

# **U.S. Department of Energy**

Oakland Operations Office, Oakland, California

# SITE-WIDE RISK ASSESSMENT, VOLUME I: HUMAN HEALTH RISK ASSESSMENT (PART B-RISK CHARACTERIZATION FOR DOE AREAS)

at the:

# LABORATORY FOR ENERGY-RELATED HEALTH RESEARCH UNIVERSITY OF CALIFORNIA, DAVIS

Prepared for:

United States Department of Energy Oakland Environmental Programs 1301 Clay Street Oakland, California 94612-5208

Prepared by:

Weiss Associates 5801 Christie Avenue, Suite 600 Emeryville, California 94608-1827

> September 30, 2005 Rev. 0

DOE Delivery Order DE-AD03-04NA99610



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## ABBREVIATIONS AND ACRONYMS

>	greater than		
<	less than or denotes analyte concentrations below the detection limit		
μCi	microCuries		
µg/kg	micrograms per kilogram		
Am	americium		
ANL	Argonne National Laboratory		
ATSDR	Agency for Toxic Substances and Disease Registry		
Bi	bismuth		
bgs	below ground surface		
bkgd	background		
C	carbon		
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act		
Co	cobalt		
COC	constituent(s) of concern		
COPC	constituent(s) of potential concern		
COPGWC	constituent(s) of potential ground water concern		
CRDL	contract-required detection limit		
Cr-VI	hexavalent chromium		
CRWQCB	California Regional Water Quality Control Board		
Cs	cesium		
cu yds	cubic yards		
DI WET	de-ionized water waste extraction test		
DL	designated-level		
D&M	Dames and Moore		
DOE	U.S. Department of Energy		
DSS	domestic septic system		

DTSC	Department of Toxic Substances Control
EE/CA	Engineering Evaluation/Cost Analysis
EPC	exposure point concentration
EPI	Environmental Physics Incorporated
ES	executive summary
FS	Feasibility Study
ft	feet/foot
FY	fiscal year
HEAST	Health Effects Assessment Summary Tables
Hg	mercury
HHRA	Human Health Risk Assessment
HSU	hydrostratigraphic unit
ID	identification (number)
IRIS	Integrated Risk Information System
Κ	potassium
Kd	partitioning coefficient
LEHR	Laboratory for Energy-Related Health Research
LFI	limited field investigation
MCL	maximum contaminant level
MEK	methyl ethyl ketone
mg/kg	milligrams per kilogram
mg/l	milligrams per liter
MIBK	methyl isobutyl ketone
ml/g	milliliters per gram
MOA	Memorandum of Agreement
Ν	nitrogen
N/A	not applicable or not available
NC	not calculated
ND	not detected
NE	not established
NNSA	National Nuclear Security Administration
No(s).	number(s)

NUFT	Non-Isothermal, Unsaturated Flow and Transport (model)
OEHHA	Office of Environmental Health Hazard Assessment
Pb	lead
PCB	polychlorinated biphenyl
pCi/g	picoCuries per gram
pCi/l	picoCuries per liter
PNNL	Pacific Northwest National Laboratory
PRGs	preliminary remediation goals
QC	quality control
Ra	radium
RBAS	risk-based action standard
RESRAD	RESidual RADioactivity (model)
RI	Remedial Investigation
RPM	remedial project managers
RME	reasonable maximum exposure
Rn	radon
RWQCB	Regional Water Quality Control Board
Sr	strontium
SVOC	semi-volatile organic compound
Th	thorium
U	uranium
UC Davis	University of California, Davis
UCL	upper confidence limit
US EPA	United States Environmental Protection Agency
VOC	volatile organic compound
WA	Weiss Associates
WRS	Wilcoxon Rank Sum
yd(s)	yard(s)

### **EXECUTIVE SUMMARY**

This human health risk characterization addresses U.S. Department of Energy (DOE) Areas at the Laboratory for Energy-Related Health Research (LEHR or the Site) at the University of California, Davis (UC Davis). The United States Environmental Protection Agency (US EPA) designated the LEHR site as a Superfund site in 1994, and DOE and UC Davis are responsible for its cleanup. This DOE areas human health risk characterization is based on the risk estimates presented in the *Site-Wide Risk Assessment, Volume I: Human Health Risk Assessment, Part A - Risk Estimate* (UC Davis, 2005). At a later date, UC Davis will issue an ecological risk estimate and risk characterization for DOE and UC Davis areas at LEHR, as well as a human health risk characterization for the UC Davis areas.

DOE has cleanup responsibility under CERCLA, as defined in the Federal Facility Agreement (US EPA, 1999), for the following areas at LEHR:

- DOE Disposal Box,
- Domestic Septic Systems Nos. 1 through 7,
- Dry Wells A through E,
- Eastern Dog Pens (excluding the underlying landfill),
- Radium/Strontium Treatment Systems Area,
- Southwest Trenches Area, and
- Western Dog Pens.

Under a separate agreement between DOE and UC Davis, UC Davis has accepted responsibility for the clean up of ground water impacted by releases at both DOE and UC Davis areas.

Based on EPA guidance, risk characterization is the final stage of risk assessment and is intended to provide the risk managers with an understanding of the uncertainties and technical basis to help formulate appropriate remedial strategies. The output of the risk estimate is a list of constituents that present cancer risks to potential receptors of  $10^{-6}$  or above, or that have a hazard quotient greater than one. These constituents are referred to as constituents of potential concern (COPCs), and are the focus of this risk characterization.

For each of the DOE areas, COPC spatial distribution, exposure conditions, analytical uncertainty, degradation/decay rates, data representativeness and other factors are evaluated. Based on multiple lines of evidence, the uncertainties associated with the risk estimate are systematically identified and discussed. To facilitate risk management decisions, the risk characterization makes recommendations on whether the COPC should be evaluated as a constituent of concern (COC) in

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the DOE Areas Feasibility Study. Recommendations for constituents with potential ground water impacts are also included.

A summary of the recommendations for risk COPCs is presented in Table ES-1. The Table shows COPCs evaluated in this risk characterization for these receptors: on-site resident, on-site outdoor researcher, on-site indoor researcher, and the on-site construction worker. The trespasser receptor is not included because the collective cancer and non-cancer risks to this receptor are below the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) points of departure of 10<sup>-6</sup> and Hazard Index of 1, respectively, and therefore require no action. Table ES-2. summarizes recommendations for ground water COPCs associated with residual site contamination.

# Table ES-1.List 2 Constituents of Potential Concern Recommended as Constituents of Concern<br/>for Evaluation in Feasibility Study

List 2 Driver COPC	On-Site Resident	On-Site Outdoor Researcher	On-Site Indoor Researcher	On-Site Construction Worker
DOE DISPOSAL BOX				
Lead-210	*	_	_	_
Thorium-228	*	*	-	-
DOMESTIC SEPTIC SY	STEM NO. 1		4	<u>.</u>
None	-	_	_	_
DOMESTIC SEPTIC SV	STEM NO 2	1	1	
	See Radium/Strop	ntium Treatment System	ms Area helow	
DOMESTIC SEDTIC SV	STEM NO 3	utum Treatment Syster	ns med, below	
DOWLESTIC SEPTIC SY	STEM NO. 5			1
Aroclor 1254		-	-	-
Lead 210	<b>.</b>	-	-	-
		-	-	-
DOMESTIC SEPTIC SY	STEM NO. 4	Γ	1	Τ
Benzo(a)anthracene		-	-	-
Benzo(a)pyrene		-	-	•
Benzo(b)fluoranthene		-	-	-
Benzo(k)fluoranthene		-	-	-
Dibenzo(a,h)anthracene		-	-	*
Indeno(1,2,3-cd)pyrene		-	-	-
Lead-210	*	-	-	-
DOMESTIC SEPTIC SY	STEM NO. 5	1	1	1
None	-	-	-	-
DOMESTIC SEPTIC SY	STEM NO. 6			
None	-	-	-	-
DOMESTIC SEPTIC SY	STEM NO. 7			
Lead-210	*	-	-	-
DRY WELLS A-E				
Arsenic	×	_	_	<b>X</b>
Radium-226	×	×	<b>x</b>	*
Thorium-228	*	*	*	*
EASTERN DOG PENS				1
Dieldrin		_		_
Lead-210	<b>x</b>	_		
Strontium-90	ě	_	_	_
DADIUM/STDONTIUM	TDFATMENT SVS	TEMS ADEA		
Strontium 00		I ENIS AREA		
Thorium-228	<b>2</b>	*	-	-
		••	-	-
SUUTHWEST IKENCH	IES 🐱		T	1
Cesium-13/		<b>₩</b>	-	-
Lead-210 Streation 00		-	-	-
Strontium-90		-	-	-
i norium-228	<b>—</b>		-	-

# Table ES-1.List 2 Constituents of Potential Concern Recommended as Constituents of Concern<br/>for Evaluation in Feasibility Study (continued)

List 2 Driver COF	PC	On-Site Resident	On-Site Outdoor Researcher	On-Site Indoor Researcher	On-Site Construction Worker
WESTERN DOG	PENS				
Lead-210 Thori um-228 Uranium-238		* * *	- *	* * -	- X -
Abbreviations         Image: Second state of the					

•	Retain as COC for evaluation in Feasibility Stud
-	No COPC to evaluate for this receptor.
COC	constituent of concern
COPC	constituent of potential concern
DOE	United States Department of Energy
FS	Feasibility Study

number

No.

 $\label{eq:linear} Weissdc01\clients\DOE\4108\142\Risk\ Characterization\RC_fnl.doc$ 

# Table ES-2.Ground Water Constituents of Potential Concern Recommended as Constituents of<br/>Concern for Evaluation in Feasibility Study

COPGWCs	COC for Evaluation in Feasibility Study
DOE DISPOSAL BOX	
None	-
DOMESTIC SEPTIC SYSTEM NO. 1	1
Aluminum	
DOMESTIC SEPTIC SYSTEM NO. 2	
See Radium/Strontium Tre	atment Systems Area, below
DOMESTIC SEPTIC SYSTEM NO. 3	
Aluminum	
Formaldehyde	•
Hexavalent Chromium	*
Molybdenum	•
Nitrate (as N)	•
Silver	
DOMESTIC SEPTIC SYSTEM NO. 4	
Aluminum	
Chromium	
Hexavalent Chromium	*
Nickel	
Selenium	
DOMESTIC SEPTIC SYSTEM NO. 5	
Aluminum	
Hexavalent Chromium	*
DOMESTIC SEPTIC SYSTEM NO. 6	
Aluminum	
Hexavalent Chromium	*
DOMESTIC SEPTIC SYSTEM NO. 7	
None	-
DRY WELLS A-E	
Chromium	
Hexavalent Chromium	
Mercury	
Molybdenum	•
Silver	•
Cesium-137	•
Strontium-90	
EASTERN DOG PENS	1
alpha-Chlordane	
gamma-Chlordane	
Dieldrin	
Hexavalent Chromium	
RADIUM/STRONTIUM TREATMENT SYSTEMS	
Hexavalent Chromium	
Nitrate (as N)	
Americium-241	
Caluon-14 Dadium 226	
Kaalum-226	

# Table ES-2.Ground Water Constituents of Potential Concern Recommended as Constituents of<br/>Concern for Evaluation in Feasibility Study (continued)

COPGWCs	COC for Evaluation in Feasibility Study
SOUTHWEST TRENCHES	
Hexavalent Chromium	*
Mercury	
Nitrate (as N)	•
Zinc	
Carbon-14	•
Tritium	*
WESTERN DOG PENS	
Hexavalent Chromium	*

Abbreviations

×	Eliminate from evaluation in Feasibility Study
•	Retain as COC for evaluation in Feasibility Study
	Include in site monitoring plan
-	No COPC to evaluate for this receptor.
COC	constituent of concern
COPC	constituent of potential concern
COPGWC	constituent of potential ground water concern
DOE	United States Department of Energy
FS	Feasibility Study
No.	number

### 1. INTRODUCTION

This human health risk characterization is based on risk estimates presented in the *Site-Wide Risk Assessment, Volume I: Human Health Risk Assessment, Part A – Risk Estimate* (HHRA Risk Estimate) (UC Davis, 2005) for the United States Department of Energy (US DOE or DOE) areas at the Laboratory for Energy-Related Health Research (LEHR or Site) (Figure 1-1). This report provides risk characterization for areas of the Site that DOE has cleanup responsibility for under the Comprehensive Emergency Response, Compensation and Liability Act (CERCLA or Superfund), as defined in the Federal Facility Agreement (US EPA, 1999). This report is consistent with the United States Environmental Protection Agency's (US EPA's) guidance for risk assessments under Superfund (US EPA, 1991).

This risk characterization report is intended to provide the risk managers with a summary of risk factors and uncertainty associated with the DOE areas in a manner that facilitates the formulation of remedial strategies that will be appropriate for the Site. The University of California at Davis (UC Davis) is responsible for the preparation of both, a separate summary of risks associated with areas of the Site for which UC Davis has responsibility, as well as a site-wide ecological risk assessment.

This report was prepared by Weiss Associates (WA) under DOE/National Nuclear Security Administration (NNSA) LEHR Environmental Management Completion, DOE Delivery Order DE-AD03-04NA99610.

### 1.1 Purpose of Risk Characterization

The purpose of risk characterization in the context of CERCLA is to clearly articulate and communicate the risks associated with contamination at a Superfund site, and to provide the context and scientific basis for risk managers that facilitate decision-making about site cleanup activities. Risk characterization is the process of summarizing the toxicity and exposure assessments, and integrating them into quantitative and qualitative expressions of risk. In this process, comparisons are made between projected intakes of substances and toxicity values; probabilities that human or ecological receptors will be negatively impacted over a lifetime of exposure are estimated from projected intakes and chemical-specific dose-response information. Major assumptions, scientific judgments and estimates of the uncertainties embodied in the assessment are presented in a risk characterization.

As illustrated in Figure 1-2, this process serves as the bridge between the risk estimate and risk management, and is a key step in the formulation of remedial activities that will ensure adequate protection of human health and the environment, as required by the National Contingency Plan (per Title 40 of the Code of Federal Regulations, Section 300). This step assimilates risk assessment

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information for the risk manager to consider alongside other factors important for clean-up decisions, such as technical feasibility and regulatory requirements.

#### 1.2 Areas Covered in this Risk Characterization

This document provides risk characterization for areas of the Site for which DOE has cleanup responsibility under CERCLA, as defined in the Federal Facility Agreement (US EPA, 1999). These areas are shown on Figure 1-3 and include the:

- DOE Disposal Box;
- Domestic Septic Systems Nos. 1 through 7;
- Dry Wells A through E;
- Eastern Dog Pens (excluding the underlying landfill);
- Radium/Strontium Treatment Systems Area;
- Southwest Trenches Area; and
- Western Dog Pens.

Under a separate agreement between DOE and UC Davis, UC Davis has accepted responsibility for the clean up of ground water impacted by releases at both DOE and UC Davis areas.

#### **1.3 Summary of Risk Assessment Activities Performed to Date**

#### 1.3.1 Agency for Toxic Substances and Disease Registry Public Health Assessment

Congress established the Agency for Toxic Substances and Disease Registry (ATSDR), an agency of the United States Public Health Service, in 1980 under CERCLA. Since 1986, ATSDR has been required by law to conduct a public health assessment at each of the sites on the US EPA National Priorities List. The aim of these evaluations is to find out if the public has been, or is being, exposed to hazardous substances and, if so, whether that exposure is harmful and should be stopped or reduced.

On July 1, 2004 the ATSDR released the Final Version of Public Health Assessment on the LEHR/Old Campus Landfill Site, Davis, California. After evaluating site investigation data and observations made during site visits, ATSDR concluded the following about off-site exposures (beyond the Site fence line):

• Past exposure to nitrate and metals in off-site ground water was possible by way of private drinking water wells and irrigation wells. These contaminants are not believed to be related to the Site.

- Exposure to mercury is possible for people who consume Putah Creek fish, primarily largemouth bass. This contaminant is not believed to be related to the Site.
- Current and future exposures to contaminants in Putah Creek surface water are possible for people who use the creek for recreational activities. ATSDR categorized this pathway as posing no apparent public health hazards for current and future exposures. A conclusion about past exposure cannot be drawn; thus, past exposure to contaminants in Putah Creek surface water is categorized as an indeterminate public health hazard.

ATSDR concluded the following about on-site exposures:

- Minimal potential, if any, exists for exposure to contaminants in on-site surface soil, airborne contaminants, or ambient radiation. ATSDR categorized these pathways as posing no apparent public health hazards for past, current, or potential future exposures.
- The public is not coming in contact with contaminated ground water beneath the Site because no one uses the shallow ground water as a source of drinking water. UC Davis continues to track ground water contaminant migration beneath the Site and away from the Site boundaries. ATSDR categorized this pathway as posing no public health hazard for past, current, or potential future exposures.

ATSDR recommended that private well users in the community surrounding LEHR:

- Regularly test their well water for nitrate/nitrite;
- Avoid giving infants under six months of age private well water if nitrate/nitrite levels exceed 10,000 parts per billion; and
- Avoid boiling water, which tends to concentrate nitrate/nitrite levels; instead, use an alternative source of water.

### 1.3.2 Risk-Based Action Standards

DOE developed risk-based action standards (RBASs) for soil potentially impacted by LEHR activities to use as guidance in conducting removal actions. The RBASs were calculated to reflect a cumulative cancer risk at a nominal range of  $10^{-4}$  to  $10^{-6}$ , using  $10^{-6}$  as the point of departure; and a cumulative non-cancer hazard quotient of 1.0.

Although removal activities at LEHR were guided by RBAS values that were calculated based on radionuclide slope factors published in the US EPA's November 1995 Health Effects Assessment Summary Tables (HEAST), the US EPA's new radionuclide toxicity values published in the 2001 HEAST have been updated to incorporate more recent baseline cancer mortality data and other minor adjustments.

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Due to the 2001 changes in radionuclide cancer slope factors, the risk estimates supporting the RBAS, while conservative at the time they were developed and applied, may underestimate the radiological risk as currently understood. The radiological evaluation subsequently developed in the HHRA Risk Estimate, which forms the basis for this risk characterization, was based on the cancer slope factors in the updated and current 2001 HEAST.

#### 1.3.3 Analysis of Regional Water Quality Control Board Soil Designated Levels

The Regional Water Quality Control Board established cleanup levels, for specific constituents of a waste, which provide a site-specific indication of the water quality impairment potential of the waste (CRWQCB, 1989). These cleanup levels are referred to as designated-levels (DL) and are calculated by first determining the bodies of water that may be affected by a waste and the present and probable future beneficial uses of these waters. Next, site-specific "water quality goals" are selected, based on background water quality or accepted criteria and standards, to protect those beneficial uses. Finally, these water quality goals are multiplied by factors that account for environmental attenuation and leachability of the constituent in question. The result is a set of soluble and total DLs that are applicable to a particular waste and disposal site and which, if not exceeded, should protect the beneficial uses of waters of the State. Wastes having constituent concentrations in excess of these DLs are assumed to pose a threat to water quality and are, therefore, classified as 'designated wastes' requiring remedial action. The results of the DL analysis are updated and included in this document to assist decision makers in determining the need for remedial action or ground water monitoring based on the potential threat to ground water posed by residual constituents of potential concern (COPCs) in unsaturated soil.

The DL analysis approach used for the Southwest Trenches Area, the Radium/Strontium Treatment System Area, and the Eastern and Western Dog Pens is described in detail in the Remedial Project Managers-approved Final Work Plan for Removal Actions in the Southwest Trenches, Ra/Sr Treatment Systems, and Domestic Septic System Areas for the Laboratory for Energy-Related Health Research (WA, 2000b) and the Final Southwest Trenches Area 1998 Removal Action Confirmation Report for the Laboratory for Energy-Related Health Research (WA, 2001b) and the DOE Areas Remedial Investigation Report (WA, 2003b).. The approach consisted of three phases. Phase A, Preliminary DL Analysis, involved screening the Remedial Action confirmation data and all validated data with accurate x- and y- coordinates for sample locations through a series of steps to arrive at a list of "DL COPCs". The screening steps included comparison with background levels and consideration of half-lives, biodegradability, and adsorption coefficients (K<sub>d</sub>), in addition to previous vadose zone modeling results. Once the DL COPC list was established, Phase B, Data Gaps Investigation, was conducted, where necessary, to collect additional vertical profile data on the DL COC. Phase C, Refined DL Analysis, entailed conducting vadose zone modeling and comparing the resultant ground water-protective soil concentration thresholds to the actual soil concentrations in the source area. The details of the vadose zone model, including the selection of input parameter values and model setup, are presented in the Draft Final One-Dimensional Vadose Zone Modeling for the U.S. DOE Areas at LEHR (WA, 1997a). The model: 1) did not consider attenuation (dilution and dispersion) in ground water away from the source; 2) focused on source-area-specific, post-Removal Action constituents of concern (COCs) only; 3) used source-area-specific, post-Removal Action soil

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profile and contaminant distribution; and 4) used the US EPA and California (if lower than US EPA) maximum contaminant level (MCL) and background levels as the ground water criteria.

The DL analysis approach used for the DOE Box and Domestic Septic Systems Nos. 1, 3, 4, 5, and 6 were based on deionized water waste extraction test (DI WET) results for selected soil samples as documented in Appendix C. The DI WET test results were directly compared to three water quality goals: ground water background, MCLs, and tap water PRGs to determine the soil's potential to degrade water quality. Background was defined by the maximum detected concentration of each constituent detected in HSU 1 ground water well UCD1-18, located upgradient of the LEHR site (Figure 2-3). The results were first compared to background. If they exceeded background, they were compared to the MCLs. If no background or MCL was available, the tap water PRGs were used.

Direct comparison between the DI WET results and the water quality goals assumes an environmental attenuation factor of ten because the WET procedure requires the use of ten parts of water per every part of waste (e.g., soil). Additional analysis and characterization of the DL COPC derived from the DL analyses are included in the area-specific risk characterization discussions presented later in this document..

#### 1.3.4 Ambient Radiation

Ambient radiation monitoring using thermoluminescent dosimeters to monitor beta and gamma radiation throughout the LEHR site has been conducted at LEHR since 1991. The thermoluminescent dosimeters were placed near perimeter fence lines, radioactive waste storage areas and various work areas around the Site on a quarterly schedule and were used to calculate an annual radiation dose. The dose was referenced to a dose obtained at an off-site location (the UC Davis Equine Center) that represented the ambient background dose. The ambient radiation dose recorded has been consistent with background in all locations, with the exception of the former Geriatrics facility and the Imhoff waste treatment tanks. The Geriatrics facility was used as a low-level radioactive waste storage area. The radiation dose at this location exceeded background during the years when waste was stored in the building and dropped to background levels in 2003 after the waste had been shipped off site. The radiation activities that exposed underground waste treatment and storage tanks. After completion of the removal action activities, the radiation dose at this location returned to background levels.

While ambient dose monitoring is not a direct predictor of risk, the data collected as part of this monitoring indicate that the radiation dose associated with site activities since 1991 is consistent with background dose levels.

### 1.4 General Risk Characterization Considerations

Considerations for human health risk characterization, such as spatial distribution of COPCs, exposed population exposure routes and durations, quality of toxicological data, additive chemical

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effects, sample set used in risk assessment, analytical uncertainty, degradation/decay rates, and data representativeness, are evaluated in the HHRA Risk Estimate. This information is summarized in this report.

### 1.5 Organization of Risk Characterization Report

This report is organized into eight sections, including this Introduction. Section 2 provides background information that is relevant to all DOE areas. It summarizes the methodology used in conducting the health risk assessment and describes data common to analyses of each DOE area. It contains a discussion of site background conditions, including the methodology employed to characterize background conditions, and the variability and uncertainty associated with the methods used. The subsequent sections (3 through 8) provide a characterization of risk for each distinct area of the Site. These sections present interpretations of the risk estimate data, toxicity values, and uncertainties, and suggest reasonable and appropriate conclusions to be drawn from the risk estimation process for use in developing risk management decisions.

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Figure 1-1. Location of the LEHR Site, UC Davis, California

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#### Figure 1-2. Risk Assessment Process

#### Section 1 Rev. 0 9/30/05 Figures

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Figure 1-3. Areas of DOE and UC Davis Responsibility Under CERCLA

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# 2. RISK CHARACTERIZATION METHODOLOGY

# 2.1 General Considerations—Transparency, Clarity, Consistency, Reasonableness

US EPA guidance governing the development of HHRAs (US EPA, 1989) stresses the following four values:

- Transparency in the decision-making process;
- **Clarity** in communication to the public regarding environmental risk and the uncertainties associated with assessments of environmental risk;
- **Consistency** in core assumptions and science policies that is well grounded in science; and
- **Reasonableness** in erring on the side of protection in the face of scientific uncertainty without being unrealistically conservative.

These core values of transparency, clarity, consistency, and reasonableness are building blocks for the development of CERCLA assessment and have been applied by DOE in the development of this risk characterization document.

# 2.2 Methodology—Human Health Risk Characterization

The DOE areas human health risk characterization refines the exposure assessment previously developed in the HHRA Risk Estimate (UC Davis, 2005), and integrates the results to characterize the risk to on- and off-site human receptors. Although the Site is located within an active university research facility, this risk characterization evaluates hypothetical residential exposure, as well as other exposure scenarios that are consistent with current site use and long-range plans for the Site. Consistent with the HHRA Risk Estimate, this risk characterization uses the terms "List 1" and "List 2." List 1 refers to the complete suite of COPCs considered in the Tier 2 HHRA Risk Estimate (i.e., constituents that exceeded the EPA Region IX preliminary remediation goals [PRGs] [US EPA, 2002b]). List 2 refers to the List 1 COPCs that have concentrations greater than background concentrations, as demonstrated by statistical comparisons (failed background comparison).

The List 2 risk values and hazard quotients presented reflect the risk due to site releases, plus the risk due to background. Therefore, these risk values and hazard quotients may overestimate the excess risk attributed to site releases for naturally occurring and ubiquitous anthropogenic COPCs.

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This risk characterization identifies a subset of the List 2 driver COPCs that represent potential site-related risks and are the best candidates for further evaluation in the Feasibility Study. This subset comprises COPCs that have a risk of at least  $10^{-6}$  or contribute more than ten percent of the total excess cumulative cancer risk equal to or greater than  $10^{-6}$  in the area evaluated.

# 2.2.1 Background Information

The risk characterization provides the following background information for each area evaluated:

- Area Description—a brief description of the area;
- Pre-Removal Action Contaminant Distribution—a discussion and a tabular listing (in the first table of each section) of contaminants found during investigations conducted prior to any removal actions;
- Removal Action Activities—a summary of removal action activities; and
- Post Removal Action Contaminant Distribution—a discussion of the contaminants remaining in the area soils after the completion of removal actions, usually based on confirmation sampling.

It should be noted that the list of contaminants summarized in the post removal action contaminant distribution sections differs from the list of contaminants used in the HHRA Risk Estimate and evaluated in the risk characterization. The HHRA Risk Estimate included post-removal action confirmation samples, but also evaluated applicable investigation samples collected prior to removal actions. The data from investigation samples was redacted in the HHRA Risk Estimate to exclude data associated with samples representative of removed waste.

# 2.2.2 Summary of Risk Estimate Data

Each section of this report includes human health risk tables, one table for each at-risk receptor at each area, that summarize the steps taken to select the List 2 COPCs and the List 2 driver COPCs from the List 1 COPCs. For radionuclide COPCs, the selection of List 2 driver COPCs were based on risks that were not corrected for radioactive decay. Radioactive decay, which will have occurred since the samples were collected, is accounted for in this report; however, after the List 2 driver COPCs are selected. Accounting for radioactive decay, and the corresponding reduction in risk, provides decision makers an up-to-date assessment of Site risk.

# 2.2.2.1 Quality of Site Data

Laboratory analyses for which the reported concentrations are below the detection limits are assigned proxy concentration values for this report. For radionuclides, proxy values are the measured values reported by the laboratory, except if the reported values are negative, in which case the proxy values are zero. For analytes that are not radionuclides, proxy values are half the analytic detection limits. The laboratory analyses for which the reported concentrations are above the

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detection limit are termed "positive" results to distinguish them from "proxy" results. Appendix A provides radionuclide values used in the HHRA Risk Estimate with associated analytical uncertainty and minimum detectable activity and/or minimum detectable concentration.

# 2.2.3 Exposure Assessment

The exposure assessment combines information regarding contamination remaining in various media at a site with assumptions about the receptors who may come into contact with these media. The HHRA Risk Estimate (UC Davis, 2005) included assumptions about the exposure to media of concern at the Site for each receptor via defined exposure pathways. Figure 2-1 is the Conceptual Site Model for the HHRA Risk Estimate, which presents the media of concern and exposure pathways by which these media may impact the receptors at DOE areas of the Site (this site model is based on the conceptual site model provided in the HHRA Risk Estimate). Site-specific factors were derived from available site data to reflect average or reasonable maximum exposure (RME) conditions.

The exposure assumptions used in the HHRA Risk Estimate are presented in Figure 2-1, which identifies the two soil-depth intervals to which different receptors are exposed. All receptors, except the off-site resident, were assumed exposed to external radiation from subsurface soil in all DOE areas. For the remaining open exposure pathways, the indoor researcher, outdoor researcher and trespasser receptors were assumed exposed to surface soil (0- to 0.5-ft depth) in the Western and Eastern Dog Pens and Southwest Trenches area. Whereas the construction worker and resident receptors were assumed exposed to subsurface soil (zero- to ten-ft depth) in all areas. Surface soil contamination does not exist at DOE Box, Domestic Septic Systems, Dry Wells and Radium/Strontium Treatment Systems areas, because:

- Releases in these areas were limited to the subsurface;
- Engineering controls during removal actions prevented contamination of surface soil from subsurface waste; and
- Clean soil was used to backfill the excavation.

The DOE areas where contamination exists in surface soil are Eastern Dog Pens, Southwest Trenches and Western Dog Pens. The conceptual site model was modified to show that the indoor researcher was exposed to fugitive dust inhalation. However, as noted in Figure 2-1, this change had negligible effects on the risk estimate. The HHRA Risk Estimate indicated that site risks for the hypothetical trespasser were the lowest of all receptors evaluated and well below the risk/hazard points of departure for all constituents at all DOE areas, and therefore is not discussed further in this document.

Intakes of lead are assessed differently from other chemicals. The models that were used combine blood lead slope-factor estimates with assumptions about adult and child exposures to lead-containing media. The models also incorporate assumptions about background lead levels in air, water, and food to which receptors are simultaneously exposed in order to develop a total blood lead level estimate from all lead exposure pathways.

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Risks associated with some radionuclides in soil are assessed both separately from and together with chemical contaminants since some radionuclides include chemical toxicity in addition to radiological risk. The Argonne National Laboratory (ANL, 2000) Residual Radioactivity (RESRAD) model was used for assessing radiological risks. All applicable exposure pathways and fate- and transport-modeling are accounted for in RESRAD.

### 2.2.3.1 Spatial Distribution of Contaminants of Potential Concern

A visual comparison of the site data to the background and risk benchmarks (e.g.,  $10^{-6}$  and  $10^{-5}$ ) should identify data anomalies and trends that may have significance in the risk assessment and characterization process. Spatial maps are provided for each driver COPC at each area discussed in this risk characterization to facilitate this visual review of the data.

The concentration values and risks presented on the maps do not account for decay of radionuclides. Because radioactive decay may have reduced the risk present at the time samples were collected, the maps will in some instances err conservatively by indicating more risk than is present today. Decay of radionuclides is accounted for elsewhere in this document, as discussed in Section 2.2.3.2 below, to provide decision makers with the current risks at the Site.

Sample results are represented on the maps with symbols keyed to whether the analytic results were above or below the detection limit ("positive" and "proxy" results, respectively), whether the analytic results were above or below the background screening value, and to level of risk. Figure 2-2 illustrates the general map symbology, which follows these rules:

- Shape—Squares represent proxy results and circles represent positive results.
- Size—Higher risk levels are represented by larger symbols and lower risk levels are represented by smaller symbols. In addition, within each risk level, the symbol representing the result less than the background screening value is smaller than the symbol representing the result greater than the background screening value.
- Color—Yellow indicates concentrations less than the background screening value and is not representative of a specific risk range; non-yellow colors indicate concentrations greater than the background screening value, and each color represents a different risk range.

All symbols are uniquely defined by shape and relative size to avoid ambiguity if the maps are ever reproduced in black-and-white. Color enhances the distinction between symbols, but does not uniquely define symbols. Although the symbology rules allow high-risk, below-background symbols to be similar in size to low-risk, above-background symbols, these categories cannot appear on the same map, precluding ambiguity.

Symbol colors, shapes, and relative sizes are consistent throughout the maps in this report, although the actual symbol sizes may vary between maps of different areas due to graphical production constraints. The explanation included on each map shows all symbols exactly as they appear on that map. The symbol explanations also specify which receptor or receptors are at risk, as

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well as the risk level for each receptor. Where multiple receptors are at risk, the receptor at highest risk determines the choice of symbol.

#### 2.2.3.2 Degradation and Decay of Contaminants of Potential Concern

Degradation of chemical COCs and decay of radionuclide COCs are discussed and, where appropriate, quantified in this risk characterization document. Although degradation and decay are not accounted for in the selection of the List 2 driver COPCs or in the spatial distribution maps, degradation and decay are discussed and presented in tables of recommendations (Summary of Major Factors Driving Risk and Recommendations for Future Action) in each section (Sections 3 through 8). References to radionuclide concentrations and associated risks are to the non-decay-corrected values, unless explicitly stated that the value is decay-corrected. A summary of the half-lives for radioactive isotopes present at LEHR is provided in this section and the decay calculation procedures are described in detail in Appendix B.

- Cesium-137 (Cs-137) has a half-life of 30.07 years and is not a naturally occurring radionuclide. It is a fission product and may be attributed to atmospheric global fallout from nuclear weapons and reactor operations. It will not be replenished by the decay of a parent isotope.
- Pb-210 is naturally occurring and is part of the uranium-decay series, where it is derived from radium-226 (Ra-226) (1,600-year half-life) and ultimately uranium-238 (U-238). It has a 22.3-year half-life. In a natural system, Pb-210 will exist at a constant concentration since it will be replenished by its long-lived parent isotopes. In most of the DOE areas, Pb-210 has been identified in soil at levels above background. None of these areas have elevated concentrations of parent isotopes of Pb-210. The elevated concentrations of Pb-210 are likely a result of analytic error, but could have also resulted from former radon releases or direct releases of Pb-210. In the absence of elevated concentrations of parent isotopes, Pb-210 will decay to background levels.
- Ra-226 has a half-life of 1,600 years. Ra-226 is naturally occurring and is part of the uranium-decay series, where it is derived from U-238. Decay of natural uranium will replenish Ra-226 at background concentrations.
- Strontium-90 (Sr-90) has a half-life of 28.79 years and is not naturally occurring. The presence of ambient Sr-90 may be attributed to atmospheric global fallout from nuclear weapons and reactor operations.
- Thorium-228 (Th-228) is naturally occurring and is part of the thorium-decay series, where it is derived from primordial Th-232, which has a half-life of  $1.4 \times 10^{10}$  years. The half-life of Th-228 is 1.9 years.
- U-238 is a naturally occurring isotope that has a half-life of 4.468 x 10<sup>9</sup> years. It is the primordial parent isotope of the uranium-decay series. Natural U-238 replenishment will not occur due to its position at the head of its decay chain.

#### 2.2.3.3 Background Evaluation

#### 2.2.3.3.1 Detections above Site Background

For each area, a Summary of Sampling Results table presents the number of analytical results that were greater than both the detection limits and the background screening levels for the List 1 COPCs.

#### 2.2.3.3.2 Parent-Daughter Activity Concentration Relationships

Radionuclides are present in concentrations greater than background in some areas where the long-lived parents or short-lived daughters of those radionuclides are, in contrast, not at concentrations greater than background. This apparent disequilibrium is cause for investigation because a long-lived parent and a short-lived daughter are expected to have approximately equal activity concentrations, barring a recent release of one or the other. To address the apparent disequilibrium, comparison graphs are included in Appendix E for both site and background samples for the two pairs Ra-226 (parent) and Pb-210 (daughter), and Th-232 (parent) and Th-228 (daughter). These graphs show, for each sample, the concentration and analytical error for both parent and daughter isotopes. The analytical errors of the parents overlap with the analytical errors of the daughters are in equilibrium. Therefore, the apparent disequilibrium indicated by the statistical comparisons (e.g. Wilcoxon Rank Sum test) to the background concentrations is most likely an artifact of the analytical limitations and not due to a release.

