,350	1,060,000	Non-parametric	99% KM (Chebyshev) UCL	1,102,300	**1,060,000**
EA2	1 - 3 ft bgs	Acenaphthene	15	60%	766,305	1,915,204	200	700	726	7,690,000	Gamma	95% KM (BCA) UCL	1,782,714	**1,782,714**
EA2	1 - 3 ft bgs	Acenaphthylene	15	27%	191,683	501,208	200	7,000,000	2,970	1,880,000	Normal	95% KM (t) UCL	464,140	**464,140**
EA2	1 - 3 ft bgs	Acetone	15	67%	304	115	200	5,000,000	213	620	Gamma	95% KM (Percentile Bootstrap) UCL	366	**366**
EA2	1 - 3 ft bgs	Anthracene	15	73%	1,826,603	4,903,139	200	200	264	19,800,000	Gamma	95% KM (Chebyshev) UCL	7,614,245	**7,614,245**
EA2	1 - 3 ft bgs	Benzene	15	33%	66,725	197,751	2	6	280	780,000	Gamma	95% KM (t) UCL	167,270	**167,270**
EA2	1 - 3 ft bgs	Benzo(a)anthracene	15	67%	641,201	1,061,887	200	7,000,000	660	3,470,000	Gamma	95% KM (BCA) UCL	1,148,770	**1,148,770**
EA2	1 - 3 ft bgs	Benzo(a)pyrene	15	67%	620,725	945,812	200	7,000,000	730	2,650,000	Gamma	95% KM (BCA) UCL	1,081,643	**1,081,643**
EA2	1 - 3 ft bgs	Benzo(b)fluoranthene	15	67%	655,628	1,026,663	200	7,000,000	528	3,150,000	Gamma	95% KM (BCA) UCL	1,130,531	**1,130,531**
EA2	1 - 3 ft bgs	Benzo(k)fluoranthene	15	67%	364,339	574,096	200	7,000,000	660	1,600,000	Gamma	95% KM (BCA) UCL	632,436	**632,436**
EA2	1 - 3 ft bgs	Carbon disulfide	15	27%	6.04	2.91	7	200,000	4	15	Normal	95% KM (t) UCL	8.05	**8**
EA2	1 - 3 ft bgs	Chloroform	15	7%	-	-	6	200,000	12	12	-	-	-	**12**
EA2	1 - 3 ft bgs	Chrysene	15	67%	719,814	1,211,895	200	7,000,000	1,020	4,120,000	Gamma	95% KM (BCA) UCL	1,313,841	**1,313,841**
EA2	1 - 3 ft bgs	Cyanide, Total	11	45%	614,545	1,861,648	50	70	7,000	6,500,000	Gamma	95% KM (t) UCL	1,751,976	**1,751,976**
EA2	1 - 3 ft bgs	Dibenz(a,h)anthracene	15	33%	125,420	290,292	200	7,000,000	12,900	1,140,000	Gamma	95% KM (t) UCL	278,582	**278,582**
EA2	1 - 3 ft bgs	Ethylbenzene	15	33%	1,062	2,981	6	200,000	6	11,400	Gamma	95% KM (t) UCL	2,631	**2,631**
EA2	1 - 3 ft bgs	Fluoranthene	15	80%	2,138,559	3,871,542	200	200	264	14,400,000	Gamma	95% KM (Chebyshev) UCL	6,689,586	**6,689,586**
EA2	1 - 3 ft bgs	Fluorene	15	47%	532,605	1,091,117	200	7,000,000	627	3,770,000	Gamma	95% KM (t) UCL	1,087,380	**1,087,380**
EA2	1 - 3 ft bgs	HPAH	15	80%	8,214,974	15,107,416	1,600	1,600	1,631	58,240,000	Gamma	95% KM (Chebyshev) UCL	25,973,856	**25,973,856**
EA2	1 - 3 ft bgs	Indeno(1,2,3-c,d)pyrene	15	67%	308,168	514,944	200	7,000,000	297	1,760,000	Gamma	95% KM (BCA) UCL	570,440	**570,440**
EA2	1 - 3 ft bgs	LPAH	15	80%	15,526,245	35,300,914	1,400	1,400	1,592	136,489,997	Gamma	95% KM (Chebyshev) UCL	57,022,738	**57,022,738**
EA2	1 - 3 ft bgs	Methyl ethyl ketone	15	13%	54.0	6.0	61	2,000,000	48	60	Non-parametric	95% KM (t) UCL	64.6	**60**
EA2	1 - 3 ft bgs	Methylene chloride	15	13%	76.6	25.2	12	500,000	69	160	Non-parametric	95% KM (t) UCL	94.7	**95**
EA2	1 - 3 ft bgs	Naphthalene	15	67%	6,161,121	15,643,017	200	10,000	231	58,700,000	Gamma	95% KM (BCA) UCL	13,662,909	**13,662,909**
EA2	1 - 3 ft bgs	Phenanthrene	15	80%	2,991,369	5,900,473	200	200	297	21,900,000	Gamma	95% KM (Chebyshev) UCL	9,927,421	**9,927,421**
EA2	1 - 3 ft bgs	Phenol	15	13%	66,896	235,499	200	7,000,000	1,580	916,000	Non-parametric	99% KM (Chebyshev) UCL	952,537	**916,000**
EA2	1 - 3 ft bgs	Pyrene	15	80%	1,732,595	2,746,733	200	200	231	9,240,000	Gamma	95% KM (Chebyshev) UCL	4,961,400	**4,961,400**
EA2	1 - 3 ft bgs	Toluene	15	33%	95,648	314,037	6	4,000	12	1,260,000	Gamma	95% KM (t) UCL	255,319	**255,319**
EA2	1 - 3 ft bgs	Xylenes (Total)	15	40%	111,381	373,349	7	18	10	1,500,000	Gamma	95% KM (t) UCL	297,374	**297,374**
EA3	0 - 1 ft bgs	2,4-Dimethylphenol	32	9%	353	778	180	70,000	7.9	2,400	Normal	95% KM (t) UCL	927	**927**
EA3	0 - 1 ft bgs	2-Methylnaphthalene	4	100%	-	-	-	-	72	9,400	-	-	-	**9,400**
EA3	0 - 1 ft bgs	2-Methylphenol	32	9%	321	676	180	70,000	11	2,100	Normal	95% KM (t) UCL	822	**822**
EA3	0 - 1 ft bgs	3&4-Methylphenol	32	9%	368	458	180	70,000	36	1,200	Normal	95% KM (t) UCL	793	**793**
EA3	0 - 1 ft bgs	Acenaphthene	32	59%	14,313	30,308	200	20,000	150	170,000	Gamma	95% KM (BCA) UCL	24,865	**24,865**
EA3	0 - 1 ft bgs	Acenaphthylene	32	13%	1,794	4,447	180	70,000	12	15,000	Gamma	95% KM (t) UCL	4,561	**4,561**
EA3	0 - 1 ft bgs	Acetone	11	55%	126	144	46	200	17	464	Normal	95% KM (t) UCL	213	**213**
EA3	0 - 1 ft bgs	Anthracene	32	69%	23,486	38,718	200	20,000	9.8	209,000	Gamma	95% KM (BCA) UCL	36,207	**36,207**
EA3	0 - 1 ft bgs	Benzo(a)anthracene	32	84%	79,138	101,154	180	20,000	51	486,000	Gamma	95% KM (Chebyshev) UCL	158,594	**158,594**
EA3	0 - 1 ft bgs	Benzo(a)pyrene	32	94%	104,034	114,754	180	200	23	530,000	Gamma	95% KM (Chebyshev) UCL	193,969	**193,969**
EA3	0 - 1 ft bgs	Benzo(b)fluoranthene	32	81%	106,945	134,328	180	20,000	30	606,000	Gamma	95% KM (Chebyshev) UCL	212,507	**212,507**
EA3	0 - 1 ft bgs	Benzo(g,h,i)perylene	1	100%	-	-	-	-	110,000	110,000	-	-	-	**110,000**
EA3	0 - 1 ft bgs	Benzo(k)fluoranthene	32	91%	54,637	51,717	180	20,000	7.1	241,000	Non-parametric	99% KM (Chebyshev) UCL	147,228	**147,228**
EA3	0 - 1 ft bgs	bis(2-Ethylhexyl)phthalate	1	100%	-	-	-	-	1,600	1,600	-	-	-	**1,600**
EA3	0 - 1 ft bgs	Carbazole	1	100%	-	-	-	-	17,000	17,000	-	-	-	**17,000**
EA3	0 - 1 ft bgs	Chrysene	32	94%	105,358	125,082	180	200	46	604,000	Gamma	95% KM (Chebyshev) UCL	203,388	**203,388**
EA3	0 - 1 ft bgs	Cyanide, Total	13	92%	4,535	11,787	50	50	30	45,000	Lognormal	99% KM (Chebyshev) UCL	38,507	**38,507**
EA3	0 - 1 ft bgs	Dibenz(a,h)anthracene	32	34%	19,215	35,102	180	20,000	29	147,000	Normal	95% KM (t) UCL	30,443	**30,443**

Table 4-8
Exposure Point Concentrations in Soil
Vertellus - Provo, Utah

Exposure Area	Depth Group	COPEC	No. of Samples	Detection Rate	Summary Statistics		Non-detect Reporting Limit (RL)		Detected Values		Goodness-of-Fit Test	Upper Confidence Limit (UCL)		Selected EPC
					Mean	Std Dev	Min RL	Max RL	Min Detected	Max Detected	Distribution	Method of UCL Calculation	Assessed 95% UCL	
EA3	0 - 1 ft bgs	Dibenzofuran	4	100%	-	-	-	-	73	11,000	-	-	-	**11,000**
EA3	0 - 1 ft bgs	Ethylbenzene	11	9%	-	-	5	260	4	4	-	-	-	**4**
EA3	0 - 1 ft bgs	Fluoranthene	32	97%	143,938	167,799	200	200	13	825,000	Gamma	95% KM (Chebyshev) UCL	275,373	**275,373**
EA3	0 - 1 ft bgs	Fluorene	32	50%	12,930	29,459	200	20,000	23	169,000	Gamma	95% KM (t) UCL	22,185	**22,185**
EA3	0 - 1 ft bgs	HPAH	32	97%	728,701	883,792	1,600	1,600	400	4,550,000	Gamma	95% KM (Chebyshev) UCL	1,420,966	**1,420,966**
EA3	0 - 1 ft bgs	Indeno(1,2,3-c,d)pyrene	32	81%	67,275	79,709	180	20,000	100	346,000	Gamma	95% KM (Chebyshev) UCL	129,935	**129,935**
EA3	0 - 1 ft bgs	LPAH	32	97%	345,312	473,370	1,400	1,400	1,145	2,585,000	Non-parametric	99% KM (Chebyshev) UCL	1,191,689	**1,191,689**
EA3	0 - 1 ft bgs	Methyl ethyl ketone	11	9%	-	-	46	2,600	8	8	-	-	-	**8**
EA3	0 - 1 ft bgs	Methylene chloride	11	82%	615	831	20	20	22	2,760	Gamma	95% KM (Chebyshev) UCL	1,774	**1,774**
EA3	0 - 1 ft bgs	Naphthalene	32	44%	15,797	48,730	200	20,000	340	282,000	Lognormal	97.5% KM (Chebyshev) UCL	71,917	**71,917**
EA3	0 - 1 ft bgs	Phenanthrene	32	91%	99,460	165,720	200	20,000	28	860,000	Gamma	95% KM (Chebyshev) UCL	229,423	**229,423**
EA3	0 - 1 ft bgs	Phenol	32	9%	309	322	180	70,000	78	900	Normal	95% KM (t) UCL	608	**608**
EA3	0 - 1 ft bgs	Pyrene	32	97%	174,366	283,442	200	200	14	1,590,000	Gamma	95% KM (Chebyshev) UCL	396,383	**396,383**
EA3	0 - 1 ft bgs	Toluene	11	18%	2.75	1.30	5	260	2	5	Non-parametric	95% KM (t) UCL	4.42	**4**
EA3	0 - 1 ft bgs	Xylenes (Total)	11	18%	37.9	91.4	6	17	9	327	Non-parametric	99% KM (Chebyshev) UCL	426	**327**
EA3	1 - 3 ft bgs	Acenaphthene	7	43%	54,429	84,809	10,000	30,000	1,000	202,000	Normal	95% KM (t) UCL	130,716	**130,716**
EA3	1 - 3 ft bgs	Acetone	7	100%	366	150	-	-	230	640	Normal	95% Student's-t UCL	476	**476**
EA3	1 - 3 ft bgs	Anthracene	7	43%	27,033	45,112	10,000	200,000	1,550	125,000	Normal	95% KM (t) UCL	70,864	**70,864**
EA3	1 - 3 ft bgs	Benzene	7	29%	15.7	27.9	2	3	4.32	84	Non-parametric	99% KM (Chebyshev) UCL	164	**84**
EA3	1 - 3 ft bgs	Benzo(a)anthracene	7	86%	69,714	82,510	10,000	10,000	1,950	261,000	Gamma	95% KM (Chebyshev) UCL	218,626	**218,626**
EA3	1 - 3 ft bgs	Benzo(a)pyrene	7	86%	229,371	277,227	10,000	10,000	3,300	860,000	Normal	95% KM (t) UCL	452,415	**452,415**
EA3	1 - 3 ft bgs	Benzo(b)fluoranthene	7	86%	87,566	116,483	10,000	10,000	2,180	363,000	Gamma	95% KM (Chebyshev) UCL	297,789	**297,789**
EA3	1 - 3 ft bgs	Benzo(k)fluoranthene	7	86%	159,683	186,589	10,000	10,000	2,540	584,000	Normal	95% KM (t) UCL	309,803	**309,803**
EA3	1 - 3 ft bgs	Chloroform	7	14%	-	-	6	8	7	7	-	-	-	**7**
EA3	1 - 3 ft bgs	Chrysene	7	86%	140,643	145,270	10,000	10,000	3,200	426,000	Normal	95% KM (t) UCL	257,520	**257,520**
EA3	1 - 3 ft bgs	Cyanide, Total	7	43%	3,504	7,553	40	60	330	22,000	Normal	95% KM (t) UCL	10,299	**10,299**
EA3	1 - 3 ft bgs	Dibenz(a,h)anthracene	7	29%	30,383	857	1,000	200,000	30,000	32,300	Non-parametric	95% KM (t) UCL	31,345	**31,345**
EA3	1 - 3 ft bgs	Fluoranthene	7	100%	203,054	205,454	-	-	5,280	551,000	Normal	95% Student's-t UCL	353,951	**353,951**
EA3	1 - 3 ft bgs	Fluorene	7	29%	26,667	57,392	10,000	200,000	1,000	155,000	Non-parametric	99% KM (Chebyshev) UCL	356,361	**155,000**
EA3	1 - 3 ft bgs	HPAH	7	100%	1,049,084	1,244,751	-	-	21,590	3,661,000	Gamma	95% Approximate Gamma UCL	3,397,173	**3,397,173**
EA3	1 - 3 ft bgs	Indeno(1,2,3-c,d)pyrene	7	86%	94,037	136,177	10,000	10,000	1,680	419,000	Gamma	95% KM (Chebyshev) UCL	339,803	**339,803**
EA3	1 - 3 ft bgs	LPAH	7	100%	696,252	736,697	-	-	16,268	2,126,999	Normal	95% Student's-t UCL	1,237,321	**1,237,321**
EA3	1 - 3 ft bgs	Methylene chloride	7	57%	86.3	52.2	20	20	50	190	Normal	95% KM (t) UCL	131	**131**
EA3	1 - 3 ft bgs	Naphthalene	7	14%	-	-	1,000	200,000	29,000	29,000	-	-	-	**29,000**
EA3	1 - 3 ft bgs	Phenanthrene	7	100%	205,834	213,556	-	-	5,440	574,000	Normal	95% Student's-t UCL	362,681	**362,681**
EA3	1 - 3 ft bgs	Pyrene	7	100%	215,434	210,148	-	-	5,740	548,000	Normal	95% Student's-t UCL	369,778	**369,778**
EA3	1 - 3 ft bgs	Toluene	7	14%	-	-	10	20	25	25	-	-	-	**25**
EA3	1 - 3 ft bgs	Xylenes (Total)	7	14%	-	-	6	8	40	40	-	-	-	**40**
EA4	1 - 3 ft bgs	2,4-Dimethylphenol	7	29%	18,971	37,162	2,000	30,000	3,800	110,000	Non-parametric	99% KM (Chebyshev) UCL	216,616	**110,000**
EA4	1 - 3 ft bgs	2-Methylnaphthalene	2	50%	-	-	10,000	10,000	1,400,000	1,400,000	-	-	-	**1,400,000**
EA4	1 - 3 ft bgs	2-Methylphenol	7	14%	-	-	2,000	30,000	150,000	150,000	-	-	-	**150,000**
EA4	1 - 3 ft bgs	3&4-Methylphenol	7	14%	-	-	2,000	30,000	470,000	470,000	-	-	-	**470,000**
EA4	1 - 3 ft bgs	Acenaphthene	7	71%	338,564	760,603	2,000	3,000	650	2,200,000	Gamma	95% KM (Chebyshev) UCL	1,739,574	**1,739,574**
EA4	1 - 3 ft bgs	Acenaphthylene	7	29%	123,714	6,649	2,000	10,000	121,000	140,000	Non-parametric	95% KM (t) UCL	130,620	**130,620**
EA4	1 - 3 ft bgs	Acetone	7	29%	357	307	400	88,000	140	792	Non-parametric	95% KM (Chebyshev) UCL	1,451	**792**
EA4	1 - 3 ft bgs	Anthracene	7	71%	139,619	268,944	2,000	3,000	1,600	790,000	Gamma	95% KM (Chebyshev) UCL	635,005	**635,005**
EA4	1 - 3 ft bgs	Benzene	7	100%	1,421	1,855	-	-	15	4,600	Gamma	95% Approximate Gamma UCL	5,700	**4,600**

Table 4-8
Exposure Point Concentrations in Soil
Vertellus - Provo, Utah

Exposure Area	Depth Group	COPEC	No. of Samples	Detection Rate	Summary Statistics		Non-detect Reporting Limit (RL)		Detected Values		Goodness-of-Fit Test	Upper Confidence Limit (UCL)		Selected EPC
					Mean	Std Dev	Min RL	Max RL	Min Detected	Max Detected	Distribution	Method of UCL Calculation	Assessed 95% UCL	
EA4	1 - 3 ft bgs	Benzo(a)anthracene	7	71%	541,620	1,289,502	2,000	3,000	5,480	3,700,000	Lognormal	99% KM (Chebyshev) UCL	5,963,446	**3,700,000**
EA4	1 - 3 ft bgs	Benzo(a)pyrene	7	71%	37,837	64,351	2,000	3,000	3,690	190,000	Gamma	95% KM (Chebyshev) UCL	156,369	**156,369**
EA4	1 - 3 ft bgs	Benzo(b)fluoranthene	7	57%	31,533	64,702	2,000	30,000	4,200	190,000	Non-parametric	99% KM (Chebyshev) UCL	312,509	**190,000**
EA4	1 - 3 ft bgs	Benzo(k)fluoranthene	7	71%	18,955	29,014	2,000	3,000	1,840	84,000	Normal	95% KM (t) UCL	42,780	**42,780**
EA4	1 - 3 ft bgs	Carbon disulfide	7	29%	172	344	50	18,000	18	940	Non-parametric	99% KM (Chebyshev) UCL	2,146	**940**
EA4	1 - 3 ft bgs	Chrysene	7	71%	544,617	1,288,347	2,000	3,000	6,440	3,700,000	Gamma	95% KM (Chebyshev) UCL	2,917,714	**2,917,714**
EA4	1 - 3 ft bgs	Cyanide, Total	5	80%	6,792	13,104	60	60	120	33,000	Lognormal	99% KM (Chebyshev) UCL	74,124	**33,000**
EA4	1 - 3 ft bgs	Dibenz(a,h)anthracene	7	14%	-	-	2,000	30,000	21,000	21,000	-	-	-	**21,000**
EA4	1 - 3 ft bgs	Dibenzofuran	2	50%	-	-	10,000	10,000	1,000,000	1,000,000	-	-	-	**1,000,000**
EA4	1 - 3 ft bgs	Ethylbenzene	7	86%	617	882	440	440	20	2,520	Gamma	95% KM (Chebyshev) UCL	2,208	**2,208**
EA4	1 - 3 ft bgs	Fluoranthene	7	71%	357,343	754,424	2,000	3,000	11,000	2,200,000	Gamma	95% KM (Chebyshev) UCL	1,746,969	**1,746,969**
EA4	1 - 3 ft bgs	Fluorene	7	71%	230,384	479,906	2,000	3,000	330	1,400,000	Gamma	95% KM (Chebyshev) UCL	1,114,357	**1,114,357**
EA4	1 - 3 ft bgs	HPAH	7	71%	1,519,409	3,407,806	16,000	24,000	46,384	9,859,000	Gamma	95% KM (Chebyshev) UCL	7,796,489	**7,796,489**
EA4	1 - 3 ft bgs	Indeno(1,2,3-c,d)pyrene	7	29%	14,000	24,495	2,000	30,000	4,000	74,000	Non-parametric	99% KM (Chebyshev) UCL	144,274	**74,000**
EA4	1 - 3 ft bgs	LPAH	7	100%	2,357,289	5,432,251	-	-	21,630	14,630,000	Gamma	95% Adjusted Gamma UCL	27,880,931	**14,630,000**
EA4	1 - 3 ft bgs	m,p-Xylene	2	100%	-	-	-	-	43	3,900	-	-	-	**3,900**
EA4	1 - 3 ft bgs	Methylene chloride	7	29%	162	44	70	18,000	140	250	Non-parametric	95% KM (t) UCL	216	**216**
EA4	1 - 3 ft bgs	Naphthalene	7	100%	981,963	2,436,246	-	-	380	6,500,000	Gamma	95% Adjusted Gamma UCL	16,400,994	**6,500,000**
EA4	1 - 3 ft bgs	o-Xylene	2	100%	-	-	-	-	31	2,000	-	-	-	**2,000**
EA4	1 - 3 ft bgs	Phenanthrene	6	67%	84,167	117,511	2,000	3,000	5,900	337,000	Normal	95% KM (t) UCL	195,791	**195,791**
EA4	1 - 3 ft bgs	Phenol	7	14%	-	-	2,000	30,000	820,000	820,000	-	-	-	**820,000**
EA4	1 - 3 ft bgs	Pyrene	7	71%	312,714	650,456	2,000	3,000	14,000	1,900,000	Gamma	95% KM (Chebyshev) UCL	1,510,834	**1,510,834**
EA4	1 - 3 ft bgs	Toluene	7	57%	1,321	2,632	70	8,800	30	7,200	Gamma	95% KM (BCA) UCL	3,755	**3,755**
EA4	1 - 3 ft bgs	Xylenes (Total)	7	71%	1,502	1,988	1,300	26,000	74	5,900	Gamma	95% KM (Chebyshev) UCL	5,468	**5,468**
EA6	0 - 1 ft bgs	2,4-Dimethylphenol	3	100%	-	-	-	-	1,100	4,200	-	-	-	**4,200**
EA6	0 - 1 ft bgs	2-Methylnaphthalene	3	100%	-	-	-	-	19,000	82,000	-	-	-	**82,000**
EA6	0 - 1 ft bgs	2-Methylphenol	3	100%	-	-	-	-	1,100	4,100	-	-	-	**4,100**
EA6	0 - 1 ft bgs	3&4-Methylphenol	3	100%	-	-	-	-	3,300	11,000	-	-	-	**11,000**
EA6	0 - 1 ft bgs	Acenaphthene	3	100%	-	-	-	-	38,000	550,000	-	-	-	**550,000**
EA6	0 - 1 ft bgs	Acenaphthylene	3	100%	-	-	-	-	2,800	140,000	-	-	-	**140,000**
EA6	0 - 1 ft bgs	Anthracene	3	100%	-	-	-	-	190,000	860,000	-	-	-	**860,000**
EA6	0 - 1 ft bgs	Benzo(a)anthracene	3	100%	-	-	-	-	530,000	2,400,000	-	-	-	**2,400,000**
EA6	0 - 1 ft bgs	Benzo(a)pyrene	3	100%	-	-	-	-	490,000	2,200,000	-	-	-	**2,200,000**
EA6	0 - 1 ft bgs	Benzo(b)fluoranthene	3	100%	-	-	-	-	660,000	2,500,000	-	-	-	**2,500,000**
EA6	0 - 1 ft bgs	Benzo(g,h,i)perylene	3	100%	-	-	-	-	260,000	1,100,000	-	-	-	**1,100,000**
EA6	0 - 1 ft bgs	Benzo(k)fluoranthene	3	100%	-	-	-	-	210,000	1,000,000	-	-	-	**1,000,000**
EA6	0 - 1 ft bgs	Carbazole	3	100%	-	-	-	-	40,000	650,000	-	-	-	**650,000**
EA6	0 - 1 ft bgs	Chrysene	3	100%	-	-	-	-	510,000	2,500,000	-	-	-	**2,500,000**
EA6	0 - 1 ft bgs	Dibenz(a,h)anthracene	3	100%	-	-	-	-	95,000	370,000	-	-	-	**370,000**
EA6	0 - 1 ft bgs	Dibenzofuran	3	100%	-	-	-	-	55,000	200,000	-	-	-	**200,000**
EA6	0 - 1 ft bgs	Fluoranthene	3	100%	-	-	-	-	960,000	5,300,000	-	-	-	**5,300,000**
EA6	0 - 1 ft bgs	Fluorene	3	100%	-	-	-	-	58,000	470,000	-	-	-	**470,000**
EA6	0 - 1 ft bgs	HPAH	3	100%	-	-	-	-	3,875,000	17,970,000	-	-	-	**17,970,000**
EA6	0 - 1 ft bgs	Indeno(1,2,3-c,d)pyrene	3	100%	-	-	-	-	280,000	1,100,000	-	-	-	**1,100,000**
EA6	0 - 1 ft bgs	LPAH	3	100%	-	-	-	-	2,218,000	11,776,200	-	-	-	**11,776,200**
EA6	0 - 1 ft bgs	Naphthalene	3	100%	-	-	-	-	27,000	450,000	-	-	-	**450,000**
EA6	0 - 1 ft bgs	Phenanthrene	3	100%	-	-	-	-	750,000	4,400,000	-	-	-	**4,400,000**

Table 4-8
Exposure Point Concentrations in Soil
Vertellus - Provo, Utah

Exposure Area	Depth Group	COPEC	No. of Samples	Detection Rate	Summary Statistics		Non-detect Reporting Limit (RL)		Detected Values		Goodness-of-Fit Test	Upper Confidence Limit (UCL)		Selected EPC
					Mean	Std Dev	Min RL	Max RL	Min Detected	Max Detected	Distribution	Method of UCL Calculation	Assessed 95% UCL	
EA6	0 - 1 ft bgs	Phenol	3	100%	-	-	-	-	2,900	6,700	-	-	-	**6,700**
EA6	0 - 1 ft bgs	Pyrene	3	100%	-	-	-	-	840,000	4,800,000	-	-	-	**4,800,000**
EA7	0 - 1 ft bgs	2-Methylnaphthalene	12	100%	522	770	-	-	10	2,700	Gamma	95% Approximate Gamma UCL	1,222	**1,222**
EA7	0 - 1 ft bgs	Acenaphthene	12	100%	518	450	-	-	28	1,400	Normal	95% Student's-t UCL	751	**751**
EA7	0 - 1 ft bgs	Acenaphthylene	12	100%	395	483	-	-	6.3	1,500	Gamma	95% Approximate Gamma UCL	879	**879**
EA7	0 - 1 ft bgs	Anthracene	12	100%	1,858	2,545	-	-	43	8,900	Gamma	95% Approximate Gamma UCL	4,016	**4,016**
EA7	0 - 1 ft bgs	Benzo(a)anthracene	12	100%	4,777	3,762	-	-	200	12,000	Normal	95% Student's-t UCL	6,727	**6,727**
EA7	0 - 1 ft bgs	Benzo(a)pyrene	12	100%	5,563	4,222	-	-	290	13,000	Normal	95% Student's-t UCL	7,752	**7,752**
EA7	0 - 1 ft bgs	Benzo(b)fluoranthene	12	100%	6,229	4,609	-	-	320	13,000	Normal	95% Student's-t UCL	8,618	**8,618**
EA7	0 - 1 ft bgs	Benzo(g,h,i)perylene	12	100%	3,653	2,719	-	-	200	8,000	Normal	95% Student's-t UCL	5,062	**5,062**
EA7	0 - 1 ft bgs	Benzo(k)fluoranthene	12	100%	2,893	2,280	-	-	150	7,300	Normal	95% Student's-t UCL	4,075	**4,075**
EA7	0 - 1 ft bgs	Carbazole	12	100%	620	481	-	-	29	1,500	Normal	95% Student's-t UCL	869	**869**
EA7	0 - 1 ft bgs	Chrysene	12	100%	6,240	4,925	-	-	260	14,000	Normal	95% Student's-t UCL	8,793	**8,793**
EA7	0 - 1 ft bgs	Dibenz(a,h)anthracene	12	100%	1,067	859	-	-	59	2,700	Normal	95% Student's-t UCL	1,512	**1,512**
EA7	0 - 1 ft bgs	Dibenzofuran	12	83%	339	294	33	330	20	900	Normal	95% KM (t) UCL	501	**501**
EA7	0 - 1 ft bgs	Fluoranthene	12	100%	8,680	6,918	-	-	330	23,000	Normal	95% Student's-t UCL	12,267	**12,267**
EA7	0 - 1 ft bgs	Fluorene	12	100%	486	404	-	-	18	1,300	Normal	95% Student's-t UCL	696	**696**
EA7	0 - 1 ft bgs	HPAH	12	100%	42,255	32,173	-	-	2,019	99,100	Normal	95% Student's-t UCL	58,934	**58,934**
EA7	0 - 1 ft bgs	Indeno(1,2,3-c,d)pyrene	12	100%	3,521	2,630	-	-	180	7,900	Normal	95% Student's-t UCL	4,884	**4,884**
EA7	0 - 1 ft bgs	LPAH	12	100%	20,926	18,314	-	-	659	53,070	Normal	95% Student's-t UCL	30,420	**30,420**
EA7	0 - 1 ft bgs	Naphthalene	12	100%	3,674	6,869	-	-	27	24,000	Gamma	95% Adjusted Gamma UCL	12,555	**12,555**
EA7	0 - 1 ft bgs	Phenanthrene	12	100%	4,793	3,498	-	-	190	10,000	Normal	95% Student's-t UCL	6,606	**6,606**
EA7	0 - 1 ft bgs	Pyrene	12	100%	8,312	6,570	-	-	360	22,000	Normal	95% Student's-t UCL	11,718	**11,718**
EA7	1 - 3 ft bgs	2-Methylnaphthalene	7	29%	153	317	17	17	23	930	Non-parametric	99% KM (Chebyshev) UCL	1,841	**930**
EA7	1 - 3 ft bgs	Acenaphthene	10	30%	126	163	17	280	71	616	Lognormal	95% KM (BCA) UCL	616	**616**
EA7	1 - 3 ft bgs	Acenaphthylene	10	40%	80.7	143.3	17	280	3.6	380	Normal	95% KM (t) UCL	177	**177**
EA7	1 - 3 ft bgs	Acetone	10	20%	87.0	120.0	19	80	47	447	Non-parametric	97.5% KM (Chebyshev) UCL	422	**422**
EA7	1 - 3 ft bgs	Anthracene	10	50%	153	266	17	280	4.4	870	Normal	95% KM (t) UCL	327	**327**
EA7	1 - 3 ft bgs	Benzene	10	10%	-	-	5	8	14	14	-	-	-	**14**
EA7	1 - 3 ft bgs	Benzo(a)anthracene	10	80%	557	1,069	17	280	5.2	3,510	Gamma	95% KM (Chebyshev) UCL	2,132	**2,132**
EA7	1 - 3 ft bgs	Benzo(a)pyrene	10	80%	626	1,159	17	280	7.4	3,720	Gamma	95% KM (Chebyshev) UCL	2,334	**2,334**
EA7	1 - 3 ft bgs	Benzo(b)fluoranthene	10	80%	740	1,422	17	280	8.6	4,660	Gamma	95% KM (Chebyshev) UCL	2,835	**2,835**
EA7	1 - 3 ft bgs	Benzo(g,h,i)perylene	7	86%	237	446	17	17	3.7	1,300	Gamma	95% KM (Chebyshev) UCL	1,042	**1,042**
EA7	1 - 3 ft bgs	Benzo(k)fluoranthene	10	70%	354	681	17	280	4.6	2,210	Gamma	95% KM (BCA) UCL	767	**767**
EA7	1 - 3 ft bgs	Carbazole	7	14%	-	-	33	330	84	84	-	-	-	**84**
EA7	1 - 3 ft bgs	Carbon disulfide	10	10%	-	-	5	16	4	4	-	-	-	**4**
EA7	1 - 3 ft bgs	Chrysene	10	80%	674	1,243	17	280	8.2	4,000	Gamma	95% KM (Chebyshev) UCL	2,505	**2,505**
EA7	1 - 3 ft bgs	Dibenz(a,h)anthracene	10	50%	95.3	151.0	17	280	3.4	407	Normal	95% KM (t) UCL	194	**194**
EA7	1 - 3 ft bgs	Dibenzofuran	7	14%	-	-	33	170	270	270	-	-	-	**270**
EA7	1 - 3 ft bgs	Ethylbenzene	10	10%	-	-	5	8	8	8	-	-	-	**8**
EA7	1 - 3 ft bgs	Fluoranthene	10	80%	897	1,708	17	280	10	5,650	Gamma	95% KM (Chebyshev) UCL	3,414	**3,414**
EA7	1 - 3 ft bgs	Fluorene	10	30%	109	83	17	280	75	352	Normal	95% KM (t) UCL	167	**167**
EA7	1 - 3 ft bgs	HPAH	10	80%	4,399	7,932	153	2,240	64.35	25,317	Gamma	95% KM (Chebyshev) UCL	16,089	**16,089**
EA7	1 - 3 ft bgs	Indeno(1,2,3-c,d)pyrene	10	70%	311	544	17	280	3.9	1,550	Gamma	95% KM (BCA) UCL	624	**624**
EA7	1 - 3 ft bgs	LPAH	10	90%	3,178	5,099	136	136	50.664	13,310	Gamma	95% KM (Chebyshev) UCL	10,633	**10,633**
EA7	1 - 3 ft bgs	Methyl ethyl ketone	10	20%	20.6	28.8	9	80	11	107	Non-parametric	97.5% KM (Chebyshev) UCL	101	**101**
EA7	1 - 3 ft bgs	Naphthalene	10	60%	952	2,371	17	250	3.5	8,000	Gamma	95% KM (BCA) UCL	2,520	**2,520**

Table 4-8
Exposure Point Concentrations in Soil
Vertellus - Provo, Utah

Exposure Area	Depth Group	COPEC	No. of Samples	Detection Rate	Summary Statistics		Non-detect Reporting Limit (RL)		Detected Values		Goodness-of-Fit Test	Upper Confidence Limit (UCL)		Selected EPC
					Mean	Std Dev	Min RL	Max RL	Min Detected	Max Detected	Distribution	Method of UCL Calculation	Assessed 95% UCL	
EA7	1 - 3 ft bgs	Phenanthrene	10	80%	636	1,317	17	280	5.5	4,410	Gamma	95% KM (Chebyshev) UCL	2,576	**2,576**
EA7	1 - 3 ft bgs	Pyrene	10	80%	840	1,593	17	280	11	5,260	Gamma	95% KM (Chebyshev) UCL	3,187	**3,187**

Notes:

All units micrograms per kilogram (µg/kg)

1 - If the dataset contains nondetects, summary statistics and UCLs are estimated by the Kaplan-Meier (KM) method.

2 - Goodness-of-Fit Test at 5% significance level is used to test for distributional assumption.
3 - The distributional assumption from (2) is used to select the appropriate UCL calculation method. For normal distribution, the UCL is based on the t-statistics. For lognormal distribution, gamma distribution, and non-parametric assumption, the UCL is based on the recommendations from USEPA (2002) and Singh (2010a and 2010b).

BCA = bias corrected and accelerated

bgs = below ground surface

COPEC = chemical of potential ecological concern

EA = exposure area

HPAH = high molecular weight PAH; calculated from individual PAH results; includes Benzo(a)anthracene, Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(g,h,i)perylene, Benzo(k)fluoranthene, Chrysene, Dibenz(a,h)anthracene, Indeno(1,2,3-cd)pyrene, and Pyrene.

LPAH = low molecular weigth PAH; calculated from individual PAH results; includes 2-Methylnaphthalene, Acenaphthene, Acenaphthylene, Anthracene, Fluoranthene, Fluorene, Naphthalene, and Phenanthrene.

Sources:

USEPA. 2002. Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites. Office of Emergency and Remedial Response, U.S. Environmental Protection Agency, Report No. OSWER 9285.6-10.

Singh, A., R. Maichle, and N. Armbya. 2010a. *ProUCL Version 4.1 User Guide*. Office of Research and Development, U.S. Environmental Protection Agency, Report No. EPA/600/R-07/038.

Singh, A., N. Armbya, and A.K. Singh. 2010b. *ProUCL Version 4.1 Technical Guide*. Office of Research and Development, U.S. Environmental Protection Agency, Report No. EPA/600/R-07/041.

Table 4-9
Exposure Point Concentrations in Sediment
Vertellus - Provo, Utah

Exposure Area	Depth Group	COPEC	No. of Samples	Detection Rate	Summary Statistics		Non-detect Reporting Limit (RL)		Detected Values		Goodness-of-Fit Test	Upper Confidence Limit (UCL)		Selected EPC
					Mean	Std Dev	Min RL	Max RL	Min Detected	Max Detected	Distribution	Method of UCL Calculation	Assessed 95% UCL	
EA1	0 - 1 ft bgs	2-Methylnaphthalene	5	40%	16 0	4 0	230	1,400	12	20	Non-parametnc	95% KM (t) UCL	24 5	**20.0**
EA1	0 - 1 ft bgs	Acenaphthene	9	56%	48,430	125,047	230	2,000	13	401,000	Gamma	95% KM (BCA) UCL	137,242	**137,242**
EA1	0 - 1 ft bgs	Acenaphthylene	9	44%	1,857	3,332	230	2,000	5	10,500	Normal	95% KM (t) UCL	4,241	**4,241**
EA1	0 - 1 ft bgs	Acetone	9	67%	69 2	58 2	200	6,400	4 1	143	Normal	95% KM (t) UCL	118	**118**
EA1	0 - 1 ft bgs	Anthracene	9	67%	40,786	83,267	230	1,400	17	261,000	Gamma	95% KM (BCA) UCL	98,768	**98,768**
EA1	0 - 1 ft bgs	Benzene	9	44%	4 73	4 01	2	320	2 2	14	Normal	95% KM (t) UCL	8 02	**8.02**
EA1	0 - 1 ft bgs	Benzo(a)anthracene	9	67%	30,405	49,006	230	1,400	84	136,000	Gamma	95% KM (BCA) UCL	64,111	**64,111**
EA1	0 - 1 ft bgs	Benzo(a)pyrene	9	67%	25,732	42,184	230	1,400	110	128,000	Normal	95% KM (t) UCL	54,376	**54,376**
EA1	0 - 1 ft bgs	Benzo(b)fluoranthene	9	67%	28,551	47,004	230	1,500	120	142,000	Normal	95% KM (t) UCL	60,467	**60,467**
EA1	0 - 1 ft bgs	Benzo(k)fluoranthene	9	67%	11,012	15,110	230	1,700	54	40,200	Normal	95% KM (t) UCL	21,272	**21,272**
EA1	0 - 1 ft bgs	Carbon disulfide	9	67%	3 11	2 37	7	1,600	0 38	8 1	Normal	95% KM (t) UCL	4 98	**4.98**
EA1	0 - 1 ft bgs	Chrysene	9	67%	41,110	66,983	230	1,700	100	197,000	Normal	95% KM (t) UCL	86,592	**86,592**
EA1	0 - 1 ft bgs	Cyanide, Total	6	83%	927	590	1,000	1,000	130	1,600	Normal	95% KM (t) UCL	1,470	**1,470**
EA1	0 - 1 ft bgs	Dibenz(a,h)anthracene	9	44%	2,750	4,666	230	2,000	22	13,900	Normal	95% KM (t) UCL	6,090	**6,090**
EA1	0 - 1 ft bgs	Ethylbenzene	9	44%	9 50	10 00	1 8	640	1 5	26 9	Normal	95% KM (t) UCL	17.6	**17.6**
EA1	0 - 1 ft bgs	Fluoranthene	9	67%	73,573	127,831	230	2,600	110	365,000	Gamma	95% KM (BCA) UCL	165,404	**165,404**
EA1	0 - 1 ft bgs	Fluorene	9	44%	34,875	89,757	230	2,000	7 9	288,000	Gamma	95% KM (t) UCL	99,118	**99,118**
EA1	0 - 1 ft bgs	Indeno(1,2,3-c,d)pyrene	9	67%	9,831	15,895	230	1,400	76	49,500	Normal	95% KM (t) UCL	20,624	**20,624**
EA1	0 - 1 ft bgs	Methyl ethyl ketone	9	44%	7 58	5 70	6 8	6,400	2 9	16 7	Normal	95% KM (t) UCL	12 6	**12.6**
EA1	0 - 1 ft bgs	Methylene chlonde	9	44%	1 97	1.01	2 8	1,600	0 49	3	Normal	95% KM (t) UCL	3 04	**3.00**
EA1	0 - 1 ft bgs	Naphthalene	9	67%	4,136	7,627	820	2,600	6 6	22,400	Gamma	95% KM (BCA) UCL	9,089	**9,089**
EA1	0 - 1 ft bgs	Phenanthrene	9	67%	65,397	125,083	230	2,600	76	388,000	Gamma	95% KM (BCA) UCL	145,545	**145,545**
EA1	0 - 1 ft bgs	Pyrene	9	67%	73,020	121,806	230	1,500	120	331,000	Gamma	95% KM (BCA) UCL	153,218	**153,218**
EA1	0 - 1 ft bgs	Toluene	9	56%	3 01	3 53	1 8	640	0.4	10 5	Normal	95% KM (t) UCL	6 00	**6.00**
EA1	0 - 1 ft bgs	PAH (Total)	9	89%	492,972	857,385	27,000	27,000	224	2,515,840	Gamma	95% KM (Chebyshev) UCL	1,824,736	**1,824,736**

Notes:

All units micrograms per kilogram (µg/kg)

1 - If the dataset contains nondetects, summary statistics and UCLs are estimated by the Kaplan-Meier (KM) method

2 - Goodness-of-Fit Test at 5% significance level is used to test for distributional assumption

3 - The distributional assumption from (2) is used to select the appropriate UCL calculation method For normal distribution, the UCL is based on the t-statistics For lognormal distribution, gamma distribution, and non-parametric assumption, the UCL is based on the recommendations from USEPA (2002) and Singh (2010a and 2010b)

BCA = bias corrected and accelerated

bgs = below ground surface

COPEC = chemical of potential ecological concern

EA = exposure area

HPAH = high molecular weight PAH, calculated from individual PAH results, includes Benzo(a)anthracene, Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(g,h,i)perylene, Benzo(k)fluoranthene, Chrysene, Dibenz(a,h)anthracene, Indeno(1,2,3-cd)pyrene, and Pyrene

LPAH = low molecular weigth PAH, calculated from individual PAH results, includes 2-Methylnaphthalene, Acenaphthene, Acenaphthylene, Anthracene, Fluoranthene, Fluorene, Naphthalene, and Phenanthrene

PAH = polycyclic aromatic hydrocarbon

Sources:

USEPA 2002. Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites Office of Emergency and Remedial Response, U.S Environmental Protection Agency, Report No OSWER 9285 6-10

Singh, A , R Maichle, and N. Armbya 2010a *ProUCL Version 4 1 User Guide* Office of Research and Development, U S. Environmental Protection Agency, Report No. EPA/600/R-07/038

Table 4-10
Exposure Point Concentrations in Surface Water
Vertellus - Provo, Utah

Exposure Area	COPEC	No. of Samples	Detection Rate	Summary Statistics		Non-detect Reporting Limit (RL)		Detected Values		Goodness-of-Fit Test	Upper Confidence Limit (UCL)		Selected EPC
				Mean	Std Dev	Min RL	Max RL	Min Detected	Max Detected	Distribution	Method of UCL Calculation	Assessed 95% UCL	
EA1	2-Methylphenol	21	10%	10 5	0 7	0 5	5 2	10.3	13 6	Non-parametnc	95% KM (t) UCL	10 8	**10.8**
EA1	3&4-Methylphenol	15	13%	28 6	95 0	0 9	5.2	3 2	384	Non-parametnc	99% KM (Chebyshev) UCL	373 7	**373.7**
EA1	Acenaphthene	21	5%	-	-	0 0095	5	0 013	0 013	-	-	-	**0.013**
EA1	Acetone	21	10%	3 50	0 80	6	50	2 7	4 3	Non-parametnc	95% KM (t) UCL	4.88	**4.30**
EA1	Benzene	21	10%	4 09	3 07	0 5	5	3 4	17 8	Non-parametnc	95% KM (BCA) UCL	17 8	**17.8**
EA1	Benzo(a)anthracene	21	19%	0 0168	0 0033	0 047	5	0.014	0 022	Normal	95% KM (t) UCL	0.0200	**0.0200**
EA1	Benzo(a)pyrene	21	19%	0 0178	0 0068	0 047	5	0.012	0 029	Normal	95% KM (t) UCL	0.0245	**0.0245**
EA1	Benzo(b)fluoranthene	21	29%	0 0185	0 0089	0 047	5	0 011	0.037	Normal	95% KM (t) UCL	0.0253	**0.0253**
EA1	Benzo(g,h,i)perylene	9	11%	-	-	0 0095	0 048	0 025	0 025	-	-	-	**0.025**
EA1	Benzo(k)fluoranthene	21	10%	0 0125	0 0043	0 0095	5	0 01	0 02	Non-parametric	95% KM (t) UCL	0 0178	**0.0178**
EA1	Chrysene	21	24%	0 0186	0 0078	0.047	5	0 01	0 033	Normal	95% KM (t) UCL	0 0253	**0.0253**
EA1	Cyanide, Total	12	42%	6.93	6.98	10	10	2 2	29	Gamma	95% KM (t) UCL	11 3	**11.3**
EA1	Fluoranthene	21	33%	0 0544	0 1030	0.047	5	0 015	0 45	Non-parametnc	95% KM (BCA) UCL	0 111	**0.111**
EA1	Fluorene	21	5%	-	-	0.0095	5	0 25	0 25	-	-	-	**0.25**
EA1	Indeno(1,2,3-c,d)pyrene	21	5%	-	-	0 0095	5	0.02	0 02	-	-	-	**0.02**
EA1	Naphthalene	21	48%	1 35	4.63	0.047	5	0 029	21 8	Lognormal	99% KM (Chebyshev) UCL	12 0	**12.0**
EA1	Phenanthrene	21	5%	-	-	0 029	5	0 32	0 32	-	-	-	**0.32**
EA1	Phenol	21	10%	1 97	0.88	0 5	5.2	1 7	4 9	Non-parametric	95% KM (t) UCL	2 59	**2.59**
EA1	Pyrene	21	24%	0 0278	0.0085	0 047	5	0 014	0 04	Normal	95% KM (t) UCL	0 0351	**0.0351**
EA1	Toluene	21	10%	4 21	0.02	0.7	5	4 2	4 3	Non-parametnc	95% KM (t) UCL	4 22	**4.22**
EA1	Xylenes (Total)	21	5%	-	-	0.8	6	1 8	1 8	-	-	-	**1.8**
EA1	HPAH	21	29%	0 189	0 101	0 423	40	0 105	0 387	Normal	95% KM (t) UCL	0 267	**0.267**
EA1	LPAH	21	52%	3 86	8.93	0.829	35	0 121	32 9	Lognormal	99% KM (Chebyshev) UCL	26 5	**26.5**
EA1	PAH (Total)	21	57%	6 60	17 40	1.26	75	0 213	72 9	Lognormal	99% KM (Chebyshev) UCL	50 5	**50.5**

Notes:

All units in micrograms per liter (µg/L)

1 - If the dataset contains nondetects, summary statistics and UCLs are estimated by the Kaplan-Meier (KM) method.

2 -Goodness-of-Fit Test at 5% significance level is used to test for distributional assumption.

3 - The distributional assumption from (2) is used to select the appropriate UCL calculation method For normal distribution, the UCL is based on the t-statistics For lognormal distribution, gamma distribution, and non-parametric assumption, the UCL is based on the recommendations from USEPA (2002) and Singh (2010a and 2010b)

BCA = bias corrected and accelerated

COPEC = chemical of potential ecological concern

EA = exposure area

HPAH = high molecular weight PAH, calculated from individual PAH results, includes Benzo(a)anthracene, Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(g,h,i)perylene, Benzo(k)fluoranthene, Chrysene, Dibenz(a,h)anthracene, Indeno(1,2,3-cd)pyrene, and Pyrene

LPAH = low molecular weigth PAH, calculated from individual PAH results, includes 2-Methylnaphthalene, Acenaphthene, Acenaphthylene, Anthracene, Fluoranthene, Fluorene, Naphthalene, and Phenanthrene

PAH = polycyclic aromatic hydrocarbon

Sources:

USEPA 2002 Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites Office of Emergency and Remedial Response, U S Environmental Protection Agency, Report No OSWER 9285.6-10.

Singh, A., R. Maichle, and N. Armbya. 2010a. *ProUCL Version 4 1 User Guide* Office of Research and Development, U.S. Environmental Protection Agency, Report No EPA/600/R-07/038

Singh, A , N Armbya, and A K Singh 2010b *ProUCL Version 4 1 Technical Guide* Office of Research and Development, U S Environmental Protection Agency, Report No EPA/600/R-07/041.

Table 4-11
Exposure Factors for Wildlife Receptors
Vertellus - Provo, Utah

Representative Species			Body Weight (bw)			Food Ingestion Rate (IR_f)			Composition of Diet (%)				Soil/Sediment Ingestion Rate (IR_s)			Water Ingestion Rate (IR_w)			Home Range		
Food-web Classification	Common Name	Scientific Name	kg	Comment	Reference	kg/day (dw)	Comment	Reference	Plants	Inverte-brates	Small Mammals	Comment (Reference)	kg/day	Comment	Reference	L/day	Comment	Reference	Acres	Comment	Reference
Carnivore	Amencan kestrel	*Falco sparvenus*	0 12	Average of male and female means, Utah	USEPA 1993	0 011	Based on 0 29 g ww/g-bw/day	USEPA 1993	0%	0%	100%	Diet assumed to consist entirely of small mammals	0.0	Negligible	Adapted from Efroymson et al 1997	0 017	0 115 g/g-day, average	USEPA 1993	668	Based on range of 100-1,235 acres in Wyoming grasslands	USEPA 1993
Herbivore	Ring-necked pheasant	*Phasianus colchicus*	1 1	Average of males and female means	Dunning 1993	0 045	Based on Galliformes ingestion (dw) (Table 3)	Nagy 2001	100%	0%	0%	Grains and weed seeds (USFS 1983)	0 0042	9 3% of diet (dw) Based on estimated soil ingestion rate for wild turkey	Beyer et al 1994	0 063	0 059 x (bw [kg]^0 67), for all birds	USEPA 1993	502	Daily range of 0 5 mile	USDA 2002
Invertivore	Tree swallow	*Tachycineta bicolor*	0 020	Mean of males and females	Dunning 1993	0 012	11 6 g/day dw (Table 1)	Nagy 2001	0%	100%	0%	Diet assumed to consist of flying insects, seasonally eats berries (USFS 1983)	0 00023	≤ 2 0% of diet (dw) Based on lowest soil ingestion rates available and foraging behavior	Beyer et al 1994	0 0043	0 059 x (bw [kg]^0.67), for all birds	USEPA 1993	9500	3 5-km range around nest (average of males and females)	Sample et al 1997
Herbivore	Mule deer	*Odocoileus hemionus*	70	Average weight, Colorado	Fitzgerald et al 1994	1 5	Based on 21.9 g/kg-bw/day dw	Sample et al 1997	100%	0%	0%	Diet consists entirely of vegetation (Sample et al 1997)	0.031	≤ 2 0% of diet (dw)	Beyer et al 1994	3 1	44 mL/kg bw, average of summer and winter rates	Sample et al 1997	705	285 3 hectares, mean annual home range	Sample et al 1997
Invertivore	Deer Mouse	*Peromyscus maniculatus*	0 018		Nagy 2001	0 0038	Table 1	Nagy 2001	0%	100%	0%	Diet assumed to consist entirely of invertebrates	0.000076	Based on white-footed mouse (≤2% of dw IR_f)	USEPA 1993	0 0034	0 19 g/g-day, two laboratory studies	USEPA 1993	0 38	Median of 0.25 to 0.50 acres	Verner and Boss 1980
Herbivore	Meadow vole	*Microtus pennsylvanicus*	0 037	Average males and females all year; south Indiana	USEPA 1993	0 012	Table 1	Nagy 2001	100%	0%	0%	Diet assumed to consist entirely of vegetation	0 00089	2 4% of diet (dw)	USEPA 1993	0 006		Sample et al 1996	0 10	Range of 0.09-0 21 acre for males and females	USEPA 1993
Omnivore	Mallard	*Anas platyrhynchos*	1 04	Average female, throughout North Amenca	USEPA 1993	0 056	=0 301*(g-bw^0 751) (g/day dw) for non-passennes	USEPA 1993	50%	50%	0%	Diet assumed to consist of vegetation and invertebrates (USEPA 1993)	0 0011	<2% of diet (dw)	USEPA 1993	0 059	0.0565 g/g-day; average of adult male and female means	USEPA 1993	274	Range of 94-596 acres, mean for laying females in North Dakota	USEPA 1993
Carnivore	Red fox	*Vulpes vulpes*	4 5	Average male and female adults in Illinois and Iowa	USEPA 1993	0 10	0 069g/g bw-day ww for non-breeding adults, assuming 68% moisture in small mammals	USEPA 1993	0%	0%	100%	Diet assumed to consist of small mammals	0 0028	2 8% of diet (dw)	USEPA 1993	0 39	0 085 g/g-day, average of adult male and female means	USEPA 1993	1730	699 hectares, spring territory for adult females in woods, fileds, swamp of Minnesota	USEPA 1993

Notes:
Percent solids 30% - plants, 39% - soil invertebrates, and 32% - small birds/mammals (USEPA 1993)

dw = dry weight
g = gram
kg = kilogram
km = kilometer
L = liter
mL = milliliter
ww = wet weight

Sources:

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Efroymson, R A , G W Suter II, B E Sample and D S Jones 1997 *Preliminary Remediation Goals for Ecological Endpoints.* Prepared for the U S Department of Energy ES/ER/TM-162/R2 (Table 5).

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Sample, B E , D.M Opresko and G W Suter II 1996 *Toxicological Benchmarks for Wildlife· 1996 Revision* Risk Assessment Program, Oak Ridge National Laboratory, Oak Ridge, TN. Prepared for U S Department of Energy ES/ER/TM-86/R3 (Table B 1)

Sample, B E , M S Aplin, R A Efroymson, G.W Suter II and C J E Welsh 1997 *Methods and Tools for Estimation of the Exposure of Terrestrial Wildlife to Contaminants* Oak Ridge National Laboratory, TN Prepared for U.S. Department of Energy ORNL/TM-13391

U S. Department of Agriculture (USDA) 2002. Ring-Necked Pheasant (*Phasianus colchicus*) Fish and Wildlife Habitat Management Guide Sheet. Accessed at http·//www mn nrcs.usda gov/technical/ecs/wild/pheasant.pdf on May 21, 2012

U S Environmental Protection Agency (USEPA) 1993 *Wildlife Exposure Factors Handbook, Volume 1* Office of Research and Development. EPA/600/R-93/187a

U S Forest Service (USFS) 1983 *New England Wildlife Habitat, Natural History, and Distribution* General Technical Report NE-108.

Verner, J and A S Boss 1980 *California Wildlife and Their Habitats· Western Sierra Nevada* Gen Tech Rep PSW-37, 439 p., illus Pacific Southwest Forest and Range Exp Stn , Forest Serv , U S Dep Agric., Berkeley, CA

Table 4-12
Area Use Factors for Ecological Receptors
Vertellus - Provo, Utah

Representative Species	Area (acres):	Ecological Exposure Areas[1]						
		EA1	EA2	EA3	EA4	EA6	EA7	Hotspots[3]
	Home Range (Acres)2	0.788	3.34	7.71	3.68	0.164	6.08	0.000023
American kestrel	668	NA	0.00500	0.01154	0.00550	0 00025	0.00910	NA
Ring-necked pheasant	502	NA	0.00665	0.01536	0.00732	0.00033	0.0121	NA
Tree swallow	9500	0.0000829	0.000352	0 000812	0 000387	0.0000173	0.000640	NA
Mule deer	705	NA	0.00474	0.0109	0.00522	0.000233	0.00862	NA
Deer mouse	0 375	NA	1	1	1	0.44	1	0.0000612
Meadow vole	0.100	NA	1	1	1	1	1	0.000230
Mallard	274	0 0029	NA	NA	NA	NA	NA	NA
Red fox	1730	NA	0.00193	0.00446	0.00213	0.0000948	0.00351	NA

Notes:
1 - EA5 and EA9 are not considered exposure areas for ecological receptors
2 - Home ranges from Table 4-11
3 - Hotspots assumed to be 1 square foot in area

AUF = area of EA / home range (AUFs are less than or equal to 1 0 [100%])
AUF = area use factor (unitless)
EA = exposure area

Table 4-13
Bioconcentration and Bioaccumulation Factors for Soil
Vertellus - Provo, Utah

Soil COPEC[1]	Plants				Invertebrates				Flesh (Small Mammals)			
	Source	slope[2]	Intercept[2]	BCF[3]	Source	slope[2]	Intercept[2]	BCF[3]	Source	slope[2]	Intercept[2]	BAF[3]
2-Methylphenol	LANL	-	-	3	LANL	-	-	0.701	LANL	-	-	1.54E-06
3&4-Methylphenol	LANL	-	-	2.63	LANL	-	-	0.730	LANL	-	-	1.69E-06
Acenaphthene	Eco-SSL regression	-0.8556	-5.562	-	Eco-SSL	-	-	1 47	Eco-SSL	-	-	0
Acenaphthylene	Eco-SSL regression	0.791	-1.144	-	Eco-SSL	-	-	22.9	Eco-SSL	-	-	0
Acetone	LANL	-	-	76	LANL	-	-	3 16	LANL	-	-	0.0472
Anthracene	Eco-SSL regression	0.7784	-0.9887	-	Eco-SSL	-	-	2.42	Eco-SSL	-	-	0
Benzene	LANL	-	-	8.26	LANL	-	-	2 68	LANL	-	-	0.0493
Benzo(a)anthracene	Eco-SSL regression	0.5944	-2.7078	-	Eco-SSL	-	-	1.59	Eco-SSL	-	-	0
Benzo(a)pyrene	Eco-SSL regression	0 975	-2 0615	-	Eco-SSL	-	-	1.33	Eco-SSL	-	-	0
Benzo(b)fluoranthene	Eco-SSL	-	-	0.31	Eco-SSL	-	-	2.6	Eco-SSL	-	-	0
Benzo(g,h,i)perylene	Eco-SSL regression	1.1829	-0 9313	-	Eco-SSL	-	-	2 94	Eco-SSL	-	-	0
Benzo(k)fluoranthene	Eco-SSL regression	0 8595	-2.1579	-	Eco-SSL	-	-	2.6	Eco-SSL	-	-	0
Bis(2-ethylhexyl)phthalate	LANL	-	-	0.05	LANL	-	-	154	LANL	-	-	329
Carbazole	LANL	-	-	1 87	LANL	-	-	0.961	LANL	-	-	0.0605
Carbon disulfide	LANL	-	-	2.01	LANL	-	-	1	LANL	-	-	2.67E-06
Chloroform	LANL	-	-	9.59	LANL	-	-	9.1	LANL	-	-	0.115
Chrysene	Eco-SSL regression	0.5944	-2.7078	-	Eco-SSL	-	-	2 29	Eco-SSL	-	-	0
Cyanide, Total	LANL	-	-	1	LANL	-	-	1	LANL	-	-	0.667
Dibenz(a,h)anthracene	Eco-SSL	-	-	0 13	Eco-SSL	-	-	2.31	Eco-SSL	-	-	0
Dibenzofuran	LANL	-	-	1.29	LANL	-	-	2 1	LANL	-	-	0 218
Fluoranthene	Eco-SSL	-	-	0.5	Eco-SSL	-	-	3.04	Eco-SSL	-	-	0
Fluorene	Eco-SSL regression	-0 8556	-5.562	-	Eco-SSL	-	-	9.57	Eco-SSL	-	-	0
HPAH	Eco-SSL regression	0.9469	-1.7026	-	Eco-SSL	-	-	2 6	Eco-SSL	-	-	0
Indeno(1,2,3-c,d)pyrene	Eco-SSL	-	-	0.11	Eco-SSL	-	-	2.86	Eco-SSL	-	-	0
LPAH	Eco-SSL	-	-	2.09	Eco-SSL	-	-	3 04	Eco-SSL	-	-	0
m,p-Xylene	LANL	-	-	3.28	LANL	-	-	7 24	LANL	-	-	0.311
Methyl ethyl ketone	LANL	-	-	46.1	LANL	-	-	3.27	LANL	-	-	0.0644
Methylene chloride	LANL	-	-	18.8	LANL	-	-	3.16	LANL	-	-	0.0484
Naphthalene	Eco-SSL	-	-	12.2	Eco-SSL	-	-	4 4	Eco-SSL	-	-	0
o-Xylene	LANL	-	-	3.28	LANL	-	-	7.24	LANL	-	-	0 311
Phenanthrene	Eco-SSL regression	0.6203	-0.1665	-	Eco-SSL	-	-	1.72	Eco-SSL	-	-	0
Phenol	LANL	-	-	0.0494	LANL	-	-	0 443	LANL	-	-	15 4
Pyrene	Eco-SSL	-	-	0.72	Eco-SSL	-	-	1.75	Eco-SSL	-	-	0
Toluene	LANL	-	-	4 71	LANL	-	-	5.6	LANL	-	-	0.157
Xylenes (Total)	LANL	-	-	3.28	LANL	-	-	7.24	LANL	-	-	0 311

Notes:

1 - Xylenes (Total) values used for m,p-Xylene and o-Xylene

2 - Regression Formula: *ln* (tissue concentration) = slope * (*ln* [soil concentration]) + Y-intercept

3 - BCFs and BAFs from the USEPA (2005) Eco-SSL guidance and LANL (2011) database are median values. All BCFs and BAFs are dry-weight based. The recommended BAF in USEPA (2005) for ingestion of PAHs by birds and mammals is zero (0) because of the rapid metabolism of these compounds after ingestion.