#### 2.2.3.3.3 Comparison of Risk Attributed to Background versus Site Activities

To determine the relative proportions of the site risk that can be attributed to background sources, the site concentrations were compared to background concentrations. In particular, site EPCs were compared to background EPCs wherever possible. Risk is a linear function of EPC, so the proportion of the site EPC that is equal to the background EPC is the proportion of the site risk that is due to background sources.

EPCs for background were calculated using the same method that was used to calculate the EPCs for the constituents at each area of the Site in the HHRA Risk Estimate (UC Davis, 2005). That is, the background EPCs are the 95% upper confidence limits (UCLs) on the mean concentrations of samples collected from depths shallower than 10 ft. The 95% UCL was used in the risk comparisons because it is the concentration term recommended by EPA for determining reasonable maximum exposure. Based on EPA guidance, the intent of the 95% UCL is to estimate a conservative exposure case (i.e., well above the average case) that is still within the range of possible exposures. This approach yields uncertainty in the upper- and lower-range of possible exposures since they are not calculated. Additionally, the 95% UTL calculation may be unreliable when large portions of the input data are censored by laboratory detection limits or when applied to data sets that are not representative of field conditions. The background 80% lower confidence limit of the 95th quantile (UTL) was not used in the comparison of background and site risks. The UTL benchmark is used in various parts of the this document to make comparisons to the UTL is conservative, since 5% or more of the background range. A point sample comparison to the UTL is conservative.

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The UTL comparison may be unreliable when applied to data points that are not representative of field conditions.

For each area, a table is included that presents statistics for the sample results for each List 2 driver COPC, for both the site and the background. These statistics are those relevant for calculating the 95% UCLs. For radionuclides, decay-corrected EPCs are also included in the table. For pesticides and polychlorinated biphenyls (PCBs), the background 95% UCLs and EPCs were assumed to be zero.

The relative proportions of the risks due to background are presented graphically in the form of bar charts, where the bars are split according to the relative proportion of the background and above-background contributions. In cases where the background contribution is either 0% or 100%, bar graphs are not presented. The proportion of the risk that is greater than the background contribution is identified as the contribution from site activities. The heights of the bars, as well as the heights of the two sections of the bars, are scaled to the associated risk. For radionuclides, the risks and proportions are corrected for decay. The values of risk presented on the bar graphs are not rounded. In the human health risk tables and the summary tables, however, the risk values are rounded. The final summary table in each section of this report presents the contribution to the risk that can be attributed to the background, as well as the proportion of the risk that is greater than the background contribution.

#### 2.2.4 Toxicity Assessment

For COPCs in the DOE areas, the toxicity values were taken from US EPA guidance (Cal/EPA, 2004), (US EPA, 1997), (US EPA, 2001), (US EPA, 2004), as determined by a peerreview process. There are uncertainties associated with the process of collecting data and extrapolating test data to environmental conditions and different individuals in a population. These uncertainties are quantitatively addressed in the development of the toxicity values to provide a conservative approach oriented to protecting public health. The toxicity values used for these COPCs are appropriate for this evaluation and make use of the best available information.

# 2.2.5 Risk Estimate

This risk characterization provides a summary of the risk estimate developed in the HHRA Risk Estimate. The risk to each receptor affected by the List 2 driver COPCs in the DOE areas is discussed in each section. These risk values are provided without decay correction.

# 2.2.6 Uncertainty

Risk estimates are values that have uncertainties associated with them. At each step of the analysis, uncertainties arise and the use of conservative assumptions is compounded to ultimately

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yield an overestimation of risk. Four main areas of uncertainty entered into the HHRA Risk Estimate at each of the following steps:

- Environmental sampling and analysis;
- Fate-and-transport modeling;
- Exposure scenario development; and
- Toxicity data and dose-response extrapolations.

Identifying the sources and potential magnitude of the major uncertainties is crucial to the appropriate interpretation of risk assessment results. A detailed analysis of the major sources of uncertainty associated with the human health risk estimate methodology (i.e., the exposure and effects assessments) is provided in Section 7 of the HHRA Risk Estimate (UC Davis, 2005). A discussion of the major sources of uncertainty, including data coverage and analytical issues, specific to each DOE area is included in each area-specific section of this risk characterization.

#### 2.2.6.1 Analytical Issues

Analytical precision and accuracy may have an effect on the uncertainty associated with the risk estimate. Analytical issues specific to each area, such as detection limits, counting errors, and other factors, are discussed in each section along with a description of their effect on the risk estimate. General analytical issues are described in this section.

One analytical issue common to DOE areas evaluated in the HHRA Risk Estimate is the analysis of Sr-90 in samples collected during the 1996 Limited Field Investigation (LFI). The LFI samples were prepared using a selective purification process to form strontium carbonate precipitate, which was analyzed by EPA Method 905.0. Because the precipitation process occasionally failed to selectively separate strontium in the sample, the Sr-90 result sometimes greatly exceeded the samples' gross beta activity. In October 1997, the laboratory improved the Sr-90 sample preparation method by implementing a column separation technique to fractionate strontium from interference in the samples. After the new technique was implemented, no Sr-90 sample results were found to significantly exceed the gross beta activity. The samples used to determine Sr-90 background were collected and analyzed in 1997, after the analytical improvement was implemented. It should be noted that background samples were collected in 1994, but these data were not used to determine Sr-90 background (WA, 2000b).

The 1996 LFI samples had the high bias from the old method, but the Sr-90 background samples collected in 1997 did not have the high bias. Comparisons between the DOE areas data and 1997 background indicated Sr-90 was above background in most of the DOE areas. However, the background tests may have drawn an incorrect conclusion about Sr-90 in some of the DOE areas because the 1996 LFI data were biased high. In addition, the DOE areas risk estimates are likely high for Sr-90 due to the 1996 LFI data.

The Ra-226 analytical method was less precise before October 1997. The 1996 LFI samples were analyzed for Ra-226 by alpha spectroscopy using modified EPA Method 903.1, and direct gamma spectroscopy using modified EPA Method 901.1, which were less precise and had poor sensitivity. The direct gamma spectroscopy method was especially problematic because it relied on

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the 186 kilo-electron volt Ra-226 gamma spectra, which is poorly resolvable due to uranium interference at the same energy. Beginning in October 1997, the Ra-226 analytical method employed a daughter product ingrowth technique as recommended by the California Department of Health Services. The daughter products, Pb-214 and bismuth-214 (Bi-214), were allowed a 30-day ingrowth period before counting and determining the Ra-226 concentrations based on decay-chain equilibrium.

Ra-226 background was determined from samples collected before and after the method improvement. The Ra-226 method improvement did not correct a bias (accuracy), but did correct precision. The older data have higher maximum values and lower minimum values, but the sample mean was not affected. The HHRA background comparisons were not affected for Ra-226 because they were based on comparing mean concentrations for DOE areas data and background data. However, the Ra-226 risk estimates were likely biased a little high, because the EPCs were a function of the sample standard deviation.

# 2.2.6.2 Data Representativeness

The locations and depth ranges of samples collected in the DOE areas differ from one area to the next, depending on the area-specific circumstance. Sample locations can be based on a random grid or be discretionary with a focus on areas of known impact. Often a combination of random grid and discretionary sampling is used. The representativeness of the data used in the risk assessment is dependent on these variables and is discussed in each section.

# 2.2.7 Relation of Concentrations of Contaminants of Potential Concern to Site Operations

Many of the identified COPCs are also naturally occurring. Some have been used in LEHR operations, whereas for others, no records indicate use in site research. The risk characterization provides a discussion of the contaminants of concern present in each DOE area and their potential relationship to site operations. Origins of the current concentrations of constituents are noted where uncertainty exists.

# 2.3 Methodology—Ground Water Impacts Characterization

# 2.3.1 Site Hydrogeology

Previous investigations have identified five hydrostratigraphic units (HSUs) beneath the LEHR Site (D&M, 1999): the vadose zone and HSUs 1 through 4. The vadose zone extends from the ground surface to the top of ground water, which has historically ranged from 15 to 65 ft bgs. The vadose zone consists primarily of unsaturated clay and silt with limited amounts of interbedded sand and gravel. HSU-1 extends from the bottom of the vadose zone and consists primarily of silt and clay, with lesser amounts of sand and gravel. HSU-2 extends from the bottom of HSU-1 to a depth of approximately 114 to 130 ft bgs. This unit is composed primarily of sand in the upper portion of the unit and gravel in the middle to lower portions of the unit. HSU-3, investigated in off-site areas,

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extends from the bottom of HSU-2 to a depth of about 250 ft bgs and is approximately 120 ft thick. The unit consists primarily of relatively fine-grained sediments varying from very fine-grained sandy silt to clayey silt and silty clay. HSU-4 extends from the bottom of HSU-3 to a depth of about 282 ft bgs and is approximately 32 ft thick. This unit consists of coarse sand and gravel. Beneath HSU-4, a sharp contact with a bluish, dark gray silt was encountered at 282 ft bgs in wells UCD4-41 and UCD4-43. The bottom of this unit was not penetrated in any of the LEHR Site borings (D&M, 1999).

In the vicinity of the LEHR Site, ground water generally flows east from the Coast Ranges toward the Sacramento River (D&M, 1993). The HSU-1 lateral gradient across the LEHR Site typically ranges from 0.01 to 0.04 ft/ft, predominantly to the northeast (Figure 2-3). Representative values of HSU-1 horizontal hydraulic conductivity are between 1 x  $10^{-4}$  and 1 x  $10^{-7}$  cm/sec (D&M, 1999). The lateral HSU-2 gradient across the LEHR Site typically ranges from 0.005 ft/ft to 0.015 ft/ft and is predominantly northeast (Figure 2-3), although it can occasionally be east-southeast. Based on pumping tests, hydraulic conductivity in HSU-2 ranges from 0.26 to 0.43 cm/sec (D&M, 1997). Not enough data are available for HSU-3 and HSU-4 to evaluate lateral gradient magnitude and direction or hydraulic conductivity ranges.

# 2.3.2 Designated-Level Methodology

Constituents remaining in vadose zone soil at the DOE areas have the potential to impact ground water quality. The potential impacts of residual soil contamination on ground water have been evaluated by DOE and are presented in the Remedial Investigation Report (RI) (WA, 2003b). The RI provides a list of constituents, termed Designated-Level (DL) COPCs, that may be present in soil in concentrations that pose a threat to ground water. These DL COPCs were developed using: 1) samples collected and analyzed during removal actions, 2) confirmation samples collected after the removal action and 3) additional data collected during the ground water impact analysis (DL analysis). The confirmation sample frequency and locations were determined using the Noether calculation, a random-start grid sampling approach. The development of constituents that could impact ground water was based on analysis of sample data representative of post-removal action conditions.

The ground water evaluation presented in the RI was updated for the DOE Box and the Domestic Septic Systems areas to include available DI WET data. The updated assessment consists of a screening evaluation described in Section 1.3.3 and presented in Appendix C.

The risk estimate portion of the ground water COC selection process (Figure 1-2) has not been documented in the RI or the HHRA Risk Estimate. Therefore, this risk characterization completes the risk assessment process by further evaluating DL COPCs using the risk estimate process shown in Figure 1-2, and identifies COPCs that may impact ground water in the next 500 years as described below. These constituents are referred to herein as constituents of potential ground water concern (COPGWCs).

As shown on Figure 1-2, the ground water COPCs selected for further evaluation in the risk characterization are those constituents that failed the DL screening test (WA, 2003b) and are:

- Present in ground water in downgradient wells at concentrations above HSU-1 and-2 background levels (measured at wells UCD2-17, UCD1-18 and UCD2-37 [Figure 2-3]); or
- Above the soil concentration estimated to increase ground water concentration above the background or MCL (see Section 1.3.3); and
- Anticipated to increase ground water concentrations to above background in the next 500 years.

The locations of ground water monitoring wells and the background wells are shown in Figure 2-3. The ground water impacts of DL COPCs are summarized for each DOE area.

Cr-VI was identified in the RI (WA, 2003b) as a pervasive DL COPC in all of the DOE areas, because it was detected in soil at concentrations above the site background reference value of 0.054 mg/kg. After finalizing the DOE Areas Remedial Investigation, DOE collected additional soil background data and established a new Cr-VI background reference value of 1.3 mg/kg in 2004 in collaboration with the regulatory agencies. The regulatory agencies approved this as the new site background value in 2004. This change was to be documented in the DOE Areas Feasibility Study Report. However, since this new value significantly changes the interpretation and characterization of potential Cr-VI impacts on ground water, it is instead addressed in this report. The application of this new value would eliminate Cr-VI as a DL COPC in all DOE areas based on the screening methodology previously applied. However, since the occurrence of Cr-VI in ground water is a significant site concern, DOE retained Cr-VI for this characterization as a COPGWC if it was detected in monitoring wells downgradient of a DOE area. Appendix D provides additional information on the Cr-VI soil background value.

The output of the ground water risk estimate process (Figure 1-2) is a set of COPGWCs. Spatial distribution, uncertainty, analytical bias and other factors that characterize the potential risk to ground water are assessed and evaluated to produce a final set of ground water COCs for further evaluation in the Feasibility Study or COPCs to be included in the Site ground water monitoring plan to address the uncertainty associated with the site characterization and/or vadose zone model predictions.

# 2.3.3 Data Disqualified from Evaluation

The analysis presented in this risk characterization excludes results for borehole ground water samples (WA, 2003b) collected in some DOE areas. The borehole samples contained excessive amounts of sediment that was not filtered in the field or in the laboratory. Therefore, these ground water results represent overestimates of the dissolved contaminant concentrations in these areas.

# 2.4 Summary of Contaminants of Concern and Recommendations

Each section identifies and contains a discussion of the COCs that should be retained for further evaluation in the Feasibility Study. The recommendations are based on the risk estimate, the

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level of uncertainty, representativeness of the data and other stated factors. A summary table of all COPCs/COPGWCs evaluated in this risk characterization is included at the end of each section. This table contains risk values that have been corrected to reflect the radioactive decay of COPCs to the present time. These decay-corrected values were used in formulating the recommendations. A discussion of the COPGWCs is also included in the recommendations.



Dor Dor Dor Dor Dor Dor

Radium/Sti

Potentially complete exposure pathway. Incomplete exposure pathway.

<sup>1</sup> This Pathway is complete but was not included in the quantitative risk calculations because the contribution to risk is negligible. Using the risk for the outdoor research work as a surrogate for the indoor research worker, the contribution to total risk for the indoor research worker for inhalation of dust is insignificant, i.e., a risk of less than 10<sup>-8</sup>. Therefore, the addition of the indoor air pathway has no impact on the risk conclusions.

<sup>2</sup>Applies to surface releases only - (i.e., Western Dog Pens, Eastern Dog Pens and Southwest Trenches Areas)

<sup>3</sup>Evaluated using soil gas data.

#### Abbreviations

HHRA Human Health Risk Assessment HSU hydrostratigraphic unit

PCBs polychlorinated biphenyls

- SVOCs
- semivolatile organic compounds VOCs volatile organic compounds

DOE Area	Depth Range of Soil (ft)
DOE Disposal Box	4.4 - 10
mestic Septic System No. 1	7.5 - 10
mestic Septic System No. 3	3.6 - 10
mestic Septic System No. 4	4.2 - 8.5
mestic Septic System No. 1	7.0 - 7.0
mestic Septic System No. 6	3.7 - 8.0
mestic Septic System No. 7	7.0 - 9.5
Dry Wells A through E	5.0 - 10
Eastern Dog Pens	0 - 3.87
rontium Treatment Systems	1.0 - 10
Southwest Trenches	0 - 10
Western Dog Pens	0 - 10
	1

Adapted from the UC Davis Site-Wide Risk Assessment

Weiss Associates

	< Background Screening Value	> Background Screening Value	
			Risk < 1E-6
Proxy Results			Risk < 1E-5
			Risk < 1E-4
	0		Risk < 1E-6
Positive Results	$\bigcirc$	$\bigcirc$	Risk < 1E-5
	$\bigcirc$		Risk < 1E-4
	$\bigcirc$		Risk < 1E-3

#### **Definitions/Abbreviations**

> = greater than

< = less than

Proxy Results = Quantitative results not available (i.e., non-detected result). Non-quantitative value used as proxy.

Positive Results = Detected analytic results above the quantitation limit.

#### Notes

The symbol colors, shapes and relative sizes are consistent for all spatial analysis maps at all areas. The actual symbol sizes may be different between maps of different areas, due to graphical production constraints. Each map, however, explicitly defines all symbols used on that map.

The squares have the same diagonal lengths as the diameters of circles of the equivalent background/risk categories.

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Figure 2-3. Monitoring Well Locations and Ground Water Flow Directions in HSU-1 and 2

Weiss Associates

# 3. DOE DISPOSAL BOX RISK CHARACTERIZATION

# **3.1** Area Description

Figure 3-1 shows the DOE Disposal Box features. The DOE Disposal Box was a repository used by the LEHR facility for disposal of miscellaneous low-level radioactive research waste, including syringes, bottles, vials and gravel.

# 3.1.1 Pre-Removal Action Contaminant Distribution

Contaminants found in the DOE Disposal Box Investigations are presented in Table 3-1.

# 3.1.2 Removal Action Summary

In 1996, a time-critical removal action was conducted at the DOE Disposal Box area in accordance with a CERCLA Action Memorandum (DOE, 1996). A backhoe was used to excavate a series of trenches to determine the location of the DOE Disposal Box. The trenching activities did not find any evidence of an actual box buried beneath the surface, but did locate gravel, medical waste and labware in an area where such items were thought to have been disposed. The excavation at the DOE Disposal Box area was approximately 40 ft by 12 ft by 10 ft deep. The waste matrix was encountered at a depth of two to three ft, beneath a layer of gravel and soil.

Approximately 110 cubic yards (cu yds) of waste were removed, including soil, gravel, steel runway matting, plywood, syringes, bottles and vials. Seventy-two bottles containing between two ounces and one gallon of unidentified fluids were recovered from the north end of the excavation. Although most of these bottles appeared to be intact, eleven bottles showed signs of leakage. Following removal of the waste matrix, the area was over-excavated to remove approximately six inches of native soil from the excavation bottom and sidewalls. The excavation was lined with 20-mil high-density polyethylene and backfilled with clean fill. The DOE Disposal Box area waste was shipped to the DOE Hanford site for disposal in 1997.

#### 3.1.3 Post-Removal Action Contaminant Distribution

Following the 1996 time-critical removal action, confirmation samples were collected from the excavation. The majority of the radionuclide concentrations in the confirmation samples were below their respective minimum detectable concentrations. There were no radionuclides detected at

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concentrations significantly above their respective background. However, the confirmation sampling plan design was not statistically based, and the confirmation samples were analyzed for a limited suite of analytes. In 2001, a sampling and analysis plan (WA, 2001d) was designed to obtain additional data that would be sufficient for proper closure of the DOE Disposal Box area. The additional sampling was conducted in the spring of 2002. The analytical results from this sampling event are discussed below.

Using a random-grid approach, thirty samples and three field duplicates were collected from the DOE Disposal Box area during the closure sampling. Nine soil samples were analyzed for a full suite of parameters and 21 were analyzed for a limited suite, including cadmium, total chromium, hexavalent chromium (Cr-VI), mercury (Hg) and nitrate. Of the 189 analytes, fifteen were detected above their respective background concentration in one or more samples.

# 3.1.4 Future Land Use

Future use of the DOE Disposal Box area by UC Davis will be consistent with the "Academic/Administrative Low Density" land use designation of the area contained in Section 3.8.1 of the UC Davis 2003 *Long Range Development Plan* (UC Davis, 2003).

# **3.2 Summary of Risk Estimate Data**

Data used in the human health risk estimate were collected during various investigations and sampling events that were conducted at the DOE Disposal Box area. The data set was evaluated and redacted to exclude information associated with samples collected in locations that were subsequently excavated. The final data set used to estimate risk at the DOE Disposal Box area reflected the post-removal action conditions of the area. Information used in the risk estimate included data from the:

- 1996 investigation of type and extent of contamination conducted by IT Corp. A limited suite of radionuclides generated in this investigation was used (IT Corp., 1997).
- 2002 DOE Disposal Box area confirmation data gaps sampling (WA, 2003b).

# 3.2.1 Quality of Site Data

This section summarizes the results of the validation process for laboratory data used in the risk estimate. Data quality evaluations for individual COPCs are discussed in the analytical issues sections.

The data set for the DOE Disposal Box area included 2,135 analytical results. None of these results were rejected from the total data set ("R"-qualified). Twenty-five of the results, or 1.2%, had "J" qualifiers, which indicate that an analyte was positively identified in the sample, but the analytical result is an approximation of the analyte concentration in the sample. Data with "J"

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qualifiers were used in developing risk estimates. A total of six records, or 0.3%, had "UJ" qualifiers, which mean that an analyte was not detected, but the detection limit is approximate. Data with "UJ" qualifiers were included in the risk estimate and were treated as a non-detection of an analyte.

One hundred fifteen of the 2,135 final records from the DOE Disposal Box area were used to generate the Tier 2 human health risk estimate (UC Davis, 2005). None of the 115 results had "J" qualifiers, and none had "UJ" qualifiers.

# 3.3 Risk Characterization—DOE Disposal Box Area

Consistent with the HHRA Risk Estimate, as discussed in Section 2.2, this risk characterization uses the terms "List 1" and "List 2". List 2 identifies constituents that failed the statistical comparison to background, which may be indicative of a release to the environment. Table 3-3 and Table 3-4, in the first column, provide the List 1 COPCs identified in the HHRA Risk Estimate. The last column of Table 3-3 and Table 3-4 provides only List 2 COPCs and their risk values. The values provided are not corrected for decay. A subset (shown in bold-type) of List 2 contains COPCs that have a risk of at least 10<sup>-6</sup> or contribute more than ten percent of the total excess cumulative cancer risk in the DOE Disposal Box area.

Specifically, this subset consists of Pb-210 and Th-228 for the hypothetical on-site resident, and Th-228 for the outdoor research worker. This subset is identified in this risk characterization as the List 2 driver COPCs, since these COPCs represent potential site-related risks and are the best candidates for further evaluation in the Feasibility Study. These COPCs are the focus of the risk characterization discussions that follow. None of the receptors evaluated for this area showed non-cancer hazard quotients above the point of departure of one.

# 3.3.1 Exposure Assessment

The exposure assessment for List 2 driver COPCs at the DOE Disposal Box area includes:

- The spatial distribution of the List 2 driver COPCs;
- Risk from COPC concentrations attributed to site background versus prior site activities; and
- Exposure intake estimates.

A conceptual site model illustrating exposure pathways and potential human receptors for all DOE areas is provided as Figure 2-1.

#### 3.3.1.1 Spatial Distribution of Contaminants of Potential Concern

Sampling at the DOE Disposal Box area covers the entire area and includes higher density sampling near the northern boundary (Figure 3-2). The sample locations were based on a random grid and discretionary sampling performed within the potential areas of contamination.

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Figure 3-3 and Figure 3-4 show the spatial distribution of sample results for Pb-210 and Th-228, respectively. None of the samples had concentrations greater than the concentrations equivalent to a risk of  $10^{-5}$  for any of the driver COPCs.

#### 3.3.1.1.1 Lead-210 Distribution

The spatial analysis of Pb-210 samples is presented in Figure 3-3. Two sample locations showed concentrations below the detection limit, but above  $10^{-6}$  risk and the site background screening value. The two elevated results were in close proximity at the northern end of the DOE Disposal Box, where most of the waste materials were recovered.

The remaining fifteen Pb-210 sample results were below the site background screening value and corresponded to residential receptor risks lower than  $10^{-6}$ . All five of the positive results were below site background and  $10^{-6}$  risk to residential receptors.

The northern end of the DOE Disposal Box is a potential hot spot based on two results with proxy concentrations above background. Because these results were below the detection limit, however, they could be under- or overestimates of the true Pb-210 concentration.

#### 3.3.1.1.2 Thorium-228 Distribution

The Th-228 spatial analysis is shown in Figure 3-4. Two sample locations had concentrations above background and the  $10^{-6}$  risk to residential and outdoor researcher receptors. Both of the elevated results were located along the western border of the DOE Disposal Box.

All of the samples located at the northern end of the DOE Disposal Box had Th-228 concentrations below the background screening value. Samples located along the eastern border were also below background. Th-228 risk in the southern border and center of the DOE Disposal Box cannot be spatially characterized, due to low sample density.

Elevated Th-228 may be present along the western border of the DOE Disposal Box. However, the sample density is too low in and around the potential area of elevated Th-228 to confidently conclude whether a significant release occurred.

#### **3.3.1.2** Degradation and Decay of Contaminants of Potential Concern

The methodology for calculating radionuclide decay is described in detail in Appendix B.

### 3.3.1.2.1 Lead-210

Pb-210 (22.3-yr half-life) is naturally occurring and is part of the uranium-decay series, where it is derived from Ra-226 (1,600-yr half-life) and ultimately U-238. These parent isotopes have been characterized at the DOE Disposal Box and found to be at levels consistent with site background. Thus, the decay of the parent isotope will replenish Pb-210 at background concentrations and any Pb-210 that has been released at levels above background will attenuate over time.

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The Pb-210 decay estimate at the DOE Disposal Box area is shown in Figure 3-5. Although Pb-210 is identified as a List 2 COPC because it failed the statistical comparison to the background screening level, the Pb-210 site EPC is equivalent to the background EPC, indicating that there is no excess Pb-210 risk associated with site activities. The site EPC is also less than the concentration equivalent to a risk of  $10^{-6}$  for the on-site residential receptor. The concentration of Pb-210 is not expected to change over time, due to replenishment from its parent isotope.

# 3.3.1.2.2 Thorium-228

Th-228 (half-life of 1.9 yrs) is naturally occurring and is part of the thorium-decay series, where it is derived from the primordial Th-232 parent, which has a half-life of  $1.4 \times 10^{10}$  yrs. The decay estimate for Th-228 at the DOE Disposal Box is shown in Figure 3-6. Based on the Th-228 half-life, the site EPC should decay to within 1% of the background EPC in approximately seven years.

# **3.3.1.3 Background Evaluation**

# 3.3.1.3.1 Parent-Daughter Activity Concentration Relationships

The concentration of Pb-210 at the DOE Disposal Box area was compared to the concentration of its longer-lived parent, Ra-226, in Appendix E (Figure E-1). As shown, the concentrations of these isotopes appear to be in secular equilibrium when quantified analytical errors are taken into account. This is evidence that the concentration of Pb-210 at the site is due to decay of Ra-226 rather than to a release of Pb-210, because any shorter-lived daughter isotope will have a concentration approximately equal to that of its longer-lived parent isotope, in the absence of excess input of the daughter. The apparent elevated concentration of Pb-210 at the site relative to background, therefore, is probably due to analytical limitations rather than to a release. The concentration of Ra-226, which was measured at much higher precision than was Pb-210, is demonstrably below background concentrations. Therefore, the Ra-226 results suggest that the Ra-226/Pb-210 decay series is not impacting the site.

The concentration of Th-228 at the DOE Disposal Box area was compared to the concentration of its longer-lived parent, Th-232, in Appendix E (Figure E-2). As shown, the concentrations of these isotopes appear to be in secular equilibrium when quantified analytical errors are taken into account. This is evidence that the concentration of Th-228 at the site is due to decay of Th-232 rather than to a release of Th-228, because any shorter-lived daughter isotope will have a concentration approximately equal to that of its longer-lived parent isotope, in the absence of excess input of the daughter. The apparent elevated concentration of Th-228 at the site relative to background, therefore, is probably due to analytical limitations rather than to a release.

#### 3.3.1.3.2 Detections Above Site Background

The number of analytical results that were greater than both the detection limits and the background screening levels are reported in Table 3-2 for the List 1 COPCs. The two COPCs that are the List 2 drivers, Pb-210 and Th-228, were detected above background in zero and two samples, respectively. The remainder of the List 1 COPCs were detected above background in zero to five samples.

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#### 3.3.1.3.3 Comparison of Risk Attributed to Background versus Site Activities

Table 3-5 presents statistics, including EPCs, for the sample results of the List 2 driver COPCs at both the site and in the background. The background EPCs were calculated using the same method used to calculate the site EPCs (Section 2.2.3.3.1). Table 3-5 also presents decay-corrected EPCs. EPCs can be used to derive relative contributions of risk because risk is directly proportional to the EPC.

All of the Pb-210 risk can be attributed to background, because the site EPC is equal to the background EPC.

The background contribution to the Th-228 risk is 89%, and is illustrated graphically for both receptors in Figure 3-7. These risks and proportions have been corrected for decay.

#### 3.3.2 Toxicity Assessment

Toxicity values for COPCs in the DOE Disposal Box area were taken from US EPA guidance, as discussed in Section 2.2.4. The toxicity values used for these COPCs are appropriate for this evaluation and make use of the best available information.

#### 3.3.3 Risk Estimate

Table 3-3 summarizes the risk-estimate information (not decay corrected) for the hypothetical on-site resident. It shows that Pb-210 risk is primarily due to plant ingestion (63%) and soil ingestion (32%) with a small secondary contribution from external radiation (5%). External radiation is the only exposure route that contributes significant risk for Th-228 (>99%).

Table 3-4 summarizes the risk-estimate information for the outdoor researcher. It shows that Th-228 risk is entirely due to external radiation. Outdoor researchers are assumed to be exposed to surface soil ingestion, dermal contact and dust inhalation. However, surface soil is clean fill in the DOE Disposal Box area, which prevents exposure to underlying contamination.

#### 3.3.4 Uncertainty

Risk estimates are values that have uncertainties associated with them, as discussed in Section 2.2.6. The objective of this section is to discuss the major sources of uncertainty that are specific to this refined assessment of the DOE Disposal Box area. These include data coverage and analytical issues.

#### 3.3.4.1 Analytical Issues

#### 3.3.4.1.1 Lead-210

Only five of the seventeen Pb-210 results were above the detection limit. Twenty-nine percent of Pb-210 results had detection limits greater than the background screening value. Seventy-one percent of the samples had counting errors in excess of 50% of the reported value.

The two results with concentrations above background shown in Figure 3-3 were  $2.4\pm 8 \text{ pCi/g}$  (Sample LEHR-S-503) and  $1.8\pm 2.5 \text{ pCi/g}$  (Sample LEHR-S-504) with detection limits of 11 pCi/g and 3.4 pCi/g, respectively. Based on the counting error for sample LEHR-S-503, its sample concentration could range from zero to 10.4 pCi/g.

High detection limits and counting errors associated with the Pb-210 data generate uncertainty in the EPC value and the resulting risk estimate. This uncertainty could lead to either an overestimate or underestimate of the true risk. The true EPC would have to be more than 167% of the calculated EPC in order to exceed the  $10^{-6}$  risk threshold. Given the high detection limits and counting error uncertainties in this data set, a true EPC above  $10^{-6}$  is possible.

#### 3.3.4.1.2 Thorium-228

No accuracy issues were identified for the Th-228 results. The reported concentrations were well above the detection limits and the counting errors were relatively small. None of the data were qualified (due to data quality issues) during data validation.

#### 3.3.4.2 Data Representativeness

The locations and depth ranges of samples collected in the DOE Disposal Box area are shown in Figure 3-2. Forty subsurface (0 to 10 ft bgs) samples were collected. The sample locations were a combination of random grid and discretionary sampling, with the discretionary samples focused along the northern end of the area.

DOE Disposal Box area samples were collected at depths ranging from 4.4 ft bgs to 10.5 ft bgs. Only samples collected at depths less than or equal to 10 ft bgs were used in the risk estimate. No surface soil samples (0 to 0.5 ft bgs) were collected in the DOE Disposal Box area, because the contamination was released to subsurface soil and the contaminant chemical characteristics and subsurface physical conditions were unlikely to result in surface contamination (i.e., no upward volatile compound diffusion or shallow water table fluctuation). Clean surface fill was placed in the excavated areas after the removal action. Human receptors were not assumed to receive contaminant exposure through DOE Disposal Box area surface soil.

The Pb-210 sample density (Figure 3-3) is not as sparse as Th-228, but a noticeable data gap is apparent near the southern end of the area. Two samples were collected near the southern end of the DOE Disposal Box area at a depth of 10.5 ft bgs. These samples were not included in the risk estimate or spatial analysis because their depths exceeded 10 ft bgs. However, they were below the detection limit and background screening value. The Pb-210 sample density is less than the density shown in Figure 3-2, because 23 samples were analyzed for limited parameter suites that did not include Pb-210.

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As shown in Figure 3-2, subsurface soil sample coverage appears extensive. However, Th-228 sample density is sparse in all but the northernmost portion of the area (Figure 3-4). Thirty of the samples shown in Figure 3-2 were analyzed for limited parameter suites that did not include Th-228.

#### 3.3.5 Relation of Concentrations of Contaminants of Potential Concern to Site Operations

Pb-210 is a naturally occurring isotope that is associated with LEHR operations, since it is a daughter product of Ra-226, which was widely used at the Site. The spatial distribution data discussed in Section 3.3.1.1.1 indicates potentially localized Pb-210 contamination near the northern border of the DOE Disposal Box area where a release may have occurred. However, as discussed in Section 3.3.4.1.1 above, the two Pb-210 concentrations reported above background may not be accurate, due to high counting errors and detection limits.

Based on historical information, Th-228 was in a sealed source form during research activities at LEHR, however there are no records or anecdotal information indicating that it was released at the Site. Since this isotope is a naturally occurring radionuclide, it is likely that the Th-228 concentrations included in the risk estimate are attributed to ambient site conditions.. The spatial distribution data discussed in Section 3.3.1.1.2 indicate a potential localized area of Th-228 contamination near the western boundary of the DOE Disposal Box area. However, as discussed above, Th-228 sampling was not dense enough to fully characterize the potential contamination.

#### **3.4 Ground Water Impacts**

In addition to evaluation of human health risk resulting from soil contamination, potential ground water impacts from contaminants remaining in the soil at the DOE Disposal Box area were evaluated and are presented in the RI (WA, 2003b). Appendix C provides an evaluation of the DI WET test data. A summary of these evaluations is presented in Table 3-6.

#### 3.4.1 Risk Characterization of Constituents of Potential Ground Water Concern

Risk characterization findings and recommended COCs at the DOE Disposal Box are summarized below and presented in Table 3-7. The recommended COCs include constituents that are considered to have potential risks to human health or may have potential impact on the ground water at the site.

As shown in Table 3-6, DL COPCs with concentrations above background in soil were identified as the ground water COPCs and include Hg, molybdenum, and U-235/236. None of these constituents were found in ground water in downgradient monitoring well UCD1-12 (Figure 2-3) in concentrations above background.

DI WET test results (Table C-1) indicate that Hg could potentially impact ground water above background and the MCL. Based on modeling results, this impact would occur after about

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3,840 years. Modeling also indicated that molybdenum may impact ground water above background in 1,488 years. Modeling results indicate that the residual U-235/236 in soil should not impact ground water above the background level or MCL.

In summary, DOE Disposal Box area downgradient well data and DL modeling suggest that any DL COPCs remaining in the DOE Disposal Box area soil are unlikely to impact ground water above background in the next 500 years (Table 3-7). None of these DL COPCs required further evaluation as COPGWC in the risk characterization.

#### 3.4.1.1 Percentage and Spatial Distribution of Samples Exceeding Background

There are no COPGWCs requiring spatial analysis at DOE Disposal Box area.

#### 3.4.1.2 Uncertainty

Similar to human health risk estimates, evaluation of ground water impacts is subject to uncertainties, such as analytical bias and data representativeness, discussed below. However, since there are no COPCs requiring evaluation at the DOE Disposal Box, there is no uncertainty discussion.

#### 3.4.1.2.1 Analytical Issues

No data quality issues affect the estimate.

#### 3.4.1.2.2 Data Representativeness

The estimate is based on data that is likely to be representative of the contamination in the area.

# 3.4.1.3 Relation of Concentrations of Contaminants of Potential Ground Water Concern to Site Operations

There are no COPGWC at the DOE Disposal Box.

# 3.5 Risk Characterization Summary and Recommendations Regarding Contaminants of Concern at the DOE Disposal Box Area

Risk characterization findings and recommended COCs for the DOE Disposal Box area are summarized below and presented in Table 3-8. The recommended COCs include constituents that are considered to have potential risks to human health or may have potential impact on the ground water at the Site. For radionuclides, risks and relative percentages of risk contributions from site operations and background are corrected for decay.

#### 3.5.1 Human Health—On-Site Resident

#### 3.5.1.1 Lead-210

The risk estimate shows that Pb-210 contributes more than ten percent to the total cancer risk. However, the Pb-210 concentrations detected at the DOE Disposal Box area correspond to a cancer risk to the on-site resident of  $6 \times 10^{-7}$ , below the CERCLA point of departure of  $10^{-6}$ . Additionally, the two Pb-210 samples with concentrations reported above background may not be accurate, due to high counting errors and detection limits. Moreover, the site EPC for Pb-210 is equivalent to the background EPC. The contribution of risk from site activities of Pb-210 to the total Pb-210 risk is zero.

Because of the low cancer risk associated with the Pb-210, no contribution or risk from site activities, and the likelihood that elevated Pb-210 results may have been caused by analytical errors, Pb-210 should not be retained as a COC and evaluated in the Feasibility Study.

#### 3.5.1.2 Thorium-228

Decay-corrected risk to the on-site resident from Th-228 is 4 x  $10^{-6}$ , slightly above the CERCLA point of departure. About 11% of the Th-228 cancer risk to the resident receptors is attributable to site activities. This isotope is a naturally occurring radionuclide with a 1.9-year half-life and will decay to background levels in approximately seven years. There are no records indicating it was released at the Site. Due to the marginal risk and the short half-life of Th-228, it should not be retained as a COC.

# 3.5.2 Human Health—On-Site Outdoor Researcher

#### 3.5.2.1 Thorium-228

The decay-corrected risk to the outdoor researcher is  $2 \times 10^{-6}$ , slightly above the CERCLA point of departure. About 11% of the Th-228 cancer risk to this receptor is attributable to site activities. As with the risk to the on-site resident, given the marginal risk of Th-228, the large contribution of risk from background concentrations, and the short half-life of Th-228, it should not be retained as a COC.

#### 3.5.3 Ground Water

No constituents of potential ground water impact have been identified.



Figure 3-1. DOE Disposal Box Features

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Figure 3-2. DOE Disposal Box Area Sample Locations and Depths



Figure 3-3. Lead-210 Spatial Analysis, DOE Disposal Box Area



Figure 3-4. Thorium-228 Spatial Analysis, DOE Disposal Box Area



Figure 3-5. Decay of Lead-210 at DOE Disposal Box Area



Figure 3-6. Decay of Thorium-228 at DOE Disposal Box Area



Figure 3-7. Cancer Risk for On-Site Resident and Outdoor Researcher from Site Activities and Background, DOE Disposal Box Area

# Table 3-1.Analytes Detected in Soil/Waste above Background at the DOE Disposal Box Area<br/>Prior to the Removal Action

Constituent	Concentration Range <sup>1</sup>	Lowest Background Concentration <sup>2</sup>
Radionuclides	(pCi/g)	(pCi/g)
Actinium-228	0.40-0.68	0.633
Bismuth-212	0.25-0.49	0.388
Bismuth-214	0.41-2.15	0.54
Lead-210	<1.3-2.5	1.5
Lead-214	0.47-2.51	0.55
Radium-226	0.29-9.7	0.752
Thorium-234	<0.53-1.97	0.78
Cesium-137	<0.02-0.038	0.00695
Carbon-14	<0.38-2.16	0.13
Strontium-90	<0.67-36.7	0.056
Tritium	<5.8-400	1.2
Metals	(mg/kg)	(mg/kg)
Barium	32-220	211
Chromium (total)	5.3-130	125
Copper	12-55	48.8
Lead	1.3-20	9.5
Mercury	<0.10-0.73	0.248
Vanadium	<1073	66.8
Zinc	32-200	72.4
Pesticides/PCBs	(µg/kg)	(µg/kg)
gamma-Chlordane	0.63-3.0	N/A
alpha-Chlordane	0.91-2.8	N/A
Dieldrin	<1.0-2.4	N/A
dichlorodiphenyl dichloroethylene	1.8-1.8	N/A
dichlorodiphenyl trichloroethane	<3.3-6.1	N/A
Herbicides	(mg/kg)	(mg/kg)
Dalapon	<1,900-2,000	N/A
VOCs	(µg/kg)	(µg/kg)
Acetone	<5.0-16	N/A
2-hexanone (MIBK data used)	1.2-8.3	N/A
2-butanone (MEK)	1.0-10	N/A
4-methyl-2-pentanone	2.2-<9.9	N/A
2-chloroethyl-vinylether	1.7-<20	N/A
Toluene	1.6-100	N/A
Ethyl benzene	4.5-14	N/A
Xylenes (total)	<6.8-95	N/A

#### Notes

<sup>1</sup>From WA, 2003b. All samples and depth intervals.

<sup>2</sup>Lowest background concentration is the lower of the shallow (0-4 ft) and the deep (4-40 ft) soil background screening values for vertically stratified analytes.

#### Abbreviations

<	less than
µg/kg	micrograms per kilogram
ft	foot
MEK	methyl ethyl ketone
MIBK	methyl isobutyl ketone

# Table 3-1.Analytes Detected in Soil/Waste above Background at the DOE Disposal Box Area<br/>Prior to the Removal Action (continued)

mg/kg	milligrams per kilogram		
N/A	not available		
PCBs	polychlorinated biphenyls		
pCi/g	picoCuries per gram		
VOCs	volatile organic compounds		
Table 3-2.	Summary of Sampling Results	s Used in the Risk Estimate at the	DOE Disposal Box Area
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			1

List 1 COPC	Units	Total Samples	Number of Detections	Number of Detections > Background	Concentration Range <sup>1</sup>	Background Screening Concentration <sup>2</sup>	ID of Sample with Highest Concentration	Depth of Sample with Highest Concentration (ft)
Metals								
Arsenic	mg/kg	10	10	0	5.9 - 8.2	9.6	SSDBC020	10
Radionuclides								
Lead-210	pCi/g	17	5	0	-0.9 - 2.4	1.6	LEHR-S-503	10
Potassium-40	pCi/g	17	17	0	9.61 - 12.8	14	SSDBC004	10
Radium-226	pCi/g	24	24	5	0.16 - 1.41	0.75	LEHR-S-506	8
Radium-228	pCi/g	10	10	0	0.442 - 0.632	0.64	SSDBC020	10
Strontium-90	pCi/g	17	13	4	-0.09 - 0.28	0.056	LEHR-S-505, LEHR-S-503	10, 10
Thorium-228	pCi/g	10	10	2	0.504 - 0.768	0.74	SSDBC034	5.5

Notes

From HHRA Risk Estimate, Appendix A (UC Davis, 2005). <sup>1</sup>The concentration ranges for metals and radionuclides include non-detects.

<sup>2</sup>The background screening concentrations are the unstratified background screening values in Appendix B of the HHRA Risk Estimate (UC Davis, 2005).

Abbreviations

>	greater than
COPC	constituent of potential concern
ft	feet
HHRA	Human Health Risk Assessment
ID	identification (number)
mg/kg	milligrams per kilogram

picoCuries per gram pCi/g

# Table 3-3. Human Health Risks to On-Site Resident by Exposure Route for Contaminants of Potential Concern in the DOE Disposal Box Area

				CANCER RISK BY	<b>EXPOSURE ROUTE</b>					
List 1 COPC	EPC <sup>1</sup>	Soil Ingestion	Soil Dermal Exposure	Above-Ground Plant Ingestion <sup>2</sup>	Below-Ground Plant Ingestion <sup>2</sup>	External Radiation	Dust Inhalation	Total Cancer Risk	Statistical Background Comparison <sup>3</sup>	List 2 Cancer Risk <sup>4</sup>
Arsenic	7.14	2.E-05	9.E-07	8.E-05	3.E-05	_	1.E-08	1.E-04	Pass	-
Lead-210	0.95	2.E-07	-	4.E-07	-	3.E-08	1.E-10	6.E-07	Fail	6.E-07
Potassium-40	12	7.E-08	-	2.E-06	-	8.E-05	1.E-12	8.E-05	Pass	-
Radium-226	0.86	1.E-07	-	4.E-07	-	6.E-05	2.E-10	6.E-05	Pass	-
Radium-228	0.59	6.E-08	-	2.E-07	-	2.E-05	4.E-10	2.E-05	Pass	-
Strontium-90	0.11	1.E-09	-	4.E-08	-	2.E-08	3.E-13	6.E-08	Fail	6.E-08
Thorium-228	0.68	6.E-09	-	5.E-10	-	5.E-06	1.E-10	5.E-06	Fail	5.E-06
ГОТАL								3.E-04		6.E-06
				HAZARD QUOTIENT	BY EXPOSURE ROUT	Έ				
List 1 COPC	EPC <sup>1</sup>	Soil Ingestion	Soil Dermal Exposure	Above-Ground Plant Ingestion	Below-Ground Plant Ingestion	External Radiation	Dust Inhalation	Non-Cancer Hazard Index	Statistical Background Comparison <sup>3</sup>	List 2 Non-Cancer Hazard Risk <sup>4</sup>
Arsenic	7.14	3.0E-01	2.6E-02	1.6E+00	2.0E-01	-	-	2.1E+00	Pass	_
ΓΟΤΑL								2.1E+00		_

Notes

From HHRA Risk Estimate, Tables 7 and 8. Statistical Background Comparison from Appendix B (UC Davis, 2005).

The non-cancer risk is for a resident child; for cancer risk it is an age-adjusted adult.

List 2 constituents shown in **bold-type** text contribute at least 10<sup>-6</sup>, or greater than 10%, to the excess cumulative cancer risk. Rounding may affect the total List 2 cancer risk values shown in the last column. Determination of whether the risk is greater than ten percent of total List 2 cancer risk as a shown in the last column.

<sup>1</sup>The 95% upper confidence limit on the mean of the exposure point concentration; chemical concentrations are in milligrams per kilogram and radionuclide concentrations are in picoCuries per gram.

<sup>2</sup>For radionuclides, plant ingestion is not subdivided into above-ground and below-ground plants.

<sup>3</sup>Based on Wilcoxon Rank Sum test or other statistical comparisons, as shown in Appendix B of the HHRA Risk Estimate.

<sup>4</sup>Dashes indicate that constituent was not identified as a List 2 COPC, since it was identified to be statistically equivalent to background.

### Abbreviations

- not calculated

COPC constituent of potential concern

EPC exposure point concentration

HHRA Human Health Risk Assessment

# Table 3-4.Human Health Risks to On-Site Outdoor Researcher by Exposure Route for Contaminants of Potential Concern at the DOE<br/>Disposal Box Area

List 1 COPC <sup>1</sup>	EPC <sup>2</sup>	External Radiation	Total Cancer Risk	Statistical Background Comparison <sup>3</sup>	List 2 Cancer Risk <sup>4</sup>
Lead-210	0.95	1.E-08	1.E-08	Fail	1.E-08
Potassium-40	12	3.E-05	3.E-05	Pass	-
Radium-226	0.86	2.E-05	2.E-05	Pass	-
Radium-228	0.59	9.E-06	9.E-06	Pass	-
Strontium-90	0.11	7.E-09	7.E-09	Fail	7.E-09
Thorium-228	0.68	<b>2.E-06</b>	<b>2.E-06</b>	Fail	<b>2.E-06</b>
TOTAL			6.E-05		2.E-06

### **CANCER RISK BY EXPOSURE ROUTE**

#### Notes

From HHRA Risk Estimate, Tables 7 and 8. Statistical Background Comparison from Appendix B (UC Davis, 2005).

List 2 constituents shown in **bold-type** text contribute at least  $10^{-6}$ , or greater than 10%, to the excess cumulative cancer risk.

<sup>1</sup>Arsenic is excluded from this list for this receptor because arsenic is a subsurface contaminant and this receptor is only exposed to surface soil, as shown in Figure 2-1.

<sup>2</sup>The 95% upper confidence limit on the mean of the exposure point concentration; radionuclide concentrations are in picoCuries per gram.

<sup>3</sup>Based on Wilcoxon Rank Sum test or other statistical comparisons, as shown in Appendix B of the HHRA Risk Estimate.

<sup>4</sup>Dashes indicate that constituent was not identified as a List 2 COPC, since it was identified to be statistically equivalent to background.

-	not calculated
COPC	constituent of potential concern
EPC	exposure point concentration
HHRA	Human Health Risk Assessment

# Table 3-5.Data Summary—Comparison of Exposure Point Concentrations to Site Background at the DOE Disposal Box Area (Human Health)

Analyte	Detections	Samples	Min Detect	Max Detect	Min Detection Limit	Max Detection Limit	Average <sup>1</sup>	Standard Deviation <sup>1</sup>	Distribution	95UCL <sup>1</sup>	EPC	Decay- Corrected EPC <sup>2</sup>
Site (0 to 10 ft)			pCi/g	pCi/g	pCi/g	pCi/g	pCi/g	pCi/g		pCi/g	pCi/g	pCi/g
Lead-210	5	17	0.323	0.515	0.0729	11	0.69	0.62	Normal	0.95	0.95	0.95
Thorium-228	10	10	0.504	0.768	0.0726	0.135	0.63	0.084	Normal	0.68	0.68	0.56
Background (0 t	to 10 ft)											
Lead-210	6	26	0.703	2.49	0.209	5.08	0.719	0.697	Non-parametric	0.95	0.95	0.95
Thorium-228	48	48	0.266	0.66	0.058	0.379	0.475	0.105	Normal	0.50	0.50	0.50

#### Notes

Source: COPC data from Appendix A from HHRA Risk Estimate.(UC Davis, 2005) 95UCL calculations for background concentrations and decay corrections added."

<sup>1</sup>Negative concentration values were set to zero and concentrations below the detection limit were used to determine the 95UCL, average, and standard deviation for radionuclides. Same as 95UCL calculation procedure used in HHRA Risk Estimate (UC Davis, 2005).

<sup>2</sup>The EPC was decay-corrected to April 2005 (see Figure 3-5, Figure 3-6 and Appendix A).

95UCL	95 percent upper confidence limit on the mean
COPC	constituent of potential concern
EPC	exposure point concentration
ft	feet
HHRA	Human Health Risk Assessment
max	maximum
min	minimum
pCi/g	picoCuries per gram

#### Summary of Potential Impact on Designated-Level Constituents of Potential Concern in the DOE Disposal Box Area Soil on Ground Water Table 3-6.

	Confirmat	ion Sampling	Designated-I	Level Sampling		NUFT Mod	lel Soil Result							Time to
Designated-Level Constituent of Concern	Maximum (mg/kg or pCi/g) <sup>1</sup>	Depth of Maximum (ft)	Maximum (mg/kg or pCi/g)	Depth of Maximum (ft)	Soil Background Value (mg/kg or pCi/g)	Background Ground Water Goal (mg/kg or pCi/g)	MCL Ground Water Goal (mg/kg or pCi/g)	Do Ground Wa (µg	wngradient ater Concentration <sup>2</sup> ;/l or pCi/l)	Groun Back Conce (µg/l	nd Water aground entration <sup>3</sup> or pCi/l)	Ground Water MCL (µg/l or pCi/l)	Tap Water PRG (μg/l or pCi/l)	Peak at Ground Water Goal Level (years)
								HSU-1	HSU-2	HSU-1	HSU-2			
Mercury <sup>4</sup>	3.9	4.4	0.19	15	0.25/0.635	0.0080	0.87	< 0.1 - < 0.2	<0.043 - <0.20 [ND]	0.1	0.2	2	11	3,840
Molybdenum	0.62	10	< 0.44	N/A	0.26	0.46	5.52	< 0.9 - < 10	$1.9 - 2.8^{6,7}$	15	$5^{6}$	N/A	180	1,488
Uranium-235/236	0.074	5.5	0.0671	25.5	0.038	3.61	7.59	N/A	<-7 - <9.69 [ND]	9.5	17.1	20	0.7	0

### Notes

Source: Data from Remedial Investigation Report (WA, 2003b). HSU-2 data added.

<sup>1</sup>Uranium-235 in pCi/g or pCi/l; all others in mg/kg or µg/l.

<sup>2</sup>Ranges of available data for nearby downgradient HSU-1 well UCD1-12, and HSU-2 well UCD2-39. <sup>3</sup>Based on data from HSU-1 well UCD1-18, and HSU-2 wells UCD2-17 and UCD2-37.

<sup>4</sup>Assumed to be mercuric chloride.

<sup>5</sup>First value is a concentration for > 4 ft below ground surface; second value is a consolidated concentration (all depths).

<sup>6</sup>Measurements of molybdenum in samples collected before 1993 were excluded here because those data are significantly less reliable than the measurements of molybdenum in later samples.

<sup>7</sup>One outlier, a non-detect, was also excluded.

Bold type indicates soil concentration is above background and above NUFT result for ground water impact at background levels, or ground water concentration is above background.

Boxed type indicates soil concentration is above background and above NUFT result for ground water impact at the MCL, or ground water concentration is above the MCL.

<	denotes analyte concentrations below the detection limit
μg/l	micrograms per liter
ft	feet
HSU	hydrostratigraphic unit
MCL	California Maximum Contaminant Level for ground water (November 2002)
mg/kg	milligrams per kilogram
NUFT	Non-Isothermal, Unsaturated Flow and Transport model
N/A	not applicable or not available
ND	no detections in any sample
pCi/g	picoCuries per gram
pCi/l	picoCuries per liter
PRG	preliminary remediation goal (US EPA, 2002a for radionuclides; US EPA, 2002b for others)
US EPA	United States Environmental Protection Agency

# Table 3-7.Summary of Designated-Level Constituents of Potential Concern at the DOE Disposal Box Area Retained as Constituents of<br/>Potential Ground Water Concern

			r	
	0	0	6	4
Designated-Level Constituent of Potential Concern	Are the DL COPCs ground water concentrations above site background? <sup>1</sup>	Are the DL COPC soil concentrations above soil background and the NUFT soil results? <sup>2</sup>	Will the DL COPC impact ground water above background levels in the next 500 years?	Retained as COPGWC in risk characterization?
	If yes, enter ✓ in ❹	If yes, go to <b>9</b>	If yes, enter ✓ in ④	$\sqrt{-V_{\text{eq}}}$
	If no, go to <b>2</b>	If no, stop and enter $\times$ below	If no, stop and enter $\times$ below	· - 105
Mercury	No	Yes	×	-
Molybdenum	No	Yes	×	-
Uranium 235/236	N/A <sup>3</sup>	×	-	-

### Notes

<sup>1</sup>See Table 3-6. Compare downgradient ground water concentration to ground water background concentration. Results below detection limits are presumed to be below site background. <sup>2</sup>The lower of background and MCL goals.

<sup>3</sup>No ground water data are available.

×	not retained as a COPGWC
$\checkmark$	retained as a COPGWC
-	skip
COPC	constituent of potential concern
COPGWC	constituent of potential ground water concern
DL	designated-level
MCL	California Maximum Contaminant Level for ground water (November 2002)
N/A	not applicable
NUFT	Non-Isothermal, Unsaturated Flow and Transport

#### Summary of Major Factors Driving Risk and Recommendations for Future Action at DOE Disposal Box Area Table 3-8.

Driver COPC / COPGWC	Total Cancer Risk <sup>1</sup>	Spatial Distribution	Background Contribution <sup>2</sup>	Above- Background Contribution <sup>3</sup>	Historically Used at the Site	Time for Attenuation to Risk Endpoint <sup>4</sup> (years)	Level of Ground Water Impact		Uncertainty	Recommended Action	n
On-Site Residen	t										
Lead-210	6.E-07	Localized	100%	0%	Yes	$< 0^{5}$	N/A	٠	Characterization/EPC is uncertain due to	No Further Action	٠
									high detection limits and counting errors		
Thorium-228	4.E-06	Localized	89%	11%	Yes	6.9	N/A	•	Characterization/EPC is uncertain due to low sample density	No Further Action	•
<b>On-Site Outdoor</b>	Research	ner									
Thorium-228	2.E-06	Localized	89%	11%	Yes	6.9	N/A	•	Characterization/EPC is uncertain due to high detection limits and counting errors	No Further Action	•
Ground Water											
None	-	-	-	-	-	-	-		-	-	

#### Notes

<sup>1</sup>For radionuclides, values are decay-corrected to April 2005 (see Figure 3-5, Figure 3-6 and Appendix B). <sup>2</sup>The background contribution is the proportion of the site EPC that can be attributed to the background EPC (see Table 3-5 and Figure 3-7).

<sup>3</sup>The above-background contribution is the proportion of the site EPC that is greater than the background EPC (see Figure 3-7). <sup>4</sup>The time for attenuation to risk endpoint is the number of years, from April 2005, for the site EPC of a radionuclide to decay to either the background EPC or the concentration equivalent to a risk of 10<sup>-6</sup>, whichever is greater. <sup>5</sup>As of April 2005, the site EPC is less than the concentration equivalent to a risk of 10<sup>-6</sup>.

### Abbreviations

<	less than
COPC	constituent of potential concern
COPGWC	constituent of potential ground water concern
EPC	exposure point concentration
N/A	not applicable

### Basis for Recommendation

-

Risk is below 1E-6.

Decay to background in 6.9 years.

Decay to background in 6.9 years.

# 4. DOMESTIC SEPTIC SYSTEMS RISK CHARACTERIZATION

Seven domestic septic systems were located at the Site (Figure 4-1). Beginning in 1958, effluent from the LEHR offices and laboratories was discharged to these domestic septic systems. The locations of the domestic septic systems are shown on Figure 4-1.

A typical system consisted of a septic tank, a leach field and interconnecting piping. Liquid waste and sewage were discharged to six of the seven septic tanks (nos. 1 through 6) prior to the Site's connection to the UC Davis Wastewater Treatment Plant in 1971. Additionally, a leach system containing five dry wells (Dry Wells A-E), a distribution box and piping connecting the system (Figure 4.8-1) were used as the leach fields for Domestic Septic System Nos. 1 and 5. The dry well structures consisted of circular concrete manways 30 inches in diameter that extended from one to six ft bgs. Drain rock filled the manway structure starting at a depth of three ft and continued beneath the manways in open boreholes to an unknown depth.

In 1971, tank nos. 1 through 6 were reportedly backfilled with sand and the influent/effluent lines for each tank were cut and capped (IT Corp., 1996). No formal closure reports for these tanks have been identified (D&M, 1994). Domestic Septic Tank No. 7 was installed adjacent to the Cobalt-60 (Co-60) Field to receive waste from the irradiator building. This tank was reportedly never used, since the Co-60 Building was connected to the new sewer before operations began (WA, 2001c). No reports or drawings of a possible distribution box or leach field associated with Domestic Septic System No. 7 have been identified.

All seven domestic septic systems and leach fields associated with DOE-funded research activities were abandoned in 1971 and have been replaced by direct sanitary sewer connections. Domestic Septic System No. 2 and portions of the dry wells associated with Domestic Septic System Nos. 1 and 5 were removed in 1999 as part of the Radium/Strontium Treatment Systems Area I removal action. Removal actions were conducted at Domestic Septic System Nos. 3 and 6 in 2002. Each of the domestic septic systems and Dry Wells A-E are discussed separately in the following subsections.

DOE/NNSA has no present or future plans for the Domestic Septic Systems area and intends to transfer the area to UC Davis, as described in a Memorandum of Agreement (MOA) established between DOE and UC Davis in 1997 (DOE, 1997). Future use of the Domestic Septic Systems area by UC Davis will be consistent with the "Academic/Administrative Low Density" land use designation of the area contained in Section 3.8.1 of the UC Davis 2003 *Long-Range Development Plan* (UC Davis, 2003).

Section 4 Rev. 0 9/30/05 **Figures** 



### 4.1 Domestic Septic System No. 1

Figure 4.1-1 shows the Domestic Septic System No. 1 features.

### 4.1.1 Area Description

Domestic Septic System No. 1 consisted of a domestic septic tank, leach field, and interconnecting piping. Liquid wastes and sewage were discharged to the tank prior to the Site's connection to the UC Davis Wastewater Treatment Plant in 1971. The septic tank was reportedly backfilled with sand and the influent/effluent lines for each tank were reportedly cut and capped in 1971 (IT Corp., 1996). No formal closure report for Domestic Septic System No. 1 is known to exist (D&M, 1994).

### 4.1.2 Pre-Removal Action Contaminant Distribution

Various investigations have been conducted at Domestic Septic System No. 1 to characterize the occurrence of potential contaminants, with the latest investigation conducted in 2001. During the 2001 investigation, soil samples were collected adjacent to the most likely sources of contamination. Table 4.1-1 summarizes sample results above the site background at Domestic Septic System No. 1.

Five soil samples (including one field duplicate) and one concrete sample were collected from the Domestic Septic Tank No. 1 area and analyzed for a full suite of constituents. Of the 173 analytes, nine were reported at concentrations above their respective background, and four were detected above their residential PRGs. A concrete sample collected from the interior tank floor identified no constituents above their specific background.

### 4.1.3 Removal Action Activities

No removal actions have been conducted at Domestic Septic System No. 1.

### 4.1.4 Post-Removal Action Contaminant Distribution

No removal action was conducted at Domestic Septic System No. 1, hence the pre-removal action contaminant distribution discussed in Section 4.1.2 is representative of the current condition of the area.

### 4.1.5 Summary of Risk Estimate Data

Data used in the human health risk estimate were collected during various investigations and sampling events that were conducted at the Domestic Septic System No. 1. Information used in the risk estimate included data from the:

- Limited Field Investigation;
- 1996 and 1997 Data Gaps Investigation; and
- 2001 Domestic Septic System Investigation.

These various investigations are summarized in Table 6-8 of the RI and details of the 2001 Domestic Septic System Investigation are presented in Appendix B of the same report (WA, 2003b). Although all radioactive waste from the LEHR operations was being treated in the Radium/Strontium Treatment Systems at the time that the septic systems were installed, a wide variety of radionuclides and chemicals may have been discharged into these systems, and samples collected in the areas of the Domestic Septic Systems were therefore analyzed for a broad suite of chemicals and radionuclides. The sample data set used in the HHRA Risk Estimate was evaluated and redacted to exclude samples collected at depths greater than ten ft bgs. Table 4.1-2 provides a summary of all characterization data used in the Tier 2 risk estimate for Domestic Septic System No. 1. The sample locations for all data used in the risk estimate are presented in Figure 4.1-2.

### 4.1.5.1 Quality of Site Data

The data set for the Domestic Septic System No. 1 area included 682 analytical results. Six of these results, or 0.9%, were rejected from the total data set ("R"-qualified). Sample results are rejected when a data validation expert reviewing laboratory data finds evidence of serious deficiencies in the ability to analyze a sample and meet quality control (QC) criteria. The "R" qualifier indicates that the data cannot be used to verify whether the analyte was present in or absent from the sample. "R"-qualified results were not used in the risk estimate. After "R"-qualified data were removed from the total data set, the final risk estimate data set contained 676 results. Thirty-four of the results, or 5.0%, had "J" qualifiers, which indicate that an analyte was positively identified in the sample, but the analytical result is an approximation of the analyte concentration in the sample. Data with "J" qualifiers were used in developing risk estimates. A total of 172 records, or 25%, had "UJ" qualifiers, which mean that an analyte was not detected but the detection limit is approximate. Data with "UJ" qualifiers were included in the risk estimate and were treated as a non-detection of an analyte.

Thirty-four of the 676 final records from the Domestic Septic System No. 1 area were used to generate the Tier 2 human health risk estimate. Four of the thirty-four results had "J" qualifiers, and none had "UJ" qualifiers.

# 4.1.6 Risk Characterization—Domestic Septic System No. 1

Consistent with the HHRA Risk Estimate, as discussed in Section 2.2, this risk characterization uses the terms "List 1" and "List 2". List 2 identifies constituents that failed the

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statistical comparison to background, which may be indicative of a release to the environment. Table 4.1-3, in the first column, provides the List 1 COPCs identified in the HHRA Risk Estimate. The last column of Table 4.1-3 provides risk values for the List 2 COPCs. The values provided are not corrected for decay.

None of the Domestic Septic System No. 1 receptors showed either a cumulative List 2 cancer risk above the point of departure of  $10^{-6}$ , or non-cancer hazard index above the point of departure of one. List 2 COPC risks and the cumulative List 2 risk for the hypothetical on-site resident, which has the highest estimated risks out of all receptors evaluated, is shown in Table 4.1-3.

### 4.1.6.1 Exposure Assessment

The exposure assessment for the Domestic Septic System No. 1 in the HHRA Risk Estimate includes a discussion of the exposure intake estimates and their effect on the overall risk estimate. The EPCs for the on-site resident in the Domestic Septic System No. 1 area are provided in Table 4.1-3.

A conceptual site model illustrating exposure pathways and potential human receptors for all DOE areas is provided as Figure 2-1.

### 4.1.6.1.1 Spatial Distribution of Contaminants of Potential Concern

A spatial distribution of contaminants was not analyzed since there are no List 2 driver COPCs identified in the area.

### 4.1.6.1.2 Degradation and Decay of Contaminants of Potential Concern

No List 2 driver COPCs have been identified in the Domestic Septic System No. 1 area.

### 4.1.6.1.3 Background Evaluation

No List 2 driver COPCs have been identified in the Domestic Septic System No. 1 area.

### 4.1.6.2 Toxicity Assessment

Toxicity values for COPCs in the Domestic Septic System No. 1 area were taken from US EPA guidance as discussed in Section 2.2.4. The toxicity values used for these COPCs are appropriate for this evaluation and make use of the best available information.

### 4.1.6.3 Risk Estimate

As shown in Table 4.1-3, Domestic Septic System No. 1 has no List 2 driver COPCs, since risks from all List 2 COPCs are below  $10^{-6}$ . The risk estimate indicates that exposures to COPCs in the Domestic Septic System No. 1 soil should not result in adverse health effects to any receptor.

### 4.1.6.4 Uncertainty

Risk estimates are values that have uncertainties associated with them, as discussed in Section 2.2.6. The objective of this section is to discuss the major sources of uncertainty that are

specific to this refined assessment of Domestic Septic System No. 1. These include data coverage and analytical issues.

### 4.1.6.4.1 Analytical Issues

No significant data quality issues were identified in data used in the Domestic Septic System No. 1 risk estimate.

### 4.1.6.4.2 Data Representativeness

The locations of soil and concrete samples used in the risk estimate are shown in Figure 4.1-2. The results are presented in Table 4.1-2. All of the sampling was discretionary. No random grid samples were collected. Two soil samples were collected on the east side of Domestic Septic Tank No. 1, and one soil sample was collected on the west side. One additional pair of field duplicate soil samples was collected on the east side of the tank, but those samples were not used in the risk estimate because they were located at 13 ft bgs, which is below the HHRA Risk Estimate subsurface soil horizon. A concrete sample was collected from the southern wall of the tank.

The soil samples collected on the east and west sides of Domestic Septic Tank No. 1 were located directly below the tank inlet and outlet pipes. Field evidence and available site plans indicate that the Domestic Septic System No. 1 effluent line discharged to Dry Wells A-E. The risk characterization for Dry Wells A-E is addressed in Section 4.8.

The influent and effluent line connections to the tank are the most likely points of potential release. Unless a release occurred at an unforeseen location, the samples are likely representative of constituent concentrations at Domestic Septic System No. 1.

# 4.1.6.5 Relation of Concentrations of Contaminants of Potential Concern to Site Operations

Of the COPCs listed in Table 4.1-3 that were found above background, Sr-90 and carbon-14 (C-14) were used at LEHR. Pb-210 was not used in research operations at LEHR, but its parent isotope, Ra-226, was.

# 4.1.7 Ground Water Impacts

In addition to evaluation of human health risk resulting from soil contamination, potential ground water impacts from contaminants remaining in the soil at the Domestic Septic System No. 1 were evaluated and are presented in the RI (WA, 2003b). Appendix C provides an evaluation of the DI WET test data. A summary of these ground water impact evaluations is presented in Table 4.1-4.

### 4.1.7.1 Risk Characterization of Constituents of Potential Ground Water Concern

The investigation data from Domestic Septic System No. 1 indicated that only Cr-VI was present above background in soil (based on the original background value of 0.054 mg/kg), and therefore required modeling to assess potential ground water impacts. During the remedial investigation, no ground water sample data were available for Domestic Septic System No. 1 since the nearest downgradient well is over 500 ft away. Soil samples collected at Domestic Septic Tank

No. 1 at 8.7 and 13.7 ft bgs were analyzed using DI WET procedures for metals, SVOCs and nitrate. The DI WET results indicate that aluminum may also be a COPC and requires evaluation (Table C-1, Appendix C).

As shown in Table 4.1-5, based on the modeling results, the Cr VI remaining in the Domestic Septic System No. 1 area will not impact ground water above background or the MCL. These negative modeling results for Cr-VI were corroborated during the 2003 Dry Wells hydropunch investigation. Samples collected in boring B-4, which is located about 100 ft downgradient of Domestic Septic System No. 1, contained Cr-VI concentrations consistent with background. Additionally, a revision of the Cr-VI soil background concentration in 2004 eliminated Cr-VI as a DL COPC.

In accordance with the DL COPC evaluation process illustrated in Figure 1-2, no further evaluation of Cr-VI as a COPGWC is required. Aluminum, however, is evaluated as a COPGWC.

### 4.1.7.1.1 Percentage and Spatial Distribution of Samples Exceeding Background

### 4.1.7.1.1.1 Aluminum

No spatial information is available for aluminum concentrations in soil because aluminum was not analyzed in soil samples. DI WET samples were collected at 8.7 feet bgs and 13.7 feet bgs on the west side of Domestic Septic Tank No. 1. Both (100%) of the DI WET sample concentrations were above the MCL. The DI WET data were not compared to background because aluminum has not been analyzed in background ground water samples.

### 4.1.7.1.2 Degradation and Decay of Contaminants of Potential Concern

Neither Cr-VI nor aluminum is not expected to undergo significant degradation or decay.

# 4.1.7.1.3 Uncertainty

Similar to human health risk estimates, evaluation of ground water impacts is subject to uncertainties such as analytical bias and data representativeness, discussed below.

### 4.1.7.1.3.1 Analytical Issues

No data quality issues affect the estimate.

### 4.1.7.1.3.2 Data Representativeness

The estimate is based on data that is likely to be representative of the contamination in the area.

### 4.1.7.1.4 Relation of Concentrations of Contaminants of Potential Ground Water Concern to Site Operations

Cr-VI is potentially associated with LEHR operations, since chromic acid and other chromium-bearing chemicals may have been used or disposed at the Site. Aluminum and/or

aluminum-bearing compounds may have been used in LEHR operations and released to the Domestic Septic System via sink and/or floor drains.

# 4.1.8 Risk Characterization Summary and Recommendations Regarding Contaminants of Concern at the Domestic Septic System No. 1 Area

Risk characterization findings and recommended COCs at the Domestic Septic System No. 1 are summarized below and presented in Table 4.1-6. The recommended COCs include constituents that are considered to have potential risks to human health or may have potential impact on the ground water at the site.

# 4.1.8.1 Human Health

The cumulative risk at the Domestic Septic System No. 1 is well below the point of departure of  $10^{-6}$  for all receptors. No data quality issues affect the estimate. The estimate is based on data that is likely to be representative of the contamination in the area. Thus, no COPCs are recommended for further evaluation in the Feasibility Study.

### 4.1.8.2 Ground Water

DI WET results suggest that aluminum has the potential to impact ground water at the site. No ground water data are available to compare aluminum in downgradient wells to background. Aluminum may have been used in LEHR operations and could have been inadvertently released at Domestic Septic System No. 1. However, there is no evidence of a significant release of any COPCs in the vicinity of the septic tank. Additionally, there are no indications that a significant mass of aluminum would have been released during LEHR operations. No soil data are available to evaluate the spatial distribution of aluminum in soil or to estimate attenuation factors. Since there is low likelihood of a significant release of aluminum at this site, ground water monitoring is recommended.



Figure 4.1-1. Domestic Septic System No. 1 Features



Figure 4.1-2. Domestic Septic System No. 1 Area Sample Locations and Depths 4108-142-DSS1.ai

# Table 4.1-1. Analytes Detected above Background in Soil/Waste at the Domestic Septic System No. 1 Area

Analyte	Total Samples	Number of Samples > Bkgd	Number of Samples > Bkgd and Residential PRGs <sup>1</sup>	Number of Samples > Bkgd and Industrial PRGs <sup>1</sup>	Maximum Conc.	Background for > 4 ft Bgs	Residential PRG <sup>1</sup>	Industrial PRG <sup>1</sup>
Radionuclides					(pCi/g)	(pCi/g)	(pCi/g)	(pCi/g)
Carbon-14	6	3	1	0	2.1	0.13	0.456	1,230
Cesium-137	6	1	0	0	0.008	0.00695	0.0597	0.111
Cobalt-60	6	1	0	0	0.008	0.006	0.0361	0.0596
Lead-210	6	2	2	2	3	1.6	0.15	1.23
Radium-226	6	1	1	0	0.78	0.75	0.0124	0.255
Strontium-90	6	4	2	0	0.4	0.056	0.231	10.7
Metals					(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)
Chromium-VI	2	2	0	0	0.683	1.3	30	64
Manganese	6	2	0	0	890	750	1800	19,000
Molybdenum	6	5	0	0	0.45	0.26	390	5,100
Selenium	6	1	0	0	1.4	1.2	390	5,100

### Notes

Data from the Remedial Investigation Report (WA, 2003b).