- = not applicable

BAF = bioaccumulation factor

BCF = bioconcentration factor

COPEC = chemical of potential ecological concern

Table 4-13
Bioconcentration and Bioaccumulation Factors for Soil
Vertellus - Provo, Utah

HPAH = high molecular weight PAH; calculated from individual PAH results, includes Benz(a)anthracene, Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(g,h,i)perylene, Benzo(k)fluoranthene, Chrysene, Dibenz(a,h)anthracene, Indeno(1,2,3-cd)pyrene, and Pyrene.
LPAH = low molecular weigth PAH, calculated from individual PAH results; includes 2-Methylnaphthalene, Acenaphthene, Acenaphthylene, Anthracene, Fluoranthene, Fluorene, Naphthalene, and Phenanthrene.
PAH = polycyclic aromatic hydrocarbor

Sources:

Los Alamos National Laboratory (LANL). 2011 ECORISK Database (Release 3.0). Environmental Programs Directorate LA-UR-11-5460. Los Alamos, New Mexico. Issued October 1. Accessed online at http://www.lanl.gov/environment/cleanup/ecorisk.shtml.

U S Environmental Protection Agency (USEPA). 2005. Guidance for Developing Ecological Soil Screening Levels – Revised Draft. OSWER Directive 9285.7-55, U.S. Environmental Protection Agency, OSWER, February.

Table 4-14
Accumulation Factors for Sediment
Vertellus - Provo, Utah

Sediment COPECs	Plants				Invertebrates	
	Source	Slope[1]	Intercept[1]	Bioconcentration Factor[2]	Source	Biota-Sediment Accumulation Factor[3]
2-Methylnaphthalene	LANL	-	-	1.64	USACE	2.6
Acenaphthene	Eco-SSL regression	-0.8556	-5.562	-	USACE	0.030
Acenaphthylene	Eco-SSL regression	0.791	-1.144	-	USACE	0.762
Acetone	LANL	-	-	76	-	-
Anthracene	Eco-SSL regression	0.7784	-0 9887	-	USACE	0.108
Benzene	LANL	-	-	8.26	-	-
Benzo(a)anthracene	Eco-SSL regression	0 5944	-2 7078	-	USACE	0.331
Benzo(a)pyrene	Eco-SSL regression	0 975	-2.0615	-	USACE	0.329
Benzo(b)fluoranthene	Eco-SSL	-	-	0.31	USACE	0.251
Benzo(g,h,i)perylene	Eco-SSL regression	1.1829	-0 9313	-	USACE	0.037
Benzo(k)fluoranthene	Eco-SSL regression	0.8595	-2.1579	-	USACE	0.197
Carbon disulfide	LANL	-	-	2.01	-	-
Chrysene	Eco-SSL regression	0.5944	-2.7078	-	USACE	0.435
Cyanide, Total	LANL	-	-	1	-	-
Dibenz(a,h)anthracene	Eco-SSL	-	-	0.13	USACE	0.377
Fluoranthene	Eco-SSL	-	-	0.5	USACE	0.716
Fluorene	Eco-SSL regression	-0 8556	-5.562	-	USACE	0.964
Indeno(1,2,3-c,d)pyrene	Eco-SSL	-	-	0.11	USACE	0.210
Methyl ethyl ketone	LANL	-	-	46.1	-	-
Methylene chloride	LANL	-	-	18.8	-	-
Naphthalene	Eco-SSL	-	-	12.2	USACE	2.637
PAH (Total)	Eco-SSL regression	0 3015	0 083	-	USACE	0.070
Phenanthrene	Eco-SSL regression	0.6203	-0.1665	-	USACE	0.607
Pyrene	Eco-SSL	-	-	0 72	USACE	0.477

Notes:

1 - Regression Formula: $Ln\ (C_{Plant}) = Slope*(Ln\ C_{Sed}) + Intercept$

2 - $C_{Plant} = BCF*C_{Sed}$

3 C_{Inv}*%lipid = $BASF*(C_{Sed})$*%OC

BCF = bioconcentration factor

BSAF = biota-sediment accumulation factor

COPEC = chemical of potential ecological concern

C_{Inv} = concentration in benthic invertebrate

C_{Plant} = concentration in plants

C_{Sed} = concentration in sediment

OC = organic carbon in sediment (assumed to be 1%)

% lipids = 3.5% (90th % in freshwaer worm [USEPA 2012])

Sources:

Los Alamos National Laboratory (LANL). 2011. ECORISK Database (Release 3.0). Environmental Programs Directorate LA-UR-11-5460 Los Alamos, New Mexico. Issued October 1. Accessed online at http://www.lanl.gov/environment/cleanup/ecorisk.shtml.

U.S. Army Corps of Engineers (USACE) 2009. Biota-Sediment Accumulation Factor (BSAF) Database USACE Environmental Laboratory Accessed June 29, 2011 at http://el erdc usace.army.mil/bsafnew/ Last update November 4. (BSAFs based on average BSAFs for all benthic invertebrates tested with the analyte).

U S Environmental Protection Agency (USEPA). 2005 Guidance for Developing Ecological Soil Screening Levels – Revised Draft OSWER Directive 9285.7-55, U S. Environmental Protection Agency, OSWER, February

USEPA. 2012 *User's Guide and Technical Documentation KABAM Version 1 0*

(Kow (based) Aquatic BioAccumulation Model). Accessed May 23, 2013 at: http://www.epa gov/oppefed1/models/water/kabam/kabam_user_guide_a

Table 4-15
Low-Effect Concentrations for Plants and Soil Invertebrates
Vertellus - Provo, Utah

Soil COPECs[1,2]	Plant NOECs		Plant LOECs	Invertebrate NOECs[3]		Invertebrate LOECs
	USEPA	LANL		USEPA	LANL	
2-Methylphenol	-	670	3,350	-	-	NV
3&4-Methylphenol	-	690	3,450	-	-	NV
Acenaphthene	-	250	1,250	LPAH	-	NV
Acenaphthylene	-	-	NV	LPAH	-	NV
Acetone	-	-	NV	-	-	NV
Anthracene	-	6,800	34,000	LPAH	-	NV
Benzene	-	-	NV	-	-	NV
Benzo(a)anthracene	-	18,000	90,000	HPAH	-	NV
Benzo(a)pyrene	-	-	NV	HPAH	-	NV
Benzo(b)fluoranthene	-	18,000	90,000	HPAH	-	NV
Benzo(g,h,i)perylene	-	-	NV	HPAH	-	NV
Benzo(k)fluoranthene	-	-	NV	HPAH	-	NV
bis(2-Ethylhexyl)phthalate	-	-	NV	-	-	NV
Carbazole	-	-	NV	-	-	NV
Carbon Disulfide	-	-	NV	-	-	NV
Chloroform	-	-	NV	-	-	NV
Chrysene	-	-	NV	HPAH	-	NV
Cyanide, Total	-	-	NV	-	-	NV
Dibenz(a,h)anthracene	-	-	NV	HPAH	-	NV
Dibenzofuran	-	6,100	30,500	-	-	NV
Fluoranthene	-	-	NV	LPAH	10,000	50,000
Fluorene	-	-	NV	LPAH	3,700	18,500
Indeno(1,2,3-c,d)pyrene	-	-	NV	HPAH	-	NV
m,p-Xylene	-	100,000	500,000	-	-	NV
Methyl ethyl ketone	-	-	NV	-	-	NV
Methylene chloride	-	1,600,000	8,000,000	-	-	NV
Naphthalene	-	1,000	5,000	LPAH	-	NV
o-Xylene	-	100,000	500,000	-	-	NV
Phenanthrene	-	-	NV	LPAH	5,500	27,500
Phenol	-	790	3,950	-	1,800	9,000
Pyrene	-	-	NV	HPAH	10,000	50,000
Toluene	-	200,000	1,000,000	-	-	NV
Xylenes (Total)	-	100,000	500,000	-	-	NV
HPAH	-	-	NV	18,000	-	90,000
LPAH	-	-	NV	29,000	-	145,000

Notes:

All units are µg/kg

1 - Xylenes (Total) ESLs are used for m,p-Xylene and o-Xylene

2 - PAHs are evaluated individually (based on LANL 2011 as available) as well as grouped as HPAHs and LPAHs (based on USEPA 2010).

3 - The LANL (2011) invertebrate values are based on earthworm data

Dash (-) = not available

COPEC = chemical of potential ecological concern

Eco-SSL = Ecological Soil Screening Level

ESL = Ecological Screening Level

HPAH = high molecular weight PAH, calculated from individual PAH results; includes Benz(a)anthracene, Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(g,h,i)perylene, Benzo(k)fluoranthene, Chrysene, Dibenz(a,h)anthracene, Indeno(1,2,3-cd)pyrene, and Pyrene The selected soil ESL (NOEC) is 1800 µg/kg for protection of invertebrates

LPAH = low molecular weigth PAH, calculated from individual PAH results, includes 2-Methylnaphthalene, Acenaphthene, Acenaphthylene, Anthracene, Fluoranthene, Fluorene, Naphthalene, and Phenanthrene The selected soil ESL (NOEC) is 29000 µg/kg for protection of invertebrates.

LANL = Los Alamos National Laboratory (ESLs)

LOEC = lowest observed effects concentration (= 5 x NOEC)

NOEC = no observed effects concentration

NV = no value available as LOEC

PAH = polycyclic aromatic hydrocarbon

ug/kg = micrograms per kilogram

USEPA = U.S Environmental Protection Agency (Eco-SSLs)

Sources:

Los Alamos National Laboratory (LANL). 2011 ECORISK Database (Release 3 0) Environmental Programs Directorate LA-UR-11-5460 Los Alamos, New Mexico Issued October 1 Accessed online at http //www lanl gov/environment/cleanup/econsk shtml U S Environmental Protection Agency (USEPA) 2010 Ecological Soil Screening Levels (Eco-SSLs) Office of Solid Waste and Emergency Response http //www epa gov/ecotox/ecossl/ Latest update October 20. Accessed online on January 30, 2012

Table 4-16
Low-Effect Concentrations for Plants and Benthic Invertebrates Exposed to Sediment
Vertellus - Provo, Utah

Sediment COPECs	Benthic Invertebrates				Plants	
	Protection of Aquatic Community[1] (LANL 2011)	Protection of Aquatic Community LOEC[2]	Consensus Sediment Probable Effect Concentration (PEC) (MacDonald et al. 2000)	Selected Benthic Invertebrate LOEC[3] (ug/kg)	NOEC (LANL 2011)[4]	LOEC[2] (µg/kg)
2-Methylnaphthalene	180	900	-	900	-	NV
Acenaphthene	620	3,100	-	3,100	250	1,250
Acenaphthylene	44	220	-	220	-	NV
Acetone	65	325	-	325	-	NV
Anthracene	0 39	1 95	845	1 95	6,800	34,000
Benzene	57	285	-	285	-	NV
Benzo(a)anthracene	110	550	1,050	550	18,000	90,000
Benzo(a)pyrene	350	1,750	1,450	1,450	-	NV
Benzo(b)fluoranthene	240	1,200	-	1,200	18,000	90,000
Benzo(k)fluoranthene	240	1,200	-	1,200	-	NV
Carbon disulfide	-	-	-	NV	-	NV
Chrysene	500	2,500	1,290	1,290	-	NV
Cyanide, Total	100	500	-	500	-	NV
Dibenz(a,h)anthracene	15	75	-	75	-	NV
Fluoranthene	2,900	14,500	2,230	2,230	-	NV
Fluorene	540	2,700	536	536	-	NV
Indeno(1,2,3-c,d)pyrene	78	390	-	390	-	NV
Methyl ethyl ketone	-	-	-	NV	-	NV
Methylene chloride	380	1,900	-	1,900	1,600,000	8,000,000
Naphthalene	470	2,350	561	561	1,000	5,000
Phenanthrene	850	4,250	1,170	1,170	-	NV
Pyrene	570	2,850	1,520	1,520	-	NV
PAH (Total)	-	-	22,800	22,800	-	NV

Notes:

All units are µg/kg

1 - Sediment screening value

2 - LOEC = 5 x Screening value

3 - Lower of LOEC or PEC

4 - NOEC for plants exposed to chemicals in soil

COPEC = chemical of potential ecological concern

NV = no value availabe from LANL (2011) or MacDonald et al (2000)

PAH = polycyclic aromatic hydrocarbon, PAH (Total) calculated from individual PAH results

PEC = probable effect concentration

µg/kg = micrograms per kilogram

Sources:

Los Alamos National Laboratory (LANL) 2011 ECORISK Database (Release 3 0) Environmental Programs Directorate LA-UR-11-5460 Los Alamos, New Mexico Issued October 1 Accessed online at http://www lanl gov/environment/cleanup/ecorisk.shtml

MacDonald, D D , C G Ingersoll and T.A. Berger 2000 Development and evaluation of consensus-based sediment quality guidelines for freshwater ecosystems. Arch Environ Contam. Toxicol 39 20-31

Table 4-17
Toxicity Reference Values for Birds
Vertellus - Provo, Utah

COPEC	Source of Toxicity Data[1]	Form	Test Species	Exposure Duration	Exposure Route	Endpoint(s)	Chronic NOAEL (mg/kg-bw/d)	Chronic LOAEL (mg/kg-bw/d)	Comments
2-Methylpheno	--	--	--	--	--	--	--	--	--
3&4-Methylpheno	--	--	--	--	--	--	--	--	--
Acenaphthene	--	--	--	--	--	--	--	--	--
Acenaphthylene	--	--	--	--	--	--	--	--	--
Acetone	LANL 2011	--	Japanese quail	5 days	OD	mortality	200 89	1004	LOAEL = 5(NOAEL)
Anthracene	--	--	--	--	--	--	--	--	--
Benzene	--	--	--	--	--	--	--	--	--
Benzo(a)anthracene	USEPA 1999	--	chicken (embryo)	acute	--	--	0 00079	0 00395	NOAEL = LD50/100 LOAEL = 5(NOAEL)
Benzo(a)pyrene	USEPA 1999	--	chicken (embryo)	acute	--	--	0 001	0 005	NOAEL = LD50/100 LOAEL = 5(NOAEL)
Benzo(b)fluoranthene	USEPA 1999	surrogate benzo(k) fluoranthene	chicken (embryo)	acute	--	--	0 00014	0.00070	NOAEL = LD50/100 LOAEL = 5(NOAEL)
Benzo(g,h,i)perylene	--	--	--	--	--	--	--	--	--
Benzo(k)fluoranthene	USEPA 1999	--	chicken (embryo)	acute	--	--	0 00014	0.00070	NOAEL = LD50/100 LOAEL = 5(NOAEL)
Bis(2-ethylhexyl)phthalate	LANL 2011	--	nnged dove	4 weeks (cntical)	OD	reproduction	1.1	5 5	LOAEL = 5(NOAEL)
Carbazole	--	--	--	--	--	--	--	--	--
Carbon disulfide	--	--	--	--	--	--	--	--	--
Chloroform	--	--	--	--	--	--	--	--	--
Chrysene	USEPA 1999	--	chicken (embryo)	acute	--	--	0 001	0.005	NOAEL = LD50/100 LOAEL = 5(NOAEL)
Cyanide, Total	LANL 2011	CN(-1)	Amencan kestrel	acute	O	mortality	0 04	0 20	NOAEL = LD50/100 LOAEL = 5(NOAEL)
Dibenz(a,h)anthracene	USEPA 1999	--	chicken (embryo)	acute	--	--	0 00039	0 0020	NOAEL = LD50/100 LOAEL = 5(NOAEL)
Dibenzofuran	--	--	--	--	--	--	--	--	--
Fluoranthene	--	--	--	--	--	--	--	--	--
Fluorene	--	--	--	--	--	--	--	--	--
HPAH	USEPA 1999	Benzo(k)fluoranthene	chicken (embryo)	acute	--	--	0 00014	0.00070	NOAEL = LD50/100 LOAEL = 5(NOAEL)
Indeno(1,2,3-c,d)pyrene	USEPA 1999	--	chicken (embryo)	acute	--	--	0 001	0 005	NOAEL = LD50/100 LOAEL = 5(NOAEL)
LPAH	LANL 2011	Naphthalene	bobwhite quail	5 days	OD	mortality	15	75	NOAEL = LC50/100 LOAEL = 5(NOAEL)
m,p-Xylene	LANL 2011	Xylenes (Total)	Japanese quail	5 days	OD	mortality	106 7	533 50000	LOAEL = 5(NOAEL)
Methyl ethyl ketone	--	--	--	--	--	--	--	--	--
Methylene chloride	--	--	--	--	--	--	--	--	--
Naphthalene	LANL 2011	--	bobwhite quail	5 days	OD	mortality	15	75	NOAEL = LC50/100 LOAEL = 5(NOAEL)
o-Xylene	LANL 2011	Xylenes (Total)	Japanese quail	5 days	OD	mortality	106 7	533.50000	LOAEL = 5(NOAEL)
PAH (Total)	USEPA 1999 LANL 2011	Benzo(k)fluoranthene Naphthalene	chicken (embryo) bobwhite quail	acute	--	--	--	0.23	Geomean (LPAH *HPAH)
Phenanthrene	--	--	--	--	--	--	--	--	--
Phenol	--	--	--	--	--	--	--	--	--
Pyrene	--	--	--	--	--	--	--	--	--
Toluene	--	--	--	--	--	--	--	--	--
Xylenes (Total)	LANL 2011	--	Japanese quail	5 days	OD	mortality	106 7	534	LOAEL = 5(NOAEL)

Notes:
-- = Information not available
COPEC = chemical of potential ecological concern
G = Gavage
LOAEL = lowest observed adverse effects level
mg/kg-bw/d = milligrams per kilogram-bodyweight per day
NOAEL = no observed adverse effects level
O = Oral exposure
OD = Oral Dose exposure
TRV = toxicity reference value

HPAH = high molecular weight PAH, calculated from individual PAH results, includes Benz(a)anthracene, Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(g,h,i)perylene, Benzo(k)fluoranthene, Chrysene, Dibenz(a,h)anthracene, Indeno(1,2,3-cd)pyrene, and Pyrene
LPAH = low molecular weigth PAH, calculated from individual PAH results; includes 2-Methylnaphthalene, Acenaphthene, Acenaphthylene, Anthracene, Fluoranthene, Fluorene, Naphthalei and Phenanthrene

Sources:
Los Alamos National Laboratory (LANL) 2011 ECORISK Database (Release 3.0) Environmental Programs Directorate LA-UR-11-5460 Los Alamos, New Mexico Issued October 1. Accessed online at http //www lanl.gov/environment/cleanup/econsk shtml
U S Environmental Protection Agency (USEPA) 1999 *Screening Level Ecological Risk Assessment Protocol for Hazardous Waste Combustion Facilities.* Appendix E Office of Solid Waste. Available at http.//www epa.gov/eaposwer/hazwaste/combust/htm November

Table 4-18
Toxicity Reference Values for Mammals
Vertellus - Provo, Utah

COPEC	Source of Toxicity Data[1]	Form	Test Species	Exposure Duration	Exposure Route	Endpoint(s)	Chronic NOAEL (mg/kg-bw/d)	Chronic LOAEL mg/kg-bw/d)	Comments
2-Methylphenol	LANL 2011	--	mink	--	O	--	220	1100	LOAEL = 5(NOAEL)
3&4-Methylphenol	LANL 2011	--	mink	--	O	--	220	1100	LOAEL = 5(NOAEL)
Acenaphthene	LANL 2011	--	mouse	90 days	O	growth, survival	70	350	LOAEL = 5(NOAEL)
Acenaphthylene	LANL 2011	(based on acenaphthene)	mouse	90 days	O	growth, survival	70	350	LOAEL = 5(NOAEL)
Acetone	LANL 2011	--	rat	90 days	OD	liver and kidney damage	10	50	LOAEL = 5(NOAEL)
Anthracene	LANL 2011	--	mouse	1 to 26 weeks	O	reproduction, survival, development	100	500	LOAEL = 5(NOAEL)
Benzene	LANL 2011	--	mouse	6 days (critical)	G	reproduction	--	263 6	--
Benzo(a)anthracene	LANL 2011	--	mouse	single dose	O	tumor growth	0.17	0.85	LOAEL = 5(NOAEL)
Benzo(a)pyrene	USEPA 2010	--	mouse	65 weeks	OD	survival	--	3.07	--
Benzo(b)fluoranthene	LANL 2011	--	rodent	--	O	carcinogenic	--	40	--
Benzo(g,h,ı)perylene	LANL 2011	--	rodent	--	O	carcinogenic	--	72	--
Benzo(k)fluoranthene	LANL 2011	--	rodent	--	O	carcinogenic	--	72	--
Bis(2-ethylhexyl)phthalate	LANL 2011	--	mouse	105 days	OD	reproduction	--	183.0	--
Carbazole	LANL 2011	--	mouse	96 weeks	OD	survival	22.8	114	LOAEL = 5(NOAEL)
Carbon disulfide	LANL 2011	--	European rabbit	25 days	OG	reproduction	0.25	1.25	LOAEL = 5(NOAEL)
Chloroform	LANL 2011	--	rat	13 weeks	G	liver, kidney, and gonad condition	15	75	LOAEL = 5(NOAEL)
Chrysene	LANL 2011	--	mouse	single dose	OD	tumor growth	0 17	0.85	LOAEL = 5(NOAEL)
Cyanide, Total	LANL 2011	CN(-1)	rat	(critical)	OD	reproduction	68.7	343.5	LOAEL = 5(NOAEL)
Dibenz(a,h)anthracene	LANL 2011	--	mouse	406 days	O	carcinogenic	--	13.3	--
Dibenzofuran	--	--	--	--	--	--	--	--	--
Fluoranthene	LANL 2011	--	mouse	1 to 26 weeks	O	reproduction, survival, development	12 5	62.5	LOAEL = 5(NOAEL)
Fluorene	LANL 2011	--	mouse	13 weeks	O	effects on blood cells	125	625	LOAEL = 5(NOAEL)
HPAH	USEPA 2010	Benzo(a)pyrene	mouse	65 weeks	OD	survival		3 07	--
Indeno(1,2,3-c,d)pyrene	LANL 2011	--	rodent	--	O	carcinogenic	--	72	--

Table 4-18
Toxicity Reference Values for Mammals
Vertellus - Provo, Utah

COPEC	Source of Toxicity Data[1]	Form	Test Species	Exposure Duration	Exposure Route	Endpoint(s)	Chronic NOAEL (mg/kg-bw/d)	Chronic LOAEL mg/kg-bw/d)	Comments
LPAH	USEPA 2010	1-Naphthaleneacetic acid	rat	6 weeks	OD	growth		328	--
m,p-Xylene	LANL 2011	Xylenes (Total)	mouse	9 days (critical)	G	reproduction	--	2 6	--
Methyl ethyl ketone	LANL 2011	--	rat	2 generations	OW	reproduction	--	4571	--
Methylene chloride	LANL 2011	--	rat	2 years	OW	liver effects	--	50	--
Naphthalene	LANL 2011	--	mammals	various	O	reproduction, development, and survival	14.3	71.5	LOAEL = 5(NOAEL)
o-Xylene	LANL 2011	Xylenes (Total)	mouse	9 days (critical)	G	reproduction	--	2 6	--
Phenanthrene	LANL 2011	--	rat	10 days	O	liver weight	5.14	25.7	LOAEL = 5(NOAEL)
Phenol	LANL 2011	--	rat	26 weeks	O	reproduction, development, and survival	60	300	LOAEL = 5(NOAEL)
Pyrene	LANL 2011	--	mouse	1 to 26 weeks	O	reproduction, survival, development	7 5	37 5	LOAEL = 5(NOAEL)
Toluene	LANL 2011	--	mouse	6 days (critical)	G	reproduction	--	260	--
Xylenes (Total)	LANL 2011	--	mouse	9 days (critical)	G	reproduction	--	2.6	--

Notes:
-- = Information not available
COPEC = chemical of potential ecological concern
G = Gavage
LOAEL = lowest observed adverse effects level
mg/kg-bw/d = milligrams per kilogram-bodyweight per day
NOAEL = no observed adverse effects level
O = Oral exposure
OD = Oral Dose exposure
TRV = toxicity reference value

HPAH = high molecular weight PAH; calculated from individual PAH results; includes Benz(a)anthracene, Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(g,h,i)perylene, Benzo(k)fluoranthene, Chrysene, Dibenz(a,h)anthracene, Indeno(1,2,3-cd)pyrene, and Pyrene

LPAH = low molecular weigth PAH; calculated from individual PAH results, includes 2-Methylnaphthalene, Acenaphthene, Acenaphthylene, Anthracene, Fluoranthene, Fluorene, Naphthalene, and Phenanthrene.

Sources:
Los Alamos National Laboratory (LANL). 2011. ECORISK Database (Release 3.0). Environmental Programs Directorate LA-UR-11-5460. Los Alamos, New Mexico. Issued October 1 Accessed online at http://www lanl.gov/environment/cleanup/ecorisk.shtml.
USEPA. 2010 Ecological Soil Screening Levels (Eco-SSLs). Office of Solid Waste and Emergency Response. http //www.epa gov/ecotox/ecossl/. Latest update. October 20. Accessed online on January 30, 2012.

Table 4-19
Summary of Risk to Plants, Soil Invertebrates, and Wildlife
Exposure Area 2
Vertellus - Provo, Utah

EA2 Soil COPECs[1]	Plant HQs	Soil Invertebrate HQs	Herbivorous Bird HQs (Ring-necked Pheasant)	Carnivorous Bird HQs (American Kestral)	Invertivorous Bird HQs (Tree Swallow)	Herbivorous Mammal HQs (Mule Deer)	Carnivorous Mammal HQs (Red Fox)	Invertivorous Mammal HQs (Deer Mouse)	Herbivorous Mammal HQs (Meadow Vole)
3&4-Methylphenol	**3.1E+02**	NC	NC	NC	NC	2.6E-04	5.6E-08	1.5E-01	8.1E-01
Acenaphthene	**1.4E+03**	NC	NC	NC	NC	9 6E-12	6.1E-12	**1.6E+00**	1.2E-01
Acenaphthylene	NC	NC	NC	NC	NC	1.2E-05	2.3E-09	**6.5E+00**	6.8E-02
Anthracene	**2.2E+02**	NC	NC	NC	NC	8.1E-05	1.6E-09	**7.8E+00**	6.1E-01
Benzene	NC	NC	NC	NC	NC	5.4E-04	1.3E-06	3.6E-01	**1.6E+00**
Benzo(a)anthracene	**1.3E+01**	NC	3.0E-01	3.5E-06	**9.4E+01**	5.4E-04	3.9E-09	**4.6E+02**	**3.4E+01**
Benzo(a)pyrene	NC	NC	**6.3E+00**	3.4E-06	**5.8E+01**	3.9E-03	1.3E-09	**1.0E+02**	**2.0E+01**
Benzo(b)fluoranthene	**1.3E+01**	NC	**1.4E+02**	2 5E-05	**8.5E+02**	9.1E-04	1.0E-10	**1.6E+01**	**3.4E+00**
Benzo(k)fluoranthene	NC	NC	**1.2E+01**	1.8E-05	**4.8E+02**	4.3E-05	4.1E-11	**4.9E+00**	3.4E-01
Chrysene	NC	NC	2.6E-01	3.5E-06	**1.2E+02**	5.8E-04	4.9E-09	**7.5E+02**	**3.9E+01**
Cyanide, Total	NC	NC	**2.4E+00**	**2.7E+00**	**1.8E+00**	5.3E-04	1.5E-04	**1.1E+00**	**1.7E+00**
Dibenz(a,h)anthracene	NC	NC	**5.1E+00**	1.8E-03	**6.7E+01**	2.8E-04	6.2E-08	**1.0E+01**	**1.3E+00**
Fluoranthene	NC	**1.3E+02**	NC	NC	NC	5.6E-03	2.9E-10	**6.9E+01**	**1.9E+01**
Fluorene	NC	**5.9E+01**	NC	NC	NC	8.5E-11	6.6E-11	**3.5E+00**	4.2E-02
HPAH	NC	**2.9E+02**	**1.1E+03**	2.7E-04	**2.0E+04**	9.3E-02	1.4E-08	**4.7E+03**	**4.8E+02**
LPAH	NC	**3.9E+02**	4.3E-01	2.5E-07	4.7E-01	3.8E-02	1.3E-08	**1.1E+02**	**1.2E+02**
Indeno(1,2,3-c,d)pyrene	NC	NC	**3.4E+00**	2.8E-06	**6.6E+01**	9.0E-05	4.6E-11	**4.8E+00**	4.6E-01
Naphthalene	**2.7E+03**	NC	6.1E-01	1.1E-07	1.6E-01	2.4E-01	2.7E-08	**1.8E+02**	**7.3E+02**
Phenanthrene	NC	**3.6E+02**	NC	NC	NC	1.0E-03	2.0E-09	**1.4E+02**	**1.2E+01**
Phenol	**2.3E+02**	**1.0E+02**	NC	NC	NC	1.6E-05	2.0E-03	2.9E-01	1.2E-01
Pyrene	NC	**9.9E+01**	NC	NC	NC	9.9E-03	1.5E-10	**4.9E+01**	**3.3E+01**
Toluene	2.6E-01	NC	NC	NC	NC	4.8E-04	6.6E-06	**1.2E+00**	**1.5E+00**
Xylenes (Total)	5.9E-01	NC	5.0E-04	8.0E-05	8.2E-04	3.9E-02	1.5E-03	**1.8E+02**	**1.2E+02**

Notes:

1 - Only COPECs with one or more HQs greater than 1.0 are shown.

HQs greater than 1.0 are in bold print

EA2 covers 3.34 acres and has only subsurface (1 to 3 feet bgs) soil samples.

bgs = below ground surface

COPEC = chemical of potential ecological concern

EA = exposure area

HPAH = high molecular weight PAH; calculated from individual PAH results; includes Benzo(a)anthracene, Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(g,h,i)perylene, Benzo(k)fluoranthene, Chrysene, Dibenz(a,h)anthracene, Indeno(1,2,3-cd)pyrene, and Pyrene

HQ = hazard quotient

LPAH = low molecular weigth PAH, calculated from individual PAH results; includes 2-Methylnaphthalene, Acenaphthene, Acenaphthylene, Anthracene, Fluoranthene, Fluorene, Naphthalene, and Phenanthrene.

NC = HQ not calculated

Table 4-20
Summary of Risk to Plants, Soil Invertebrates, and Wildlife
Exposure Area 3
Vertellus - Provo, Utah

EA3 Soil COPECs[1]	Plant HQs	Soil Invertebrate HQs	Herbivorous Bird HQs (Ring-necked Pheasant)	Carnivorous Bird HQs (American Kestral)	Invertivorous Bird HQs (Tree Swallow)	Herbivorous Mammal HQs (Mule Deer)	Carnivorous Mammal HQs (Red Fox)	Invertivorous Mammal HQs (Deer Mouse)	Herbivorous Mammal HQs (Meadow Vole)
Acenaphthene	**1.0E+02**	NC	NC	NC	NC	3.4E-07	2.0E-07	1.2E-01	9.0E-03
Anthracene	**2.1E+00**	NC	NC	NC	NC	5.3E-06	2.0E-07	7.3E-02	9.7E-03
Benzo(a)anthracene	**2.4E+00**	NC	**2.6E+00**	8.2E-06	**4.2E+01**	1.4E-03	5.1E-04	**8.8E+01**	**6.8E+00**
Benzo(a)pyrene	NC	NC	**8.5E+00**	7.9E-06	**5.7E+01**	4.2E-03	1.7E-04	**4.2E+01**	**8.5E+00**
Benzo(b)fluoranthene	**3.3E+00**	NC	**1.0E+02**	5.8E-05	**5.2E+02**	5.8E-04	1.5E-05	**4.1E+00**	8.9E-01
Benzo(k)fluoranthene	NC	NC	**2.7E+01**	4.1E-05	**5.4E+02**	6.3E-05	5.6E-06	**2.4E+00**	1.7E-01
Chrysene	NC	NC	**2.6E+00**	8.2E-06	**5.6E+01**	1.7E-03	6.6E-04	**1.5E+02**	**7.9E+00**
Dibenz(a,h)anthracene	NC	NC	**2.2E+00**	4.1E-03	**1.8E+01**	8.5E-05	6.4E-06	**1.2E+00**	1.5E-01
Fluoranthene	NC	**7.1E+00**	NC	NC	NC	7.0E-04	1.2E-05	**3.7E+00**	1.0E+00
Fluorene	NC	**8.4E+00**	NC	NC	NC	1.7E-07	9.8E-08	5.1E-01	6.0E-03
HPAH	NC	**3.8E+01**	**4.8E+02**	6.2E-04	**5.9E+03**	3.4E-02	1.3E-03	**6.1E+02**	**6.7E+01**
LPAH	NC	**8.5E+00**	2.3E-02	5.7E-07	2.4E-02	1.9E-03	1.0E-05	**2.5E+00**	**2.5E+00**
Indeno(1,2,3-c,d)pyrene	NC	NC	**6.2E+00**	6.5E-06	**9.1E+01**	1.3E-04	5.0E-06	**2.9E+00**	2.7E-01
Naphthalene	**1.4E+01**	NC	7.4E-03	2.6E-07	2.0E-03	2.9E-03	2.8E-06	9.5E-01	**3.8E+00**
Phenanthrene	NC	**1.3E+01**	NC	NC	NC	3.5E-04	2.5E-05	**5.2E+00**	7.3E-01
Pyrene	NC	**7.9E+00**	NC	NC	NC	1.9E-03	2.9E-05	**4.0E+00**	**2.6E+00**

Notes:

1 - Only COPECs with one or more HQs greater than 1 0 are shown.

HQs greater than 1.0 are in bold print.

EA3 covers 7.71 acres and has surface (0 to 1 feet bgs) and subsurface (1 to 3 feet bgs) soil samples.

bgs = below ground surface

COPEC = chemical of potential ecological concern

EA = exposure area

HPAH = high molecular weight PAH; calculated from individual PAH results; includes Benzo(a)anthracene, Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(g,h,i)perylene, Benzo(k)fluoranthene, Chrysene, Dibenz(a,h)anthracene, Indeno(1,2,3-cd)pyrene, and Pyrene.

HQ = hazard quotient

LPAH = low molecular weigth PAH, calculated from individual PAH results, includes 2-Methylnaphthalene, Acenaphthene, Acenaphthylene, Anthracene, Fluoranthene, Fluorene, Naphthalene, and Phenanthrene.

NC = HQ not calculated

Table 4-21
Summary of Risk to Plants, Soil Invertebrates, and Wildlife
Exposure Area 4
Vertellus - Provo, Utah

EA4 Soil COPECs[1]	Plant HQs	Soil Invertebrate HQs	Herbivorous Bird HQs (Ring-necked Pheasant)	Carnivorous Bird HQs (American Kestral)	Invertivorous Bird HQs (Tree Swallow)	Herbivorous Mammal HQs (Mule Deer)	Carnivorous Mammal HQs (Red Fox)	Invertivorous Mammal HQs (Deer Mouse)	Herbivorous Mammal HQs (Meadow Vole)
2-Methylphenol	**4.5E+01**	NC	NC	NC	NC	4.7E-05	1.8E-09	2.0E-02	1.3E-01
3&4-Methylphenol	**1.4E+02**	NC	NC	NC	NC	1.3E-04	6.1E-08	6.6E-02	3.6E-01
Acenaphthene	**1.4E+03**	NC	NC	NC	NC	1.1E-11	6 7E-12	**1.6E+00**	1.2E-01
Acenaphthylene	NC	NC	NC	NC	NC	4.9E-06	2.6E-09	**1.8E+00**	2.2E-02
Anthracene	**1.9E+01**	NC	NC	NC	NC	1.3E-05	1.8E-09	6.5E-01	6.5E-02
Benzo(a)anthracene	**4.1E+01**	NC	6.7E-01	3.9E-06	**3.3E+02**	1.2E-03	4.3E-09	**1.5E+03**	**1.1E+02**
Benzo(a)pyrene	NC	NC	**1.1E+00**	3.8E-06	**9.3E+00**	6.5E-04	1.4E-09	**1.4E+01**	**3.0E+00**
Benzo(b)fluoranthene	**2.1E+00**	NC	**2.5E+01**	2.8E-05	**1.6E+02**	1.7E-04	1.1E-10	**2.6E+00**	5.7E-01
Benzo(k)fluoranthene	NC	NC	**1.3E+00**	2.0E-05	**3.5E+01**	4.6E-06	4.5E-11	3.3E-01	2.7E-02
Chrysene	NC	NC	4.6E-01	3.9E-06	**3.0E+02**	1.0E-03	5.4E-09	**1.7E+03**	**8.5E+01**
Dibenz(a,h)anthracene	NC	NC	4.2E-01	2.0E-03	**5.6E+00**	2.4E-05	6.8E-08	7.8E-01	1.0E-01
Dibenzofuran	**3.3E+01**	NC	NC	NC	NC	NC	NC	NC	NC
Fluoranthene	NC	**3.5E+01**	NC	NC	NC	1.6E-03	3.2E-10	**1.8E+01**	**5.0E+00**
Fluorene	NC	**6.0E+01**	NC	NC	NC	9.4E-11	7.2E-11	**3.6E+00**	4.3E-02
HPAH	NC	**8.7E+01**	**3.8E+02**	2.9E-04	**6.5E+03**	3.3E-02	1.6E-08	**1.4E+03**	**1.5E+02**
LPAH	NC	**1.0E+02**	1.2E-01	2.7E-07	1.3E-01	1.1E-02	1.5E-08	**2.9E+01**	**3.0E+01**
Indeno(1,2,3-c,d)pyrene	NC	NC	4.9E-01	3.1E-06	**9.5E+00**	1.3E-05	5.0E-11	6.3E-01	6.0E-02
m,p-Xylene	7.8E-03	NC	7.2E-06	1.2E-06	1.2E-05	5.6E-04	2.2E-05	**2.3E+00**	**1.6E+00**
Naphthalene	**1.3E+03**	NC	3.2E-01	1.2E-07	8.5E-02	1.3E-01	3.0E-08	**8.5E+01**	**3.5E+02**
o-Xylene	4.0E-03	NC	3.7E-06	6.0E-07	6.1E-06	2.9E-04	1.1E-05	**1.2E+00**	8.0E-01
Phenanthrene	NC	**7.1E+00**	NC	NC	NC	9.9E-05	2.2E-09	**2.8E+00**	4.5E-01
Phenol	**2.1E+02**	**9.1E+01**	NC	NC	NC	1.5E-05	2.0E-03	2.6E-01	1.1E-01
Pyrene	NC	**3.0E+01**	NC	NC	NC	3.3E-03	1.7E-10	**1.5E+01**	**9.9E+00**
Xylenes (Total)	1.1E-02	NC	1.0E-05	1.6E-06	1.7E-05	7.9E-04	3.1E-05	**3.2E+00**	**2.2E+00**

Notes:

1 - Only COPECs with one or more HQs greater than 1.0 are shown.

HQs greater than 1.0 are in bold print.

EA4 covers 3.68 acres and has only subsurface (1 to 3 feet bgs) soil samples

bgs = below ground surface

COPEC = chemical of potential ecological concern

EA = exposure area

HPAH = high molecular weight PAH, calculated from individual PAH results; includes Benzo(a)anthracene, Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(g,h,i)perylene, Benzo(k)fluoranthene, Chrysene, Dibenz(a,h)anthracene, Indeno(1,2,3-cd)pyrene, and Pyrene.

HQ = hazard quotient

LPAH = low molecular weigth PAH; calculated from individual PAH results; includes 2-Methylnaphthalene, Acenaphthene, Acenaphthylene, Anthracene, Fluoranthene, Fluorene, Naphthalene, and Phenanthrene.

NC = HQ not calculated

Table 4-22
Summary of Risk to Plants, Soil Invertebrates, and Wildlife
Exposure Area 6
Vertellus - Provo, Utah

EA6 Soil COPECs[1]	Plant HQs	Soil Invertebrate HQs	Herbivorous Bird HQs (Ring-necked Pheasant)	Carnivorous Bird HQs (American Kestral)	Invertivorous Bird HQs (Tree Swallow)	Herbivorous Mammal HQs (Mule Deer)	Carnivorous Mammal HQs (Red Fox)	Invertivorous Mammal HQs (Deer Mouse)	Herbivorous Mammal HQs (Meadow Vole)
2-Methylphenol	**1.2E+00**	NC	NC	NC	NC	5.7E-08	3.0E-10	2.5E-04	3.5E-03
3&4-Methylphenol	**3.2E+00**	NC	NC	NC	NC	1.4E-07	3.3E-09	7.3E-04	8.4E-03
Acenaphthene	**4.4E+02**	NC	NC	NC	NC	1.6E-07	9.2E-08	2.2E-01	3.8E-02
Anthracene	**2.5E+01**	NC	NC	NC	NC	9.0E-07	1.0E-07	3.9E-01	8.6E-02
Benzo(a)anthracene	**2.7E+01**	NC	7.8E-01	1.7E-07	**9.7E+00**	3.3E-04	1.7E-04	**4.2E+02**	**7.0E+01**
Benzo(a)pyrene	NC	NC	**1.2E+00**	1.7E-07	**5.9E+00**	4.6E-04	4.2E-05	**9.0E+01**	**4.0E+01**
Benzo(b)fluoranthene	**2.8E+01**	NC	**1.9E+01**	1.2E-06	**9.3E+01**	1.1E-04	3.7E-06	**1.5E+01**	**7.5E+00**
Benzo(g,h,i)perylene	NC	NC	NC	NC	NC	1.1E-04	9.0E-07	**4.2E+00**	**7.1E+00**
Benzo(k)fluoranthene	NC	NC	**2.6E+00**	8.7E-07	**3.7E+01**	4.5E-06	8.1E-07	**3.4E+00**	5.2E-01
Carbazole	NC	NC	NC	NC	NC	5.5E-05	1.1E-06	5.2E-01	**3.4E+00**
Chrysene	NC	NC	6.4E-01	1.7E-07	**1.2E+01**	3.4E-04	1.7E-04	**6.3E+02**	**7.3E+01**
Dibenz(a,h)anthracene	NC	NC	5.7E-01	8.8E-05	**4.4E+00**	2.1E-05	1.6E-06	**6.0E+00**	**1.8E+00**
Dibenzofuran	**6.6E+00**	NC	NC	NC	NC	NC	NC	NC	NC
Fluoranthene	NC	**1.1E+02**	NC	NC	NC	2.2E-04	5.0E-06	**2.4E+01**	**1.5E+01**
Fluorene	NC	**2.5E+01**	NC	NC	NC	7.7E-08	4.4E-08	6.7E-01	1.8E-02
HPAH	NC	**2.0E+02**	**6.9E+01**	1.3E-05	**6.7E+02**	3.8E-03	3.4E-04	**1.4E+03**	**3.4E+02**
LPAH	NC	**8.1E+01**	4.6E-03	1.2E-08	4.8E-03	3.9E-04	2.1E-06	**1.0E+01**	**2.4E+01**
Indeno(1,2,3-c,d)pyrene	NC	NC	6.0E-01	1.4E-07	**6.3E+00**	1.0E-05	9.0E-07	**4.1E+00**	8.9E-01
Naphthalene	**9.0E+01**	NC	9.9E-04	5.5E-09	2.6E-04	3.9E-04	3.7E-07	**2.6E+00**	**2.4E+01**
Phenanthrene	NC	**1.6E+02**	NC	NC	NC	4.8E-05	1.0E-05	**2.8E+01**	**6.0E+00**
Phenol	**1.7E+00**	7.4E-01	NC	NC	NC	8.0E-09	7.2E-07	9.6E-04	8.8E-04
Pyrene	NC	**9.6E+01**	NC	NC	NC	4.8E-04	7.5E-06	**2.1E+01**	**3.2E+01**

Notes:

1 - Only COPECs with one or more Hazard Quotients greater than 1.0 are shown

Hazard Quotients greater than 1.0 are in bold print.

EA6 covers 0.164 acres and has only surface (0 to 1 feet bgs) soil samples

bgs = below ground surface

COPEC = chemical of potential ecological concern

EA = exposure area

HPAH = high molecular weight PAH; calculated from individual PAH results; includes Benzo(a)anthracene, Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(g,h,i)perylene, Benzo(k)fluoranthene, Chrysene, Dibenz(a,h)anthracene, Indeno(1,2,3-cd)pyrene, and Pyrene.

HQ = hazard quotient

LPAH = low molecular weigth PAH, calculated from individual PAH results; includes 2-Methylnaphthalene, Acenaphthene, Acenaphthylene, Anthracene, Fluoranthene, Fluorene, Naphthalene, and Phenanthrene.

NC = HQ not calculated

Table 4-23
Summary of Risk to Plants, Soil Invertebrates, and Wildlife
Exposure Area 7
Vertellus - Provo, Utah

EA7 Soil COPECs[1]	Plant HQs	Soil Invertebrate HQs	Herbivorous Bird HQs (Ring-necked Pheasant)	Carnivorous Bird HQs (American Kestral)	Invertivorous Bird HQs (Tree Swallow)	Herbivorous Mammal HQs (Mule Deer)	Carnivorous Mammal HQs (Red Fox)	Invertivorous Mammal HQs (Deer Mouse)	Herbivorous Mammal HQs (Meadow Vole)
Benzo(a)anthracene	7.5E-02	NC	1.0E-01	6.5E-06	1.0E+00	7.6E-05	1.7E-05	**2.7E+00**	2.7E-01
Benzo(b)fluoranthene	9.6E-02	NC	**2.5E+00**	4.6E-05	**1.2E+01**	1.3E-05	4.7E-07	1.2E-01	2.6E-02
Benzo(k)fluoranthene	NC	NC	5.4E-01	3.2E-05	**5.6E+00**	1.2E-06	1.2E-07	3.2E-02	3.0E-03
Chrysene	NC	NC	1.1E-01	6.4E-06	**1.5E+00**	9.3E-05	2 2E-05	**5.1E+00**	3.4E-01
HPAH	NC	6.5E-01	**1.0E+01**	4.9E-04	**8.1E+01**	6.0E-04	4 2E-05	**1.1E+01**	**1.3E+00**
Naphthalene	**2.5E+00**	NC	1.0E-03	2.0E-07	2.7E-04	4.1E-04	4 3E-07	1.7E-01	6.7E-01

Notes:

1 - Only COPECs with one or more HQs greater than 1.0 are shown.

2 - Although retained as a surface water COPEC, Cyanide, Total was not an analyte in EA7, so no calculation was performed.

HQs greater than 1.0 are in bold print.

EA7 covers 6.08 acres and has both surface (0 to 1 feet bgs) and subsurface (1 to 3 feet bgs) soil samples.

bgs = below ground surface

COPEC = chemical of potential ecological concern

EA = exposure area

HPAH = high molecular weight PAH; calculated from individual PAH results; includes Benzo(a)anthracene, Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(g,h,i)perylene, Benzo(k)fluoranthene, Chrysene, Dibenz(a,h)anthracene, Indeno(1,2,3-cd)pyrene, and Pyrene.

HQ = hazard quotient

LPAH = low molecular weigth PAH; calculated from individual PAH results; includes 2-Methylnaphthalene, Acenaphthene, Acenaphthylene, Anthracene, Fluoranthene, Fluorene, Naphthalene, and Phenanthrene.

NC = HQ not calculated

Table 4-24
Summary of Risk to Plants, Soil Invertebrates, and Small Mammals
Hotspot 2-SF-2-18
Vertellus - Provo, Utah

Hotspot 2-SF-2-18 Soil COPECs[1]	Plant HQs	Soil Invertebrate HQs	Invertivorous Mammal HQs (Deer Mouse)	Herbivorous Mammal HQs (Meadow Vole)
Acenaphthene	**1.6E+00**	NC	1.1E-07	3.2E-08
HPAH	NC	**2.1E+00**	2.1E-03	9.4E-04

Notes:

1 - Only COPECs with one or more HQs greater than 1.0 are shown.

HQs greater than 1.0 are in bold print.

Hotspot 2-SF-2-18 (located in EA2) covers 1 square foot and has only surface soil samples.

bgs = below ground surface

COPEC = chemical of potential ecological concern

EA = exposure area

HPAH = high molecular weight PAH; calculated from individual PAH results; includes Benz(a)anthracene, Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(g,h,i)perylene, Benzo(k)fluoranthene, Chrysene, Dibenz(a,h)anthracene, Indeno(1,2,3-cd)pyrene, and Pyrene.

HQ = Hazard Quotient

NC = HQ not calculated

Table 4-25
Summary of Risk to Plants, Soil Invertebrates, and Small Mammals
Hotspot 2-SF-2-19
Vertellus - Provo, Utah

Hotspot 2-SF-2-19 Soil COPECs[1]	Plant HQs	Soil Invertebrate HQs	Invertivorous Mammal HQs (Deer Mouse)	Herbivorous Mammal HQs (Meadow Vole)
Acenaphthene	**3.4E+01**	NC	2.4E-06	6.8E-07
Anthracene	**2.1E+00**	NC	4.6E-06	2 3E-06
Benzo(b)fluoranthene	**1.1E+00**	NC	8.5E-05	6 9E-05
Fluoranthene	NC	**4.4E+00**	1.4E-04	1 4E-04
Fluorene	NC	**1.9E+00**	7.0E-06	3.1E-07
HPAH	NC	**7.9E+00**	7.9E-03	3 4E-03
LPAH	NC	**4.4E+00**	7.8E-05	3.0E-04
Naphthalene	**8.8E+00**	NC	3.5E-05	5.4E-04
Phenanthrene	NC	**7.3E+00**	1.8E-04	1.1E-04
Pyrene	NC	**3.8E+00**	1.2E-04	2.9E-04

Notes:

1 - Only COPECs with one or more HQs greater than 1.0 are shown.

HQs greater than 1.0 are in bold print.

Hotspot 2-SF-2-19 (located in EA2) covers 1 square foot and has only surface soil samples.

bgs = below ground surface

COPEC = chemical of potential ecological concern

EA = exposure area

HPAH = high molecular weight PAH; calculated from individual PAH results; includes Benz(a)anthracene, Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(g,h,i)perylene, Benzo(k)fluoranthene, Chrysene, Dibenz(a,h)anthracene, Indeno(1,2,3-cd)pyrene, and Pyrene.

HQ = hazard quotient

LPAH = low molecular weigth PAH; calculated from individual PAH results; includes 2-Methylnaphthalene, Acenaphthene, Acenaphthylene, Anthracene, Fluoranthene, Fluorene, Naphthalene, and Phenanthrene

NC = HQ not calculated

Table 4-26
Summary of Risk to Plants, Soil Invertebrates, and Small Mammals
Hotspot 2-SF-3-36
Vertellus - Provo, Utah

Hotspot 2-SF-3-36 Soil COPECs[1]	Plant HQs	Soil Invertebrate HQs	Invertivorous Mammal HQs (Deer Mouse)	Herbivorous Mammal HQs (Meadow Vole)
3&4-Methylphenol	**2.5E+00**	NC	7.9E-08	1 5E-06
Acenaphthene	**8.0E+00**	NC	5.5E-07	1.6E-07
Anthracene	**1.7E+00**	NC	3.8E-06	1.9E-06
Dibenzofuran	**1.5E+00**	NC	NC	NC
Fluoranthene	NC	**4.2E+00**	1.3E-04	1 4E-04
Fluorene	NC	**3.9E+00**	1.4E-05	6.3E-07
HPAH	NC	**6.3E+00**	6.3E-03	2.7E-03
LPAH	NC	**6.6E+00**	1 2E-04	4.5E-04
Naphthalene	**4.4E+01**	NC	1.8E-04	2.7E-03
Phenanthrene	NC	**9.8E+00**	2.4E-04	1.3E-04
Phenol	**2.5E+00**	**1.1E+00**	2 0E-07	3.0E-07
Pyrene	NC	**3.2E+00**	9.8E-05	2.4E-04

Notes:
1 - Only COPECs with one or more HQs greater than 1.0 are shown.
HQs greater than 1.0 are in bold print.
Hotspot 2-SF-3-36 (located in EA3) covers 1 square foot and has only surface soil samples.

bgs = below ground surface
COPEC = chemical of potential ecological concern
EA = exposure area
HPAH = high molecular weight PAH; calculated from individual PAH results; includes Benz(a)anthracene, Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(g,h,i)perylene, Benzo(k)fluoranthene, Chrysene, Dibenz(a,h)anthracene, Indeno(1,2,3-cd)pyrene, and Pyrene.
HQ = hazard quotient

LPAH = low molecular weigth PAH; calculated from individual PAH results; includes 2-Methylnaphthalene, Acenaphthene, Acenaphthylene, Anthracene, Fluoranthene, Fluorene, Naphthalene, and Phenanthrene.
NC = HQ not calculated

Table 4-27
Summary of Risk to Plants, Soil Invertebrates, and Small Mammals
Hotspot 2-SF-4-23
Vertellus - Provo, Utah

Hotspot 2-SF-4-23 Soil COPECs[1]	Plant HQs	Soil Invertebrate HQs	Invertivorous Mammal HQs (Deer Mouse)	Herbivorous Mammal HQs (Meadow Vole)
Acenaphthene	**6.6E+01**	NC	4.5E-06	1.3E-06
Anthracene	**3.8E+00**	NC	8.3E-06	3.8E-06
Benzo(a)anthracene	**2.8E+00**	NC	6.2E-03	1.8E-03
Benzo(b)fluoranthene	**3.4E+00**	NC	2.6E-04	2.1E-04
Dibenzofuran	**1.3E+00**	NC	NC	NC
Fluoranthene	NC	**1.2E+01**	3.7E-04	3.8E-04
Fluorene	NC	**3.0E+00**	1.1E-05	4.9E-07
HPAH	NC	**2.1E+01**	2.1E-02	8.7E-03
LPAH	NC	**8.8E+00**	1.6E-04	6.0E-04
Naphthalene	**1.6E+01**	NC	6.5E-05	9.9E-04
Phenanthrene	NC	**1.1E+01**	2.7E-04	1.5E-04
Pyrene	NC	**9.4E+00**	2.9E-04	7.1E-04

Notes:

1 - Only COPECs with one or more HQs greater than 1.0 are shown.

HQs greater than 1.0 are in bold print.

Hotspot 2-SF-4-23 (located in EA4) covers 1 square foot and has only surface soil samples.

bgs = below ground surface

COPEC = chemical of potential ecological concern

EA = exposure area

HPAH = high molecular weight PAH; calculated from individual PAH results; includes Benzo(a)anthracene, Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(g,h,i)perylene, Benzo(k)fluoranthene, Chrysene, Dibenz(a,h)anthracene, Indeno(1,2,3-cd)pyrene, and Pyrene.

HQ = hazard quotient

LPAH = low molecular weigth PAH; calculated from individual PAH results; includes 2-Methylnaphthalene, Acenaphthene, Acenaphthylene, Anthracene, Fluoranthene, Fluorene, Naphthalene, and Phenanthrene.

NC = HQ not calculated

Table 4-28
Summary of Risk to Plants, Benthic Invertebrates, and Birds Exposed to Sediment
Exposure Area 1
Vertellus - Provo, Utah

EA 1 Sediment COPECs	Sediment EPC (µg/kg)	Plants		Benthic Invertebrates		Omnivorous Bird (Mallard)	Invertivorous Bird (Tree Swallow)
		LOEC (µg/kg)	HQ[1]	LOEC (µg/kg)	HQ[1]	HQ[2]	HQ[2]
Acenaphthene	1 4E+05	1 3E+03	**1.1E+02**	3.1E+03	**4.4E+01**	NC	NC
Acenaphthylene	4 2E+03	NV	NC	2 2E+02	**1.9E+01**	NC	NC
Anthracene	9 9E+04	3 4E+04	**2.9E+00**	2.0E+00	**5.1E+04**	NC	NC
Benzo(a)anthracene	6 4E+04	9 0E+04	7.1E-01	5.5E+02	**1.2E+02**	1.8E-01	8.9E-02
Benzo(a)pyrene	5 4E+04	NV	NC	1 5E+03	**3.8E+01**	2.1E-01	5.9E-02
Benzo(b)fluoranthene	6 0E+04	9 0E+04	6 7E-01	1.2E+03	**5.0E+01**	**2.8E+00**	3.8E-01
Benzo(k)fluoranthene	2 1E+04	NV	NC	1 2E+03	**1.8E+01**	4.0E-01	1.1E-01
Chrysene	8 7E+04	NV	NC	1 3E+03	**6.7E+01**	2.3E-01	1.2E-01
Cyanide, Total	1 5E+03	NV	NC	5 0E+02	**2.9E+00**	NC	NC
Dibenz(a,h)anthracene	6 1E+03	NV	NC	7.5E+01	**8.1E+01**	6.7E-02	1.9E-02
Fluoranthene	1 7E+05	NV	NC	2 2E+03	**7.4E+01**	NC	NC
Fluorene	9 9E+04	NV	NC	5 4E+02	**1.8E+02**	NC	NC
Indeno(1,2,3-c,d)pyrene	2 1E+04	NV	NC	3 9E+02	**5.3E+01**	6.6E-02	1.6E-02
Naphthalene	9 1E+03	5 0E+03	**1.8E+00**	5.6E+02	**1.6E+01**	1.2E-04	4 5E-06
PAH (Total)	1 8E+06	NV	NC	2.3E+04	**8.0E+01**	4.0E-02	1.5E-02
Phenanthrene	1 5E+05	NV	NC	1.2E+03	**1.2E+02**	NC	NC
Pyrene	1 5E+05	NV	NC	1 5E+03	**1.0E+02**	NC	NC

Notes:

1 - For plants and benthic invertebrates, HQ = Sediment EPC / LOEC

2 - For wildlife, HQ = ADD / LOAEL

Hazard Quotients greater than 1.0 are in bold print

Only COPECs with one or more Hazard Quotients greater than 1 0 are shown

Hazard Quotients greater than 1.0 are in bold print.

EA1 is the Ironton Canal It has an area of 0 788 acre and only surface sediment (0 to 1 foot bgs) is considered for the BERA.

ADD = average daily dose (calculated)
BERA = Baseline Ecological Risk Assessment
bgs = below ground surface
COPEC = chemical of potential ecological concern
C_{SD} = concentration in sediment
EA = exposure area
EPC = exposure point concentration
HQ = hazard quotient
LOAEL =lowest observed adverse effect level
LOEC = lowest observed effect concentration
ug/kg = micrograms per kilogram
NC = not calculated
NV = no value
PAH = polycyclic aromatic hydrocarbon

Table 4-29
Summary of Risk to the Aquatic Community
Exposure Area 1
Vertellus - Provo, Utah

EA1 Surface Water COPECs	Surface Water EPC (µg/L)	Aquatic Community Chronic Criteria (µg/L)	Aquatic Community Hazard Quotients
Benzo(a)anthracene	0.02	0.027	7.4E-01
Benzo(a)pyrene	0.0245	0.014	**1.8E+00**
Benzo(b)fluoranthene	0.0253	30	8.4E-04
Benzo(g,h,i)perylene	0.025	30	8.3E-04
Benzo(k)fluoranthene	0.0178	30	5.9E-04
Chrysene	0.0253	30	8.4E-04
Cyanide, Total	11.29	5.2	**2.2E+00**
Fluoranthene	0.111	6.1	1.8E-02
Fluorene	0.25	3.9	6.4E-02
Indeno(1,2,3-c,d)pyrene	0.02	30	6.7E-04

Notes:

EA1 is the Ironton Canal

Aquatic Community Hazard Quotient = Surface Water EPC / Chronic Criteria

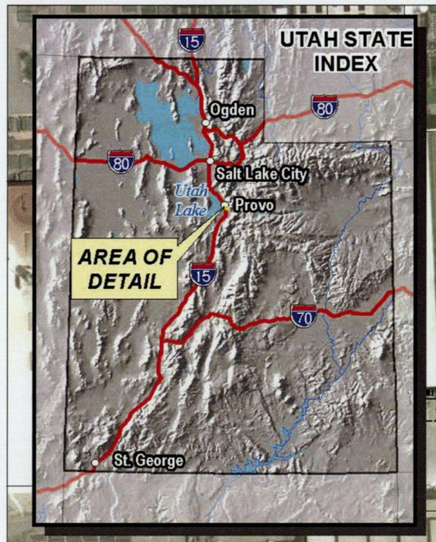
Hazard Quotients greater than 1.0 are in bold print.

COPEC = chemical of potential ecological concern

EA = exposure area

EPC = exposue point concentration

Figures



SWMU Area #1

SWMU #1

SWMU #14

SWMU #11

SWMU #8

SWMU #7

SWMU #4

SWMU #5

SWMU #6

SWMU #9

Former Ironton Site

SWMU #10
Former metal evaporation pan

SWMU Area #3

SWMU Area #2

SWMU #2

SWMU #3

Pacific States Cast Iron Pipe Company

SWMU #12

SWMU Area #4

File: T:\Vertellus Specialties\09_Data\GIS\CAD\Maps\Vertellus_Areas_mxd

Source Aerial Photography: AGRC, High Resolution Ortho-Imagery (HRO)1-foot, 2009

SWMU

SWMU Area

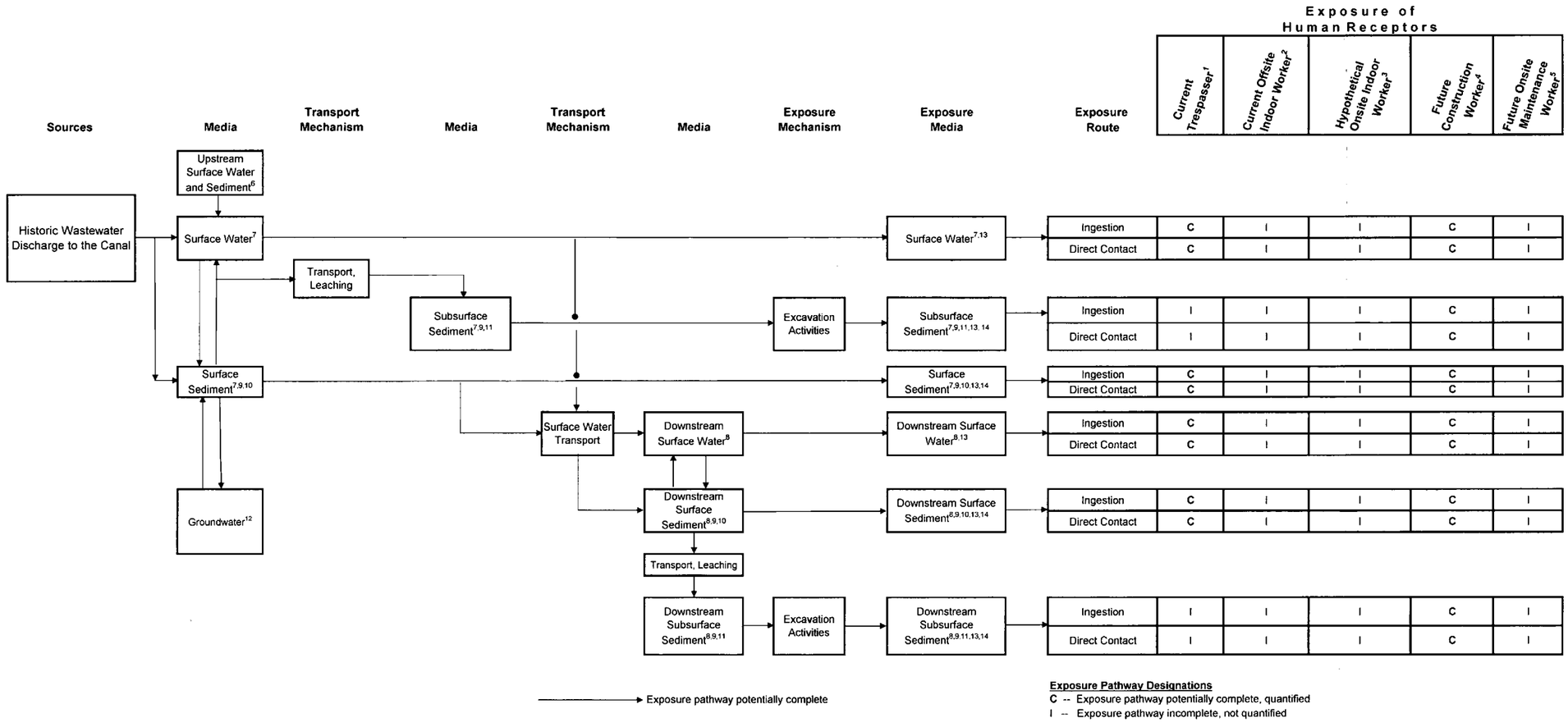
Site

* SWMU Area 5, Groundwater, is not shown on this figure.

0 100 200 300
Feet

Site Map	
Vertellus Specialties 2555 Industrial Parkway Provo, Utah	Vertellus
June 28, 2011	Figure 1-1

Figure 3-1
Human Health Conceptual Site Model
for Surface Water and Sediment in the Ironton Canal
Non-Hunting and Non-Fishing Scenarios
Vertellus - Provo, Utah



Notes:

[1] The Site is not located near any residences. However, to be protective a trespasser (child) assumed to play in the fenced and unfenced portions of the canal was evaluated.

[2] Indoor workers employed at facilities adjacent to the Vertellus property were assumed not to spend time during their workday in a canal.

[3] Vertellus plans to maintain the Site as a vacant fenced lot for the foreseeable future. However, for risk management purposes a hypothetical onsite indoor worker scenario was evaluated for exposure to surface soil and indoor air. Hypothetical onsite indoor workers were assumed not to spend time during their workday in a canal.

[4] Future construction workers were assumed to pipe the canal and to repair the pipe as necessary.

[5] Future maintenance work at the site will be limited to work on the grounds in SWMU Areas 2 (EA2), 3 (EA3), and 4 (EA4) and portions of the South Parcel (EA7). It will not include work in the canal, which will be piped.

[6] Surface water and sediment located upstream of the fenced area of the canal.

[7] Surface water and sediment located in the fenced area of the canal.

[8] Surface water and sediment located downstream of the fenced area of the canal.

[9] Includes both sidewall and bottom sediment in the canal.

[10] Surface sediment is defined as sediment at depths of 0-1 foot bgs.

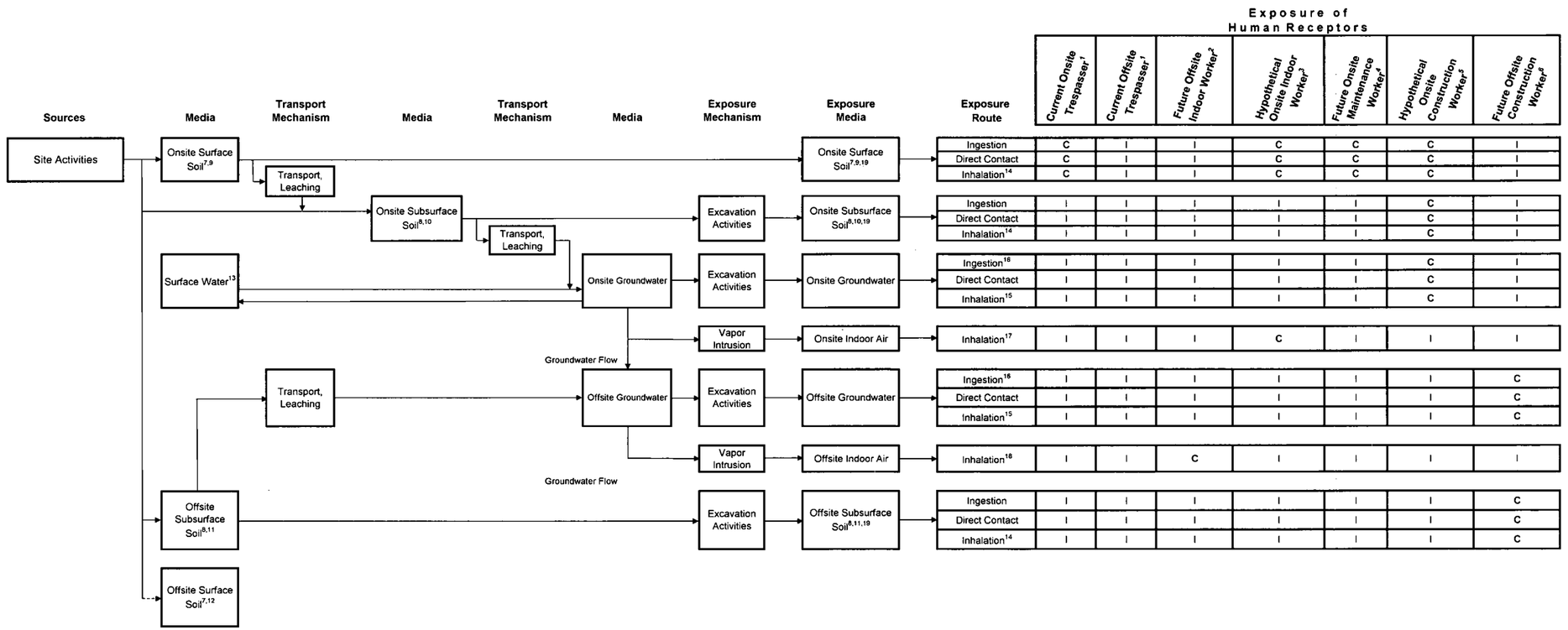
[11] Subsurface sediment is defined as sediment at depths of 1-10 feet bgs.

[12] Groundwater may flow into surface water/sediments depending on the height of the groundwater table which varies through the year. Groundwater pathways are shown in the CSM for soil and groundwater (Figure 3-2).

[13] Inhalation of VOCs from surface water and wet sediments is not shown on the CSM because it is considered to be negligible or incomplete.

[14] Dermal absorption of SVOCs from sediments is a potentially complete and significant pathway. As recommended for soil in USEPA's dermal guidance, dermal absorption of VOCs from sediments was considered to be a potentially complete, but negligible, pathway.

Figure 3-2
Human Health Conceptual Site Model
for Soil and Groundwater
Non-Hunting Scenarios
Vertellus - Provo, Utah



Notes:

[1] The Site is not located near any residences and is fenced. However, to be protective trespassers (children) assumed to play on surface soil were evaluated.

[2] Indoor workers employed at facilities adjacent to the Vertellus property could be exposed to offsite surface soil and indoor air. However, offsite surface soil is not impacted.

[3] Vertellus plans to maintain the Site as a vacant fenced lot for the foreseeable future. However, for risk management purposes a hypothetical onsite indoor worker scenario was evaluated for exposure to surface soil and indoor air.

[4] It was assumed that in the future maintenance (grounds) work will be performed occasionally in SWMU Areas 2 (EA2), 3 (EA3), 4 (EA4), EA6, and the South Parcel (EA7).

[5] Vertellus plans to maintain the Site as a vacant fenced lot for the foreseeable future. However, for risk management purposes a hypothetical onsite construction worker scenario was used primarily to evaluate potential impacts of onsite subsurface soil and onsite shallow groundwater during work in a trench.

[6] A future offsite construction worker exposed to subsurface soil and groundwater during work in a trench is a possiblility in offsite portions of the site (offsite surface soil is not impacted).

[7] Surface soil is defined as soil at depths of 0-1 foot bgs.

[8] Subsurface soil is defined as soil at depth of 1-10 feet bgs.

[9] Impacts to onsite surface soil were assumed to be limited to a portion of SWMU Area 3 (EA3), SWMU 8 (EA6), the South Parcel (EA7), and hotspots in SWMU Areas 2 (EA2) and 4 (EA4).

[10] Leaching of chemicals from onsite surface soil (e.g., SWMU Area 3 [EA3], EA6, the South Parcel [EA7]) could lead to impacts to underlying onsite subsurface soil. Chemicals from wastewater in waste storage areas (e.g., lagoons, impoundments) seeped into underlying soil in SWMU Areas 2 (EA2) and 4 (EA4). The soil was later covered by clean soil or fill. Therefore, contaminated onsite soil in SWMU Areas 2 (EA2) and 4 (EA4) is now subsurface soil.

[11] Chemicals from wastewater in waste storage areas (lagoons and Evaporation Areas) seeped into underlying soil in the offsite area (EA5) adjacent to SWMU Area 4. The soil was later covered by clean fill and an asphalt parking lot. Therefore, contaminated soil in the offsite area (EA5) adjacent to SWMU Area 4 is now subsurface soil. The sources of impacts to subsurface soil in EA9 and EA10 are unknown.

[12] Offsite surface soil was not evaluated because it was not considered to be impacted by activities at the site.

[13] Surface water may flow into groundwater, depending on the height of the groundwater table which varies through the year. Surface water pathways are shown in the CSM for the canal (Figure 3-1).
Ingestion and dermal exposure to onsite ephemeral water bodies that form occasionally near Industrial Parkway were considered to be potentially complete, but negligible, pathways, due to limited potential for human exposure.

[14] Inhalation of particulates in outdoor air was evaluated. Inhalation of VOCs in outdoor air was not evaluated because concentrations of VOCs that enter outdoor air from volatilization from soil is negligible due to dilution and wind dispersion.

[15] Inhalation of VOCs volatilizing from groundwater pooled in a trench.

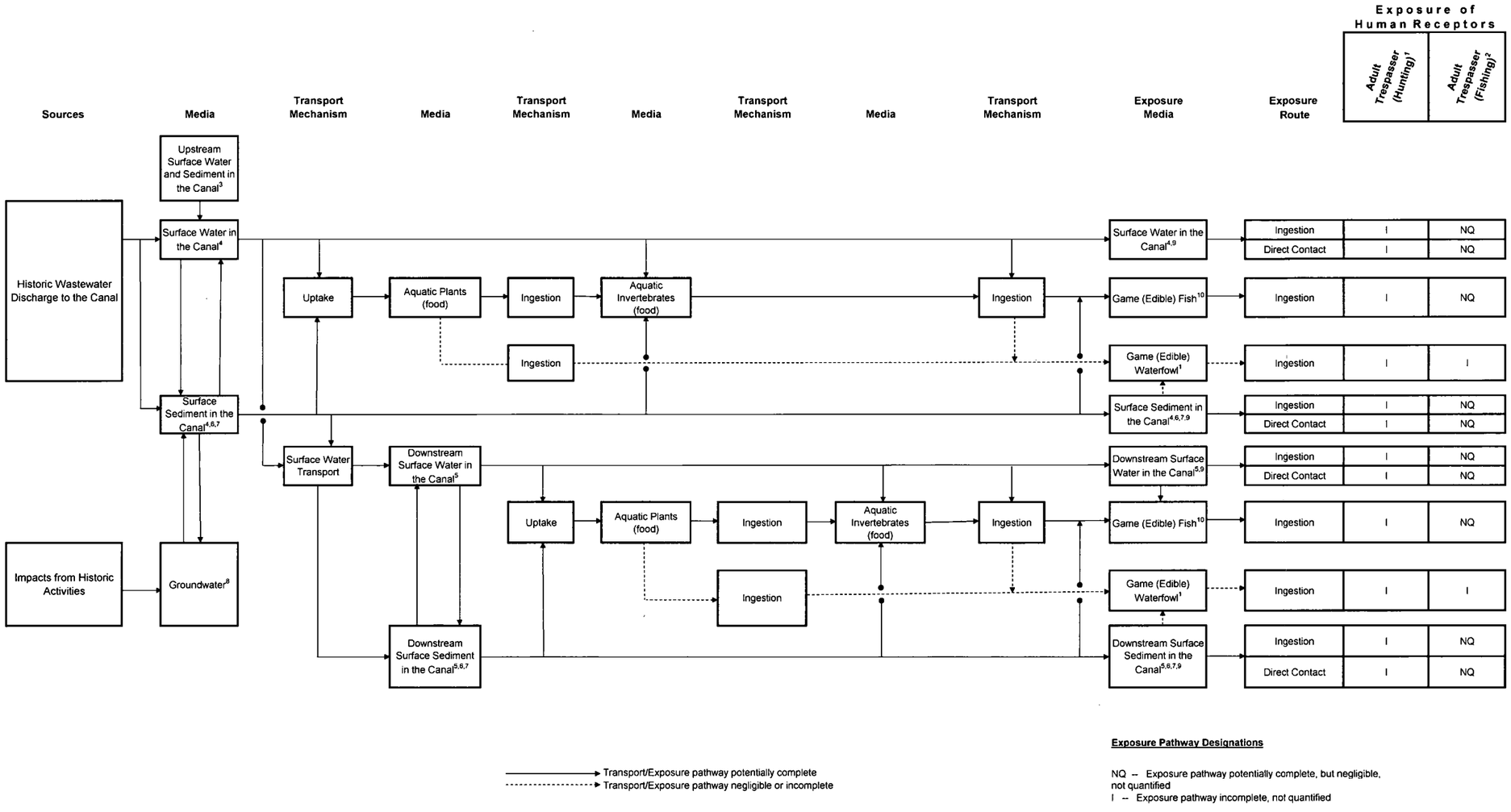
[16] Incidental ingestion of groundwater pooling in a trench.

[17] There are currently no buildings on the site.

[18] There are currently no buildings over impacted groundwater offsite.

[19] Dermal absorption of SVOCs from soil is a potentially complete and significant pathway. As recommended in USEPA's dermal guidance, dermal absorption of VOCs from soil was considered to be a potentially complete, but negligible, pathway.

Figure 3-3
Human Health Conceptual Site Model
for Surface Water and Sediment in the Ironton Canal
Adult Trespasser Hunting and Fishing Scenarios
Vertellus - Provo, Utah



Exposure Pathway Designations

NQ -- Exposure pathway potentially complete, but negligible, not quantified
I -- Exposure pathway incomplete, not quantified

Notes:

[1]The canal does not provide good habitat for waterfowl, due to the fast flowing water and steep sides. Therefore, it was assumed that exposure of waterfowl to media in the canal is negligible or incomplete and that adult trespassers (if any) do not hunt in the canal.

[2]Adult trespassers were assumed to fish in the canal. The canal is not a good place to fish, since the canal is only 1 to 2 feet deep and is fenced. Therefore, it was assumed that fishing by adult trespassers in the canal (if it occurs at all) does not occur regularly and that all exposure pathways from fishing in the canal are either negligible or incomplete.

[3]Surface water and sediment located upstream of the fenced area of the canal.

[4]Surface water and sediment located in the fenced area of the canal.

[5]Surface water and sediment located downstream of the fenced area of the canal.

[6]Includes both sidewall and bottom sediment in the canal.

[7]Surface sediment is defined as sediment at depths of 0-1 foot bgs.

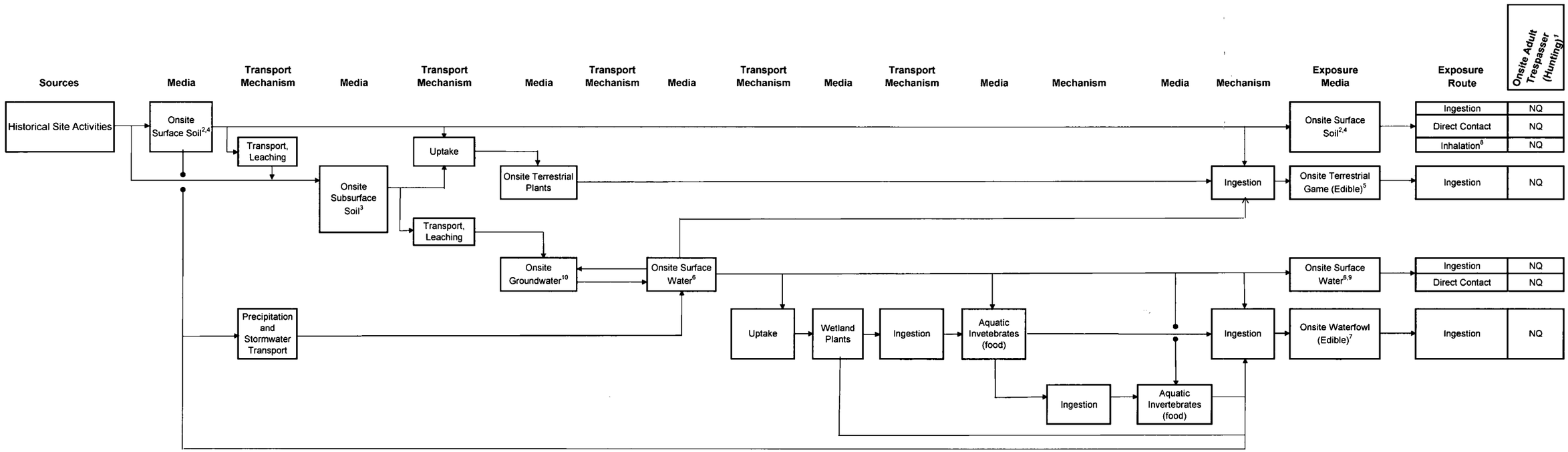
[8]Groundwater and soil pathways are shown in Figure 3-4. Groundwater may flow into sediment/surface water depending on the relative heights of the groundwater table and surface water.

[9]Inhalation of VOCs from surface water and wet sediments is not shown on the CSM because it was considered to be negligible or incomplete.

[10]It was assumed that game fish could be impacted by exposure to surface water and surface sediments and by ingesting aquatic invertebrates.

[11]Impacts from subsurface sediment (depths of 1-10 feet bgs) are not shown on the CSM because they were considered negligible or incomplete.

Figure 3-4
Human Health Conceptual
Site Model for Soil, Groundwater, and Surface Water
Onsite Adult Trespasser Hunting Scenario
Vertellus - Provo, Utah



Exposure Pathway Designations

NQ -- Exposure pathway potentially complete, but negligible, not quantified

Notes:

[1] Adult trespassers were assumed to hunt on the Site. The Site is not a good place to hunt, because it is fenced, it is illegal to trepass there, and it is illegal to hunt in an industrial area. Therefore, it was assumed that hunting by adult trespassers onsite (if it occurs at all) does not occur regularly and that all exposure pathways from hunting onsite are either negligible or incomplete.

[2] Surface soil is defined as soil at depths of 0-1 foot bgs.

[3] Subsurface soil is defined as soil at depth of 1-10 feet bgs. Exposure to subsurface soil is incomplete for adult trespassers who may hunt on the Site.

[4] Impacts to onsite surface soil were assumed to be limited to a portion of SWMU Area 3 (EA3), SWMU 8 (EA6), the South Parcel (EA7), and hotspots in SWMU Areas 2 (EA2), 3 (EA3), and 4 (EA4).

[5] Onsite terrestrial game could include mourning doves, ring-neck pheasant, and mule deer. These game are primarily herbivores. It was assumed that onsite terrestrial game could ingest surface soil, surface water, and terrestrial plants.

[6] Onsite surface water is ephemeral and may collect in the western portion of the Site near Industrial Parkway from groundwater surfacing during high water table periods and surface water runoff collecting in the area during wet months (winter and spring).

[7] Onsite waterfowl could include mallard ducks and geese assumed to be exposed at the ephemeral pond in EA4. Mallard ducks are omnivores that primarily ingest aquatic plants and aquatic animals. Therefore, it was assumed that onsite waterfowl could ingest surface soil and surface water, aquatic plants, and aquatic invertebrates in the ephemeral pond in EA4.

[8] Inhalation of particulates in outdoor air was evaluated. Inhalation of VOCs in outdoor air was not be evaluated because concentrations of VOCs that enter outdoor air from volatilization from soil are negligible due to dilution and wind dispersion.

[9] Inhalation of VOCs from surface water is not shown on the CSM because it was considered to be negligible or incomplete.

[10] Exposure to groundwater was incomplete for adult trespassers who may hunt on the Site.

EA10
EA1
SWMU AREA #1
EA9
EA3
EA6
SWMU AREA #3
Former metal evaporation pan
EA5
EA4
SWMU AREA #4
SWMU AREA #2
EA2
EA7
Pacific States Cast Iron Pipe Company

Source Aerial Photography: AGRC, High Resolution Ortho-Imagery (HRO) 6-inch, 2012

Path: T:\Vertellus Specialties\24585210 Provo Corrective Action\09 Data\GIS-CAD\Maps\2012\December2012\Exposure Areas\Fig3-5_ExposureAreas_Vertellus.mxd

EA 5 Exposure Areas

SWMU

SWMU Area

Site

* EA8 is shown on Figure 3-9.

0 75 150 225 Feet

Risk Assessment Exposure Areas (EAs)	
Vertellus Specialties	Vertellus we are part of your life
2555 Industrial Parkway	
Provo, Utah	
December, 2012	Figure 3-5

Source: Aerial Photography: AGRC, High Resolution Ortho-Imagery (HRO)6-inch, 2012

Path: Q:\Projects\Vertellus Specialties\245852\10 Provo Corrective Action\09_Data\GIS-CAD\Maps\2012\December 2012\Exposure Areas\Fig3-6_EA1_EA3_EA6.mxd

- Surface Water Sample Location
- Surface Soil Sample Location
- Subsurface Soil Sample Location
- Surface and Subsurface Soil Sample Location
- Sediment Sample Location
- Hotspot
- EA3 — Exposure Areas
- SWMU
- SWMU Area
- Site

0 40 80 120 Feet

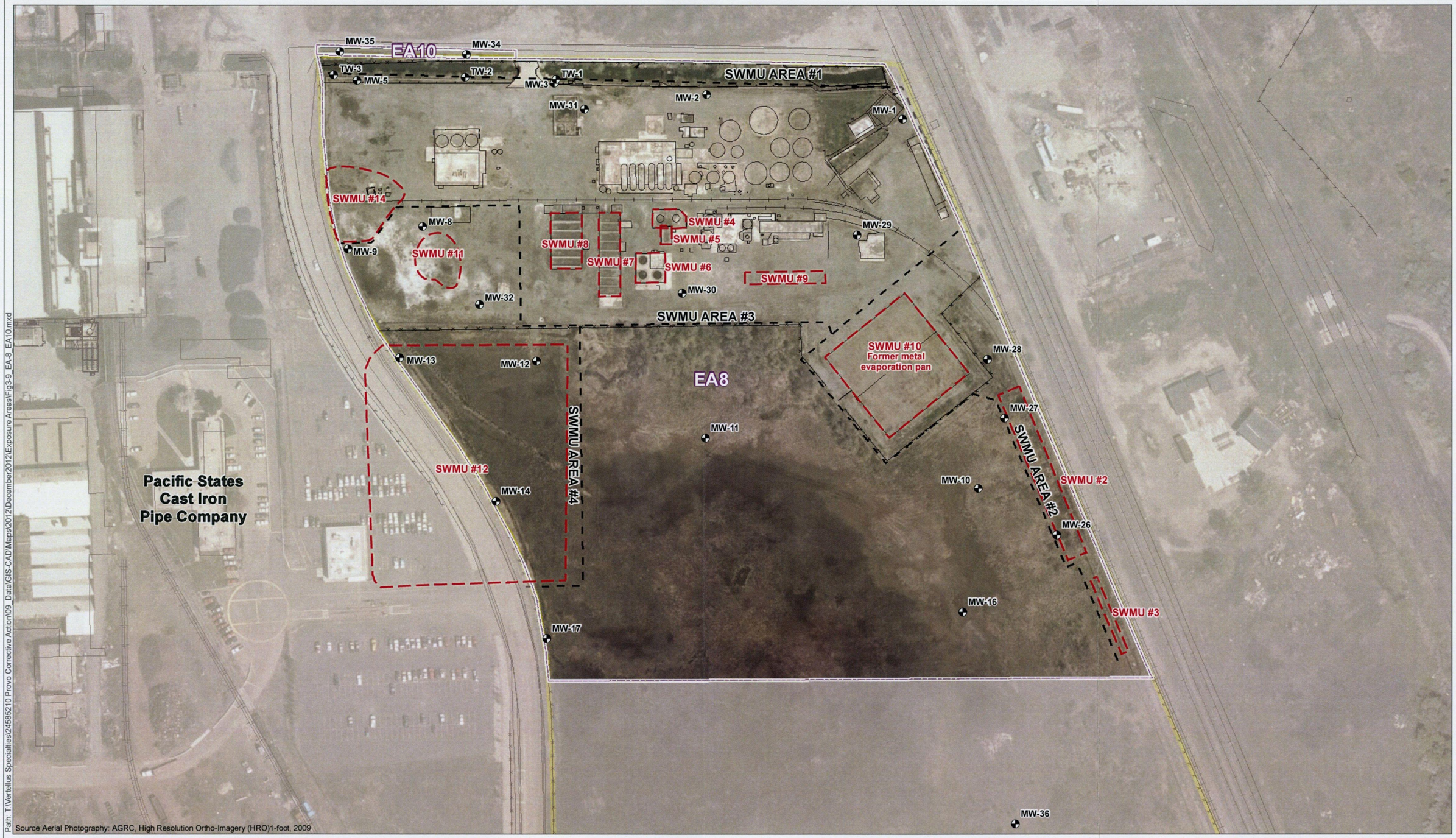
Sampling Locations: EA1, EA3, and EA6

Vertellus Specialties	Vertellus — we are part of your life
2555 Industrial Parkway	
Provo, Utah	
December, 2012	Figure 3-6

Sampling Locations: EA4, EA5, and EA9

Vertellus Specialties	Vertellus
2555 Industrial Parkway	
Provo, Utah	
December, 2012	Figure 3-7


2-SF-3-44
2-SF-3-43
2-SF-3-42
2-SF-3-41
SS-10-6
SS-10-1
SS-10-2
2-SS-2-10
2-SS-2-12
2-SS-2-4
2-SF/SS-2-23
2-SF/SS-2-25
2-SF/SS-2-27
2-SS-2-11
2-SF-2-24
2-SF/SS-2-26
2-SF/SS-2-22
EA7
2-SF/SS-2-20
TP-3
2-SF/SS-2-21
Path: T:\Vertellus Specialties\09_Data\GIS-CAD\Maps\2012\June\ExposureAreas\Fig3-8_EA2_EA7.mxd
Source Aerial Photography: AGRC, High Resolution Ortho-Imagery (HRO)1-foot, 2009
Surface Soil Sample Location
Subsurface Soil Sample Location
Surface and Subsurface Soil Sample Location
Test Pit - Suplemental Phase 2 - Subsurface Soil Location
Hotspot
EA 2
Exposure Areas
SWMU Area
SWMU
Site



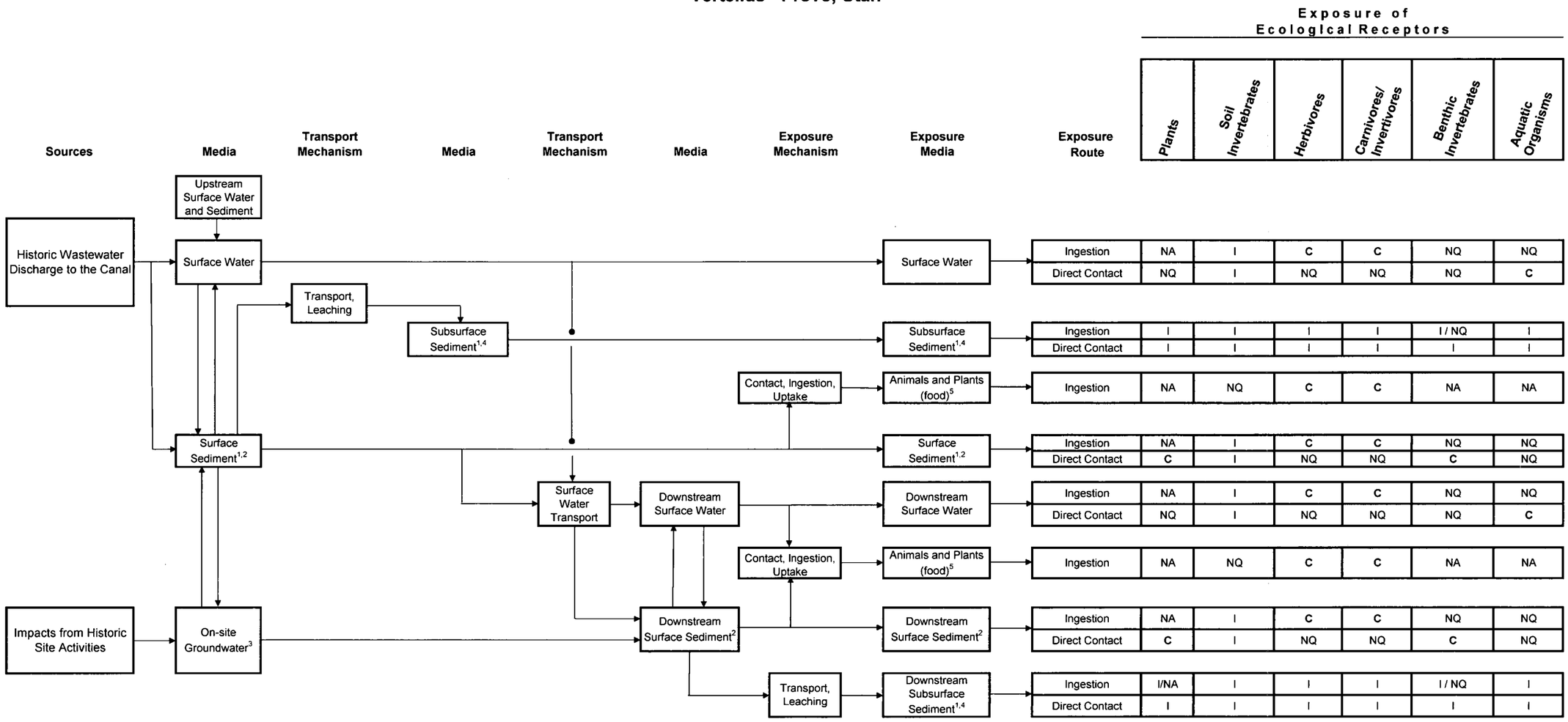
Path: T:\Vertellus Specialties\245852\10 Provo Corrective Action\09_Data\GIS-CAD\Maps\2012\December2012\Exposure Areas\Fig3-9_EA-8_EA10.mxd

Monitoring Well
EA 8 Exposure Areas
SWMU
SWMU Area
Site

0 75 150 225 Feet

Sampling Locations: EA8 and EA10	
Vertellus Specialties 2555 Industrial Parkway Provo, Utah	Vertellus we are part of your life
December, 2012	Figure 3-9

Figure 4-1
Ecological Conceptual Site Model
for Surface Water and Sediment in the Ironton Canal
Vertellus - Provo, Utah



Exposure Pathway Designations

C -- Exposure pathway potentially complete, quantified
I -- Exposure pathway incomplete, not quantified
NA -- Exposure pathway not applicable, not quantified
NQ -- Exposure pathway potentially complete, not quantified

Notes:

The mallard represents aquatic omnivores that eat both plants and invertebrates.
The tree swallow represents aquatic invertivores that eat emerging aquatic invertebrates.

[1] Includes both sidewall and bottom sediment in the canal.

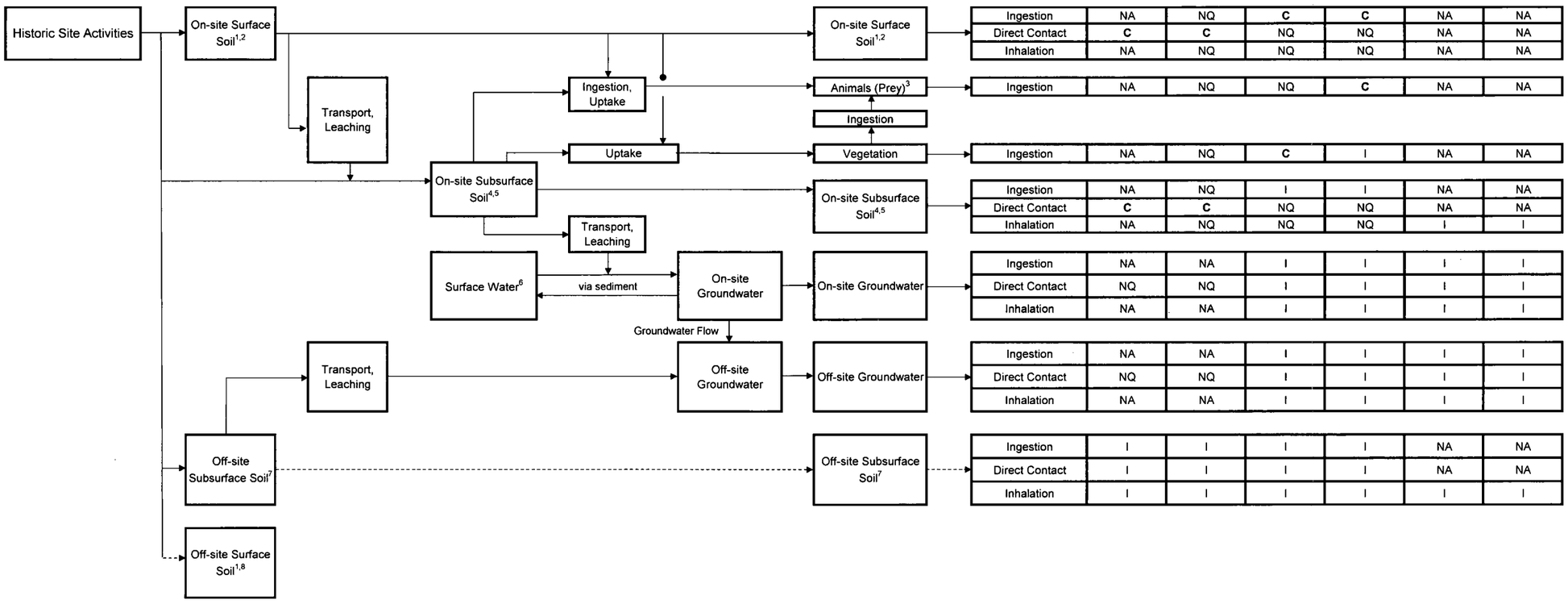
[2] Surface sediment is defined as sediment at depths of 0 to 1 foot below the surface of sediment.

[3] Groundwater and soil pathways are shown in Figure 4-2. Groundwater may flow into sediment/surface water depending on the relative elevations of the groundwater table and surface water.

[4] Subsurface sediment is defined as sediment at depths of 1 to 12 feet below the surface of sediment. Analytical results of these deep sediment samples are not representative of exposure to ecological receptors.

[5] Animal prey can include aquatic invertebrates or fish. Plants include rooted aquatic plants.

Figure 4-2
Ecological Conceptual Site Model
for Soil and Groundwater
Vertellus - Provo, Utah



Exposure Route	Exposure of Ecological Receptors: Plants	Soil Invertebrates	Herbivores	Carnivores/ Invertivores	Benthic Invertebrates	Aquatic Organisms
Ingestion	NA	NQ	C	C	NA	NA
Direct Contact	C	C	NQ	NQ	NA	NA
Inhalation	NA	NQ	NQ	NQ	NA	NA
Ingestion	NA	NQ	NQ	C	NA	NA
Ingestion	NA	NQ	C	I	NA	NA
Ingestion	NA	NQ	I	I	NA	NA
Direct Contact	C	C	NQ	NQ	NA	NA
Inhalation	NA	NQ	NQ	NQ	I	I
Ingestion	NA	NA	I	I	I	I
Direct Contact	NQ	NQ	I	I	I	I
Inhalation	NA	NA	I	I	I	I
Ingestion	NA	NA	I	I	I	I
Direct Contact	NQ	NQ	I	I	I	I
Inhalation	NA	NA	I	I	I	I
Ingestion	I	I	I	I	NA	NA
Direct Contact	I	I	I	I	NA	NA
Inhalation	I	I	I	I	I	I

Exposure Pathway Designations

C -- Exposure pathway potentially complete, quantified

NQ -- Exposure pathway potentially complete, not quantified

Notes:

[1] Surface soil is defined as soil at depths of 0 to 1 foot.

[2] Impacts to on-site surface soil are limited to EA3, EA6, and EA7 .

[3] Animal prey can include soil invertebrates or wildlife (small birds and mammals).

[4] Subsurface soil for exposue of ecoloigical receptors is defined as soil at depths of 1 to 3 feet below ground surface (bgs). Deeper soil samples are not representative of exposure of ecological receptors. Impacts to on-site subsurface soil are limited to EA2, EA3, EA4, and EA7.

[5] Leaching of chemicals from on-site surface soil in SWMU Area 3 could lead to impacts to underlying on-site subsurface soil. Chemicals from wastewater in waste storage areas (e.g., lagoons, impoundments) seeped into underlying soil in SWMU Areas 2 and 4 (now parts of EA2 and EA4). The soil was later covered by clean soil or fill. Therefore, contaminated onsite soil in SWMU Areas 2 and 4 is now subsurface soil.

[6] Surface water exposure pathways are shown in Figure 4-1. Surface water may flow into groundwater or groundwater may flow into surface water via sediment, depending on the relative elevations of the groundwater table and surface water.

[7] Chemicals from wastewater in waste storage areas (lagoons and Evaporation Areas) in the off-site portion of SWMU Area 4 (i.e., EA5) seeped into underlying soil. The soil was later covered by clean fill and an asphalt parking lot. Therefore, contaminated soil in EA5 is now subsurface soil covered with asphalt and does not represent a complete exposure pathway to ecological receptors.

[8] Off-site surface soil is not evaluated because it is not considered impacted by activities at the site and is now covered by asphalt.

Appendix A

Calculation of Volatilization Factors for VOCs in Groundwater

Table 1
Calculation of the Overall Mass Transfer Coefficient (K)
VOCs in Air in a Trench Impacted by Groundwater Pooled in the Trench

OVERALL MASS TRANSFER COEFFICIENT (K) CALCULATION
According to TNRCC LPST Method
CONSTRUCTION WORKER SCENARIO

$1/K = 1/KL + 1/KG*H'_H$

where

K =	overall mass transfer coefficient, m/sec		
KL =	liquid-phase mass transfer coefficient, m/sec		
	where		Default
	KL =	2 78E-06*((Dw/Dether)$^{2/3}$)	
		Dw = diffusivity of constituent in water, cm^2/sec	chem-specific
		Dether = diffusivity of diethyl ether in water, cm^2/sec	8 50E-06
KG =	gas-phase mass transfer coefficient, m/sec		
	where		
	KG =	4 82E-03*((U)$^{0\ 78}$)*((Scg)$^{-0\ 67}$)*((de)$^{-0\ 11}$)	
		U = windspeed, m/sec	0 225
	Scg =	Schmidt number on gas side, unitless	
	where	Scg = ug/pg*Da	
		ug = viscosity of air, g/cm*sec	1.81E-04
		pg = density of air, g/cm*sec	1 20E-03
		Da = diffusivity of constituent in air, cm^2/sec	chem-specific
	de =	effective diameter of impoundment, m	
	where	de = (4A/pi)$^{0\ 5}$	5 328531
		A = area of impoundment, m^2	22 3
		pi = pi, or 3 1416	3 141593
K'_H =	dimensionless Henry's Law Constant, unitless		
	where		
	K'_H =	Henry's Law Constant (K_H), in atm-m^3/mol*41	chem-specific

1 m^2 = 10000 cm^2

Constituent	Dw	Da	K_H	KL	KG	K'_H	1/K	K
Units	cm^2/sec	cm^2/sec	atm-m^3/mol	m/sec	m/sec	unitless	sec/m	m/sec
Benzene	1.03E-05	8 95E-02	5 55E-03	3 16E-06	0 000883	2 28E-01	3 21E+05	3 11E-06
Ethylbenzene	8 46E-06	6 85E-02	7 88E-03	2.77E-06	0 000738	3 23E-01	365165 6	2.74E-06
Methylene Chloride	1 25E-05	9 99E-02	3 25E-03	3 6E-06	0.000951	1 33E-01	285696 2	3 50E-06
Toluene	9 20E-06	7 78E-02	6 64E-03	2 93E-06	0 000804	2 72E-01	345593 9	2 89E-06
Naphthalene	8 38E-06	6 05E-02	4.40E-04	2 75E-06	0 000679	1 80E-02	444855 7	2 25E-06
Xylene	9.90E-06	8 47E-02	5 18E-03	3 08E-06	0 000851	2 12E-01	330288	3 03E-06
2-methylnaphthalene	7 78E-06	5 24E-02	5 18E-04	2 62E-06	0 000617	2 12E-02	457953.4	2 18E-06
Acetone	1 15E-05	1 06E-01	3 50E-05	3 4E-06	0 000988	1 44E-03	998742 2	1 00E-06
Carbon Disulfide	1 30E-05	1 06E-01	1 44E-02	3 7E-06	0 000992	5 90E-01	272305 4	3 67E-06
Methyl Ethyl Ketone	1 02E-05	9 14E-02	5 69E-05	3.14E-06	0 000896	2 33E-03	796868 6	1 25E-06

Notes:

atm-m^3/mol	atmosphere-cubic meter per mole
cm^2/sec	square centimeters per second
g/cm*sec	grams per centimeter-second
m	meters
m/sec	meters per second
m^2	square meters
sec/m	seconds per meter
ug/pg	micrograms per picograms

Table 2
Calculation of the Volatilization Factor (VF)
VOCs in Air in a Trench Impacted by Groundwater Pooled in the Trench

VOLATILIZATION FACTOR (VF) CALCULATION
CONSTRUCTION WORKER SCENARIO
INHALATION OF VOLATILES IN CONSTRUCTION EXCAVATION
VOLATILE CONSTITUENTS EMANATING FROM GROUNDWATER

$VF = (K \times A \times CF)/(W \times U_{air} \times H_{air})$

where

VF =	volatization factor (L/m^3)	calculated
K =	overall mass transfer coefficient, m/sec	chem-specific
A =	area of excavation floor, m^2	22.3
CF =	conversion factor (L/m^3)	1000
W =	width of contaminated area, m	4.7
U_{air} =	wind velocity in excavation, m/sec	0.225
H_{air} =	air mixing zone height, m	2

Constituent	K (m/sec)	VF (L/m^3)
Benzene	3.11E-06	3.28E-02
Ethylbenzene	2.74E-06	2.89E-02
Methylene Chloride	3.50E-06	3.69E-02
Toluene	2.89E-06	3.05E-02
Naphthalene	2.25E-06	2.37E-02
Xylene	3.03E-06	3.19E-02
2-methylnaphthalene	2.18E-06	2.30E-02
Acetone	1.00E-06	1.06E-02
Carbon Disulfide	3.67E-06	3.87E-02
Methyl Ethyl Ketone	1.25E-06	1.32E-02

Notes:

L/m^3	liters per cubic meter
m	meters
m/sec	meters per second
m^2	square meters

Appendix B

Johnson and Ettinger Model Calculations of Indoor Air Concentrations

DATA ENTRY SHEET
EA5

GW-ADV
Version 3.1, 02/04

Reset to Defaults

CALCULATE RISK-BASED GROUNDWATER CONCENTRATION (enter "X" in "YES" box)

YES [ ]

OR

CALCULATE INCREMENTAL RISKS FROM ACTUAL GROUNDWATER CONCENTRATION (enter "X" in "YES" box and initial groundwater conc below)

YES [X]

ENTER Chemical CAS No (numbers only, no dashes)	ENTER Initial groundwater conc., C_W (µg/L)	Chemical
71432	57	Benzene

MORE ↓

ENTER Average soil/ groundwater temperature, T_S (°C)	ENTER Depth below grade to bottom of enclosed space floor, L_F (cm)	ENTER Depth below grade to water table, L_{WT} (cm)	ENTER Totals must add up to value of L_{WT} (cell G28) Thickness of soil stratum A, h_A (cm)	ENTER Thickness of soil stratum B, (Enter value or 0) h_B (cm)	ENTER Thickness of soil stratum C, (Enter value or 0) h_C (cm)	ENTER Soil stratum directly above water table, (Enter A, B, or C)	ENTER SCS soil type directly above water table	ENTER Soil stratum A SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined stratum A soil vapor permeability, k_v (cm^2)
11	15	83 82	83 82			A	SIL	SIL		

MORE ↓

ENTER Stratum A SCS soil type (Lookup Soil Parameters)	ENTER Stratum A soil dry bulk density, ρ_b^A (g/cm^3)	ENTER Stratum A soil total porosity, n^A (unitless)	ENTER Stratum A soil water-filled porosity, θ_w^A (cm^3/cm^3)	ENTER Stratum B SCS soil type (Lookup Soil Parameters)	ENTER Stratum B soil dry bulk density, ρ_b^B (g/cm^3)	ENTER Stratum B soil total porosity, n^B (unitless)	ENTER Stratum B soil water-filled porosity, θ_w^B (cm^3/cm^3)	ENTER Stratum C SCS soil type (Lookup Soil Parameters)	ENTER Stratum C soil dry bulk density, ρ_b^C (g/cm^3)	ENTER Stratum C soil total porosity, n^C (unitless)	ENTER Stratum C soil water-filled porosity, θ_w^C (cm^3/cm^3)
SIL	1 49	0 439	0 180								

MORE ↓

ENTER Enclosed space floor thickness, L_{crack} (cm)	ENTER Soil-bldg pressure differential, ΔP ($g/cm\text{-}s^2$)	ENTER Enclosed space floor length, L_B (cm)	ENTER Enclosed space floor width, W_B (cm)	ENTER Enclosed space height, H_B (cm)	ENTER Floor-wall seam crack width, w (cm)	ENTER Indoor air exchange rate, ER (1/h)	ENTER Average vapor flow rate into bldg OR Leave blank to calculate Q_{soil} (L/m)
10	40	1000	1000	244	0 1	1	5

MORE ↓

ENTER Averaging time for carcinogens, AT_C (yrs)	ENTER Averaging time for noncarcinogens, AT_{NC} (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)	ENTER Target risk for carcinogens, TR (unitless)	ENTER Target hazard quotient for noncarcinogens, THQ (unitless)
70	25	25	250	1 0E-06	1
				Used to calculate risk-based groundwater concentration	

END

CHEMICAL PROPERTIES SHEET

Diffusivity in air, D_a (cm^2/s)	Diffusivity in water, D_w (cm^2/s)	Henry's law constant at reference temperature, H (atm-m^3/mol)	Henry's law constant reference temperature, T_R (°C)	Enthalpy of vaporization at the normal boiling point, $\Delta H_{v,b}$ (cal/mol)	Normal boiling point, T_B (°K)	Critical temperature, T_C (°K)	Organic carbon partition coefficient, K_{oc} (cm^3/g)	Pure component water solubility, S (mg/L)	Unit risk factor, URF ($\mu g/m^3)^{-1}$	Reference conc , RfC (mg/m^3)
8.80E-02	9 80E-06	5 54E-03	25	7,342	353.24	562 16	5 89E+01	1.79E+03	7.8E-06	3 0E-02

END

INTERMEDIATE CALCULATIONS SHEET
Benzene EA5

Exposure duration, τ (sec)	Source-building separation, L_T (cm)	Stratum A soil air-filled porosity, θ_a^A (cm^3/cm^3)	Stratum B soil air-filled porosity, θ_a^B (cm^3/cm^3)	Stratum C soil air-filled porosity, θ_a^C (cm^3/cm^3)	Stratum A effective total fluid saturation, S_{te} (cm^3/cm^3)	Stratum A soil intrinsic permeability, k_i (cm^2)	Stratum A soil relative air permeability, k_{rg} (cm^2)	Stratum A soil effective vapor permeability, k_v (cm^2)	Thickness of capillary zone, L_{cz} (cm)	Total porosity in capillary zone, n_{cz} (cm^3/cm^3)	Air-filled porosity in capillary zone, $\theta_{a,cz}$ (cm^3/cm^3)	Water-filled porosity in capillary zone, $\theta_{w,cz}$ (cm^3/cm^3)	Floor-wall seam perimeter, X_{crack} (cm)
7.88E+08	68 82	0 259	ERROR	ERROR	0 307	2 82E-09	0 798	2 25E-09	68 18	0 439	0 090	0 349	4,000

Bldg ventilation rate, $Q_{building}$ (cm^3/s)	Area of enclosed space below grade, A_B (cm^2)	Crack-to-total area ratio, η (unitless)	Crack depth below grade, Z_{crack} (cm)	Enthalpy of vaporization at ave groundwater temperature, $\Delta H_{v,TS}$ (cal/mol)	Henry's law constant at ave groundwater temperature, H_{TS} (atm-m^3/mol)	Henry's law constant at ave groundwater temperature, H'_{TS} (unitless)	Vapor viscosity at ave soil temperature, μ_{TS} (g/cm-s)	Stratum A effective diffusion coefficient, D^{eff}_A (cm^2/s)	Stratum B effective diffusion coefficient, D^{eff}_B (cm^2/s)	Stratum C effective diffusion coefficient, D^{eff}_C (cm^2/s)	Capillary zone effective diffusion coefficient, D^{eff}_{cz} (cm^2/s)	Total overall effective diffusion coefficient, D^{eff}_T (cm^2/s)	Diffusion path length, L_d (cm)
6 78E+04	1.06E+06	3 77E-04	15	8,112	2.82E-03	1 21E-01	1 76E-04	5 08E-03	0 00E+00	0 00E+00	1 65E-04	1 66E-04	68 82

Convection path length, L_p (cm)	Source vapor conc , C_{source} ($\mu g/m^3$)	Crack radius, r_{crack} (cm)	Average vapor flow rate into bldg , Q_{soil} (cm^3/s)	Crack effective diffusion coefficient, D^{crack} (cm^2/s)	Area of crack, A_{crack} (cm^2)	Exponent of equivalent foundation Peclet number, exp(Pe^f) (unitless)	Infinite source indoor attenuation coefficient, α (unitless)	Infinite source bldg conc , $C_{building}$ ($\mu g/m^3$)	Unit risk factor, URF $(\mu g/m^3)^{-1}$	Reference conc , RfC (mg/m^3)
15	6 89E+03	0 10	8 33E+01	5 08E-03	4 00E+02	1 17E+178	3 66E-05	2 53E-01	7 8E-06	3 0E-02

END

DATA ENTRY SHEET
EA5

GW-ADV
Version 3 1, 02/04

Reset to Defaults

CALCULATE RISK-BASED GROUNDWATER CONCENTRATION (enter "X" in "YES" box)

YES

OR

CALCULATE INCREMENTAL RISKS FROM ACTUAL GROUNDWATER CONCENTRATION (enter "X" in "YES" box and initial groundwater conc below)

YES X

ENTER Chemical CAS No (numbers only, no dashes)	ENTER Initial groundwater conc, C_W (µg/L)	Chemical
100414	6	Ethylbenzene

MORE

ENTER Average soil/ groundwater temperature, T_S (°C)	ENTER Depth below grade to bottom of enclosed space floor, L_F (cm)	ENTER Depth below grade to water table, L_{WT} (cm)	ENTER Totals must add up to value of L_{WT} (cell G28) Thickness of soil stratum A, h_A (cm)	ENTER Thickness of soil stratum B, (Enter value or 0) h_B (cm)	ENTER Thickness of soil stratum C, (Enter value or 0) h_C (cm)	ENTER Soil stratum directly above water table, (Enter A, B, or C)	ENTER SCS soil type directly above water table	ENTER Soil stratum A SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined stratum A soil vapor permeability, k_v (cm^2)
11	15	83 82	83 82			A	SIL	SIL		

MORE

ENTER Stratum A SCS soil type (Lookup Soil Parameters)	ENTER Stratum A soil dry bulk density, ρ_b^A (g/cm^3)	ENTER Stratum A soil total porosity, n^A (unitless)	ENTER Stratum A soil water-filled porosity, θ_w^A (cm^3/cm^3)	ENTER Stratum B SCS soil type (Lookup Soil Parameters)	ENTER Stratum B soil dry bulk density, ρ_b^B (g/cm^3)	ENTER Stratum B soil total porosity, n^B (unitless)	ENTER Stratum B soil water-filled porosity, θ_w^B (cm^3/cm^3)	ENTER Stratum C SCS soil type (Lookup Soil Parameters)	ENTER Stratum C soil dry bulk density, ρ_b^C (g/cm^3)	ENTER Stratum C soil total porosity, n^C (unitless)	ENTER Stratum C soil water-filled porosity, θ_w^C (cm^3/cm^3)
SIL	1 49	0 439	0 180								

MORE

ENTER Enclosed space floor thickness, L_{crack} (cm)	ENTER Soil-bldg pressure differential, ΔP ($g/cm\text{-}s^2$)	ENTER Enclosed space floor length, L_B (cm)	ENTER Enclosed space floor width, W_B (cm)	ENTER Enclosed space height, H_B (cm)	ENTER Floor-wall seam crack width, w (cm)	ENTER Indoor air exchange rate, ER (1/h)	ENTER Average vapor flow rate into bldg OR Leave blank to calculate Q_{soil} (L/m)
10	40	1000	1000	244	0 1	1	5

MORE

ENTER Averaging time for carcinogens, AT_C (yrs)	ENTER Averaging time for noncarcinogens, AT_{NC} (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)	ENTER Target risk for carcinogens, TR (unitless)	ENTER Target hazard quotient for noncarcinogens, THQ (unitless)
70	25	25	250	1 0E-06	1

Used to calculate risk-based groundwater concentration

END

CHEMICAL PROPERTIES SHEET

Diffusivity in air, D_a (cm^2/s)	Diffusivity in water, D_w (cm^2/s)	Henry's law constant at reference temperature, H ($atm\text{-}m^3/mol$)	Henry's law constant reference temperature, T_R (°C)	Enthalpy of vaporization at the normal boiling point, $\Delta H_{v,b}$ (cal/mol)	Normal boiling point, T_B (°K)	Critical temperature, T_C (°K)	Organic carbon partition coefficient, K_{oc} (cm^3/g)	Pure component water solubility, S (mg/L)	Unit risk factor, URF $(\mu g/m^3)^{-1}$	Reference conc , RfC (mg/m^3)
7.50E-02	7 80E-06	7 86E-03	25	8,501	409 34	617 20	3 63E+02	1 69E+02	0 0E+00	1.0E+00

END

INTERMEDIATE CALCULATIONS SHEET
Ethylbenzene EA5

Exposure duration, τ (sec)	Source-building separation, L_T (cm)	Stratum A soil air-filled porosity, θ_a^A (cm^3/cm^3)	Stratum B soil air-filled porosity, θ_a^B (cm^3/cm^3)	Stratum C soil air-filled porosity, θ_a^C (cm^3/cm^3)	Stratum A effective total fluid saturation, S_{te} (cm^3/cm^3)	Stratum A soil intrinsic permeability, k_i (cm^2)	Stratum A soil relative air permeability, k_{rg} (cm^2)	Stratum A soil effective vapor permeability, k_v (cm^2)	Thickness of capillary zone, L_{cz} (cm)	Total porosity in capillary zone, n_{cz} (cm^3/cm^3)	Air-filled porosity in capillary zone, $\theta_{a,cz}$ (cm^3/cm^3)	Water-filled porosity in capillary zone, $\theta_{w,cz}$ (cm^3/cm^3)	Floor-wall seam perimeter, X_{crack} (cm)
7 88E+08	68 82	0 259	ERROR	ERROR	0 307	2 82E-09	0.798	2 25E-09	68 18	0 439	0 090	0 349	4,000

Bldg ventilation rate, $Q_{building}$ (cm^3/s)	Area of enclosed space below grade, A_B (cm^2)	Crack-to-total area ratio, η (unitless)	Crack depth below grade, Z_{crack} (cm)	Enthalpy of vaporization at ave groundwater temperature, $\Delta H_{v\,TS}$ (cal/mol)	Henry's law constant at ave. groundwater temperature, H_{TS} ($atm\text{-}m^3/mol$)	Henry's law constant at ave. groundwater temperature, H'_{TS} (unitless)	Vapor viscosity at ave soil temperature, μ_{TS} (g/cm-s)	Stratum A effective diffusion coefficient, D^{eff}_A (cm^2/s)	Stratum B effective diffusion coefficient, D^{eff}_B (cm^2/s)	Stratum C effective diffusion coefficient, D^{eff}_C (cm^2/s)	Capillary zone effective diffusion coefficient, D^{eff}_{cz} (cm^2/s)	Total overall effective diffusion coefficient, D^{eff}_T (cm^2/s)	Diffusion path length, L_d (cm)
6 78E+04	1 06E+06	3.77E-04	15	10,144	3 38E-03	1 45E-01	1 76E-04	4 33E-03	0 00E+00	0.00E+00	1.38E-04	1.39E-04	68 82

Convection path length, L_p (cm)	Source vapor conc , C_{source} ($\mu g/m^3$)	Crack radius, r_{crack} (cm)	Average vapor flow rate into bldg , Q_{soil} (cm^3/s)	Crack effective diffusion coefficient, D^{crack} (cm^2/s)	Area of crack, A_{crack} (cm^2)	Exponent of equivalent foundation Peclet number, exp(Pe') (unitless)	Infinite source indoor attenuation coefficient, α (unitless)	Infinite source bldg conc., $C_{building}$ ($\mu g/m^3$)	Unit risk factor, URF $(\mu g/m^3)^{-1}$	Reference conc , RfC (mg/m^3)
15	8 70E+02	0 10	8 33E+01	4 33E-03	4 00E+02	8 79E+208	3 08E-05	2 68E-02	NA	1 0E+00

END

DATA ENTRY SHEET
EA5

GW-ADV
Version 3 1, 02/04

Reset to Defaults

CALCULATE RISK-BASED GROUNDWATER CONCENTRATION (enter "X" in "YES" box)

YES [ ]

OR

CALCULATE INCREMENTAL RISKS FROM ACTUAL GROUNDWATER CONCENTRATION (enter "X" in "YES" box and initial groundwater conc below)

YES [X]

ENTER Chemical CAS No (numbers only, no dashes)	ENTER Initial groundwater conc , C_W (µg/L)	Chemical
91203	7800	Naphthalene

MORE ↓

ENTER Average soil/ groundwater temperature, T_S (°C)	ENTER Depth below grade to bottom of enclosed space floor, L_F (cm)	ENTER Depth below grade to water table, L_{WT} (cm)	ENTER Totals must add up to value of L_{WT} (cell G28) Thickness of soil stratum A, h_A (cm)	ENTER Thickness of soil stratum B, (Enter value or 0) h_B (cm)	ENTER Thickness of soil stratum C, (Enter value or 0) h_C (cm)	ENTER Soil stratum directly above water table, (Enter A, B, or C)	ENTER SCS soil type directly above water table	ENTER Soil stratum A SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined stratum A soil vapor permeability, k_v (cm^2)
11	15	83 82	83 82			A	SIL	SIL		

MORE ↓

ENTER Stratum A SCS soil type (Lookup Soil Parameters)	ENTER Stratum A soil dry bulk density, ρ_b^A (g/cm^3)	ENTER Stratum A soil total porosity, n^A (unitless)	ENTER Stratum A soil water-filled porosity, θ_w^A (cm^3/cm^3)	ENTER Stratum B SCS soil type (Lookup Soil Parameters)	ENTER Stratum B soil dry bulk density, ρ_b^B (g/cm^3)	ENTER Stratum B soil total porosity, n^B (unitless)	ENTER Stratum B soil water-filled porosity, θ_w^B (cm^3/cm^3)	ENTER Stratum C SCS soil type (Lookup Soil Parameters)	ENTER Stratum C soil dry bulk density, ρ_b^C (g/cm^3)	ENTER Stratum C soil total porosity, n^C (unitless)	ENTER Stratum C soil water-filled porosity, θ_w^C (cm^3/cm^3)
SIL	1 49	0 439	0 180								

MORE ↓

ENTER Enclosed space floor thickness, L_{crack} (cm)	ENTER Soil-bldg pressure differential, ΔP ($g/cm\text{-}s^2$)	ENTER Enclosed space floor length, L_B (cm)	ENTER Enclosed space floor width, W_B (cm)	ENTER Enclosed space height, H_B (cm)	ENTER Floor-wall seam crack width, w (cm)	ENTER Indoor air exchange rate, ER (1/h)	ENTER Average vapor flow rate into bldg OR Leave blank to calculate Q_{soil} (L/m)
10	40	1000	1000	244	0 1	1	5

MORE ↓

ENTER Averaging time for carcinogens, AT_C (yrs)	ENTER Averaging time for noncarcinogens, AT_{NC} (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)	ENTER Target risk for carcinogens, TR (unitless)	ENTER Target hazard quotient for noncarcinogens, THQ (unitless)
70	25	25	250	1 0E-06	1

Used to calculate risk-based groundwater concentration

END

CHEMICAL PROPERTIES SHEET

Diffusivity in air, D_a (cm^2/s)	Diffusivity in water, D_w (cm^2/s)	Henry's law constant at reference temperature, H (atm-m^3/mol)	Henry's law constant reference temperature, T_R (°C)	Enthalpy of vaporization at the normal boiling point, $\Delta H_{v,b}$ (cal/mol)	Normal boiling point, T_B (°K)	Critical temperature, T_C (°K)	Organic carbon partition coefficient, K_{oc} (cm^3/g)	Pure component water solubility, S (mg/L)	Unit risk factor, URF $(\mu g/m^3)^{-1}$	Reference conc., RfC (mg/m^3)
5 90E-02	7 50E-06	4 82E-04	25	10,373	491 14	748 40	2 00E+03	3 10E+01	0 0E+00	3 0E-03