Contaminant data includes data collected from all depth intervals instead of the 0-10 ft interval used in the risk estimate.

<sup>1</sup>Chemical PRGs are from US EPA Region 9 PRGs Table, dated October 1, 2002. Radionuclide PRGs are from Radionuclide Toxicity and PRGs for Superfund, dated April 14, 2003 (US EPA, <u>http://epa-prgs.ornl.gov/radionuclides/download/rad\_master\_prg\_</u>

table\_pci.xls). The industrial PRGs for radionuclides are for "outdoor worker soil." California-modified PRGs are shown in brackets.

>	greater than
bgs	below ground surface
bkgd	background
conc.	concentration
ft	feet
mg/kg	milligrams per kilogram
pCi/g	picoCuries per gram
PRG	preliminary remediation goal (US EPA, 2002a for radionuclides; US EPA, 2002b for others)
US EPA	United States Environmental Protection Agency

# Table 4.1-2. Summary of Sampling Results Used in the Risk Estimate at the Domestic Septic System No. 1 Area

List 1 COPC	Units	Total Samples	Number of Detections	Number of Detections > Background	Concentration Range <sup>1</sup>	Background Screening Concentration <sup>2</sup>	ID of Sample with Highest Concentration	Depth of Sample with Highest Concentration (ft)
Metals								
Arsenic	mg/kg	4	4	0	6.6 - 8.1	9.6	LEHR-S-431	7.5
Radionuclides								
Carbon-14	pCi/g	4	1	1	0.0364 - 2.1	0.13	LEHR-S-431	7.5
Lead-210	pCi/g	4	0	0	-4.5 - 1.8	1.6	LEHR-S-432	10
Potassium-40	pCi/g	4	4	0	9.3 - 11.8	14	SSD1C001	8.7
Radium-226	pCi/g	6	4	0	0.38 - 0.62	0.75	LEHR-S-432	10
Radium-228	pCi/g	2	2	0	0.492 - 0.537	0.64	SSD1C001	8.7
Strontium-90	pCi/g	4	1	1	-0.0112 - 0.4	0.056	LEHR-S-432	10
Thorium-228	pCi/g	2	2	0	0.424 - 0.655	0.74	SSD1C001	8.7

Notes

Source: COPC data from the HHRA-Risk Estimate, Appendix A (UC Davis, 2005).

<sup>1</sup>The concentration ranges for metals and radionuclides include non-detects.

<sup>2</sup>The background screening concentrations are the unstratified background screening values in Appendix B of the HHRA Risk Estimate.

greater than
constituent of potential concern
feet
Human Health Risk Assessment
identification (number)
milligrams per kilogram
picoCuries per gram

Table 4.1-3. Human Health Risks to On-Site Resident by Exposure Route for Contaminants of Potential Concern in the Domestic Septic System No. 1 Area

				CANCER	R RISK BY EXPOSURE	E ROUTE				
List 1 COPC	EPC <sup>1</sup> (0-10 ft)	Soil Ingestion	Soil Dermal Exposure	Above-Ground Plant Ingestion <sup>2</sup>	Below-Ground Plant Ingestion <sup>2</sup>	External Radiation	Dust Inhalation	Total Cancer Risk	Statistical Background Comparison <sup>3</sup>	List 2 Cancer Risk <sup>4</sup>
Arsenic	8.1	2.E-05	1.E-06	9.E-05	3.E-05	-	1.E-08	1.E-04	Pass	-
Carbon-14	1.8	1.E-12	-	6.E-11	-	2.E-12	5.E-11	1.E-10	Fail	1.1E-10
Lead-210	1.6	5.E-08	-	9.E-08	-	4.E-08	2.E-10	2.E-07	Fail	1.8E-07
Potassium-40	12	1.E-08	-	2.E-07	-	5.E-05	1.E-12	5.E-05	Pass	-
Radium-226	0.58	1.E-08	-	4.E-08	-	3.E-05	9.E-11	3.E-05	Pass	-
Radium-228	0.54	8.E-09	-	2.E-08	-	1.E-05	3.E-10	1.E-05	Pass	-
Strontium-90+Daughter	0.36	6.E-10	-	2.E-08	-	4.E-08	4.E-13	6.E-08	Fail	6.E-08
Thorium-228	0.66	8.E-10	-	6.E-11	-	3.E-06	1.E-10	3.E-06	Pass	-
TOTAL								<b>2.E-04</b>		2.E-07
				HAZARD Q	UOTIENT BY EXPOSU	JRE ROUTE				
List 1 COPC	EPC <sup>1</sup>	Soil Ingestion	Soil Dermal Exposure	Above-Ground Plant Ingestion	Below-Ground Plant Ingestion	External Radiation	Dust Inhalation	Non-Cancer Hazard Index	Statistical Background Comparison <sup>3</sup>	List 2 Non-Cancer Hazard Risk <sup>4</sup>
Arsenic	8.1	3.5E-01	2.9E-02	1.8E+00	2.2E-01	-	-	2.4E+00	Pass	-
TOTAL								2.4E+00		-

		Son ingestion	Son Dermar Exposure	Ingestion	Ingestion		Dust initiation	
Arsenic	8.1	3.5E-01	2.9E-02	1.8E+00	2.2E-01	-	-	,
TOTAL								

Notes

Source Data from HHRA Risk Estimate, Tables 7 and 8. Statistical Background Comparison from Appendix B (UC Davis, 2005).

The non-cancer risk is for a resident child; for cancer risk it is an age-adjusted adult.

<sup>1</sup>The 95% upper confidence limit on the mean of the exposure point concentration; chemical concentrations are in milligrams per kilogram and radionuclide concentrations are in picoCuries per gram.

<sup>2</sup>For radionuclides, plant ingestion is not subdivided into above-ground and below-ground plants.

<sup>3</sup>Based on Wilcoxon Rank Sum test or other statistical comparisons, as shown in Appendix B of the HHRA Risk Estimate. <sup>4</sup>Dashes indicate that constituent was not identified as a List 2 COPC, since it was identified to be statistically equivalent to background.

### Abbreviations

not calculated

COPC constituent of potential concern

EPC exposure point concentration

feet ft

HHRA Human Health Risk Assessment Table 4.1-4. Summary of Potential Impacts of Designated-Level Constituents of Potential Concern in the Domestic Septic System No. 1 Area Soil on Ground Water

Designated-Level Constituent of Potential Concern	Investigation Sampling		Designated-Level Sampling		Soil	NUFT Mode	NUFT Model Soil Result		Doumgradient		Ground Water		Тар	Time to Peak at
	Maximum (mg/kg)	Depth of Maximum (ft)	Maximum (mg/kg) <sup>1</sup>	Depth of Maximum (ft)	Background Value (mg/kg)	Background Ground Water Goal (mg/kg)	MCL Ground Water Goal (mg/kg)	Ground Water Concentration <sup>2</sup> $(\mu g/l)$		Background Concentration <sup>3</sup> (µg/l)		Water MCL (µg/l)	Water PRG (µg/l) <sup>3</sup>	Ground Water Goal Level (years)
								HSU-1	HSU-2	HSU-1	HSU-2			
Aluminum <sup>4</sup> Hexavalent Chromium	N/A 0.361	N/A 8.7	$\frac{20,800}{0.165}^{5}$	N/A 23.7	N/A 1.3	N/A 0.64	N/A 0.81	N/A N/A <sup>2</sup>	N/A 15.0 - <b>110</b> / < 6.0 - <b>25.0</b>	N/A 39	N/A 20	200 50	110	N/A No impact expected

Notes

<sup>1</sup>µg/L for DI WET results. <sup>2</sup>Data not available for HSU-1 because the nearest downgradient well is over 500 ft away. Ranges of available data for HSU-2 from wells UCD2-7 and UCD2-36. <sup>3</sup>Based on data from HSU-1 well UCD1-18, and HSU-2 wells UCD2-17 and UCD2-37.

<sup>4</sup>Aluminum is a designated-level COC because the DI WET result is above the MCL. No data are available for soil or downgradient ground water. No NUFT modeling has been done. <sup>5</sup>Based on DI WET Results.

Bold type indicates soil concentration is above background and above NUFT result for ground water impact at background levels, or ground water concentration is above background. Boxed type indicates DI WET concentration or ground water concentration is above the MCL.

<	less than
μg/l	micrograms per liter
COC	constituent of concern
DI WET	deionized water waste extraction test
ft	feet
MCL	California Maximum Contaminant Level for ground water (November 2002)
mg/kg	milligrams per kilogram
mg/l	milligrams per liter
N/A	not applicable or not available
NUFT	Non-Isothermal, Unsaturated Flow and Transport model
PRG	primary remediation goal

# Table 4.1-5. Summary of Designated-Level Constituents of Potential Concern at Domestic Septic System No. 1 Area Retained as Constituents of Potential Ground Water Concern

	2	8	0	•	
	U	0	6		
Designated-Level Constituent of Potential Concern	Are the DL COPCs ground water concentrations above site background? <sup>1</sup>	Are the DL COPC soil concentrations above soil background and the NUFT soil results? <sup>2</sup>	Will the DL COPC impact ground water above background levels in the next 500 years?	Retained as COPGWC in risk characterization?	
	If yes, enter ✓ in ❹	If yes, go to 🖲	If yes, enter ✓ in ❹	$\sqrt{1} = V_{\text{PS}}$	
	If no, go to <b>2</b>	If no, stop and enter $\times$ below	If no, stop and enter $\times$ below	• - 105	
Aluminum	Yes <sup>3</sup>	N/A	N/A	$\checkmark$	
Hexavalent	$No^4$	×	_	_	
Chromium	110				

#### Notes

<sup>1</sup>See Table 4.1-4. Compare downgradient ground water concentration to ground water background concentration. Results below detection limits are presumed to be below site background. <sup>2</sup>The lower of background and MCL goals.

<sup>3</sup>Based on DI WET Results.

<sup>4</sup>Based on 2003 Dry Wells Hydropunch samples collected in boring B-4.

×	not retained as a COPGWC
$\checkmark$	retained as a COPGWC
-	skip
COPC	constituent of potential concern
COPGWC	constituent of potential ground water concern
DI WET	deionized water waste extraction test
DL	designated-level
N/A	Not Available
NUFT	Non-Isothermal, Unsaturated Flow and Transport

# Table 4.1-6. Summary of Major Factors Driving Risk and Recommendations for Future Action at Domestic Septic System No. 1 Area

Driver COPC / COPGWC	Total Cancer Risk <sup>1</sup>	Spatial Distribution	Background Contribution <sup>2</sup>	Above- Background Contribution <sup>3</sup>	Historically Used at the Site	Time for Attenuation to Risk Endpoint <sup>4</sup> (years)	Level of Ground Water Impact	Uncertainty	Recommended Action
Human Health I None	Receptors N/A	N/A	N/A	N/A	N/A	N/A	N/A	<ul><li>Good data quality</li><li>Representative</li></ul>	N/A
Ground Water Aluminum	N/A	N/A	N/A	N/A	Yes	N/A	>bkgd >MCL	<ul> <li>Unknown vertical and horizontal distribution</li> <li>Unknown attenuation factor between source and ground water</li> </ul>	Monitoring

Notes

<sup>1</sup>For radionuclides, values are decay-corrected to April 2005 (see Figure 3-5, Figure 3-6 and Appendix B).

<sup>2</sup>The background contribution is the proportion of the site EPC that can be attributed to the background EPC (see Table 3-5 and Figure 3-7).

<sup>3</sup>The above-background contribution is the proportion of the site EPC that is greater than the background EPC (see Figure 3-7).

<sup>4</sup>The time for attenuation to risk endpoint is the number of years, from April 2005, for the site EPC of a radionuclide to decay to either the background EPC or the concentration equivalent to a risk of 10<sup>-6</sup>, whichever is greater.

### Abbreviations

>greater thanbkgdbackgroundCOPCconstituent of potential concernCOPGWCconstituent of potential ground water concernDI WETdeionized water waste extraction testEPCexposure point concentrationMCLCalifornia Maximum Contaminant Level for ground water (November 2002)N/Anot applicable

### Basis for Recommendation

N/A

DI WET results suggest a potential impact above MCL and background.Release unlikely.

# 4.2 Domestic Septic System No. 2

Figure 4-1 and Figure 6-1 show the location of Domestic Septic System No. 2.

### 4.2.1 Area Description

Domestic Septic System No. 2 consisted of a reinforced concrete septic tank 8 ft wide by 16 ft long by 10 ft deep.

# 4.2.2 Pre-Removal Action Contaminant Distribution

No characterization data were collected prior to the removal action for this specific location.

# 4.2.3 Removal Action Activities

Domestic Septic Tank No. 2 was removed during the Radium Strontium Treatment Systems Area I removal action in 1999. The reinforced concrete tank was demolished and the surrounding soil was excavated to an approximate depth of 12 ft bgs. The top two to four ft of soil were classified as overburden to minimize the amount of low-level radioactive waste generated. The concrete, rebar, tank sediments and surrounding soil were packaged and disposed as low-level radioactive waste. The tank area was backfilled with imported clean soil in 1999.

# 4.2.4 Post-Removal Action Contaminant Distribution

Data generated during and after the removal action are discussed in Section 6.1.3.

# 4.2.5 Summary of Risk Estimate Data

Data generated during and after the removal action of the Radium/Strontium Treatment System, which includes the Domestic Septic System No. 2, is discussed in Section 6.3.3.

# 4.2.6 Risk Characterization—Domestic Septic System No. 2

Risks associated with the Domestic Septic System No. 2 are included in the Radium/Strontium Treatment System risks discussed in Section 6.5.

### 4.2.7 Ground Water Impacts

In addition to evaluation of human health risk resulting from soil contamination, potential ground water impacts from contaminants remaining in the soil at the Domestic Septic Tank No. 2 were evaluated and are presented in the RI (WA, 2003b).

Discussion of potential impacts to ground water at Domestic Septic System No. 2 is included in the Radium/Strontium Treatment Systems analysis in Section 6.4.

# 4.2.8 Risk Characterization Summary and Recommendations Regarding Contaminants of Concern at the Domestic Septic Systems Area

Risk characterization findings and recommended COCs at Domestic Septic System No. 2 are included in the findings and recommendations for the Radium/Strontium Treatment Systems summarized in Section 6.5 and presented in Table 6-8.

### 4.3 Domestic Septic System No. 3

Figure 4.3-1 shows the Domestic Septic System No. 3.

### 4.3.1 Area Description

Domestic Septic System No. 3 was apparently installed between 1962 and 1964, during construction of the Reproductive Biology Laboratory (Building H-215) and the Specimen Storage Building (Building H-216), when the capacity of the tank serving the Inter-Regional Project No. 4 Building (Building H-217) may have become insufficient (WA, 2002b). Domestic Septic System No. 3 consisted of a septic tank with an effluent line leading to a distribution box that eventually led to a leach field (Figure 4-1).

The distribution box was constructed of eight-inch thick concrete and measured 4.75 ft long, 4.5 ft wide and 2.33 ft deep. Located on the southern end of the distribution box were two six-inch diameter vitrified clay pipe effluent lines. The western effluent line terminated 15 ft to the south. The eastern effluent was joined to an east-west oriented, perforated Orangeburg leach line that was bedded in one- to two-inch rounded gravel (WA, 2003a). A 3-ft leach line in a gravel trench 4 to 9 ft deep extended 45 ft to the east.

### 4.3.2 Pre-Removal Action Contaminant Distribution

Analytical results collected from the Domestic Septic System No. 3 area in 2001, along with data from previous investigations, indicated that several constituents, particularly Hg, were present in concentrations that exceeded site background. Based on comparison to site background and PRGs, additional COPCs include chromium, Cr-VI, mercury, alpha-chlordane, gamma-chlordane, Cs-137, Pb-210, Sr-90, Ra-226, and several polynuclear aromatic hydrocarbons (PAHs) (Table 4.3-1). Hg and Ra-226 were the two constituents associated with past operations that were consistently detected throughout the area (UC Davis, 2002).

The pre-removal action data suggested that the Ra-226 contamination was limited to the distribution box sediment and immediately below the first point of perforation. The PAHs were reported in a sample (SSD3C022) collected 4.5 ft beneath the leach line midpoint (WA, 2003b).

Hg concentrations in soil ranged from 0.35 mg/kg to 498 mg/kg. A sediment sample from the distribution box (SSD3C018) and the soil sample collected beneath the first point of perforation of the leach line (SSD3C020) had the maximum reported concentrations for the majority of the detected constituents. The maximum reported Hg concentration of 751 mg/kg was detected in this sediment sample (not included in Table 4.3-1, since it was not collected in soil/waste).

### 4.3.3 Removal Action Activities

A removal action at Domestic Septic System No. 3 was conducted between April and July 2002, and began with the demolition and removal of the distribution box. All of the associated effluent lines were removed along with concrete, perforated Orangeburg pipe and leach trench gravel. Approximately one ft of additional soil from the trench floor and sidewalls was also removed. The leach trench excavation depth ranged from 11 to 12.5 ft bgs, and was up to eight ft wide and 50 ft long. No evidence of a release from the septic tank or associated piping was found, and the tank contained no sludge. The tank was, therefore, left in place and backfilled with clean soil.

### 4.3.4 Post-Removal Action Contaminant Distribution

Following the removal action at Domestic Septic System No. 3, 36 confirmation samples and four field duplicates were collected between 3.6 and 12.5 ft bgs from the soil in the excavation floor and sidewalls (WA, 2003b). Three tank-content samples (including one field duplicate) and one concrete sample were also collected from the bottom of the septic tank. This section provides a discussion of the soil and tank sediment samples.

### 4.3.4.1 Soil Contaminants

The maximum reported Cr-VI concentration, 0.384 mg/kg, was detected in a sample (SSD3C046) collected 5.9 ft bgs from the leach trench's northern sidewall. Three of the four highest concentrations were detected in soil samples collected from the leach trench's northern sidewall. The maximum reported formaldehyde concentration of 2.2 mg/kg was detected in a sample (SSD3C055) collected 12 ft bgs on the leach trench floor. Six of the seven maximum reported formaldehyde concentrations (1.1 to 2.2 mg/kg) were detected in soil samples collected 10 to 13 ft bgs.

The maximum detected total chromium concentration, 174 mg/kg, was detected in a sample (SSD3C047) collected 5.9 ft bgs from the northern sidewall of the leach trench. The ten highest chromium concentrations (131 to 174 mg/kg) were detected in soil samples collected from the excavation sidewalls at depths ranging from five to six ft bgs.

The maximum reported Hg concentration, 4.4 mg/kg, was detected in a sample (SSD3C066) collected 5.2 ft bgs on the leach trench's south sidewall. The seven highest Hg concentrations (2.4 to 4.4 mg/kg) were detected in soil samples collected five to six ft bgs. Silver was reported above the detection limit in only five of 27 samples. The maximum reported silver concentration, 2.4 mg/kg, was detected in a sample (SSD3C053) collected 10.5 ft bgs from the leach trench floor.

The maximum reported alpha- and gamma-chlordane concentrations of 161 and 294 micrograms per kilogram ( $\mu$ g/kg), respectively, were detected in a sample (SSD3C047DL) collected 5.9 ft bgs from the leach trench's northern sidewall. The nine highest alpha and gamma-chlordane concentrations were detected in samples collected between five and six ft bgs. Heptachlor epoxide was detected in only one of 27 soil samples. The maximum reported heptachlor epoxide concentration, 4  $\mu$ g/kg, was detected in a sample (SSD3C061) collected 5.2 ft bgs from the leach trench's southern sidewall.

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Cs-137 was measured above the detection limit in only two of 27 samples. The maximum reported Cs-137 concentration of  $0.126\pm0.043$  pCi/g was detected in a sample (LEHR-ST301) collected eight ft bgs.

Pb-210 was detected in only five of 27 soil samples. The maximum reported Sr-90 concentration,  $1.6 \pm 0.0888$  pCi/g, was detected in a sample (SSD3C056) collected 13 ft bgs from the leach trench floor (this sample is excluded from the risk estimate since it is below ten ft bgs. The five highest Sr-90 concentrations (0.597±0.0476 to  $1.6\pm0.0888$  pCi/g) were detected in samples collected between 10 and 13 ft bgs.

All PAH soil sample results were below the detection limits.

The maximum reported nitrate concentration, 106 mg/kg, was detected in a sample (SSD3C049) collected 12.5 ft bgs beneath the first points of perforation on the leach line. The six samples with the highest nitrate concentrations (45.2 to 106 mg/kg) were collected from the trench floor beneath the former location of the leach line at depths ranging from 11 to 13 ft bgs.

A detailed confirmation sample data evaluation is presented in the *Final Domestic Septic* Systems 3 and 6 Removal Actions Confirmation Report (WA, 2003a).

### 4.3.4.2 Domestic Septic Tank No. 3 Sediment Contaminants

Two samples were collected of contents at the bottom of the septic tank. Notable results of the analyses of these samples include:

- All of the SVOC and VOC results were below their respective detection limits.
- Hg, molybdenum, Cr-VI, silver and Cs-137 were the only analytes detected above the lowest site soil background values.
- The 3.2 and 1.1 mg/kg Hg concentrations reported in the tank contents exceeded the lowest site soil background value of 0.248 mg/kg.
- Cs-137 sediment concentrations of 0.0195 and 0.0108 pCi/g were above the lowest site soil background value of 0.00695 pCi/g.
- Silver was detected above the site soil background of 0.55 mg/kg in one sediment sample at a concentration of 1.9 mg/kg.
- Molybdenum tank contents concentrations, 0.74 and 0.63 mg/kg, exceeded the site soil background concentration of 0.26 mg/kg.
- gamma-chlordane was detected above the detection limit in one sediment sample at  $47.8 \ \mu g/kg$ .
- Aroclor 1254, at 225 µg/kg, was the only polychlorinated biphenyl (PCB) detected.

A concrete sample was collected from the bottom of the tank. Notable results from this sample include:

- All SVOCs and pesticides results were below their respective detection limits.
- Molybdenum and thallium were the only analytes detected above the lowest site soil background values.
- Molybdenum was detected at 0.52 mg/kg, above the soil background of 0.26 mg/kg.
- Thallium was detected at 2.8 mg/kg, above the soil background of 1.6 mg/kg.
- Acetone at 30.9 µg/kg was the only VOC detected in concrete.

### 4.3.5 Summary of Risk Estimate Data

Data used in the human health risk estimate were collected during various investigations and sampling events that were conducted at Domestic Septic System No. 3. Information used in the risk estimate included data from the:

- Limited Field Investigation;
- 1997 Data Gaps Investigation; and
- 2001 Domestic Septic System Investigation.

These various investigations are discussed in Section 4.1.5. They are summarized in Table 6-8 of the RI, and details of the 2001 Domestic Septic System Investigation are presented in Appendix B of the same report (WA, 2003b).

The complete data set generated during these investigations was evaluated and redacted to exclude information associated with samples collected in locations that were subsequently excavated. Additionally, data from samples collected at depths greater than ten ft bgs were excluded. The final data set used to estimate risk at Domestic Septic System No. 3 reflected the post-removal action conditions of the area. Table 4.3-2 provides a summary of all data used in the Tier 2 risk estimate for Domestic Septic System No. 3. The sample locations for all data used in the risk estimate are presented in Figure 4.3-2.

### 4.3.5.1 Quality of Site Data

The total data set for the Domestic Septic System No. 3 area included 2,107 results. Eleven of these results, or 0.5%, were rejected from the total data set ("R"-qualified). Sample results are rejected when a data validation expert reviewing laboratory data finds evidence of serious deficiencies in the ability to analyze a sample and meet QC criteria. The "R" qualifier indicates that the data cannot be used to verify whether the analyte was present in or absent from the sample. "R"-qualified results were not used in the risk estimate. After "R"-qualified data were removed from the total data set, the final risk estimate data set contained 2,096 results. One hundred and six of the results, or 5.0%, had "J" qualifiers, which indicate that an analyte was positively identified in the sample, but the analytical result is an approximation of the analyte concentration in the sample. Data with "J" qualifiers were used in developing risk estimates. One hundred and fifteen records, or 5.5%, had "UJ" qualifiers, which mean that an analyte was not detected but the detection limit is

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approximate. Data with "UJ" qualifiers were included in the risk estimate and were treated as a non-detection of an analyte.

Two hundred and four of the 2,096 final records from Domestic Septic System No. 3 were used to generate the Tier 2 human health risk estimates. Four of the 204 results had "J" qualifiers. and no results had "UJ" qualifiers.

### 4.3.6 Risk Characterization—Domestic Septic System No. 3

Consistent with the HHRA Risk Estimate, as discussed in Section 2.2, this risk characterization uses the terms "List 1" and "List 2". List 2 identifies constituents that failed the statistical comparison to background, which may be indicative of a release to the environment. Table 4.3-3, in the first column, provides the List 1 COPCs identified in the HHRA Risk Estimate. The last column of Table 4.3-3 provides only List 2 COPCs and their risk values. The values provided are not corrected for decay. A subset (shown in bold-type) of List 2 contains COPCs that have a risk of at least  $10^{-6}$  or contribute more than ten percent of the total excess cumulative cancer risk in the Domestic Septic System No. 3 area.

Specifically, this subset consists of Aroclor 1254, Cs-137, and Pb-210 for the hypothetical on-site resident. This subset is identified in this risk characterization as the List 2 driver COPCs since these COPCs represent potential site-related risks and are the best candidates for further evaluation in the Feasibility Study. These COPCs are the focus of the risk characterization discussions that follow. None of the receptors evaluated for this area showed non-cancer hazard quotients above the point of departure of one.

Carcinogenic risks estimated in the HHRA Risk Estimate were below  $10^{-6}$  for all receptors except hypothetical on-site residents. The List 2 cumulative carcinogenic risk to hypothetical future on-site residents was estimated in the HHRA Risk Estimate to be  $2 \times 10^{-6}$ .

### 4.3.6.1 Exposure Assessment

The exposure assessment for List 2 driver COPCs at the Domestic Septic System No. 3 area includes:

- The spatial distribution of the List 2 driver COPCs;
- Risk from COPC concentrations attributed to site background versus prior site activities; and
- Exposure intake estimates and their effect on the overall risk estimate.

A conceptual site model illustrating exposure pathways and potential human receptors for all DOE areas is provided as Figure 2-1.

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### 4.3.6.1.1 Spatial Distribution of Contaminants of Potential Concern

Sampling at Domestic Septic System No. 3 was focused on Domestic Septic Tank No. 3, its distribution box and the associated leach trench (Figure 4.3-1 and Figure 4.3-2). Samples were collected at a depth of 3.6 to 10 ft bgs. No surface soil samples were used in estimating risk in the area, since releases from the Domestic Septic Systems are limited to deeper soil and structures and contamination control practices during the removal action protected surface soils from inadvertent contamination. Figure 4.3-2 provides the sample locations.

Figure 4.3-3, Figure 4.3-4, and Figure 4.3-5 show the spatial distribution of post-removal action sample results for Aroclor 1254, Cs-137, and Pb-210, respectively. Removal action samples were collected below the center of the trench and were not included in the spatial distribution analysis because they were at a depth below 10 ft.

The sample locations were not part of an overall random grid, but represent a combination of random grid, hot spot and vertical profile sampling performed within the potential areas of contamination.

### 4.3.6.1.1.1 Aroclor 1254 Distribution

The Aroclor 1254 spatial analysis is shown in Figure 4.3-3. Samples from six locations were analyzed for Aroclor 1254. A seventh sample representing imported backfill soil was used in the risk estimate, but is not included in the spatial analysis because it does not represent a specific location. Aroclor 1254 was not detected in the imported backfill sample. The imported backfill soil was placed in the excavation created during the removal of the Domestic Septic System No. 3 leach trench in 2002.

Aroclor 1254 was detected in two tank content (sludge) samples collected at the bottom of Domestic Septic Tank No. 3. The Aroclor 1254 concentration in one tank content sample indicated a risk of less than  $10^{-6}$ , and the other tank content sample indicated a risk slightly above  $10^{-6}$ .

Aroclor 1254 was not detected in a concrete sample collected from the bottom of Domestic Septic Tank No. 3 and three soil samples collected in the vicinity of Domestic Septic System No. 3. No data are available for Aroclor 1254 in the former Domestic Septic System No. 3 leach field.

The available data and site conditions suggest that Aroclor 1254 is contained in Domestic Septic Tank No. 3. Aroclor 1254 concentrations in the tank are presently low. Aroclor 1254 sorbs strongly to soil particles and has low mobility in subsurface soil. Thus, any contamination that may have been discharged to the former leach field was likely removed during the removal of the leach field and surrounding soil in 2002.

### 4.3.6.1.1.2 Cesium-137 Distribution

The Cs-137 spatial analysis is shown in Figure 4.3-4. Cs-137 concentrations were below background in all of the samples collected in the removal action excavation area for the former Domestic Septic System No. 3 leach trench. Four samples collected north of the former distribution box had Cs-137 concentrations above the background screening value. One of the results (not shown

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in Figure 4.3-4) with a concentration above background was from an imported backfill sample. Its concentrations correspond to a risk below  $10^{-6}$ .

Of the samples with concentrations of Cs-137 above background, only one sample result indicated a risk greater than  $10^{-6}$ . This sample (LEHR-S-T301) is surrounded by sample results that are below the background screening value, suggesting that the slightly elevated Cs-137 is limited in extent.

### 4.3.6.1.1.3 Lead-210 Distribution

Only one of the thirty samples collected at Domestic Septic System No. 3 had concentrations of Pb-210 above the background screening value (Figure 4.3-5). This sample (LEHR-S-T301) corresponds to a cancer risk between  $10^{-6}$  and  $10^{-5}$ . It was collected near Domestic Septic System No. 3, but not in the immediate vicinity of any associated features (domestic septic tank, piping, distribution box, leach trench). This sample also contained an elevated Cs-137 concentration discussed above, which may suggest a potential site release. Natural concentrations of Pb-210 appear uniform throughout Domestic Septic System No. 3.

### 4.3.6.1.2 Degradation and Decay of Contaminants of Potential Concern

The methodology for calculating radionuclide decay is described in detail in Appendix B.

### 4.3.6.1.2.1 Aroclor 1254

Aroclor 1254 is a PCB that is highly persistent in the environment and does not readily degrade.

### 4.3.6.1.2.2 Cesium-137

Cs-137 has a half-life of 30.07 years and is not a naturally occurring radionuclide. It is a fission product that will not be replenished by a parent isotope.

The Cs-137 decay estimate for Domestic Septic System No. 3 is shown in Figure 4.3-6. The site EPC is currently below both the background EPC and the concentration is equivalent to a risk of  $10^{-6}$  for the residential receptor.

### 4.3.6.1.2.3 Lead-210

Pb-210 (22.3-yr half-life) is naturally occurring and is part of the uranium-decay series, where it is derived from Ra-226 (1,600-yr half-life) and ultimately U-238. These parent isotopes have been characterized at Domestic Septic System No. 3 and found to be at levels consistent with site background. Thus, the decay of the parent isotope will replenish Pb-210 at background concentrations and any Pb-210 that has been released at levels above background will attenuate over time.

The site concentration of Pb-210 at the Domestic Septic System No. 3 and its relationship to the background concentration is shown in Figure 4.3-7. The site EPC is less than the concentration

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equivalent to a risk of  $10^{-6}$  for the residential receptor. The change in site EPC over time is unknown because Pb-210 is naturally replenished and is less than the background concentration.

### 4.3.6.1.3 Background Evaluation

### 4.3.6.1.3.1 Detections above Site Background

The number of analytical results that were greater than both the detection limits and the background screening levels are reported in Table 4.3-2 for the List 1 COPCs. The three COPCs that are the List 2 drivers, Aroclor 1254, Cs-137 and Pb-210 were detected above background in two, four, and one samples, respectively. The remainder of the List 1 COPCs were detected above background in zero to 13 samples.

### 4.3.6.1.3.2 Parent-Daughter Activity Concentration Relationships

The concentration of Pb-210 at the Domestic Septic System No. 3 area was compared to the concentration of its longer-lived parent, Ra-226, in Appendix E (Figure E-3). As shown, the concentrations of these isotopes appear to be in secular equilibrium when quantified analytical errors are taken into account. This is evidence that the concentration of Pb-210 at the site is due to decay of Ra-226 rather than to a release of Pb-210, because any shorter-lived daughter isotope will have a concentration approximately equal to that of its longer-lived parent isotope, in the absence of excess input of the daughter. The apparent elevated concentration of Pb-210 at the site relative to background, therefore, is probably due to analytical limitations rather than to a release. The concentration of Ra-226, which was measured at much higher precision than was Pb-210, is demonstrably below background concentrations. Therefore, the Ra-226 results suggest that the Ra-226/Pb-210 decay series is not impacting the site.

### 4.3.6.1.3.3 Comparison of Risk Attributed to Background versus Site Activities

Table 4.3-4 presents statistics, including EPCs, for the sample results of the List 2 driver COPCs at both the site and in the background. The background EPCs were calculated using the same method used to calculate the site EPCs (Section 2.2.3.3.1). Table 4.3-4 also presents decay-corrected EPCs for radionuclides. EPCs can be used to derive relative contributions of risk because risk is directly proportional to the EPC.

None of the Aroclor 1254 risk can be attributed to background, because the background concentration of Aroclor 1254 was assumed to be equal to zero. All of the Cs-137 and Pb-210 risks can be attributed to background, because their site EPCs are less than their respective background EPCs.

The observation that the Cs-137 and Pb-210 site risks are below the background risks does not contradict the earlier conclusion, in the HHRA Risk Estimate, that both Cs-137 and Pb-210 failed the statistical background comparison and therefore qualified to be List 2 COPCs (Table 4.3-3). Unlike the background comparison in the HHRA Risk Estimate for some of the other COPCs, these COPCs were not compared to background using the Wilcoxon Rank Sum (WRS) test, which compares the means of two data sets. Following the specifications in the HHRA work plan, the WRS test was used only if more than 50% of the results in both compared data sets were above the

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analytical detection limits. This requirement was not satisfied because in only 6 of 30 samples (20%) from the site was Cs-137 above the detection limit; and in only 9 of 30 samples (30%) from the site, and 6 of 26 samples (23%) from the background, was Pb-210 above the detection limit (Table 4.3-4). Instead of comparing the mean site concentrations to mean background concentrations using the WRS test, the HHRA Risk Estimate compared the highest measured site concentrations to the background screening values. This latter comparison is significantly different from a comparison of mean concentrations. Therefore, the conclusion that Cs-137 and Pb-210 failed the statistical background comparison does not contradict the conclusion that the background concentrations contribute all of the site risk.

Although the rule in the HHRA work plan that restricted the WRS test to data sets with at least 50% detections was a useful rule for processing censored data, it was an arbitrary rule, and therefore generally does not generally preclude the use of statistical calculations to determine relative risk contributions, particularly for radiological data. Unlike most chemical data, radioactive analytical results, are not censored below the detection limit. Thus, when using data with low percentages of data above the detection limit, the WRS comparisons will have less statistical power, but the test results still yield useful (but more uncertain) results. Under these conditions, both Cs-137 and Pb-210 passed the WRS background comparison test, supporting the conclusion that their site EPCs are less than their background EPCs. Furthermore, of the 30 samples analyzed for Cs-137, only four results are greater than background (Figure 4.3-4); of the 30 samples analyzed for Pb-210, only one result is greater than background (Figure 4.3-5).

### 4.3.6.2 Toxicity Assessment

Toxicity values for COPCs in the Domestic Septic System No. 3 area were taken from US EPA guidance as discussed in Section 2.2.4. The toxicity values used for these COPCs are appropriate for this evaluation and make use of the best available information.

### 4.3.6.3 Risk Estimate

Table 4.3-3 summarizes the risk estimate information for the hypothetical future on-site resident. It shows that Aroclor 1254 risk is driven equally by soil ingestion (42%) and above-ground plant ingestion (42%), with secondary contributions from soil dermal exposure (10%) and below-ground plant ingestion (6%). Since the Aroclor 1254 is contained in the concrete septic tank, the plant ingestion fractions are not applicable and the true risk is much lower. Cs-137 risk is driven by external radiation with no significant contributions from the other exposure pathways. Pb-210 risk is driven by a combination of plant ingestion (60%) and soil ingestion (36%), with a small contribution from external radiation (4%).

### 4.3.6.4 Uncertainty

Risk estimates are values that have uncertainties associated with them, as discussed in Section 2.2.6. The objective of this section is to discuss the major sources of uncertainty that are specific to this refined assessment of the Domestic Septic System No. 3. These include data coverage and analytical issues.