END

INTERMEDIATE CALCULATIONS SHEET
Naphthalene EA5

Exposure duration, τ (sec)	Source-building separation, L_T (cm)	Stratum A soil air-filled porosity, θ_a^A (cm^3/cm^3)	Stratum B soil air-filled porosity, θ_a^B (cm^3/cm^3)	Stratum C soil air-filled porosity, θ_a^C (cm^3/cm^3)	Stratum A effective total fluid saturation, S_{te} (cm^3/cm^3)	Stratum A soil intrinsic permeability, k_i (cm^2)	Stratum A soil relative air permeability, k_{rg} (cm^2)	Stratum A soil effective vapor permeability, k_v (cm^2)	Thickness of capillary zone, L_{cz} (cm)	Total porosity in capillary zone, n_{cz} (cm^3/cm^3)	Air-filled porosity in capillary zone, $\theta_{a,cz}$ (cm^3/cm^3)	Water-filled porosity in capillary zone, $\theta_{w,cz}$ (cm^3/cm^3)	Floor-wall seam perimeter, X_{crack} (cm)
7 88E+08	68 82	0 259	ERROR	ERROR	0 307	2 82E-09	0 798	2 25E-09	68 18	0 439	0 090	0 349	4,000

Bldg. ventilation rate, $Q_{building}$ (cm^3/s)	Area of enclosed space below grade, A_B (cm^2)	Crack-to-total area ratio, η (unitless)	Crack depth below grade, Z_{crack} (cm)	Enthalpy of vaporization at ave groundwater temperature, $\Delta H_{v,TS}$ (cal/mol)	Henry's law constant at ave groundwater temperature, H_{TS} (atm-m^3/mol)	Henry's law constant at ave groundwater temperature, H'_{TS} (unitless)	Vapor viscosity at ave. soil temperature, μ_{TS} (g/cm-s)	Stratum A effective diffusion coefficient, D^{eff}_A (cm^2/s)	Stratum B effective diffusion coefficient, D^{eff}_B (cm^2/s)	Stratum C effective diffusion coefficient, D^{eff}_C (cm^2/s)	Capillary zone effective diffusion coefficient, D^{eff}_{cz} (cm^2/s)	Total overall effective diffusion coefficient, D^{eff}_T (cm^2/s)	Diffusion path length, L_d (cm)
6 78E+04	1 06E+06	3 77E-04	15	12,902	1 65E-04	7 07E-03	1 76E-04	3 42E-03	0.00E+00	0 00E+00	2 67E-04	2.69E-04	68 82

Convection path length, L_p (cm)	Source vapor conc., C_{source} ($\mu g/m^3$)	Crack radius, r_{crack} (cm)	Average vapor flow rate into bldg , Q_{soil} (cm^3/s)	Crack effective diffusion coefficient, D^{crack} (cm^2/s)	Area of crack, A_{crack} (cm^2)	Exponent of equivalent foundation Peclet number, exp(Pe^f) (unitless)	Infinite source indoor attenuation coefficient, α (unitless)	Infinite source bldg conc , $C_{building}$ ($\mu g/m^3$)	Unit risk factor, URF $(\mu g/m^3)^{-1}$	Reference conc , RfC (mg/m^3)
15	5 51E+04	0 10	8 33E+01	3 42E-03	4.00E+02	1.77E+264	5 83E-05	3 21E+00	NA	3 0E-03

END

DATA ENTRY SHEET
EA8

GW-ADV
Version 3 1; 02/04

Reset to Defaults

CALCULATE RISK-BASED GROUNDWATER CONCENTRATION (enter "X" in "YES" box)

YES [ ]

OR

CALCULATE INCREMENTAL RISKS FROM ACTUAL GROUNDWATER CONCENTRATION (enter "X" in "YES" box and initial groundwater conc below)

YES [X]

ENTER Chemical CAS No (numbers only, no dashes)	ENTER Initial groundwater conc, C_W (µg/L)	Chemical
71432	1152	Benzene

MORE ↓

ENTER Average soil/ groundwater temperature, T_S (°C)	ENTER Depth below grade to bottom of enclosed space floor, L_F (cm)	ENTER Depth below grade to water table, L_{WT} (cm)	ENTER Totals must add up to value of L_{WT} (cell G28) Thickness of soil stratum A, h_A (cm)	ENTER Thickness of soil stratum B, (Enter value or 0) h_B (cm)	ENTER Thickness of soil stratum C, (Enter value or 0) h_C (cm)	ENTER Soil stratum directly above water table, (Enter A, B, or C)	ENTER SCS soil type directly above water table	ENTER Soil stratum A SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined stratum A soil vapor permeability, k_v (cm^2)
11	15	90 53	90 53			A	SIL	SIL		

MORE ↓

ENTER Stratum A SCS soil type (Lookup Soil Parameters)	ENTER Stratum A soil dry bulk density, ρ_b^A (g/cm^3)	ENTER Stratum A soil total porosity, n^A (unitless)	ENTER Stratum A soil water-filled porosity, θ_w^A (cm^3/cm^3)	ENTER Stratum B SCS soil type (Lookup Soil Parameters)	ENTER Stratum B soil dry bulk density, ρ_b^B (g/cm^3)	ENTER Stratum B soil total porosity, n^B (unitless)	ENTER Stratum B soil water-filled porosity, θ_w^B (cm^3/cm^3)	ENTER Stratum C SCS soil type (Lookup Soil Parameters)	ENTER Stratum C soil dry bulk density, ρ_b^C (g/cm^3)	ENTER Stratum C soil total porosity, n^C (unitless)	ENTER Stratum C soil water-filled porosity, θ_w^C (cm^3/cm^3)
SIL	1 49	0 439	0 180								

MORE ↓

ENTER Enclosed space floor thickness, L_{crack} (cm)	ENTER Soil-bldg pressure differential, ΔP ($g/cm\text{-}s^2$)	ENTER Enclosed space floor length, L_B (cm)	ENTER Enclosed space floor width, W_B (cm)	ENTER Enclosed space height, H_B (cm)	ENTER Floor-wall seam crack width, w (cm)	ENTER Indoor air exchange rate, ER (1/h)	ENTER Average vapor flow rate into bldg OR Leave blank to calculate Q_{soil} (L/m)
10	40	1000	1000	244	0 1	1	5

MORE ↓

ENTER Averaging time for carcinogens, AT_C (yrs)	ENTER Averaging time for noncarcinogens, AT_{NC} (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)	ENTER Target risk for carcinogens, TR (unitless)	ENTER Target hazard quotient for noncarcinogens, THQ (unitless)
70	25	25	250	1 0E-06	1
				Used to calculate risk-based groundwater concentration	

END

CHEMICAL PROPERTIES SHEET

Diffusivity in air, D_a (cm^2/s)	Diffusivity in water, D_w (cm^2/s)	Henry's law constant at reference temperature, H ($atm\text{-}m^3/mol$)	Henry's law constant reference temperature, T_R (°C)	Enthalpy of vaporization at the normal boiling point, $\Delta H_{v,b}$ (cal/mol)	Normal boiling point, T_B (°K)	Critical temperature, T_C (°K)	Organic carbon partition coefficient, K_{oc} (cm^3/g)	Pure component water solubility, S (mg/L)	Unit risk factor, URF $(\mu g/m^3)^{-1}$	Reference conc., RfC (mg/m^3)
8 80E-02	9 80E-06	5 54E-03	25	7,342	353 24	562 16	5 89E+01	1 79E+03	7 8E-06	3 0E-02

END

INTERMEDIATE CALCULATIONS SHEET
Benzene EA8

Exposure duration, τ (sec)	Source-building separation, L_T (cm)	Stratum A soil air-filled porosity, θ_a^A (cm^3/cm^3)	Stratum B soil air-filled porosity, θ_a^B (cm^3/cm^3)	Stratum C soil air-filled porosity, θ_a^C (cm^3/cm^3)	Stratum A effective total fluid saturation, S_{te} (cm^3/cm^3)	Stratum A soil intrinsic permeability, k_i (cm^2)	Stratum A soil relative air permeability, k_{rg} (cm^2)	Stratum A soil effective vapor permeability, k_v (cm^2)	Thickness of capillary zone, L_{cz} (cm)	Total porosity in capillary zone, n_{cz} (cm^3/cm^3)	Air-filled porosity in capillary zone, $\theta_{a,cz}$ (cm^3/cm^3)	Water-filled porosity in capillary zone, $\theta_{w,cz}$ (cm^3/cm^3)	Floor-wall seam perimeter, X_{crack} (cm)
7 88E+08	75.53	0 259	ERROR	ERROR	0 307	2 82E-09	0 798	2.25E-09	68 18	0.439	0 090	0 349	4,000

Bldg ventilation rate, $Q_{building}$ (cm^3/s)	Area of enclosed space below grade, A_B (cm^2)	Crack-to-total area ratio, η (unitless)	Crack depth below grade, Z_{crack} (cm)	Enthalpy of vaporization at ave groundwater temperature, $\Delta H_{v,TS}$ (cal/mol)	Henry's law constant at ave groundwater temperature, H_{TS} (atm-m^3/mol)	Henry's law constant at ave. groundwater temperature, H'_{TS} (unitless)	Vapor viscosity at ave soil temperature, μ_{TS} (g/cm-s)	Stratum A effective diffusion coefficient, D^{eff}_A (cm^2/s)	Stratum B effective diffusion coefficient, D^{eff}_B (cm^2/s)	Stratum C effective diffusion coefficient, D^{eff}_C (cm^2/s)	Capillary zone effective diffusion coefficient, D^{eff}_{cz} (cm^2/s)	Total overall effective diffusion coefficient, D^{eff}_T (cm^2/s)	Diffusion path length, L_d (cm)
6 78E+04	1 06E+06	3 77E-04	15	8,112	2 82E-03	1 21E-01	1 76E-04	5.08E-03	0 00E+00	0.00E+00	1 65E-04	1 82E-04	75 53

Convection path length, L_p (cm)	Source vapor conc., C_{source} ($\mu g/m^3$)	Crack radius, r_{crack} (cm)	Average vapor flow rate into bldg., Q_{soil} (cm^3/s)	Crack effective diffusion coefficient, D^{crack} (cm^2/s)	Area of crack, A_{crack} (cm^2)	Exponent of equivalent foundation Peclet number, $\exp(Pe^f)$ (unitless)	Infinite source indoor attenuation coefficient, α (unitless)	Infinite source bldg. conc., $C_{building}$ ($\mu g/m^3$)	Unit risk factor, URF $(\mu g/m^3)^{-1}$	Reference conc., RfC (mg/m^3)
15	1 39E+05	0 10	8 33E+01	5 08E-03	4 00E+02	1 17E+178	3 65E-05	5 09E+00	7 8E-06	3 0E-02

END

DATA ENTRY SHEET
EA8

GW-ADV
Version 3 1, 02/04

Reset to Defaults

CALCULATE RISK-BASED GROUNDWATER CONCENTRATION (enter "X" in "YES" box)

YES

OR

CALCULATE INCREMENTAL RISKS FROM ACTUAL GROUNDWATER CONCENTRATION (enter "X" in "YES" box and initial groundwater conc below)

YES X

ENTER Chemical CAS No (numbers only, no dashes)	ENTER Initial groundwater conc, C_W (µg/L)	Chemical
100414	169	Ethylbenzene

MORE

ENTER Average soil/ groundwater temperature, T_S (°C)	ENTER Depth below grade to bottom of enclosed space floor, L_F (cm)	ENTER Depth below grade to water table, L_{WT} (cm)	ENTER Thickness of soil stratum A, h_A (cm)	ENTER Thickness of soil stratum B, (Enter value or 0) h_B (cm)	ENTER Thickness of soil stratum C, (Enter value or 0) h_C (cm)	ENTER Soil stratum directly above water table, (Enter A, B, or C)	ENTER SCS soil type directly above water table	ENTER Soil stratum A SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined stratum A soil vapor permeability, k_v (cm^2)
			Totals must add up to value of L_{WT} (cell G28)							
11	15	90 53	90 53			A	SIL	SIL		

MORE

ENTER Stratum A SCS soil type (Lookup Soil Parameters)	ENTER Stratum A soil dry bulk density, ρ_b^A (g/cm^3)	ENTER Stratum A soil total porosity, n^A (unitless)	ENTER Stratum A soil water-filled porosity, θ_w^A (cm^3/cm^3)	ENTER Stratum B SCS soil type (Lookup Soil Parameters)	ENTER Stratum B soil dry bulk density, ρ_b^B (g/cm^3)	ENTER Stratum B soil total porosity, n^B (unitless)	ENTER Stratum B soil water-filled porosity, θ_w^B (cm^3/cm^3)	ENTER Stratum C SCS soil type (Lookup Soil Parameters)	ENTER Stratum C soil dry bulk density, ρ_b^C (g/cm^3)	ENTER Stratum C soil total porosity, n^C (unitless)	ENTER Stratum C soil water-filled porosity, θ_w^C (cm^3/cm^3)
SIL	1 49	0 439	0 180								

MORE

ENTER Enclosed space floor thickness, L_{crack} (cm)	ENTER Soil-bldg pressure differential, ΔP ($g/cm\text{-}s^2$)	ENTER Enclosed space floor length, L_B (cm)	ENTER Enclosed space floor width, W_B (cm)	ENTER Enclosed space height, H_B (cm)	ENTER Floor-wall seam crack width, w (cm)	ENTER Indoor air exchange rate, ER (1/h)	ENTER Average vapor flow rate into bldg OR Leave blank to calculate Q_{soil} (L/m)
10	40	1000	1000	244	0 1	1	5

MORE

ENTER Averaging time for carcinogens, AT_C (yrs)	ENTER Averaging time for noncarcinogens, AT_{NC} (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)	ENTER Target risk for carcinogens, TR (unitless)	ENTER Target hazard quotient for noncarcinogens, THQ (unitless)
70	25	25	250	1 0E-06	1

Used to calculate risk-based groundwater concentration

END

CHEMICAL PROPERTIES SHEET

Diffusivity in air, D_a (cm^2/s)	Diffusivity in water, D_w (cm^2/s)	Henry's law constant at reference temperature, H (atm-m^3/mol)	Henry's law constant reference temperature, T_R (°C)	Enthalpy of vaporization at the normal boiling point, $\Delta H_{v,b}$ (cal/mol)	Normal boiling point, T_B (°K)	Critical temperature, T_C (°K)	Organic carbon partition coefficient, K_{oc} (cm^3/g)	Pure component water solubility, S (mg/L)	Unit risk factor, URF ($(\mu g/m^3)^{-1}$)	Reference conc , RfC (mg/m^3)
7 50E-02	7 80E-06	7 86E-03	25	8,501	409.34	617.20	3 63E+02	1 69E+02	0 0E+00	1 0E+00

END

INTERMEDIATE CALCULATIONS SHEET
Ethylbenzene EA8

Exposure duration, τ (sec)	Source-building separation, L_T (cm)	Stratum A soil air-filled porosity, θ_a^A (cm^3/cm^3)	Stratum B soil air-filled porosity, θ_a^B (cm^3/cm^3)	Stratum C soil air-filled porosity, θ_a^C (cm^3/cm^3)	Stratum A effective total fluid saturation, S_{te} (cm^3/cm^3)	Stratum A soil intrinsic permeability, k_i (cm^2)	Stratum A soil relative air permeability, k_{rg} (cm^2)	Stratum A soil effective vapor permeability, k_v (cm^2)	Thickness of capillary zone, L_{cz} (cm)	Total porosity in capillary zone, n_{cz} (cm^3/cm^3)	Air-filled porosity in capillary zone, $\theta_{a,cz}$ (cm^3/cm^3)	Water-filled porosity in capillary zone, $\theta_{w,cz}$ (cm^3/cm^3)	Floor-wall seam perimeter, X_{crack} (cm)
7 88E+08	75 53	0 259	ERROR	ERROR	0 307	2 82E-09	0 798	2 25E-09	68 18	0 439	0 090	0.349	4,000

Bldg. ventilation rate, $Q_{building}$ (cm^3/s)	Area of enclosed space below grade, A_B (cm^2)	Crack-to-total area ratio, η (unitless)	Crack depth below grade, Z_{crack} (cm)	Enthalpy of vaporization at ave. groundwater temperature, $\Delta H_{v,TS}$ (cal/mol)	Henry's law constant at ave groundwater temperature, H_{TS} (atm-m^3/mol)	Henry's law constant at ave groundwater temperature, H'_{TS} (unitless)	Vapor viscosity at ave soil temperature, μ_{TS} (g/cm-s)	Stratum A effective diffusion coefficient, D^{eff}_A (cm^2/s)	Stratum B effective diffusion coefficient, D^{eff}_B (cm^2/s)	Stratum C effective diffusion coefficient, D^{eff}_C (cm^2/s)	Capillary zone effective diffusion coefficient, D^{eff}_{cz} (cm^2/s)	Total overall effective diffusion coefficient, D^{eff}_T (cm^2/s)	Diffusion path length, L_d (cm)
6 78E+04	1 06E+06	3 77E-04	15	10,144	3 38E-03	1 45E-01	1 76E-04	4 33E-03	0 00E+00	0 00E+00	1 38E-04	1 52E-04	75 53

Convection path length, L_p (cm)	Source vapor conc , C_{source} ($\mu g/m^3$)	Crack radius, r_{crack} (cm)	Average vapor flow rate into bldg , Q_{soil} (cm^3/s)	Crack effective diffusion coefficient, D^{crack} (cm^2/s)	Area of crack, A_{crack} (cm^2)	Exponent of equivalent foundation Peclet number, exp(Pe^f) (unitless)	Infinite source indoor attenuation coefficient, α (unitless)	Infinite source bldg conc , $C_{building}$ ($\mu g/m^3$)	Unit risk factor, URF ($\mu g/m^3)^{-1}$	Reference conc., RfC (mg/m^3)
15	2 45E+04	0.10	8.33E+01	4 33E-03	4 00E+02	8 79E+208	3 08E-05	7 54E-01	NA	1 0E+00

END

DATA ENTRY SHEET
EA8

GW-ADV
Version 3 1, 02/04

Reset to Defaults

CALCULATE RISK-BASED GROUNDWATER CONCENTRATION (enter "X" in "YES" box)

YES

OR

CALCULATE INCREMENTAL RISKS FROM ACTUAL GROUNDWATER CONCENTRATION (enter "X" in "YES" box and initial groundwater conc below)

YES X

ENTER Chemical CAS No (numbers only, no dashes)	ENTER Initial groundwater conc , C_W (µg/L)	Chemical
91203	4810	Naphthalene

MORE ↓

ENTER Average soil/ groundwater temperature, T_S (°C)	ENTER Depth below grade to bottom of enclosed space floor, L_F (cm)	ENTER Depth below grade to water table, L_{WT} (cm)	ENTER Totals must add up to value of L_{WT} (cell G28) Thickness of soil stratum A, h_A (cm)	ENTER Thickness of soil stratum B, (Enter value or 0) h_B (cm)	ENTER Thickness of soil stratum C, (Enter value or 0) h_C (cm)	ENTER Soil stratum directly above water table, (Enter A, B, or C)	ENTER SCS soil type directly above water table	ENTER Soil stratum A SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined stratum A soil vapor permeability, k_v (cm^2)
11	15	90 53	90 53			A	SIL	SIL		

MORE ↓

ENTER Stratum A SCS soil type (Lookup Soil Parameters)	ENTER Stratum A soil dry bulk density, ρ_b^A (g/cm^3)	ENTER Stratum A soil total porosity, n^A (unitless)	ENTER Stratum A soil water-filled porosity, θ_w^A (cm^3/cm^3)	ENTER Stratum B SCS soil type (Lookup Soil Parameters)	ENTER Stratum B soil dry bulk density, ρ_b^B (g/cm^3)	ENTER Stratum B soil total porosity, n^B (unitless)	ENTER Stratum B soil water-filled porosity, θ_w^B (cm^3/cm^3)	ENTER Stratum C SCS soil type (Lookup Soil Parameters)	ENTER Stratum C soil dry bulk density, ρ_b^C (g/cm^3)	ENTER Stratum C soil total porosity, n^C (unitless)	ENTER Stratum C soil water-filled porosity, θ_w^C (cm^3/cm^3)
SIL	1 49	0 439	0 180								

MORE ↓

ENTER Enclosed space floor thickness, L_{crack} (cm)	ENTER Soil-bldg pressure differential, ΔP ($g/cm\text{-}s^2$)	ENTER Enclosed space floor length, L_B (cm)	ENTER Enclosed space floor width, W_B (cm)	ENTER Enclosed space height, H_B (cm)	ENTER Floor-wall seam crack width, w (cm)	ENTER Indoor air exchange rate, ER (1/h)	ENTER Average vapor flow rate into bldg OR Leave blank to calculate Q_{soil} (L/m)
10	40	1000	1000	244	0 1	1	5

MORE ↓

ENTER Averaging time for carcinogens, AT_C (yrs)	ENTER Averaging time for noncarcinogens, AT_{NC} (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)	ENTER Target risk for carcinogens, TR (unitless)	ENTER Target hazard quotient for noncarcinogens, THQ (unitless)
70	25	25	250	1 0E-06	1
				Used to calculate risk-based groundwater concentration	

END

CHEMICAL PROPERTIES SHEET

Diffusivity in air, D_a (cm^2/s)	Diffusivity in water, D_w (cm^2/s)	Henry's law constant at reference temperature, H (atm-m^3/mol)	Henry's law constant reference temperature, T_R (°C)	Enthalpy of vaporization at the normal boiling point, $\Delta H_{v,b}$ (cal/mol)	Normal boiling point, T_B (°K)	Critical temperature, T_C (°K)	Organic carbon partition coefficient, K_{oc} (cm^3/g)	Pure component water solubility, S (mg/L)	Unit risk factor, URF ($\mu g/m^3)^{-1}$	Reference conc , RfC (mg/m^3)
5 90E-02	7 50E-06	4.82E-04	25	10,373	491 14	748.40	2.00E+03	3 10E+01	0 0E+00	3 0E-03

END

INTERMEDIATE CALCULATIONS SHEET
Naphthalene EA8

Exposure duration, τ (sec)	Source-building separation, L_T (cm)	Stratum A soil air-filled porosity, θ_a^A (cm^3/cm^3)	Stratum B soil air-filled porosity, θ_a^B (cm^3/cm^3)	Stratum C soil air-filled porosity, θ_a^C (cm^3/cm^3)	Stratum A effective total fluid saturation, S_{te} (cm^3/cm^3)	Stratum A soil intrinsic permeability, k_i (cm^2)	Stratum A soil relative air permeability, k_{rg} (cm^2)	Stratum A soil effective vapor permeability, k_v (cm^2)	Thickness of capillary zone, L_{cz} (cm)	Total porosity in capillary zone, n_{cz} (cm^3/cm^3)	Air-filled porosity in capillary zone, $\theta_{a,cz}$ (cm^3/cm^3)	Water-filled porosity in capillary zone, $\theta_{w,cz}$ (cm^3/cm^3)	Floor-wall seam perimeter, X_{crack} (cm)
7 88E+08	75.53	0.259	ERROR	ERROR	0 307	2 82E-09	0 798	2 25E-09	68 18	0.439	0 090	0 349	4,000

Bldg. ventilation rate, $Q_{building}$ (cm^3/s)	Area of enclosed space below grade, A_B (cm^2)	Crack-to-total area ratio, η (unitless)	Crack depth below grade, Z_{crack} (cm)	Enthalpy of vaporization at ave groundwater temperature, $\Delta H_{v,TS}$ (cal/mol)	Henry's law constant at ave groundwater temperature, H_{TS} (atm-m^3/mol)	Henry's law constant at ave. groundwater temperature, H'_{TS} (unitless)	Vapor viscosity at ave soil temperature, μ_{TS} (g/cm-s)	Stratum A effective diffusion coefficient, D^{eff}_A (cm^2/s)	Stratum B effective diffusion coefficient, D^{eff}_B (cm^2/s)	Stratum C effective diffusion coefficient, D^{eff}_C (cm^2/s)	Capillary zone effective diffusion coefficient, D^{eff}_{cz} (cm^2/s)	Total overall effective diffusion coefficient, D^{eff}_T (cm^2/s)	Diffusion path length, L_d (cm)
6 78E+04	1 06E+06	3 77E-04	15	12,902	1 65E-04	7 07E-03	1 76E-04	3 42E-03	0 00E+00	0 00E+00	2.67E-04	2 93E-04	75 53

Convection path length, L_p (cm)	Source vapor conc., C_{source} ($\mu g/m^3$)	Crack radius, r_{crack} (cm)	Average vapor flow rate into bldg , Q_{soil} (cm^3/s)	Crack effective diffusion coefficient, D^{crack} (cm^2/s)	Area of crack, A_{crack} (cm^2)	Exponent of equivalent foundation Peclet number, exp(Pe') (unitless)	Infinite source indoor attenuation coefficient, α (unitless)	Infinite source bldg. conc , $C_{building}$ ($\mu g/m^3$)	Unit risk factor, URF $(\mu g/m^3)^{-1}$	Reference conc , RfC (mg/m^3)
15	3 40E+04	0 10	8 33E+01	3 42E-03	4.00E+02	1 77E+264	5 79E-05	1 97E+00	NA	3 0E-03

END

DATA ENTRY SHEET
EA8

GW-ADV
Version 3 1, 02/04

Reset to Defaults

CALCULATE RISK-BASED GROUNDWATER CONCENTRATION (enter "X" in "YES" box)

YES

OR

CALCULATE INCREMENTAL RISKS FROM ACTUAL GROUNDWATER CONCENTRATION (enter "X" in "YES" box and initial groundwater conc below)

YES X

MORE

ENTER Chemical CAS No (numbers only, no dashes)	ENTER Initial groundwater conc, C_W (µg/L)	Chemical
106423	631 6	p-Xylene

MORE

ENTER Average soil/ groundwater temperature, T_S (°C)	ENTER Depth below grade to bottom of enclosed space floor, L_F (cm)	ENTER Depth below grade to water table, L_{WT} (cm)	ENTER Thickness of soil stratum A, h_A (cm)	ENTER Thickness of soil stratum B, (Enter value or 0) h_B (cm)	ENTER Thickness of soil stratum C, (Enter value or 0) h_C (cm)	ENTER Soil stratum directly above water table, (Enter A, B, or C)	ENTER SCS soil type directly above water table	ENTER Soil stratum A SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined stratum A soil vapor permeability, k_v (cm^2)
			Totals must add up to value of L_{WT} (cell G28)							
11	15	90 53	90 53			A	SIL	SIL		

MORE

ENTER Stratum A SCS soil type (Lookup Soil Parameters)	ENTER Stratum A soil dry bulk density, ρ_b^A (g/cm^3)	ENTER Stratum A soil total porosity, n^A (unitless)	ENTER Stratum A soil water-filled porosity, θ_w^A (cm^3/cm^3)	ENTER Stratum B SCS soil type (Lookup Soil Parameters)	ENTER Stratum B soil dry bulk density, ρ_b^B (g/cm^3)	ENTER Stratum B soil total porosity, n^B (unitless)	ENTER Stratum B soil water-filled porosity, θ_w^B (cm^3/cm^3)	ENTER Stratum C SCS soil type (Lookup Soil Parameters)	ENTER Stratum C soil dry bulk density, ρ_b^C (g/cm^3)	ENTER Stratum C soil total porosity, n^C (unitless)	ENTER Stratum C soil water-filled porosity, θ_w^C (cm^3/cm^3)
SIL	1 49	0 439	0 180								

MORE

ENTER Enclosed space floor thickness, L_{crack} (cm)	ENTER Soil-bldg pressure differential, ΔP ($g/cm\text{-}s^2$)	ENTER Enclosed space floor length, L_B (cm)	ENTER Enclosed space floor width, W_B (cm)	ENTER Enclosed space height, H_B (cm)	ENTER Floor-wall seam crack width, w (cm)	ENTER Indoor air exchange rate, ER (1/h)	ENTER Average vapor flow rate into bldg OR Leave blank to calculate Q_{soil} (L/m)
10	40	1000	1000	244	0 1	1	5

MORE

ENTER Averaging time for carcinogens, AT_C (yrs)	ENTER Averaging time for noncarcinogens, AT_{NC} (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)	ENTER Target risk for carcinogens, TR (unitless)	ENTER Target hazard quotient for noncarcinogens, THQ (unitless)
70	25	25	250	1 0E-06	1
				Used to calculate risk-based groundwater concentration	

END

CHEMICAL PROPERTIES SHEET

Diffusivity in air, D_a (cm^2/s)	Diffusivity in water, D_w (cm^2/s)	Henry's law constant at reference temperature, H (atm-m^3/mol)	Henry's law constant reference temperature, T_R (°C)	Enthalpy of vaporization at the normal boiling point, $\Delta H_{v,b}$ (cal/mol)	Normal boiling point, T_B (°K)	Critical temperature, T_C (°K)	Organic carbon partition coefficient, K_{oc} (cm^3/g)	Pure component water solubility, S (mg/L)	Unit risk factor, URF $(\mu g/m^3)^{-1}$	Reference conc , RfC (mg/m^3)
7 69E-02	8 44E-06	7.64E-03	25	8,525	411 52	616 20	3 89E+02	1 85E+02	0 0E+00	1 0E-01

END

INTERMEDIATE CALCULATIONS SHEET
Xylenes EA8

Exposure duration, τ (sec)	Source-building separation, L_T (cm)	Stratum A soil air-filled porosity, θ_a^A (cm^3/cm^3)	Stratum B soil air-filled porosity, θ_a^B (cm^3/cm^3)	Stratum C soil air-filled porosity, θ_a^C (cm^3/cm^3)	Stratum A effective total fluid saturation, S_{te} (cm^3/cm^3)	Stratum A soil intrinsic permeability, k_i (cm^2)	Stratum A soil relative air permeability, k_{rg} (cm^2)	Stratum A soil effective vapor permeability, k_v (cm^2)	Thickness of capillary zone, L_{cz} (cm)	Total porosity in capillary zone, n_{cz} (cm^3/cm^3)	Air-filled porosity in capillary zone, $\theta_{a,cz}$ (cm^3/cm^3)	Water-filled porosity in capillary zone, $\theta_{w,cz}$ (cm^3/cm^3)	Floor-wall seam perimeter, X_{crack} (cm)
7 88E+08	75.53	0 259	ERROR	ERROR	0.307	2 82E-09	0 798	2.25E-09	68 18	0 439	0 090	0 349	4,000

Bldg ventilation rate, $Q_{building}$ (cm^3/s)	Area of enclosed space below grade, A_B (cm^2)	Crack-to-total area ratio, η (unitless)	Crack depth below grade, Z_{crack} (cm)	Enthalpy of vaporization at ave groundwater temperature, $\Delta H_{v,TS}$ (cal/mol)	Henry's law constant at ave groundwater temperature, H_{TS} (atm-m^3/mol)	Henry's law constant at ave groundwater temperature, H'_{TS} (unitless)	Vapor viscosity at ave. soil temperature, μ_{TS} (g/cm-s)	Stratum A effective diffusion coefficient, D^{eff}_A (cm^2/s)	Stratum B effective diffusion coefficient, D^{eff}_B (cm^2/s)	Stratum C effective diffusion coefficient, D^{eff}_C (cm^2/s)	Capillary zone effective diffusion coefficient, D^{eff}_{cz} (cm^2/s)	Total overall effective diffusion coefficient, D^{eff}_T (cm^2/s)	Diffusion path length, L_d (cm)
6 78E+04	1 06E+06	3 77E-04	15	10,237	3 26E-03	1 40E-01	1 76E-04	4 44E-03	0.00E+00	0 00E+00	1 42E-04	1 57E-04	75 53

Convection path length, L_p (cm)	Source vapor conc , C_{source} ($\mu g/m^3$)	Crack radius, r_{crack} (cm)	Average vapor flow rate into bldg , Q_{soil} (cm^3/s)	Crack effective diffusion coefficient, D^{crack} (cm^2/s)	Area of crack, A_{crack} (cm^2)	Exponent of equivalent foundation Peclet number, $\exp(Pe^i)$ (unitless)	Infinite source indoor attenuation coefficient, α (unitless)	Infinite source bldg conc , $C_{building}$ ($\mu g/m^3$)	Unit risk factor, URF $(\mu g/m^3)^{-1}$	Reference conc , RfC (mg/m^3)
15	8 83E+04	0 10	8 33E+01	4 44E-03	4 00E+02	5 99E+203	3 17E-05	2 80E+00	NA	1 0E-01

END

Appendix C

Cancer Risk and Hazard Index Calculations

(on attached CD)

Appendix D

Calculation of His for Individual Target Organs in EA2 and EA4

APPENDIX D

Calculation of His for Individual Target Organs in EA2 and EA4

For non-cancer effects it is appropriate to assume that additive effects apply only to constituents that affect the same target organ (USEPA, 1989). This Appendix D identifies the critical effects (target organs/toxic endpoints) for chemicals of potential concern (COPCs) that significantly contribute to HIs for hypothetical on-site construction workers exposed to subsurface soil in EA2 and EA4 and groundwater in EA8. This information was used to calculate target organ specific HIs for (1) hypothetical on-site construction workers exposed to subsurface soil in EA2 and groundwater in EA8 and (2) hypothetical on-site construction workers exposed to subsurface soil in EA4 and groundwater in EA8.

Table 1 lists the COPCs for which target organs were identified, the type of toxicity value used in the HHRA, the source of the toxicity value, the target organs/toxic endpoints, and the basis for the selected target organs/toxic endpoints.

Table 2 summaries the HI calculations for subsurface soil in EA2 and groundwater in EA8. Table 3 summarizes the HI calculations for the COPCs for which target organs were identified for subsurface soil in EA2 and groundwater in EA8. Table 4 summarizes the HI calculations for the COPCs for which target organs were not identified for subsurface soil in EA2 and groundwater in EA8. These were COPCs that did not contribute measurably to the total HI, therefore target organs were not identified. Table 4 also calculates the residual HI of 2.36E-02. The residual HI is the sum of the HIs for the COPCs for which target organs were not identified for subsurface soil in EA2 and groundwater in EA8.

Table 5 shows the calculation of HIs for each specific target organ/toxic endpoint for hypothetical on-site construction workers exposed to subsurface soil in EA2 and groundwater in EA8. For each specific target organ/toxic endpoint, the HIs for COPCs associated with that target organ/toxic endpoint were summed with the residual HI to yield a total HI. Therefore, for each specific target organ/toxic endpoint, the HIs for COPCs associated with that target organ/toxic endpoint were summed with the HIs for all the chemicals for which target organs were not identified. Table 6 summarizes the HIs for each specific target organ/toxic endpoint for hypothetical on-site construction workers exposed to subsurface soil in EA2 and groundwater in EA8. The HIs were each less than 1. USEPA (1989) states that the HI should not exceed 1 for groups of chemicals that affect the same target organ. Therefore, exposure of hypothetical on-site construction workers to subsurface soil in EA2 plus groundwater in EA8 would not pose an unacceptable threat of non-cancer health effects.

Table 7 summaries the HI calculations for subsurface soil in EA4 and groundwater in EA8. Table 8 summarizes the HI calculations for the COPCs for which target organs were identified for subsurface soil in EA4 and groundwater in EA8. Table 9 summarizes the HI calculations for the COPCs for which target organs were not identified for subsurface soil in EA4 and groundwater in EA8. These were COPCs that did not contribute measurably to the total HI, therefore target organs were not identified. Table 9 also calculates the residual HI of 2.79E-03. The residual HI is the sum of the HIs for the COPCs for which target organs were not identified for subsurface soil in EA4 and groundwater in EA8.

Table 10 shows the calculation of HIs for each specific target organ/toxic endpoint for hypothetical on-site construction workers exposed to subsurface soil in EA4 and groundwater in EA8. For each specific target organ/toxic endpoint, the HIs for COPCs associated with that target organ/toxic endpoint were summed with the residual HI to yield a total HI. Table 11 summarizes the HIs for each specific target organ/toxic endpoint for hypothetical on-site construction workers exposed to subsurface soil in EA4 and groundwater in EA8. The HIs were each 1 or less. Therefore, exposure of hypothetical on-site construction workers to subsurface soil in EA4 plus groundwater in EA8 would not pose an unacceptable threat of non-cancer health effects.

Table 1
Target Organs for Non-Cancer Toxicity Values for COPCs
Subsurface Soil in EA2 and Groundwater in EA8
Vertellus

COPCs	Toxicity Value Used in the HHRA	Source	Target Organs/Toxic Endpoints	Basis for the Target Organs/Toxic Endpoints
2,4-Dimethylphenol	Oral subchronic	PPRTV	circulatory system	(1)
2-Methylnaphthalene	Oral chronic	IRIS	respiratory system	(2)
2-Methylphenol	Oral chronic	IRIS	CNS,decreased body weight	(2)
3&4-Methylphenol	Oral chronic	IRIS	CNS, decreased body weight, respiratory system	(3)
3&4-Methylphenol	Inhalation chronic	CalEPA	CNS	(4)
Acenaphthene	Oral subchronic	PPRTV	liver	(5)
Benzene	Oral subchronic	PPRTV	circulatory system	(5)
Benzene	Inhalation chronic	IRIS	circulatory system	(2)
Benzo(g,h,i)perylene	Oral subchronic	Surrogate (pyrene)	kidney	(6)
Cyanide, Total	Oral subchronic	ATSDR	reproductive/developmental	(7)
Cyanide, Total	Inhalation chronic	IRIS	thyroid	(2)
Dibenzofuran	Oral subchronic	PPRTV	decreased body weight	(5)
Fluoranthene	Oral subchronic	PPRTV	kidney	(5)
Fluorene	Oral subchronic	ATSDR	liver	(7)
Naphthalene	Oral subchronic	ATSDR	CNS	(7)
Naphthalene	Inhalation chronic	IRIS	nasal respiratory	(2)
Phenanthrene	Oral chronic	Surrogate (anthracene)	kidney	(6)
Phenol	Oral chronic	IRIS	reproductive/developmental	(2)
Pyrene	Oral subchronic	PPRTV	kidney	(5)
Toluene	Oral chronic	IRIS	kidney	(2)
Toluene	Inhalation chronic	IRIS	CNS	(2)
Xylenes (Total)	Oral chronic	IRIS	decreased body weight	(2)
Xylenes (Total)	Inhalation chronic	IRIS	CNS	(2)

Notes:

(1) PPRTV subchronic oral RfD for 2,4-methylphenol is based on a NOAEL (USEPA 2013a) To be conservative, the target organ for the chronic RfD for 2,4-methylphenol on IRIS (USEPA 2013b)was used.

(2) IRIS (USEPA 2013b)

(3) Target organs for the chronic oral RfD for 3&4-methylphenol were decreased body weights and CNS for 3-methylphenol on IRIS (USEPA 2013b) and respiratory for 4-methylphenol on ATSDR (2013)

(4) Target organ for the chronic RfC for 3&4-methylphenol was the CNS for cresols on CalEPA (2013)

(5) PPRTV (USEPA 2013a)

(6) Target organs for benzo(g,h,i)perylene and phenanthrene from Illinois EPA (2007)

COPC = chemical of potential concern
HHRA = human health risk assessment
ATSDR = Agency for Toxic Substances and Disease Registry
CalEPA = California Environmental Protection Agency
IRIS = Intergrated Risk Information Systeme
PPRTV = Provisional Peer-Reviewed Toxicity Value
CNS = Central nervous system
EPA = environmental protection agency
RfD = reference dose

Agency for Toxic Substances and Disease Registry (ATSDR) 2013 Minimum Risk Levels (MRLs) for Hazardous Substances December Online at http://www.atsdr.cdc.gov/mrls/index.asp.

California Environmental Protection Agency (CalEPA). 2013. Toxicity Criteria Database Office of Environmental Health Hazard Assessment Online at http://www.oehha.ca.gov/risk/ChemicalDB/index.asp.

Illinois Environmental Protection Agency (Illinois EPA). 2007 Chemicals With Noncarcinogenic Toxic Effects on Specific Target organs/Organ Systems or Similar Modes of Action Prepared by the Illinois EPA Toxicity Assessment Unit May 1

U.S. Environmental Protection Agency (USEPA). 2013a. Provisional Peer Reviewed Toxicity Values for Superfund (PPRTV) PPRTV Assessments Electronic Library Online at: http://hhpprtv.ornl.gov/index.html

USEPA 2013b Integrated Risk Information System (IRIS) On-line database at http://www.epa.gov/ins.

Table 2
Construction Worker Summary
Noncarcinogenic Hazard
Subsurface Soil in EA2 and Groundwater in EA8
Vertellus

	Noncarcinogenic Hazard for Subsurface Soil in EA2							Noncarcinogenic Hazard for Groundwater in EA8							
Equation	HI	=	Ingestion	+	Dermal	+	Inhalation	HI	=	Ingestion	+	Dermal	+	Inhalation
Units	unitless		unitless		unitless		unitless	unitless		unitless		unitless		unitless
2,4-Dimethylphenol	NCOPC	=	NA	+	NA	+	NA	3.87E-02	=	5.26E-04	+	3.82E-02	+	NC
2-Chlorophenol	NCOPC	=	NA	+	NA	+	NA	5.53E-05	=	8.81E-06	+	4.65E-05	+	NC
2-Methylnaphthalene	NCOPC	=	NA	+	NA	+	NA	6 37E-02	=	1 04E-03	+	6.27E-02	+	NC
2-Methylphenol	NCOPC	=	NA	+	NA	+	NA	6.68E-03	=	1.10E-03	+	5.58E-03	+	NC
3&4-Methylphenol	2.65E-02	=	2 03E-02	+	6.08E-03	+	1.19E-04	1.84E-02	=	3.00E-03	+	1.54E-02	+	NC
Acenaphthene	1.21E-02	=	8.70E-03	+	3.39E-03	+	NC	6 35E-04	=	1.10E-05	+	6.24E-04	+	NC
Acenaphthylene	2.88E-03	=	2.07E-03	+	8.08E-04	+	NC	1.06E-04	=	1.73E-06	+	1.04E-04	+	NC
Acetone	NCOPC	=	NA	+	NA	+	NA	8 28E-07	=	5.46E-07	+	1.84E-07	+	9.76E-08
Anthracene	1 95E-02	=	1 40E-02	+	5.46E-03	+	NC	9.56E-05	=	1.01E-06	+	9.46E-05	+	NC
Benzene	1 55E-02	=	1 51E-02	+	NC	+	3.57E-04	1.75E-02	=	1.01E-03	+	1.00E-02	+	6 47E-03
Benzenethiol	NCOPC	=	NA	+	NA	+	NA	3.85E-04	=	3.02E-05	+	3.55E-04	+	NC
Benzo(g,h,i)perylene	NCOPC	=	NA	+	NA	+	NA	3.13E-05	=	4 23E-08	+	3.12E-05	+	NC
Carbon disulfide	1.17E-07	=	1 16E-07	+	NC	+	1.17E-09	3.25E-06	=	2 11E-07	+	2 36E-06	+	6.79E-07
Chloroform	1.95E-06	=	1.94E-06	+	NC	+	1.40E-08	NCOPC	=	NA	+	NA	+	NA
Cyanide, Total	7.46E-01	=	1.38E-01	+	NC	+	6.08E-01	1.00E-04	=	6.04E-05	+	3 98E-05	+	NC
Dibenzofuran	NCOPC	=	NA	+	NA	+	NA	1.74E-02	=	2 67E-04	+	1 72E-02	+	NC
Ethylbenzene	3.72E-05	=	3.70E-05	+	NC	+	2.61E-07	5.20E-04	=	1.49E-05	+	4.80E-04	+	2.50E-05
Fluoranthene	5.68E-02	=	4.09E-02	+	1 59E-02	+	NC	4.00E-04	=	2 74E-06	+	3 97E-04	+	NC
Fluorene	3.48E-03	=	2.50E-03	+	9.76E-04	+	NC	2.66E-04	=	3.62E-06	+	2 63E-04	+	NC
Methyl ethyl ketone	NCOPC	=	NA	+	NA	+	NA	1 07E-06	=	4.17E-07	+	2 64E-07	+	3.86E-07
Methylene chloride	7.75E-06	=	7.74E-06	+	NC	+	5.48E-09	3.52E-05	=	9 98E-06	+	2.31E-05	+	2.15E-06
Naphthalene	3 24E-01	=	2 14E-02	+	NC	+	3.02E-01	1 98E-01	=	7.06E-05	+	2.19E-03	+	1.95E-01
Phenanthrene	2.68E-02	=	1 93E-02	+	7.53E-03	+	NC	1.80E-04	=	1.93E-06	+	1.78E-04	+	NC
Phenol	3.59E-03	=	2.56E-03	+	7.67E-04	+	2.71E-04	1.21E-02	=	3.16E-03	+	8.96E-03	+	NC
Pyrene	1 39E-02	=	9 97E-03	+	3.89E-03	+	NC	9 23E-05	=	6.90E-07	+	9.16E-05	+	NC
Toluene	2.92E-03	=	2 92E-03	+	NC	+	3.30E-06	1 41E-03	=	6.47E-05	+	1.32E-03	+	1.84E-05
Xylenes (Total)	1.55E-03	=	1.35E-03	+	NC	+	1.92E-04	1.98E-03	=	2.78E-05	+	9.18E-04	+	1.04E-03

Notes:
HI = hazard index
NA = not applicable
NC = not calculated
NCOPC = Not a COPC in soil or not a COPC in groundwater

Table 3
Construction Worker Summary
Noncarcinogenic Hazard for COPCs with Identified Target Organs
Subsurface Soil in EA2 and Groundwater in EA8
Vertellus

	Noncarcinogenic Hazard for Subsurface Soil in EA2						
Equation	HI	=	Ingestion	+	Dermal	+	Inhalation
Units	unitless		unitless		unitless		unitless
2,4-Dimethylphenol	NCPOC	=	NA	+	NA	+	NA
2-Methylnaphthalene	NCPOC	=	NA	+	NA	+	NA
2-Methylphenol	NCPOC	=	NA	+	NA	+	NA
3&4-Methylphenol	2 65E-02	=	2 03E-02	+	6.08E-03	+	1.19E-04
Acenaphthene	1.21E-02	=	8.70E-03	+	3 39E-03	+	NC
Benzene	1 55E-02	=	1 51E-02	+	NC	+	3.57E-04
Cyanide, Total	7 46E-01	=	1.38E-01	+	NC	+	6 08E-01
Dibenzofuran	NCPOC	=	NA	+	NA	+	NA
Fluoranthene	5.68E-02	=	4.09E-02	+	1 59E-02	+	NC
Fluorene	3 48E-03	=	2.50E-03	+	9.76E-04	+	NC
Naphthalene	3 24E-01	=	2.14E-02	+	NC	+	3.02E-01
Phenanthrene	2.68E-02	=	1.93E-02	+	7 53E-03	+	NC
Phenol	3 59E-03	=	2.56E-03	+	7.67E-04	+	2.71E-04
Pyrene	1 39E-02	=	9.97E-03	+	3 89E-03	+	NC
Toluene	2.92E-03	=	2.92E-03	+	NC	+	3.30E-06
Xylenes (Total)	1 55E-03	=	1.35E-03	+	NC	+	1.92E-04

Noncarcinogenic Hazard for Groundwater in EA8						
HI	=	Ingestion	+	Dermal	+	Inhalation
unitless		unitless		unitless		unitless
3 87E-02	=	5.26E-04	+	3 82E-02	+	NC
6.37E-02	=	1.04E-03	+	6.27E-02	+	NC
6.68E-03	=	1.10E-03	+	5 58E-03	+	NC
1 84E-02	=	3.00E-03	+	1 54E-02	+	NC
6.35E-04	=	1.10E-05	+	6.24E-04	+	NC
1 75E-02	=	1.01E-03	+	1 00E-02	+	6.47E-03
1.00E-04	=	6.04E-05	+	3 98E-05	+	NC
1.74E-02	=	2.67E-04	+	1.72E-02	+	NC
4.00E-04	=	2.74E-06	+	3 97E-04	+	NC
2.66E-04	=	3.62E-06	+	2.63E-04	+	NC
1.98E-01	=	7.06E-05	+	2 19E-03	+	1.95E-01
1.80E-04	=	1.93E-06	+	1.78E-04	+	NC
1.21E-02	=	3.16E-03	+	8 96E-03	+	NC
9.23E-05	=	6.90E-07	+	9.16E-05	+	NC
1 41E-03	=	6.47E-05	+	1.32E-03	+	1 84E-05
1 98E-03	=	2.78E-05	+	9.18E-04	+	1.04E-03

Notes:
HI = hazard index
NA = not applicable
NC = not calculated
NCOPC = Not a COPC in soil or not a COPC in groundwater

Table 4
Construction Worker Summary
Noncarcinogenic Hazard for COPCs without Identified Target Organs
Subsurface Soil in EA2 and Groundwater in EA8
Vertellus

	Noncarcinogenic Hazard for Subsurface Soil In EA2							Noncarcinogenic Hazard for Groundwater in EA8								Noncarcinogenic Hazard for Subsurface Soil and Groundwater
Equation	HI	=	Ingestion	+	Dermal	+	Inhalation	HI	=	Ingestion	+	Dermal	+	Inhalation		HI
Units	unitless		unitless		unitless		unitless	unitless		unitless		unitless		unitless		unitless
2-Chlorophenol	NCPOC	=	NA	+	NA	+	NA	5 53E-05	=	8.81E-06	+	4 65E-05	+	NC		5 53E-05
Acenaphthylene	2 88E-03	=	2 07E-03	+	8 08E-04	+	NC	1 06E-04	=	1 73E-06	+	1 04E-04	+	NC		2 99E-03
Acetone	NCPOC	=	NA	+	NA	+	NA	8 28E-07	=	5 46E-07	+	1 84E-07	+	9 76E-08		8.28E-07
Anthracene	1 95E-02	=	1 40E-02	+	5 46E-03	+	NC	9 56E-05	=	1 01E-06	+	9 46E-05	+	NC		1 96E-02
Benzenethiol	NCPOC	=	NA	+	NA	+	NA	3 85E-04	=	3 02E-05	+	3 55E-04	+	NC		3.85E-04
Benzo(g,h,i)perylene	NCPOC	=	NA	+	NA	+	NA	3 13E-05	=	4 23E-08	+	3 12E-05	+	NC		3.13E-05
Carbon disulfide	1 17E-07	=	1 16E-07	+	NC	+	1 17E-09	3 25E-06	=	2 11E-07	+	2 36E-06	+	6 79E-07		3 37E-06
Chloroform	1.95E-06	=	1 94E-06	+	NC	+	1 40E-08	NCPOC	=	NA	+	NA	+	NA		1 95E-06
Ethylbenzene	3 72E-05	=	3 70E-05	+	NC	+	2 61E-07	5 20E-04	=	1 49E-05	+	4 80E-04	+	2 50E-05		5 58E-04
Methyl ethyl ketone	NCPOC	=	NA	+	NA	+	NA	1.07E-06	=	4 17E-07	+	2 64E-07	+	3 86E-07		1 07E-06
Methylene chloride	7 75E-06	=	7 74E-06	+	NC	+	5 48E-09	3 52E-05	=	9.98E-06	+	2 31E-05	+	2.15E-06		4 29E-05
															Residual HI	**2.36E-02**

Notes
HI = hazard index
NA = not applicable
NC = not calculated
NCOPC = Not a COPC in soil or not a COPC in groundwater

Table 5
Calculation of Target Organ Specific His
Subsurface Soil in EA2 and Groundwater in EA8
Vertellus

Target Organ/Toxic Endpoints	COPC	Medium	Intake Route	HI
CNS	3&4-Methylphenol	Soil	Oral and Dermal	2.63E-02
	3&4-Methylphenol	Soil	Inhalation	1.19E-04
	Naphthalene	Soil	Oral and Dermal	2.14E-02
	Toluene	Soil	Inhalation	3.30E-06
	2-Methylphenol	Groundwater	Oral and Dermal	6 68E-03
	3&4-Methylphenol	Groundwater	Oral and Dermal	1 84E-02
	3&4-Methylphenol	Groundwater	Inhalation	NC
	Naphthalene	Groundwater	Oral and Dermal	2.26E-03
	Toluene	Groundwater	Inhalation	1.84E-05
	Xylenes (Total)	Groundwater	Inhalation	1.04E-03
	Residual HI			2.36E-02
			Total HI	**1E-01**

Target Organ/Toxic Endpoints	COPC	Medium	Intake Route	HI
Kidney	Fluoranthene	Soil	Oral and Dermal	5.68E-02
	Phenanthrene	Soil	Oral and Dermal	2.68E-02
	Pyrene	Soil	Oral and Dermal	1.39E-02
	Toluene	Soil	Oral and Dermal	2 92E-03
	Pyrene	Groundwater	Oral and Dermal	9.23E-05
	Fluoranthene	Groundwater	Oral and Dermal	4.00E-04
	Phenanthrene	Groundwater	Oral and Dermal	1.80E-04
	Toluene	Groundwater	Oral and Dermal	1.39E-03
	Residual HI			2.36E-02
			Total HI	**1E-01**

Target Organ/Toxic Endpoints	COPC	Medium	Intake Route	HI
Liver	Acenaphthene	Soil	Oral and Dermal	1.21E-02
	Fluorene	Soil	Oral and Dermal	3.48E-03
	Acenaphthene	Groundwater	Oral and Dermal	6 35E-04
	Fluorene	Groundwater	Oral and Dermal	2.66E-04
	Residual HI			2 36E-02
			Total HI	**4E-02**

Table 5
Calculation of Target Organ Specific His
Subsurface Soil in EA2 and Groundwater in EA8
Vertellus

Target Organ/Toxic Endpoints	COPC	Medium	Intake Route	HI
Circulatory System	Benzene	Soil	Oral and Dermal	1 51E-02
	Benzene	Soil	Inhalation	3.57E-04
	Benzene	Groundwater	Oral and Dermal	1.11E-02
	2,4-Dimethylphenol	Groundwater	Oral and Dermal	3 87E-02
	Benzene	Groundwater	Inhalation	6.47E-03
	Residual HI			2.36E-02
			Total HI	**1E-01**

Target Organ/Toxic Endpoints	COPC	Medium	Intake Route	HI
Respiratory System	3&4-Methylphenol	Soil	Oral and Dermal	1 21E-02
	Naphthalene	Soil	Inhalation	3 02E-01
	2-Methylnaphthalene	Groundwater	Oral and Dermal	6.37E-02
	3&4-Methylphenol	Groundwater	Oral and Dermal	1.84E-02
	Naphthalene	Groundwater	Inhalation	1 95E-01
	Residual HI			2.36E-02
			Total HI	**6E-01**

Target Organ/Toxic Endpoints	COPC	Medium	Intake Route	HI
Decreased body weight	3&4-Methylphenol	Soil	Oral and Dermal	2 63E-02
	Xylenes (Total)	Soil	Oral and Dermal	1.35E-03
	Dibenzofuran	Groundwater	Oral and Dermal	1.74E-02
	2-Methylphenol	Groundwater	Oral and Dermal	6.68E-03
	3&4-Methylphenol	Groundwater	Oral and Dermal	1.84E-02
	Xylenes (Total)	Groundwater	Oral and Dermal	9.46E-04
	Residual HI			2.36E-02
			Total HI	**7E-02**

Target Organ/Toxic Endpoints	COPC	Medium	Intake Route	HI
Reproductive/ developmental	Cyanide, Total	Soil	Oral and Dermal	1.38E-01
	Phenol	Soil	Oral and Dermal	3 32E-03
	Phenol	Groundwater	Oral and Dermal	1.21E-02
	Cyanide, Total	Groundwater	Oral and Dermal	1.00E-04
	Residual HI			2.36E-02
			Total HI	**2E-01**

Table 5
Calculation of Target Organ Specific His
Subsurface Soil in EA2 and Groundwater in EA8
Vertellus

Target Organ/Toxic Endpoints	COPC	Medium	Intake Route	HI
Thyroid	Cyanide, Total	Soil	Inhalation	6.08E-01
	Residual HI			2.36E-02
			Total HI	**6E-01**

Notes:

CNS = Central nervous system

COPC = chemical of potential concern

HI = hazard index

Table 6
Summary of Target Organ Specific His
Subsurface Soil in EA2 and Groundwater in EA8
Vertellus

Target Organ/ Toxic Endpoint	HI for Target Organs/Toxic Endpoints
CNS	1E-01
Kidney	1E-01
Liver	4E-02
Circulatory System	1E-01
Respiratory System	6E-01
Decreased body weight	7E-02
Reproductive/ developmental	2E-01
Thyroid	6E-01

Notes:

CNS = Central nervous system

HI = hazard index

Table 7
Construction Worker Summary
Noncarcinogenic Hazard
Subsurface Soil in EA4 and Groundwater in EA8
Vertellus

	Noncarcinogenic Hazard for Subsurface Soil in EA4						
Equation	HI	=	Ingestion	+	Dermal	+	Inhalation
Units	unitless		unitless		unitless		unitless
2,4-Dimethylphenol	NCPOC	=	NA	+	NA	+	NA
2-Chlorophenol	NCPOC	=	NA	+	NA	+	NA
2-Methylnaphthalene	5 65E-01	=	5 65E-01	+	NC	+	NC
2-Methylphenol	NCPOC	=	NA	+	NA	+	NA
3&4-Methylphenol	3 95E-03	=	3 03E-03	+	9.08E-04	+	1.78E-05
Acenaphthene	7.48E-03	=	5.38E-03	+	2 10E-03	+	NC
Acenaphthylene	NCPOC	=	NA	+	NA	+	NA
Acetone	NCPOC	=	NA	+	NA	+	NA
Anthracene	NCPOC	=	NA	+	NA	+	NA
Benzene	1 58E-03	=	1.54E-03	+	NC	+	3.64E-05
Benzenethiol	NCPOC	=	NA	+	NA	+	NA
Benzo(g,h,i)perylene	NCPOC	=	NA	+	NA	+	NA
Carbon disulfide	NCPOC	=	NA	+	NA	+	NA
Cyanide, Total	1.54E-02	=	2.84E-03	+	NC	+	1 26E-02
Dibenzofuran	4 04E-01	=	4.04E-01	+	NC	+	NC
Ethylbenzene	NCPOC	=	NA	+	NA	+	NA
Fluoranthene	1.61E-02	=	1.16E-02	+	4 52E-03	+	NC
Fluorene	2.50E-03	=	1.80E-03	+	7.01E-04	+	NC
Methyl ethyl ketone	NCPOC	=	NA	+	NA	+	NA
Methylene chloride	NCPOC	=	NA	+	NA	+	NA
Naphthalene	1.49E-01	=	9.86E-03	+	NC	+	1 39E-01
Phenanthrene	NCPOC	=	NA	+	NA	+	NA
Phenol	NCPOC	=	NA	+	NA	+	NA
Pyrene	4 55E-03	=	3 27E-03	+	1.28E-03	+	NC
Toluene	NCPOC	=	NA	+	NA	+	NA
Xylenes (Total)	NCPOC	=	NA	+	NA	+	NA
Resorcinol	2 11E-06	=	1.63E-06	+	4.88E-07	+	NC

Noncarcinogenic Hazard for Groundwater in EA8						
HI	=	Ingestion	+	Dermal	+	Inhalation
unitless		unitless		unitless		unitless
3.87E-02	=	5.26E-04	+	3.82E-02	+	NC
5.53E-05	=	8.81E-06	+	4.65E-05	+	NC
6.37E-02	=	1.04E-03	+	6.27E-02	+	NC
6 68E-03	=	1.10E-03	+	5.58E-03	+	NC
1.84E-02	=	3.00E-03	+	1.54E-02	+	NC
6.35E-04	=	1.10E-05	+	6.24E-04	+	NC
1 06E-04	=	1.73E-06	+	1.04E-04	+	NC
8 28E-07	=	5.46E-07	+	1.84E-07	+	9.76E-08
9.56E-05	=	1.01E-06	+	9.46E-05	+	NC
1 75E-02	=	1.01E-03	+	1.00E-02	+	6.47E-03
3.85E-04	=	3.02E-05	+	3.55E-04	+	NC
3 13E-05	=	4.23E-08	+	3.12E-05	+	NC
3 25E-06	=	2.11E-07	+	2 36E-06	+	6.79E-07
1.00E-04	=	6.04E-05	+	3 98E-05	+	NC
1 74E-02	=	2.67E-04	+	1 72E-02	+	NC
5.20E-04	=	1 49E-05	+	4.80E-04	+	2 50E-05
4.00E-04	=	2 74E-06	+	3.97E-04	+	NC
2.66E-04	=	3.62E-06	+	2 63E-04	+	NC
1.07E-06	=	4.17E-07	+	2 64E-07	+	3.86E-07
3.52E-05	=	9.98E-06	+	2.31E-05	+	2.15E-06
1.98E-01	=	7 06E-05	+	2.19E-03	+	1.95E-01
1.80E-04	=	1.93E-06	+	1.78E-04	+	NC
1.21E-02	=	3.16E-03	+	8.96E-03	+	NC
9.23E-05	=	6.90E-07	+	9.16E-05	+	NC
1.41E-03	=	6.47E-05	+	1.32E-03	+	1.84E-05
1.98E-03	=	2.78E-05	+	9.18E-04	+	1.04E-03
NCPOC	=	NA	+	NA	+	NA

Notes:

HI = hazard index

NA = not applicable

NC = not calculated

NCOPC = Not a COPC in soil or not a COPC in groundwater

Table 8
Construction Worker Summary
Noncarcinogenic Hazard for COPCs with Identified Target Organs
Subsurface Soil in EA4 and Groundwater in EA8
Vertellus

	Noncarcinogenic Hazard for Subsurface Soil in EA4						
Equation	HI	=	Ingestion	+	Dermal	+	Inhalation
Units	unitless		unitless		unitless		unitless
2,4-Dimethylphenol	NCPOC	=	NA	+	NA	+	NA
2-Methylnaphthalene	5.65E-01	=	5.65E-01	+	NC	+	NC
2-Methylphenol	NCPOC	=	NA	+	NA	+	NA
3&4-Methylphenol	3.95E-03	=	3 03E-03	+	9.08E-04	+	1.78E-05
Acenaphthene	7.48E-03	=	5.38E-03	+	2.10E-03	+	NC
Benzene	1.58E-03	=	1.54E-03	+	NC	+	3 64E-05
Benzo(g,h,i)perylene	NCPOC	=	NA	+	NA	+	NA
Cyanide, Total	1.54E-02	=	2.84E-03	+	NC	+	1 26E-02
Dibenzofuran	4.04E-01	=	4.04E-01	+	NC	+	NC
Fluoranthene	1.61E-02	=	1 16E-02	+	4.52E-03	+	NC
Fluorene	2.50E-03	=	1.80E-03	+	7.01E-04	+	NC
Naphthalene	1.49E-01	=	9 86E-03	+	NC	+	1.39E-01
Phenol	NCPOC	=	NA	+	NA	+	NA
Pyrene	4.55E-03	=	3.27E-03	+	1.28E-03	+	NC
Xylenes (Total)	NCPOC	=	NA	+	NA	+	NA

Noncarcinogenic Hazard for Groundwater in EA8						
HI	=	Ingestion	+	Dermal	+	Inhalation
unitless		unitless		unitless		unitless
3.87E-02	=	5.26E-04	+	3.82E-02	+	NC
6.37E-02	=	1.04E-03	+	6.27E-02	+	NC
6.68E-03	=	1.10E-03	+	5.58E-03	+	NC
1.84E-02	=	3.00E-03	+	1 54E-02	+	NC
6.35E-04	=	1.10E-05	+	6 24E-04	+	NC
1.75E-02	=	1.01E-03		1 00E-02	+	6.47E-03
3.13E-05		4.23E-08		3.12E-05		NC
1.00E-04		6.04E-05		3.98E-05		NC
1 74E-02		2.67E-04		1.72E-02		NC
4.00E-04		2.74E-06		3.97E-04		NC
2 66E-04		3.62E-06		2.63E-04		NC
1.98E-01		7.06E-05		2.19E-03		1 95E-01
1.21E-02		3.16E-03		8.96E-03		NC
9.23E-05		6.90E-07		9.16E-05		NC
1.98E-03		2.78E-05		9.18E-04		1 04E-03

Notes:

HI = hazard index

NA = not applicable

NC = not calculated

NCOPC = Not a COPC in soil or not a COPC in groundwater

Table 9
Construction Worker Summary
Noncarcinogenic Hazard for COPCs without Identified Target Organs
Subsurface Soil in EA4 and Groundwater in EA8
Vertellus

	Noncarcinogenic Hazard for Subsurface Soil in EA4							Noncarcinogenic Hazard for Groundwater in EA8							Noncarcinogenic Hazard for Subsurface Soil and Groundwater
Equation	**HI**	**=**	**Ingestion**	**+**	**Dermal**	**+**	**Inhalation**	**HI**	**=**	**Ingestion**	**+**	**Dermal**	**+**	**Inhalation**	**HI**
Units	**unitless**		**unitless**		**unitless**		**unitless**	**unitless**		**unitless**		**unitless**		**unitless**	**unitless**
2-Chlorophenol	NCPOC	=	NA	+	NA	+	NA	5 53E-05	=	8.81E-06	+	4.65E-05	+	NC	5.53E-05
Acenaphthylene	NCPOC	=	NA	+	NA	+	NA	1 06E-04	=	1.73E-06	+	1.04E-04	+	NC	1 06E-04
Acetone	NCPOC	=	NA	+	NA	+	NA	8.28E-07	=	5.46E-07	+	1.84E-07	+	9.76E-08	8.28E-07
Anthracene	NCPOC	=	NA	+	NA	+	NA	9.56E-05	=	1.01E-06	+	9.46E-05	+	NC	9.56E-05
Benzenethiol	NCPOC	=	NA	+	NA	+	NA	3.85E-04	=	3 02E-05		3.55E-04	+	NC	3 85E-04
Carbon disulfide	NCPOC	=	NA	+	NA	+	NA	3.25E-06		2.11E-07		2.36E-06		6 79E-07	3.25E-06
Ethylbenzene	NCPOC	=	NA	+	NA	+	NA	5.20E-04		1.49E-05		4.80E-04		2.50E-05	5 20E-04
Methyl ethyl ketone	NCPOC	=	NA	+	NA	+	NA	1.07E-06		4.17E-07		2 64E-07		3 86E-07	1.07E-06
Methylene chloride	NCPOC	=	NA	+	NA	+	NA	3 52E-05		9.98E-06		2.31E-05		2.15E-06	3.52E-05
Phenanthrene	NCPOC	=	NA	+	NA	+	NA	1.80E-04		1.93E-06		1 78E-04		NC	1.80E-04
Toluene	NCPOC	=	NA	+	NA	+	NA	1.41E-03		6.47E-05		1 32E-03		1.84E-05	1.41E-03
Resorcinol	2.11E-06	=	1 63E-06	+	4.88E-07	+	NC	NCPOC	=	NA	+	NA	+	NA	2.11E-06
														Residual HI	2.79E-03

Notes:

HI = hazard index

NA = not applicable

NC = not calculated

NCOPC = Not a COPC in soil or not a COPC in groundwater

Table 10
Calculation of Target Organ Specific His
Subsurface Soil in EA4 and Groundwater in EA8
Vertellus

Target Organ/ Toxic Endpoints	COPC	Medium	Intake Route	HI
CNS	3&4-Methylphenol	Soil	Oral	3.93E-03
	3&4-Methylphenol	Soil	Inhalation	1.78E-05
	Naphthalene	Soil	Oral	9.86E-03
	2-Methylphenol	Groundwater	Oral	6 68E-03
	3&4-Methylphenol	Groundwater	Oral	1.84E-02
	3&4-Methylphenol	Groundwater	Inhalation	NC
	Naphthalene	Groundwater	Oral	2.26E-03
	Xylenes (Total)	Groundwater	Inhalation	1.04E-03
	Residual HI			2 79E-03
			Total	**5E-02**

Target Organ/ Toxic Endpoints	COPC	Medium	Intake Route	HI
Kidney	Fluoranthene	Soil	Oral	1.61E-02
	Pyrene	Soil	Oral	4.55E-03
	Pyrene	Groundwater	Oral	9.23E-05
	Fluoranthene	Groundwater	Oral	4.00E-04
	Benzo(g,h,i)perylene	Groundwater	Oral	3.13E-05
	Residual HI			2.79E-03
			Total	**2E-02**

Target Organ/ Toxic Endpoints	COPC	Medium	Intake Route	HI
Liver	Acenaphthene	Soil	Oral	7.48E-03
	Fluorene	Soil	Oral	2 50E-03
	Acenaphthene	Groundwater	Oral	6.35E-04
	Fluorene	Groundwater	Oral	2 66E-04
	Residual HI			2.79E-03
			Total	**1E-02**

Target Organ/ Toxic Endpoints	COPC	Medium	Intake Route	HI
Circulatory System	Benzene	Soil	Oral	1.54E-03
	Benzene	Soil	Inhalation	3.64E-05
	Benzene	Groundwater	Oral	1.11E-02
	2,4-Dimethylphenol	Groundwater	Oral	3.87E-02
	Benzene	Groundwater	Inhalation	6.47E-03
	Residual HI			2.79E-03
			Total	**6E-02**

Table 10
Calculation of Target Organ Specific His
Subsurface Soil in EA4 and Groundwater in EA8
Vertellus

Target Organ/ Toxic Endpoints	COPC	Medium	Intake Route	HI
Respiratory System	2-Methylnaphthalene	Soil	Oral	5.65E-01
	3&4-Methylphenol	Soil	Oral	3 93E-03
	Naphthalene	Soil	Inhalation	1 39E-01
	2-Methylnaphthalene	Groundwater	Oral	6 37E-02
	3&4-Methylphenol	Groundwater	Oral	1.84E-02
	Naphthalene	Groundwater	Inhalation	1.95E-01
	Residual HI			2.79E-03
			Total	**1E+00**

Target Organ/ Toxic Endpoints	COPC	Medium	Intake Route	HI
Decreased body weight	Dibenzofuran	Soil	Oral	4.04E-01
	3&4-Methylphenol	Soil	Oral	3.93E-03
	Dibenzofuran	Groundwater	Oral	1.74E-02
	2-Methylphenol	Groundwater	Oral	6.68E-03
	3&4-Methylphenol	Groundwater	Oral	1.84E-02
	Xylenes (Total)	Groundwater	Oral	9.46E-04
	Residual HI			2.79E-03
			Total	**5E-01**

Target Organ/ Toxic Endpoints	COPC	Medium	Intake Route	HI
Reproductive/ developmental	Cyanide, Total	Soil	Oral	2.84E-03
	Phenol	Groundwater	Oral	1.21E-02
	Cyanide, Total	Groundwater	Oral	1 00E-04
	Residual HI			2.79E-03
			Total	**2E-02**

Target Organ/ Toxic Endpoints	COPC	Medium	Intake Route	HI
Thyroid	Cyanide, Total	Soil	Inhalation	1.26E-02
	Residual HI			2 79E-03
			Total	**2E-02**

Notes:

CNS = Central nervous system

COPC = chemical of potential concern

HI = hazard index

Table 11
Summary of Target Organ Specific His
Subsurface Soil in EA4 and Groundwater in EA8
Vertellus

Target Organ/ Toxic Endpoint	HI for Target Organs/Toxic Endpoints
CNS	5E-02
Kidney	2E-02
Liver	1E-02
Circulatory System	6E-02
Respiratory System	1E+00
Decreased body weight	5E-01
Reproductive/ developmental	2E-02
Thyroid	2E-02

Notes:

CNS = Central nervous system

HI = hazard index

Appendix E

Plant and Soil Invertebrate HQ Calculations

Table 1
Plants and Soil Invertebrates
HQ Calculations
Vertellus - Provo, Utah

Soil COPECs[1]	Soil EPC 0 - 1 ft bgs (ug/kg)	Soil EPC 1 - 3 ft bgs (ug/kg)	C_{so} (ug/kg)	Plant LOEC (ug/kg)	Plant LOEC-HQ	Soil Invertebrate LOEC (ug/kg)	Soil Invertebrate LOEC-HQ
Exposure Area 2 - subsurface soil							
3&4-Methylphenol	NV	1,060,000	1,060,000	3,450	**3.1E+02**	NV	NC
Acenaphthene	NV	1,782,714	1,782,714	1,250	**1.4E+03**	NV	NC
Acenaphthylene	NV	464,140	464,140	NV	NC	NV	NC
Acetone	NV	366	366	NV	NC	NV	NC
Anthracene	NV	7,614,245	7,614,245	34,000	**2.2E+02**	NV	NC
Benzene	NV	167,270	167,270	NV	NC	NV	NC
Benzo(a)anthracene	NV	1,148,770	1,148,770	90,000	**1.3E+01**	NV	NC
Benzo(a)pyrene	NV	1,081,643	1,081,643	NV	NC	NV	NC
Benzo(b)fluoranthene	NV	1,130,531	1,130,531	90,000	**1.3E+01**	NV	NC
Benzo(k)fluoranthene	NV	632,436	632,436	NV	NC	NV	NC
Carbon disulfide	NV	8	8	NV	NC	NV	NC
Chloroform	NV	12	12	NV	NC	NV	NC
Chrysene	NV	1,313,841	1,313,841	NV	NC	NV	NC
Cyanide, Total	NV	1,751,976	1,751,976	NV	NC	NV	NC
Dibenz(a,h)anthracene	NV	278,582	278,582	NV	NC	NV	NC
Fluoranthene	NV	6,689,586	6,689,586	NV	NC	50,000	**1.3E+02**
Fluorene	NV	1,087,380	1,087,380	NV	NC	18,500	**5.9E+01**
HPAH	NV	25,973,856	25,973,856	NV	NC	90,000	**2.9E+02**
LPAH	NV	57,022,738	57,022,738	NV	NC	145,000	**3.9E+02**
Indeno(1,2,3-c,d)pyrene	NV	570,440	570,440	NV	NC	NV	NC
Methyl ethyl ketone	NV	60	60	NV	NC	NV	NC
Methylene chlonde	NV	95	95	8,000,000	1 2E-05	NV	NC
Naphthalene	NV	13,662,909	13,662,909	5,000	**2.7E+03**	NV	NC
Phenanthrene	NV	9,927,421	9,927,421	NV	NC	27,500	**3.6E+02**
Phenol	NV	916,000	916,000	3,950	**2.3E+02**	9,000	**1.0E+02**
Pyrene	NV	4,961,400	4,961,400	NV	NC	50,000	**9.9E+01**
Toluene	NV	255,319	255,319	1,000,000	2 6E-01	NV	NC
Xylenes (Total)	NV	297,374	297,374	500,000	5 9E-01	NV	NC
Exposure Area 3 - surface and subsurface soil							
2-Methylphenol	822	ND	822	3,350	2 5E-01	NV	NC
3&4-Methylphenol	793	ND	793	3,450	2 3E-01	NV	NC
Acenaphthene	24865	130,716	130,716	1,250	**1.0E+02**	NV	NC
Acenaphthylene	4561	ND	4,561	NV	NC	NV	NC
Anthracene	36207	70,864	70,864	34,000	**2.1E+00**	NV	NC
Benzo(a)anthracene	158594	218,626	218,626	90,000	**2.4E+00**	NV	NC
Benzo(a)pyrene	193969	452,415	452,415	NV	NC	NV	NC
Benzo(b)fluoranthene	212507	297,789	297,789	90,000	**3.3E+00**	NV	NC
Benzo(g,h,i)perylene	110000	NV	110,000	NV	NC	NV	NC
Benzo(k)fluoranthene	147228	309,803	309,803	NV	NC	NV	NC
bis(2-Ethylhexyl)phthalate	1600	NV	1,600	NV	NC	NV	NC
Chrysene	203388	257,520	257,520	NV	NC	NV	NC
Cyanide, Total	38507	10,299	38,507	NV	NC	NV	NC
Dibenz(a,h)anthracene	30443	31,345	31,345	NV	NC	NV	NC
Dibenzofuran	11000	NV	11,000	30,500	3 6E-01	NV	NC
Fluoranthene	275373	353,951	353,951	NV	NC	50,000	**7.1E+00**
Fluorene	22185	155,000	155,000	NV	NC	18,500	**8.4E+00**
HPAH	1420966	3,397,173	3,397,173	NV	NC	90,000	**3.8E+01**
LPAH	1191689	1,237,321	1,237,321	NV	NC	145,000	**8.5E+00**
Indeno(1,2,3-c,d)pyrene	129935	339,803	339,803	NV	NC	NV	NC
Methylene chlonde	1774	131	1,774	8,000,000	2 2E-04	NV	NC
Naphthalene	71917	29,000	71,917	5,000	**1.4E+01**	NV	NC
Phenanthrene	229423	362,681	362,681	NV	NC	27,500	**1.3E+01**
Phenol	608 2	ND	608	3,950	1 5E-01	9,000	6 8E-02
Pyrene	396383	369,778	396,383	NV	NC	50,000	**7.9E+00**
Exposure Area 4 - subsurface soil							
2-Methylphenol	NV	150,000	150,000	3,350	**4.5E+01**	NV	NC
3&4-Methylphenol	NV	470,000	470,000	3,450	**1.4E+02**	NV	NC
Acenaphthene	NV	1,739,574	1,739,574	1,250	**1.4E+03**	NV	NC
Acenaphthylene	NV	130,620	130,620	NV	NC	NV	NC
Acetone	NV	792	792	NV	NC	NV	NC
Anthracene	NV	635,005	635,005	34,000	**1.9E+01**	NV	NC
Benzo(a)anthracene	NV	3,700,000	3,700,000	90,000	**4.1E+01**	NV	NC
Benzo(a)pyrene	NV	156,369	156,369	NV	NC	NV	NC
Benzo(b)fluoranthene	NV	190,000	190,000	90,000	**2.1E+00**	NV	NC
Benzo(k)fluoranthene	NV	42,780	42,780	NV	NC	NV	NC
Carbon disulfide	NV	940	940	NV	NC	NV	NC
Chrysene	NV	2,917,714	2,917,714	NV	NC	NV	NC
Cyanide, Total	NV	33,000	33,000	NV	NC	NV	NC
Dibenz(a,h)anthracene	NV	21,000	21,000	NV	NC	NV	NC
Dibenzofuran	NV	1,000,000	1,000,000	30,500	**3.3E+01**	NV	NC
Fluoranthene	NV	1,746,969	1,746,969	NV	NC	50,000	**3.5E+01**
Fluorene	NV	1,114,357	1,114,357	NV	NC	18,500	**6.0E+01**
HPAH	NV	7,796,489	7,796,489	NV	NC	90,000	**8.7E+01**
LPAH	NV	14,630,000	14,630,000	NV	NC	145,000	**1.0E+02**
Indeno(1,2,3-c,d)pyrene	NV	74,000	74,000	NV	NC	NV	NC
m,p-Xylene	NV	3,900	3,900	500,000	7 8E-03	NV	NC
Methylene chlonde	NV	216	216	8,000,000	2 7E-05	NV	NC
Naphthalene	NV	6,500,000	6,500,000	5,000	**1.3E+03**	NV	NC
o-Xylene	NV	2,000	2,000	500,000	4 0E-03	NV	NC
Phenanthrene	NV	195,791	195,791	NV	NC	27,500	**7.1E+00**
Phenol	NV	820,000	820,000	3,950	**2.1E+02**	9,000	**9 1E+01**
Pyrene	NV	1,510,834	1,510,834	NV	NC	50,000	**3.0E+01**
Xylenes (Total)	NV	5,468	5,468	500,000	1 1E-02	NV	NC

Table 1
Plants and Soil Invertebrates
HQ Calculations
Vertellus - Provo, Utah

Soil COPECs[1]	Soil EPC 0 - 1 ft bgs *(ug/kg)*	Soil EPC 1 - 3 ft bgs *(ug/kg)*	C_{so} *(ug/kg)*	Plant LOEC *(ug/kg)*	Plant LOEC-HQ	Soil Invertebrate LOEC *(ug/kg)*	Soil Invertebrate LOEC-HQ
Exposure Area 6 - surface soil							
2-Methylphenol	4100	NV	4,100	3,350	**1.2E+00**	NV	NC
3&4-Methylphenol	11000	NV	11,000	3,450	**3.2E+00**	NV	NC
Acenaphthene	550000	NV	550,000	1,250	**4.4E+02**	NV	NC
Acenaphthylene	140000	NV	140,000	NV	NC	NV	NC
Anthracene	860000	NV	860,000	34,000	**2.5E+01**	NV	NC
Benzo(a)anthracene	2400000	NV	2,400,000	90,000	**2.7E+01**	NV	NC
Benzo(a)pyrene	2200000	NV	2,200,000	NV	NC	NV	NC
Benzo(b)fluoranthene	2500000	NV	2,500,000	90,000	**2.8E+01**	NV	NC
Benzo(g,h,i)perylene	1100000	NV	1,100,000	NV	NC	NV	NC
Benzo(k)fluoranthene	1000000	NV	1,000,000	NV	NC	NV	NC
Carbazole	650000	NV	650,000	NV	NC	NV	NC
Chrysene	2500000	NV	2,500,000	NV	NC	NV	NC
Dibenz(a,h)anthracene	370000	NV	370,000	NV	NC	NV	NC
Dibenzofuran	200000	NV	200,000	30,500	**6.6E+00**	NV	NC
Fluoranthene	5300000	NV	5,300,000	NV	NC	50,000	**1.1E+02**
Fluorene	470000	NV	470,000	NV	NC	18,500	**2.5E+01**
HPAH	17970000	NV	17,970,000	NV	NC	90,000	**2.0E+02**
LPAH	11776200	NV	11,776,200	NV	NC	145,000	**8.1E+01**
Indeno(1,2,3-c,d)pyrene	1100000	NV	1,100,000	NV	NC	NV	NC
Naphthalene	450000	NV	450,000	5,000	**9.0E+01**	NV	NC
Phenanthrene	4400000	NV	4,400,000	NV	NC	27,500	**1.6E+02**
Phenol	6700	NV	6,700	3,950	**1.7E+00**	9,000	7 4E-01
Pyrene	4800000	NV	4,800,000	NV	NC	50,000	**9.6E+01**
Exposure Area 7 - surface and subsurface soil							
Acenaphthene	750 8	616	751	1,250	6 0E-01	NV	NC
Anthracene	4016	327	4,016	34,000	1 2E-01	NV	NC
Benzo(a)anthracene	6727	2,132	6,727	90,000	7 5E-02	NV	NC
Benzo(a)pyrene	7752	2,334	7,752	NV	NC	NV	NC
Benzo(b)fluoranthene	8618	2,835	8,618	90,000	9 6E-02	NV	NC
Benzo(g,h,i)perylene	5062	1,042	5,062	NV	NC	NV	NC
Benzo(k)fluoranthene	4075	767	4,075	NV	NC	NV	NC
Chrysene	8793	2,505	8,793	NV	NC	NV	NC
Dibenz(a,h)anthracene	1512	194	1,512	NV	NC	NV	NC
Fluoranthene	12267	3,414	12,267	NV	NC	50,000	2 5E-01
HPAH	58934	16,089	58,934	NV	NC	90,000	6 5E-01
LPAH	30420	10,633	30,420	NV	NC	145,000	2 1E-01
Indeno(1,2,3-c,d)pyrene	4884	624	4,884	NV	NC	NV	NC
Naphthalene	12555	2,520	12,555	5,000	**2.5E+00**	NV	NC
Phenanthrene	6606	2,576	6,606	NV	NC	27,500	2 4E-01
Pyrene	11718	3,187	11,718	NV	NC	50,000	2 3E-01
Hotspot 2-SF-2-18 - surface soil							
Acenaphthene	2000	NV	2,000	1,250	**1.6E+00**	NV	NC
Benzo(a)anthracene	22000	NV	22,000	90,000	2 4E-01	NV	NC
Benzo(a)pyrene	26000	NV	26,000	NV	NC	NV	NC
Benzo(b)fluoranthene	28000	NV	28,000	90,000	3 1E-01	NV	NC
Benzo(g,h,i)perylene	15000	NV	15,000	NV	NC	NV	NC
Benzo(k)fluoranthene	13000	NV	13,000	NV	NC	NV	NC
bis(2-Ethylhexyl)phthalate	930	NV	930	NV	NC	NV	NC
Chrysene	26000	NV	26,000	NV	NC	NV	NC
Dibenz(a,h)anthracene	4900	NV	4,900	NV	NC	NV	NC
Fluoranthene	41000	NV	41,000	NV	NC	50,000	8 2E-01
HPAH	188900	NV	188,900	NV	NC	90,000	**2.1E+00**
LPAH	85680	NV	85,680	NV	NC	145,000	5 9E-01
Indeno(1,2,3-c,d)pyrene	15000	NV	15,000	NV	NC	NV	NC
Naphthalene	1400	NV	1,400	5,000	2 8E-01	NV	NC
Phenanthrene	28000	NV	28,000	NV	NC	27,500	1 0E+00
Pyrene	39000	NV	39,000	NV	NC	50,000	7 8E-01
Hotspot 2-SF-2-19 - surface soil							
3&4-Methylphenol	1200	NV	1,200	3,450	3 5E-01	NV	NC
Acenaphthene	43000	NV	43,000	1,250	**3.4E+01**	NV	NC
Anthracene	73000	NV	73,000	34,000	**2.1E+00**	NV	NC
Benzo(a)anthracene	89000	NV	89,000	90,000	9.9E-01	NV	NC
Benzo(a)pyrene	80000	NV	80,000	NV	NC	NV	NC
Benzo(b)fluoranthene	100000	NV	100,000	90,000	**1.1E+00**	NV	NC
Benzo(g,h,i)perylene	48000	NV	48,000	NV	NC	NV	NC
Benzo(k)fluoranthene	43000	NV	43,000	NV	NC	NV	NC
Chrysene	100000	NV	100,000	NV	NC	NV	NC
Dibenz(a,h)anthracene	15000	NV	15,000	NV	NC	NV	NC
Dibenzofuran	20000	NV	20,000	30,500	6 6E-01	NV	NC
Fluoranthene	220000	NV	220,000	NV	NC	50,000	**4.4E+00**
Fluorene	35000	NV	35,000	NV	NC	18,500	**1.9E+00**
HPAH	710000	NV	710,000	NV	NC	90,000	**7.9E+00**
LPAH	638600	NV	638,600	NV	NC	145,000	**4.4E+00**
Indeno(1,2,3-c,d)pyrene	45000	NV	45,000	NV	NC	NV	NC
Naphthalene	44000	NV	44,000	5,000	**8.8E+00**	NV	NC
Phenanthrene	200000	NV	200,000	NV	NC	27,500	**7.3E+00**
Phenol	1200	NV	1,200	3,950	3 0E-01	9,000	1 3E-01
Pyrene	190000	NV	190,000	NV	NC	50,000	**3.8E+00**

Table 1
Plants and Soil Invertebrates
HQ Calculations
Vertellus - Provo, Utah

Soil COPECs[1]	Soil EPC 0 - 1 ft bgs (ug/kg)	Soil EPC 1 - 3 ft bgs (ug/kg)	C_{so} (ug/kg)	Plant LOEC (ug/kg)	Plant LOEC-HQ	Soil Invertebrate LOEC (ug/kg)	Soil Invertebrate LOEC-HQ
Hotspot 2-SF-3-36 - surface soil							
2-Methylphenol	2400	NV	2,400	3,350	7 2E-01	NV	NC
3&4-Methylphenol	8500	NV	8,500	3,450	**2.5E+00**	NV	NC
Acenaphthene	10000	NV	10,000	1,250	**8.0E+00**	NV	NC
Anthracene	59000	NV	59,000	34,000	**1.7E+00**	NV	NC
Benzo(a)anthracene	79000	NV	79,000	90,000	8 8E-01	NV	NC
Benzo(a)pyrene	63000	NV	63,000	NV	NC	NV	NC
Benzo(b)fluoranthene	73000	NV	73,000	90,000	8 1E-01	NV	NC
Benzo(g,h,i)perylene	35000	NV	35,000	NV	NC	NV	NC
Benzo(k)fluoranthene	27000	NV	27,000	NV	NC	NV	NC
Chrysene	80000	NV	80,000	NV	NC	NV	NC
Dibenz(a,h)anthracene	12000	NV	12,000	NV	NC	NV	NC
Dibenzofuran	45000	NV	45,000	30,500	**1.5E+00**	NV	NC
Fluoranthene	210000	NV	210,000	NV	NC	50,000	**4.2E+00**
Fluorene	72000	NV	72,000	NV	NC	18,500	**3.9E+00**
HPAH	568000	NV	568,000	NV	NC	90,000	**6.3E+00**
LPAH	953000	NV	953,000	NV	NC	145,000	**6.6E+00**
Indeno(1,2,3-c,d)pyrene	39000	NV	39,000	NV	NC	NV	NC
Naphthalene	220000	NV	220,000	5,000	**4.4E+01**	NV	NC
Phenanthrene	270000	NV	270,000	NV	NC	27,500	**9.8E+00**
Phenol	10000	NV	10,000	3,950	**2.5E+00**	9,000	**1.1E+00**
Pyrene	160000	NV	160,000	NV	NC	50,000	**3.2E+00**
Hotspot 2-SF-4-23 - surface soil							
3&4-Methylphenol	1500	NV	1,500	3,450	4 3E-01	NV	NC
Acenaphthene	82000	NV	82,000	1,250	**6.6E+01**	NV	NC
Anthracene	130000	NV	130,000	34,000	**3.8E+00**	NV	NC
Benzo(a)anthracene	250000	NV	250,000	90,000	**2.8E+00**	NV	NC
Benzo(a)pyrene	200000	NV	200,000	NV	NC	NV	NC
Benzo(b)fluoranthene	310000	NV	310,000	90,000	**3.4E+00**	NV	NC
Benzo(g,h,i)perylene	100000	NV	100,000	NV	NC	NV	NC
Benzo(k)fluoranthene	100000	NV	100,000	NV	NC	NV	NC
Chrysene	310000	NV	310,000	NV	NC	NV	NC
Dibenz(a,h)anthracene	39000	NV	39,000	NV	NC	NV	NC
Dibenzofuran	40000	NV	40,000	30,500	**1.3E+00**	NV	NC
Fluoranthene	580000	NV	580,000	NV	NC	50,000	**1.2E+01**
Fluorene	56000	NV	56,000	NV	NC	18,500	**3.0E+00**
HPAH	1889000	NV	1,889,000	NV	NC	90,000	**2.1E+01**
LPAH	1279000	NV	1,279,000	NV	NC	145,000	**8.8E+00**
Indeno(1,2,3-c,d)pyrene	110000	NV	110,000	NV	NC	NV	NC
Naphthalene	81000	NV	81,000	5,000	**1.6E+01**	NV	NC
Phenanthrene	310000	NV	310,000	NV	NC	27,500	**1.1E+01**
Phenol	1600	NV	1,600	3,950	4 1E-01	9,000	1 8E-01
Pyrene	470000	NV	470,000	NV	NC	50,000	**9.4E+00**

Notes:

1 - For the calculation of HPAH and LPAH, Kaplan-Meir method was applied for summing detects and non-detects of PAHs at individual sample locations For sample locations where no individual PAHs were detected, the resulting calculated concentration is treated as a non-detect and the calculated RL is reported

Bold HQs are greater than 1 0

bgs = below ground surface
COPEC = chemical of potential ecological concern
C_{so} = concentration in soil
EPC = exposure point concentration
ft = feet
HPAH = high molecular weight PAH, calculated from individual PAH results, includes Benz(a)anthracene, Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(g,h,i)perylene, Benzo(k)fluoranthene, Chrysene, Dibenz(a,h)anthracene, Indeno(1,2,3-cd)pyrene, and Pyrene
HQ = hazard quotient, HQ = EPC / LOEC
LOEC = lowest observed effects concentration
LPAH = low molecular weigth PAH, calculated from individual PAH results, includes 2-Methylnaphthalene, Acenaphthene, Acenaphthylene, Anthracene, Fluoranthene, Fluorene, Naphthalene, and Phenanthrene
ug/kg = micrograms per kilogram
NV = no value
NC = not calculated
PAH = polycyclic aromatic hydrocarbon
RL = reporting limit

Appendix F

Wildlife HQ Calculations

Table 1
Herbivorous Bird (Ring-Necked Pheasant)
Soil HQ Calculations
Vertellus - Provo, Utah

Receptor	Ring-necked Pheasant
Body weight	1 1 kg
Food Ingestion Rate	0 045 kg/day dw
Composition of Diet	100% Plants
Soil Ingestion Rate	0 0042 kg/day
Water Ingestion Rate	0 063 L/day

Soil COPECs	Soil EPC 0 - 1 ft bgs (ug/kg)	Soil EPC 1 - 3 ft bgs (ug/kg)	C_{SO} (mg/kg)	C_{SW} (mg/L)	Slope p	Intercept p	BCF p	C_p (mg/kg)	AUF	Average Daily Dose (mg/kg-bw/d)	Avian LOEC-TRV (mg/kg-bw/d)	LOEC-HQ
Exposure Area 2 - subsurface soi												
3&4-Methylphenol	NV	1,060,000	1 06E+03	3 74E-01	-	-	2 63	2 79E+03	0 00665339	7 61E-01	--	NC
Acenaphthene	NV	1,782,714	1 78E+03	1 30E-05	-0.8556	-5 562	-	6 35E-06	0.00665339	6 68E-09	--	NC
Acenaphthylene	NV	464,140	4 64E+02	5 00E-03	0 791	-1 144	-	4 10E+01	0 00665339	1.12E-02	--	NC
Acetone	NV	366	3 66E-01	4 30E-03	-	-	76	2 78E+01	0 00665339	7 59E-03	1 0E+03	7 6E-06
Anthracene	NV	7,614,245	7 61E+03	5 00E-03	0 7784	-0 9887	-	3 91E+02	0.00665339	1 07E-01	--	NC
Benzene	NV	167,270	1 67E+02	1 78E-02	-	-	8 26	1 38E+03	0.00665339	3 77E-01	--	NC
Benzo(a)anthracene	NV	1,148,770	1 15E+03	2 00E-05	0 5944	-2 7078	-	4 40E+00	0 00665339	1.20E-03	4 0E-03	3.0E-01
Benzo(a)pyrene	NV	1,081,643	1 08E+03	2 45E-05	0 975	-2 0615	-	1.16E+02	0 00665339	3.15E-02	5 0E-03	**6.3E+00**
Benzo(b)fluoranthene	NV	1,130,531	1 13E+03	2 53E-05	-	-	0 31	3 50E+02	0 00665339	9 56E-02	7 0E-04	**1.4E+02**
Benzo(g,h,i)perylene	NV	NV	NV	2.50E-05	1 1829	-0 9313	-	NC	0 00665339	NC	--	NC
Benzo(k)fluoranthene	NV	632,436	6 32E+02	1 78E-05	0 8595	-2 1579	-	2 95E+01	0 00665339	8.06E-03	7 0E-04	**1.2E+01**
Carbon disulfide	NV	8	8 05E-03	5 00E-03	-	-	2 01	1 62E-02	0 00665339	6 32E-06	--	NC
Chloroform	NV	12	1 20E-02	5 00E-03	-	-	9 59	1 15E-01	0.00665339	3 33E-05	--	NC
Chrysene	NV	1,313,841	1 31E+03	2 53E-05	0 5944	-2 7078	-	4.76E+00	0 00665339	1.30E-03	5 0E-03	2 6E-01
Cyanide, Total	NV	1,751,976	1 75E+03	1 13E-02	-	-	1	1 75E+03	0 00665339	4.78E-01	2 0E-01	**2.4E+00**
Dibenz(a,h)anthracene	NV	278,582	2 79E+02	5 00E-03	-	-	0 13	3 62E+01	0 00665339	9.89E-03	2 0E-03	**5.1E+00**
Fluoranthene	NV	6,689,586	6 69E+03	1 11E-04	-	-	0.5	3 34E+03	0 00665339	9.13E-01	--	NC
Fluorene	NV	1,087,380	1 09E+03	2 50E-04	-0 8556	-5.562	-	9 69E-06	0 00665339	9 77E-08	--	NC
HPAH	NV	25,973,856	2 60E+04	2 67E-04	0 9469	-1.7026	-	2 76E+03	0 00665339	7 53E-01	7 0E-04	**1.1E+03**
LPAH	NV	57,022,738	5 70E+04	2 65E-02	-	-	2 09	1 19E+05	0.00665339	3 25E+01	7.5E+01	4 3E-01
Indeno(1,2,3-c,d)pyrene	NV	570,440	5 70E+02	2 00E-05	-	-	0 11	6 27E+01	0 00665339	1 71E-02	5.0E-03	**3.4E+00**
Methyl ethyl ketone	NV	60	6 00E-02	1 00E-02	-	-	46 1	2 77E+00	0 00665339	7 59E-04	--	NC
Methylene chlonde	NV	95	9 47E-02	5.00E-03	-	-	18 8	1.78E+00	0 00665339	4 88E-04	--	NC
Naphthalene	NV	13,662,909	1 37E+04	1 20E-02	-	-	12 2	1.67E+05	0 00665339	4 55E+01	7 5E+01	6.1E-01
Phenanthrene	NV	9,927,421	9 93E+03	3 20E-04	0 6203	-0 1665	-	2 55E+02	0 00665339	6 97E-02	--	NC
Phenol	NV	916,000	9 16E+02	2 59E-03	-	-	0 0494	4 53E+01	0 00665339	1 24E-02	--	NC
Pyrene	NV	4,961,400	4 96E+03	3 51E-05	-	-	0 72	3.57E+03	0 00665339	9 75E-01	--	NC
Toluene	NV	255,319	2 55E+02	4 22E-03	-	-	4 71	1 20E+03	0 00665339	3 28E-01	--	NC
Xylenes (Total)	NV	297,374	2 97E+02	1.80E-03	-	-	3 28	9 75E+02	0 00665339	2 66E-01	5 3E+02	5.0E-04
Exposure Area 3 - surface and subsurface soi												
2-Methylphenol	822	ND	8 22E-01	1 08E-02	-	-	3	2 47E+00	0 01535857	1 61E-03	--	NC
3&4-Methylphenol	793	ND	7 93E-01	3 74E-01	-	-	2 63	2 09E+00	0.01535857	1 69E-03	--	NC
Acenaphthene	24,865	130,716	1 31E+02	1 30E-05	-0 8556	-5 562	-	5 94E-05	0 01535857	1.46E-03	--	NC
Acenaphthylene	4,561	ND	4 56E+00	5 00E-03	0 791	-1 144	-	1 06E+00	0 01535857	9.38E-04	--	NC
Anthracene	36,207	70,864	7 09E+01	5 00E-03	0 7784	-0.9887	-	1 03E+01	0 01535857	8 59E-03	--	NC
Benzo(a)anthracene	158,594	218,626	2 19E+02	2 00E-05	0 5944	-2.7078	-	1 64E+00	0 01535857	1 03E-02	4 0E-03	**2.6E+00**
Benzo(a)pyrene	193,969	452,415	4 52E+02	2 45E-05	0 975	-2.0615	-	4 94E+01	0.01535857	4 25E-02	5 0E-03	**8.5E+00**
Benzo(b)fluoranthene	212,507	297,789	2 98E+02	2 53E-05	-	-	0 31	9 23E+01	0.01535857	7 06E-02	7 0E-04	**1.0E+02**
Benzo(g,h,i)perylene	110,000	NV	1 10E+02	2 50E-05	1.1829	-0 9313	-	1 02E+02	0 01535857	7.10E-02	--	NC
Benzo(k)fluoranthene	147,228	309,803	3 10E+02	1 78E-05	0 8595	-2.1579	-	1 60E+01	0 01535857	1 87E-02	7 0E-04	**2.7E+01**
bis(2-Ethylhexyl)phthalate	1,600	NV	1.60E+00	5 00E-03	-	-	0 05	8 00E-02	0 01535857	1 49E-04	5 5E+00	2 7E-05
Chrysene	203,388	257,520	2.58E+02	2 53E-05	0 5944	-2 7078	-	1 81E+00	0 01535857	1 31E-02	5 0E-03	**2.6E+00**
Cyanide, Total	38,507	10,299	3.85E+01	1 13E-02	-	-	1	3 85E+01	0 01535857	2 65E-02	2 0E-01	1 3E-01
Dibenz(a,h)anthracene	30,443	31,345	3 13E+01	5 00E-03	-	-	0 13	4 07E+00	0 01535857	4 36E-03	2 0E-03	**2.2E+00**
Dibenzofuran	11,000	NV	1.10E+01	1 00E-03	-	-	1 29	1 42E+01	0 01535857	9 58E-03	--	NC
Fluoranthene	275,373	353,951	3.54E+02	1 11E-04	-	-	0.5	1 77E+02	0 01535857	1 28E-01	--	NC
Fluorene	22,185	155,000	1 55E+02	2 50E-04	-0 8556	-5 562	-	5 13E-05	0 01535857	1 30E-03	--	NC
HPAH	1,420,966	3,397,173	3 40E+03	2.67E-04	0 9469	-1 7026	-	4.02E+02	0 01535857	3 36E-01	7 0E-04	**4.8E+02**
LPAH	1,191,689	1,237,321	1 24E+03	2 65E-02	-	-	2.09	2 59E+03	0 01535857	1 70E+00	7 5E+01	2 3E-02
Indeno(1,2,3-c,d)pyrene	129,935	339,803	3 40E+02	2 00E-05	-	-	0 11	3 74E+01	0 01535857	3 12E-02	5 0E-03	**6.2E+00**
Methylene chloride	1,774	131	1 77E+00	5 00E-03	-	-	18 8	3 34E+01	0.01535857	2 11E-02	--	NC

Table 1
Herbivorous Bird (Ring-Necked Pheasant)
Soil HQ Calculations
Vertellus - Provo, Utah

Soil COPECs	Soil EPC 0 - 1 ft bgs (ug/kg)	Soil EPC 1 - 3 ft bgs (ug/kg)	C_{so} (mg/kg)	C_{sw} (mg/L)	Slope p	Intercept p	BCF p	C_p (mg/kg)	AUF	Average Daily Dose (mg/kg-bw/d)	Avian LOEC-TRV (mg/kg-bw/d)	LOEC-HQ
Naphthalene	71,917	29,000	7 19E+01	1 20E-02	-	-	12 2	8 77E+02	0 01535857	5.57E-01	7 5E+01	7 4E-03
Phenanthrene	229,423	362,681	3.63E+02	3.20E-04	0.6203	-0 1665	-	3 28E+01	0 01535857	3 41E-02	--	NC
Phenol	608	ND	6 08E-01	2 59E-03	-	-	0 0494	3 00E-02	0 01535857	5 68E-05	--	NC
Pyrene	396,383	369,778	3.96E+02	3.51E-05	-	-	0 72	2 85E+02	0 01535857	2 03E-01	--	NC
Exposure Area 4 - subsurface soil												
2-Methylphenol	NV	150,000	1.50E+02	1.08E-02	-	-	3	4 50E+02	0 0073243	1 35E-01	--	NC
3&4-Methylphenol	NV	470,000	4 70E+02	3 74E-01	-	-	2.63	1.24E+03	0 0073243	3 72E-01	--	NC
Acenaphthene	NV	1,739,574	1 74E+03	1 30E-05	-0 8556	-5 562	-	6.49E-06	0 0073243	7 39E-09	--	NC
Acenaphthylene	NV	130,620	1 31E+02	5 00E-03	0 791	-1.144	-	1.50E+01	0 0073243	4 52E-03	--	NC
Acetone	NV	792	7 92E-01	4 30E-03	-	-	76	6 02E+01	0 0073243	1 81E-02	1 0E+03	1 8E-05
Anthracene	NV	635,005	6 35E+02	5 00E-03	0 7784	-0 9887	-	5 65E+01	0 0073243	1.70E-02	--	NC
Benzo(a)anthracene	NV	3,700,000	3 70E+03	2 00E-05	0.5944	-2.7078	-	8 81E+00	0 0073243	2 65E-03	4 0E-03	6 7E-01
Benzo(a)pyrene	NV	156,369	1 56E+02	2 45E-05	0 975	-2.0615	-	1.75E+01	0 0073243	5 27E-03	5 0E-03	**1.1E+00**
Benzo(b)fluoranthene	NV	190,000	1 90E+02	2 53E-05	-	-	0 31	5.89E+01	0 0073243	1.77E-02	7 0E-04	**2.5E+01**
Benzo(g,h,i)perylene	NV	NV	NV	2 50E-05	1 1829	-0 9313	-	NC	0 0073243	NC	--	NC
Benzo(k)fluoranthene	NV	42,780	4 28E+01	1 78E-05	0 8595	-2 1579	-	2 92E+00	0 0073243	8 76E-04	7 0E-04	**1.3E+00**
Carbon disulfide	NV	940	9 40E-01	5 00E-03	-	-	2 01	1.89E+00	0 0073243	5.70E-04	--	NC
Chrysene	NV	2,917,714	2 92E+03	2 53E-05	0 5944	-2 7078	-	7 65E+00	0 0073243	2 30E-03	5.0E-03	4 6E-01
Cyanide, Total	NV	33,000	3 30E+01	1 13E-02	-	-	1	3 30E+01	0 0073243	9 92E-03	2 0E-01	5 0E-02
Dibenz(a,h)anthracene	NV	21,000	2 10E+01	5 00E-03	-	-	0.13	2 73E+00	0 0073243	8 22E-04	2 0E-03	4 2E-01
Dibenzofuran	NV	1,000,000	1.00E+03	1 00E-03	-	-	1 29	1 29E+03	0 0073243	3 88E-01	--	NC
Fluoranthene	NV	1,746,969	1.75E+03	1 11E-04	-	-	0 5	8 73E+02	0 0073243	2 62E-01	--	NC
Fluorene	NV	1,114,357	1.11E+03	2 50E-04	-0 8556	-5 562	-	9 49E-06	0 0073243	1 08E-07	--	NC
HPAH	NV	7,796,489	7 80E+03	2 67E-04	0.9469	-1.7026	-	8.83E+02	0 0073243	2 65E-01	7 0E-04	**3.8E+02**
LPAH	NV	14,630,000	1 46E+04	2 65E-02	-	-	2 09	3.06E+04	0 0073243	9.19E+00	7 5E+01	1 2E-01
Indeno(1,2,3-c,d)pyrene	NV	74,000	7 40E+01	2 00E-05	-	-	0 11	8.14E+00	0 0073243	2.45E-03	5 0E-03	4 9E-01
m,p-Xylene	NV	3,900	3 90E+00	1 80E-03	-	-	3 28	1.28E+01	0 0073243	3.84E-03	5 3E+02	7 2E-06
Methylene chlonde	NV	216	2 16E-01	5 00E-03	-	-	18.8	4.06E+00	0 0073243	1 22E-03	--	NC
Naphthalene	NV	6,500,000	6 50E+03	1 20E-02	-	-	12 2	7 93E+04	0 0073243	2 38E+01	7 5E+01	3 2E-01
o-Xylene	NV	2,000	2 00E+00	1 80E-03	-	-	3 28	6.56E+00	0 0073243	1 97E-03	5 3E+02	3 7E-06
Phenanthrene	NV	195,791	1 96E+02	3 20E-04	0 6203	-0.1665	-	2.24E+01	0 0073243	6.71E-03	--	NC
Phenol	NV	820,000	8 20E+02	2 59E-03	-	-	0 0494	4 05E+01	0 0073243	1 22E-02	--	NC
Pyrene	NV	1,510,834	1 51E+03	3 51E-05	-	-	0 72	1 09E+03	0 0073243	3 27E-01	--	NC
Xylenes (Total)	NV	5,468	5 47E+00	1 80E-03	-	-	3 28	1 79E+01	0 0073243	5 39E-03	5 3E+02	1 0E-05
Exposure Area 6 - surface soil												
2-Methylphenol	4,100	NV	4 10E+00	1 08E-02	-	-	3	1.23E+01	0 00032669	1 70E-04	--	NC
3&4-Methylphenol	11,000	NV	1 10E+01	3 74E-01	-	-	2 63	2.89E+01	0 00032669	4 08E-04	--	NC
Acenaphthene	550,000	NV	5 50E+02	1 30E-05	-0 8556	-5.562	-	1.74E-05	0 00032669	6 85E-04	--	NC
Acenaphthylene	140,000	NV	1 40E+02	5 00E-03	0 791	-1 144	-	1.59E+01	0 00032669	3 87E-04	--	NC
Anthracene	860,000	NV	8 60E+02	5 00E-03	0 7784	-0 9887	-	7.16E+01	0 00032669	2.03E-03	--	NC
Benzo(a)anthracene	2,400,000	NV	2.40E+03	2 00E-05	0 5944	-2.7078	-	6 81E+00	0 00032669	3 08E-03	4 0E-03	7 8E-01
Benzo(a)pyrene	2,200,000	NV	2 20E+03	2 45E-05	0 975	-2.0615	-	2.31E+02	0 00032669	5.84E-03	5.0E-03	**1.2E+00**
Benzo(b)fluoranthene	2,500,000	NV	2 50E+03	2 53E-05	-	-	0.31	7.75E+02	0 00032669	1 35E-02	7.0E-04	**1.9E+01**
Benzo(g,h,i)perylene	1,100,000	NV	1 10E+03	2 50E-05	1 1829	-0.9313	-	1.56E+03	0 00032669	2 23E-02	--	NC
Benzo(k)fluoranthene	1,000,000	NV	1 00E+03	1 78E-05	0 8595	-2 1579	-	4 38E+01	0 00032669	1 83E-03	7 0E-04	**2.6E+00**
Carbazole	650,000	NV	6 50E+02	1 00E-03	-	-	1 87	1.22E+03	0 00032669	1 71E-02	--	NC
Chrysene	2,500,000	NV	2.50E+03	2 53E-05	0 5944	-2 7078	-	6 98E+00	0 00032669	3 21E-03	5 0E-03	6 4E-01
Cyanide, Total	NV	NV	NV	1 13E-02	-	-	1	NC	0 00032669	NC	2 0E-01	NC
Dibenz(a,h)anthracene	370,000	NV	3 70E+02	5 00E-03	-	-	0 13	4 81E+01	0 00032669	1 11E-03	2 0E-03	5 7E-01
Dibenzofuran	200,000	NV	2 00E+02	1 00E-03	-	-	1 29	2 58E+02	0 00032669	3 71E-03	--	NC
Fluoranthene	5,300,000	NV	5 30E+03	1 11E-04	-	-	0.5	2 65E+03	0 00032669	4 21E-02	--	NC
Fluorene	470,000	NV	4 70E+02	2 50E-04	-0 8556	-5 562	-	1 99E-05	0 00032669	5 86E-04	--	NC
HPAH	17,970,000	NV	1.80E+04	2.67E-04	0.9469	-1 7026	-	1 95E+03	0 00032669	4 85E-02	7 0E-04	6.9E+01
LPAH	11,776,200	NV	1 18E+04	2 65E-02	-	-	2.09	2 46E+04	0 00032669	3.44E-01	7.5E+01	4.6E-03
Indeno(1,2,3-c,d)pyrene	1,100,000	NV	1 10E+03	2 00E-05	-	-	0.11	1 21E+02	0 00032669	2.99E-03	5.0E-03	6.0E-01
Naphthalene	450,000	NV	4.50E+02	1 20E-02	-	-	12 2	5 49E+03	0 00032669	7 41E-02	7.5E+01	9 9E-04
Phenanthrene	4,400,000	NV	4.40E+03	3.20E-04	0 6203	-0 1665	-	1 54E+02	0 00032669	7 55E-03	--	NC

Table 1
Herbivorous Bird (Ring-Necked Pheasant)
Soil HQ Calculations
Vertellus - Provo, Utah

Soil COPECs	Soil EPC 0 - 1 ft bgs *(ug/kg)*	Soil EPC 1 - 3 ft bgs *(ug/kg)*	C_{SO} *(mg/kg)*	C_{SW} *(mg/L)*	Slope p	Intercept p	BCF p	C_p *(mg/kg)*	AUF	Average Daily Dose *(mg/kg-bw/d)*	Avian LOEC-TRV *(mg/kg-bw/d)*	LOEC-HQ
Phenol	6,700	NV	6 70E+00	2 59E-03	-	-	0 0494	3 31E-01	0.00032669	1.28E-05	--	NC
Pyrene	4,800,000	NV	4 80E+03	3 51E-05	-	-	0.72	3.46E+03	0 00032669	5 23E-02	--	NC
Exposure Area 7 - surface and subsurface soi												
Acenaphthene	751	616	7 51E-01	1.30E-05	-0 8556	-5 562	-	4 91E-03	0 01211255	3 71E-05	--	NC
Anthracene	4,016	327	4 02E+00	5.00E-03	0 7784	-0 9887	-	1 10E+00	0 01211255	7 35E-04	--	NC
Benzo(a)anthracene	6,727	2,132	6 73E+00	2 00E-05	0 5944	-2 7078	-	2 07E-01	0 01211255	4 14E-04	4 0E-03	1 0E-01
Benzo(a)pyrene	7,752	2,334	7 75E+00	2 45E-05	0 975	-2 0615	-	9 37E-01	0 01211255	8 24E-04	5 0E-03	1 6E-01
Benzo(b)fluoranthene	8,618	2,835	8 62E+00	2 53E-05	-	-	0 31	2 67E+00	0 01211255	1.73E-03	7 0E-04	**2.5E+00**
Benzo(g,h,i)perylene	5,062	1,042	5 06E+00	2 50E-05	1 1829	-0 9313	-	2 68E+00	0 01211255	1 57E-03	--	NC
Benzo(k)fluoranthene	4,075	767	4.08E+00	1 78E-05	0 8595	-2 1579	-	3 87E-01	0 01211255	3 80E-04	7 0E-04	5 4E-01
Chrysene	8,793	2,505	8 79E+00	2 53E-05	0 5944	-2 7078	-	2 43E-01	0 01211255	5 27E-04	5 0E-03	1.1E-01
Cyanide, Total	NV	NV	NV	1 13E-02	-	-	1	NC	0 01211255	NC	2 0E-01	NC
Dibenz(a,h)anthracene	1,512	194	1 51E+00	5 00E-03	-	-	0 13	1.97E-01	0 01211255	1 71E-04	2.0E-03	8.8E-02
Fluoranthene	12,267	3,414	1.23E+01	1 11E-04	-	-	0.5	6.13E+00	0 01211255	3 61E-03	--	NC
Fluorene	696	167	6 96E-01	2 50E-04	-0 8556	-5 562	-	5 24E-03	0.01211255	3 49E-05	--	NC
HPAH	58,934	16,089	5 89E+01	2.67E-04	0 9469	-1 7026	-	8 65E+00	0.01211255	7.02E-03	7 0E-04	**1.0E+01**
LPAH	30,420	10,633	3.04E+01	2 65E-02	-	-	2.09	6 36E+01	0 01211255	3 30E-02	7 5E+01	4 4E-04
Indeno(1,2,3-c,d)pyrene	4,884	624	4.88E+00	2 00E-05	-	-	0.11	5.37E-01	0 01211255	4 93E-04	5 0E-03	9 9E-02
Naphthalene	12,555	2,520	1 26E+01	1 20E-02	-	-	12 2	1 53E+02	0 01211255	7 67E-02	7 5E+01	1 0E-03
Phenanthrene	6,606	2,576	6 61E+00	3 20E-04	0 6203	-0 1665	-	2 73E+00	0 01211255	1.66E-03	--	NC
Pyrene	11,718	3,187	1 17E+01	3 51E-05	-	-	0 72	8 44E+00	0 01211255	4.73E-03	--	NC

Notes:

For the calculation of HPAH and LPAH, Kaplan-Meir method was applied for summing detects and non-detects of PAHs at individual sample locations. For sample locations where no individual PAHs were detected, the resulting calculated concentration is treated as a non-detect and the calculated RL is reported

EPC set equal to 95% UCL If not enough samples were available to calculate a UCL, the EPC was set to the maximum detected concentration, "ND" if no samples were detected at that depth, or "NV" if the COPEC was not analyzed at that depth
Incidentially ingested soil is assumed to be from surface soil. If no surface-level data are available (NV or ND), subsurface soil data are used for soil ingestion
Risk calculation not performed at Hotspots given the negligable Area Use Factor

Bold HQs are greater than 1 0

AUF = area use factor
BAF = bioaccumulation factor
bgs = below ground surface
COPEC = chemical of potential ecological concern
C_i = concentration in invertebrate tissue
C_m = concentration in mammal tissue
C_p = concentration in plant tissue
C_{SO} = concentration in soil (maximum of surface and subsurface EPCs, if available)
C_{SW} = concentration in surface water
EPC = exposure point concentration
HPAH = high molecular weight PAH, calculated from individual PAH results, includes Benz(a)anthracene, Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(g,h,i)perylene, Benzo(k)fluoranthene, Chrysene, Dibenz(a,h)anthracene, Indeno(1,2,3-cd)pyrene, and Pyrene
HQ = hazard quotient, HQ = EPC / LOEC
LOEC = lowest observed effects concentration
LPAH = low molecular weigth PAH, calculated from individual PAH results, includes 2-Methylnaphthalene, Acenaphthene, Acenaphthylene, Anthracene, Fluoranthene, Fluorene, Naphthalene, and Phenanthrene
ug/kg = micrograms per kilogram
mg/kg = milligrams per kilogram
mg/kg-bw/day = milligrams per kilogram body weight per day
mg/L = milligrams per liter
NC = not calculated
NV = no value
P = plants
PAH = polycyclic aromatic hydrocarbon
TRV = toxicity reference value

Table 2
Carnivorous Bird (American Kestrel)
Soil HQ Calculations
Vertellus - Provo, Utah

Receptor	American kestrel
Body weight	0 119 kg
Food Ingestion Rate	0 011 kg/day dw
Composition of Diet	100% Small Mammals
Soil Ingestion Rate	0 0000 kg/day
Water Ingestion Rate	0 017 L/day

Soil COPECs	Soil EPC 0 - 1 ft bgs (ug/kg)	Soil EPC 1 - 3 ft bgs (ug/kg)	C_{SO} (mg/kg)	C_{SW} (mg/L)	Slope m	Intercept m	BAF m	C_m (mg/kg)	AUF	Average Daily Dose (mg/kg-bw/d)	Avian LOEC-TRV (mg/kg-bw/d)	LOEC-HQ
Exposure Area 2 - subsurface soi												
3&4-Methylphenol	NV	1,060,000	1 06E+03	3 74E-01	-	-	0 00000169	1 79E-03	0 005	2 62E-04	--	NC
Acenaphthene	NV	1,782,714	1 78E+03	1 30E-05	-	-	0	0 00E+00	0 005	9 10E-09	--	NC
Acenaphthylene	NV	464,140	4 64E+02	5 00E-03	-	-	0	0.00E+00	0 005	3 50E-06	--	NC
Acetone	NV	366	3 66E-01	4.30E-03	-	-	0 0472	1.73E-02	0 005	1 10E-05	1 0E+03	1 1E-08
Anthracene	NV	7,614,245	7 61E+03	5 00E-03	-	-	0	0.00E+00	0 005	3 50E-06	--	NC
Benzene	NV	167,270	1 67E+02	1.78E-02	-	-	0.0493	8.25E+00	0 005	3 84E-03	--	NC
Benzo(a)anthracene	NV	1,148,770	1 15E+03	2.00E-05	-	-	0	0 00E+00	0 005	1 40E-08	4 0E-03	3 5E-06
Benzo(a)pyrene	NV	1,081,643	1 08E+03	2 45E-05	-	-	0	0 00E+00	0 005	1 72E-08	5 0E-03	3 4E-06
Benzo(b)fluoranthene	NV	1,130,531	1 13E+03	2 53E-05	-	-	0	0 00E+00	0 005	1 77E-08	7.0E-04	2.5E-05
Benzo(g,h,i)perylene	NV	NV	NV	2.50E-05	-	-	0	NC	0 005	NC	--	NC
Benzo(k)fluoranthene	NV	632,436	6 32E+02	1 78E-05	-	-	0	0 00E+00	0 005	1 25E-08	7.0E-04	1 8E-05
Carbon disulfide	NV	8	8 05E-03	5.00E-03	-	-	0 00000267	2 15E-08	0.005	3.50E-06	--	NC
Chloroform	NV	12	1 20E-02	5 00E-03	-	-	0 115	1 38E-03	0.005	4.14E-06	--	NC
Chrysene	NV	1,313,841	1 31E+03	2 53E-05	-	-	0	0 00E+00	0.005	1 77E-08	5 0E-03	3 5E-06
Cyanide, Total	NV	1,751,976	1 75E+03	1.13E-02	-	-	0 667	1 17E+03	0.005	5 42E-01	2.0E-01	**2.7E+00**
Dibenz(a,h)anthracene	NV	278,582	2 79E+02	5.00E-03	-	-	0	0 00E+00	0.005	3.50E-06	2.0E-03	1 8E-03
Fluoranthene	NV	6,689,586	6 69E+03	1 11E-04	-	-	0	0 00E+00	0 005	7.77E-08	--	NC
Fluorene	NV	1,087,380	1 09E+03	2 50E-04	-	-	0	0 00E+00	0 005	1 75E-07	--	NC
HPAH	NV	25,973,856	2 60E+04	2 67E-04	-	-	0	0 00E+00	0.005	1 87E-07	7 0E-04	2 7E-04
LPAH	NV	57,022,738	5 70E+04	2 65E-02	-	-	0	0 00E+00	0 005	1 85E-05	7 5E+01	2 5E-07
Indeno(1,2,3-c,d)pyrene	NV	570,440	5 70E+02	2 00E-05	-	-	0	0 00E+00	0 005	1 40E-08	5 0E-03	2 8E-06
Methyl ethyl ketone	NV	60	6 00E-02	1 00E-02	-	-	0 0644	3 86E-03	0 005	8 79E-06	--	NC
Methylene chloride	NV	95	9 47E-02	5 00E-03	-	-	0 0484	4 58E-03	0 005	5 63E-06	--	NC
Naphthalene	NV	13,662,909	1 37E+04	1 20E-02	-	-	0	0 00E+00	0 005	8 38E-06	7 5E+01	1 1E-07
Phenanthrene	NV	9,927,421	9 93E+03	3 20E-04	-	-	0	0.00E+00	0.005	2 24E-07	--	NC
Phenol	NV	916,000	9 16E+02	2.59E-03	-	-	15.4	1 41E+04	0.005	6 55E+00	--	NC
Pyrene	NV	4,961,400	4 96E+03	3 51E-05	-	-	0	0 00E+00	0 005	2 46E-08	--	NC
Toluene	NV	255,319	2 55E+02	4 22E-03	-	-	0 157	4 01E+01	0 005	1 86E-02	--	NC
Xylenes (Total)	NV	297,374	2 97E+02	1 80E-03	-	-	0 311	9 25E+01	0 005	4 29E-02	5.3E+02	8 0E-05
Exposure Area 3 - surface and subsurface soi												
2-Methylphenol	822	ND	8 22E-01	1 08E-02	-	-	0 00000154	1 27E-06	0 01154192	1 75E-05	--	NC
3&4-Methylphenol	793	ND	7 93E-01	3 74E-01	-	-	0 00000169	1 34E-06	0 01154192	6 04E-04	--	NC
Acenaphthene	24,865	130,716	1 31E+02	1 30E-05	-	-	0	0 00E+00	0 01154192	2 10E-08	--	NC
Acenaphthylene	4,561	ND	4 56E+00	5 00E-03	-	-	0	0 00E+00	0 01154192	8 08E-06	--	NC
Anthracene	36,207	70,864	7 09E+01	5 00E-03	-	-	0	0 00E+00	0 01154192	8.08E-06	--	NC
Benzo(a)anthracene	158,594	218,626	2 19E+02	2 00E-05	-	-	0	0 00E+00	0 01154192	3 23E-08	4 0E-03	8.2E-06
Benzo(a)pyrene	193,969	452,415	4 52E+02	2 45E-05	-	-	0	0 00E+00	0 01154192	3 96E-08	5 0E-03	7 9E-06
Benzo(b)fluoranthene	212,507	297,789	2 98E+02	2 53E-05	-	-	0	0 00E+00	0 01154192	4 09E-08	7 0E-04	5.8E-05
Benzo(g,h,i)perylene	110,000	NV	1 10E+02	2 50E-05	-	-	0	0 00E+00	0 01154192	4 04E-08	--	NC
Benzo(k)fluoranthene	147,228	309,803	3 10E+02	1 78E-05	-	-	0	0 00E+00	0 01154192	2.88E-08	7 0E-04	4 1E-05
bis(2-Ethylhexyl)phthalate	1,600	NV	1 60E+00	5 00E-03	-	-	329	5 26E+02	0 01154192	5 64E-01	5 5E+00	1 0E-01
Chrysene	203,388	257,520	2 58E+02	2 53E-05	-	-	0	0 00E+00	0 01154192	4 09E-08	5.0E-03	8 2E-06
Cyanide, Total	38,507	10,299	3 85E+01	1 13E-02	-	-	0 667	2 57E+01	0 01154192	2.75E-02	2 0E-01	1 4E-01
Dibenz(a,h)anthracene	30,443	31,345	3 13E+01	5 00E-03	-	-	0	0 00E+00	0 01154192	8.08E-06	2.0E-03	4 1E-03
Dibenzofuran	11,000	NV	1 10E+01	1 00E-03	-	-	0 218	2 40E+00	0 01154192	2 57E-03	--	NC
Fluoranthene	275,373	353,951	3 54E+02	1 11E-04	-	-	0	0 00E+00	0 01154192	1 79E-07	--	NC
Fluorene	22,185	155,000	1.55E+02	2 50E-04	-	-	0	0 00E+00	0 01154192	4 04E-07	--	NC
HPAH	1,420,966	3,397,173	3 40E+03	2 67E-04	-	-	0	0 00E+00	0.01154192	4 31E-07	7 0E-04	6 2E-04
LPAH	1,191,689	1,237,321	1.24E+03	2 65E-02	-	-	0	0 00E+00	0 01154192	4 28E-05	7 5E+01	5 7E-07
Indeno(1,2,3-c,d)pyrene	129,935	339,803	3 40E+02	2 00E-05	-	-	0	0 00E+00	0 01154192	3 23E-08	5 0E-03	6 5E-06