### 4.3.6.4.1 Analytical Issues

### 4.3.6.4.1.1 Aroclor 1254

No significant data quality issues were identified for Domestic Septic System No. 3 Aroclor 1254 data. One sample had an Aroclor 1254 concentration above the quantitation limit. One sample was qualified because Aroclor 1254 was detected in the sample, but the result was below the quantitation limit. Aroclor 1254 was not detected in the remaining five samples. There is no history of analytical methodology problems or changes that would impact Aroclor 1254 data quality or accuracy. The only potential issue is that five of the seven results were below the detection limit. The EPC was determined assuming the sample concentration to be one-half of the detection limit when the result was reported as not detected. While the half-detection-limit assumption is generally conservative, it can still result in over or under estimation of the true EPC.

### 4.3.6.4.1.2 Cesium-137

No significant data quality issues were identified for Domestic Septic System No. 3 Cs-137 data. There is no history of analytical methodology problems or changes that would impact Cs-137 data quality or accuracy. The only potential issue is that 24 of the 30 results were below the detection limit. Thirteen of the non-detect results were negative values, which were converted to zero to calculate the EPC in the risk estimate. The high percentage of non-detect results introduces moderate uncertainty in the EPC calculation and background comparison. Additionally, changing negative results to zero has likely introduced a positive bias on the Domestic Septic System No. 3 EPC and risk.

### 4.3.6.4.1.3 Lead-210

The contract-required detection limit (CRDL) of 0.5 pCi/g was met in only 20% of the Pb-210 sample results. Meeting the CRDL improves the accuracy because the counting error is reduced in the process. The laboratory was not always able to achieve the CRDL due to high background counts from sources of radiation, other than the sample, that the laboratory cannot always prevent. High background counts can cause a failure to meet the CRDL, because the detection limit is proportional to the background count standard deviation. Background counts also increase the counting error because counting error is proportional to the square root of background counts.

Because the Domestic Septic System No. 3 area Pb-210 EPC is less than the background EPC, and there is no apparent reason it would be below background, the high detection limits and counting errors may have resulted in a risk underestimate. The Pb-210 risk at Domestic Septic System No. 3 is likely equal to natural background risk. Based on the background EPC of 0.95 pCi/g, the risk due to natural background at Domestic Septic System No. 3 would be approximately  $9 \times 10^{-7}$ .

### 4.3.6.4.2 Data Representativeness

Soil boring samples were collected at Domestic Septic System No. 3 to characterize the site prior to a removal action conducted in 2002. Random grid, soil boring, and discretionary grab

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samples were collected after the leach trench was removed and additional leach trench area soil was excavated. The samples were collected at depths ranging from 3.6 ft bgs to 40 ft bgs. Only samples collected at depths less than or equal to ten ft were used in the risk estimate. Several confirmation samples collected after the completion of removal action activities were located near the leach trench centerline, but were at a depth below ten ft, thus they were not used in the risk estimate.

No surface soil samples (0 to 0.5 ft bgs) were collected in the Domestic Septic System No. 3 area because the contamination was released to subsurface soil and the contaminant chemical characteristics and subsurface physical conditions were unlikely to result in surface contamination (i.e., no upward volatile compound diffusion, no shallow water table fluctuation). Removal action practices mitigated inadvertent contamination of surface soil. Clean backfill was placed in the excavated area after the removal action. Human receptors were not assumed to receive contaminant exposure through Domestic Septic System No. 3 area surface soil.

For most COPCs, subsurface soil sample coverage was extensive and covers the known potential source areas. Figure 4.3-2 shows the soil samples used in the risk estimate. Aroclor 1254 sample coverage did not include the leach trench area. Because Aroclor 1254 was detected above background and above 10<sup>-6</sup> risk in Domestic Septic Tank No. 3 tank contents samples, contamination could have discharged to the leach field. This potential contamination was likely removed during the leach-trench removal action due to the low environmental mobility of the Aroclor 1254, but no data are available to verify whether Aroclor 1254 contamination is still present. No potential data gaps were identified in Cs-137 and Pb-210 sample coverage.

The data used to determine radiological risk estimates (Table 4.3-3) were representative of site conditions at the time they were collected because the data coverage was extensive and the samples were collected and analyzed according to Superfund risk assessment data quality standards. However, due to radiological decay, some of the radionuclide data is not representative of current site conditions. Decay-corrected values are included in Table 4.3-4 and Table 4.3-7 to provide decision makers with the most accurate data with which to evaluate the risk at the Site.

### 4.3.6.5 Relation of Concentrations of Contaminants of Potential Concern to Site Operations

Aroclor 1254 is a chemical used in common electrical equipment, such as transformers and light ballasts. It is reasonable to assume that electrical equipment containing Aroclor 1254 was used at LEHR and that a release could have occurred. However, given the nature of LEHR's research activities and available chemical inventories, there is no suggestion of significant PCB use or releases.

Cs-137 is an anthropogenic fission product. Its widespread presence in soil is primarily a result of global fallout from nuclear weapons testing. However, Cs-137 was used in LEHR experiments and may have been released into Domestic Septic System No. 3.

Available information indicates that Pb-210 was not used at LEHR, but its parent, Ra-226, was used extensively in experiments at LEHR. It is possible that releases of Ra-226 or its intermediate progeny, such as radon-222 (Rn-222), could have resulted in indirect releases of Pb-210.
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Pb-210 concentrations at Domestic Septic System No. 3 present a risk of 8 x  $10^{-7}$ , below the CERCLA point of departure. No potential data gaps were identified in Pb-210 sample coverage and the spatial analysis suggests that the Pb-210 concentrations are randomly distributed.

#### 4.3.7 Ground Water Impacts

In addition to evaluation of human health risk resulting from soil contamination, potential ground water impacts from contaminants remaining in the soil at the Domestic Septic Tank No. 3 were evaluated and are presented in the RI (WA, 2003b). A summary of this evaluation is presented in Table 4.3-5.

#### 4.3.7.1 Risk Characterization of Constituents of Potential Ground Water Concern

Removal action confirmation sample data indicated that Hg, formaldehyde, molybdenum, nitrate, and silver were present above background in soil and could potentially impact ground water.

Cr-VI and nitrate have been detected in downgradient monitoring wells UCD1-13 and UCD1-21 (Figure 2-3) above their respective background concentrations and MCLs. None of the other constituents were detected in these downgradient wells. The DI WET results (Table C-3) indicate that Hg and aluminum leachate concentrations exceed the MCL.

Modeling results for Cr-VI in soil suggests that no ground water impact at background and MCL levels will occur. In contrast, modeling results for nitrate in soil confirm that it may have a localized impact to ground water, and may exceed the MCL and background with the peak ground water impact occurring in approximately 13 years. Modeling results indicate that residual mercury concentrations in soil at Domestic Septic System No. 3 might result in some measurable impact to ground water above the MCL and current background in more than 3,300 years. Modeling suggests that localized impact on ground water may exceed the MCL and background for formaldehyde. The peak impact is predicted to occur in approximately ten years. Based on the DL modeling, localized impact on ground water of molybdenum may exceed current ground water background and the peak concentration in ground water is occurring or has already passed. Silver in area soil is estimated to locally impact ground water, but the impact is expected to be below the MCL.

As shown in Table 4.3-5, Cr-VI and nitrate have been detected in downgradient wells; therefore, Cr-VI and nitrate are retained for further evaluation in this risk characterization in conformance with the DL COPC evaluation process illustrated in Figure 1-2. Modeling results for formaldehyde, molybdenum, and silver suggest that these constituents may impact local ground water at concentrations above background, with the impact from formaldehyde estimated to be above MCLs, and the impact occurring in the next 500 years. In accordance with the DL COPC evaluation process illustrated in Figure 1-2, these constituents will be evaluated further as COPGWC in this risk characterization. Based on the DI WET data, aluminum will also be evaluated further as COPGWC.

Hg is anticipated to impact ground water above background, but the impact will not occur in the next 500 years. Therefore, Hg is not evaluated further.

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4.3.7.1.1 Percentage and Spatial Distribution of Samples Exceeding Background

#### 4.3.7.1.1.1 Aluminum

No spatial information is available for aluminum concentrations in soil because aluminum was not analyzed in soil samples. DI WET samples were collected at 15 feet bgs and 20 feet bgs beneath the first point of perforation on the Domestic Septic System No. 3 leach line. Both of the DI WET leachate concentrations were above the MCL. The DI WET data were not compared to background because aluminum has not been analyzed in background ground water samples.

#### 4.3.7.1.1.2 Formaldehyde

Formaldehyde was detected in 32 of 35 confirmation samples (91%) collected at Domestic Septic System No. 3. All of the confirmation samples collected from the Domestic Septic System No. 3 leach trench excavation had concentrations above the detection limit. Concentrations along the former leach trench centerline were generally above 1 mg/kg, but did not exceed 2.2 mg/kg. Samples collected along the north and south walls of the trench and at each end of the trench were generally below 1 mg/kg. However, wall samples at the west end of the leach line, near the first point of perforation, were above 1 mg/kg, indicating a broader area of contamination near the west end. Soil boring samples collected below the west end indicate formaldehyde concentrations of almost 1 mg/kg down to 20 ft bgs and then attenuation to 0.19 mg/kg at 40 ft bgs. These data indicate formaldehyde was released at Domestic Septic System No. 3 and has spread laterally and vertically from the former leach trench.

#### 4.3.7.1.1.3 Hexavalent Chromium

All forty-one hexavalent chromium soil sample results were below background (1.3 mg/kg) at Domestic Septic System No. 3. Hexavalent chromium appears to be randomly distributed in soil throughout the area.

#### 4.3.7.1.1.4 Molybdenum

Molybdenum was above background in seven of fourteen soil sample results (50%) at Domestic Septic System No. 3. The elevated concentrations were in samples of the domestic septic tank contents and concrete at the bottom of the tank and in soil beneath the first point of perforation on the Domestic Septic System No. 3 leach line. Molybdenum was below background and not detected in soil samples collected in areas adjacent to Domestic Septic Tank No. 3, around the distribution box and a few ft west of the leach field. Molybdenum was detected above background in soil boring samples collected at depths of 15, 20, 25 and 35 ft bgs beneath the first point of perforation of molybdenum at Domestic Septic System No. 3 (2.5 mg/kg) was present in the soil boring sample collected at 36 ft bgs. Molybdenum was below background and not detected in the samples collected six ft above (30 ft bgs) and four ft below (40 ft bgs) the highest concentration. Based on these data, molybdenum was released to soil below the former Domestic Septic System No. 3 leach line and has migrated to a depth below 35 ft in the soil column.

#### 4.3.7.1.1.5 Nitrate

Nitrate was above background in seven of 41 soil sample results (17%) at Domestic Septic System No. 3. The elevated results were located in soil below the former leach line and in one excavation sidewall sample positioned a few ft north of the leach line. The highest nitrate concentration in soil (106 mg/kg) was located beneath the first point of perforation on the Domestic Septic System No. 3 leach line at 12.5 ft bgs. All but one of the excavation trench sidewall samples and all of the samples collected at the east and west ends of the excavation were below background. All of the samples collected near the distribution box and domestic septic tank were below background. The soil boring samples collected beneath the first point of perforation on the Domestic Septic System No. 3 leach line were below background. The shallowest soil boring sample, collected at 15 ft bgs, contained 33.2 mg/kg of nitrate, which was slightly below the background screening value (36 mg/kg). The other five soil boring samples, collected between 20 and 40 ft bgs, had concentrations below 11 mg/kg. Based on these data, nitrate was released to subsurface soil below the former leach line, but the contamination is very limited in lateral and vertical extent.

#### 4.3.7.1.1.6 Silver

Silver was above background in only four of 41 soil samples (10%) collected at Domestic Septic System No. 3. The highest silver concentration was 2.4 mg/kg. Two of the elevated results (0.57 mg/kg each) were only slightly above the background screening value (0.55mg/kg). These two results and the highest result were located in soil below the eastern half of the former leach trench. The fourth elevated result was a tank contents sample. None of the soil boring samples collected beneath the first point of perforation on the Domestic Septic System No. 3 leach line were above background. Based on the reported concentrations, a limited mass of silver may have been released to soil at Domestic Septic System No. 3. Alternately, the apparent contamination may be due to analytical issues discussed below.

# 4.3.7.1.2 Degradation and Decay of Contaminants of Potential Concern

Aluminum, Cr-VI, silver, nitrate and molybdenum are not expected to undergo significant degradation or decay.

#### 4.3.7.1.3 Uncertainty

Similar to human health risk estimates, evaluation of ground water impacts is subject to uncertainties, such as analytical bias and data representativeness, discussed below.

# 4.3.7.1.3.1 Analytical Issues

# 4.3.7.1.3.1.1 Aluminum

No analytical issues were identified with the aluminum DI WET analysis.

#### 4.3.7.1.3.1.2 Formaldehyde

Three of the formaldehyde results were qualified due to matrix spike recovery failure. A matrix spike consists of adding a known quantity of analyte to a sample and determining the percent

recovered by the analytical method. Poor matrix spike recovery indicates the sample matrix may be interfering with quantitative accuracy.

Formaldehyde was not detected in the qualified results. The poor matrix spike recovery may indicate these three results are biased low. All three qualified results were located in the former storm water drain and not immediately adjacent to any Domestic Septic System No. 3 features. The qualified results are not likely relevant to Domestic Septic System No. 3 area characterization.

The other 32 results were unqualified detected concentrations that should accurately represent the formaldehyde concentration at the Domestic Septic System No. 3 leach trench excavation.

#### 4.3.7.1.3.1.3 Hexavalent Chromium

Nine of 41 hexavalent chromium results were qualified. Eight results were qualified due to low matrix spike recoveries. Seven samples were qualified due to field duplicate imprecision, which does not indicate a high or low bias. However, the highest value among field duplicate pairs is selected for DOE areas data. The field duplicate selection process does cause DOE areas data to be biased high.

One sample was qualified because the result was between the method detection limit and the quantitation limit. This result is not as accurate as results that are above the quantitation limit, but the qualification does not indicate a positive or negative bias.

It should be noted that seven samples were qualified for more than one reason.

# 4.3.7.1.3.1.4 Molybdenum

All seven of the detected molybdenum concentrations in Domestic Septic System No. 3 soil samples were qualified. No qualifications were applied to the seven results that were below the detection limit. The seven detected concentrations were qualified because their results were between the method detection limit and the quantitation limit. These results are less accurate than results that are above the quantitation limit, but the qualification does not indicate a positive or negative bias. Two of the seven detected results were also qualified due to laboratory contamination, which can cause false positive detection and may cause an overall positive bias in a data set. The laboratory contamination qualifiers were applied to the two tank contents samples (SSD3C024 and SSD3C025).

# 4.3.7.1.3.1.5 Nitrate

Five of the 41 nitrate results were qualified during data validation. Four of these results were qualified due to expired holding time. Nitrate was not detected in two of the holding time-qualified samples and the other two samples had detected concentrations that were below background. These four samples (SSD3C036 and SSD3C038 through SSD3C040) were located at the west end of the leach trench excavation, upstream of first point of perforation on the Domestic Septic System No. 3 leach line. Samples could lose nitrate after the holding time is expired, which can give these data a negative bias. One sample was qualified because the result was between the method detection limit

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and the quantitation limit. This result is not as accurate as results that are above the quantitation limit, but the qualification does not indicate a positive or negative bias.

#### 4.3.7.1.3.1.6 Silver

Eleven of the 41 silver results were qualified. Five of the results were qualified due to laboratory contamination, which can cause false positive detection and/or cause an overall positive bias in a data set. Four of the laboratory contamination-qualified results were also the only silver results that were reportedly above background.

Eight samples were qualified because their results were between the method detection limit and the quantitation limit. These results are less accurate than results that are above the quantitation limit, but the qualification does not indicate a positive or negative bias. Two samples were qualified for more than one reason.

#### 4.3.7.1.3.2 Data Representativeness

Domestic Septic System No. 3 sampling consisted of random grid, discretionary grab samples, and soil boring samples collected at depths ranging from 3.6 ft bgs to 40 ft bgs. Confirmation sample coverage was extensive throughout the former leach trench excavation. Sampling is less dense around the tank and other Domestic Septic Systems features, but the only suspected release is at the leach trench. Formaldehyde was detected in all of the confirmation samples collected throughout the leach trench and in the soil boring samples collected below the leach trench. Formaldehyde likely extends laterally beyond the confirmation samples and vertically beyond the soil boring samples. The extent of molybdenum and nitrate contamination is likely well characterized. Silver may not have been released at Domestic Septic System No. 3 since samples reportedly containing elevated silver concentrations were qualified, as discussed above. Domestic Septic System No. 3 does not appear to have hexavalent chromium contamination based on the soil data. There are insufficient data to characterize the horizontal and vertical extent and vertical attenuation of aluminum in the vadose zone.

# 4.3.7.1.4 Relation of Concentrations of Contaminants of Potential Ground Water Concern to Site Operations

Aluminum and/or aluminum-bearing compounds may have been used in LEHR operations and released to the Domestic Septic System via sink and/or floor drains.

Cr-VI is potentially associated with LEHR operations, since chromic acid and other chromium-bearing chemicals may have been used or disposed at the Site. Although Cr-VI has been detected at levels slightly above background (36 to 94  $\mu$ g/l) in downgradient wells UCD1-13 and UCD1-21, wells may contain Cr-VI from several sources, including Domestic Septic System No. 3, Landfill No. 2 or from regional sources.

Nitrate is potentially associated with septic releases, the former dog pens, and buried waste at LEHR. There are also known regional nitrate impacts to ground water in the LEHR area from agricultural activities. Formaldehyde, molybdenum, and silver are likely to have been used in LEHR operations.

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# 4.3.8 Risk Characterization Summary and Recommendations Regarding Contaminants of Concern at the Domestic Septic System No. 3 Area

Risk characterization findings and recommended COCs at the Domestic Septic System No. 3 are summarized below and presented in Table 4.3-7. The recommended COCs include constituents that are considered to have potential risks to human health or may have potential impact on the ground water at the Site.

#### 4.3.8.1 Human Health—On-Site Resident

#### 4.3.8.1.1 Aroclor 1254

Small quantities of Aroclor 1254 were likely to have been used at LEHR. The cancer estimated risk due to Aroclor 1254 was equal to the CERCLA point of departure of  $1 \times 10^{-6}$ . Aroclor 1254 was only detected in samples of sludge contained in the concrete septic tank. No significant analytical data quality issues were identified for Aroclor 1254. No leach trench samples were analyzed for Aroclor 1254. However, any Aroclor 1254 contamination that may have been released to soil in the leach trench was likely removed during the removal action. The residential receptor exposure pathway is closed for Aroclor 1254 because the contamination is within a buried and sealed tank. We recommend that Aroclor 1254 not be retained as a COC due its marginal risk (10<sup>-6</sup>) and incomplete exposure for residential receptors.

#### 4.3.8.1.2 Cesium-137

Cs-137 is present in global fallout and was used in research activities at LEHR. The estimated cancer risk attributed to Cs-137 ( $3 \times 10^{-7}$ ), was below the CERCLA point of departure. The spatial distribution of Cs-137 appears random and most of the results are below background. Cs-137 concentrations in the area will decline and the risk will remain below  $10^{-6}$  in the absence of any new releases. The estimated Site EPC was less than the estimated background EPC. No significant analytical issues were identified. Cs-137 should not be retained as a COC because:

- The risk is less than  $10^{-6}$ ;
- The spatial distribution is random; and
- The site EPC is below the background EPC.

#### 4.3.8.1.3 Lead-210

The estimated Pb-210 cancer risk  $(8x10^{-7})$  is below the CERCLA point of departure. The background evaluation indicated that Pb-210 concentrations were equal to natural background in the Domestic Septic System No. 3 area. No localized areas of contamination were found in the spatial analysis. However, analytical precision was poor and may have resulted in underestimated risk. There is no historical evidence of Pb-210 releases due to site operations at the Domestic Septic System No. 3 area. We recommend that Pb-210 not be retained as a COC because:

- The estimated risk was below  $10^{-6}$ ;
- The site data were found to be statistically below background; and

• No localized areas of contamination were found.

#### 4.3.8.2 Ground Water

#### 4.3.8.2.1 Aluminum

DI WET results suggest that aluminum may have the potential to impact ground water at the site. No ground water data are available to compare aluminum in downgradient wells to background. Aluminum may have been used in LEHR operations and could have been inadvertently disposed at Domestic Septic System No. 3, but there are no indications that a significant mass of aluminum was released during LEHR operations. No soil data are available to evaluate the spatial distribution of aluminum in soil or to estimate attenuation factors. Both of the DI WET samples were above the MCL and no significant analytical accuracy issues were identified. Since there appears to be a moderately low likelihood of significant ground water impacts from aluminum at this site, ground water monitoring is recommended.

#### 4.3.8.2.2 Formaldehyde

Formaldehyde has not been detected in downgradient wells, however modeling suggests that residual formaldehyde in vadose zone soil is likely to impact ground water concentrations above background and the MCL in the next ten years. Spatial analysis suggests that formaldehyde was released at Domestic Septic System No. 3 and has spread laterally and vertically in soil from the former leach trench. Formaldehyde should be retained as a COC and evaluated in the Feasibility Study.

#### 4.3.8.2.3 Hexavalent Chromium

Cr-VI is potentially associated with LEHR operations and has been detected at levels slightly above background and the MCL (36 to 94  $\mu$ g/l) in downgradient wells in HSU-1 and HSU-2. However, current soil concentrations are below background. Modeling indicates no future impact above background or the MCL. No gaps in sample coverage were identified and no significant analytical accuracy issues were identified. The soil data, modeling results, sample coverage, and analytical accuracy indicate no future impacts to ground water. Therefore Cr-VI should not be retained as a COC and ground water monitoring is not recommended.

#### 4.3.8.2.4 Molybdenum

Molybdenum has not been detected in downgradient wells, however modeling suggests that its concentrations in soil have elevated ground water concentrations above background, but not the MCL. Spatial analysis suggests that molybdenum was released to soil below the former Domestic Septic System No. 3 leach line and has migrated to a depth below 35 ft in the soil column. Molybdenum should be retained as a COC and evaluated in the Feasibility Study.

#### 4.3.8.2.5 Nitrate

Nitrate has been detected in concentrations above background and the MCL in HSU-1 well UCD1-21 and above background in HSU-2 well UCD2-39, downgradient of Domestic Septic System No. 3. Modeling confirms that residual nitrate is likely to impact ground water at concentrations above background and MCL in the next thirteen years. Spatial analysis of the soil samples suggests that nitrate was released to subsurface soil below the former leach line, but the contamination is very limited in lateral and vertical extent. Approximately 10% of the nitrate data may be underestimated based on analytical issues found in the uncertainty evaluation. Nitrate should be retained as COC and evaluated in the Feasibility Study.

#### 4.3.8.2.6 Silver

Silver has not been detected in downgradient wells. All four of the soil samples with elevated silver concentrations (2.4 mg/kg, 1.9 mg/kg, 0.57 mg/kg, and 0.57 mg/kg) were found to contain laboratory contamination. Silver is likely below background (0.55 mg/kg) in soil at Domestic Septic System No. 3. The spatial analysis indicated the elevated samples were randomly located and no gaps in sample coverage were identified. No elevated silver was found in the soil boring samples representing the vertical extent. Silver was likely used in LEHR operations and could have been inadvertently discharged at Domestic Septic System No. 3. Modeling suggests that residual silver in vadose zone soil is likely to impact ground water at concentrations above background and the MCL. However, the impact is not expected until 500 years from present. No impacts to ground water are anticipated based on the ground water data, soil data, spatial analysis, and sample coverage. Although silver should not be retained as a COC for evaluation in the Feasibility Study based on the modeling results, it should be included in the ground water monitoring program to address the uncertainty in the model predictions.



Figure 4.3-1. Domestic Septic System No. 3 Features



Figure 4.3-2. Domestic Septic System No. 3 Area Sample Locations and Depths









Figure 4.3-6. Decay of Cesium-137, Domestic Septic System No. 3 Area



Figure 4.3-7. Decay of Lead-210, Domestic Septic System No. 3 Area

Constituent	Total	Number of	Number of	Maximum	Sample	Depth
Constituent	Samples	Background <sup>1</sup>	$PPC^2$	Concentration	Identification	(ft)
Conoral Chomistry		Dackground	TKO	mg/kg		
Formaldebyde	1	1	0	1 02	\$\$D3C018	1
Heyayalent Chromium	5	1	0	0.836	SSD3C010	
Nitrate	5	3	U NE	101	SSD3C019	9-11.5 Q
Matels	5	5	INL	101 mg/kg	55D5C025	0
Arsonio	5	1	5	$\frac{mg}{Kg}$	\$\$D3C020	1
Dorium	5	1	3	44.1	SSD3C020	4
	5	0	0	222	SSD3C020	4
Charmin	5	5	0	2.0	SSD3C020	4
Chromium	5	5	1	249	SSD3C020	4
Copper	2	1	0	106	SSD3C020	4
Iron	2	0	5	37,900	SSD3C023	8
Lead	5	1	05	21.8	SSD3C020	4
Manganese	5	1	0	752	SSD3C022	4.5
Mercury	5	5	2	498	SSD3C020	4
Molybdenum	5	4	0	26.2	SSD3C020	4
Nickel	5	3	0	285	SSD3C023	8
Selenium	5	4	0	10.7	SSD3C020	4
Silver	5	4	0	186	SSD3C020	4
Zinc	5	1	0	116	SSD3C020	4
Pesticides				μg/kg		
alpha-Chlordane	5	N/A	NE	806	SSD3C020	4
gamma-Chlordane	5	N/A	NE	1,150	SSD3C020	4
Heptachlor epoxide	5	N/A	0	12.8	SSD3C022	4.5
Radionuclides				pCi/g		
Bismuth-214	5	1	0	2.18	SSD3C020	4
Carbon-14	5	1	0	0.155	SSD3C023	8
Cesium-137	5	1	1	0.0619	SSD3C020	4
Lead-210	5	1	3	1.72	SSD3C020	4
Lead-214	5	1	0	2.33	SSD3C020	4
Potassium-40	5	0	5	11.7	SSD3C023	8
Radium-226	5	1	5	2.44	SSD3C020	4
Radium-228	5	0	5	0.55	SSD3C021	8.5
Strontium-90	5	4	3	2.01	SSD3C020	4
Thorium-228	5	0	5	0.595	SSD3C021	8.5
Thorium-232	5	0	0	0.525	SSD3C020	4
Uranium- $233/234$	5	1	Ő	11	SSD3C020	4
Uranium-238	5	1	Ő	0 649	SSD3C020	4
SVOCs	U	1	0	0.012 μσ/kσ	55252020	•
Benzo(a)anthracene	5	$N/\Delta$	1	μ <u>σ</u> /Ν <u>σ</u> 6 540	\$\$D3C022	45
Benzo(a)pyrene	5	N/A	1	1,660	SSD3C022	4.5
Benzo(h)fluoranthene	5	$N/\Delta$	1	5,600	SSD3C022	4.5 4.5
Chrysene	5	N/A	1 <sup>3</sup>	5,000	SSD3C022	т.3 15
Dihanzo(a h)anthragana	5	IN/A N/A	1	1 150	SSD3C022	4.5
Indeno(1.2.2. ad)pyrona	5	N/A	1	1,130	SSD3C022	4.5
mucho(1,2,3-cu)pyrene	3	1N/A	1	1,110	55030022	4.3

Table 4.3-1.	Analytes Detected in Soil/Waste at the Domestic Septic System No. 3 Area Prior to
	Removal Actions

# Table 4.3-1.Analytes Detected in Soil/Waste at the Domestic Septic System No. 3 Area Prior to<br/>Removal Actions (continued)

#### Notes

<sup>1</sup>Site-specific background for greater than four ft below ground surface.

<sup>3</sup>Lead and chrysene were evaluated against California-modified PRGs.

>	greater than
µg/kg	micrograms per kilogram
ft	feet
mg/kg	milligrams per kilogram
N/A	not applicable
NE	not established
pCi/g	picoCuries per gram
PRG	preliminary remediation goal
SVOCs	semi-volatile organic compounds
US EPA	United States Environmental Protection Agency

Source: Data from the Remedial Investigation Report (WA, 2003b).

Contaminant data includes data collected from all depth intervals instead of the 0-10 ft interval used in the risk estimate.

<sup>&</sup>lt;sup>2</sup>Chemical PRGs for residential soil are from US EPA Region 9 PRGs table, dated October 1, 2002. Radionuclide PRGs for residential soil are from Radionuclide Toxicity and PRGs for Superfund, dated April 14, 2003 (US EPA, <u>http://epa-prgs.orrl.gov/radionuclides/</u> download/rad\_master\_prg\_table.xls).

# Table 4.3-2. Summary of Sampling Results Used in the Risk Estimate at the Domestic Septic System No. 3 Area

List 1 COPC	Units	Total Samples	Number of Detections	Number of Detections > Background	Concentration Range <sup>1</sup>	Background Screening Concentration <sup>2</sup>	ID of Sample with Highest Concentration	Depth of Sample with Highest Concentration (ft)
Metals								
Arsenic	mg/kg	9	9	1	3.6 - 10.6	9.6	LEHR-S-T301	8
Pesticides/PCBs								
Aroclor 1254	mg/kg	7	2	2	0.0217 - 0.225	0	SSD3C024	8
Radionuclides								
Cesium-137	pCi/g	30	6	4	-0.00617 - 0.126	0.012	LEHR-S-T301	8
Lead-210	pCi/g	30	9	1	-0.0922 - 4.4	1.6	LEHR-S-T301	8
Potassium-40	pCi/g	30	30	0	4.6 - 13	14	SSD3C048, SSD3C015	5, 10
Radium-226	pCi/g	30	30	0	0.264 - 0.616	0.75	SSD3C015	10
Radium-228	pCi/g	29	29	0	0.229 - 0.614	0.64	SSD3C009	10
Strontium-90	pCi/g	25	16	13	-0.0133 - 0.591	0.056	SSD3C062	5.2
Thorium-228	pCi/g	5	5	0	0.238 - 0.529	0.74	SSIBF155	6.5

#### Notes

Source: COPC data from the HHRA Risk Estimate, Appendix A (UC Davis, 2005).

<sup>1</sup>The concentration ranges for metals and radionuclides include non-detects. The concentration ranges for pesticides/PCBs do not include non-detects.

<sup>2</sup>The background screening concentrations are the unstratified background screening values in Appendix B of the HHRA Risk Estimate.

>	greater than
COPC	constituent of potential concern
ft	feet
HHRA	Human Health Risk Assessment
ID	identification (number)
mg/kg	milligrams per kilogram
PCBs	polychlorinated biphenyls
pCi/g	picoCuries per gram

# Table 4.3-3.Human Health Risks to On-Site Resident by Exposure Route for Contaminants of Potential Concern in the Domestic Septic<br/>System No. 3 Area

List 1 COPC	EPC <sup>1</sup>	Soil Ingestion	Soil Dermal Exposure	Above- Ground Plant Ingestion <sup>2</sup>	Below- Ground Plant Ingestion <sup>2</sup>	External Radiation	Dust Inhalation	Total Cancer Risk	Statistical Background Comparison <sup>3</sup>	List 2 Cancer Risk <sup>4</sup>
Aroclor 1254	0.13	4.E-07	1.E-07	4.E-07	6.E-08	-	5.E-12	1.E-06	Fail	1.E-06
Arsenic	8.2	2.E-05	1.E-06	9.E-05	3.E-05	-	1.E-08	1.E-04	Pass	-
Cesium-137	0.015	8.E-11	-	4.E-10	-	3.E-07	2.E-15	3.E-07	Fail	3.E-07
Lead-210	0.85	3.E-07	-	5.E-07	-	3.E-08	1.E-10	8.E-07	Fail	8.E-07
Potassium-40	12	1.E-07	-	3.E-06	-	9.E-05	2.E-12	9.E-05	Pass	-
Radium-226	0.48	1.E-07	-	3.E-07	-	4.E-05	1.E-10	4.E-05	Pass	-
Radium-228	0.49	7.E-08	-	2.E-07	-	2.E-05	3.E-10	2.E-05	Pass	-
Strontium- 90+Daughter	0.21	4.E-09	-	1.E-07	-	3.E-08	3.E-13	1.E-07	Fail	1.E-07
Thorium-228	0.48	6.E-09	-	5.E-10	-	4.E-06	1.E-10	4.E-06	Pass	-
TOTAL								3.E-04		2.E-06

#### **CANCER RISK BY EXPOSURE ROUTE**

#### HAZARD QUOTIENT BY EXPOSURE ROUTE

List 1 COPC	EPC <sup>1</sup>	Soil Ingestion	Soil Dermal Exposure	Above- Ground Plant Ingestion	Below- Ground Plant Ingestion	External Radiation	Dust Inhalation	Non-Cancer Hazard Index	Statistical Background Comparison <sup>3</sup>	List 2 Non- Cancer Hazard Risk <sup>4</sup>
Aroclor 1254	0.13	8.3E-02	3.2E-02	9.0E-02	4.9E-03	-	-	2.1E-01	Fail	2.1E-01
Arsenic	8.2	3.5E-01	3.0E-02	1.9E+00	2.3E-01	-	-	2.5E+00	Pass	-
TOTAL								2.7E+00		2.1E-01

#### Notes

Source Data from HHRA Risk Estimate, Tables 7 and 8. Statistical Background Comparison from Appendix B (UC Davis, 2005).

The non-cancer risk is for a resident child; for cancer risk it is an age-adjusted adult.

List 2 constituents shown in **bold-type** text contribute at least 10<sup>-6</sup>, or greater than 10%, to the excess cumulative cancer risk. Rounding may affect the total List 2 cancer risk values shown in the last column. Determination of whether the risk is greater than ten percent of total List 2 cancer risk is based on unrounded values.

# Table 4.3-3.Human Health Risks to On-Site Resident by Exposure Route for Contaminants of Potential Concern in the Domestic Septic<br/>System No. 3 Area (continued)

<sup>1</sup>The 95% upper confidence limit on the mean of the exposure point concentration; chemical concentrations are in milligrams per kilogram and radionuclide concentrations are in picoCuries per gram.

<sup>2</sup>For radionuclides, plant ingestion is not subdivided into above-ground and below-ground plants.

<sup>3</sup>Based on Wilcoxon Rank Sum test or other statistical comparisons, as shown in Appendix B of the HHRA Risk Estimate.

<sup>4</sup>Dashes indicate that constituent was not identified as a List 2 COPC, since it was identified to be statistically equivalent to background.

-	not calculated
COPC	constituent of potential concern
EPC	exposure point concentration
HHRA	Human Health Risk Assessment

# Table 4.3-4. Data Summary—Comparison of Exposure Point Concentrations to Site Background at the Domestic Septic System No. 3 Area

Analyte	Detections	Samples	Min Detect	Max Detect	Min Detection Limit	Max Detection Limit	Average <sup>1</sup>	Standard Deviation <sup>1</sup>	Distribution	95UCL <sup>1</sup>	EPC	Decay- Corrected EPC <sup>2</sup>
Site (0 to 10 ft)	)		mg/kg or pCi/g	mg/kg or pCi/g	mg/kg or pCi/g	mg/kg or pCi/g	mg/kg or pCi/g	mg/kg or pCi/g		mg/kg or pCi/g	mg/kg or pCi/g	mg/kg or pCi/g
Aroclor 1254	2	7	0.0217	0.282	0.0333	0.139	0.056	0.099	Non-parametric	0.13	0.13	N/A
Cesium-137	6	30	0.0049	0.126	0.0033	0.053	0.0078	0.023	Non-parametric	0.015	0.015	0.014
Lead-210	9	30	0.48	4.4	0.0691	1.76	0.61	0.78	Non-parametric	0.85	0.85	$N/A^3$
Background (0	) to 10 ft)											
Aroclor 1254	0	23	0	0	0.034	0.0414	0.018	0.0011	N/A	$0^4$	$0^4$	N/A
Cesium-137	43	75	0.00532	0.275	0.0386	0.065	0.031	0.435	Non-parametric	0.039	0.039	0.034
Lead-210	6	26	0.703	2.49	0.209	5.08	0.719	0.697	Non-parametric	0.95	0.95	0.95

#### Notes

Source: COPC data from Appendix A from HHRA Risk Estimate.(UC Davis, 2005) 95UCL calculations for background concentrations and decay corrections added."

<sup>1</sup>Negative concentration values were set to zero and concentrations below the detection limit were used to determine the 95UCL, average, and standard deviation for radionuclides. Half of the detection limit was used when chemicals were not detected. Same as 95UCL calculation procedure used in HHRA Risk Estimate (UC Davis, 2005).

<sup>2</sup>The EPC was decay-corrected to April 2005 (see Figures 4.3-6, 4.3-7 and Appendix A).

<sup>3</sup>Site EPC is less than the background EPC, so the change in site EPC over time is unknown due to simultaneous replenishment and decay.

<sup>4</sup>Background 95UCL and EPC assumed equal to zero for Aroclor 1254.

95UCL	95 percent upper confidence limit on the mean
COPC	constituent of potential concern
EPC	exposure point concentration
ft	feet
HHRA	Human Health Risk Assessment
max	maximum
mg/kg	micrograms per kilogram
min	minimum
N/A	not applicable
pCi/g	picoCuries per gram

Designated Level	Con	Confirmation Sampling		Designated-Level Sampling		Soil	NUFT Mode	el Soil Result	Downg Cround Water	radient	Groune Backs	d Water ground	Ground	Тар	Time to Peak at
Constituent of Potential Concern	Maximum	Depth of Maximum	95% UCL	Maximum	Depth of Maximum	Background Value	Background Ground Water	MCL Ground Water	- Ground water (μg	z/l)	Concer (µ	ntration <sup>3</sup> g/l)	Water MCL	Water PRG	Ground Water Goal Level
	(mg/kg)	(ft)	(mg/kg)	$(mg/kg)^1$	(ft)	(mg/kg)	Goal (mg/kg)	Goal (mg/kg)	HSU-1	HSU-2	HSU-1	HSU-2	(µg/l)	(µg/l)	(years)
Aluminum <sup>4</sup>	N/A	N/A	N/A	$112,000^{5}$	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	200	36,000	N/A
Formaldehyde	2.2	12.5	0.99	0.92	15	N/A	0.167	0.0151	ND/ND	$N/A^6$	1,140	500	$100^{7}$	5,500	10
Hexavalent Chromium	0.384	5.9	0.2	0.387	15	1.3	0.638	0.809	<b>61-94</b> /36- <b>66</b>	5 <b>- 27.0</b>	39	20	50	110	No impact
8															expected
Mercury <sup>°</sup>	4.4	5.2	1.96	0.28	14	3.94/0.25/0.63*	0.00759	0.760	ND/ND	<0.043 - <0.20	< 0.20	0.2	2	11	3,300
Molybdenum	N/A	N/A	N/A	2.5	35	<0.26	0.253	3.11	ND/ND	[ND] 1.9 - 2.8 <sup>10, 11</sup>	14.9	5 <sup>10</sup>	180 <sup>12</sup>	180	Likely already occurred
Nitrate (as N)	106	12.5	33.5	33.2	15	36	6.22	2.6	11,800-19,000/	1,280 - <b>9,880</b>	25,144	4,229	10,000	10,000	13
									56,000-64,000						
Silver	2.4	10.5	N/A	0.37	30	0.55	0.143	0.268	ND/ND	<0.030 - <4 <sup>13</sup>	5	$1.7^{13}$	100	180	500

# Table 4.3-5. Summary of Potential Impact on Ground Water of Designated-Level Constituents of Potential Concern in Domestic Septic System No. 3 Area Soil

Notes

Source: Data from Remedial Investigation Report (WA, 2003b). HSU-2 data added.

<sup>1</sup>µg/L for DI WET results

<sup>2</sup>Range of available data for nearby downgradient HSU-1 wells UCD1-013/UCD1-021, and HSU-2 well UCD2-39.

<sup>3</sup>Based on data from HSU-1 well UCD1-18, and HSU-2 wells UCD2-17 and UCD2-37.

<sup>4</sup>Aluminum is a designated-level COC because the DI WET result is above the MCL. No data are available for soil or downgradient ground water. No NUFT modeling has been done.

<sup>5</sup>Based on DI WET results.

<sup>6</sup>Formaldehyde was not analyzed in samples from well UCD2-39.

<sup>7</sup>California State Action Level, California Department of Health Services.

<sup>8</sup>Assumed to be mercuric chloride.

<sup>9</sup>First value is a concentration for 0 to 4 ft below ground surface, second is for greater than 4 ft below ground surface and third is a consolidated concentration (all depths).

<sup>10</sup>Measurements of molybdenum in samples collected before 1993 were excluded here because those data are significantly less reliable than the measurements of molybdenum in later samples.

<sup>11</sup>One outlier, a non-detect, was also excluded.

<sup>12</sup>Preliminary remediation goal.

<sup>13</sup>Measurements of silver in samples collected before 1997 were excluded here because those data are significantly less reliable than are the measurements of silver in later samples. Outliers were also excluded. **Bold type** indicates soil concentration is above background and above NUFT result for ground water impact at background levels, or ground water concentration above background.

Boxed type indicates soil is above background concentration and above NUFT result for ground water impact at the MCL, or DI WET concentration or ground water concentration above the MCL.

<	denotes analyte concentrations below the detection limit
μg/l	microgram per liter
COC	constituent of concern
DI WET	deionized water waste extraction test
ft	feet
MCL	California Maximum Contaminant Level for ground water (February 2003)
mg/kg	milligrams per kilogram
mg/l	milligrams per liter
N	nitrogen
N/A	not applicable or not available
ND	not detected
NUFT	Non-Isothermal, Unsaturated Flow and Transport model
PRG	preliminary remediation goal (US EPA, 2002a for radionuclides; US EPA, 2002b for others)
UCL	upper confidence limit on the true mean based on sample data

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# Table 4.3-6.Summary of Designated-Level Ground Water Constituents of Potential Concern at Domestic Septic System No. 3 Area<br/>Retained as Constituents of Potential Ground Water Concern

	0	0	6	4
Designated-Level Constituent of Potential Concern	Are the DL COPCs ground water concentrations above site background? <sup>1</sup>	Are the DL COPC soil concentrations above soil background and the NUFT soil results? <sup>2</sup>	Will the DL COPC impact ground water above background levels in the next 500 years?	Retained as COPGWC in risk
	If yes, enter ✓ in ❹	If yes, go to <b>9</b>	If yes, enter ✓ in ❹	$\sqrt{-V_{es}}$
	If no, go to 🛛	If no, stop and enter $\times$ below	If no, stop and enter $\times$ below	v – 105
Aluminum	Yes <sup>3</sup>	N/A	N/A	$\checkmark$
Formaldehyde	No	Yes	Yes	$\checkmark$
Hexavalent	Yes	-	-	$\checkmark$
Chromium				
Mercury	No	Yes	×	-
Molybdenum	No	Yes	Yes	$\checkmark$
Nitrate (as N)	Yes	-	-	✓
Silver	No	Yes	Yes	$\checkmark$

#### Note

<sup>1</sup>See Table 4.3-5. Compare downgradient ground water concentration to ground water background concentration. Results below detection limits are presumed to be below site background. <sup>2</sup>The lower of background and MCL goals.

<sup>3</sup>Based on DI WET results.

×	not retained as a COPGWC
$\checkmark$	retained as a COPGWC
-	skip
COPC	constituent of potential concern
COPGWC	constituent of potential ground water concern
DI WET	deionized water waste extraction test
DL	designated-level
MCL	California Maximum Contaminant Level for ground water (February 2003)
Ν	nitrogen
N/A	not available
NUFT	Non-Isothermal, Unsaturated Flow and Transport

Driver COPC/ COPGWC	Total Cancer Risk <sup>1</sup>	Spatial Distribution	Background Contribution <sup>2</sup>	Above- Background Contribution <sup>3</sup>	Historically Used at the Site	Time for Attenuation to Risk Endpoint <sup>4</sup> (years)	Level of Ground Water Impact	Uncertainty Recommended Action
<b>On-Site Resider</b>	nt							
Aroclor 1254	1E-6	Localized	0%	100%	Yes	N/A	N/A	• Characterization/EPC uncertain due to no No Further Action samples in the leach trench area.
Cesium-137	3E-7	Localized	100%	0%	Yes	<0 <sup>5</sup>	N/A	<ul><li>No significant data quality issues. No Further Action</li><li>Representative data.</li></ul>
Lead-210	8E-7	Localized	100%	0%	Yes	$<\!0^{6}$	N/A	<ul> <li>Characterization/EPC uncertain due to high No Further Action counting errors (under-estimate).</li> <li>Representative data.</li> </ul>
Aluminum	N/A	Unknown	N/A	N/A	Yes	N/A	>MCL, >bkgd <sup>7</sup>	<ul> <li>Unknown vertical and horizontal Monitoring distribution.</li> <li>Unknown attenuation factor between source and ground water</li> </ul>
Formaldehvde	N/A	Localized	N/A	N/A	Yes	N/A	>MCL. >bkgd <sup>8</sup>	• No down gradient ground water samples Evaluate in FS
Hexavalent Chromium	N/A	Random	N/A	N/A	No	N/A	>MCL, >bkgd	<ul> <li>Nine of 41 results qualified. No Further Action</li> <li>Representative data.</li> </ul>
Molybdenum	N/A	Localized	N/A	N/A	No	N/A	>bkgd <sup>8</sup>	<ul> <li>Characterization/EPC uncertain since all Evaluate in FS (seven) detected results qualified.</li> <li>Results below detection limit – not qualified.</li> <li>Representative date</li> </ul>
Nitrate (as N)	N/A	Localized	N/A	N/A	Yes	N/A	>MCL, >bkgd	<ul> <li>Representative data.</li> <li>Five of 41 results qualified.</li> <li>Bepresentative data</li> </ul>
Silver	N/A	Random	N/A	N/A	Yes	N/A	>MCL, >bkgd <sup>8</sup>	<ul> <li>Eleven of 41 results qualified. Monitoring</li> <li>Representative data.</li> </ul>

#### Table 4.3-7. Summary of Major Factors Driving Risk and Recommendations for Future Action at Domestic Septic System No. 3

Notes

<sup>1</sup>For radionuclides, values are decay-corrected to April 2005 (see Figure 4.3-6, Figure 4.3-7 and Appendix B).

<sup>2</sup>The background contribution is the proportion of the site EPC that can be attributed to the background EPC (see Table 4.3-4).

<sup>3</sup>The above-background contribution is the proportion of the site EPC that is greater than the background EPC.

<sup>4</sup>The time for attenuation to risk endpoint is the time, from April 2005, for the site EPC of a radionuclide to decay to either the background EPC or the concentration equivalent to a risk of 10<sup>-6</sup>, whichever is greater.

Ν

N/A

nitrogen

not applicable

<sup>5</sup>As of April 2005, the site EPC is less than the concentration equivalent to a risk of 10<sup>-6</sup>.

<sup>6</sup>The Site EPC is less than both the background EPC and the concentration equivalent to a risk of 10<sup>-6</sup>.

<sup>7</sup>No ground water data available. Impact based on DI WET results.

<sup>8</sup>Not detected in ground water. Impact based on modeling.

#### Abbreviations

greater than > < less than bkgd background COPC constituent of potential concern COPGWC constituent of potential ground water concern DI WET deionized water waste extraction test EPC exposure point concentration FS Feasibility Study

MCL California Maximum Contaminant Level for ground water (February 2003)

# Contamination detected only in tank-contents samples. Spatial analysis indicated localized risk at 1E-6. Site concentrations generally below background concentrations. Risk less than 1E-6. Site concentrations are below background concentrations. DI WET results suggest potential impact above the MCL and background. Low likelihood of a significant release.

Basis for Recommendation

- Modeling indicated impact above the MCL and background.
- Residual soil concentrations are below background.
- Modeling suggests no impact to ground water.
- Above background in downgradient ground water could be from other sources.
- Modeling indicates impact above background.
- Currently impacting ground water.
- Modeling indicates impact above MCL and background.
- Residual soil concentrations are mostly below background, however release may have occurred.

#### 4.4 Domestic Septic System No. 4

Figure 4.4-1 shows the Domestic Septic System No. 4 features.

#### 4.4.1 Area Description

Domestic Septic System No. 4 consisted of a domestic septic tank, leach field, and interconnecting piping. The leach lines extended under Building H-215. Liquid wastes and sewage were discharged to the tank prior to the Site's connection to the UC Davis Wastewater Treatment Plant in 1971. The septic tank was reportedly backfilled and the influent/effluent lines for each tank were reportedly cut and capped in 1971 (IT Corp., 1996). No formal closure report for Domestic Septic System No. 4 is known to exist (D&M, 1994).

# 4.4.2 Pre-Removal Action Contaminant Distribution

Table 4.4-1 summarizes contaminants found in concentrations exceeding background at Domestic Septic System No. 4. A total of nine soil samples (including one field duplicate) were collected from the area. Of the 173 analytes, 24 were detected above their respective background levels as summarized in Table 4.4-1. Eight soil samples were analyzed for Hg. Six of these contained Hg in concentrations greater than background. Lead was detected above background in three of eight samples. The maximum reported Hg and lead concentrations of 3.5 mg/kg and 20.1 mg/kg, respectively, were detected in a composite sample (SSD4C002A/B) collected beneath the first points of perforation on the two leach lines. The second-highest Hg and lead concentrations were detected in a sample (SSD4C005) collected directly beneath the leach line at the approximate midpoint of the southern leach line. The highest Hg and lead concentrations were detected in the soil that was intermixed with the leach field gravel. The remaining samples show a trend of decreasing concentration with depth.

Copper was detected above background at 64.6 mg/kg in sample SSD4C002A/B. Th-234 was detected above background in sample LEHR-S-401 at 4.15±0.59 pCi/g. U-235 was detected above background in sample LEHR-S-T401 at 0.16±0.17 pCi/g (WA, 2003b).

As shown in Table 4.4-6, analysis of samples collected to determine potential ground water impacts indicated that chromium, lead, Hg, and selenium were present above background. One boring was drilled at the first point of perforation on the western leach line (sample SSD4C004). A sample composited from this location and beneath the first point of perforation on the southern leach line contained the maximum Hg, lead and selenium concentrations. Sample SSD4C004 was collected at 7.8 ft bgs. Additional samples were collected and analyzed for Cr-VI, total chromium, lead, Hg and selenium at five-ft intervals starting at 12.8 ft bgs and terminating at 37.7 ft bgs.

Total chromium was detected at a concentration of 153 mg/kg, in a sample collected at 12.8 ft bgs. This sample exceeds the site background value of 125 mg/kg (for soil at depths greater than four ft). Lead was detected at concentrations that were slightly above the site background of

9.5 mg/kg, in a sample (SSD4DL07) collected at 37.8 ft bgs, at 9.6 mg/kg. Selenium was also detected at concentrations that were slightly above the site background of 1.2 mg/kg, in a sample (SSD4DL03) collected 17.8 ft bgs, at 1.3 mg/kg. None of the constituents showed a concentration distribution trend with depth.

# 4.4.3 Removal Action Activities

No removal action was conducted at the Domestic Septic System No. 4 area.

# 4.4.4 Post-Removal Action Contaminant Distribution

Since no removal action was conducted at Domestic Septic System No. 4, the pre-removal action contaminant distribution discussed in 4.4.2 is representative of current site conditions.

# 4.4.5 Summary of Risk Estimate Data

Data used in the human health risk estimate were collected during various investigations and sampling events that were conducted at Domestic Septic System No. 4. Information used in the risk estimate included data from the:

- 1997 Data Gaps Investigation; and
- 2001 Domestic Septic System Investigation.

These investigations are summarized in Table 6-8 of the RI and details of the 2001 Domestic Septic System Investigation are presented in Appendix B of the same report (WA, 2003b). Although all radionuclide waste from the LEHR operations was being treated in the Radium/Strontium Treatment Systems at the time that the septic systems were installed, there is a possibility that a wide variety of radionuclide and chemical lab waste were discharged into these systems. Samples collected in the areas of the Domestic Septic Systems were therefore analyzed for a broad suite of chemicals and radionuclides. The sample data set used in the HHRA Risk Estimate was evaluated and redacted to exclude samples collected at depths greater than ten ft bgs. Table 4.4-2 provides a summary of all data used in the Tier 2 risk estimate for Domestic Septic System No. 4. The sample locations for all data used in the risk estimate are presented in Figure 4.4-2.

# 4.4.5.1 Quality of Site Data

Data quality procedures common to evaluations of all DOE areas and site background are discussed in Section 2. The total data set for the Domestic Septic System No. 4 area included 1,000 results. Four of these results, or 0.4%, were rejected from the total data set ("R"-qualified). Sample results are rejected when a data validation expert reviewing laboratory data finds evidence of serious deficiencies in the ability to analyze a sample and meet QC criteria. The "R" qualifier indicates that the data cannot be used to verify whether the analyte was present in or absent from the sample. "R"-qualified results were not used in the risk estimate. After "R"-qualified data were removed from

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the total data set, the final risk estimate data set contained 996 results. Seventy-three of the results, or 7.3%, had "J" qualifiers, which indicate that an analyte was positively identified in the sample, but the analytical result is an approximation of the analyte concentration in the sample. Data with "J" qualifiers were used in developing risk estimates. A total of ninety-eight records, or 9.8%, had "UJ" qualifiers, which mean that an analyte was not detected but the analytic QC results indicate that the detection limit is approximate. Data with "UJ" qualifiers were included in the risk estimate and were treated as non-detection of an analyte.

Seventy-four of the 996 final records from the Domestic Septic System No. 4 area were used to generate the Tier 2 human health risk estimate. Nine of the seventy-four results had "J" qualifiers, and one result had a "UJ" qualifier.

#### 4.4.6 Risk Characterization—Domestic Septic System No. 4

Consistent with the HHRA Risk Estimate, as discussed in Section 2.2, this risk characterization uses the terms "List 1" and "List 2". List 2 identifies constituents that failed the statistical comparison to background, which may be indicative of a release to the environment. Table 4.4-3 and Table 4.4-4, in the first column, provide the List 1 COPCs identified in the HHRA Risk Estimate. The last column of Table 4.4-3 and Table 4.4-4 provides only List 2 COPCs and their risk values. The values provided are not corrected for decay. A subset (shown in bold-type) of List 2 contains COPCs that have a risk of at least 10<sup>-6</sup> or contribute more than ten percent of the total excess cumulative cancer risk in the Domestic Septic System No. 4 area.

Specifically, this subset consists of benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, dibenzo(a,h)anthracene, indeno(1,2,3-cd)pyrene, and Pb-210 for the hypothetical on-site resident, and benzo(a)pyrene and dibenzo(a,h)anthracene for the construction worker. The constituents of this subset are identified in this risk characterization as List 2 driver COPCs, since they represent potential site-related risks and are the best candidates for further evaluation in the Feasibility Study. These COPCs are the focus of the risk characterization discussions that follow. None of the receptors evaluated for this area showed non-cancer hazard quotients above the point of departure of one.

#### 4.4.6.1 Exposure Assessment

The exposure assessment for List 2 driver COPCs at the Domestic Septic System No. 4 Area includes:

- The spatial distribution of the List 2 driver COPCs with figures showing sample locations;
- Further evaluation of risk from COPC concentrations attributed to site background versus prior site activities; and
- A discussion of the exposure intake estimates and their effect on the overall risk estimate.

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A conceptual site model illustrating exposure pathways and potential human receptors for all DOE areas is provided as Figure 2-1.

#### 4.4.6.1.1 Spatial Distribution of Contaminants of Potential Concern

Figure 4.4-3 through Figure 4.4-9 show the spatial distribution of sample results for benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, dibenzo(a,h)-anthracene, indeno(1,2,3-cd)pyrene, and Pb-210, respectively. The symbols used in spatial analysis figures are described in Section 2.2.3.1.

Sampling at Domestic Septic System No. 4 was focused on the septic tank, distribution box and leach field (Figure 4.4-1). The sample locations were not part of an overall random grid, but represent discretionary sampling performed within the potential areas of contamination.

#### 4.4.6.1.1.1 Distribution of Polynuclear Aromatic Hydrocarbons

The spatial analyses for benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, dibenzo(a,h)anthracene, and indeno(1,2,3-cd)pyrene are shown in Figure 4.4-3 through Figure 4.4-8, respectively. These compounds are commonly referred to as PAHs, which are a typical mixture of SVOCs that can be found in petroleum or can be produced by various combustion processes.

As shown in Figure 4.4-3 through Figure 4.4-8, all of the PAHs were detected in the composite samples (field duplicates SSD4C002A/B and SSD4C003A/B, see Figure 4.4-2) collected beneath the first points of perforation of the two leach lines at 4.2 ft bgs. Note that the map location for these composite samples is shown as the approximate midpoint of a line connecting the two sample points. All of the PAHs, except indeno(1,2,3-cd)pyrene, were detected in a sample (SSD4C004) collected at 7.75 ft bgs beneath the first point of perforation of the western leach line. All of the PAHs, except dibenzo(a,h)anthracene, were detected in sample SSD4C005 collected beneath the midpoint of the southern leach line at 4.2 ft bgs. No PAHs were detected in the remaining three samples (LEHR-S-T401, LEHR-S-T402, and SSD4C001). Samples LEHR-S-T401 and LEHR-S-T402 were collected from depths of 5.5 and 8 ft, respectively.

Field duplicate samples (SSD4C002A/B and SSD4C003A/B) had the highest PAH concentrations. There appears to be a trend of decreasing PAH concentrations in the leach field with increased distance from the distribution box. However, it is likely that PAHs persist in the unsampled portions of the leach field. The vertical and horizontal extent of the PAHs are not characterized by the available data. However, given the low solubility and high sorptivity of the PAHs, they are not likely to have migrated significantly past the gravel fill in the leach field under Building H-215. A single data point (sample SSD40C001) at the junction between the septic tank and vitrified clay pipe distribution line suggests that no PAHs have been released in this area.

#### 4.4.6.1.1.2 Lead-210 Distribution

One sample (LEHR-S-T401) had a reported Pb-210 concentration  $(4.7 \pm 1.2 \text{ pCi/g})$  above the background screening value of 1.6 pCi/g with a corresponding risk between 10<sup>-5</sup> and 10<sup>-6</sup>. The other

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five samples showed concentrations of Pb-210 below background. The elevated Pb-210 concentration does not appear to be related to the elevated PAH concentrations.

#### 4.4.6.1.2 Degradation and Decay of Contaminants of Potential Concern

The methodology for calculating radionuclide decay is described in detail in Appendix B.

#### 4.4.6.1.2.1 Polynuclear Aromatic Hydrocarbons

Microbial metabolism is the major process for degradation of PAHs in soil environments. Photolysis, hydrolysis, and oxidation generally are not considered to be important processes for the degradation of PAHs in soils (Sims and Overcash, 1989). A study that assessed the fate of several PAHs, which included benzo[a]anthracene, benzo[b]fluoranthene, dibenzo[a,h]anthracene, benzo[a]pyrene, and indeno[1,2,3-c,d]pyrene, in two soils found no significant abiotic loss for these PAHs (Park *et al.*, 1990).

Based on experimental results (Park et al., 1990), the estimated half-lives of the PAHs in soil were:

- benzo[a]anthracene, 162-261 days;
- benzo[b]fluoranthene, 211-294 days;
- benzo[a]pyrene, 229-309 days;
- dibenzo[a,h]anthracene, 361-420 days;
- dibenzo(a,i)pyrene, 232-361 days; and
- indeno[1,2,3-c,d]pyrene, 288-289 days.

Environmental factors that may influence the rate of PAH degradation in soil include temperature, pH, oxygen concentration, PAH concentrations and contamination history of soil, soil type, moisture, nutrients, and other substances that may act as substrate co-metabolites (Sims and Overcash, 1989). Although this large number of factors precludes specific decay calculations for the PAHs at the Site, it is clear that the PAHs will degrade and that their half-lives are generally greater than 200 days.

#### 4.4.6.1.2.2 Lead-210

Pb-210 (22.3-yr half-life) is naturally occurring and is part of the uranium-decay series, where it is derived from Ra-226 (1,600-yr half-life) and ultimately U-238. These parent isotopes have been characterized at Domestic Septic System No. 4 and found to be at levels consistent with site background. Thus, the decay of the parent isotope will replenish Pb-210 at background concentrations, and any Pb-210 that has been released at levels above background will attenuate over time.

The Pb-210 decay estimate for the Domestic Septic System No. 4 is shown in Figure 4.4-10. Based on its half-life, the site EPC for Pb-210 will decay to a concentration equivalent to a risk of  $10^{-6}$  for the residential receptor in approximately 10.4 years.

#### 4.4.6.1.3 Background Evaluation

#### 4.4.6.1.3.1 Detections above Site Background

The number of analytical results that were greater than both the detection limits and the background screening levels are reported in Table 4.4-2 for the List 1 COPCs. The six PAH COPCs that are List 2 drivers were each detected above background in two to three samples, and the seventh List 2 driver COPC, Pb-210, was detected above background in one sample. The remainder of the List 1 COPCs were not detected above background in any samples.

#### 4.4.6.1.3.2 Parent-Daughter Activity Concentration Relationships

The concentration of Pb-210 at the Domestic Septic System No. 4 area was compared to the concentration of its longer-lived parent, Ra-226, in Appendix E (Figure E-4). As shown, the concentrations of these isotopes appear to be in secular equilibrium when quantified analytical errors are taken into account. This is evidence that the concentration of Pb-210 at the site is due to decay of Ra-226 rather than to a release of Pb-210, because any shorter-lived daughter isotope will have a concentration approximately equal to that of its longer-lived parent isotope, in the absence of excess input of the daughter. The apparent elevated concentration of Pb-210 at the site relative to background, therefore, is probably due to analytical limitations rather than to a release. The concentration of Ra-226, which was measured at much higher precision than was Pb-210, is demonstrably below background concentrations. Therefore, the Ra-226 results suggest that the Ra-226/Pb-210 decay series is not impacting the site.

#### 4.4.6.1.3.3 Comparison of Risk Attributed to Background versus Site Activities

Table 4.4-5 presents statistics, including EPCs, for the sample results of the List 2 driver COPCs at both the site and in the background. The background EPCs were calculated using the same method used to calculate the site EPCs (Section 2.2.2.3.1). Table 4.4-5 also presents the decay-corrected EPCs for Pb-210. EPCs can be used to derive relative contributions of risk because risk is directly proportional to the EPC.

None of the PAHs risks can be attributed to background, because the background concentrations of the PAHs were assumed to be equal to zero.

The background contribution to the Pb-210 risk is 41%, and is illustrated graphically for the on-site resident receptor in Figure 4.4-11. This risk and these proportions have been corrected for decay.

#### 4.4.6.2 Toxicity Assessment

Toxicity values for COPCs in the Domestic Septic System No. 4 area were taken from US EPA guidance as discussed in Section 2.2.4. The toxicity values used for these COPCs are appropriate for this evaluation and make use of the best available information.

#### 4.4.6.3 Risk Estimate

Table 4.4-3 summarizes the risk estimate information for the hypothetical future on-site resident. This table shows that soil ingestion and plant ingestion contribute the most risk for the List 2 driver COPCs (PAHs and Pb-210). Soil dermal exposure is a secondary risk contributor for PAHs, and external radiation is a secondary risk contributor for Pb-210. The dust inhalation exposure route did not contribute significant risk to hypothetical residential receptors for PAHs or Pb-210.

Table 4.4-4 summarizes the risk estimate information for the on-site construction worker. This table shows that soil ingestion contributes the most risk for the List 2 driver COPCs (benzo(a)pyrene and dibenzo(a,h)anthracene), and soil dermal exposure is a secondary risk contributor. The dust inhalation exposure route did not contribute significant risk to on-site construction workers for benzo(a)pyrene and dibenzo(a,h)anthracene.

#### 4.4.6.4 Uncertainty

Risk estimates are values that have uncertainties associated with them, as discussed in Section 2.2.6. The objective of this section is to discuss the major sources of uncertainty that are specific to this refined assessment of the Domestic Septic System No. 4. These include data coverage and analytical issues.

#### 4.4.6.4.1 Analytical Issues

#### 4.4.6.4.1.1 Polynuclear Aromatic Hydrocarbons

No significant data quality issues were identified for the PAHs in Domestic Septic System No. 4 soil samples. There were no analytical problems or methodology changes that would impact the data quality. The only potential problem was that PAHs were not detected in three of the six samples. Because half of the data were below detection limits, there is some uncertainty in the site EPC value. The site EPC could be slightly underestimated or overestimated. However, the data validation results do not indicate a positive or negative bias.

#### 4.4.6.4.1.2 Lead-210

No significant data quality issues were identified for Pb-210 in Domestic Septic System No. 4 soil samples. The counting errors and detection limits were less than the background screening value for all of these samples. Three of the six samples had concentrations below the detection limit, but these results should nevertheless provide a reasonably accurate EPC.

#### 4.4.6.4.2 Data Representativeness

Six discretionary soil samples were collected in the Domestic Septic System No. 4 area. The samples were collected in soil adjacent to and/or below the Domestic Septic System No. 4 features (domestic septic tank, distribution box, leach line). The samples were collected at the most likely hot spots, such as below the first perforations in the leach lines and at the piping connection to the domestic septic tank. Random grid samples have not been collected in Domestic Septic System No. 4 that

may be in unexpected locations. The number of samples (six) is less than desirable for determining EPCs based on the 95% UCL.

#### 4.4.6.5 Relation of Concentrations of Contaminants of Potential Concern to Site Operations

There are no records that indicate PAHs were released into Domestic Septic System No. 4. The PAHs contamination is suspected to originate from a petroleum tar contained in the leach piping. The piping did not likely release a large mass of PAHs because the piping mass is small. As discussed above, the PAHs have not likely migrated a significant distance in soil, because they sorb strongly to soil.

There are no records indicating that Pb-210 was released at Domestic Septic System No. 4. Five of the six sample results were below the background screening value. The Pb-210 concentration could be due to natural background.

#### 4.4.7 Ground Water Impacts

In addition to evaluation of human health risk resulting from soil contamination, potential ground water impacts from contaminants remaining in the soil at the Domestic Septic Tank No. 4 were evaluated and are presented in the RI (WA, 2003b). An evaluation of DI WET results is presented in Appendix C. Table 4.4-6 summarizes the ground water evaluation.

#### 4.4.7.1 Risk Characterization of Constituents of Potential Ground Water Concern

Domestic Septic System No. 4 soil sampling data indicated that chromium, Cr-VI, Pb, Hg and selenium failed the statistical comparison to background. DI WET results show leachate concentrations above the MCL for aluminum, chromium, Pb and nickel. Ground water concentrations of Cr-VI, chromium and selenium at downgradient HSU-1 wells UCD1-20 and UCD1-24, and Cr-VI and chromium in downgradient HSU-2 well UCD2-39 (Figure 2-3) exceeded background, while lead and mercury concentrations were below detection limits.

The potential impacts to ground water of Cr-VI, chromium, Pb, Hg, and selenium were estimated using the NUFT model. The modeling results indicate that chromium, Pb, and Hg in Domestic Septic System No. 4 area soil might impact local ground water above background, and that impact from chromium and Hg might be above MCLs. However, the time to peak impact from these COPCs ranges from nearly 1,400 to 83,000 years. The modeling results also indicate that selenium and Cr-VI in Domestic Septic System No. 4 area soil will not impact ground water above background or the MCL.

As shown in Table 4.4-7, Cr-VI, chromium and selenium have been detected in downgradient wells; therefore, they are retained for further evaluation in this risk characterization in conformance with the DL COPC evaluation process illustrated in Figure 1-2. Aluminum and nickel were also retained as a COPGWs based on their potential to impact ground water above background and MCL indicated by the DI WET leachate concentrations.

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Pb and Hg are anticipated to impact ground water above background, and Hg is also anticipated to impact ground water above MCL, but these impacts will not occur in the next 500 years. Therefore, these DL COPCs will not be evaluated further.

#### 4.4.7.1.1 Percentage and Spatial Distribution of Samples Exceeding Background

#### 4.4.7.1.1.1.1 Aluminum

No spatial information is available for aluminum concentrations in soil because aluminum was not analyzed in soil samples. DI WET samples were collected at 7.8 feet bgs and 12.8 feet bgs beneath the first point of perforation on the western leach line. Both of the DI WET sample concentrations were above the MCL. The DI WET data were not compared to background because aluminum has not been analyzed in background ground water samples.

# 4.4.7.1.1.1.2 Chromium

Chromium was above background in four of thirteen soil samples (31%) collected at Domestic Septic System No. 4. Three of four elevated samples were collected below the southern and western leach lines. The fourth elevated sample was collected below the effluent connection to the domestic septic tank. The composite sample collected beneath the first points of perforation on the southern and western leach lines was below background. Chromium was below background in all of the soil boring samples collected beneath the first point of perforation on the western leach line at depths ranging from 13 ft bgs to 38 ft bgs. These data indicate a small amount of chromium may have been released at Domestic Septic System No. 4, but suggest that chromium has not migrated significantly down the soil column.

#### 4.4.7.1.1.1.3 Hexavalent Chromium

All thirteen hexavalent chromium soil sample results were below background (1.3 mg/kg) at Domestic Septic System No. 4. Hexavalent chromium appears to be uniformly below background in soil throughout the lateral and vertical extent of the area.

# 4.4.7.1.1.1.4 Nickel

Nickel was above the consolidated background value of 330 mg/kg in one of eight soil samples (12.5%) collected at Domestic Septic System No. 4. The elevated sample (405 mg/kg) was collected below the southern leach line. All of the samples were collected below 4 ft bgs and all of their concentrations exceeded the deep soil (>4 ft bgs) background value (246 mg/kg). The vertical distribution of nickel in soil cannot be evaluated because no data were collected below 13 ft bgs. DI WET samples were collected at 7.8 ft bgs and 12.8 ft bgs, below the first point of perforation at the northern leach trench. The DI WET sample concentrations were slightly above ground water background for HSU-1 and the DI WET sample collected at 12.8 ft bgs was slightly above the MCL.

#### 4.4.7.1.1.1.5 Selenium

Three of thirteen selenium results (23%) were above background in soil at Domestic Septic System No. 4. One of the elevated results was in the composite soil sample collected beneath the

first points of perforation on the southern and western leach lines. Another elevated sample was collected beneath the midpoint of the southern leach line. The third elevated sample was collected from the soil boring at the first point of perforation on the western leach line at a depth of 18 ft bgs. The selenium concentration was equal to the background screening value (1.2 mg/kg) in the soil boring sample collected at 13 ft bgs. Selenium was below background in the soil boring samples collected between 23 ft bgs and 38 ft bgs, and at the effluent connection to the domestic septic tank. The data indicate that selenium may have been released to soil below the Domestic Septic System No. 4 leach lines, and may have migrated as deep as 18 ft bgs. The maximum detected concentration was 2 mg/kg, which indicates a low mass of contamination.

# 4.4.7.1.2 Degradation and Decay of Contaminants of Potential Concern

Aluminum, Cr-VI, chromium and selenium are not expected to undergo significant degradation or decay.

# 4.4.7.1.3 Uncertainty

Similar to human health risk estimates, evaluation of ground water impacts is subject to uncertainties. such as analytical bias and data representativeness, discussed below.

#### 4.4.7.1.3.1 Analytical Issues

#### 4.4.7.1.3.1.1 Aluminum

No analytical issues were identified for the aluminum data.

# 4.4.7.1.3.1.2 Chromium

No significant analytical issues were identified for the chromium data. Three of the thirteen chromium results were qualified due to matrix duplicate imprecision, which means the relative percent difference was above the laboratory control limit. Matrix duplicate imprecision does not indicate a high or low bias in the data. The remaining ten results were unqualified detected concentrations.

# 4.4.7.1.3.1.3 Hexavalent Chromium

Four of thirteen hexavalent chromium results were qualified. Three of the results were qualified due to laboratory contamination, which can cause false positive detection and may cause an overall positive bias in a data set. One sample was qualified because the result was between the method detection limit and the quantitation limit, but this qualification does not indicate a positive or negative bias.

#### 4.4.7.1.3.1.4 Nickel

No significant analytical issues were identified for the nickel data. Three of the soil sample results were qualified due to matrix duplicate imprecision, which means the relative percent difference was above the laboratory control limit. Matrix duplicate imprecision does not indicate a

high or low bias in the data. The remaining five soil results and two DI WET results were unqualified detected concentrations.

#### 4.4.7.1.3.1.5 Selenium

No significant analytical issues were identified for the selenium data. Three of thirteen selenium results were qualified because their results were between the method detection limit and the quantitation limit. These results are less accurate than results that are above the quantitation limit, but the qualification does not indicate a positive or negative bias.

#### 4.4.7.1.3.2 Data Representativeness

Domestic Septic System No. 4 sampling consisted of discretionary grab samples and soil boring samples collected at depths ranging from 4 ft bgs to 38 ft bgs. Lateral sample coverage was limited to discretionary soil samples collected directly below the leach lines and effluent piping.