Table 2
Carnivorous Bird (American Kestrel)
Soil HQ Calculations
Vertellus - Provo, Utah

Soil COPECs	Soil EPC 0 - 1 ft bgs (ug/kg)	Soil EPC 1 - 3 ft bgs (ug/kg)	C_{so} (mg/kg)	C_{sw} (mg/L)	Slope m	Intercept m	BAF m	C_m (mg/kg)	AUF	Average Daily Dose (mg/kg-bw/d)	Avian LOEC-TRV (mg/kg-bw/d)	LOEC-HQ
Methylene chlonde	1,774	131	1 77E+00	5 00E-03	-	-	0 0484	8 59E-02	0 01154192	1 00E-04	--	NC
Naphthalene	71,917	29,000	7 19E+01	1 20E-02	-	-	0	0 00E+00	0 01154192	1 93E-05	7.5E+01	2.6E-07
Phenanthrene	229,423	362,681	3 63E+02	3 20E-04	-	-	0	0 00E+00	0 01154192	5 17E-07	--	NC
Phenol	608	ND	6 08E-01	2 59E-03	-	-	15 4	9 37E+00	0 01154192	1 00E-02	--	NC
Pyrene	396,383	369,778	3 96E+02	3 51E-05	-	-	0	0 00E+00	0 01154192	5 67E-08	--	NC
Exposure Area 4 - subsurface soi												
2-Methylphenol	NV	150,000	1 50E+02	1 08E-02	-	-	0.00000154	2.31E-04	0 00550419	8 46E-06	--	NC
3&4-Methylphenol	NV	470,000	4 70E+02	3 74E-01	-	-	0 00000169	7 94E-04	0 00550419	2 88E-04	--	NC
Acenaphthene	NV	1,739,574	1.74E+03	1 30E-05	-	-	0	0 00E+00	0 00550419	1.00E-08	--	NC
Acenaphthylene	NV	130,620	1 31E+02	5 00E-03	-	-	0	0 00E+00	0 00550419	3.85E-06	--	NC
Acetone	NV	792	7 92E-01	4 30E-03	-	-	0.0472	3 74E-02	0 00550419	2.24E-05	1.0E+03	2 2E-08
Anthracene	NV	635,005	6.35E+02	5 00E-03	-	-	0	0 00E+00	0 00550419	3 85E-06	--	NC
Benzo(a)anthracene	NV	3,700,000	3.70E+03	2 00E-05	-	-	0	0 00E+00	0 00550419	1.54E-08	4 0E-03	3 9E-06
Benzo(a)pyrene	NV	156,369	1.56E+02	2 45E-05	-	-	0	0 00E+00	0 00550419	1 89E-08	5 0E-03	3 8E-06
Benzo(b)fluoranthene	NV	190,000	1.90E+02	2 53E-05	-	-	0	0 00E+00	0.00550419	1.95E-08	7.0E-04	2 8E-05
Benzo(g,h,i)perylene	NV	NV	NV	2 50E-05	-	-	0	NC	0 00550419	NC	--	NC
Benzo(k)fluoranthene	NV	42,780	4 28E+01	1 78E-05	-	-	0	0 00E+00	0 00550419	1 37E-08	7.0E-04	2 0E-05
Carbon disulfide	NV	940	9.40E-01	5 00E-03	-	-	0 00000267	2 51E-06	0 00550419	3 85E-06	--	NC
Chrysene	NV	2,917,714	2.92E+03	2 53E-05	-	-	0	0 00E+00	0 00550419	1 95E-08	5 0E-03	3 9E-06
Cyanide, Total	NV	33,000	3.30E+01	1.13E-02	-	-	0.667	2 20E+01	0.00550419	1.13E-02	2.0E-01	5 6E-02
Dibenz(a,h)anthracene	NV	21,000	2.10E+01	5 00E-03	-	-	0	0.00E+00	0.00550419	3 85E-06	2.0E-03	2.0E-03
Dibenzofuran	NV	1,000,000	1 00E+03	1 00E-03	-	-	0 218	2 18E+02	0 00550419	1 11E-01	--	NC
Fluoranthene	NV	1,746,969	1 75E+03	1 11E-04	-	-	0	0 00E+00	0 00550419	8 55E-08	--	NC
Fluorene	NV	1,114,357	1 11E+03	2 50E-04	-	-	0	0 00E+00	0 00550419	1 93E-07	--	NC
HPAH	NV	7,796,489	7 80E+03	2 67E-04	-	-	0	0 00E+00	0 00550419	2 06E-07	7 0E-04	2 9E-04
LPAH	NV	14,630,000	1 46E+04	2 65E-02	-	-	0	0 00E+00	0 00550419	2 04E-05	7 5E+01	2 7E-07
Indeno(1,2,3-c,d)pyrene	NV	74,000	7.40E+01	2 00E-05	-	-	0	0 00E+00	0.00550419	1 54E-08	5.0E-03	3.1E-06
m,p-Xylene	NV	3,900	3 90E+00	1 80E-03	-	-	0 311	1 21E+00	0 00550419	6 21E-04	5 3E+02	1 2E-06
Methylene chlonde	NV	216	2 16E-01	5 00E-03	-	-	0 0484	1 05E-02	0 00550419	9 20E-06	--	NC
Naphthalene	NV	6,500,000	6 50E+03	1 20E-02	-	-	0	0 00E+00	0 00550419	9 22E-06	7 5E+01	1 2E-07
o-Xylene	NV	2,000	2 00E+00	1 80E-03	-	-	0 311	6 22E-01	0 00550419	3 19E-04	5 3E+02	6 0E-07
Phenanthrene	NV	195,791	1 96E+02	3 20E-04	-	-	0	0 00E+00	0 00550419	2 47E-07	--	NC
Phenol	NV	820,000	8 20E+02	2 59E-03	-	-	15 4	1 26E+04	0.00550419	6 45E+00	--	NC
Pyrene	NV	1,510,834	1 51E+03	3.51E-05	-	-	0	0 00E+00	0.00550419	2.70E-08	--	NC
Xylenes (Total)	NV	5,468	5 47E+00	1.80E-03	-	-	0 311	1 70E+00	0.00550419	8 70E-04	5.3E+02	1 6E-06
Exposure Area 6 - surface soil												
2-Methylphenol	4,100	NV	4 10E+00	1 08E-02	-	-	0 00000154	6 31E-06	0.00024551	3 72E-07	--	NC
3&4-Methylphenol	11,000	NV	1 10E+01	3.74E-01	-	-	0 00000169	1 86E-05	0.00024551	1 28E-05	--	NC
Acenaphthene	550,000	NV	5 50E+02	1.30E-05	-	-	0	0 00E+00	0 00024551	4 47E-10	--	NC
Acenaphthylene	140,000	NV	1 40E+02	5 00E-03	-	-	0	0 00E+00	0 00024551	1 72E-07	--	NC
Anthracene	860,000	NV	8 60E+02	5.00E-03	-	-	0	0.00E+00	0 00024551	1 72E-07	--	NC
Benzo(a)anthracene	2,400,000	NV	2 40E+03	2 00E-05	-	-	0	0 00E+00	0 00024551	6 87E-10	4 0E-03	1 7E-07
Benzo(a)pyrene	2,200,000	NV	2 20E+03	2 45E-05	-	-	0	0 00E+00	0.00024551	8 42E-10	5.0E-03	1 7E-07
Benzo(b)fluoranthene	2,500,000	NV	2 50E+03	2 53E-05	-	-	0	0.00E+00	0.00024551	8 70E-10	7 0E-04	1 2E-06
Benzo(g,h,i)perylene	1,100,000	NV	1 10E+03	2 50E-05	-	-	0	0 00E+00	0 00024551	8 59E-10	--	NC
Benzo(k)fluoranthene	1,000,000	NV	1 00E+03	1.78E-05	-	-	0	0.00E+00	0.00024551	6 12E-10	7 0E-04	8 7E-07
Carbazole	650,000	NV	6 50E+02	1.00E-03	-	-	0 0605	3 93E+01	0.00024551	8 96E-04	--	NC
Chrysene	2,500,000	NV	2 50E+03	2.53E-05	-	-	0	0 00E+00	0 00024551	8 70E-10	5 0E-03	1 7E-07
Cyanide, Total	NV	NV	NV	1.13E-02	-	-	0.667	NC	0.00024551	NC	2.0E-01	NC
Dibenz(a,h)anthracene	370,000	NV	3 70E+02	5.00E-03	-	-	0	0.00E+00	0 00024551	1 72E-07	2 0E-03	8 8E-05
Dibenzofuran	200,000	NV	2 00E+02	1 00E-03	-	-	0 218	4 36E+01	0 00024551	9 93E-04	--	NC
Fluoranthene	5,300,000	NV	5 30E+03	1.11E-04	-	-	0	0 00E+00	0 00024551	3 82E-09	--	NC
Fluorene	470,000	NV	4 70E+02	2 50E-04	-	-	0	0 00E+00	0 00024551	8 59E-09	--	NC
HPAH	17,970,000	NV	1 80E+04	2.67E-04	-	-	0	0 00E+00	0 00024551	9 18E-09	7.0E-04	1 3E-05
LPAH	11,776,200	NV	1 18E+04	2 65E-02	-	-	0	0 00E+00	0.00024551	9 09E-07	7.5E+01	1 2E-08
Indeno(1,2,3-c,d)pyrene	1,100,000	NV	1 10E+03	2.00E-05	-	-	0	0 00E+00	0.00024551	6 87E-10	5 0E-03	1 4E-07
Naphthalene	450,000	NV	4 50E+02	1 20E-02	-	-	0	0 00E+00	0.00024551	4 11E-07	7 5E+01	5 5E-09

Table 2
Carnivorous Bird (American Kestrel)
Soil HQ Calculations
Vertellus - Provo, Utah

Soil COPECs	Soil EPC 0 - 1 ft bgs *(ug/kg)*	Soil EPC 1 - 3 ft bgs *(ug/kg)*	C_{so} *(mg/kg)*	C_{sw} *(mg/L)*	Slope m	Intercept m	BAF m	C_m *(mg/kg)*	AUF	Average Daily Dose *(mg/kg-bw/d)*	Avian LOEC-TRV *(mg/kg-bw/d)*	LOEC-HQ
Phenanthrene	4,400,000	NV	4 40E+03	3 20E-04	-	-	0	0 00E+00	0 00024551	1.10E-08	--	NC
Phenol	6,700	NV	6 70E+00	2 59E-03	-	-	15 4	1 03E+02	0.00024551	2 35E-03	--	NC
Pyrene	4,800,000	NV	4 80E+03	3 51E-05	-	-	0	0 00E+00	0 00024551	1 21E-09	--	NC
Exposure Area 7 - surface and subsurface soi												
Acenaphthene	751	616	7 51E-01	1 30E-05	-	-	0	0 00E+00	0 00910254	1 66E-08	--	NC
Anthracene	4,016	327	4 02E+00	5 00E-03	-	-	0	0 00E+00	0 00910254	6 37E-06	--	NC
Benzo(a)anthracene	6,727	2,132	6 73E+00	2 00E-05	-	-	0	0 00E+00	0 00910254	2 55E-08	4 0E-03	6 5E-06
Benzo(a)pyrene	7,752	2,334	7 75E+00	2.45E-05	-	-	0	0 00E+00	0 00910254	3 12E-08	5.0E-03	6 2E-06
Benzo(b)fluoranthene	8,618	2,835	8 62E+00	2 53E-05	-	-	0	0 00E+00	0 00910254	3 22E-08	7.0E-04	4 6E-05
Benzo(g,h,i)perylene	5,062	1,042	5 06E+00	2 50E-05	-	-	0	0 00E+00	0.00910254	3 19E-08	--	NC
Benzo(k)fluoranthene	4,075	767	4 08E+00	1 78E-05	-	-	0	0 00E+00	0.00910254	2 27E-08	7 0E-04	3 2E-05
Chrysene	8,793	2,505	8 79E+00	2 53E-05	-	-	0	0 00E+00	0.00910254	3 22E-08	5 0E-03	6 4E-06
Cyanide, Total	NV	NV	NV	1 13E-02	-	-	0 667	NC	0.00910254	NC	2 0E-01	NC
Dibenz(a,h)anthracene	1,512	194	1 51E+00	5 00E-03	-	-	0	0 00E+00	0 00910254	6.37E-06	2 0E-03	3 3E-03
Fluoranthene	12,267	3,414	1 23E+01	1 11E-04	-	-	0	0 00E+00	0 00910254	1.41E-07	--	NC
Fluorene	696	167	6 96E-01	2 50E-04	-	-	0	0 00E+00	0 00910254	3 19E-07	--	NC
HPAH	58,934	16,089	5 89E+01	2 67E-04	-	-	0	0 00E+00	0 00910254	3 40E-07	7 0E-04	4 9E-04
LPAH	30,420	10,633	3.04E+01	2 65E-02	-	-	0	0 00E+00	0 00910254	3 37E-05	7 5E+01	4.5E-07
Indeno(1,2,3-c,d)pyrene	4,884	624	4 88E+00	2 00E-05	-	-	0	0 00E+00	0.00910254	2 55E-08	5 0E-03	5.1E-06
Naphthalene	12,555	2,520	1 26E+01	1 20E-02	-	-	0	0 00E+00	0 00910254	1 53E-05	7 5E+01	2 0E-07
Phenanthrene	6,606	2,576	6 61E+00	3 20E-04	-	-	0	0 00E+00	0.00910254	4 08E-07	--	NC
Pyrene	11,718	3,187	1 17E+01	3 51E-05	-	-	0	0 00E+00	0 00910254	4 47E-08	--	NC

Notes:

For the calculation of HPAH and LPAH, Kaplan-Meir method was applied for summing detects and non-detects of PAHs at individual sample locations. For sample locations where no individual PAHs were detected, the resulting calculated concentration is treated as a non-detect and the calculated RL is reported

EPC set equal to 95% UCL If not enough samples were available to calculate a UCL, the EPC is set to the maximum detected concentration, "ND" if no samples were detected at that depth, or "NV" if the COPEC was not analyzed at that depth
Ingested soil is assumed to be surface-level If no surface-level concentration is available (NV or ND), subsurface-level concentration is used for soil ingestion
Risk calculation not performed at Hotspots given the negligable Area Use Factor

Bold HQs are greater than 1.0.

AUF = area use factor
BAF = bioaccumulation factor
bgs = below ground surface
COPEC = chemical of potential ecological concern
C_i = concentration in invertebrate tissue
C_m = concentration in mammal tissue
C_p = concentration in plant tissue
C_{so} = concentration in soil (maximum of surface and subsurface EPCs, if available)
C_{sw} = concentration in surface water
EPC = exposure point concentration
HPAH = high molecular weight PAH, calculated from individual PAH results, includes Benz(a)anthracene, Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(g,h,i)perylene, Benzo(k)fluoranthene, Chrysene, Dibenz(a,h)anthracene, Indeno(1,2,3-
HQ = hazard quotient, HQ = EPC / LOEC
LOEC = lowest observed effects concentration
LPAH = low molecular weigth PAH, calculated from individual PAH results; includes 2-Methylnaphthalene, Acenaphthene, Acenaphthylene, Anthracene, Fluoranthene, Fluorene, Naphthalene, and Phenanthrene
ug/kg = micrograms per kilogram
mg/kg = milligrams per kilogram
mg/kg-bw/day = milligrams per kilogram body weight per day
mg/L = milligrams per liter
NC = not calculated
NV = no value
P = plants
PAH = polycyclic aromatic hydrocarbon
TRV = toxicity reference value

Table 3
Invertivorous Bird (Tree Swallow)
Soil HQ Calculations
Vertellus - Provo, Utah

Receptor	Tree swallow
Body weight	0 0201 kg
Food Ingestion Rate	0 012 kg/day dw
Composition of Diet	100% Invertebrates
Soil Ingestion Rate	0 0002 kg/day
Water Ingestion Rate	0 004 L/day

Soil COPECs	Soil EPC 0 - 1 ft bgs (ug/kg)	Soil EPC 1 - 3 ft bgs (ug/kg)	C_{so} (mg/kg)	C_{sw} (mg/L)	Slope i	Intercept i	BCF i	C_i (mg/kg)	AUF	Average Daily Dose (mg/kg-bw/d)	Avian LOEC-TRV (mg/kg-bw/d)	LOEC-HQ
Exposure Area 2 - subsurface soi												
3&4-Methylphenol	NV	1,060,000	1 06E+03	3 74E-01	-	-	0 73	7 74E+02	0 00035158	1 57E-01	--	NC
Acenaphthene	NV	1,782,714	1 78E+03	1 30E-05	-	-	1 47	2 62E+03	0 00035158	5 32E-01	--	NC
Acenaphthylene	NV	464,140	4 64E+02	5 00E-03	-	-	22 9	1 06E+04	0.00035158	2 16E+00	--	NC
Acetone	NV	366	3 66E-01	4 30E-03	-	-	3 16	1 16E+00	0 00035158	2.35E-04	1 0E+03	2 3E-07
Anthracene	NV	7,614,245	7 61E+03	5 00E-03	-	-	2 42	1 84E+04	0 00035158	3.74E+00	--	NC
Benzene	NV	167,270	1 67E+02	1 78E-02	-	-	2 68	4 48E+02	0 00035158	9 10E-02	--	NC
Benzo(a)anthracene	NV	1,148,770	1 15E+03	2 00E-05	-	-	1.59	1 83E+03	0 00035158	3.71E-01	4 0E-03	**9.4E+01**
Benzo(a)pyrene	NV	1,081,643	1 08E+03	2 45E-05	-	-	1.33	1 44E+03	0 00035158	2 92E-01	5 0E-03	**5.8E+01**
Benzo(b)fluoranthene	NV	1,130,531	1.13E+03	2 53E-05	-	-	2 6	2 94E+03	0 00035158	5 96E-01	7.0E-04	**8.5E+02**
Benzo(g,h,i)perylene	NV	NV	NV	2 50E-05	-	-	2 94	NC	0 00035158	NC	--	NC
Benzo(k)fluoranthene	NV	632,436	6.32E+02	1 78E-05	-	-	2 6	1 64E+03	0 00035158	3 34E-01	7.0E-04	**4.8E+02**
Carbon disulfide	NV	8	8 05E-03	5 00E-03	-	-	1	8 05E-03	0 00035158	2 01E-06	--	NC
Chloroform	NV	12	1 20E-02	5 00E-03	-	-	9 1	1 09E-01	0 00035158	2 25E-05	--	NC
Chrysene	NV	1,313,841	1 31E+03	2 53E-05	-	-	2 29	3 01E+03	0 00035158	6 10E-01	5 0E-03	**1.2E+02**
Cyanide, Total	NV	1,751,976	1 75E+03	1 13E-02	-	-	1	1.75E+03	0 00035158	3 55E-01	2 0E-01	**1.8E+00**
Dibenz(a,h)anthracene	NV	278,582	2 79E+02	5 00E-03	-	-	2 31	6 44E+02	0 00035158	1 31E-01	2 0E-03	**6.7E+01**
Fluoranthene	NV	6,689,586	6 69E+03	1 11E-04	-	-	3 04	2 03E+04	0 00035158	4 13E+00	--	NC
Fluorene	NV	1,087,380	1.09E+03	2 50E-04	-	-	9 57	1.04E+04	0 00035158	2 11E+00	--	NC
HPAH	NV	25,973,856	2 60E+04	2 67E-04	-	-	2.6	6 75E+04	0 00035158	1 37E+01	7 0E-04	**2.0E+04**
LPAH	NV	57,022,738	5 70E+04	2 65E-02	-	-	3.04	1 73E+05	0 00035158	3 52E+01	7 5E+01	4 7E-01
Indeno(1,2,3-c,d)pyrene	NV	570,440	5 70E+02	2.00E-05	-	-	2 86	1 63E+03	0 00035158	3 31E-01	5 0E-03	**6.6E+01**
Methyl ethyl ketone	NV	60	6 00E-02	1 00E-02	-	-	3 27	1 96E-01	0 00035158	4.06E-05	--	NC
Methylene chlonde	NV	95	9 47E-02	5 00E-03	-	-	3 16	2 99E-01	0 00035158	6 11E-05	--	NC
Naphthalene	NV	13,662,909	1 37E+04	1 20E-02	-	-	4 4	6 01E+04	0 00035158	1.22E+01	7 5E+01	1 6E-01
Phenanthrene	NV	9,927,421	9 93E+03	3 20E-04	-	-	1 72	1 71E+04	0 00035158	3.46E+00	--	NC
Phenol	NV	916,000	9 16E+02	2 59E-03	-	-	0 443	4 06E+02	0 00035158	8.23E-02	--	NC
Pyrene	NV	4,961,400	4 96E+03	3 51E-05	-	-	1 75	8 68E+03	0 00035158	1.76E+00	--	NC
Toluene	NV	255,319	2 55E+02	4 22E-03	-	-	5 6	1 43E+03	0 00035158	2 90E-01	--	NC
Xylenes (Total)	NV	297,374	2 97E+02	1.80E-03	-	-	7 24	2 15E+03	0 00035158	4 37E-01	5 3E+02	8 2E-04
Exposure Area 3 - surface and subsurface soi												
2-Methylphenol	822	ND	8 22E-01	1 08E-02	-	-	0 701	5 76E-01	0 00081158	2 79E-04	--	NC
3&4-Methylphenol	793	ND	7 93E-01	3 74E-01	-	-	0 73	5 79E-01	0 00081158	3 44E-04	--	NC
Acenaphthene	24,865	130,716	1,31E+02	1 30E-05	-	-	1 47	1 92E+02	0 00081158	9 02E-02	--	NC
Acenaphthylene	4,561	ND	4 56E+00	5 00E-03	-	-	22 9	1 04E+02	0 00081158	4 90E-02	--	NC
Anthracene	36,207	70,864	7 09E+01	5 00E-03	-	-	2.42	1 71E+02	0 00081158	8 07E-02	--	NC
Benzo(a)anthracene	158,594	218,626	2 19E+02	2 00E-05	-	-	1 59	3 48E+02	0 00081158	1 64E-01	4 0E-03	**4.2E+01**
Benzo(a)pyrene	193,969	452,415	4 52E+02	2 45E-05	-	-	1 33	6 02E+02	0 00081158	2 84E-01	5 0E-03	**5.7E+01**
Benzo(b)fluoranthene	212,507	297,789	2 98E+02	2 53E-05	-	-	2 6	7 74E+02	0 00081158	3 65E-01	7 0E-04	**5.2E+02**
Benzo(g,h,i)perylene	110,000	NV	1 10E+02	2 50E-05	-	-	2 94	3 23E+02	0 00081158	1 53E-01	--	NC
Benzo(k)fluoranthene	147,228	309,803	3 10E+02	1 78E-05	-	-	2 6	8 05E+02	0 00081158	3 79E-01	7 0E-04	**5.4E+02**
bis(2-Ethylhexyl)phthalate	1,600	NV	1 60E+00	5 00E-03	-	-	154	2 46E+02	0 00081158	1 15E-01	5 5E+00	2 1E-02
Chrysene	203,388	257,520	2.58E+02	2 53E-05	-	-	2 29	5 90E+02	0 00081158	2 78E-01	5 0E-03	**5.6E+01**
Cyanide, Total	38,507	10,299	3 85E+01	1 13E-02	-	-	1	3 85E+01	0 00081158	1 84E-02	2 0E-01	9 2E-02
Dibenz(a,h)anthracene	30,443	31,345	3.13E+01	5 00E-03	-	-	2 31	7 24E+01	0 00081158	3 42E-02	2 0E-03	**1.8E+01**
Dibenzofuran	11,000	NV	1 10E+01	1 00E-03	-	-	2 1	2 31E+01	0.00081158	1 09E-02	--	NC
Fluoranthene	275,373	353,951	3 54E+02	1 11E-04	-	-	3 04	1 08E+03	0 00081158	5.07E-01	--	NC
Fluorene	22,185	155,000	1 55E+02	2 50E-04	-	-	9 57	1 48E+03	0 00081158	6.95E-01	--	NC
HPAH	1,420,966	3,397,173	3 40E+03	2 67E-04	-	-	2 6	8 83E+03	0 00081158	4 15E+00	7 0E-04	**5.9E+03**
LPAH	1,191,689	1,237,321	1 24E+03	2 65E-02	-	-	3 04	3 76E+03	0 00081158	1 77E+00	7 5E+01	2 4E-02
Indeno(1,2,3-c,d)pyrene	129,935	339,803	3 40E+02	2 00E-05	-	-	2 86	9 72E+02	0 00081158	4 56E-01	5 0E-03	**9.1E+01**

Table 3
Invertivorous Bird (Tree Swallow)
Soil HQ Calculations
Vertellus - Provo, Utah

Soil COPECs	Soil EPC 0 - 1 ft bgs (ug/kg)	Soil EPC 1 - 3 ft bgs (ug/kg)	C_{so} (mg/kg)	C_{sw} (mg/L)	Slope i	Intercept i	BCF i	C_i (mg/kg)	AUF	Average Daily Dose (mg/kg-bw/d)	Avian LOEC-TRV (mg/kg-bw/d)	LOEC-HQ
Methylene chloride	1,774	131	1 77E+00	5 00E-03	-	-	3 16	5 61E+00	0.00081158	2 64E-03	--	NC
Naphthalene	71,917	29,000	7 19E+01	1 20E-02	-	-	4 4	3 16E+02	0.00081158	1 49E-01	7 5E+01	2 0E-03
Phenanthrene	229,423	362,681	3 63E+02	3 20E-04	-	-	1 72	6 24E+02	0 00081158	2 94E-01	--	NC
Phenol	608	ND	6.08E-01	2 59E-03	-	-	0 443	2 69E-01	0 00081158	1 32E-04	--	NC
Pyrene	396,383	369,778	3 96E+02	3 51E-05	-	-	1 75	6 94E+02	0 00081158	3 29E-01	--	NC
Exposure Area 4 - subsurface soi												
2-Methylphenol	NV	150,000	1.50E+02	1 08E-02	-	-	0 701	1 05E+02	0 00038703	2 35E-02	--	NC
3&4-Methylphenol	NV	470,000	4 70E+02	3 74E-01	-	-	0 73	3 43E+02	0 00038703	7.67E-02	--	NC
Acenaphthene	NV	1,739,574	1 74E+03	1 30E-05	-	-	1 47	2 56E+03	0 00038703	5.71E-01	--	NC
Acenaphthylene	NV	130,620	1.31E+02	5 00E-03	-	-	22 9	2 99E+03	0 00038703	6 68E-01	--	NC
Acetone	NV	792	7 92E-01	4.30E-03	-	-	3 16	2 50E+00	0 00038703	5 59E-04	1 0E+03	5 6E-07
Anthracene	NV	635,005	6 35E+02	5 00E-03	-	-	2 42	1.54E+03	0 00038703	3 43E-01	--	NC
Benzo(a)anthracene	NV	3,700,000	3 70E+03	2 00E-05	-	-	1 59	5.88E+03	0 00038703	1 31E+00	4 0E-03	**3.3E+02**
Benzo(a)pyrene	NV	156,369	1 56E+02	2 45E-05	-	-	1 33	2.08E+02	0 00038703	4 65E-02	5 0E-03	**9.3E+00**
Benzo(b)fluoranthene	NV	190.000	1 90E+02	2 53E-05	-	-	2 6	4.94E+02	0 00038703	1.10E-01	7 0E-04	**1.6E+02**
Benzo(g,h,i)perylene	NV	NV	NV	2 50E-05	-	-	2.94	NC	0 00038703	NC	--	NC
Benzo(k)fluoranthene	NV	42,780	4 28E+01	1.78E-05	-	-	2 6	1 11E+02	0 00038703	2 48E-02	7 0E-04	**3.5E+01**
Carbon disulfide	NV	940	9.40E-01	5.00E-03	-	-	1	9 40E-01	0 00038703	2 10E-04	--	NC
Chrysene	NV	2,917,714	2 92E+03	2.53E-05	-	-	2 29	6 68E+03	0 00038703	1 49E+00	5 0E-03	**3.0E+02**
Cyanide, Total	NV	33,000	3 30E+01	1 13E-02	-	-	1	3 30E+01	0 00038703	7 37E-03	2 0E-01	3 7E-02
Dibenz(a,h)anthracene	NV	21.000	2 10E+01	5 00E-03	-	-	2 31	4.85E+01	0 00038703	1 08E-02	2 0E-03	**5.6E+00**
Dibenzofuran	NV	1,000,000	1 00E+03	1 00E-03	-	-	2 1	2.10E+03	0 00038703	4 69E-01	--	NC
Fluoranthene	NV	1,746,969	1 75E+03	1 11E-04	-	-	3.04	5 31E+03	0 00038703	1 19E+00	--	NC
Fluorene	NV	1,114,357	1 11E+03	2.50E-04	-	-	9 57	1 07E+04	0 00038703	2 38E+00	--	NC
HPAH	NV	7,796,489	7.80E+03	2 67E-04	-	-	2 6	2 03E+04	0 00038703	4 53E+00	7.0E-04	**6.5E+03**
LPAH	NV	14,630,000	1 46E+04	2 65E-02	-	-	3 04	4 45E+04	0 00038703	9 93E+00	7.5E+01	1.3E-01
Indeno(1,2,3-c,d)pyrene	NV	74,000	7 40E+01	2 00E-05	-	-	2 86	2 12E+02	0 00038703	4 73E-02	5 0E-03	**9.5E+00**
m,p-Xylene	NV	3,900	3 90E+00	1 80E-03	-	-	7.24	2.82E+01	0 00038703	6 31E-03	5 3E+02	1 2E-05
Methylene chloride	NV	216	2 16E-01	5 00E-03	-	-	3.16	6 83E-01	0 00038703	1 53E-04	--	NC
Naphthalene	NV	6,500,000	6 50E+03	1 20E-02	-	-	4 4	2 86E+04	0 00038703	6 39E+00	7 5E+01	8.5E-02
o-Xylene	NV	2,000	2.00E+00	1 80E-03	-	-	7 24	1 45E+01	0 00038703	3 23E-03	5 3E+02	6 1E-06
Phenanthrene	NV	195,791	1.96E+02	3 20E-04	-	-	1 72	3 37E+02	0.00038703	7 52E-02	--	NC
Phenol	NV	820,000	8.20E+02	2 59E-03	-	-	0 443	3 63E+02	0 00038703	8 11E-02	--	NC
Pyrene	NV	1,510,834	1 51E+03	3 51E-05	-	-	1 75	2 64E+03	0 00038703	5 91E-01	--	NC
Xylenes (Total)	NV	5,468	5.47E+00	1 80E-03	-	-	7 24	3 96E+01	0 00038703	8 84E-03	5 3E+02	1 7E-05
Exposure Area 6 - surface soil												
2-Methylphenol	4,100	NV	4 10E+00	1 08E-02	-	-	0 701	2 87E+00	1 7263E-05	2 95E-05	--	NC
3&4-Methylphenol	11,000	NV	1 10E+01	3 74E-01	-	-	0 73	8 03E+00	1 7263E-05	8 36E-05	--	NC
Acenaphthene	550,000	NV	5.50E+02	1 30E-05	-	-	1 47	8 09E+02	1 7263E-05	8 16E-03	--	NC
Acenaphthylene	140,000	NV	1 40E+02	5 00E-03	-	-	22 9	3 21E+03	1 7263E-05	3.20E-02	--	NC
Anthracene	860,000	NV	8 60E+02	5 00E-03	-	-	2 42	2 08E+03	1 7263E-05	2 09E-02	--	NC
Benzo(a)anthracene	2,400,000	NV	2 40E+03	2.00E-05	-	-	1 59	3 82E+03	1 7263E-05	3.85E-02	4 0E-03	**9.7E+00**
Benzo(a)pyrene	2,200,000	NV	2.20E+03	2 45E-05	-	-	1 33	2 93E+03	1 7263E-05	2.96E-02	5 0E-03	**5.9E+00**
Benzo(b)fluoranthene	2,500,000	NV	2 50E+03	2 53E-05	-	-	2 6	6.50E+03	1 7263E-05	6 53E-02	7 0E-04	**9.3E+01**
Benzo(g,h,i)perylene	1,100,000	NV	1 10E+03	2 50E-05	-	-	2 94	3 23E+03	1 7263E-05	3 24E-02	--	NC
Benzo(k)fluoranthene	1,000,000	NV	1 00E+03	1.78E-05	-	-	2 6	2 60E+03	1 7263E-05	2 61E-02	7 0E-04	**3.7E+01**
Carbazole	650,000	NV	6 50E+02	1 00E-03	-	-	0 961	6 25E+02	1 7263E-05	6 35E-03	--	NC
Chrysene	2,500,000	NV	2 50E+03	2 53E-05	-	-	2 29	5.73E+03	1 7263E-05	5 75E-02	5 0E-03	**1.2E+01**
Cyanide, Total	NV	NV	NV	1.13E-02	-	-	1	NC	1 7263E-05	NC	2 0E-01	NC
Dibenz(a,h)anthracene	370,000	NV	3 70E+02	5.00E-03	-	-	2 31	8 55E+02	1 7263E-05	8.59E-03	2 0E-03	**4.4E+00**
Dibenzofuran	200,000	NV	2 00E+02	1.00E-03	-	-	2 1	4 20E+02	1 7263E-05	4 22E-03	--	NC
Fluoranthene	5,300,000	NV	5 30E+03	1 11E-04	-	-	3.04	1.61E+04	1 7263E-05	1 62E-01	--	NC
Fluorene	470,000	NV	4 70E+02	2 50E-04	-	-	9 57	4.50E+03	1 7263E-05	4 49E-02	--	NC
HPAH	17,970,000	NV	1 80E+04	2 67E-04	-	-	2.6	4.67E+04	1 7263E-05	4 69E-01	7 0E-04	**6.7E+02**
LPAH	11,776,200	NV	1 18E+04	2 65E-02	-	-	3.04	3.58E+04	1 7263E-05	3 59E-01	7 5E+01	4.8E-03
Indeno(1,2,3-c,d)pyrene	1,100,000	NV	1 10E+03	2 00E-05	-	-	2 86	3 15E+03	1 7263E-05	3 16E-02	5.0E-03	**6.3E+00**
Naphthalene	450,000	NV	4 50E+02	1 20E-02	-	-	4.4	1 98E+03	1 7263E-05	1 98E-02	7 5E+01	2 6E-04

Table 3
Invertivorous Bird (Tree Swallow)
Soil HQ Calculations
Vertellus - Provo, Utah

Soil COPECs	Soil EPC 0 - 1 ft bgs (ug/kg)	Soil EPC 1 - 3 ft bgs (ug/kg)	C_{so} (mg/kg)	C_{sw} (mg/L)	Slope i	Intercept i	BCF i	C_i (mg/kg)	AUF	Average Daily Dose (mg/kg-bw/d)	Avian LOEC-TRV (mg/kg-bw/d)	LOEC-HQ
Phenanthrene	4,400,000	NV	4 40E+03	3 20E-04	-	-	1 72	7 57E+03	1 7263E-05	7 63E-02	--	NC
Phenol	6,700	NV	6 70E+00	2 59E-03	-	-	0 443	2 97E+00	1 7263E-05	3 09E-05	--	NC
Pyrene	4,800,000	NV	4 80E+03	3 51E-05	-	-	1 75	8 40E+03	1 7263E-05	8 46E-02	--	NC
Exposure Area 7 - surface and subsurface soi												
Acenaphthene	751	616	7.51E-01	1 30E-05	-	-	1 47	1 10E+00	0 00064005	4 13E-04	--	NC
Anthracene	4,016	327	4.02E+00	5 00E-03	-	-	2.42	9 72E+00	0 00064005	3 62E-03	--	NC
Benzo(a)anthracene	6,727	2,132	6.73E+00	2 00E-05	-	-	1.59	1 07E+01	0 00064005	4 00E-03	4 0E-03	1 0E+00
Benzo(a)pyrene	7,752	2,334	7.75E+00	2 45E-05	-	-	1 33	1 03E+01	0 00064005	3.87E-03	5 0E-03	7 7E-01
Benzo(b)fluoranthene	8,618	2,835	8 62E+00	2 53E-05	-	-	2.6	2 24E+01	0 00064005	8 34E-03	7 0E-04	**1.2E+01**
Benzo(g,h,i)perylene	5,062	1,042	5 06E+00	2 50E-05	-	-	2 94	1 49E+01	0 00064005	5 53E-03	--	NC
Benzo(k)fluoranthene	4,075	767	4 08E+00	1 78E-05	-	-	2 6	1 06E+01	0 00064005	3 94E-03	7 0E-04	**5.6E+00**
Chrysene	8,793	2,505	8 79E+00	2.53E-05	-	-	2 29	2 01E+01	0 00064005	7 50E-03	5 0E-03	**1.5E+00**
Cyanide, Total	NV	NV	NV	1 13E-02	-	-	1	NC	0 00064005	NC	2 0E-01	NC
Dibenz(a,h)anthracene	1,512	194	1 51E+00	5 00E-03	-	-	2 31	3 49E+00	0 00064005	1 30E-03	2 0E-03	6 7E-01
Fluoranthene	12,267	3,414	1 23E+01	1 11E-04	-	-	3 04	3.73E+01	0 00064005	1 39E-02	--	NC
Fluorene	696	167	6 96E-01	2 50E-04	-	-	9 57	6 66E+00	0.00064005	2 46E-03	--	NC
HPAH	58,934	16,089	5 89E+01	2 67E-04	-	-	2 6	1 53E+02	0 00064005	5 70E-02	7 0E-04	**8.1E+01**
LPAH	30,420	10,633	3 04E+01	2 65E-02	-	-	3 04	9 25E+01	0 00064005	3 44E-02	7.5E+01	4 6E-04
Indeno(1,2,3-c,d)pyrene	4,884	624	4 88E+00	2 00E-05	-	-	2 86	1 40E+01	0 00064005	5 20E-03	5 0E-03	1 0E+00
Naphthalene	12,555	2,520	1 26E+01	1 20E-02	-	-	4 4	5 52E+01	0 00064005	2 05E-02	7 5E+01	2 7E-04
Phenanthrene	6,606	2,576	6 61E+00	3 20E-04	-	-	1.72	1 14E+01	0 00064005	4 25E-03	--	NC
Pyrene	11,718	3,187	1 17E+01	3 51E-05	-	-	1 75	2 05E+01	0 00064005	7 66E-03	--	NC

Notes:

For the calculation of HPAH and LPAH, Kaplan-Meir method was applied for summing detects and non-detects of PAHs at individual sample locations For sample locations where no individual PAHs were detected, the resulting calculated concentration is treated as a non-detect and the calculated RL is reported.

EPC set equal to 95% UCL If not enough samples were available to calculate a UCL, the EPC was set to the maximum detected concentration, "ND" if no samples were detected at that depth, or "NV" if the COPEC was not analyzed at that depth
Incidentially ingested soil is assumed to be from surface soil If no surface-level data are available (NV or ND), subsurface soil data are used for soil ingestion
Risk calculation not performed at Hotspots given the negligable Area Use Factor

Bold HQs are greater than 1 0

AUF = area use factor
BAF = bioaccumulation factor
bgs = below ground surface
COPEC = chemical of potential ecological concern
C_i = concentration in invertebrate tissue
C_m = concentration in mammal tissue
C_p = concentration in plant tissue
C_{so} = concentration in soil (maximum of surface and subsurface EPCs, if available)
C_{sw} = concentration in surface water
EPC = exposure point concentration
HPAH = high molecular weight PAH; calculated from individual PAH results, includes Benz(a)anthracene, Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(g,h,i)perylene, Benzo(k)fluoranthene, Chrysene, Dibenz(a,h)anthracene, Indeno(1,2,3-
HQ = hazard quotient, HQ = EPC / LOEC
LOEC = lowest observed effects concentration
LPAH = low molecular weigth PAH, calculated from individual PAH results, includes 2-Methylnaphthalene, Acenaphthene, Acenaphthylene, Anthracene, Fluoranthene, Fluorene, Naphthalene, and Phenanthrene
ug/kg = micrograms per kilogram
mg/kg = milligrams per kilogram
mg/kg-bw/day = milligrams per kilogram body weight per day
mg/L = milligrams per liter
NC = not calculated
NV = no value
P = plants
PAH = polycyclic aromatic hydrocarbon
TRV = toxicity reference value

Table 4
Herbivorous Mammal (Mule Deer)
Soil HQ Calculations
Vertellus - Provo, Utah

Receptor	Mule deer
Body weight	70 kg
Food Ingestion Rate	1 533 kg/day dw
Composition of Diet	100% Plants
Soil Ingestion Rate	0 0307 kg/day
Water Ingestion Rate	3 080 L/day

Soil COPECs	Soil EPC 0 - 1 ft bgs (ug/kg)	Soil EPC 1 - 3 ft bgs (ug/kg)	C_{so} (mg/kg)	C_{sw} (mg/L)	Slope p	Intercept p	BCF p	C_p (mg/kg)	AUF	Average Daily Dose (mg/kg-bw/d)	Mammalian LOEC-TRV (mg/kg-bw/d)	LOEC-HQ
Exposure Area 2 - subsurface soi												
3&4-Methylphenol	NV	1,060,000	1 06E+03	3.74E-01	-	-	2.63	2 79E+03	0 00473759	2 89E-01	1 1E+03	2 6E-04
Acenaphthene	NV	1,782,714	1.78E+03	1 30E-05	-0 8556	-5 562	-	6 35E-06	0 00473759	3.37E-09	3 5E+02	9 6E-12
Acenaphthylene	NV	464,140	4 64E+02	5 00E-03	0 791	-1.144	-	4 10E+01	0 00473759	4.25E-03	3 5E+02	1 2E-05
Acetone	NV	366	3 66E-01	4 30E-03	-	-	76	2 78E+01	0 00473759	2.89E-03	5 0E+01	5 8E-05
Anthracene	NV	7,614,245	7 61E+03	5 00E-03	0 7784	-0 9887	-	3 91E+02	0 00473759	4 06E-02	5 0E+02	8 1E-05
Benzene	NV	167,270	1 67E+02	1 78E-02	-	-	8 26	1 38E+03	0 00473759	1 43E-01	2.6E+02	5 4E-04
Benzo(a)anthracene	NV	1,148,770	1 15E+03	2 00E-05	0 5944	-2 7078	-	4 40E+00	0 00473759	4 56E-04	8.5E-01	5 4E-04
Benzo(a)pyrene	NV	1,081,643	1 08E+03	2 45E-05	0 975	-2 0615	-	1 16E+02	0.00473759	1 20E-02	3.1E+00	3 9E-03
Benzo(b)fluoranthene	NV	1,130,531	1 13E+03	2 53E-05	-	-	0.31	3 50E+02	0 00473759	3 64E-02	4 0E+01	9.1E-04
Benzo(g,h,i)perylene	NV	NV	NV	2 50E-05	1.1829	-0 9313	-	NC	0 00473759	NC	7 2E+01	NC
Benzo(k)fluoranthene	NV	632,436	6 32E+02	1 78E-05	0 8595	-2 1579	-	2 95E+01	0.00473759	3.06E-03	7 2E+01	4 3E-05
Carbon disulfide	NV	8	8 05E-03	5 00E-03	-	-	2 01	1 62E-02	0.00473759	2 72E-06	1 3E+00	2 2E-06
Chloroform	NV	12	1 20E-02	5 00E-03	-	-	9 59	1 15E-01	0 00473759	1 30E-05	7 5E+01	1 7E-07
Chrysene	NV	1,313,841	1 31E+03	2 53E-05	0 5944	-2.7078	-	4 76E+00	0 00473759	4.94E-04	8 5E-01	5 8E-04
Cyanide, Total	NV	1,751,976	1 75E+03	1 13E-02	-	-	1	1 75E+03	0 00473759	1 82E-01	3 4E+02	5 3E-04
Dibenz(a,h)anthracene	NV	278,582	2.79E+02	5 00E-03	-	-	0 13	3 62E+01	0 00473759	3.76E-03	1 3E+01	2 8E-04
Fluoranthene	NV	6,689,586	6 69E+03	1.11E-04	-	-	0 5	3 34E+03	0 00473759	3.47E-01	6 3E+01	5 6E-03
Fluorene	NV	1,087,380	1 09E+03	2.50E-04	-0 8556	-5 562	-	9 69E-06	0.00473759	5 31E-08	6 3E+02	8 5E-11
HPAH	NV	25,973,856	2 60E+04	2 67E-04	0 9469	-1 7026	-	2 76E+03	0 00473759	2.86E-01	3 1E+00	9 3E-02
LPAH	NV	57,022,738	5 70E+04	2 65E-02	-	-	2 09	1 19E+05	0 00473759	1.24E+01	3 3E+02	3 8E-02
Indeno(1,2,3-c,d)pyrene	NV	570,440	5 70E+02	2 00E-05	-	-	0 11	6 27E+01	0 00473759	6.51E-03	7 2E+01	9 0E-05
Methyl ethyl ketone	NV	60	6 00E-02	1 00E-02	-	-	46 1	2 77E+00	0 00473759	2.89E-04	4 6E+03	6 3E-08
Methylene chlonde	NV	95	9 47E-02	5 00E-03	-	-	18 8	1 78E+00	0 00473759	1 86E-04	5 0E+01	3 7E-06
Naphthalene	NV	13,662,909	1 37E+04	1 20E-02	-	-	12 2	1 67E+05	0 00473759	1 73E+01	7 2E+01	2 4E-01
Phenanthrene	NV	9,927,421	9 93E+03	3 20E-04	0 6203	-0 1665	-	2.55E+02	0 00473759	2 65E-02	2 6E+01	1.0E-03
Phenol	NV	916,000	9 16E+02	2 59E-03	-	-	0.0494	4.53E+01	0 00473759	4 70E-03	3.0E+02	1.6E-05
Pyrene	NV	4,961,400	4 96E+03	3 51E-05	-	-	0.72	3.57E+03	0 00473759	3 71E-01	3 8E+01	9 9E-03
Toluene	NV	255,319	2 55E+02	4 22E-03	-	-	4.71	1 20E+03	0 00473759	1 25E-01	2 6E+02	4.8E-04
Xylenes (Total)	NV	297,374	2 97E+02	1 80E-03	-	-	3.28	9 75E+02	0 00473759	1 01E-01	2 6E+00	3.9E-02
Exposure Area 3 - surface and subsurface soi												
2-Methylphenol	822	ND	8 22E-01	1 08E-02	-	-	3	2 47E+00	0 01093617	6.00E-04	1 1E+03	5 5E-07
3&4-Methylphenol	793	ND	7 93E-01	3 74E-01	-	-	2.63	2 09E+00	0 01093617	6 83E-04	1 1E+03	6.2E-07
Acenaphthene	24,865	130,716	1 31E+02	1.30E-05	-0 8556	-5 562	-	5 94E-05	0 01093617	1 19E-04	3 5E+02	3.4E-07
Acenaphthylene	4,561	ND	4 56E+00	5.00E-03	0 791	-1 144	-	1 06E+00	0 01093617	2 78E-04	3 5E+02	7 9E-07
Anthracene	36,207	70,864	7 09E+01	5 00E-03	0 7784	-0 9887	-	1 03E+01	0 01093617	2 63E-03	5 0E+02	5 3E-06
Benzo(a)anthracene	158,594	218,626	2 19E+02	2.00E-05	0 5944	-2 7078	-	1 64E+00	0 01093617	1 15E-03	8 5E-01	1 4E-03
Benzo(a)pyrene	193,969	452,415	4 52E+02	2 45E-05	0 975	-2 0615	-	4 94E+01	0 01093617	1 28E-02	3 1E+00	4 2E-03
Benzo(b)fluoranthene	212,507	297,789	2 98E+02	2 53E-05	-	-	0 31	9 23E+01	0 01093617	2 31E-02	4 0E+01	5 8E-04
Benzo(g,h,i)perylene	110,000	NV	1 10E+02	2 50E-05	1 1829	-0 9313	-	1.02E+02	0 01093617	2 51E-02	7 2E+01	3 5E-04
Benzo(k)fluoranthene	147,228	309,803	3 10E+02	1 78E-05	0 8595	-2 1579	-	1 60E+01	0 01093617	4 54E-03	7 2E+01	6 3E-05
bis(2-Ethylhexyl)phthalate	1,600	NV	1 60E+00	5 00E-03	-	-	0 05	8 00E-02	0 01093617	2 92E-05	1 8E+02	1.6E-07
Chrysene	203,388	257,520	2 58E+02	2 53E-05	0 5944	-2.7078	-	1.81E+00	0 01093617	1 41E-03	8 5E-01	1 7E-03
Cyanide, Total	38,507	10,299	3 85E+01	1 13E-02	-	-	1	3 85E+01	0 01093617	9 41E-03	3.4E+02	2 7E-05
Dibenz(a,h)anthracene	30,443	31,345	3.13E+01	5 00E-03	-	-	0 13	4 07E+00	0 01093617	1 12E-03	1.3E+01	8 5E-05
Dibenzofuran	11,000	NV	1 10E+01	1 00E-03	-	-	1.29	1 42E+01	0 01093617	3 45E-03	--	NC
Fluoranthene	275,373	353,951	3 54E+02	1 11E-04	-	-	0.5	1.77E+02	0 01093617	4 37E-02	6 3E+01	7 0E-04
Fluorene	22,185	155,000	1 55E+02	2 50E-04	-0 8556	-5 562	-	5 13E-05	0 01093617	1 06E-04	6 3E+02	1 7E-07
HPAH	1,420,966	3,397,173	3 40E+03	2 67E-04	0 9469	-1 7026	-	4 02E+02	0.01093617	1 03E-01	3 1E+00	3 4E-02
LPAH	1,191,689	1,237,321	1 24E+03	2.65E-02	-	-	2 09	2 59E+03	0.01093617	6.25E-01	3 3E+02	1 9E-03
Indeno(1,2,3-c,d)pyrene	129,935	339,803	3 40E+02	2.00E-05	-	-	0 11	3 74E+01	0 01093617	9 57E-03	7 2E+01	1 3E-04

Table 4
Herbivorous Mammal (Mule Deer)
Soil HQ Calculations
Vertellus - Provo, Utah

Soil COPECs	Soil EPC 0 - 1 ft bgs (ug/kg)	Soil EPC 1 - 3 ft bgs (ug/kg)	C_{so} (mg/kg)	C_{sw} (mg/L)	Slope p	Intercept p	BCF p	C_p (mg/kg)	AUF	Average Daily Dose (mg/kg-bw/d)	Mammalian LOEC-TRV (mg/kg-bw/d)	LOEC-HQ
Methylene chloride	1,774	131	1.77E+00	5.00E-03	-	-	18 8	3 34E+01	0 01093617	8 00E-03	5 0E+01	1 6E-04
Naphthalene	71,917	29,000	7.19E+01	1.20E-02	-	-	12 2	8 77E+02	0.01093617	2 10E-01	7 2E+01	2 9E-03
Phenanthrene	229,423	362,681	3.63E+02	3 20E-04	0.6203	-0 1665	-	3.28E+01	0.01093617	8.95E-03	2 6E+01	3 5E-04
Phenol	608	ND	6.08E-01	2 59E-03	-	-	0.0494	3 00E-02	0.01093617	1 14E-05	3 0E+02	3 8E-08
Pyrene	396,383	369,778	3 96E+02	3 51E-05	-	-	0.72	2 85E+02	0.01093617	7 03E-02	3.8E+01	1 9E-03
Exposure Area 4 - subsurface soi												
2-Methylphenol	NV	150,000	1.50E+02	1 08E-02	-	-	3	4 50E+02	0.00521532	5.14E-02	1 1E+03	4 7E-05
3&4-Methylphenol	NV	470,000	4 70E+02	3 74E-01	-	-	2 63	1 24E+03	0 00521532	1.41E-01	1 1E+03	1 3E-04
Acenaphthene	NV	1,739,574	1 74E+03	1 30E-05	-0 8556	-5 562	-	6 49E-06	0 00521532	3 72E-09	3 5E+02	1 1E-11
Acenaphthylene	NV	130,620	1.31E+02	5 00E-03	0 791	-1.144	-	1 50E+01	0.00521532	1.72E-03	3 5E+02	4 9E-06
Acetone	NV	792	7 92E-01	4 30E-03	-	-	76	6 02E+01	0.00521532	6.88E-03	5.0E+01	1 4E-04
Anthracene	NV	635,005	6.35E+02	5 00E-03	0 7784	-0 9887	-	5 65E+01	0 00521532	6 46E-03	5 0E+02	1 3E-05
Benzo(a)anthracene	NV	3,700,000	3 70E+03	2 00E-05	0.5944	-2.7078	-	8 81E+00	0.00521532	1.01E-03	8 5E-01	1 2E-03
Benzo(a)pyrene	NV	156,369	1 56E+02	2 45E-05	0 975	-2.0615	-	1 75E+01	0.00521532	2.00E-03	3 1E+00	6 5E-04
Benzo(b)fluoranthene	NV	190,000	1 90E+02	2 53E-05	-	-	0 31	5 89E+01	0 00521532	6.73E-03	4.0E+01	1 7E-04
Benzo(g,h,i)perylene	NV	NV	NV	2 50E-05	1 1829	-0.9313	-	NC	0 00521532	NC	7 2E+01	NC
Benzo(k)fluoranthene	NV	42,780	4 28E+01	1 78E-05	0 8595	-2.1579	-	2 92E+00	0 00521532	3.33E-04	7 2E+01	4 6E-06
Carbon disulfide	NV	940	9 40E-01	5 00E-03	-	-	2 01	1 89E+00	0 00521532	2 17E-04	1 3E+00	1 7E-04
Chrysene	NV	2,917,714	2 92E+03	2 53E-05	0 5944	-2.7078	-	7.65E+00	0 00521532	8.74E-04	8 5E-01	1 0E-03
Cyanide, Total	NV	33,000	3 30E+01	1.13E-02	-	-	1	3 30E+01	0 00521532	3.77E-03	3 4E+02	1 1E-05
Dibenz(a,h)anthracene	NV	21,000	2 10E+01	5.00E-03	-	-	0 13	2 73E+00	0 00521532	3.13E-04	1 3E+01	2 4E-05
Dibenzofuran	NV	1,000,000	1 00E+03	1 00E-03	-	-	1 29	1 29E+03	0 00521532	1.47E-01	--	NC
Fluoranthene	NV	1,746,969	1 75E+03	1.11E-04	-	-	0 5	8 73E+02	0.00521532	9.98E-02	6 3E+01	1 6E-03
Fluorene	NV	1,114,357	1 11E+03	2 50E-04	-0.8556	-5.562	-	9 49E-06	0.00521532	5.85E-08	6 3E+02	9 4E-11
HPAH	NV	7,796,489	7 80E+03	2 67E-04	0 9469	-1.7026	-	8 83E+02	0 00521532	1 01E-01	3 1E+00	3 3E-02
LPAH	NV	14,630,000	1 46E+04	2 65E-02	-	-	2 09	3 06E+04	0 00521532	3 49E+00	3 3E+02	1 1E-02
Indeno(1,2,3-c,d)pyrene	NV	74,000	7 40E+01	2 00E-05	-	-	0 11	8 14E+00	0 00521532	9 30E-04	7 2E+01	1.3E-05
m,p-Xylene	NV	3,900	3 90E+00	1.80E-03	-	-	3 28	1 28E+01	0 00521532	1.46E-03	2 6E+00	5 6E-04
Methylene chloride	NV	216	2 16E-01	5.00E-03	-	-	18.8	4 06E+00	0 00521532	4.65E-04	5 0E+01	9 3E-06
Naphthalene	NV	6,500,000	6 50E+03	1 20E-02	-	-	12.2	7 93E+04	0 00521532	9 06E+00	7 2E+01	1 3E-01
o-Xylene	NV	2,000	2 00E+00	1 80E-03	-	-	3 28	6 56E+00	0 00521532	7.50E-04	2 6E+00	2 9E-04
Phenanthrene	NV	195,791	1 96E+02	3 20E-04	0 6203	-0 1665	-	2.24E+01	0 00521532	2.55E-03	2 6E+01	9 9E-05
Phenol	NV	820,000	8 20E+02	2.59E-03	-	-	0 0494	4.05E+01	0 00521532	4.63E-03	3.0E+02	1 5E-05
Pyrene	NV	1,510,834	1 51E+03	3 51E-05	-	-	0 72	1 09E+03	0 00521532	1.24E-01	3 8E+01	3 3E-03
Xylenes (Total)	NV	5,468	5 47E+00	1 80E-03	-	-	3 28	1.79E+01	0 00521532	2 05E-03	2 6E+00	7 9E-04
Exposure Area 6 - surface soil												
2-Methylphenol	4,100	NV	4 10E+00	1 08E-02	-	-	3	1 23E+01	0 00023262	6 32E-05	1 1E+03	5 7E-08
3&4-Methylphenol	11,000	NV	1 10E+01	3 74E-01	-	-	2 63	2 89E+01	0 00023262	1.52E-04	1 1E+03	1 4E-07
Acenaphthene	550,000	NV	5 50E+02	1.30E-05	-0 8556	-5 562	-	1.74E-05	0 00023262	5.60E-05	3 5E+02	1 6E-07
Acenaphthylene	140,000	NV	1.40E+02	5.00E-03	0.791	-1.144	-	1 59E+01	0 00023262	9 52E-05	3 5E+02	2 7E-07
Anthracene	860,000	NV	8 60E+02	5.00E-03	0.7784	-0 9887	-	7.16E+01	0 00023262	4 52E-04	5 0E+02	9 0E-07
Benzo(a)anthracene	2,400,000	NV	2 40E+03	2 00E-05	0 5944	-2 7078	-	6.81E+00	0 00023262	2.79E-04	8 5E-01	3 3E-04
Benzo(a)pyrene	2,200,000	NV	2 20E+03	2 45E-05	0 975	-2 0615	-	2.31E+02	0 00023262	1.40E-03	3.1E+00	4 6E-04
Benzo(b)fluoranthene	2,500,000	NV	2 50E+03	2 53E-05	-	-	0.31	7.75E+02	0 00023262	4.20E-03	4 0E+01	1 1E-04
Benzo(g,h,i)perylene	1,100,000	NV	1 10E+03	2.50E-05	1 1829	-0 9313	-	1.56E+03	0 00023262	8 06E-03	7 2E+01	1 1E-04
Benzo(k)fluoranthene	1,000,000	NV	1 00E+03	1.78E-05	0.8595	-2 1579	-	4.38E+01	0 00023262	3 25E-04	7 2E+01	4 5E-06
Carbazole	650,000	NV	6 50E+02	1 00E-03	-	-	1 87	1 22E+03	0 00023262	6 26E-03	1 1E+02	5 5E-05
Chrysene	2,500,000	NV	2 50E+03	2 53E-05	0 5944	-2 7078	-	6.98E+00	0 00023262	2 90E-04	8 5E-01	3 4E-04
Cyanide, Total	NV	NV	NV	1 13E-02	-	-	1	NC	0 00023262	NC	3 4E+02	NC
Dibenz(a,h)anthracene	370,000	NV	3 70E+02	5 00E-03	-	-	0 13	4.81E+01	0 00023262	2.83E-04	1 3E+01	2 1E-05
Dibenzofuran	200,000	NV	2 00E+02	1 00E-03	-	-	1 29	2.58E+02	0 00023262	1.33E-03	--	NC
Fluoranthene	5,300,000	NV	5 30E+03	1.11E-04	-	-	0 5	2 65E+03	0 00023262	1 40E-02	6 3E+01	2 2E-04
Fluorene	470,000	NV	4 70E+02	2 50E-04	-0 8556	-5 562	-	1 99E-05	0 00023262	4 79E-05	6 3E+02	7 7E-08
HPAH	17,970,000	NV	1 80E+04	2 67E-04	0 9469	-1.7026	-	1 95E+03	0 00023262	1.17E-02	3 1E+00	3 8E-03
LPAH	11,776,200	NV	1 18E+04	2 65E-02	-	-	2 09	2 46E+04	0 00023262	1.27E-01	3.3E+02	3 9E-04
Indeno(1,2,3-c,d)pyrene	1,100,000	NV	1 10E+03	2 00E-05	-	-	0 11	1 21E+02	0 00023262	7.29E-04	7 2E+01	1 0E-05
Naphthalene	450,000	NV	4 50E+02	1 20E-02	-	-	12 2	5.49E+03	0 00023262	2 80E-02	7 2E+01	3 9E-04

Table 4
Herbivorous Mammal (Mule Deer)
Soil HQ Calculations
Vertellus - Provo, Utah