The leach trench extends under the Clinical Pathology Building (H-215). Contamination may extend below the building along the trench line where samples have not been collected. The vertical profile has likely been defined by the soil boring samples, which were conservatively collected at the first point of perforation on the leach line. Based on observations at the other domestic septic systems, the largest mass of released contamination is expected to be located near the first point of perforation.

The data are likely representative of the vertical extent of contamination in Domestic Septic System No. 4, but the lateral extent of contamination along the leach lines has not been fully defined in the direction of building H-215.

# 4.4.7.1.4 Relation of Concentrations of Contaminants of Potential Ground Water Concern to Site Operations

Aluminum and/or aluminum-bearing compounds may have been used in LEHR operations and released to the Domestic Septic System via sink and/or floor drains.

Cr-VI is potentially associated with LEHR operations, since chromic acid and other chromium-bearing chemicals may have been used or disposed at the Site. The nearest downgradient wells (UCD1-20 and UCD1-24) contain Cr-VI concentrations that are similar to those in background well UCD1-18 (Table 4.4-6). The maximum ground water concentration of Cr-VI detected was less than 3  $\mu$ g/l above the background concentration measured in well UCD1-18.

Chromium, nickel and selenium may have been used in LEHR operations and released at the site.

# 4.4.8 Risk Characterization Summary and Recommendations Regarding Contaminants of Concern at the Domestic Septic System No. 4 Area

Risk characterization findings and recommended COCs at the Domestic Septic System No. 4 are summarized below and presented in Table 4.4-8. The recommended COCs include constituents that are considered to have potential risks to human health or may have potential impact on the ground water at the site.

# 4.4.8.1 Human Health—On-Site Resident

#### 4.4.8.1.1 Polynuclear Aromatic Hydrocarbons

Six PAHs listed in Table 4.4-8 have concentrations corresponding to risks between  $10^{-4}$  and  $10^{-6}$  to the on-site resident. There is uncertainty in the risk estimate due to the limited number of samples (six) collected. However, it is likely that the discretionary sampling is representative of the potential contamination, and no significant data quality issues were identified for the six soil samples. The PAHs are suspected to originate from a petroleum tar contained in the leach piping and have not likely migrated a significant distance in soil, since they sorb strongly to soil.

These constituents should be retained as COCs and evaluated in the Feasibility Study.

4.4.8.1.2 Lead-210

Only one sample collected at Domestic Septic System No. 4 had a reported Pb-210 concentration with a corresponding risk between  $10^{-5}$  and  $10^{-6}$ . This sample may potentially be indicative of localized contamination. Although the risk estimate is subject to the same uncertainty as the PAH estimate, due to the small sample set used in the estimate, no significant data quality issues were identified for Pb-210 samples. Natural decay will reduce the Pb-210 concentrations to below the  $10^{-6}$  risk level in 10.4 years. Thus, Pb-210 should not be retained as a COC.

# 4.4.8.2 Human Health—On-Site Construction Worker

#### 4.4.8.2.1 Polynuclear Aromatic Hydrocarbons

Benzo(a)pyrene was found at the Domestic Septic System No. 4 in concentrations corresponding to a  $10^{-6}$  cancer risk to the on-site construction worker. Dibenzo(a,h)anthracene concentrations had a risk of  $10^{-7}$ , below the point of departure for CERCLA action. As previously discussed, PAHs contamination is suspected to originate from a petroleum tar coating of the septic system piping and cannot be attributed to background. Based on the risk posed by benzo(a)pyrene, it should be retained as a COC in the Feasibility Study. Dibenzo(a,h)anthracene should not be retained as a COC, due to its marginal risk.

# 4.4.8.3 Ground Water

#### 4.4.8.3.1 Aluminum

DI WET results suggest that aluminum and nickel may have the potential to impact ground water at the site. No ground water data are available to compare aluminum in downgradient wells to background. Aluminum may have been used in LEHR operations and could have been inadvertently
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disposed at Domestic Septic System No. 4, but there are no indications that a significant mass of aluminum was released during LEHR operations. No soil data are available to evaluate the spatial distribution of aluminum in soil or to estimate attenuation factors. Both of the DI WET leachate results were above the MCL and no significant analytical accuracy issues were identified. Since there appears to be a moderately low likelihood of significant ground water impacts from aluminum at this site, ground water monitoring is recommended.

## 4.4.8.3.2 Chromium

Chromium concentrations have been detected above background, but below the MCL in HSU-1 and HSU-2 ground water wells downgradient of Domestic Septic System No. 4. Modeling results indicate that chromium remaining in the soil might impact local ground water above background and the MCL in the future. The modeled impact is not expected until approximately 1,400 years from present. Chromium was likely used in LEHR operations and could have been inadvertently disposed at Domestic Septic System No. 4. Elevated chromium concentrations in soil were localized at the site features (leach line, effluent line), but did not extend down the soil column. Sampling covered the soil column and system features, but was not laterally extensive. No significant analytical accuracy issues were identified with these data. Although, chromium should not be retained as a COC in the Feasibility Study based on the modeling results, chromium should be included in the ground water monitoring program to ensure that the model predictions are appropriate.

#### 4.4.8.3.3 Hexavalent Chromium

Cr-VI concentrations have been slightly above background, but below the MCL, in HSU-1 and HSU-2 wells downgradient of Domestic Septic System No. 4. Current residual soil concentrations of Cr-VI at Domestic Septic System No. 4 are below background. Modeling results indicate the time to ground water impact is zero years and the existing Cr-VI concentrations in soil have impacted ground water above background and the MCL. The uncertainty evaluation indicated 23% of the soil data might be biased high due to laboratory contamination. Sample coverage was likely sufficient, but not laterally extensive. Various forms of chromium were potentially used at LEHR and could have been inadvertently disposed at Domestic Septic System No. 4. Based on the soil data, Cr-VI should not be retained as a COC in the Feasibility Study. Additionally, ground water monitoring is not recommended for this area since all residual Cr-VI soil concentrations are below background.

#### 4.4.8.3.4 Nickel

HSU-1 and HSU-2 nickel concentrations have been below background and the MCL in ground water wells downgradient of Domestic Septic System No. 4. The potential impact to local ground water has not been modeled. Nickel may have been used in LEHR operations and could have been inadvertently disposed at Domestic Septic System No. 4. Elevated nickel concentrations in soil were found in samples collected below the site features (leach line, effluent line). Nickel sampling covered the system features, but was not laterally extensive and soil data were not collected below 13 ft bgs. No significant analytical accuracy issues were identified with these data. Nickel should not be retained as a COC because it has not been detected in downgradient wells and the DI WET

results do not indicate significant leaching. It should, however, be included in the ground water monitoring program.

#### 4.4.8.3.5 Selenium

Well data show that selenium is currently present in the downgradient HSU-1 well in concentrations slightly exceeding background, but well below the MCL. Residual soil concentrations exceeding background occurred in 23% of the samples collected. Slightly elevated concentrations in soil ( $\leq 2$  mg/kg) were localized at the site features (leach line, effluent line), and extended about 18 ft down the soil column. Sample coverage appeared sufficient, but was not laterally extensive. Selenium was likely used at LEHR and could have been inadvertently disposed at Domestic Septic System No. 4. No significant analytical accuracy issues were identified with the data. Although, modeling suggests that the downgradient ground water concentrations may not be related to releases at Domestic Septic System No. 4, selenium should be retained as a COC in the Feasibility Study.

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Figure 4.4-1. Domestic Septic System No. 4 Features



Figure 4.4-2. Domestic Septic System No. 4 Area Sample Locations and Depths

4108-142-DSS4.ai



Figure 4.4-3. Benzo(a)anthracene Spatial Analysis, Domestic Septic System No. 4 Area



Figure 4.4-4. Benzo(a)pyrene Spatial Analysis, Domestic Septic System No. 4 Area



Figure 4.4-5. Benzo(b)fluoranthene Spatial Analysis, Domestic Septic System No. 4 Area



Figure 4.4-6. Benzo(k)fluoranthene Spatial Analysis, Domestic Septic System No. 4 Area

4108-142-DSS4\_Benzo(k)fluoranthene.ai



Figure 4.4-7. Dibenzo(a,h)anthracene Spatial Analysis, Domestic Septic System No. 4 Area



Figure 4.4-8. Indeno(1,2,3-cd)pyrene Spatial Analysis, Domestic Septic System No. 4 Area



Figure 4.4-9. Lead-210 Spatial Analysis, Domestic Septic System No. 4 Area 4108-142-DSS4\_Pb-210.ai





Figure 4.4-10. Decay of Lead-210 at Domestic Septic System No. 4 Area





Analyte	Total Samples	Number of Samples > Bkgd	Number of Samples > Bkgd and Residential	Number of Samples > Bkgd and Industrial	Maximum Conc.	Bkgd for > 4 ft bgs	Residential PRG <sup>1</sup>	Industrial PRG <sup>1</sup>
		DK5u	PRGs <sup>1</sup>	PRGs <sup>1</sup>		411.055		
Radionuclides					(pCi/g)	(pCi/g)	(pCi/g)	(pCi/g)
Actinium-228	7	1	0	0	0.7	0.642	732	1,180
Cesium-137	7	4	0	0	0.0517	0.00695	0.0597	0.111
Lead-210	7	2	2	2	9	1.6	0.15	1.23
Lead-214	7	1	0	0	0.617	0.581	46,300	74,800
Thorium-234	4	2	0	0	4.15	0.78	1,330	3,250
Tritium	7	1	1	1	6.35	1.2	2.28	4.23
Uranium-	5	3	0	0	0.16	0.038	0.195	0.394
235/236								
Metals					(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)
Cadmium	7	1	0	0	0.78	0.51	37	450
Chromium	7	7	1	0	319	125	210	450
Chromium VI	4	0	0	0	0.925	1.3	30	64
Copper	7	1	0	0	64.6	61.8	3,100	41,000
Lead	8	3	0	0	20.1	9.5	150 (2)	750
Mercury	8	6	0	0	3.5	0.248	23	610
Molybdenum	4	3	0	0	1.1	0.26	390	5,100
Nickel	7	7	0	0	405	246	1,600	20,000
Selenium	7	2	0	0	2	1.2	390	5,100
Silver	7	1	0	0	0.58	0.55	390	5,100
Zinc	7	2	0	0	144	93.1	23,000	100,000
Semi-volatile Or	ganic Con	npounds			(µg/kg)	(µg/kg)	(µg/kg)	(µg/kg)
Benzo(a)-	7	N/A	2	1	3,760	N/A	620	2,100
anthracene								
Benzo(a)pyrene	7	N/A	2	2	2,380	N/A	62	210
Benzo(b)-	7	N/A	2	0	2,700	N/A	620	2,100
fluoranthene								
Benzo(k)-	7	N/A	0	0	1,530	N/A	[0.38]	[1.3]
fluoranthene								
Dibenzo(a,h)-	7	N/A	1	0	1,080	N/A	62	210
anthracene					·			
Indeno(1,2,3-	7	N/A	1	0	1,470	N/A	620	2,100
cd)-pyrene					-			

Table 4.4-1.	Analytes Detected above Background in Soil/Waste at the Domestic Septic System
	No. 4 Area

#### Notes

Data from the Remedial Investigation Report (WA, 2003b).

Contaminant data includes data collected from all depth intervals instead of the 0-10 ft interval used in the risk estimate.

<sup>1</sup>Chemical PRGs are from US EPA Region 9 PRGs table, dated October 1, 2002. Radionuclide PRGs are from Radionuclide Toxicity and PRGs for Superfund, dated April 14, 2003 (US EPA, <u>http://epa-</u>

prgs.ornl.gov/radionuclides/download/rad master prg\_table\_pci.xls). The industrial PRGs for radionuclides are for "outdoor worker soil." California-modified PRGs are shown in brackets.

>	greater than
µg/kg	micrograms per kilogram
bgs	below ground surface

# Table 4.4-1.Analytes Detected above Background in Soil/Waste at the Domestic Septic System<br/>No. 4 Area (continued)

bkgd	background
conc.	concentration
ft	foot or feet
mg/kg	milligrams per kilogram
N/A	not applicable
pCi/g	picoCuries per gram
PRG	preliminary remediation goal
US EPA	United States Environmental Protection Agency

List 1 COPC	Units	Total Samples	Number of Detections	Number of Detections > Background	Concentration Range <sup>1</sup>	Background Screening Concentration <sup>2</sup>	ID of Sample with Highest Concentration	Depth of Sample with Highest Concentration (ft)
Metals								
Arsenic	mg/kg	6	6	0	5.7 - 8.3	9.6	LEHR-S-T401	5.5
Pesticides/PCBs								
Benzo(a)anthracene	mg/kg	6	3	3	0.0503 - 3.76	0	SSD4C003A/B	4.2
Benzo(a)pyrene	mg/kg	6	3	3	0.0388 - 2.38	0	SSD4C003A/B	4.2
Benzo(b)fluoranthene	mg/kg	6	3	3	0.0357 - 2.7	0	SSD4C002A/B	4.2
Benzo(k)fluoranthene	mg/kg	6	3	3	0.04 - 1.53	0	SSD4C003A/B	4.2
Dibenzo(a,h)anthracene	mg/kg	6	2	2	0.0091 - 1.08	0	SSD4C002A/B	4.2
Indeno(1,2,3-cd)pyrene	mg/kg	6	2	2	0.431 - 1.47	0	SSD4C003A/B	4.2
Radionuclides								
Lead-210	pCi/g	6	3	1	0.26 - 4.7	1.6	LEHR-S-T401	5.5
Potassium-40	pCi/g	6	6	0	8.7 - 11.4	14	SSD4C002A/B	4.2
Radium-226	pCi/g	6	6	0	0.364 - 0.62	0.75	LEHR-S-T401	5.5
Radium-228	pCi/g	4	4	0	0.342 - 0.431	0.64	SSD4C003A/B	4.2
Thorium-228	pCi/g	4	4	0	0.28 - 0.493	0.74	SSD4C002A/B	4.2

## Table 4.4-2. Summary of Sampling Results Used in the Risk Estimate at the Domestic Septic System No. 4 Area

#### Notes

Source: COPC data from the HHRA Risk Estimate, Appendix A (UC Davis, 2005).

<sup>1</sup>The concentration ranges for metals and radionuclides include non-detects. The concentration ranges for pesticides/PCBs do not include non-detects.

<sup>2</sup>The background screening concentrations are the unstratified background screening values in Appendix B of the HHRA Risk Estimate.

greater than
constituent of potential concern
feet
Human Health Risk Assessment
identification (number)
milligrams per kilogram
polychlorinated biphenyls
picoCuries per gram

## Table 4.4-3.Human Health Risks to On-Site Resident by Exposure Route for Contaminants of Potential Concern in the Domestic Septic<br/>System No. 4 Area

List 1 COPC	EPC <sup>1</sup> (0-10 ft)	Soil Ingestion	Soil Dermal Exposure	Above-Ground Plant Ingestion <sup>2</sup>	l Below-Ground Plant Ingestion <sup>2</sup>	External Radiation	Dust Inhalation	Total Cancer Risk	Statistical Background Comparison <sup>3</sup>	List 2 Cancer Risk <sup>4</sup>
Arsenic	8.1	2.E-05	1.E-06	9.E-05	3.E-05	-	1.E-08	1.E-04	Pass	-
Benzo(a)anthracene	3.8	4.E-06	1.E-06	9.E-06	1.E-06	-	3.E-10	2.E-05	Fail	2.E-05
Benzo(a)pyrene	2.4	3.E-05	7.E-06	3.E-05	5.E-06	-	2.E-09	7.E-05	Fail	7.E-05
Benzo(b)fluoranthene	2.7	3.E-06	8.E-07	<b>3.E-06</b>	5.E-07	-	2.E-10	7.E-06	Fail	7.E-06
Benzo(k)fluoranthene	1.5	3.E-06	7.E-07	<b>3.E-04</b>	5.E-05	-	7.E-11	4.E-04	Fail	4.E-04
Dibenzo(a,h)anthracene	1.1	7.E-06	2.E-06	4.E-06	6.E-07	-	5.E-10	1.E-05	Fail	1.E-05
Indeno(1,2,3-cd)pyrene	0.86	2.E-06	4.E-07	1.E-06	1.E-07	-	4.E-11	4.E-06	Fail	4.E-06
Lead-210	2.5	4.E-07	-	8.E-07	-	8.E-08	3.E-10	1.E-06	Fail	1.E-06
Potassium-40	11	5.E-08	-	1.E-06	-	7.E-05	1.E-12	7.E-05	Pass	-
Radium-226	0.54	7.E-08	-	2.E-07	-	4.E-05	1.E-10	4.E-05	Pass	-
Radium-228	0.43	4.E-08	-	1.E-07	-	1.E-05	3.E-10	1.E-05	Pass	-
Thorium-228	0.49	4.E-09	-	3.E-10	-	4.E-06	1.E-10	4.E-06	Pass	-
TOTAL								7.E-04		5.E-04

#### **CANCER RISK BY EXPOSURE ROUTE**

#### HAZARD QUOTIENT BY EXPOSURE ROUTE

List 1 COPC	EPC <sup>1</sup>	Soil Ingestion	Soil Dermal Exposure	Above- Ground Plant Ingestion	Below- Ground Plant Ingestion	External Radiation	Dust Inhalation	Non-Cancer Hazard Index	Statistical Background Comparison <sup>3</sup>	List 2 Non- Cancer Hazard Risk <sup>4</sup>
Arsenic	8.1	3.5E-01	2.9E-02	1.9E+00	2.3E-01	-	-	2.5E+00	Pass	-
TOTAL								2.5E+00		-

#### Notes

Source Data from HHRA Risk Estimate, Tables 7 and 8. Statistical Background Comparison from Appendix B (UC Davis, 2005). The non-cancer risk is for a resident child; for cancer risk it is an age-adjusted adult.

## Table 4.4-3.Human Health Risks to On-Site Resident by Exposure Route for Contaminants of Potential Concern in the Domestic Septic<br/>System No. 4 Area (continued)

List 2 constituents shown in **bold-type** text contribute at least 10<sup>-6</sup>, or greater than 10%, to the excess cumulative cancer risk. Rounding may affect the total List 2 cancer risk values shown in the last column. Determination of whether the risk is greater than ten percent of total List 2 cancer risk is based on unrounded values.

<sup>1</sup>The 95% upper confidence limit on the mean of the exposure point concentration; chemical concentrations are in milligrams per kilogram and radionuclide concentrations are in picoCuries per gram.

<sup>2</sup>For radionuclides, plant ingestion is not subdivided into above-ground and below-ground plants.

<sup>3</sup>Based on Wilcoxon Rank Sum test or other statistical comparisons, as shown in Appendix B of the HHRA Risk Estimate.

<sup>4</sup>Dashes indicate that constituent was not identified as a List 2 COPC, since it was identified to be statistically equivalent to background.

-	not calculated
COPC	constituent of potential concern
EPC	exposure point concentration
HHRA	Human Health Risk Assessment

## Table 4.4-4.Human Health Risks to On-Site Construction Worker by Exposure Route for Contaminants of Potential Concern in the<br/>Domestic Septic System No. 4 Area

List 1 COPC	EPC <sup>1</sup>	Soil Ingestion	Soil Dermal Exposure	External Radiation	Dust Inhalation	Total Cancer Risk	Statistical Background Comparison <sup>2</sup>	List 2 Cancer Risk <sup>3</sup>
Arsenic	8.1	6.E-07	5.E-08	-	5.E-09	7.E-07	Pass	-
Benzo(a)anthracene	3.8	1.E-07	5.E-08	-	1.E-10	2.E-07	Fail	2.E-07
Benzo(a)pyrene	2.4	8.E-07	3.E-07	-	7.E-10	1.E-06	Fail	1.E-06
Benzo(b)fluoranthene	2.7	9.E-08	4.E-08	-	8.E-11	1.E-07	Fail	1.E-07
Benzo(k)fluoranthene	1.5	8.E-08	3.E-08	-	2.E-11	1.E-07	Fail	1.E-07
Dibenzo(a,h)anthracene	1.1	2.E-07	8.E-08	-	2.E-10	<b>3.E-07</b>	Fail	<b>3.E-07</b>
Indeno(1,2,3-cd)pyrene	0.86	5.E-08	2.E-08	-	1.E-11	7.E-08	Fail	7.E-08
Lead-210	2.5	2.E-08	-	2.E-09	7.E-12	2.E-08	Fail	2.E-08
Potassium-40	11	2.E-09	-	2.E-06	2.E-14	2.E-06	Pass	-
Radium-226	0.54	1.E-09	-	8.E-07	1.E-12	8.E-07	Pass	-
Radium-228	0.43	3.E-09	-	4.E-07	2.E-12	4.E-07	Pass	-
Thorium-228	0.49	9.E-10	-	6.E-07	1.E-11	6.E-07	Pass	-
TOTAL						6.E-06		2.E-06
		Ι	HAZARD QUO	DTIENT BY	EXPOSURI	E ROUTE		
List 1 COPC	EPC <sup>1</sup>	Soil Ingestion	Soil Dermal Exposure	External Radiation	Dust Inhalation	Non-Cancer Hazard Index	Statistical Background Comparison <sup>2</sup>	List 2 Non-Cancer Hazard Risk

#### **CANCER RISK BY EXPOSURE ROUTE**

List 1 COPC	$EPC^1$	Soil Ingestion	Soil Dermal Exposure	External Radiation	Dust Inhalation	Non-Cancer Hazard Index	Statistical Background Comparison <sup>2</sup>	List 2 Non-Cancer Hazard Risk
Nickel	8.1	8.8E-02	7.9E-03	-	-	9.6E-02	Pass	-
TOTAL						9.6E-02		-

#### Notes

Source Data from HHRA Risk Estimate, Tables 7 and 8. Statistical Background Comparison from Appendix B (UC Davis, 2005).

List 2 constituents shown in **bold-type** text contribute at least 10<sup>-6</sup>, or greater than 10<sup>-6</sup>, to the excess cumulative cancer risk.

<sup>1</sup>The 95% upper confidence limit on the mean of the exposure point concentration; chemical concentrations are in milligrams per kilogram and radionuclide concentrations are in picoCuries per gram.

#### Table 4.4-4. Human Health Risks to On-Site Construction Worker by Exposure Route for Contaminants of Potential Concern in the Domestic Septic System No. 4 Area (continued)

<sup>2</sup>Based on Wilcoxon Rank Sum test or other statistical comparisons, as shown in Appendix B of the HHRA Risk Estimate. <sup>3</sup>Dashes indicate that constituent was not identified as a List 2 COPC, since it was identified to be statistically equivalent to background.

-	not calculated
COPC	constituent of potential concern
EPC	exposure point concentration
HHRA	Human Health Risk Assessment

Table 4.4-5.	Data Summary—Comparison of Exposure Point Concentrations to Site Background at the Domestic Septic System No.	. 4
	Area (Human Health)	

Analyte	Detections	Samples	Min Detect	Max Detect	Min Detection Limit	Max Detection Limit	Average <sup>1</sup>	Standard Deviation <sup>1</sup>	Distribution	95UCL <sup>1</sup>	EPC	Decay- Corrected EPC <sup>2</sup>
Site (0 to 10 ft)			mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg		mg/kg	mg/kg	mg/kg
			or pCi/g	or pCi/g	or pCi/g	or pCi/g	or pCi/g	or pCi/g		or pCi/g	or pCi/g	or pCi/g
Benzo(a)anthracene	3	6	0.0503	3.76	0.35	0.36	0.861	1.447	Non-parametric	N/A <sup>3</sup>	3.8	N/A
Benzo(a)pyrene	3	6	0.0388	2.38	0.35	0.36	0.606	0.897	Non-parametric	$N/A^3$	2.4	N/A
Benzo(b)fluoranthene	3	6	0.0357	2.7	0.35	0.36	0.655	1.025	Non-parametric	$N/A^3$	2.7	N/A
Benzo(k)fluoranthene	3	6	0.04	1.53	0.35	0.36	0.457	0.565	Non-parametric	$N/A^3$	1.5	N/A
Dibenzo(a,h)anthracene	2	6	0.0091	1.08	0.35	0.36	0.3	0.388	Non-parametric	$N/A^3$	1.1	N/A
Indeno(1,2,3-cd)pyrene	2	6	0.431	1.47	0.35	0.36	0.435	0.517	Non-parametric	0.86	0.86	N/A
Lead-210	3	6	0.434	4.7	0.0352	1.3	1.08	1.78	Non-parametric	2.5	2.5	2.3
Background (0 to 10 ft	)											
Benzo(a)anthracene	0	12	0	0	0.346	0.412	0.184	0.0122	$N/A^4$	$0^{5}$	$0^{5}$	N/A
Benzo(a)pyrene	0	12	0	0	0.346	0.412	0.184	0.0122	$N/A^4$	$0^{5}$	$0^{5}$	N/A
Benzo(b)fluoranthene	0	12	0	0	0.346	0.412	0.184	0.0122	$N/A^4$	$0^{5}$	$0^{5}$	N/A
Benzo(k)fluoranthene	0	12	0	0	0.346	0.412	0.184	0.0122	$N/A^4$	$0^{5}$	$0^{5}$	N/A
Dibenzo(a,h)anthracene	0	12	0	0	0.346	0.412	0.184	0.0122	$N/A^4$	$0^{5}$	$0^{5}$	N/A
Indeno(1,2,3-cd)pyrene	0	12	0	0	0.346	0.412	0.184	0.0122	$N/A^4$	$0^{5}$	$0^{5}$	N/A
Lead-210	6	26	0.703	2.49	0.209	5.08	0.719	0.697	Non-parametric	0.95	0.95	0.95

#### Notes

Source: COPC data from Appendix A from HHRA Risk Estimate (UC Davis, 2005). 95UCL calculations for background concentrations and decay corrections added."

<sup>1</sup>Negative concentration values were set to zero and concentrations below the detection limit were used to determine the 95UCL, average, and standard deviation for radionuclides. Half of the detection limit was used when chemicals were not detected. Same as 95UCL calculation procedure used in HHRA Risk Estimate (UC Davis, 2005).

<sup>2</sup>The EPC was decay-corrected to April 2005 (see Figure 4.4-10 and Appendix A).

<sup>3</sup>95UCL was not calculated because of insufficient number of samples per HHRA Risk Estimate, Appendix B.

<sup>4</sup>Distribution testing was not applicable due to non-detect data.

<sup>5</sup>Background 95UCL assumed equal to zero for benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, dibenzo(a,h)anthracene and indeno(1,2,3-cd)pyrene.

#### Abbreviations

95UCL 95 percent upper confidence limit on the mean

EPC exposure point concentration

## Table 4.4-5.Data Summary—Comparison of Exposure Point Concentrations to Site Background at the Domestic Septic System No. 4<br/>Area (Human Health) (continued)

ft	feet
HHRA	Human Health Risk Assessment
max	maximum
min	minimum
mg/kg	milligrams per kilogram
N/A	not applicable
pCi/g	picoCuries per gram

Decisionate d Level	Investigation Sampling		Designated-Level Sampling		Coil Dochermour d	NUFT Model Soil Result		Downgradient		Ground Water Background		Ground	Тар	Time to Peak at
Constituent of Potential	Maximum	Depth of Maximum	Maximum	Depth of Maximum	Value (mg/kg)	Background Ground Water	MCL Ground Water	(µ	.g/l)	Concer (µ	ntration <sup>3</sup> g/l)	Water MCL	Water PRG	Ground Water Goal Level
	(mg/kg)	(ft)	(mg/kg) <sup>1</sup>	(ft)	(IIIg/Kg)	Goal (mg/kg)	Goal (mg/kg)	HSU-1	HSU-2	HSU-1	HSU-2	(µg/l)	(µg/l)	(years)
Aluminum <sup>4</sup>	N/A	N/A	$20,300^{5}$	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	200	36,000	N/A
Chromium	199	7.75	153	12.8	$125/181^7$	0.51	1.00	27.7 - 37.1	6.9 <b>- 30.5</b>	25	27.1	50	110	1,392
Hexavalent Chromium	0.925	7.75	0.16	37.8	1.3	0.64	0.81	19 – <b>42</b>	5 <b>- 27.0</b>	39.4	20	50	110	0
Lead	20.1	4.2	9.6	37.8	9.5	2.2	28	< 1 - < 3	<0.010 - <3.0	1.3	1.5	15	N/A	83,143
Mercury <sup>6</sup>	3.5	4.2	0.24	17.8	0.25/0.637	0.0086	0.85	< 0.1 - < 0.2	<0.043 - <0.20	0.10	0.2	2	11	4,582
									[ND]					I
Nickel	405	8.0	N/A	N/A	246/330 <sup>7</sup>	N/A	N/A	0.64 - < 30	< 1.1 - < 9	69	15	100	730	N/A
Selenium	2	4.2	1.3	17.8	1.2	4.0	35	< 2.6 – <b>7.3</b>	1.4 - < 3	5.67	5	50	180	No impact expected

## Table 4.4-6. Summary of Potential Impact on Ground Water of Designated-Level Constituents of Potential Concern in Domestic Septic System No. 4 Area Soil

#### Notes

Source: Data from Remedial Investigation Report (WA, 2003b). HSU-2 data added.

<sup>1</sup>µg/L for DI WET results.

<sup>2</sup>Range of available data for nearby downgradient HSU-1 wells UCD1-20 and UCD1-24, and HSU-2 well UCD2-39.

<sup>3</sup>Based on data from HSU-1 well UCD1-18, and HSU-2 wells UCD2-17 and UCD2-37.

<sup>4</sup>Aluminum is a designated-level COC because the DI WET result is above the MCL. No data are available for soil or downgradient ground water. No NUFT modeling has been done.

<sup>5</sup>Based on DI WET results.

<sup>6</sup>Assumed to be mercuric chloride.

<sup>7</sup>First value is a concentration greater than 4 ft below ground surface and second is a consolidated concentration (all depths).

Bold type indicates soil concentration is above background and concentration above NUFT result for ground water impact at background levels, or ground water concentration is above background.

Boxed type indicates soil concentration is above background and above NUFT result for ground water impact at the MCL, or DI WET concentration or ground water concentration is above the MCL.

<	denotes analyte concentrations below the detection limit
μg/l	micrograms per liter
DI WET	deionized water waste extraction test
ft	feet
MCL	California Maximum Contaminant Level for ground water (November 2002)
mg/kg	milligrams per kilogram
N/A	not applicable or not available
ND	no detections in any samples
NUFT	Non-Isothermal, Unsaturated Flow and Transport model
PRG	preliminary remediation goal (US EPA, 2002a for radionuclides; US EPA, 2002b for others)

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#### Summary of Designated-Level Ground Water Constituents of Potential Concern at Domestic Septic System No. 4 Area Table 4.4-7. Retained as Constituents of Potential Ground Water Concern

	0	0	6	4	
Designated-Level Constituent of Potential Concern	Are the DL COPCs ground water concentrations above site background? <sup>1</sup>	Are the DL COPC soil concentrations above soil background and the NUFT soil results? <sup>2</sup>	Will the DL COPC impact ground water above background levels in the next 500 years?	Retained as COPGWC in risk	
	If yes, enter ✓ in ❹	If yes, go to <b>S</b>	If yes, enter ✓ in ④	$\sqrt{-V_{ec}}$	
	If no, go to 🛛	If no, stop and enter $\times$ below	If no, stop and enter $\times$ below	• - 1 65	
Aluminum	Yes <sup>3</sup>	N/A	N/A	$\checkmark$	
Chromium	Yes	-	-	$\checkmark$	
Hexavalent Chromium	Yes	-	-	$\checkmark$	
Lead	No	Yes	×	-	
Mercury	No	Yes	×	-	
Nickel	No	Yes	N/A	$\checkmark$	
Selenium	Yes	-	-	$\checkmark$	

#### Note

<sup>1</sup>See Table 4.4-6. Compare downgradient ground water concentration to ground water background concentration. Results below detection limits are presumed to be below site background. <sup>2</sup>The lower of background and MCL goals. <sup>3</sup>Based on DI WET Results.

×	not retained as a COPGWC
✓	retained as a COPGWC
-	skip
COPC	constituent of potential concern
COPGWC	constituent of potential ground water concern
DI WET	deionized water waste extraction test
DL	designated-level
MCL	California Maximum Contaminant Level for ground water (November 2002)
N/A	not applicable or not available
NUFT	Non-Isothermal, Unsaturated Flow and Transport

Driver COPC / COPGWC	Total Cancer Risk <sup>1</sup>	Spatial Distribution	Background Contribution <sup>2</sup>	Above- Background Contribution <sup>3</sup>	Historically Used at the Site	Time for Attenuation to Risk Endpoint <sup>4</sup> (years)	Level of Ground Water Impact	Uncertainty	Recommended Action	Basis for Recommendation
<b>On-Site Resident</b> Benzo(a)anthracene	2E-05	Localized	0%	100%	Yes	N/A	N/A	• Characterization/EPC uncertain due to non-gridded sample	Evaluate in FS	• Spatial analysis shows localized risk.
Benzo(a)pyrene	7E-05	Localized	0%	100%	Yes	N/A	N/A	<ul> <li>collection.</li> <li>Characterization/EPC uncertain due to non-gridded sample</li> </ul>	Evaluate in FS	• Spatial analysis shows localized risk.
Benzo(b)fluoranthene	7E-06	Localized	0%	100%	Yes	N/A	N/A	<ul> <li>collection.</li> <li>Characterization/EPC uncertain due to non-gridded sample</li> </ul>	Evaluate in FS	• Spatial analysis shows localized risk.
Benzo(k)fluoranthene	4E-04	Localized	0%	100%	Yes	N/A	N/A	<ul> <li>Characterization/EPC uncertain due to non-gridded sample</li> </ul>	Evaluate in FS	• Spatial analysis shows localized risk.
Dibenzo(a,h)anthracene	1E-05	Localized	0%	100%	Yes	N/A	N/A	<ul> <li>Characterization/EPC uncertain due to non-gridded sample</li> </ul>	Evaluate in FS	• Spatial analysis shows localized risk.
Indeno(1,2,3-cd)pyrene	4E-06	Localized	0%	100%	Yes	N/A	N/A	<ul> <li>Characterization/EPC uncertain due to non-gridded sample</li> </ul>	Evaluate in FS	• Spatial analysis shows localized risk.
Lead-210	1E-06	Localized	41%	59%	No	10.4	N/A	<ul> <li>Characterization/EPC uncertain due to non-gridded sample collection.</li> </ul>	No Further Action	<ul><li>Only one sample with elevated risk.</li><li>Decay to below 1E-6 in 10.4 years.</li></ul>
On-Site Construction W	Vorker									
Benzo(a)pyrene	1E-06	Localized	0%	100%	Yes	N/A	N/A	Characterization/EPC uncertain due to non-gridded sample collection	Evaluate in FS	• Spatial analysis shows localized risk.
Dibenzo(a,h)anthracene	3E-07	Localized	0%	100%	Yes	N/A	N/A	<ul> <li>Characterization/EPC uncertain due to non-gridded sample collection.</li> </ul>	No Further Action	• Risk is below 1E-6.
Ground Water										
Aluminum	N/A	N/A	N/A	N/A	Yes	N/A	>bkgd >MCL	• Unknown vertical and horizontal distribution.	Monitoring	• DI WET results suggest a potential impact above MCL and background.
								Unknown attenuation factor     between source and ground water		• No ground water data are available.
Chromium	N/A	Localized	N/A	N/A	Yes	N/A	>MCL, >bkgd	<ul> <li>Characterization/EPC uncertain due to limited samples.</li> </ul>	Monitoring	<ul> <li>Ground water marginally elevated above background.</li> <li>Modeling suggests impacts above background and MCL after 500 years.</li> </ul>
Hexavalent Chromium	N/A	Random	N/A	N/A	No	N/A	>MCL, >bkgd	• Same as above.	No Further Action	<ul> <li>Possible release.</li> <li>Ground water marginally elevated above background.</li> <li>Residual soil concentrations are below background.</li> </ul>
Nickel	N/A	Localized	N/A	N/A	Yes	N/A	<bkgd< td=""><td>• Same as above.</td><td>Monitoring</td><td><ul> <li>Residual soil concentrations are below background.</li> <li>Ground water below background</li> <li>Residual soil concentrations above background.</li> </ul></td></bkgd<>	• Same as above.	Monitoring	<ul> <li>Residual soil concentrations are below background.</li> <li>Ground water below background</li> <li>Residual soil concentrations above background.</li> </ul>
Selenium	N/A	Localized	N/A	N/A	Yes	N/A	>bkgd	• Same as above.	Evaluate in FS	<ul> <li>Ground water marginally elevated above background.</li> </ul>

Table 4.4-8. Summary of Major Factors Driving Risk and Recommendations for Future Action at Domestic Septic System No. 4

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 Table 4.4-8.
 Summary of Major Factors Driving Risk and Recommendations for Future Action at Domestic Septic System No. 4 (continued)

Notes

<sup>2</sup>The background contribution is the proportion of the site EPC that can be attributed to the background EPC (see Table 4.4-5 and Figure 4.4-11).