Soil COPECs	Soil EPC 0 - 1 ft bgs *(ug/kg)*	Soil EPC 1 - 3 ft bgs *(ug/kg)*	C_{SO} *(mg/kg)*	C_{SW} *(mg/L)*	Slope p	Intercept p	BCF p	C_p *(mg/kg)*	AUF	Average Daily Dose *(mg/kg-bw/d)*	Mammalian LOEC-TRV *(mg/kg-bw/d)*	LOEC-HQ
Phenanthrene	4,400,000	NV	4 40E+03	3 20E-04	0 6203	-0 1665	-	1 54E+02	0 00023262	1 23E-03	2 6E+01	4 8E-05
Phenol	6,700	NV	6 70E+00	2 59E-03	-	-	0 0494	3 31E-01	0 00023262	2 40E-06	3.0E+02	8 0E-09
Pyrene	4,800,000	NV	4 80E+03	3 51E-05	-	-	0 72	3 46E+03	0 00023262	1 81E-02	3 8E+01	4 8E-04
Exposure Area 7 - surface and subsurface soi												
Acenaphthene	751	616	7 51E-01	1 30E-05	-0 8556	-5 562	-	4.91E-03	0 00862482	3 77E-06	3 5E+02	1 1E-08
Anthracene	4,016	327	4 02E+00	5.00E-03	0 7784	-0 9887	-	1 10E+00	0 00862482	2.24E-04	5 0E+02	4 5E-07
Benzo(a)anthracene	6,727	2,132	6 73E+00	2 00E-05	0 5944	-2 7078	-	2 07E-01	0.00862482	6 45E-05	8 5E-01	7 6E-05
Benzo(a)pyrene	7,752	2,334	7 75E+00	2 45E-05	0 975	-2.0615	-	9 37E-01	0 00862482	2 06E-04	3 1E+00	6 7E-05
Benzo(b)fluoranthene	8,618	2,835	8 62E+00	2 53E-05	-	-	0 31	2 67E+00	0 00862482	5 37E-04	4 0E+01	1 3E-05
Benzo(g,h,i)perylene	5,062	1,042	5 06E+00	2 50E-05	1 1829	-0.9313	-	2 68E+00	0 00862482	5 26E-04	7 2E+01	7 3E-06
Benzo(k)fluoranthene	4,075	767	4 08E+00	1 78E-05	0 8595	-2 1579	-	3 87E-01	0 00862482	8 84E-05	7 2E+01	1 2E-06
Chrysene	8,793	2,505	8 79E+00	2 53E-05	0 5944	-2.7078	-	2 43E-01	0 00862482	7 91E-05	8 5E-01	9 3E-05
Cyanide, Total	NV	NV	NV	1 13E-02	-	-	1	NC	0 00862482	NC	3 4E+02	NC
Dibenz(a,h)anthracene	1,512	194	1 51E+00	5 00E-03	-	-	0 13	1 97E-01	0 00862482	4 47E-05	1 3E+01	3 4E-06
Fluoranthene	12,267	3,414	1 23E+01	1 11E-04	-	-	0 5	6 13E+00	0 00862482	1 20E-03	6 3E+01	1 9E-05
Fluorene	696	167	6.96E-01	2 50E-04	-0 8556	-5 562	-	5.24E-03	0.00862482	3 71E-06	6 3E+02	5 9E-09
HPAH	58,934	16,089	5.89E+01	2 67E-04	0 9469	-1 7026	-	8 65E+00	0 00862482	1 86E-03	3 1E+00	6 0E-04
LPAH	30,420	10,633	3 04E+01	2 65E-02	-	-	2 09	6 36E+01	0 00862482	1 21E-02	3 3E+02	3 7E-05
Indeno(1,2,3-c,d)pyrene	4,884	624	4 88E+00	2 00E-05	-	-	0 11	5 37E-01	0 00862482	1 20E-04	7 2E+01	1 7E-06
Naphthalene	12,555	2,520	1 26E+01	1 20E-02	-	-	12 2	1 53E+02	0 00862482	2 90E-02	7 2E+01	4 1E-04
Phenanthrene	6,606	2,576	6 61E+00	3 20E-04	0 6203	-0.1665	-	2 73E+00	0 00862482	5 41E-04	2 6E+01	2 1E-05
Pyrene	11,718	3,187	1 17E+01	3 51E-05	-	-	0 72	8 44E+00	0 00862482	1 64E-03	3 8E+01	4 4E-05

Notes:

For the calculation of HPAH and LPAH, Kaplan-Meir method was applied for summing detects and non-detects of PAHs at individual sample locations. For sample locations where no individual PAHs were detected, the resulting calculated concentration is treated as a non-detect and the calculated RL is reported

EPC set equal to 95% UCL If not enough samples were available to calculate a UCL, the EPC was set to the maximum detected concentration, "ND" if no samples were detected at that depth, or "NV" if the COPEC was not analyzed at that depth
Incidentially ingested soil is assumed to be from surface soil If no surface-level data are available (NV or ND), subsurface soil data are used for soil ingestion
Risk calculation not performed at Hotspots given the negligable Area Use Factor

Bold HQs are greater than 1 0

AUF = area use factor
BAF = bioaccumulation factor
bgs = below ground surface
COPEC = chemical of potential ecological concern
C_i = concentration in invertebrate tissue
C_m = concentration in mammal tissue
C_p = concentration in plant tissue
C_{SO} = concentration in soil (maximum of surface and subsurface EPCs, if available)
C_{SW} = concentration in surface water
EPC = exposure point concentration
HPAH = high molecular weight PAH, calculated from individual PAH results, includes Benz(a)anthracene, Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(g,h,i)perylene, Benzo(k)fluoranthene, Chrysene, Dibenz(a,h)anthracene, Indeno(1,2,3-
HQ = hazard quotient, HQ = EPC / LOEC
LOEC = lowest observed effects concentration
LPAH = low molecular weigth PAH, calculated from individual PAH results, includes 2-Methylnaphthalene, Acenaphthene, Acenaphthylene, Anthracene, Fluoranthene, Fluorene, Naphthalene, and Phenanthrene
ug/kg = micrograms per kilogram
mg/kg = milligrams per kilogram
mg/kg-bw/day = milligrams per kilogram body weight per day
mg/L = milligrams per liter
NC = not calculated
NV = no value
P = plants
PAH = polycyclic aromatic hydrocarbon
TRV = toxicity reference value

Table 5
Carnivorous Mammal (Red Fox)
Soil HQ Calculations
Vertellus - Provo, Utah

Receptor	Red fox
Body weight	4 54 kg
Food Ingestion Rate	0 100 kg/day dw
Composition of Diet	100% Small Mammals
Soil Ingestion Rate	0 0028 kg/day
Water Ingestion Rate	0 386 L/day

Soil COPECs	Soil EPC 0 - 1 ft bgs (ug/kg)	Soil EPC 1 - 3 ft bgs (ug/kg)	C_{so} (mg/kg)	C_{sw} (mg/L)	Slope m	Intercept m	BAF m	C_m (mg/kg)	AUF	Average Daily Dose (mg/kg-bw/d)	Mammalian LOEC-TRV (mg/kg-bw/d)	LOEC-HQ
Exposure Area 2 - subsurface soi												
3&4-Methylphenol	NV	1,060,000	1 06E+03	3 74E-01	-	-	0 00000169	1 79E-03	0 00193064	6 14E-05	1 1E+03	5 6E-08
Acenaphthene	NV	1,782,714	1.78E+03	1 30E-05	-	-	0	0 00E+00	0 00193064	2 13E-09	3 5E+02	6 1E-12
Acenaphthylene	NV	464,140	4 64E+02	5 00E-03	-	-	0	0 00E+00	0 00193064	8 21E-07	3 5E+02	2.3E-09
Acetone	NV	366	3 66E-01	4.30E-03	-	-	0 0472	1.73E-02	0 00193064	1 44E-06	5 0E+01	2 9E-08
Anthracene	NV	7,614,245	7 61E+03	5 00E-03	-	-	0	0.00E+00	0 00193064	8.21E-07	5 0E+02	1 6E-09
Benzene	NV	167,270	1 67E+02	1 78E-02	-	-	0 0493	8 25E+00	0 00193064	3 54E-04	2 6E+02	1.3E-06
Benzo(a)anthracene	NV	1,148,770	1 15E+03	2 00E-05	-	-	0	0.00E+00	0 00193064	3 28E-09	8 5E-01	3.9E-09
Benzo(a)pyrene	NV	1,081,643	1 08E+03	2 45E-05	-	-	0	0 00E+00	0 00193064	4 02E-09	3 1E+00	1.3E-09
Benzo(b)fluoranthene	NV	1,130,531	1 13E+03	2 53E-05	-	-	0	0 00E+00	0 00193064	4 15E-09	4 0E+01	1 0E-10
Benzo(g,h,i)perylene	NV	NV	NV	2 50E-05	-	-	0	NC	0 00193064	NC	7 2E+01	NC
Benzo(k)fluoranthene	NV	632,436	6 32E+02	1 78E-05	-	-	0	0 00E+00	0 00193064	2 92E-09	7 2E+01	4 1E-11
Carbon disulfide	NV	8	8 05E-03	5 00E-03	-	-	0 00000267	2.15E-08	0 00193064	8 21E-07	1 3E+00	6 6E-07
Chloroform	NV	12	1 20E-02	5.00E-03	-	-	0 115	1.38E-03	0 00193064	8 79E-07	7 5E+01	1 2E-08
Chrysene	NV	1,313,841	1 31E+03	2 53E-05	-	-	0	0.00E+00	0 00193064	4 15E-09	8 5E-01	4 9E-09
Cyanide, Total	NV	1,751,976	1 75E+03	1 13E-02	-	-	0 667	1 17E+03	0.00193064	4 98E-02	3.4E+02	1 5E-04
Dibenz(a,h)anthracene	NV	278,582	2 79E+02	5 00E-03	-	-	0	0 00E+00	0 00193064	8 21E-07	1 3E+01	6 2E-08
Fluoranthene	NV	6,689,586	6.69E+03	1 11E-04	-	-	0	0 00E+00	0 00193064	1 82E-08	6 3E+01	2 9E-10
Fluorene	NV	1,087,380	1 09E+03	2 50E-04	-	-	0	0 00E+00	0 00193064	4 10E-08	6 3E+02	6 6E-11
HPAH	NV	25,973,856	2 60E+04	2 67E-04	-	-	0	0 00E+00	0 00193064	4 38E-08	3 1E+00	1.4E-08
LPAH	NV	57,022,738	5 70E+04	2 65E-02	-	-	0	0.00E+00	0 00193064	4 34E-06	3 3E+02	1 3E-08
Indeno(1,2,3-c,d)pyrene	NV	570,440	5 70E+02	2 00E-05	-	-	0	0.00E+00	0 00193064	3.28E-09	7 2E+01	4 6E-11
Methyl ethyl ketone	NV	60	6 00E-02	1.00E-02	-	-	0 0644	3 86E-03	0 00193064	1 81E-06	4 6E+03	4 0E-10
Methylene chlonde	NV	95	9 47E-02	5.00E-03	-	-	0 0484	4 58E-03	0.00193064	1 02E-06	5 0E+01	2 0E-08
Naphthalene	NV	13,662,909	1 37E+04	1 20E-02	-	-	0	0 00E+00	0.00193064	1 96E-06	7.2E+01	2 7E-08
Phenanthrene	NV	9,927,421	9 93E+03	3 20E-04	-	-	0	0.00E+00	0 00193064	5.25E-08	2 6E+01	2 0E-09
Phenol	NV	916,000	9 16E+02	2 59E-03	-	-	15.4	1 41E+04	0 00193064	6 01E-01	3 0E+02	2.0E-03
Pyrene	NV	4,961,400	4 96E+03	3 51E-05	-	-	0	0 00E+00	0 00193064	5.76E-09	3 8E+01	1.5E-10
Toluene	NV	255,319	2 55E+02	4 22E-03	-	-	0.157	4 01E+01	0 00193064	1 71E-03	2 6E+02	6 6E-06
Xylenes (Total)	NV	297,374	2 97E+02	1 80E-03	-	-	0 311	9 25E+01	0 00193064	3 94E-03	2 6E+00	1 5E-03
Exposure Area 3 - surface and subsurface soi												
2-Methylphenol	822	ND	8 22E-01	1 08E-02	-	-	0 00000154	1 27E-06	0 00445665	6 37E-06	1.1E+03	5 8E-09
3&4-Methylphenol	793	ND	7 93E-01	3 74E-01	-	-	0 00000169	1.34E-06	0 00445665	1 44E-04	1 1E+03	1 3E-07
Acenaphthene	24,865	130,716	1.31E+02	1 30E-05	-	-	0	0 00E+00	0 00445665	6 85E-05	3 5E+02	2 0E-07
Acenaphthylene	4,561	ND	4 56E+00	5 00E-03	-	-	0	0 00E+00	0 00445665	1.45E-05	3 5E+02	4 1E-08
Anthracene	36,207	70,864	7 09E+01	5 00E-03	-	-	0	0 00E+00	0 00445665	1 02E-04	5 0E+02	2.0E-07
Benzo(a)anthracene	158,594	218,626	2 19E+02	2 00E-05	-	-	0	0.00E+00	0 00445665	4 37E-04	8 5E-01	5.1E-04
Benzo(a)pyrene	193,969	452,415	4 52E+02	2 45E-05	-	-	0	0 00E+00	0 00445665	5 34E-04	3 1E+00	1 7E-04
Benzo(b)fluoranthene	212,507	297,789	2 98E+02	2 53E-05	-	-	0	0 00E+00	0 00445665	5 86E-04	4 0E+01	1.5E-05
Benzo(g,h,i)perylene	110,000	NV	1 10E+02	2 50E-05	-	-	0	0 00E+00	0 00445665	3 03E-04	7 2E+01	4 2E-06
Benzo(k)fluoranthene	147,228	309,803	3 10E+02	1 78E-05	-	-	0	0 00E+00	0 00445665	4 06E-04	7 2E+01	5 6E-06
bis(2-Ethylhexyl)phthalate	1,600	NV	1 60E+00	5 00E-03	-	-	329	5 26E+02	0 00445665	5.18E-02	1 8E+02	2 8E-04
Chrysene	203,388	257,520	2 58E+02	2 53E-05	-	-	0	0 00E+00	0 00445665	5 60E-04	8 5E-01	6 6E-04
Cyanide, Total	38,507	10,299	3 85E+01	1 13E-02	-	-	0 667	2 57E+01	0 00445665	2 64E-03	3 4E+02	7 7E-06
Dibenz(a,h)anthracene	30,443	31,345	3 13E+01	5 00E-03	-	-	0	0.00E+00	0 00445665	8 58E-05	1 3E+01	6 4E-06
Dibenzofuran	11,000	NV	1 10E+01	1 00E-03	-	-	0 218	2 40E+00	0 00445665	2 67E-04	--	NC
Fluoranthene	275,373	353,951	3 54E+02	1 11E-04	-	-	0	0 00E+00	0 00445665	7 59E-04	6 3E+01	1.2E-05
Fluorene	22,185	155,000	1 55E+02	2 50E-04	-	-	0	0.00E+00	0 00445665	6 12E-05	6.3E+02	9 8E-08
HPAH	1,420,966	3,397,173	3 40E+03	2 67E-04	-	-	0	0 00E+00	0.00445665	3 92E-03	3.1E+00	1 3E-03
LPAH	1,191,689	1,237,321	1 24E+03	2 65E-02	-	-	0	0 00E+00	0 00445665	3 29E-03	3 3E+02	1.0E-05
Indeno(1,2,3-c,d)pyrene	129,935	339,803	3 40E+02	2 00E-05	-	-	0	0 00E+00	0 00445665	3 58E-04	7 2E+01	5 0E-06
Methylene chloride	1,774	131	1 77E+00	5 00E-03	-	-	0 0484	8 59E-02	0 00445665	1 52E-05	5 0E+01	3 0E-07

Table 5
Carnivorous Mammal (Red Fox)
Soil HQ Calculations
Vertellus - Provo, Utah

Soil COPECs	Soil EPC 0 - 1 ft bgs (ug/kg)	Soil EPC 1 - 3 ft bgs (ug/kg)	C_{so} (mg/kg)	C_{sw} (mg/L)	Slope m	Intercept m	BAF m	C_m (mg/kg)	AUF	Average Daily Dose (mg/kg-bw/d)	Mammalian LOEC-TRV (mg/kg-bw/d)	LOEC-HQ
Naphthalene	71,917	29,000	7.19E+01	1.20E-02	-	-	0	0 00E+00	0 00445665	2.03E-04	7 2E+01	2 8E-06
Phenanthrene	229,423	362,681	3.63E+02	3.20E-04	-	-	0	0 00E+00	0 00445665	6.32E-04	2 6E+01	2 5E-05
Phenol	608	ND	6 08E-01	2.59E-03	-	-	15 4	9 37E+00	0 00445665	9 24E-04	3 0E+02	3.1E-06
Pyrene	396,383	369,778	3 96E+02	3 51E-05	-	-	0	0 00E+00	0 00445665	1 09E-03	3 8E+01	2.9E-05
Exposure Area 4 - subsurface soi												
2-Methylphenol	NV	150,000	1 50E+02	1 08E-02	-	-	0 00000154	2 31E-04	0 00212532	1 97E-06	1 1E+03	1 8E-09
3&4-Methylphenol	NV	470,000	4.70E+02	3 74E-01	-	-	0.00000169	7.94E-04	0 00212532	6.75E-05	1.1E+03	6.1E-08
Acenaphthene	NV	1,739,574	1.74E+03	1.30E-05	-	-	0	0.00E+00	0 00212532	2 35E-09	3 5E+02	6.7E-12
Acenaphthylene	NV	130,620	1 31E+02	5 00E-03	-	-	0	0 00E+00	0 00212532	9 03E-07	3 5E+02	2.6E-09
Acetone	NV	792	7 92E-01	4 30E-03	-	-	0 0472	3 74E-02	0 00212532	2 53E-06	5 0E+01	5 1E-08
Anthracene	NV	635,005	6 35E+02	5 00E-03	-	-	0	0 00E+00	0 00212532	9 03E-07	5 0E+02	1 8E-09
Benzo(a)anthracene	NV	3,700,000	3.70E+03	2 00E-05	-	-	0	0 00E+00	0 00212532	3 61E-09	8 5E-01	4.3E-09
Benzo(a)pyrene	NV	156,369	1 56E+02	2 45E-05	-	-	0	0 00E+00	0 00212532	4 43E-09	3 1E+00	1 4E-09
Benzo(b)fluoranthene	NV	190,000	1 90E+02	2 53E-05	-	-	0	0 00E+00	0 00212532	4 57E-09	4 0E+01	1 1E-10
Benzo(g,h,i)perylene	NV	NV	NV	2 50E-05	-	-	0	NC	0 00212532	NC	7 2E+01	NC
Benzo(k)fluoranthene	NV	42,780	4 28E+01	1 78E-05	-	-	0	0.00E+00	0 00212532	3 22E-09	7.2E+01	4.5E-11
Carbon disulfide	NV	940	9 40E-01	5 00E-03	-	-	0.00000267	2.51E-06	0 00212532	9 03E-07	1 3E+00	7.2E-07
Chrysene	NV	2,917,714	2 92E+03	2 53E-05	-	-	0	0.00E+00	0 00212532	4 57E-09	8 5E-01	5.4E-09
Cyanide, Total	NV	33,000	3 30E+01	1.13E-02	-	-	0 667	2 20E+01	0 00212532	1 03E-03	3 4E+02	3 0E-06
Dibenz(a,h)anthracene	NV	21,000	2.10E+01	5 00E-03	-	-	0	0.00E+00	0 00212532	9 03E-07	1 3E+01	6 8E-08
Dibenzofuran	NV	1,000,000	1 00E+03	1.00E-03	-	-	0 218	2 18E+02	0 00212532	1 02E-02	--	NC
Fluoranthene	NV	1,746,969	1.75E+03	1 11E-04	-	-	0	0 00E+00	0 00212532	2 01E-08	6 3E+01	3 2E-10
Fluorene	NV	1,114,357	1.11E+03	2 50E-04	-	-	0	0.00E+00	0 00212532	4 52E-08	6 3E+02	7 2E-11
HPAH	NV	7,796,489	7 80E+03	2 67E-04	-	-	0	0.00E+00	0 00212532	4 82E-08	3 1E+00	1 6E-08
LPAH	NV	14,630,000	1 46E+04	2 65E-02	-	-	0	0.00E+00	0.00212532	4 78E-06	3 3E+02	1.5E-08
Indeno(1,2,3-c,d)pyrene	NV	74,000	7.40E+01	2 00E-05	-	-	0	0 00E+00	0 00212532	3 61E-09	7 2E+01	5 0E-11
m,p-Xylene	NV	3,900	3 90E+00	1 80E-03	-	-	0.311	1 21E+00	0.00212532	5 72E-05	2.6E+00	2 2E-05
Methylene chlonde	NV	216	2.16E-01	5 00E-03	-	-	0.0484	1.05E-02	0.00212532	1 39E-06	5.0E+01	2 8E-08
Naphthalene	NV	6,500,000	6 50E+03	1 20E-02	-	-	0	0.00E+00	0.00212532	2 16E-06	7.2E+01	3 0E-08
o-Xylene	NV	2,000	2 00E+00	1 80E-03	-	-	0.311	6.22E-01	0.00212532	2.95E-05	2.6E+00	1.1E-05
Phenanthrene	NV	195,791	1 96E+02	3 20E-04	-	-	0	0.00E+00	0.00212532	5 78E-08	2.6E+01	2 2E-09
Phenol	NV	820,000	8.20E+02	2 59E-03	-	-	15 4	1.26E+04	0.00212532	5 93E-01	3.0E+02	2 0E-03
Pyrene	NV	1,510,834	1.51E+03	3.51E-05	-	-	0	0 00E+00	0 00212532	6 34E-09	3 8E+01	1 7E-10
Xylenes (Total)	NV	5,468	5.47E+00	1.80E-03	-	-	0 311	1 70E+00	0 00212532	8 01E-05	2 6E+00	3 1E-05
Exposure Area 6 - surface soil												
2-Methylphenol	4,100	NV	4 10E+00	1 08E-02	-	-	0 00000154	6 31E-06	9 4798E-05	3 28E-07	1.1E+03	3 0E-10
3&4-Methylphenol	11,000	NV	1 10E+01	3 74E-01	-	-	0 00000169	1 86E-05	9.4798E-05	3 66E-06	1.1E+03	3 3E-09
Acenaphthene	550,000	NV	5.50E+02	1 30E-05	-	-	0	0.00E+00	9.4798E-05	3 22E-05	3 5E+02	9 2E-08
Acenaphthylene	140,000	NV	1.40E+02	5.00E-03	-	-	0	0 00E+00	9 4798E-05	8 25E-06	3 5E+02	2 4E-08
Anthracene	860,000	NV	8 60E+02	5 00E-03	-	-	0	0 00E+00	9 4798E-05	5 04E-05	5 0E+02	1 0E-07
Benzo(a)anthracene	2,400,000	NV	2 40E+03	2 00E-05	-	-	0	0 00E+00	9.4798E-05	1.41E-04	8.5E-01	1 7E-04
Benzo(a)pyrene	2,200,000	NV	2 20E+03	2 45E-05	-	-	0	0 00E+00	9 4798E-05	1 29E-04	3 1E+00	4 2E-05
Benzo(b)fluoranthene	2,500,000	NV	2 50E+03	2 53E-05	-	-	0	0 00E+00	9 4798E-05	1 47E-04	4.0E+01	3.7E-06
Benzo(g,h,i)perylene	1,100,000	NV	1 10E+03	2 50E-05	-	-	0	0 00E+00	9 4798E-05	6.45E-05	7.2E+01	9.0E-07
Benzo(k)fluoranthene	1,000,000	NV	1 00E+03	1 78E-05	-	-	0	0 00E+00	9 4798E-05	5.86E-05	7.2E+01	8.1E-07
Carbazole	650,000	NV	6 50E+02	1 00E-03	-	-	0 0605	3 93E+01	9 4798E-05	1.20E-04	1 1E+02	1.1E-06
Chrysene	2,500,000	NV	2 50E+03	2 53E-05	-	-	0	0 00E+00	9.4798E-05	1.47E-04	8.5E-01	1 7E-04
Cyanide, Total	NV	NV	NV	1 13E-02	-	-	0.667	NC	9.4798E-05	NC	3 4E+02	NC
Dibenz(a,h)anthracene	370,000	NV	3 70E+02	5 00E-03	-	-	0	0 00E+00	9 4798E-05	2 17E-05	1 3E+01	1 6E-06
Dibenzofuran	200,000	NV	2 00E+02	1 00E-03	-	-	0 218	4 36E+01	9 4798E-05	1.03E-04	--	NC
Fluoranthene	5,300,000	NV	5 30E+03	1 11E-04	-	-	0	0 00E+00	9 4798E-05	3.11E-04	6.3E+01	5 0E-06
Fluorene	470,000	NV	4 70E+02	2 50E-04	-	-	0	0 00E+00	9 4798E-05	2.75E-05	6 3E+02	4 4E-08
HPAH	17,970,000	NV	1 80E+04	2 67E-04	-	-	0	0 00E+00	9 4798E-05	1.05E-03	3 1E+00	3 4E-04
LPAH	11,776,200	NV	1 18E+04	2 65E-02	-	-	0	0 00E+00	9.4798E-05	6.90E-04	3 3E+02	2 1E-06
Indeno(1,2,3-c,d)pyrene	1,100,000	NV	1 10E+03	2 00E-05	-	-	0	0 00E+00	9 4798E-05	6 45E-05	7 2E+01	9 0E-07
Naphthalene	450,000	NV	4.50E+02	1.20E-02	-	-	0	0 00E+00	9 4798E-05	2 65E-05	7 2E+01	3.7E-07
Phenanthrene	4,400,000	NV	4 40E+03	3 20E-04	-	-	0	0.00E+00	9 4798E-05	2.58E-04	2 6E+01	1 0E-05
Phenol	6,700	NV	6 70E+00	2 59E-03	-	-	15.4	1.03E+02	9 4798E-05	2 16E-04	3 0E+02	7 2E-07

Table 5
Carnivorous Mammal (Red Fox)
Soil HQ Calculations
Vertellus - Provo, Utah

Soil COPECs	Soil EPC 0 - 1 ft bgs (ug/kg)	Soil EPC 1 - 3 ft bgs (ug/kg)	C_{SO} (mg/kg)	C_{SW} (mg/L)	Slope m	Intercept m	BAF m	C_m (mg/kg)	AUF	Average Daily Dose (mg/kg-bw/d)	Mammalian LOEC-TRV (mg/kg-bw/d)	LOEC-HQ
Pyrene	4,800,000	NV	4 80E+03	3 51E-05	-	-	0	0 00E+00	9 4798E-05	2 81E-04	3 8E+01	7.5E-06
Exposure Area 7 - surface and subsurface soi												
Acenaphthene	751	616	7 51E-01	1 30E-05	-	-	0	0.00E+00	0 00351474	1 64E-06	3 5E+02	4 7E-09
Anthracene	4,016	327	4 02E+00	5 00E-03	-	-	0	0.00E+00	0.00351474	1 02E-05	5 0E+02	2 0E-08
Benzo(a)anthracene	6,727	2,132	6 73E+00	2 00E-05	-	-	0	0 00E+00	0.00351474	1 46E-05	8 5E-01	1 7E-05
Benzo(a)pyrene	7,752	2,334	7.75E+00	2 45E-05	-	-	0	0.00E+00	0 00351474	1 69E-05	3 1E+00	5 5E-06
Benzo(b)fluoranthene	8,618	2,835	8 62E+00	2 53E-05	-	-	0	0.00E+00	0.00351474	1 87E-05	4 0E+01	4 7E-07
Benzo(g,h,i)perylene	5,062	1,042	5 06E+00	2.50E-05	-	-	0	0 00E+00	0 00351474	1 10E-05	7 2E+01	1 5E-07
Benzo(k)fluoranthene	4,075	767	4 08E+00	1 78E-05	-	-	0	0 00E+00	0 00351474	8 86E-06	7 2E+01	1 2E-07
Chrysene	8,793	2,505	8 79E+00	2 53E-05	-	-	0	0 00E+00	0 00351474	1 91E-05	8 5E-01	2 2E-05
Cyanide, Total	NV	NV	NV	1 13E-02	-	-	0 667	NC	0 00351474	NC	3 4E+02	NC
Dibenz(a,h)anthracene	1,512	194	1 51E+00	5 00E-03	-	-	0	0 00E+00	0 00351474	4 78E-06	1 3E+01	3 6E-07
Fluoranthene	12,267	3,414	1 23E+01	1.11E-04	-	-	0	0 00E+00	0 00351474	2 67E-05	6 3E+01	4 3E-07
Fluorene	696	167	6 96E-01	2 50E-04	-	-	0	0 00E+00	0 00351474	1 59E-06	6 3E+02	2 5E-09
HPAH	58,934	16,089	5 89E+01	2 67E-04	-	-	0	0 00E+00	0 00351474	1.28E-04	3 1E+00	4 2E-05
LPAH	30,420	10,633	3 04E+01	2 65E-02	-	-	0	0 00E+00	0 00351474	7 40E-05	3 3E+02	2.3E-07
Indeno(1,2,3-c,d)pyrene	4,884	624	4 88E+00	2 00E-05	-	-	0	0 00E+00	0 00351474	1 06E-05	7 2E+01	1 5E-07
Naphthalene	12,555	2,520	1 26E+01	1.20E-02	-	-	0	0 00E+00	0 00351474	3 09E-05	7 2E+01	4 3E-07
Phenanthrene	6,606	2,576	6 61E+00	3.20E-04	-	-	0	0 00E+00	0 00351474	1 45E-05	2 6E+01	5 6E-07
Pyrene	11,718	3,187	1 17E+01	3 51E-05	-	-	0	0 00E+00	0 00351474	2 55E-05	3 8E+01	6.8E-07

Notes:

For the calculation of HPAH and LPAH, Kaplan-Meir method was applied for summing detects and non-detects of PAHs at individual sample locations For sample locations where no individual PAHs were detected, the resulting calculated concentration is treated as a non-detect and the calculated RL is reported.

EPC set equal to 95% UCL If not enough samples were available to calculate a UCL, the EPC was set to the maximum detected concentration, "ND" if no samples were detected at that depth, or "NV" if the COPEC was not analyzed at that depth.
Incidentially ingested soil is assumed to be from surface soil If no surface-level data are available (NV or ND), subsurface soil data are used for soil ingestion
Risk calculation not performed at Hotspots given the negligable Area Use Factor

Bold HQs are greater than 1 0

AUF = area use factor

BAF = bioaccumulation factor

bgs = below ground surface

COPEC = chemical of potential ecological concern

C_i = concentration in invertebrate tissue

C_m = concentration in mammal tissue

C_p = concentration in plant tissue

C_{SO} = concentration in soil (maximum of surface and subsurface EPCs, if available)

C_{SW} = concentration in surface water

EPC = exposure point concentration

HPAH = high molecular weight PAH, calculated from individual PAH results, includes Benz(a)anthracene, Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(g,h,i)perylene, Benzo(k)fluoranthene, Chrysene, Dibenz(a,h)anthracene, Indeno(1,2,3-

HQ = hazard quotient, HQ = EPC / LOEC

LOEC = lowest observed effects concentration

LPAH = low molecular weigth PAH, calculated from individual PAH results, includes 2-Methylnaphthalene, Acenaphthene, Acenaphthylene, Anthracene, Fluoranthene, Fluorene, Naphthalene, and Phenanthrene

ug/kg = micrograms per kilogram

mg/kg = milligrams per kilogram

mg/kg-bw/day = milligrams per kilogram body weight per day

mg/L = milligrams per liter

NC = not calculated

NV = no value

P = plants

PAH = polycyclic aromatic hydrocarbon

TRV = toxicity reference value

Table 6
Invertivorous Mammal (Deer Mouse)
Soil HQ Calculations
Vertellus - Provo, Utah

Receptor	Deer mouse
Body weight	0 0179 kg
Food Ingestion Rate	0 004 kg/day dw
Composition of Diet	100% Invertebrates
Soil Ingestion Rate	0 0001 kg/day
Water Ingestion Rate	0 003 L/day

Soil COPECs	Soil EPC 0 - 1 ft bgs (ug/kg)	Soil EPC 1 - 3 ft bgs (ug/kg)	C_{so} (mg/kg)	C_{sw} (mg/L)	Slope i	Intercept i	BCF i	C_i (mg/kg)	AUF	Average Daily Dose (mg/kg-bw/d)	Mammalian LOEC-TRV (mg/kg-bw/d)	LOEC-HQ
Exposure Area 2 - subsurface soi												
3&4-Methylphenol	NV	1,060,000	1 06E+03	3 74E-01	-	-	0 73	7 74E+02	1	1,65E+02	1.1E+03	1 5E-01
Acenaphthene	NV	1,782,714	1 78E+03	1 30E-05	-	-	1 47	2 62E+03	1	5 58E+02	3 5E+02	**1.6E+00**
Acenaphthylene	NV	464,140	4 64E+02	5 00E-03	-	-	22 9	1 06E+04	1	2.26E+03	3 5E+02	**6.5E+00**
Acetone	NV	366	3 66E-01	4 30E-03	-	-	3 16	1 16E+00	1	2 47E-01	5 0E+01	4.9E-03
Anthracene	NV	7,614,245	7 61E+03	5 00E-03	-	-	2 42	1 84E+04	1	3 92E+03	5 0E+02	**7.8E+00**
Benzene	NV	167,270	1 67E+02	1 78E-02	-	-	2 68	4 48E+02	1	9 54E+01	2 6E+02	3 6E-01
Benzo(a)anthracene	NV	1,148,770	1 15E+03	2 00E-05	-	-	1 59	1 83E+03	1	3 89E+02	8 5E-01	**4.6E+02**
Benzo(a)pyrene	NV	1,081,643	1 08E+03	2 45E-05	-	-	1 33	1 44E+03	1	3 06E+02	3 1E+00	**1.0E+02**
Benzo(b)fluoranthene	NV	1,130,531	1 13E+03	2 53E-05	-	-	2 6	2 94E+03	1	6.26E+02	4 0E+01	**1.6E+01**
Benzo(g,h,i)perylene	NV	NV	NV	2.50E-05	-	-	2 94	NC	1	NC	7 2E+01	NC
Benzo(k)fluoranthene	NV	632,436	6 32E+02	1 78E-05	-	-	2 6	1 64E+03	1	3 50E+02	7 2E+01	**4.9E+00**
Carbon disulfide	NV	8	8.05E-03	5.00E-03	-	-	1	8 05E-03	1	2 66E-03	1 3E+00	2 1E-03
Chloroform	NV	12	1 20E-02	5.00E-03	-	-	9.1	1 09E-01	1	2 42E-02	7 5E+01	3 2E-04
Chrysene	NV	1,313,841	1 31E+03	2 53E-05	-	-	2 29	3 01E+03	1	6 40E+02	8 5E-01	**7.5E+02**
Cyanide, Total	NV	1,751,976	1.75E+03	1.13E-02	-	-	1	1 75E+03	1	3 73E+02	3 4E+02	**1.1E+00**
Dibenz(a,h)anthracene	NV	278,582	2 79E+02	5 00E-03	-	-	2 31	6 44E+02	1	1 37E+02	1 3E+01	**1.0E+01**
Fluoranthene	NV	6,689,586	6 69E+03	1 11E-04	-	-	3 04	2 03E+04	1	4 33E+03	6 3E+01	**6.9E+01**
Fluorene	NV	1,087,380	1 09E+03	2 50E-04	-	-	9 57	1 04E+04	1	2 21E+03	6 3E+02	**3.5E+00**
HPAH	NV	25,973,856	2.60E+04	2 67E-04	-	-	2 6	6 75E+04	1	1 44E+04	3 1E+00	**4.7E+03**
LPAH	NV	57,022,738	5.70E+04	2 65E-02	-	-	3 04	1 73E+05	1	3 69E+04	3 3E+02	**1.1E+02**
Indeno(1,2,3-c,d)pyrene	NV	570,440	5 70E+02	2 00E-05	-	-	2.86	1 63E+03	1	3 47E+02	7 2E+01	**4.8E+00**
Methyl ethyl ketone	NV	60	6 00E-02	1 00E-02	-	-	3 27	1 96E-01	1	4 37E-02	4 6E+03	9 6E-06
Methylene chlonde	NV	95	9 47E-02	5 00E-03	-	-	3 16	2 99E-01	1	6 46E-02	5 0E+01	1 3E-03
Naphthalene	NV	13,662,909	1 37E+04	1 20E-02	-	-	4 4	6 01E+04	1	1 28E+04	7 2E+01	**1.8E+02**
Phenanthrene	NV	9,927,421	9.93E+03	3 20E-04	-	-	1 72	1 71E+04	1	3 63E+03	2 6E+01	**1.4E+02**
Phenol	NV	916,000	9 16E+02	2 59E-03	-	-	0 443	4.06E+02	1	8 64E+01	3 0E+02	2 9E-01
Pyrene	NV	4,961,400	4 96E+03	3 51E-05	-	-	1 75	8 68E+03	1	1 85E+03	3 8E+01	**4.9E+01**
Toluene	NV	255,319	2 55E+02	4 22E-03	-	-	5 6	1.43E+03	1	3 04E+02	2 6E+02	**1.2E+00**
Xylenes (Total)	NV	297,374	2 97E+02	1 80E-03	-	-	7 24	2 15E+03	1	4 58E+02	2 6E+00	**1.8E+02**
Exposure Area 3 - surface and subsurface soi												
2-Methylphenol	822	ND	8 22E-01	1 08E-02	-	-	0 701	5 76E-01	1	1 28E-01	1 1E+03	1 2E-04
3&4-Methylphenol	793	ND	7.93E-01	3 74E-01	-	-	0 73	5 79E-01	1	1 98E-01	1 1E+03	1.8E-04
Acenaphthene	24,865	130,716	1 31E+02	1 30E-05	-	-	1 47	1 92E+02	1	4 10E+01	3 5E+02	1 2E-01
Acenaphthylene	4,561	ND	4 56E+00	5 00E-03	-	-	22.9	1.04E+02	1	2 23E+01	3 5E+02	6 4E-02
Anthracene	36,207	70,864	7 09E+01	5 00E-03	-	-	2 42	1 71E+02	1	3 67E+01	5 0E+02	7 3E-02
Benzo(a)anthracene	158,594	218,626	2 19E+02	2 00E-05	-	-	1 59	3 48E+02	1	7 47E+01	8 5E-01	**8.8E+01**
Benzo(a)pyrene	193,969	452,415	4 52E+02	2 45E-05	-	-	1 33	6 02E+02	1	1 29E+02	3 1E+00	**4.2E+01**
Benzo(b)fluoranthene	212,507	297,789	2.98E+02	2 53E-05	-	-	2 6	7 74E+02	1	1 66E+02	4 0E+01	**4.1E+00**
Benzo(g,h,i)perylene	110,000	NV	1.10E+02	2 50E-05	-	-	2 94	3 23E+02	1	6 93E+01	7 2E+01	9.6E-01
Benzo(k)fluoranthene	147,228	309,803	3 10E+02	1 78E-05	-	-	2 6	8 05E+02	1	1 72E+02	7 2E+01	**2.4E+00**
bis(2-Ethylhexyl)phthalate	1,600	NV	1.60E+00	5 00E-03	-	-	154	2 46E+02	1	5 25E+01	1 8E+02	2 9E-01
Chrysene	203,388	257,520	2 58E+02	2 53E-05	-	-	2 29	5 90E+02	1	1 26E+02	8 5E-01	**1.5E+02**
Cyanide, Total	38,507	10,299	3 85E+01	1 13E-02	-	-	1	3 85E+01	1	8 36E+00	3 4E+02	2 4E-02
Dibenz(a,h)anthracene	30,443	31,345	3 13E+01	5 00E-03	-	-	2 31	7.24E+01	1	1 55E+01	1 3E+01	**1.2E+00**
Dibenzofuran	11,000	NV	1 10E+01	1 00E-03	-	-	2 1	2 31E+01	1	4 96E+00	--	NC
Fluoranthene	275,373	353,951	3 54E+02	1 11E-04	-	-	3 04	1 08E+03	1	2 30E+02	6 3E+01	**3.7E+00**

Table 6
Invertivorous Mammal (Deer Mouse)
Soil HQ Calculations
Vertellus - Provo, Utah

Soil COPECs	Soil EPC 0 - 1 ft bgs (ug/kg)	Soil EPC 1 - 3 ft bgs (ug/kg)	C_{so} (mg/kg)	C_{sw} (mg/L)	Slope i	Intercept i	BCF i	C_i (mg/kg)	AUF	Average Daily Dose (mg/kg-bw/d)	Mammalian LOEC-TRV (mg/kg-bw/d)	LOEC-HQ
Fluorene	22,185	155,000	1 55E+02	2 50E-04	-	-	9.57	1 48E+03	1	3 16E+02	6 3E+02	5 1E-01
HPAH	1,420,966	3,397,173	3 40E+03	2 67E-04	-	-	2.6	8.83E+03	1	1 89E+03	3 1E+00	**6.1E+02**
LPAH	1,191,689	1,237,321	1 24E+03	2 65E-02	-	-	3.04	3.76E+03	1	8 06E+02	3 3E+02	**2.5E+00**
Indeno(1,2,3-c,d)pyrene	129,935	339,803	3 40E+02	2 00E-05	-	-	2 86	9 72E+02	1	2.07E+02	7 2E+01	**2.9E+00**
Methylene chlonde	1,774	131	1 77E+00	5 00E-03	-	-	3 16	5 61E+00	1	1 20E+00	5 0E+01	2 4E-02
Naphthalene	71,917	29,000	7 19E+01	1 20E-02	-	-	4 4	3 16E+02	1	6 77E+01	7 2E+01	9 5E-01
Phenanthrene	229,423	362,681	3 63E+02	3 20E-04	-	-	1 72	6.24E+02	1	1 34E+02	2 6E+01	**5.2E+00**
Phenol	608	ND	6 08E-01	2 59E-03	-	-	0 443	2 69E-01	1	6 04E-02	3 0E+02	2.0E-04
Pyrene	396,383	369,778	3 96E+02	3.51E-05	-	-	1 75	6 94E+02	1	1 49E+02	3 8E+01	**4.0E+00**
Exposure Area 4 - subsurface soi												
2-Methylphenol	NV	150,000	1 50E+02	1 08E-02	-	-	0.701	1.05E+02	1	2 24E+01	1 1E+03	2 0E-02
3&4-Methylphenol	NV	470,000	4 70E+02	3 74E-01	-	-	0 73	3 43E+02	1	7.31E+01	1 1E+03	6 6E-02
Acenaphthene	NV	1,739,574	1 74E+03	1 30E-05	-	-	1 47	2.56E+03	1	5 44E+02	3 5E+02	**1.6E+00**
Acenaphthylene	NV	130,620	1 31E+02	5 00E-03	-	-	22.9	2 99E+03	1	6 37E+02	3 5E+02	**1.8E+00**
Acetone	NV	792	7 92E-01	4.30E-03	-	-	3 16	2 50E+00	1	5 34E-01	5 0E+01	1.1E-02
Anthracene	NV	635,005	6 35E+02	5 00E-03	-	-	2 42	1 54E+03	1	3 27E+02	5 0E+02	6 5E-01
Benzo(a)anthracene	NV	3,700,000	3 70E+03	2 00E-05	-	-	1 59	5 88E+03	1	1 25E+03	8.5E-01	**1.5E+03**
Benzo(a)pyrene	NV	156,369	1 56E+02	2 45E-05	-	-	1 33	2 08E+02	1	4.43E+01	3.1E+00	**1.4E+01**
Benzo(b)fluoranthene	NV	190,000	1.90E+02	2 53E-05	-	-	2 6	4 94E+02	1	1 05E+02	4 0E+01	**2.6E+00**
Benzo(g,h,i)perylene	NV	NV	NV	2 50E-05	-	-	2 94	NC	1	NC	7.2E+01	NC
Benzo(k)fluoranthene	NV	42,780	4 28E+01	1 78E-05	-	-	2 6	1 11E+02	1	2 37E+01	7 2E+01	3 3E-01
Carbon disulfide	NV	940	9 40E-01	5 00E-03	-	-	1	9 40E-01	1	2 01E-01	1 3E+00	1 6E-01
Chrysene	NV	2,917,714	2 92E+03	2 53E-05	-	-	2 29	6 68E+03	1	1 42E+03	8 5E-01	**1.7E+03**
Cyanide, Total	NV	33,000	3 30E+01	1 13E-02	-	-	1	3 30E+01	1	7 03E+00	3.4E+02	2 0E-02
Dibenz(a,h)anthracene	NV	21,000	2 10E+01	5 00E-03	-	-	2 31	4 85E+01	1	1.03E+01	1 3E+01	7 8E-01
Dibenzofuran	NV	1,000,000	1 00E+03	1 00E-03	-	-	2 1	2 10E+03	1	4.47E+02	--	NC
Fluoranthene	NV	1,746,969	1 75E+03	1.11E-04	-	-	3.04	5 31E+03	1	1 13E+03	6 3E+01	**1.8E+01**
Fluorene	NV	1,114,357	1 11E+03	2 50E-04	-	-	9 57	1 07E+04	1	2 27E+03	6 3E+02	**3.6E+00**
HPAH	NV	7,796,489	7 80E+03	2 67E-04	-	-	2 6	2 03E+04	1	4 31E+03	3 1E+00	**1.4E+03**
LPAH	NV	14,630,000	1 46E+04	2 65E-02	-	-	3 04	4 45E+04	1	9 47E+03	3 3E+02	**2.9E+01**
Indeno(1,2,3-c,d)pyrene	NV	74,000	7 40E+01	2 00E-05	-	-	2 86	2 12E+02	1	4 50E+01	7 2E+01	6 3E-01
m,p-Xylene	NV	3,900	3 90E+00	1 80E-03	-	-	7 24	2 82E+01	1	6 01E+00	2 6E+00	**2.3E+00**
Methylene chloride	NV	216	2 16E-01	5 00E-03	-	-	3.16	6.83E-01	1	1 46E-01	5 0E+01	2 9E-03
Naphthalene	NV	6,500,000	6 50E+03	1 20E-02	-	-	4 4	2.86E+04	1	6 09E+03	7 2E+01	**8.5E+01**
o-Xylene	NV	2,000	2 00E+00	1 80E-03	-	-	7 24	1.45E+01	1	3 08E+00	2 6E+00	**1.2E+00**
Phenanthrene	NV	195,791	1 96E+02	3 20E-04	-	-	1 72	3 37E+02	1	7 17E+01	2 6E+01	**2.8E+00**
Phenol	NV	820,000	8 20E+02	2 59E-03	-	-	0 443	3.63E+02	1	7 73E+01	3 0E+02	2 6E-01
Pyrene	NV	1,510,834	1 51E+03	3 51E-05	-	-	1.75	2.64E+03	1	5 63E+02	3 8E+01	**1.5E+01**
Xylenes (Total)	NV	5,468	5 47E+00	1 80E-03	-	-	7 24	3 96E+01	1	8 43E+00	2.6E+00	**3.2E+00**
Exposure Area 6 - surface soil												
2-Methylphenol	4,100	NV	4 10E+00	1 08E-02	-	-	0 701	2 87E+00	0 43733333	2 76E-01	1.1E+03	2.5E-04
3&4-Methylphenol	11,000	NV	1 10E+01	3 74E-01	-	-	0 73	8 03E+00	0 43733333	7 99E-01	1 1E+03	7 3E-04
Acenaphthene	550,000	NV	5 50E+02	1 30E-05	-	-	1 47	8 09E+02	0 43733333	7 63E+01	3 5E+02	2.2E-01
Acenaphthylene	140,000	NV	1 40E+02	5 00E-03	-	-	22 9	3 21E+03	0 43733333	2 99E+02	3.5E+02	8 5E-01
Anthracene	860,000	NV	8 60E+02	5 00E-03	-	-	2 42	2 08E+03	0 43733333	1.95E+02	5 0E+02	3 9E-01
Benzo(a)anthracene	2,400,000	NV	2.40E+03	2.00E-05	-	-	1 59	3 82E+03	0 43733333	3 60E+02	8 5E-01	**4.2E+02**
Benzo(a)pyrene	2,200,000	NV	2 20E+03	2 45E-05	-	-	1 33	2 93E+03	0 43733333	2.76E+02	3.1E+00	**9.0E+01**
Benzo(b)fluoranthene	2,500,000	NV	2 50E+03	2 53E-05	-	-	2 6	6 50E+03	0 43733333	6.10E+02	4 0E+01	**1.5E+01**
Benzo(g,h,i)perylene	1,100,000	NV	1 10E+03	2 50E-05	-	-	2 94	3 23E+03	0 43733333	3 03E+02	7.2E+01	**4.2E+00**
Benzo(k)fluoranthene	1,000,000	NV	1 00E+03	1 78E-05	-	-	2 6	2 60E+03	0 43733333	2.44E+02	7 2E+01	**3.4E+00**
Carbazole	650,000	NV	6 50E+02	1 00E-03	-	-	0 961	6 25E+02	0 43733333	5 94E+01	1.1E+02	5 2E-01
Chrysene	2,500,000	NV	2 50E+03	2 53E-05	-	-	2 29	5 73E+03	0 43733333	5 38E+02	8 5E-01	**6.3E+02**
Cyanide, Total	NV	NV	NV	1 13E-02	-	-	1	NC	0 43733333	NC	3.4E+02	NC

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Invertivorous Mammal (Deer Mouse)
Soil HQ Calculations
Vertellus - Provo, Utah

Soil COPECs	Soil EPC 0 - 1 ft bgs (ug/kg)	Soil EPC 1 - 3 ft bgs (ug/kg)	C_{SO} (mg/kg)	C_{SW} (mg/L)	Slope i	Intercept i	BCF i	C_i (mg/kg)	AUF	Average Daily Dose (mg/kg-bw/d)	Mammalian LOEC-TRV (mg/kg-bw/d)	LOEC-HQ
Dibenz(a,h)anthracene	370,000	NV	3 70E+02	5 00E-03	-	-	2 31	8 55E+02	0 43733333	8 02E+01	1.3E+01	**6.0E+00**
Dibenzofuran	200,000	NV	2 00E+02	1 00E-03	-	-	2 1	4 20E+02	0 43733333	3 95E+01	--	NC
Fluoranthene	5,300,000	NV	5 30E+03	1 11E-04	-	-	3 04	f 61E+04	0 43733333	1 51E+03	6 3E+01	**2.4E+01**
Fluorene	470,000	NV	4 70E+02	2 50E-04	-	-	9 57	4 50E+03	0 43733333	4 20E+02	6 3E+02	6 7E-01
HPAH	17,970,000	NV	1 80E+04	2 67E-04	-	-	2 6	4 67E+04	0.43733333	4 38E+03	3 1E+00	**1.4E+03**
LPAH	11,776,200	NV	1 18E+04	2 65E-02	-	-	3 04	3 58E+04	0.43733333	3 35E+03	3 3E+02	**1.0E+01**
Indeno(1,2,3-c,d)pyrene	1,100,000	NV	1 10E+03	2 00E-05	-	-	2 86	3 15E+03	0.43733333	2 95E+02	7 2E+01	**4.1E+00**
Naphthalene	450,000	NV	4 50E+02	1 20E-02	-	-	4 4	1 98E+03	0 43733333	1 85E+02	7 2E+01	**2.6E+00**
Phenanthrene	4,400,000	NV	4 40E+03	3.20E-04	-	-	1 72	7 57E+03	0 43733333	7 13E+02	2 6E+01	**2.8E+01**
Phenol	6,700	NV	6 70E+00	2 59E-03	-	-	0 443	2 97E+00	0 43733333	2 89E-01	3.0E+02	9 6E-04
Pyrene	4,800,000	NV	4 80E+03	3 51E-05	-	-	1 75	8 40E+03	0 43733333	7 91E+02	3 8E+01	**2.1E+01**
Exposure Area 7 - surface and subsurface soi												
Acenaphthene	751	616	7 51E-01	1 30E-05	-	-	1 47	1 10E+00	1	2 38E-01	3 5E+02	6 8E-04
Anthracene	4,016	327	4 02E+00	5 00E-03	-	-	2.42	9 72E+00	1	2 09E+00	5 0E+02	4 2E-03
Benzo(a)anthracene	6,727	2,132	6 73E+00	2 00E-05	-	-	1.59	1 07E+01	1	2 31E+00	8 5E-01	**2.7E+00**
Benzo(a)pyrene	7,752	2,334	7 75E+00	2 45E-05	-	-	1 33	1 03E+01	1	2 23E+00	3.1E+00	7 3E-01
Benzo(b)fluoranthene	8,618	2,835	8 62E+00	2 53E-05	-	-	2 6	2 24E+01	1	4 81E+00	4 0E+01	1 2E-01
Benzo(g,h,i)perylene	5,062	1,042	5 06E+00	2 50E-05	-	-	2 94	1 49E+01	1	3 19E+00	7 2E+01	4.4E-02
Benzo(k)fluoranthene	4,075	767	4 08E+00	1 78E-05	-	-	2 6	1 06E+01	1	2.27E+00	7 2E+01	3 2E-02
Chrysene	8,793	2,505	8 79E+00	2 53E-05	-	-	2 29	2 01E+01	1	4.32E+00	8 5E-01	**5.1E+00**
Cyanide, Total	NV	NV	NV	1 13E-02	-	-	1	NC	1	NC	3 4E+02	NC
Dibenz(a,h)anthracene	1,512	194	1.51E+00	5 00E-03	-	-	2 31	3 49E+00	1	7 51E-01	1 3E+01	5 6E-02
Fluoranthene	12,267	3,414	1 23E+01	1 11E-04	-	-	3 04	3 73E+01	1	7 99E+00	6 3E+01	1 3E-01
Fluorene	696	167	6 96E-01	2.50E-04	-	-	9 57	6.66E+00	1	1 42E+00	6 3E+02	2 3E-03
HPAH	58,934	16,089	5 89E+01	2.67E-04	-	-	2 6	1 53E+02	1	3 29E+01	3 1E+00	**1.1E+01**
LPAH	30,420	10,633	3 04E+01	2 65E-02	-	-	3 04	9 25E+01	1	1.98E+01	3 3E+02	6 0E-02
Indeno(1,2,3-c,d)pyrene	4,884	624	4 88E+00	2 00E-05	-	-	2 86	1 40E+01	1	2 99E+00	7 2E+01	4.2E-02
Naphthalene	12,555	2,520	1 26E+01	1 20E-02	-	-	4 4	5 52E+01	1	1 18E+01	7 2E+01	1 7E-01
Phenanthrene	6,606	2,576	6 61E+00	3 20E-04	-	-	1 72	1 14E+01	1	2 45E+00	2 6E+01	9 5E-02
Pyrene	11,718	3,187	1 17E+01	3 51E-05	-	-	1 75	2 05E+01	1	4 41E+00	3 8E+01	1.2E-01
Hotspot 2-SF-2-18 - surface soil												
Acenaphthene	2,000	NV	2	1 30E-05	-	-	1.47	2 94E+00	6.1218E-05	3 88E-05	3 5E+02	1 1E-07
Benzo(a)anthracene	22,000	NV	22	2 00E-05	-	-	1 59	3 50E+01	6 1218E-05	4 62E-04	8 5E-01	5 4E-04
Benzo(a)pyrene	26,000	NV	26	2 45E-05	-	-	1 33	3 46E+01	6 1218E-05	4 57E-04	3 1E+00	1 5E-04
Benzo(b)fluoranthene	28,000	NV	28	2 53E-05	-	-	2 6	7 28E+01	6 1218E-05	9 56E-04	4 0E+01	2 4E-05
Benzo(g,h,i)perylene	15,000	NV	15	2 50E-05	-	-	2 94	4 41E+01	6 1218E-05	5 79E-04	7 2E+01	8 0E-06
Benzo(k)fluoranthene	13,000	NV	13	1 78E-05	-	-	2 6	3 38E+01	6 1218E-05	4 44E-04	7.2E+01	6 2E-06
bis(2-Ethylhexyl)phthalate	930	NV	0 93	5 00E-03	-	-	154	1 43E+02	6 1218E-05	1 87E-03	1.8E+02	1 0E-05
Chrysene	26,000	NV	26	2 53E-05	-	-	2 29	5 95E+01	6 1218E-05	7 83E-04	8 5E-01	9 2E-04
Dibenz(a,h)anthracene	4,900	NV	4 9	5 00E-03	-	-	2 31	1 13E+01	6 1218E-05	1.49E-04	1 3E+01	1 1E-05
Fluoranthene	41,000	NV	41	1 11E-04	-	-	3 04	1 25E+02	6 1218E-05	1 63E-03	6 3E+01	2 6E-05
HPAH	188,900	NV	188 9	2.67E-04	-	-	2 6	4 91E+02	6 1218E-05	6 45E-03	3 1E+00	2 1E-03
LPAH	85,680	NV	85 68	2 65E-02	-	-	3 04	2.60E+02	6 1218E-05	3 42E-03	3 3E+02	1 0E-05
Indeno(1,2,3-c,d)pyrene	15,000	NV	15	2.00E-05	-	-	2 86	4 29E+01	6 1218E-05	5 63E-04	7 2E+01	7 8E-06
Naphthalene	1,400	NV	1 4	1 20E-02	-	-	4.4	6 16E+00	6 1218E-05	8.08E-05	7 2E+01	1 1E-06
Phenanthrene	28,000	NV	28	3 20E-04	-	-	1 72	4 82E+01	6 1218E-05	6 35E-04	2.6E+01	2 5E-05
Pyrene	39,000	NV	39	3 51E-05	-	-	1 75	6 83E+01	6 1218E-05	8 99E-04	3.8E+01	2 4E-05
Hotspot 2-SF-2-19 - surface soil												
3&4-Methylphenol	1,200	NV	1 2	3 74E-01	-	-	0 73	8 76E-01	6 1218E-05	1.61E-05	1 1E+03	1 5E-08
Acenaphthene	43,000	NV	43	1 30E-05	-	-	1.47	6 32E+01	6 1218E-05	8 35E-04	3 5E+02	2 4E-06
Anthracene	73,000	NV	73	5 00E-03	-	-	2.42	1 77E+02	6 1218E-05	2 32E-03	5 0E+02	4 6E-06
Benzo(a)anthracene	89,000	NV	89	2 00E-05	-	-	1 59	1 42E+02	6 1218E-05	1 87E-03	8 5E-01	2 2E-03

Table 6
Invertivorous Mammal (Deer Mouse)
Soil HQ Calculations
Vertellus - Provo, Utah

Soil COPECs	Soil EPC 0 - 1 ft bgs (ug/kg)	Soil EPC 1 - 3 ft bgs (ug/kg)	C_{so} (mg/kg)	C_{sw} (mg/L)	Slope i	Intercept i	BCF i	C_i (mg/kg)	AUF	Average Daily Dose (mg/kg-bw/d)	Mammalian LOEC-TRV (mg/kg-bw/d)	LOEC-HQ
Benzo(a)pyrene	80,000	NV	80	2 45E-05	-	-	1 33	1 06E+02	6 1218E-05	1 41E-03	3.1E+00	4 6E-04
Benzo(b)fluoranthene	100,000	NV	100	2 53E-05	-	-	2 6	2 60E+02	6.1218E-05	3 41E-03	4 0E+01	8 5E-05
Benzo(g,h,i)perylene	48,000	NV	48	2 50E-05	-	-	2 94	1 41E+02	6 1218E-05	1 85E-03	7.2E+01	2 6E-05
Benzo(k)fluoranthene	43,000	NV	43	1 78E-05	-	-	2 6	1 12E+02	6 1218E-05	1 47E-03	7.2E+01	2 0E-05
Chrysene	100,000	NV	100	2 53E-05	-	-	2 29	2.29E+02	6.1218E-05	3 01E-03	8.5E-01	3.5E-03
Dibenz(a,h)anthracene	15,000	NV	15	5 00E-03	-	-	2 31	3 47E+01	6.1218E-05	4 55E-04	1.3E+01	3.4E-05
Dibenzofuran	20,000	NV	20	1 00E-03	-	-	2 1	4 20E+01	6 1218E-05	5.52E-04	--	NC
Fluoranthene	220,000	NV	220	1 11E-04	-	-	3 04	6 69E+02	6 1218E-05	8.77E-03	6 3E+01	1 4E-04
Fluorene	35,000	NV	35	2 50E-04	-	-	9 57	3 35E+02	6 1218E-05	4 37E-03	6 3E+02	7 0E-06
HPAH	710,000	NV	710	2 67E-04	-	-	2 6	1.85E+03	6.1218E-05	2 42E-02	3 1E+00	7 9E-03
LPAH	638,600	NV	638 6	2 65E-02	-	-	3 04	1 94E+03	6 1218E-05	2 55E-02	3 3E+02	7 8E-05
Indeno(1,2,3-c,d)pyrene	45,000	NV	45	2 00E-05	-	-	2 86	1.29E+02	6 1218E-05	1 69E-03	7 2E+01	2.3E-05
Naphthalene	44,000	NV	44	1 20E-02	-	-	4 4	1 94E+02	6 1218E-05	2 53E-03	7 2E+01	3 5E-05
Phenanthrene	200,000	NV	200	3 20E-04	-	-	1 72	3 44E+02	6.1218E-05	4 53E-03	2.6E+01	1 8E-04
Phenol	1,200	NV	1.2	2 59E-03	-	-	0 443	5 32E-01	6 1218E-05	7 27E-06	3.0E+02	2 4E-08
Pyrene	190,000	NV	190	3 51E-05	-	-	1 75	3 33E+02	6 1218E-05	4 38E-03	3 8E+01	1.2E-04
Hotspot 2-SF-3-36 - surface soil												
2-Methylphenol	2,400	NV	2.4	1 08E-02	-	-	0 701	1 68E+00	6 1218E-05	2 27E-05	1.1E+03	2 1E-08
3&4-Methylphenol	8,500	NV	8 5	3 74E-01	-	-	0 73	6 21E+00	6 1218E-05	8 74E-05	1.1E+03	7 9E-08
Acenaphthene	10,000	NV	10	1 30E-05	-	-	1 47	1 47E+01	6 1218E-05	1 94E-04	3 5E+02	5 5E-07
Anthracene	59,000	NV	59	5 00E-03	-	-	2 42	1 43E+02	6 1218E-05	1 88E-03	5.0E+02	3 8E-06
Benzo(a)anthracene	79,000	NV	79	2 00E-05	-	-	1 59	1 26E+02	6 1218E-05	1 66E-03	8.5E-01	1.9E-03
Benzo(a)pyrene	63,000	NV	63	2 45E-05	-	-	1 33	8 38E+01	6 1218E-05	1 11E-03	3.1E+00	3 6E-04
Benzo(b)fluoranthene	73,000	NV	73	2 53E-05	-	-	2 6	1 90E+02	6 1218E-05	2 49E-03	4.0E+01	6 2E-05
Benzo(g,h,i)perylene	35,000	NV	35	2 50E-05	-	-	2 94	1 03E+02	6 1218E-05	1 35E-03	7 2E+01	1 9E-05
Benzo(k)fluoranthene	27,000	NV	27	1.78E-05	-	-	2 6	7 02E+01	6.1218E-05	9 22E-04	7.2E+01	1 3E-05
Chrysene	80,000	NV	80	2 53E-05	-	-	2 29	1 83E+02	6.1218E-05	2 41E-03	8 5E-01	2 8E-03
Dibenz(a,h)anthracene	12,000	NV	12	5 00E-03	-	-	2 31	2 77E+01	6.1218E-05	3 64E-04	1.3E+01	2 7E-05
Dibenzofuran	45,000	NV	45	1 00E-03	-	-	2 1	9 45E+01	6.1218E-05	1 24E-03	--	NC
Fluoranthene	210,000	NV	210	1 11E-04	-	-	3 04	6 38E+02	6 1218E-05	8 37E-03	6.3E+01	1 3E-04
Fluorene	72,000	NV	72	2 50E-04	-	-	9 57	6 89E+02	6 1218E-05	9 00E-03	6 3E+02	1 4E-05
HPAH	568,000	NV	568	2 67E-04	-	-	2 6	1 48E+03	6 1218E-05	1 94E-02	3.1E+00	6 3E-03
LPAH	953,000	NV	953	2 65E-02	-	-	3 04	2 90E+03	6 1218E-05	3 80E-02	3 3E+02	1 2E-04
Indeno(1,2,3-c,d)pyrene	39,000	NV	39	2 00E-05	-	-	2 86	1 12E+02	6 1218E-05	1 46E-03	7 2E+01	2.0E-05
Naphthalene	220,000	NV	220	1 20E-02	-	-	4 4	9 68E+02	6 1218E-05	1 27E-02	7 2E+01	1 8E-04
Phenanthrene	270,000	NV	270	3 20E-04	-	-	1 72	4 64E+02	6 1218E-05	6 12E-03	2 6E+01	2 4E-04
Phenol	10,000	NV	10	2 59E-03	-	-	0 443	4 43E+00	6 1218E-05	6 04E-05	3 0E+02	2 0E-07
Pyrene	160,000	NV	160	3 51E-05	-	-	1 75	2.80E+02	6 1218E-05	3 69E-03	3 8E+01	9 8E-05
Hotspot 2-SF-4-23 - surface soil												
3&4-Methylphenol	1,500	NV	1 5	3 74E-01	-	-	0.73	1 10E+00	6 1218E-05	1 90E-05	1 1E+03	1 7E-08
Acenaphthene	82,000	NV	82	1 30E-05	-	-	1 47	1.21E+02	6 1218E-05	1.59E-03	3 5E+02	4 5E-06
Anthracene	130,000	NV	130	5 00E-03	-	-	2 42	3 15E+02	6 1218E-05	4 13E-03	5 0E+02	8 3E-06
Benzo(a)anthracene	250,000	NV	250	2 00E-05	-	-	1 59	3.98E+02	6 1218E-05	5 24E-03	8 5E-01	6 2E-03
Benzo(a)pyrene	200,000	NV	200	2 45E-05	-	-	1 33	2.66E+02	6 1218E-05	3.52E-03	3 1E+00	1 1E-03
Benzo(b)fluoranthene	310,000	NV	310	2 53E-05	-	-	2 6	8.06E+02	6 1218E-05	1.06E-02	4 0E+01	2 6E-04
Benzo(g,h,i)perylene	100,000	NV	100	2 50E-05	-	-	2 94	2.94E+02	6 1218E-05	3 86E-03	7 2E+01	5.4E-05
Benzo(k)fluoranthene	100,000	NV	100	1.78E-05	-	-	2 6	2 60E+02	6 1218E-05	3 41E-03	7 2E+01	4.7E-05
Chrysene	310,000	NV	310	2 53E-05	-	-	2.29	7 10E+02	6 1218E-05	9 33E-03	8 5E-01	1 1E-02
Dibenz(a,h)anthracene	39,000	NV	39	5.00E-03	-	-	2 31	9 01E+01	6 1218E-05	1 18E-03	1 3E+01	8.9E-05
Dibenzofuran	40,000	NV	40	1.00E-03	-	-	2 1	8 40E+01	6 1218E-05	1 10E-03	--	NC
Fluoranthene	580,000	NV	580	1.11E-04	-	-	3.04	1 76E+03	6 1218E-05	2 31E-02	6 3E+01	3 7E-04

Table 6
Invertivorous Mammal (Deer Mouse)
Soil HQ Calculations
Vertellus - Provo, Utah

Soil COPECs	Soil EPC 0 - 1 ft bgs *(ug/kg)*	Soil EPC 1 - 3 ft bgs *(ug/kg)*	C_{so} *(mg/kg)*	C_{sw} *(mg/L)*	Slope i	Intercept i	BCF i	C_i *(mg/kg)*	AUF	Average Daily Dose *(mg/kg-bw/d)*	Mammalian LOEC-TRV *(mg/kg-bw/d)*	LOEC-HQ
Fluorene	56,000	NV	56	2 50E-04	-	-	9 57	5 36E+02	6 1218E-05	7 00E-03	6 3E+02	1 1E-05
HPAH	1,889,000	NV	1889	2 67E-04	-	-	2.6	4 91E+03	6 1218E-05	6 45E-02	3 1E+00	2 1E-02
LPAH	1,279,000	NV	1279	2 65E-02	-	-	3 04	3 89E+03	6 1218E-05	5 10E-02	3 3E+02	1 6E-04
Indeno(1,2,3-c,d)pyrene	110,000	NV	110	2 00E-05	-	-	2 86	3.15E+02	6 1218E-05	4 13E-03	7 2E+01	5 7E-05
Naphthalene	81,000	NV	81	1 20E-02	-	-	4 4	3.56E+02	6 1218E-05	4 67E-03	7 2E+01	6 5E-05
Phenanthrene	310,000	NV	310	3 20E-04	-	-	1 72	5.33E+02	6 1218E-05	7 03E-03	2 6E+01	2.7E-04
Phenol	1,600	NV	1 6	2 59E-03	-	-	0.443	7 09E-01	6 1218E-05	9.68E-06	3 0E+02	3 2E-08
Pyrene	470,000	NV	470	3 51E-05	-	-	1.75	8 23E+02	6 1218E-05	1 08E-02	3 8E+01	2 9E-04

Notes:

For the calculation of HPAH and LPAH, Kaplan-Meir method was applied for summing detects and non-detects of PAHs at individual sample locations For sample locations where no individual PAHs were detected, the resulting calculated concentration is treated as a non-detect and the calculated RL is reported

EPC set equal to 95% UCL. If not enough samples were available to calculate a UCL, the EPC was set to the maximum detected concentration, "ND" if no samples were detected at that depth, or "NV" if the COPEC was not analyzed at that depth
Incidentially ingested soil is assumed to be from surface soil If no surface-level data are available (NV or ND), subsurface soil data are used for soil ingestion
Risk calculation not performed at Hotspots given the negligable Area Use Factor

Bold HQs are greater than 1 0

bgs = below ground surface
COPEC = chemical of potential ecological concern
C_i = concentration in invertebrate tissue
C_m = concentration in mammal tissue
C_p = concentration in plant tissue
C_{so} = concentration in soil (maximum of surface and subsurface EPCs, if available)
C_{sw} = concentration in surface water
EPC = exposure point concentration
HPAH = high molecular weight PAH, calculated from individual PAH results, includes Benz(a)anthracene, Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(g,h,i)perylene, Benzo(k)fluoranthene, Chrysene, Dibenz(a,h)anthracene, Indeno(1,2,3-
HQ = hazard quotient, HQ = EPC / LOEC
LOEC = lowest observed effects concentration
LPAH = low molecular weigth PAH, calculated from individual PAH results, includes 2-Methylnaphthalene, Acenaphthene, Acenaphthylene, Anthracene, Fluoranthene, Fluorene, Naphthalene, and Phenanthrene.
ug/kg = micrograms per kilogram
mg/kg = milligrams per kilogram
mg/kg-bw/day = milligrams per kilogram body weight per day
mg/L = milligrams per liter
NC = not calculated
NV = no value
P = plants
PAH = polycyclic aromatic hydrocarbon
TRV = toxicity reference value

Table 7
Herbivorous Mammal (Meadow Vole)
Soil HQ Calculations
Vertellus - Provo, Utah

Receptor	Meadow vole
Body weight	0 0372 kg
Food Ingestion Rate	0 012 kg/day dw
Composition of Diet	100% Plants
Soil Ingestion Rate	0 0009 kg/day
Water Ingestion Rate	0 006 L/day

Soil COPECs	Soil EPC 0 - 1 ft bgs (ug/kg)	Soil EPC 1 - 3 ft bgs (ug/kg)	C_{so} (mg/kg)	C_{sw} (mg/L)	Slope p	Intercept p	BCF p	C_p (mg/kg)	AUF	Average Daily Dose (mg/kg-bw/d)	Mammalian LOEC-TRV (mg/kg-bw/d)	LOEC-HQ
Exposure Area 2 - subsurface soi												
3&4-Methylphenol	NV	1,060,000	1.06E+03	3 74E-01	-	-	2 63	2 79E+03	1	8 87E+02	1 1E+03	8 1E-01
Acenaphthene	NV	1,782,714	1 78E+03	1 30E-05	-0 8556	-5 562	-	6 35E-06	1	4 28E+01	3 5E+02	1 2E-01
Acenaphthylene	NV	464,140	4 64E+02	5 00E-03	0 791	-1 144	-	4 10E+01	1	2 38E+01	3 5E+02	6 8E-02
Acetone	NV	366	3 66E-01	4 30E-03	-	-	76	2 78E+01	1	8 61E+00	5 0E+01	1 7E-01
Anthracene	NV	7,614,245	7 61E+03	5 00E-03	0 7784	-0 9887	-	3 91E+02	1	3 04E+02	5 0E+02	6 1E-01
Benzene	NV	167,270	1 67E+02	1 78E-02	-	-	8 26	1 38E+03	1	4 31E+02	2 6E+02	**1.6E+00**
Benzo(a)anthracene	NV	1,148,770	1 15E+03	2 00E-05	0 5944	-2 7078	-	4 40E+00	1	2 89E+01	8 5E-01	**3.4E+01**
Benzo(a)pyrene	NV	1,081,643	1 08E+03	2 45E-05	0 975	-2 0615	-	1 16E+02	1	6 17E+01	3.1E+00	**2.0E+01**
Benzo(b)fluoranthene	NV	1,130,531	1 13E+03	2 53E-05	-	-	0 31	3.50E+02	1	1 35E+02	4 0E+01	**3.4E+00**
Benzo(g,h,i)perylene	NV	NV	NV	2 50E-05	1 1829	-0 9313	-	NC	1	NC	7 2E+01	NC
Benzo(k)fluoranthene	NV	632,436	6 32E+02	1 78E-05	0 8595	-2 1579	-	2 95E+01	1	2 43E+01	7 2E+01	3.4E-01
Carbon disulfide	NV	8	8 05E-03	5 00E-03	-	-	2 01	1 62E-02	1	6.00E-03	1 3E+00	4 8E-03
Chloroform	NV	12	1 20E-02	5 00E-03	-	-	9 59	1 15E-01	1	3 67E-02	7.5E+01	4 9E-04
Chrysene	NV	1,313,841	1 31E+03	2 53E-05	0 5944	-2 7078	-	4 76E+00	1	3 30E+01	8.5E-01	**3.9E+01**
Cyanide, Total	NV	1,751,976	1 75E+03	1 13E-02	-	-	1	1 75E+03	1	5 84E+02	3 4E+02	**1.7E+00**
Dibenz(a,h)anthracene	NV	278,582	2 79E+02	5 00E-03	-	-	0 13	3 62E+01	1	1 79E+01	1 3E+01	**1.3E+00**
Fluoranthene	NV	6,689,586	6 69E+03	1 11E-04	-	-	0 5	3 34E+03	1	1 19E+03	6 3E+01	**1.9E+01**
Fluorene	NV	1,087,380	1.09E+03	2 50E-04	-0 8556	-5 562	-	9 69E-06	1	2 61E+01	6 3E+02	4 2E-02
HPAH	NV	25,973,856	2 60E+04	2 67E-04	0.9469	-1 7026	-	2 76E+03	1	1 48E+03	3 1E+00	**4.8E+02**
LPAH	NV	57,022,738	5 70E+04	2 65E-02	-	-	2 09	1 19E+05	1	3 82E+04	3 3E+02	**1.2E+02**
Indeno(1,2,3-c,d)pyrene	NV	570,440	5 70E+02	2.00E-05	-	-	0 11	6 27E+01	1	3 31E+01	7.2E+01	4.6E-01
Methyl ethyl ketone	NV	60	6 00E-02	1 00E-02	-	-	46.1	2 77E+00	1	8 58E-01	4 6E+03	1 9E-04
Methylene chloride	NV	95	9 47E-02	5 00E-03	-	-	18 8	1 78E+00	1	5 53E-01	5 0E+01	1 1E-02
Naphthalene	NV	13,662,909	1 37E+04	1 20E-02	-	-	12 2	1 67E+05	1	5 19E+04	7 2E+01	**7.3E+02**
Phenanthrene	NV	9,927,421	9 93E+03	3 20E-04	0 6203	-0 1665	-	2 55E+02	1	3.17E+02	2 6E+01	**1.2E+01**
Phenol	NV	916,000	9 16E+02	2 59E-03	-	-	0 0494	4 53E+01	1	3 60E+01	3 0E+02	1 2E-01
Pyrene	NV	4,961,400	4 96E+03	3 51E-05	-	-	0 72	3 57E+03	1	1 22E+03	3.8E+01	**3.3E+01**
Toluene	NV	255,319	2 55E+02	4 22E-03	-	-	4 71	1 20E+03	1	3 78E+02	2.6E+02	**1.5E+00**
Xylenes (Total)	NV	297,374	2 97E+02	1 80E-03	-	-	3.28	9 75E+02	1	3 09E+02	2 6E+00	**1.2E+02**
Exposure Area 3 - surface and subsurface soi												
2-Methylphenol	822	ND	8 22E-01	1 08E-02	-	-	3	2 47E+00	1	7 84E-01	1 1E+03	7 1E-04
3&4-Methylphenol	793	ND	7 93E-01	3 74E-01	-	-	2 63	2 09E+00	1	7 24E-01	1 1E+03	6 6E-04
Acenaphthene	24,865	130,716	1 31E+02	1 30E-05	-0 8556	-5 562	-	5 94E-05	1	3.14E+00	3.5E+02	9.0E-03
Acenaphthylene	4,561	ND	4 56E+00	5 00E-03	0.791	-1 144	-	1 06E+00	1	4 37E-01	3.5E+02	1 2E-03
Anthracene	36,207	70,864	7 09E+01	5 00E-03	0 7784	-0.9887	-	1 03E+01	1	4 87E+00	5 0E+02	9 7E-03
Benzo(a)anthracene	158,594	218,626	2 19E+02	2 00E-05	0 5944	-2.7078	-	1 64E+00	1	5 75E+00	8 5E-01	**6.8E+00**
Benzo(a)pyrene	193,969	452,415	4 52E+02	2 45E-05	0 975	-2 0615	-	4 94E+01	1	2.61E+01	3 1E+00	**8.5E+00**
Benzo(b)fluoranthene	212,507	297,789	2 98E+02	2 53E-05	-	-	0 31	9 23E+01	1	3 57E+01	4 0E+01	8 9E-01
Benzo(g,h,i)perylene	110,000	NV	1 10E+02	2 50E-05	1 1829	-0 9313	-	1.02E+02	1	3 43E+01	7 2E+01	4 8E-01
Benzo(k)fluoranthene	147,228	309,803	3 10E+02	1 78E-05	0.8595	-2 1579	-	1 60E+01	1	1 24E+01	7.2E+01	1.7E-01
bis(2-Ethylhexyl)phthalate	1,600	NV	1 60E+00	5 00E-03	-	-	0 05	8 00E-02	1	6.39E-02	1 8E+02	3.5E-04
Chrysene	203,388	257,520	2 58E+02	2.53E-05	0 5944	-2 7078	-	1 81E+00	1	6.74E+00	8 5E-01	**7.9E+00**
Cyanide, Total	38,507	10,299	3 85E+01	1 13E-02	-	-	1	3 85E+01	1	1.28E+01	3 4E+02	3 7E-02
Dibenz(a,h)anthracene	30,443	31,345	3 13E+01	5 00E-03	-	-	0 13	4 07E+00	1	2.01E+00	1 3E+01	1 5E-01
Dibenzofuran	11,000	NV	1 10E+01	1 00E-03	-	-	1 29	1 42E+01	1	4 65E+00	--	NC

Table 7
Herbivorous Mammal (Meadow Vole)
Soil HQ Calculations
Vertellus - Provo, Utah

Soil COPECs	Soil EPC 0 - 1 ft bgs (ug/kg)	Soil EPC 1 - 3 ft bgs (ug/kg)	C_{SO} (mg/kg)	C_{SW} (mg/L)	Slope p	Intercept p	BCF p	C_p (mg/kg)	AUF	Average Daily Dose (mg/kg-bw/d)	Mammalian LOEC-TRV (mg/kg-bw/d)	LOEC-HQ
Fluoranthene	275,373	353,951	3.54E+02	1 11E-04	-	-	0 5	1 77E+02	1	6 32E+01	6 3E+01	1 0E+00
Fluorene	22,185	155,000	1 55E+02	2.50E-04	-0 8556	-5 562	-	5.13E-05	1	3 72E+00	6.3E+02	6 0E-03
HPAH	1,420,966	3,397,173	3 40E+03	2 67E-04	0 9469	-1 7026	-	4 02E+02	1	2 06E+02	3 1E+00	**6.7E+01**
LPAH	1,191,689	1,237,321	1 24E+03	2 65E-02	-	-	2 09	2.59E+03	1	8 29E+02	3 3E+02	**2.5E+00**
Indeno(1,2,3-c,d)pyrene	129,935	339,803	3 40E+02	2 00E-05	-	-	0.11	3 74E+01	1	1 97E+01	7.2E+01	2 7E-01
Methylene chloride	1,774	131	1 77E+00	5 00E-03	-	-	18 8	3 34E+01	1	1 04E+01	5 0E+01	2 1E-01
Naphthalene	71,917	29,000	7 19E+01	1 20E-02	-	-	12 2	8 77E+02	1	2 73E+02	7 2E+01	**3.8E+00**
Phenanthrene	229,423	362,681	3 63E+02	3 20E-04	0 6203	-0 1665	-	3 28E+01	1	1 88E+01	2 6E+01	7 3E-01
Phenol	608	ND	6 08E-01	2 59E-03	-	-	0 0494	3 00E-02	1	2 43E-02	3.0E+02	8 1E-05
Pyrene	396,383	369,778	3 96E+02	3 51E-05	-	-	0 72	2 85E+02	1	9 77E+01	3.8E+01	**2.6E+00**
Exposure Area 4 - subsurface soi												
2-Methylphenol	NV	150,000	1.50E+02	1 08E-02	-	-	3	4 50E+02	1	1.43E+02	1 1E+03	1 3E-01
3&4-Methylphenol	NV	470,000	4 70E+02	3 74E-01	-	-	2 63	1 24E+03	1	3 93E+02	1 1E+03	3 6E-01
Acenaphthene	NV	1,739,574	1 74E+03	1.30E-05	-0 8556	-5 562	-	6 49E-06	1	4 17E+01	3.5E+02	1 2E-01
Acenaphthylene	NV	130,620	1 31E+02	5.00E-03	0 791	-1 144	-	1.50E+01	1	7 78E+00	3.5E+02	2 2E-02
Acetone	NV	792	7 92E-01	4.30E-03	-	-	76	6 02E+01	1	1.86E+01	5 0E+01	3 7E-01
Anthracene	NV	635,005	6.35E+02	5 00E-03	0 7784	-0 9887	-	5 65E+01	1	3.27E+01	5 0E+02	6 5E-02
Benzo(a)anthracene	NV	3,700,000	3 70E+03	2 00E-05	0 5944	-2.7078	-	8 81E+00	1	9.15E+01	8 5E-01	**1.1E+02**
Benzo(a)pyrene	NV	156,369	1.56E+02	2 45E-05	0 975	-2.0615	-	1 75E+01	1	9.17E+00	3 1E+00	**3.0E+00**
Benzo(b)fluoranthene	NV	190,000	1 90E+02	2 53E-05	-	-	0 31	5 89E+01	1	2 28E+01	4 0E+01	5.7E-01
Benzo(g,h,i)perylene	NV	NV	NV	2 50E-05	1 1829	-0 9313	-	NC	1	NC	7 2E+01	NC
Benzo(k)fluoranthene	NV	42,780	4 28E+01	1 78E-05	0 8595	-2 1579	-	2 92E+00	1	1 93E+00	7 2E+01	2 7E-02
Carbon disulfide	NV	940	9 40E-01	5.00E-03	-	-	2 01	1 89E+00	1	6 07E-01	1.3E+00	4 9E-01
Chrysene	NV	2,917,714	2 92E+03	2 53E-05	0 5944	-2 7078	-	7 65E+00	1	7 24E+01	8 5E-01	**8.5E+01**
Cyanide, Total	NV	33,000	3.30E+01	1 13E-02	-	-	1	3 30E+01	1	1 10E+01	3 4E+02	3 2E-02
Dibenz(a,h)anthracene	NV	21,000	2 10E+01	5 00E-03	-	-	0 13	2 73E+00	1	1 35E+00	1.3E+01	1 0E-01
Dibenzofuran	NV	1,000,000	1.00E+03	1 00E-03	-	-	1 29	1 29E+03	1	4.23E+02	--	NC
Fluoranthene	NV	1,746,969	1 75E+03	1.11E-04	-	-	0 5	8 73E+02	1	3.12E+02	6 3E+01	**5.0E+00**
Fluorene	NV	1,114,357	1 11E+03	2 50E-04	-0 8556	-5 562	-	9.49E-06	1	2 67E+01	6 3E+02	4 3E-02
HPAH	NV	7,796,489	7 80E+03	2.67E-04	0.9469	-1 7026	-	8 83E+02	1	4 60E+02	3 1E+00	**1.5E+02**
LPAH	NV	14,630,000	1 46E+04	2.65E-02	-	-	2 09	3 06E+04	1	9 80E+03	3 3E+02	**3.0E+01**
Indeno(1,2,3-c,d)pyrene	NV	74,000	7 40E+01	2.00E-05	-	-	0.11	8.14E+00	1	4 29E+00	7 2E+01	6 0E-02
m,p-Xylene	NV	3,900	3 90E+00	1 80E-03	-	-	3 28	1 28E+01	1	4 05E+00	2 6E+00	**1.6E+00**
Methylene chlonde	NV	216	2 16E-01	5 00E-03	-	-	18 8	4 06E+00	1	1.26E+00	5 0E+01	2 5E-02
Naphthalene	NV	6,500,000	6 50E+03	1 20E-02	-	-	12 2	7 93E+04	1	2 47E+04	7 2E+01	**3.5E+02**
o-Xylene	NV	2,000	2.00E+00	1 80E-03	-	-	3 28	6 56E+00	1	2 08E+00	2 6E+00	8.0E-01
Phenanthrene	NV	195,791	1 96E+02	3 20E-04	0 6203	-0 1665	-	2 24E+01	1	1 16E+01	2.6E+01	4 5E-01
Phenol	NV	820,000	8 20E+02	2 59E-03	-	-	0 0494	4 05E+01	1	3 22E+01	3.0E+02	1 1E-01
Pyrene	NV	1,510,834	1 51E+03	3 51E-05	-	-	0 72	1 09E+03	1	3 73E+02	3 8E+01	9.9E+00
Xylenes (Total)	NV	5,468	5 47E+00	1.80E-03	-	-	3 28	1 79E+01	1	5.68E+00	2 6E+00	**2.2E+00**
Exposure Area 6 - surface soil												
2-Methylphenol	4,100	NV	4.10E+00	1 08E-02	-	-	3	1 23E+01	1	3 90E+00	1.1E+03	3 5E-03
3&4-Methylphenol	11,000	NV	1 10E+01	3 74E-01	-	-	2 63	2 89E+01	1	9 27E+00	1 1E+03	8 4E-03
Acenaphthene	550,000	NV	5 50E+02	1 30E-05	-0.8556	-5 562	-	1 74E-05	1	1 32E+01	3 5E+02	3 8E-02
Acenaphthylene	140,000	NV	1 40E+02	5 00E-03	0,791	-1 144	-	1 59E+01	1	8 27E+00	3 5E+02	2 4E-02
Anthracene	860,000	NV	8 60E+02	5 00E-03	0 7784	-0 9887	-	7.16E+01	1	4 28E+01	5 0E+02	8 6E-02
Benzo(a)anthracene	2,400,000	NV	2 40E+03	2 00E-05	0.5944	-2 7078	-	6.81E+00	1	5 97E+01	8 5E-01	**7.0E+01**
Benzo(a)pyrene	2,200,000	NV	2 20E+03	2 45E-05	0 975	-2 0615	-	2 31E+02	1	1 24E+02	3 1E+00	**4.0E+01**
Benzo(b)fluoranthene	2,500,000	NV	2 50E+03	2 53E-05	-	-	0 31	7.75E+02	1	3 00E+02	4 0E+01	**7.5E+00**
Benzo(g,h,i)perylene	1,100,000	NV	1 10E+03	2 50E-05	1 1829	-0 9313	-	1.56E+03	1	5 09E+02	7 2E+01	**7.1E+00**
Benzo(k)fluoranthene	1,000,000	NV	1 00E+03	1 78E-05	0.8595	-2 1579	-	4.38E+01	1	3 75E+01	7 2E+01	5 2E-01
Carbazole	650,000	NV	6 50E+02	1 00E-03	-	-	1.87	1 22E+03	1	3 91E+02	1 1E+02	**3.4E+00**

Table 7
Herbivorous Mammal (Meadow Vole)
Soil HQ Calculations
Vertellus - Provo, Utah

Soil COPECs	Soil EPC 0 - 1 ft bgs (ug/kg)	Soil EPC 1 - 3 ft bgs (ug/kg)	C_{so} (mg/kg)	C_{sw} (mg/L)	Slope p	Intercept p	BCF p	C_p (mg/kg)	AUF	Average Daily Dose (mg/kg-bw/d)	Mammalian LOEC-TRV (mg/kg-bw/d)	LOEC-HQ
Chrysene	2,500,000	NV	2 50E+03	2 53E-05	0 5944	-2 7078	-	6 98E+00	1	6 22E+01	8 5E-01	**7.3E+01**
Cyanide, Total	NV	NV	NV	1 13E-02	-	-	1	NC	1	NC	3 4E+02	NC
Dibenz(a,h)anthracene	370,000	NV	3.70E+02	5 00E-03	-	-	0 13	4 81E+01	1	2 38E+01	1 3E+01	**1.8E+00**
Dibenzofuran	200,000	NV	2.00E+02	1 00E-03	-	-	1 29	2 58E+02	1	8.46E+01	--	NC
Fluoranthene	5,300,000	NV	5 30E+03	1.11E-04	-	-	0 5	2 65E+03	1	9 46E+02	6.3E+01	**1.5E+01**
Fluorene	470,000	NV	4 70E+02	2 50E-04	-0.8556	-5 562	-	1 99E-05	1	1 13E+01	6 3E+02	1 8E-02
HPAH	17,970,000	NV	1 80E+04	2 67E-04	0 9469	-1 7026	-	1 95E+03	1	1 03E+03	3 1E+00	**3.4E+02**
LPAH	11,776,200	NV	1 18E+04	2 65E-02	-	-	2 09	2 46E+04	1	7 89E+03	3 3E+02	**2.4E+01**
Indeno(1,2,3-c,d)pyrene	1,100,000	NV	1 10E+03	2 00E-05	-	-	0 11	1 21E+02	1	6 38E+01	7 2E+01	8 9E-01
Naphthalene	450,000	NV	4 50E+02	1 20E-02	-	-	12 2	5 49E+03	1	1 71E+03	7 2E+01	**2.4E+01**
Phenanthrene	4,400,000	NV	4 40E+03	3 20E-04	0.6203	-0 1665	-	1.54E+02	1	1 53E+02	2 6E+01	**6.0E+00**
Phenol	6,700	NV	6 70E+00	2 59E-03	-	-	0 0494	3.31E-01	1	2 64E-01	3 0E+02	8 8E-04
Pyrene	4,800,000	NV	4 80E+03	3 51E-05	-	-	0 72	3 46E+03	1	1 18E+03	3 8E+01	**3.2E+01**
Exposure Area 7 - surface and subsurface soi												
Acenaphthene	751	616	7 51E-01	1 30E-05	-0 8556	-5 562	-	4 91E-03	1	1 95E-02	3 5E+02	5 6E-05
Anthracene	4,016	327	4 02E+00	5 00E-03	0 7784	-0.9887	-	1 10E+00	1	4.37E-01	5 0E+02	8 7E-04
Benzo(a)anthracene	6,727	2,132	6 73E+00	2 00E-05	0 5944	-2 7078	-	2 07E-01	1	2 25E-01	8 5E-01	2 7E-01
Benzo(a)pyrene	7,752	2,334	7 75E+00	2 45E-05	0 975	-2 0615	-	9 37E-01	1	4.76E-01	3 1E+00	1 5E-01
Benzo(b)fluoranthene	8,618	2,835	8 62E+00	2 53E-05	-	-	0.31	2 67E+00	1	1 03E+00	4.0E+01	2 6E-02
Benzo(g,h,i)perylene	5,062	1,042	5.06E+00	2 50E-05	1 1829	-0.9313	-	2 68E+00	1	9 51E-01	7 2E+01	1.3E-02
Benzo(k)fluoranthene	4,075	767	4 08E+00	1 78E-05	0 8595	-2 1579	-	3 87E-01	1	2 17E-01	7 2E+01	3 0E-03
Chrysene	8,793	2,505	8.79E+00	2 53E-05	0 5944	-2.7078	-	2 43E-01	1	2 86E-01	8 5E-01	3 4E-01
Cyanide, Total	NV	NV	NV	1 13E-02	-	-	1	NC	1	NC	3.4E+02	NC
Dibenz(a,h)anthracene	1,512	194	1 51E+00	5 00E-03	-	-	0 13	1 97E-01	1	9 79E-02	1.3E+01	7 4E-03
Fluoranthene	12,267	3,414	1 23E+01	1 11E-04	-	-	0.5	6 13E+00	1	2 19E+00	6 3E+01	3 5E-02
Fluorene	696	167	6 96E-01	2 50E-04	-0 8556	-5 562	-	5 24E-03	1	1 84E-02	6 3E+02	2.9E-05
HPAH	58,934	16,089	5 89E+01	2 67E-04	0 9469	-1 7026	-	8 65E+00	1	4.09E+00	3.1E+00	**1.3E+00**
LPAH	30,420	10,633	3 04E+01	2 65E-02	-	-	2.09	6 36E+01	1	2 04E+01	3.3E+02	6.2E-02
Indeno(1,2,3-c,d)pyrene	4,884	624	4 88E+00	2 00E-05	-	-	0 11	5 37E-01	1	2.83E-01	7.2E+01	3 9E-03
Naphthalene	12,555	2,520	1 26E+01	1 20E-02	-	-	12.2	1 53E+02	1	4 77E+01	7.2E+01	6 7E-01
Phenanthrene	6,606	2,576	6 61E+00	3 20E-04	0 6203	-0 1665	-	2 73E+00	1	1 00E+00	2 6E+01	3 9E-02
Pyrene	11,718	3,187	1.17E+01	3 51E-05	-	-	0 72	8 44E+00	1	2 89E+00	3 8E+01	7.7E-02
Hotspot 2-SF-2-18 - surface soil												
Acenaphthene	2,000	NV	2	1 30E-05	-0 8556	-5 562	-	2 12E-03	0 00022957	1 12E-05	3 5E+02	3 2E-08
Benzo(a)anthracene	22,000	NV	22	2 00E-05	0 5944	-2 7078	-	4 19E-01	0 00022957	1 51E-04	8 5E-01	1 8E-04
Benzo(a)pyrene	26,000	NV	26	2 45E-05	0 975	-2 0615	-	3 05E+00	0 00022957	3.60E-04	3.1E+00	1 2E-04
Benzo(b)fluoranthene	28,000	NV	28	2 53E-05	-	-	0 31	8 68E+00	0 00022957	7.70E-04	4.0E+01	1.9E-05
Benzo(g,h,i)perylene	15,000	NV	15	2 50E-05	1 1829	-0 9313	-	9 70E+00	0 00022957	7 71E-04	7.2E+01	1.1E-05
Benzo(k)fluoranthene	13,000	NV	13	1 78E-05	0 8595	-2 1579	-	1 05E+00	0 00022957	1 46E-04	7 2E+01	2.0E-06
bis(2-Ethylhexyl)phthalate	930	NV	0 93	5 00E-03	-	-	0 05	4 65E-02	0 00022957	8 61E-06	1 8E+02	4 7E-08
Chrysene	26,000	NV	26	2 53E-05	0 5944	-2 7078	-	4 62E-01	0 00022957	1.76E-04	8 5E-01	2 1E-04
Dibenz(a,h)anthracene	4,900	NV	4 9	5.00E-03	-	-	0 13	6.37E-01	0 00022957	7 24E-05	1 3E+01	5 4E-06
Fluoranthene	41,000	NV	41	1.11E-04	-	-	0 5	2.05E+01	0 00022957	1 68E-03	6 3E+01	2 7E-05
HPAH	188,900	NV	188 9	2 67E-04	0 9469	-1 7026	-	2 61E+01	0 00022957	2 89E-03	3 1E+00	9 4E-04
LPAH	85,680	NV	85.68	2 65E-02	-	-	2 09	1 79E+02	0 00022957	1 32E-02	3 3E+02	4 0E-05
Indeno(1,2,3-c,d)pyrene	15,000	NV	15	2 00E-05	-	-	0 11	1 65E+00	0 00022957	2 00E-04	7 2E+01	2 8E-06
Naphthalene	1,400	NV	1 4	1 20E-02	-	-	12.2	1 71E+01	0.00022957	1 22E-03	7 2E+01	1 7E-05
Phenanthrene	28,000	NV	28	3 20E-04	0 6203	-0 1665	-	6 69E+00	0 00022957	6.29E-04	2.6E+01	2 4E-05
Pyrene	39,000	NV	39	3 51E-05	-	-	0 72	2 81E+01	0 00022957	2 21E-03	3 8E+01	5 9E-05
Hotspot 2-SF-2-19 - surface soil												
3&4-Methylphenol	1,200	NV	1 2	3 74E-01	-	-	2 63	3 16E+00	0 00022957	2 44E-04	1 1E+03	2 2E-07

Table 7
Herbivorous Mammal (Meadow Vole)
Soil HQ Calculations
Vertellus - Provo, Utah

Soil COPECs	Soil EPC 0 - 1 ft bgs (ug/kg)	Soil EPC 1 - 3 ft bgs (ug/kg)	C_{SO} (mg/kg)	C_{SW} (mg/L)	Slope p	Intercept p	BCF p	C_p (mg/kg)	AUF	Average Daily Dose (mg/kg-bw/d)	Mammalian LOEC-TRV (mg/kg-bw/d)	LOEC-HQ
Acenaphthene	43,000	NV	43	1 30E-05	-0 8556	-5 562	-	1 54E-04	0 00022957	2 37E-04	3 5E+02	6 8E-07
Anthracene	73,000	NV	73	5 00E-03	0 7784	-0 9887	-	1 05E+01	0 00022957	1 15E-03	5 0E+02	2 3E-06
Benzo(a)anthracene	89,000	NV	89	2 00E-05	0 5944	-2 7078	-	9 61E-01	0 00022957	5 59E-04	8 5E-01	6.6E-04
Benzo(a)pyrene	80,000	NV	80	2 45E-05	0 975	-2 0615	-	9.12E+00	0 00022957	1 09E-03	3.1E+00	3 5E-04
Benzo(b)fluoranthene	100,000	NV	100	2 53E-05	-	-	0 31	3 10E+01	0 00022957	2 75E-03	4.0E+01	6 9E-05
Benzo(g,h,i)perylene	48,000	NV	48	2.50E-05	1 1829	-0 9313	-	3 84E+01	0 00022957	2.99E-03	7.2E+01	4 2E-05
Benzo(k)fluoranthene	43,000	NV	43	1.78E-05	0.8595	-2 1579	-	2 93E+00	0 00022957	4 45E-04	7 2E+01	6 2E-06
Chrysene	100,000	NV	100	2 53E-05	0 5944	-2 7078	-	1.03E+00	0 00022957	6 24E-04	8 5E-01	7 3E-04
Dibenz(a,h)anthracene	15,000	NV	15	5 00E-03	-	-	0 13	1.95E+00	0 00022957	2 21E-04	1.3E+01	1.7E-05
Dibenzofuran	20,000	NV	20	1.00E-03	-	-	1 29	2 58E+01	0 00022957	1 94E-03	--	NC
Fluoranthene	220,000	NV	220	1.11E-04	-	-	0 5	1 10E+02	0 00022957	9 02E-03	6.3E+01	1 4E-04
Fluorene	35,000	NV	35	2 50E-04	-0 8556	-5 562	-	1.83E-04	0 00022957	1 93E-04	6.3E+02	3 1E-07
HPAH	710,000	NV	710	2 67E-04	0.9469	-1 7026	-	9 13E+01	0 00022957	1 04E-02	3.1E+00	3 4E-03
LPAH	638,600	NV	638.6	2 65E-02	-	-	2 09	1 33E+03	0 00022957	9 82E-02	3.3E+02	3 0E-04
Indeno(1,2,3-c,d)pyrene	45,000	NV	45	2.00E-05	-	-	0 11	4 95E+00	0 00022957	5 99E-04	7 2E+01	8 3E-06
Naphthalene	44,000	NV	44	1 20E-02	-	-	12 2	5 37E+02	0 00022957	3 83E-02	7 2E+01	5 4E-04
Phenanthrene	200,000	NV	200	3 20E-04	0 6203	-0.1665	-	2.26E+01	0.00022957	2 71E-03	2 6E+01	1 1E-04
Phenol	1,200	NV	1 2	2 59E-03	-	-	0.0494	5 93E-02	0.00022957	1 09E-05	3 0E+02	3 6E-08
Pyrene	190,000	NV	190	3 51E-05	-	-	0 72	1 37E+02	0 00022957	1 08E-02	3 8E+01	2 9E-04
Hotspot 2-SF-3-36 - surface soil												
2-Methylphenol	2,400	NV	2 4	1 08E-02	-	-	3	7 20E+00	0.00022957	5 25E-04	1 1E+03	4 8E-07
3&4-Methylphenol	8,500	NV	8.5	3 74E-01	-	-	2 63	2.24E+01	0 00022957	1 65E-03	1 1E+03	1.5E-06
Acenaphthene	10,000	NV	10	1 30E-05	-0 8556	-5.562	-	5 36E-04	0 00022957	5 51E-05	3 5E+02	1.6E-07
Anthracene	59,000	NV	59	5 00E-03	0 7784	-0 9887	-	8 89E+00	0 00022957	9 56E-04	5 0E+02	1.9E-06
Benzo(a)anthracene	79,000	NV	79	2 00E-05	0.5944	-2 7078	-	8 95E-01	0 00022957	4 99E-04	8 5E-01	5 9E-04
Benzo(a)pyrene	63,000	NV	63	2 45E-05	0 975	-2 0615	-	7 23E+00	0 00022957	8.60E-04	3 1E+00	2.8E-04
Benzo(b)fluoranthene	73,000	NV	73	2.53E-05	-	-	0 31	2 26E+01	0 00022957	2.01E-03	4 0E+01	5 0E-05
Benzo(g,h,i)perylene	35,000	NV	35	2 50E-05	1.1829	-0 9313	-	2 64E+01	0 00022957	2.07E-03	7 2E+01	2.9E-05
Benzo(k)fluoranthene	27,000	NV	27	1.78E-05	0.8595	-2 1579	-	1 96E+00	0 00022957	2.88E-04	7 2E+01	4 0E-06
Chrysene	80,000	NV	80	2 53E-05	0.5944	-2 7078	-	9 02E-01	0 00022957	5 05E-04	8.5E-01	5 9E-04
Dibenz(a,h)anthracene	12,000	NV	12	5.00E-03	-	-	0 13	1 56E+00	0 00022957	1 77E-04	1 3E+01	1 3E-05
Dibenzofuran	45,000	NV	45	1.00E-03	-	-	1 29	5 81E+01	0 00022957	4 37E-03	--	NC
Fluoranthene	210,000	NV	210	1.11E-04	-	-	0 5	1 05E+02	0 00022957	8 61E-03	6 3E+01	1 4E-04
Fluorene	72,000	NV	72	2 50E-04	-0.8556	-5 562	-	9 89E-05	0 00022957	3 97E-04	6 3E+02	6 3E-07
HPAH	568,000	NV	568	2 67E-04	0.9469	-1 7026	-	7 39E+01	0.00022957	8 37E-03	3 1E+00	2 7E-03
LPAH	953,000	NV	953	2 65E-02	-	-	2.09	1 99E+03	0.00022957	1 47E-01	3 3E+02	4 5E-04
Indeno(1,2,3-c,d)pyrene	39,000	NV	39	2 00E-05	-	-	0.11	4.29E+00	0 00022957	5 19E-04	7.2E+01	7.2E-06
Naphthalene	220,000	NV	220	1 20E-02	-	-	12 2	2 68E+03	0 00022957	1 92E-01	7 2E+01	2 7E-03
Phenanthrene	270,000	NV	270	3 20E-04	0 6203	-0.1665	-	2 73E+01	0 00022957	3 42E-03	2.6E+01	1 3E-04
Phenol	10,000	NV	10	2 59E-03	-	-	0 0494	4 94E-01	0 00022957	9 03E-05	3 0E+02	3 0E-07
Pyrene	160,000	NV	160	3 51E-05	-	-	0 72	1 15E+02	0.00022957	9 06E-03	3 8E+01	2 4E-04
Hotspot 2-SF-4-23 - surface soil												
3&4-Methylphenol	1,500	NV	1 5	3 74E-01	-	-	2 63	3 95E+00	0.00022957	3 02E-04	1 1E+03	2.7E-07
Acenaphthene	82,000	NV	82	1 30E-05	-0 8556	-5 562	-	8 85E-05	0 00022957	4 52E-04	3 5E+02	1 3E-06
Anthracene	130,000	NV	130	5 00E-03	0 7784	-0.9887	-	1 64E+01	0 00022957	1.88E-03	5 0E+02	3 8E-06
Benzo(a)anthracene	250,000	NV	250	2 00E-05	0 5944	-2.7078	-	1 78E+00	0.00022957	1 50E-03	8 5E-01	1 8E-03
Benzo(a)pyrene	200,000	NV	200	2 45E-05	0 975	-2 0615	-	2 23E+01	0 00022957	2.68E-03	3 1E+00	8 7E-04
Benzo(b)fluoranthene	310,000	NV	310	2 53E-05	-	-	0 31	9 61E+01	0 00022957	8 53E-03	4 0E+01	2 1E-04
Benzo(g,h,i)perylene	100,000	NV	100	2 50E-05	1 1829	-0 9313	-	9 15E+01	0 00022957	7.04E-03	7 2E+01	9 8E-05
Benzo(k)fluoranthene	100,000	NV	100	1 78E-05	0 8595	-2 1579	-	6 05E+00	0 00022957	9.80E-04	7 2E+01	1 4E-05
Chrysene	310,000	NV	310	2 53E-05	0 5944	-2 7078	-	2 02E+00	0 00022957	1.85E-03	8 5E-01	2 2E-03

Table 7
Herbivorous Mammal (Meadow Vole)
Soil HQ Calculations
Vertellus - Provo, Utah

Soil COPECs	Soil EPC 0 - 1 ft bgs *(ug/kg)*	Soil EPC 1 - 3 ft bgs *(ug/kg)*	C_{so} *(mg/kg)*	C_{sw} *(mg/L)*	Slope p	Intercept p	BCF p	C_p *(mg/kg)*	AUF	Average Daily Dose *(mg/kg-bw/d)*	Mammalian LOEC-TRV *(mg/kg-bw/d)*	LOEC-HQ
Dibenz(a,h)anthracene	39,000	NV	39	5 00E-03	-	-	0 13	5 07E+00	0 00022957	5 75E-04	1 3E+01	4 3E-05
Dibenzofuran	40,000	NV	40	1 00E-03	-	-	1 29	5 16E+01	0 00022957	3 88E-03	--	NC
Fluoranthene	580,000	NV	580	1 11E-04	-	-	0 5	2 90E+02	0 00022957	2 38E-02	6 3E+01	3 8E-04
Fluorene	56,000	NV	56	2 50E-04	-0 8556	-5 562	-	1 23E-04	0 00022957	3 09E-04	6 3E+02	4 9E-07
HPAH	1,889,000	NV	1889	2 67E-04	0 9469	-1 7026	-	2 31E+02	0 00022957	2.68E-02	3 1E+00	8 7E-03
LPAH	1,279,000	NV	1279	2 65E-02	-	-	2 09	2 67E+03	0.00022957	1.97E-01	3 3E+02	6 0E-04
Indeno(1,2,3-c,d)pyrene	110,000	NV	110	2 00E-05	-	-	0 11	1 21E+01	0 00022957	1 46E-03	7 2E+01	2 0E-05
Naphthalene	81,000	NV	81	1 20E-02	-	-	12 2	9 88E+02	0.00022957	7 06E-02	7 2E+01	9.9E-04
Phenanthrene	310,000	NV	310	3.20E-04	0 6203	-0.1665	-	2 97E+01	0 00022957	3 82E-03	2 6E+01	1 5E-04
Phenol	1,600	NV	1 6	2 59E-03	-	-	0 0494	7 90E-02	0 00022957	1 45E-05	3 0E+02	4 8E-08
Pyrene	470,000	NV	470	3 51E-05	-	-	0 72	3 38E+02	0 00022957	2 66E-02	3 8E+01	7 1E-04

Notes:

For the calculation of HPAH and LPAH, Kaplan-Meir method was applied for summing detects and non-detects of PAHs at individual sample locations For sample locations where no individual PAHs were detected, the resulting calculated concentration is treated as a non-detect and the calculated RL is reported

EPC set equal to 95% UCL If not enough samples were available to calculate a UCL, the EPC was set to the maximum detected concentration, "ND" if no samples were detected at that depth, or "NV" if the COPEC was not analyzed at that depth
Incidentially ingested soil is assumed to be from surface soil. If no surface-level data are available (NV or ND), subsurface soil data are used for soil ingestion
Risk calculation not performed at Hotspots given the negligable Area Use Factor

Bold HQs are greater than 1 0

BAF = bioaccumulation factor
bgs = below ground surface
COPEC = chemical of potential ecological concern
C_i = concentration in invertebrate tissue
C_m = concentration in mammal tissue
C_p = concentration in plant tissue
C_{so} = concentration in soil (maximum of surface and subsurface EPCs, if available)
C_{sw} = concentration in surface water
EPC = exposure point concentration
HPAH = high molecular weight PAH, calculated from individual PAH results, includes Benz(a)anthracene, Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(g,h,i)perylene, Benzo(k)fluoranthene, Chrysene, Dibenz(a,h)anthracene, Indeno(1,2,3-
HQ = hazard quotient, HQ = EPC / LOEC
LOEC = lowest observed effects concentration
LPAH = low molecular weigth PAH; calculated from individual PAH results, includes 2-Methylnaphthalene, Acenaphthene, Acenaphthylene, Anthracene, Fluoranthene, Fluorene, Naphthalene, and Phenanthrene
ug/kg = micrograms per kilogram
mg/kg = milligrams per kilogram
mg/kg-bw/day = milligrams per kilogram body weight per day
mg/L = milligrams per liter
NC = not calculated
NV = no value
P = plants
PAH = polycyclic aromatic hydrocarbon
TRV = toxicity reference value

Table 8
Omnivorous Bird (Mallard)
Sediment HQ Calculations
Vertellus - Provo, Utah

Receptor	Mallard
Body weight	1 043 kg
Food Ingestion Rate	0 056 kg/day dw
Composition of Diet	50% Plants
	50% Invertebrates
Soil Ingestion Rate	0 0011 kg/day
Water Ingestion Rate	0 059 L/day

Sediment COPECs	C_{SD} (mg/kg)	C_{SW} (mg/L)	Slope p	Intercept p	BCF p	Cp (mg/kg)	BSAF i	% Lipid i	Sediment % OC	CI (mg/kg)	AUF	Average Daily Dose (mg/kg-bw/d)	Avian LOEC-TRV (mg/kg-bw/d)	LOEC-HQ
Exposure Area 1 - surface sediment														
2-Methylnaphthalene	2 00E-02	5 00E-04	-	-	1 64	3 28E-02	2 6	3 5%	1%	1 49E-02	0 00287591	3 80E-06	--	NC
Acenaphthene	1 37E+02	1 30E-05	-0 8556	-5 562	-	5 70E-05	0 03	3 5%	1%	1 18E+00	0 00287591	5 11E-04	--	NC
Acenaphthylene	4 24E+00	5 00E-03	0 791	-1 144	-	9 99E-01	0 762	3 5%	1%	9 23E-01	0 00287591	1 61E-04	--	NC
Acetone	1 18E-01	4 30E-03	-	-	76	8 94E+00	-	3 5%	1%	NC	0 00287591	NC	1 0E+03	NC
Anthracene	9 88E+01	5 00E-03	0 7784	-0 9887	-	1 33E+01	0 108	3 5%	1%	3 05E+00	0 00287591	1 56E-03	--	NC
Benzene	8 02E-03	1 78E-02	-	-	8 26	6 62E-02	-	3 5%	1%	NC	0 00287591	NC	--	NC
Benzo(a)anthracene	6 41E+01	2 00E-05	0 5944	-2 7078	-	7 91E-01	0 331	3 5%	1%	6 06E+00	0 00287591	7 22E-04	4 0E-03	1 8E-01
Benzo(a)pyrene	5 44E+01	2 45E-05	0 975	-2 0615	-	6 26E+00	0 329	3 5%	1%	5 11E+00	0 00287591	1 04E-03	5 0E-03	2 1E-01
Benzo(b)fluoranthene	6 05E+01	2 53E-05	-	-	0 31	1 87E+01	0 251	3 5%	1%	4 34E+00	0 00287591	1 96E-03	7 0E-04	**2.8E+00**
Benzo(g,h,i)perylene	NV	2 50E-05	1 1829	-0 9313	-	NC	0 037	3 5%	1%	NC	0 00287591	NC	--	NC
Benzo(k)fluoranthene	2 13E+01	1 78E-05	0 8595	-2 1579	-	1 60E+00	0 197	3 5%	1%	1 20E+00	0 00287591	2 80E-04	7 0E-04	4 0E-01
Carbon disulfide	4 98E-03	5 00E-03	-	-	2 01	1 00E-02	-	3 5%	1%	NC	0 00287591	NC	--	NC
Chrysene	8 66E+01	2 53E-05	0 5944	-2 7078	-	9 45E-01	0 435	3 5%	1%	1 08E+01	0 00287591	1 16E-03	5 0E-03	2 3E-01
Cyanide, Total	1 47E+00	1 13E-02	-	-	1	1 47E+00	-	3 5%	1%	NC	0 00287591	NC	2 0E-01	NC
Dibenz(a,h)anthracene	6 09E+00	5 00E-03	-	-	0 13	7 92E-01	0 377	3 5%	1%	6 56E-01	0 00287591	1 31E-04	2 0E-03	6 7E-02
Fluoranthene	1 65E+02	1 11E-04	-	-	0 5	8 27E+01	0 716	3 5%	1%	3 38E+01	0 00287591	9 45E-03	--	NC
Fluorene	9 91E+01	2 50E-04	-0 8556	-5 562	-	7 53E-05	0 964	3 5%	1%	2 73E+01	0 00287591	2 40E-03	--	NC
Indeno(1,2,3-c,d)pyrene	2 06E+01	2 00E-05	-	-	0 11	2 27E+00	0 21	3 5%	1%	1 24E+00	0 00287591	3 32E-04	5 0E-03	6 6E-02
Methyl ethyl ketone	1 26E-02	1 00E-02	-	-	46 1	5 81E-01	-	3 5%	1%	NC	0 00287591	NC	--	NC
Methylene chloride	3 00E-03	5 00E-03	-	-	18 8	5 64E-02	-	3 5%	1%	NC	0 00287591	NC	--	NC
Naphthalene	9 09E+00	1 20E-02	-	-	12 2	1 11E+02	2 637	3 5%	1%	6 85E+00	0 00287591	9 06E-03	7 5E+01	1 2E-04
PAH (Total)	1 82E+03	5 05E-02	0 3015	0 083	-	1 05E+01	0 07	3 5%	1%	3 65E+01	0 00287591	9 21E-03	2 3E-01	4 0E-02
Phenanthrene	1 46E+02	3 20E-04	0 6203	-0 1665	-	1 86E+01	0 607	3 5%	1%	2 52E+01	0 00287591	3 81E-03	--	NC
Pyrene	1 53E+02	3 51E-05	-	-	0 72	1 10E+02	0 477	3 5%	1%	2 09E+01	0 00287591	1 05E-02	--	NC

Notes:

For the calculation of HPAH and LPAH, Kaplan-Meir method was applied for summing detects and non-detects of PAHs at individual sample locations For sample locations where no individual PAHs were detected, the resulting calculated concentration is treated as a non-detect and the calculated RL is reported

EPC set equal to 95% UCL If not enough samples were available to calculate a UCL, the EPC is set to the maximum detected concentration, "ND" if no samples were detected at that depth, or "NV" if the COPEC was not analyzed at that depth
Lipid concentration in benthic invertebrates assumed to be 3 5% by weight
Organic compound concentration in sediment assumed to be 1% by weight
Bold HQs are greater than 1 0

COPEC = chemical of potential ecological concern
C_i = concentration in benthic invertebrate tissue
C_p = concentration in plant tissue
C_{SD} = concentration in sediment
C_{SW} = concentration in surface water
EPC = exposure point concentration

HPAH = high molecular weight PAH, calculated from individual PAH results, includes Benz(a)anthracene, Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(g,h,i)perylene, Benzo(k)fluoranthene, Chrysene, Dibenz(a,h)anthracene, Indeno(1,2,3-cd)pyrene, and Pyrene
HQ = hazard quotient, HQ = EPC / LOEC
LOEC = lowest observed effects concentration
LPAH = low molecular weigth PAH, calculated from individual PAH results, includes 2-Methylnaphthalene, Acenaphthene, Acenaphthylene, Anthracene, Fluoranthene, Fluorene, Naphthalene, and Phenanthrene
NV = no value
NC = not calculated
PAH = polycyclic aromatic hydrocarbon

Table 9
Invertivorous Bird (Tree Swallow)
Sediment HQ Calculations
Vertellus - Provo, Utah

Receptor	Tree swallow
Body weight	0 0201 kg
Food Ingestion Rate	0 012 kg/day dw
Composition of Diet	100% Invertebrates
Soil Ingestion Rate	0 0002 kg/day
Water Ingestion Rate	0 004 L/day

Sediment COPECs	C_{SD} *(mg/kg)*	C_{SW} *(mg/L)*	BSAF i	% Lipid i	Sediment % OC	Ci *(mg/kg)*	AUF	Average Daily Dose *(mg/kg-bw/d)*	Avian LOEC-TRV *(mg/kg-bw/d)*	LOEC-HQ
Exposure Area 1 - surface sediment										
2-Methylnaphthalene	2 00E-02	5 00E-04	2 6	3.5%	1%	1 49E-02	8 2947E-05	7 39E-07	--	NC
Acenaphthene	1 37E+02	1 30E-05	0 03	3 5%	1%	1 18E+00	8 2947E-05	1 88E-04	--	NC
Acenaphthylene	4 24E+00	5 00E-03	0 762	3 5%	1%	9.23E-01	8 2947E-05	4 83E-05	--	NC
Acetone	1 18E-01	4 30E-03	-	3 5%	1%	NC	8.2947E-05	NC	1.0E+03	NC
Anthracene	9 88E+01	5 00E-03	0 108	3 5%	1%	3 05E+00	8 2947E-05	2 41E-04	--	NC
Benzene	8 02E-03	1 78E-02	-	3 5%	1%	NC	8 2947E-05	NC	--	NC
Benzo(a)anthracene	6 41E+01	2 00E-05	0 331	3 5%	1%	6 06E+00	8 2947E-05	3 52E-04	4 0E-03	8 9E-02
Benzo(a)pyrene	5 44E+01	2 45E-05	0 329	3 5%	1%	5 11E+00	8 2947E-05	2 97E-04	5 0E-03	5 9E-02
Benzo(b)fluoranthene	6 05E+01	2 53E-05	0 251	3 5%	1%	4.34E+00	8 2947E-05	2 65E-04	7.0E-04	3 8E-01
Benzo(g,h,i)perylene	NV	2 50E-05	0 037	3 5%	1%	NC	8 2947E-05	NC	--	NC
Benzo(k)fluoranthene	2 13E+01	1 78E-05	0 197	3 5%	1%	1 20E+00	8 2947E-05	7 77E-05	7 0E-04	1 1E-01
Carbon disulfide	4 98E-03	5 00E-03	-	3.5%	1%	NC	8 2947E-05	NC	--	NC
Chrysene	8 66E+01	2 53E-05	0 435	3.5%	1%	1 08E+01	8.2947E-05	5 98E-04	5 0E-03	1.2E-01
Cyanide, Total	1 47E+00	1 13E-02	-	3 5%	1%	NC	8.2947E-05	NC	2 0E-01	NC
Dibenz(a,h)anthracene	6 09E+00	5 00E-03	0 377	3 5%	1%	6 56E-01	8 2947E-05	3 73E-05	2 0E-03	1.9E-02
Fluoranthene	1 65E+02	1 11E-04	0 716	3 5%	1%	3 38E+01	8 2947E-05	1 78E-03	--	NC
Fluorene	9.91E+01	2 50E-04	0 964	3 5%	1%	2 73E+01	8 2947E-05	1 40E-03	--	NC
Indeno(1,2,3-c,d)pyrene	2 06E+01	2 00E-05	0 21	3 5%	1%	1.24E+00	8 2947E-05	7 90E-05	5.0E-03	1 6E-02
Methyl ethyl ketone	1 26E-02	1 00E-02	-	3 5%	1%	NC	8 2947E-05	NC	--	NC
Methylene chloride	3 00E-03	5 00E-03	-	3 5%	1%	NC	8 2947E-05	NC	--	NC
Naphthalene	9 09E+00	1 20E-02	2 637	3 5%	1%	6 85E+00	8 2947E-05	3 37E-04	7 5E+01	4 5E-06
PAH (Total)	1 82E+03	5 05E-02	0 07	3 5%	1%	3 65E+01	8 2947E-05	3 49E-03	2.3E-01	1 5E-02
Phenanthrene	1 46E+02	3 20E-04	0 607	3 5%	1%	2 52E+01	8 2947E-05	1.35E-03	--	NC
Pyrene	1 53E+02	3 51E-05	0 477	3 5%	1%	2 09E+01	8 2947E-05	1 15E-03	--	NC

Notes:

For the calculation of HPAH and LPAH, Kaplan-Meir method was applied for summing detects and non-detects of PAHs at individual sample locations For sample locations where no individual PAHs were detected, the resulting calculated concentration is treated as a non-detect and the calculated RL is reported

EPC set equal to 95% UCL If not enough samples were available to calculate a UCL, the EPC is set to the maximum detected concentration, "ND" if no samples were detected at that depth, or "NV" if the COPEC was not analyzed at that depth

Lipid concentration in benthic invertebrates assumed to be 3 5% by weight.

Organic compound concentration in sediment assumed to be 1% by weight

Bold HQs are greater than 1 0

COPEC = chemical of potential ecological concern

C_I = concentration in benthic invertebrate tissue

C_p = concentration in plant tissue

C_{SD} = concentration in sediment

C_{SW} = concentration in surface water

Table 9
Invertivorous Bird (Tree Swallow)
Sediment HQ Calculations
Vertellus - Provo, Utah

EPC = exposure point concentration

HPAH = high molecular weight PAH, calculated from individual PAH results, includes Benz(a)anthracene, Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(g,h,i)perylene, Benzo(k)fluoranthene, Chrysene, Dibenz(a,h)anthracene, Indeno(1,2,3-cd)pyrene, and Pyrene

HQ = hazard quotient, HQ = EPC / LOEC

LOEC = lowest observed effects concentration

LPAH = low molecular weigth PAH, calculated from individual PAH results, includes 2-Methylnaphthalene, Acenaphthene, Acenaphthylene, Anthracene, Fluoranthene, Fluorene, Naphthalene, and Phenanthrene

NV = no value

NC = not calculated

PAH = polycyclic aromatic hydrocarbon

Table 10
Surface Water Concentration Selection
for Wildlife Water Intake

EA1 Detected Analytes	SW EPCs *(ug/L)*	SW Max RL *(ug/L)*	SW EPC or Max RL *(mg/L)*	Notes
2,4-Dimethylphenol	9.393		**0.009393**	
2-Methylnaphthalene	ND	0.5	**0.0005**	
2-Methylphenol	10.83		**0.01083**	
3&4-Methylphenol	373.7		**0.3737**	
Acenaphthene	0.013		**0.000013**	
Acenaphthylene	ND	5	**0.005**	
Acetone	4.3		**0.0043**	
Anthracene	ND	5	**0.005**	
Benzene	17.8		**0.0178**	
Benzo(a)anthracene	0.02		**0.00002**	
Benzo(a)pyrene	0.0245		**0.0000245**	
Benzo(b)fluoranthene	0.0253		**0.0000253**	
Benzo(g,h,i)perylene	0.025		**0.000025**	
Benzo(k)fluoranthene	0.0178		**0.0000178**	
Bis(2-ethylhexyl)phthalate	ND	5	**0.005**	
Carbazole	ND	1	**0.001**	
Carbon Disulfide	ND	5	**0.005**	
Chloroform	ND	5	**0.005**	
Chrysene	0.0253		**0.0000253**	
Cyanide, Total	11.29		**0.01129**	
Dibenz(a,h)anthracene	ND	5	**0.005**	
Dibenzofuran	ND	1	**0.001**	
Fluoranthene	0.111		**0.000111**	
Fluorene	0.25		**0.00025**	
HPAH	0.267		**0.000267**	
Indeno(1,2,3-c,d)pyrene	0.02		**0.00002**	
LPAH	26.46		**0.02646**	
m,p-Xylene	1.8		**0.0018**	Based on Xylenes (Total)
Methyl ethyl ketone	ND	10	**0.01**	
Methylene chloride	ND	5	**0.005**	
Naphthalene	11.97		**0.01197**	
o-Xylene	1.8		**0.0018**	Based on Xylenes (Total)
PAH (Total)	50.46		**0.05046**	
Phenanthrene	0.32		**0.00032**	
Phenol	2.589		**0.002589**	
Pyrene	0.0351		**0.0000351**	
Toluene	4.222		**0.004222**	
Xylenes (Total)	1.8		**0.0018**	