<sup>4</sup>The time for attenuation to risk endpoint is the time, from April 2005, for the site EPC of a radionuclide to decay to either the background EPC or the concentration equivalent to a risk of 10<sup>-6</sup>, whichever is greater.

Abbreviations

>	greater than
bkgd	background
COPC	constituent of potential concern
COPGWC	constituent of potential ground water concern
DI WET	deionized water waste extraction test
EPC	exposure point concentration
FS	Feasibility Study
MCL	California Maximum Contaminant Level for ground water (November 2002)
N/A	not applicable

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<sup>&</sup>lt;sup>1</sup>For radionuclides, values are decay-corrected to April 2005 (see Figure 4.4-10 and Appendix B).

<sup>&</sup>lt;sup>3</sup>The above-background contribution is the proportion of the site EPC that is greater than the background EPC (see Figure 4.4-11).

## 4.5 Domestic Septic System No. 5

Figure 4.5-1 shows the Domestic Septic System No. 5 features.

#### 4.5.1 Area Description

Domestic Septic System No. 5 consisted of a domestic septic tank, leach field, and interconnecting piping. Liquid wastes and sewage were discharged to the tank prior to the Site's connection to the UC Davis Wastewater Treatment Plant in 1971. The septic tank was reportedly backfilled with sand and the influent/effluent lines for each tank were reportedly cut and capped in 1971 (IT Corp., 1996). No formal closure report for Domestic Septic System No. 5 is known to exist (D&M, 1994).

## 4.5.2 Pre-Removal Action Contaminant Distribution

Table 4.5-1 summarizes all of the radionuclide concentrations found above their respective background at the Domestic Septic System No. 5 area. One soil sample (SSD5C001) was collected from the tank area and analyzed for a full suite of analytes. Of the 173 analytes, five were detected at concentrations above their respective background. Hg was detected at 0.35 mg/kg in sample SSD5C001 above its deep soil background (0.248 mg/kg).

The tank contained standing water and one water sample was collected from the eastern hatch of the tank. Lead, chromium, antimony, barium, Hg, benzene and 1,2-dichloroethane were detected above their respective MCLs. Benzene was detected at 1.04 milligrams per liter (mg/l), over 200 times the MCL of 0.005 mg/l.

Preliminary analysis of potential ground water impacts was conducted to identify constituents at the septic tank that could potentially impact ground water. Based on this analysis, U-235 was deemed to be of potential concern. Additional samples were collected and analyzed for potential ground water impacts. U-235/236 was measured above background in two samples. The maximum detected U-235/236 concentration, 0.0594±0.0193 pCi/g, was measured in sample SSD5DL08, collected 37 ft bgs.

## 4.5.3 Removal Action Activities

Parts of the Domestic Septic System No. 5 leach field (i.e., Dry Wells A-E) were removed during the Radium/Strontium Treatment Systems area removal action conducted in 1999-2000. No other removal actions were conducted at Domestic Septic System No. 5.

#### 4.5.4 Post-Removal Action Contaminant Distribution

The data discussed in Section 4.5.2 is representative of the post-removal action contaminant distribution at Domestic Septic System No. 5.

## 4.5.5 Summary of Risk Estimate Data

Data used in the human health risk estimate were collected during various investigations and sampling events that were conducted at Domestic Septic System No. 5. Information used in the risk estimate included data from the:

- Limited Field Investigation;
- 1997 Data Gaps Investigation;
- 1999 Radium/Strontium Treatment Systems Area I removal action; and
- 2001 Domestic Septic System Investigation.

These various investigations are summarized in Table 6-8 of the RI and details of the 2001 Domestic Septic System Investigation are presented in Appendix B of the same report (WA, 2003b). Although all radionuclide waste from the LEHR operations was being treated in the Radium/Strontium Treatment Systems at the time that the septic systems were installed, there is a potential that a wide variety of radionuclide and chemical lab waste were improperly discharged into these systems. Samples collected in the areas of the Domestic Septic Systems were therefore analyzed for a broad suite of chemicals and radionuclides.

The data set was evaluated and redacted to exclude information associated with samples collected in locations that were subsequently excavated. The final data set used to estimate risk at the Domestic Septic System No. 5 area reflected the post-removal action conditions of the area. The sample data also excluded data associated with samples collected at depths greater than ten ft bgs. Table 4.5-2 provides a summary of all data used in the Tier 2 risk estimate for Domestic Septic System No. 5. The sample locations for all data used in the risk estimate are presented in Figure 4.5-2.

#### 4.5.5.1 Quality of Site Data

The total data set for Domestic Septic System No. 5 included 232 results. One of these results, or 0.4%, was rejected from the total data set ("R"-qualified). Sample results are rejected when a data validation expert reviewing laboratory data finds evidence of serious deficiencies in the ability to analyze a sample and meet QC criteria. The "R" qualifier indicates that the data cannot be used to verify whether the analyte was present in or absent from the sample. "R"-qualified results were not used in the risk estimate. After "R"-qualified data were removed from the total data set, the final risk estimate data set contained 231 results. Seven of the results, or 3.0%, had "J" qualifiers, which indicate that an analyte was positively identified in the sample, but the analytical result is an approximation of the analyte concentration in the sample. Data with "J" qualifiers were used in developing risk estimates. A total of eight records, or 3.5%, had "UJ" qualifiers, which mean that an

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analyte was not detected but the analytic QC results indicate that the detection limit is approximate. Data with "UJ" qualifiers were included in the risk estimate, and were treated as non-detection of an analyte.

A total of 13 of the 231 final records from Domestic Septic System No. 5 were used to generate the Tier 2 human health risk estimate. One of the 13 results had "J" qualifiers and none of the results had "UJ" qualifiers.

#### 4.5.6 Risk Characterization—Domestic Septic System No. 5

Consistent with the HHRA Risk Estimate, as discussed in Section 2.2, this risk characterization uses the terms "List 1" and "List 2". List 2 identifies constituents that failed the statistical comparison to background, which may be indicative of a release to the environment. Table 4.5-3, in the first column, provides the List 1 COPCs identified in the HHRA Risk Estimate. The last column of Table 4.5-3 provides only List 2 COPCs and their risk values. The values provided are not corrected for decay. A subset (shown in bold-type) of List 2 contains COPCs that have a risk of at least  $10^{-6}$  or contribute more than ten percent of the total excess cumulative cancer risk in the Domestic Septic System No. 5 area.

None of the Domestic Septic System No. 5 receptors showed a cumulative List 2 cancer risk above the point of departure of  $10^{-6}$  or non-cancer hazard index above the point of departure of one. List 2 COPC risks and the cumulative List 2 risk for the hypothetical on-site resident, which has the highest estimated risks out of all receptors evaluated, is shown in Table 4.5-3.

#### 4.5.6.1 Exposure Assessment

The exposure assessment for the Domestic Septic System No. 5 in the HHRA Risk Estimate includes a discussion of the exposure intake estimates and their effect on the overall risk estimate. The EPCs for the on-site resident in the Domestic Septic System No. 5 area are provided in Table 4.5-3.

A conceptual site model illustrating exposure pathways and potential human receptors for all DOE areas is provided as Figure 2-1.

4.5.6.1.1 Spatial Distribution of Contaminants of Potential Concern

A spatial distribution of contaminants was not analyzed, since there are no List 2 driver COPCs identified in the area.

#### 4.5.6.1.2 Degradation and Decay of Contaminants of Potential Concern

No List 2 driver COPCs have been identified in the area.

#### 4.5.6.1.3 Background Evaluation

No List 2 driver COPCs have been identified in the area.

#### 4.5.6.2 Toxicity Assessment

Toxicity values for COPCs in the Domestic Septic System No. 5 area were taken from US EPA guidance, as discussed in Section 2.2.4. The toxicity values used for these COPCs are appropriate for this evaluation and make use of the best available information.

#### 4.5.6.3 Risk Estimate

As shown in Table 4.5-3, Domestic Septic System No. 5 has no List 2 driver COPCs, since risks from all List 2 COPCs are below 10<sup>-6</sup>. The risk estimate indicates that exposures to COPCs in the Domestic Septic System No. 5 soil should not result in adverse health effects to any receptor.

#### 4.5.6.4 Uncertainty

Risk estimates are values that have uncertainties associated with them, as discussed in Section 2.2.6. The objective of this section is to discuss the major sources of uncertainty that are specific to this refined assessment of the Domestic Septic System No. 5. These include data coverage and analytical issues.

## 4.5.6.4.1 Analytical Issues

No significant data quality issues were identified in data used in the Domestic Septic System No. 5 risk estimate.

## 4.5.6.4.2 Data Representativeness

The locations of samples used in the risk estimate are shown in Figure 4.5-2. The results are presented in Table 4.5-1. All of the sampling was discretionary. No random grid samples were collected.

Sampling consisted of one discretionary soil sample and one discretionary sample of water from the Domestic Septic Tank No. 5 contents. The soil sample was collected near the west side of the tank, below the effluent line. Because the soil sample did not indicate contamination, no other soil samples were collected near the tank. In addition, no soil sample was collected below the influent line on the east side of the tank, due to technical difficulties with sample collection.

The tank contents water sample was analyzed for a full suite of organic, inorganic, and radiological constituents with the exception of the radiological fraction of the water sample, the risk assessor excluded all other detected constituents from the Tier 1 risk assessment. The exclusion of detected organic and non-organic constituents from the Tier 1 risk assessment is generally reasonable for residential, trespasser and research worker receptors since the exposure pathway for contact with the tank contents is closed for these receptors due to the tank being sealed. A construction worker could potentially be exposed to the tank contents during demolition and construction activities. However, due to the short duration of the exposure, the resulting risks are expected to be minimal. The risk assessor converted the radiological fraction of the water sample results from picoCuries per liter (pCi/l) to pCi/g and used them in the risk estimate. None of the tank water sample results became EPCs, except for the Sr-90 result, which was converted from 8.75 pCi/l to 1.3 pCi/g. A

List 2 risk for the hypothetical residential receptor was determined from this Sr-90 water sample result.

The Sr-90 result from the tank contents water sample may not be representative data the radiological fraction of the water the following reasons:

- 1. The concentration conversion from volume basis (8.75 pCi/l) to mass basis (1.3 pCi/g) appears incorrect or overestimated by at least a factor of 100.
- 2. The sample was collected from within a buried and sealed tank. Except for the construction worker, human receptors will not be exposed to the tank contents water.

#### 4.5.6.5 Relation of Concentrations of Contaminants of Potential Concern to Site Operations

Sr-90 was the only COPC listed in Table 4.5-3 that was found above background. Sr-90 was used extensively in research operations at LEHR. All of the Sr-90 experiment waste should have been disposed to the Radium/Strontium Treatment Systems area. However, it is possible that Sr-90 waste could have been improperly disposed into sinks and other drains that were connected to Domestic Septic System No. 5.

## 4.5.7 Ground Water Impacts

In addition to evaluation of human health risk resulting from soil contamination, potential ground water impacts from contaminants remaining in the soil at the Domestic Septic Tank No. 5 were evaluated. An evaluation of DI WET results is presented in Appendix C. Potential impacts to ground water at Domestic Septic Tank No. 5 are summarized in Table 4.5-4.

#### 4.5.7.1 Risk Characterization of Constituents of Potential Ground Water Concern

Soil sampling results indicate that U-235 is present above background and therefore required evaluation for potential ground water impacts. DI WET leachate results indicated that aluminum may impact ground water above background and MCL. Cr-VI was detected above background in monitoring wells UCD1-21, UCD2-7 and UCD2-36 (Figure 2-3) downgradient of Domestic Septic Tank No. 5. U-235 was not detected in ground water in these wells (Table 4.5-4).

Modeling to evaluate potential ground water impact of U-235 (Table 4.5-4) indicates that the residual U-235 in vadose zone soil at Domestic Septic System No. 5 will not impact ground water above background or MCL.

In conformance to the COC selection process illustrated in Figure 1-2, only aluminum and Cr-VI will be retained as a COPGWC and evaluated further in this risk characterization (Table 4.5-5).

#### 4.5.7.1.1 Percentage and Spatial Distribution of Samples Exceeding Background

#### 4.5.7.1.1.1 Aluminum

No spatial information is available for aluminum concentrations in soil because aluminum was not analyzed in soil samples. DI WET samples were collected at 7.0 feet bgs and 12 feet bgs on the west side of Domestic Septic Tank No. 5. Both of the DI WET sample concentrations were above the MCL. The DI WET data were not compared to background because aluminum has not been analyzed in background well samples.

## 4.5.7.1.1.2 Hexavalent Chromium

All seven Cr-VI soil sample results were below background (1.3 mg/kg) at Domestic Septic System No. 5. Hexavalent chromium appears to be uniformly below background in soil throughout the vertical extent of the area.

## 4.5.7.1.2 Degradation and Decay of Contaminants of Potential Concern

Aluminum and Cr-VI are not expected to undergo significant degradation or decay.

## 4.5.7.1.3 Uncertainty

Similar to human health risk estimates, evaluation of ground water impacts is subject to uncertainties, such as analytical bias and data representativeness, discussed below.

#### 4.5.7.1.3.1 Analytical Issues

## 4.5.7.1.3.1.1 Aluminum

No analytical issues were identified for the DI WET analysis of aluminum.

## 4.5.7.1.3.1.2 Hexavalent Chromium

Six of seven hexavalent chromium results were qualified due to matrix spike recovery failure, which is likely due to soil chemistry in the matrix spike sample. Hexavalent chromium spike solution may change its valiance sate when it is added to a sample. If the spiked hexavalent chromium changes states during sample preparation the analytical instrument will not detect it. This matrix effect is not considered an analytical accuracy issue.

#### 4.5.7.1.3.2 Data Representativeness

Domestic Septic System No. 5 sampling consisted of a single discretionary soil sample and soil boring samples collected at depths ranging from 7 ft bgs to 37 ft bgs. Domestic Septic System No. 5 has no lateral sample coverage. The discretionary soil sample and soil boring samples were collected from the same lateral location at the effluent line connection to Domestic Septic Tank 5. The vertical profile has likely been defined by the soil boring samples. No gaps in data representativeness were identified because the soil samples are below background and no analytical issues were identified.

4.5.7.1.4 Relation of Concentrations of Contaminants of Potential Ground Water Concern to Site Operations

Aluminum and/or aluminum-bearing compounds may have been used in LEHR operations and released to the Domestic Septic System via sink and/or floor drains.

Cr-VI is potentially associated with LEHR operations, since chromic acid and other chromium-bearing chemicals may have been used or disposed at the Site.

## 4.5.8 Risk Characterization Summary and Recommendations Regarding Contaminants of Concern at the Domestic Septic Systems Area

Risk characterization findings and recommended COCs at Domestic Septic System No. 5 are summarized below and presented in Table 4.5-6. The recommended COCs include constituents that are considered to have potential risks to human health or may have potential impact on the ground water at the Site.

#### 4.5.8.1 Human Health

Because the cumulative risk at the Domestic Septic System No. 5 is below the point of departure of  $10^{-6}$  for all receptors, no COCs are recommended for further evaluation in the Feasibility Study.

## 4.5.8.2 Ground Water

#### 4.5.8.2.1 Aluminum

DI WET results suggest that aluminum may have the potential to impact ground water at the site. No ground water data are available to compare aluminum in downgradient wells to background. Aluminum may have been used in LEHR operations and could have been inadvertently disposed at Domestic Septic System No. 5, but there are no indications that a significant mass of aluminum was released during LEHR operations. No soil data are available to evaluate the spatial distribution of aluminum in soil or to estimate attenuation factors. Both of the DI WET samples were above the MCL and no significant analytical accuracy issues were identified. Since there appears to be a moderately low likelihood of significant ground water impacts from aluminum at this site, ground water monitoring is recommended.

#### 4.5.8.2.2 Hexavalent Chromium

Domestic Septic Tank No. 5 ground water results indicate that impact to ground water from Cr-VI is currently occurring in concentrations slightly exceeding background and the MCL. Various forms of chromium were potentially used at LEHR and could have been inadvertently disposed at Domestic Septic Tank No. 5. No significant analytical accuracy issues were identified with the data. Samples were only collected below the septic tank effluent connection, but did cover the soil column. Modeling results indicate that hexavalent chromium in soil will not impact ground water above background or the MCL. Since residual Cr-VI soil concentrations are below background, no future

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impacts to ground water are expected. Therefore, Cr-VI should not be retained as a COC in the FS and ground water monitoring is not recommended for this area.



Figure 4.5-1. Domestic Septic System No. 5 Features



Figure 4.5-2. Domestic Septic System No. 5 Area Sample Locations and Depths 4108-142-DSS5.ai
## Table 4.5-1.Analytes Detected above Background in Soil/Waste at the Domestic Septic System<br/>No. 5 Area Prior to Removal Actions

Analyte	Total Samples	Number of Samples > Bkgd	Number of Samples > Bkgd and Residential PRGs <sup>1</sup>	Number of Samples > Bkgd and Industrial PRGs <sup>1</sup>	Maximum Conc.	Bkgd > 4 ft bgs	Residential PRG <sup>1</sup>	Industrial PRG
Radionuclides					(pCi/g)	(pCi/g)	(pCi/g)	(pCi/g)
Uranium-235	1	1	0	0	0.063	0.706	0.195	0.394
Metals					(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)
Mercury	1	1	0	0	0.35	0.248	23	310
Molybdenum	1	1	0	0	0.35	0.26	390	5,100
Selenium	1	1	0	0	1.3	1.2	390	5,100

#### Notes

Data from the Remedial Investigation Report (WA, 2003b).

Contaminant data includes data collected from all depth intervals instead of the 0-10 ft interval used in the risk estimate.

<sup>1</sup>Chemical PRGs are from US EPA Region 9 PRG table, dated October 1, 2002. Radionuclide PRGs are from Radionuclide Toxicity and PRGs for Superfund, dated April 14, 2003 (US EPA, <u>http://epa-prgs.ornl.gov/radionuclides/download/rad\_master\_prg\_table\_pci.xls</u>). The industrial PRGs for radionuclides are for "outdoor worker soil."

>	greater than
bkgd	background
bgs	below ground surface
conc.	concentration
ft	feet
mg/kg	milligrams per kilogram
pCi/g	picoCuries per gram
PRG	preliminary remediation goal
US EPA	United States Environmental Protection Agency

## Table 4.5-2. Summary of Sampling Results Used in the Risk Estimate at the Domestic Septic System No. 5 Area

List 1 COPC	Units	Total Samples	Number of Detections	Number of Detections > Background	Concentration Range <sup>1</sup>	Background Screening Concentration <sup>2</sup>	ID of Sample with Highest Concentration	Depth of Sample with Highest Concentration (ft)
Metals								
Arsenic	mg/kg	1	1	0	8.6 - 8.6	9.6	SSD5C001	7
Radionuclides								
Lead-210	pCi/g	2	1	0	0 - 0.616	1.6	SSD5C001	7
Potassium-40	pCi/g	2	1	0	0 - 11.6	14	SSD5C001	7
Radium-226	pCi/g	2	2	0	0.2115 - 0.462	0.75	SSD5C001	7
Radium-228	pCi/g	1	1	0	0.585 - 0.585	0.64	SSD5C001	7
Strontium-90	pCi/g	2	1	1	-0.00673 - 1.3125	0.056	WSD5C001	7
Thorium-228	pCi/g	2	1	0	0.00324 - 0.624	0.74	SSD5C001	7

Notes

Source: COPC data from the HHRA Risk Estimate, Appendix A (UC Davis, 2005). <sup>1</sup>The concentration ranges for metals and radionuclides include non-detects.

<sup>2</sup>The background screening concentrations are the unstratified background screening values in Appendix B of the HHRA Risk Estimate.

>	greater than
COPC	constituent of potential concern
ft	feet
HHRA	Human Health Risk Assessment
ID	identification (number)
mg/kg	milligrams per kilogram
pCi/g	picoCuries per gram

Table 4.5-3. Human Health Risks to On-Site Resident by Exposure Route for Contaminants of Potential Concern at the Domestic Septic System No. 5 Area

				CANCEF	R RISK BY EXPOSURI	E ROUTE				
List 1 COPC	EPC <sup>1</sup> (0-10 ft)	Soil Ingestion	Soil Dermal Exposure	Above-Ground Plant Ingestion <sup>2</sup>	Below-Ground Plant Ingestion <sup>2</sup>	External Radiation	Dust Inhalation	Total Cancer Risk	Statistical Background Comparison <sup>3</sup>	List 2 Cancer Risk <sup>4</sup>
Arsenic	8.6	2.E-05	1.E-06	9.E-05	3.E-05	-	1.E-08	1.E-04	Pass	-
Lead-210	0.62	1.E-08	-	3.E-08	-	1.E-08	7.E-11	5.E-08	Pass	-
Potassium-40	12	8.E-09	-	2.E-07	-	5.E-05	1.E-12	5.E-05	Pass	-
Radium-226	0.46	8.E-09	-	2.E-08	-	2.E-05	7.E-11	2.E-05	Pass	-
Radium-228	0.59	6.E-09	-	2.E-08	-	1.E-05	3.E-10	1.E-05	Pass	-
Strontium-90	1.3	2.E-09	-	5.E-08	-	1.E-07	1.E-12	2.E-07	Fail	2.E-07
Thorium-228	0.62	6.E-10	-	5.E-11	-	3.E-06	1.E-10	3.E-06	Pass	-
TOTAL								2.E-04		2.E-07
				HAZARD Q	UOTIENT BY EXPOSI	URE ROUTE				
List 1 COPC	EPC <sup>1</sup>	Soil Ingestion	Soil Dermal Exposure	Above-Ground Plant Ingestion	Below-Ground Plant Ingestion	External Radiation	Dust Inhalation	Non-Cancer Hazard Index	Statistical Background Comparison <sup>3</sup>	List 2 Non-Cancer Hazard Risk <sup>4</sup>
Arsenic	8.6	3.7E-01	3.1E-02	2.0E+00	2.4E-01	-	-	2.6E+00	Pass	-
TOTAL								2.6E+00		-

		-	-	Ingestion	Ingestion			
Arsenic	8.6	3.7E-01	3.1E-02	2.0E+00	2.4E-01	-	-	2
TOTAL								2.

Notes

Source Data from HHRA Risk Estimate, Tables 7 and 8. Statistical Background Comparison from Appendix B (UC Davis, 2005).

The non-cancer risk is for a resident child; for cancer risk it is an age-adjusted adult. <sup>1</sup>The 95% upper confidence limit on the mean of the exposure point concentration; chemical concentrations are in milligrams per kilogram and radionuclide concentrations are in picoCuries per gram.

<sup>2</sup>For radionuclides, plant ingestion is not subdivided into above-ground and below-ground plants.

<sup>3</sup>Based on Wilcoxon Rank Sum test or other statistical comparisons, as shown in Appendix B of the HHRA Risk Estimate. <sup>4</sup>Dashes indicate that constituent was not identified as a List 2 COPC, since it was identified to be statistically equivalent to background.

#### Abbreviations

not calculated -COPC constituent of potential concern EPC exposure point concentration ft foot or feet Human Health Risk Assessment HHRA

	Investigation Sampling Designa		Designated-L	Designated-Level Sampling		NUFT Model Soil Result		Downgradient		Ground Water Background		Ground		Time to Beak at
Designated-Level Constituent of Potential	Maximum	Depth of	Maximum	Depth of	Soil Background Value	Background Ground Water	MCL Ground Water	Ground water (μg/l or	pCi/l) <sup>3</sup>	Concen (µg/l o	tration <sup>4</sup> r pCi/l)	Water MCL	Tap Water PRG	Ground Water Goal Level
Concern	(mg/kg or pCi/g) <sup>1</sup>	Maximum (ft)	(mg/kg or pCi/g) <sup>2</sup>	Maximum (ft)	(mg/kg or pC1/g)	Goal (mg/kg or pCi/g)	Goal (mg/kg or pCi/g)	HSU-1	HSU-2	HSU-1	HSU-2	(µg/l or pCi/l)	(µg/l or pC1/l)	(years)
Aluminum <sup>5</sup>	N/A	N/A	$60,700^{6}$	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	200	36,000	N/A
Hexavalent Chromium	0.339	7	0.175	12	1.3	0.64	0.81	36 – <b>66</b>	15.0 - <b>110</b> / < 6.0 <b>-25.0</b>	41.3	20	50	110	No impact expected
Uranium-235	0.0631	7	0.0594	37	0.038	4.7	9.8	< 14.5 - < 42	<-27 - <10 / <-8.54 - <11 [ND]	9.5	17.1	20	0.7	No impact expected

#### Summary of Potential Impact on Ground Water of Designated-Level Constituents of Potential Concern in Domestic Septic System No. 5 Area Soil Table 4.5-4.

#### Notes

Source: Data from Remedial Investigation Report (WA, 2003b). HSU-2 data added.

<sup>1</sup>Uranium-235 in pCi/g or pCi/l; all other constituents in mg/kg or  $\mu$ g/l. <sup>2</sup> $\mu$ g/L for DI WET results.

<sup>3</sup>Range of available data for nearby downgradient HSU-1 well UCD1-21, and HSU-2 wells UCD-7 and UCD2-36.

<sup>4</sup>Based on data from HSU-1 well UCD1-18, and HSU-2 wells UCD2-17 and UCD2-37.

<sup>5</sup>Aluminum is a designated-level COC because the DI WET result is above the MCL. No data are available for soil or downgradient ground water. No NUFT modeling has been done.

<sup>6</sup>Based on DI WET results.

 $\label{eq:weissdc01} weissdc01\clients\DOE\4108\142\Risk\ Characterization\RC_fnl.doc$ 

Bold type indicates soil concentration is above background and above NUFT result for ground water impact at background levels, or ground water concentration is above background.

Boxed type indicates soil concentration is above background and above NUFT result for ground water impact at the MCL, or DI WET concentration or ground water concentration is above the MCL.

<	denotes analyte concentrations below the detection limit
μg/l	micrograms per liter
COC	constituent of concern
DI WET	deionized water waste extraction test
ft	feet
MCL	California Maximum Contaminant Level for ground water (November 2002)
mg/kg	milligrams per kilogram
N/A	not applicable or not available
ND	no detections in any sample
NUFT	Non-Isothermal, Unsaturated Flow and Transport model
pCi/g	picoCuries per gram
pCi/l	picoCuries per liter
PRG	preliminary remediation goal (US EPA, 2002a for radionuclides; US EPA, 2002b for others)
US EPA	United States Environmental Protection Agency

#### Summary of Designated-Level Ground Water Constituents of Potential Concern at Domestic Septic System No. 5 Area Table 4.5-5. Retained as Constituents of Potential Ground Water Concern

	0	0	6	4
Designated-Level Constituent of Potential Concern	Are the DL COPCs ground water concentrations above site background? <sup>1</sup>	Are the DL COPC soil concentrations above soil background and the NUFT soil results? <sup>2</sup>	Will the DL COPC impact ground water above background levels in the next 500 years?	Retained as COPGWC in risk
	If yes, enter ✓ in ❹	If yes, enter ✓ in ④ If yes, go to ❸		$\sqrt{-12} = V_{es}$
	If no, go to <b>2</b>	If no, stop and enter $\times$ below	If no, stop and enter $\times$ below	v - 105
Aluminum	Yes <sup>3</sup>	N/A	N/A	$\checkmark$
Hexavalent Chromium	Yes	-	-	✓
Uranium-235	No	×	-	-

#### Note

<sup>1</sup>See Table 4.5-4. Compare downgradient ground water concentration to ground water background concentration. Results below detection limits are presumed to be below site background. <sup>2</sup>The lower of background and MCL goals. <sup>3</sup>Based on DI WET results.

×	not retained as a COPGWC
$\checkmark$	retained as a COPGWC
-	skip
COPC	constituent of potential concern
COPGWC	constituent of potential ground water concern
DI WET	deionized water waste extraction test
DL	designated-level
MCL	California Maximum Contaminant Level for ground water (November 2002)
N/A	not applicable or not available
NUFT	Non-Isothermal, Unsaturated Flow and Transport

## Table 4.5-6. Summary of Major Factors Driving Risk and Recommendations for Future Action at Domestic Septic System No. 5 Area

Driver COPC / COPGWC	Total Cancer Risk	- Spatial Distribution	95UCL Background Contribution	95UCL Site Contribution	Historically Used at the Site	Time for Attenuation to Risk Endpoint (years)	Above Ground Water Background or MCL	Uncertainty	Recommended Action	Basis for Recommendation
Human Health Receptor										
None	N/A	N/A	N/A	N/A	N/A	N/A	N/A	• No significant data quality issues.	N/A	N/A
Ground Water										
Aluminum	N/A	N/A	N/A	N/A	Yes	N/A	>bkgd >MCL	• Unknown vertical and horizontal distribution.	Monitoring	• DI WET results suggest a potential impact above MCL and background.
								• Unknown attenuation factor between source and ground water.		• No ground water data are available.
Hexavalent Chromium	N/A	Undetermined	l N/A	N/A	No	N/A	>MCL, >bkgd	• Six of seven results were qualified.	No Further Action	• Ground water marginally elevated above background and MCL
										Residual soil concentrations are below background

Abbreviations 95UCL > bkgd COPC COPGWC DI WET MCL	95 percent upper confidence limit on the mean greater than background constituent of potential concern constituent of potential ground water concern deionized water waste extraction test California Maximum Contaminant Level for ground water (February 2003)
MCL N/A	California Maximum Contaminant Level for ground water (February 2003) not applicable
	11

## 4.6 Domestic Septic System No. 6

Figure 4.6-1 shows the Domestic Septic System No. 6 features.

## 4.6.1 Area Description

The oldest septic system at LEHR, Domestic Septic System No. 6, was shown on a plan dated December 12, 1958 as connected to the "Animal Holding Building." The system consisted of a septic tank attached to a distribution box with two vitrified clay pipe effluent lines leading north and south to perforated Orangeburg pipes set in gravel (WA, 2003a). The septic tank was constructed of six-inch thick reinforced concrete and measured approximately ten ft in length, four ft in width and was five ft deep. The majority of the tank's top and bottom were no longer present, appearing to have been destroyed during installation of a sewer line (WA, 2003a). Effluent from the tank flowed through the effluent lines into two parallel, perforated Orangeburg pipes set in gravel that were separated laterally by 4.5 ft. The leach line gravel trenches were approximately 1.5 ft wide and ranged in depth from 2 ft deep to 5 ft deep. Each of the four leach trenches was approximately 40 ft long.

## 4.6.2 Pre-Removal Action Contaminant Distribution

Analytical results collected from the Domestic Septic System No. 6 area, along with data from previous investigations, identified Cr-VI, antimony, barium, copper, lead, Hg and nickel as COCs. However, of the constituents known to be associated with past operations and/or released to the environment, only mercury was consistently detected throughout the area (WA, 2003a). Table 4.6-1 summarizes all constituents detected in pre-removal action soil samples at concentrations that exceed background.

Hg was detected above background in 34 of 44 samples in concentrations ranging from 0.13 to 101 mg/kg (see Table 4.6-1). The pre-removal action data suggested that the lateral extent of contamination was limited to the areas surrounding the leach lines.

## 4.6.3 Removal Action Activities

In 2002, all effluent lines associated with Domestic Septic System No. 6 were removed, along with the perforated Orangeburg pipe and leach trench gravel. Approximately one ft of soil was also removed from the trench floor and sidewalls. The excavation depth ranged from six to seven ft bgs and was 11 ft wide by 105 ft long. The Domestic Septic Tank No. 6 and the attached distribution box were not removed, because the concrete sample collected from the bottom of tank showed no significant signs of contamination (WA, 2003b).

Approximately 215 cu yd of piping, gravel and underlying soil were shipped for off site disposal.

## 4.6.4 Post-Removal Action Contaminant Distribution

Twenty-three confirmation samples and three field duplicates were collected from the Domestic Septic System No. 6 excavation and analyzed for Cr-VI, copper, barium and Hg. Four additional discretionary samples were collected and analyzed for Hg. Of the 117 analytes, only Hg was detected above its background value with a maximum concentration of eight mg/kg, detected in soil sample SSD6C038, collected seven ft bgs beneath the former location of the northeastern leach line. The second highest Hg concentration, seven mg/kg, was detected in soil sample SSD6C025, collected 4.4 ft bgs, approximately seven ft west of sample SSD6C038. No obvious concentration trends with depth were observed in the Hg data.

## 4.6.5 Summary of Risk Estimate Data

Data used in the human health risk estimate were collected during various investigations and sampling events that were conducted at Domestic Septic System No. 6. Information used in the risk estimate included data from the:

- Limited Field Investigation;
- Data Gaps Investigation; and
- 2001 Domestic Septic System Investigation.

These various investigations are summarized in Table 6-8 of the RI, and details of the 2001 Domestic Septic System Investigation are presented in Appendix B of the same report (WA, 2003b).

The data set was evaluated and redacted to exclude information associated with samples collected in locations that were subsequently excavated. The final data set used to estimate risk at Domestic Septic System No. 6 reflected the post-removal action conditions of the area. Data from samples collected at depths greater than ten ft bgs was also excluded. Table 4.6-2 provides a summary of sample data used in the Tier 2 risk estimate. The sample locations for all data used in the risk estimate are presented in Figure 4.6-2.

## 4.6.5.1 Quality of Site Data

Data quality procedures common to evaluations of all DOE areas and site background at LEHR are discussed in Section 2. The total data set for Domestic Septic System No. 6 included 1,083 results. None of these results were rejected from the total data set ("R"-qualified). Forty-seven of the results, or 4.3%, had "J" qualifiers, which indicate that an analyte was positively identified in the sample, but the analytical result is an approximation of the analyte concentration in the sample. Data with "J" qualifiers were used in developing risk estimates. A total of 144 records, or 13%, had "UJ" qualifiers, which mean that an analyte was not detected but the analytic QC results

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indicate that the detection limit is approximate. Data with "UJ" qualifiers were included in the risk estimate and were treated as non-detection of an analyte.

A total of twelve of the 1,083 final records from Domestic Septic System No. 6 were used to generate the Tier 2 human health risk estimate. Three of the twelve results had "J" qualifiers, and none of the results had "UJ" qualifiers.

## 4.6.6 Risk Characterization—Domestic Septic System No. 6

Consistent with the HHRA Risk Estimate, as discussed in Section 2.2, this risk characterization uses the terms "List 1" and "List 2". List 2 identifies constituents that failed the statistical comparison to background, which may be indicative of a release to the environment. Table 4.6-3, in the first column, provides the List 1 COPCs identified in the HHRA Risk Estimate. The last column of Table 4.6-3 provides only List 2 COPCs and their risk values. The values provided are not corrected for decay. A subset (shown in bold-type) of List 2 contains COPCs that have a risk of at least 10<sup>-6</sup> or contribute more than ten percent of the total excess cumulative cancer risk in the Domestic Septic System No. 6 area. Domestic Septic System No. 6 had no List 2 COPC risks.

### 4.6.6.1 Exposure Assessment

The exposure assessment for Domestic Septic System No. 6 in the HHRA Risk Estimate includes a discussion of the exposure intake estimates and their effect on the overall risk estimate. The EPCs for the on-site resident in the Domestic Septic System No. 6 area are provided in Table 4.6-3.

A conceptual site model illustrating exposure pathways and potential human receptors for all DOE areas is provided as Figure 2-1.

## 4.6.6.1.1 Spatial Distribution of Contaminants of Potential Concern

A spatial distribution of contaminants was not analyzed, since no List 2 driver COPCs were identified in the area.

4.6.6.1.2 Degradation and Decay of Contaminants of Potential Concern

No List 2 driver COPCs were identified in the area.

## 4.6.6.1.3 Background Evaluation

No List 2 driver COPCs were identified in the area.

### 4.6.6.2 Toxicity Assessment

Toxicity values for COPCs in the Domestic Septic System No. 6 area were taken from US EPA guidance as discussed in Section 2.2.4. The toxicity values used for these COPCs are appropriate for this evaluation and make use of the best available information.

## 4.6.6.3 Risk Estimate

As shown in Table 4.6-2, Domestic Septic System No. 6 has no List 2 driver COPCs, since all List 1 COPCs passed the statistical comparison to background.

## 4.6.6.4 Uncertainty

Risk estimates are values that have uncertainties associated with them, as discussed in Section 2.2.6. The objective of this section is to discuss the major sources of uncertainty that are specific to this refined assessment of Domestic Septic System No. 6. These include data coverage and analytical issues.

## 4.6.6.4.1 Analytical Issues

No significant data quality issues were identified in data used in the Domestic Septic System No. 6 risk estimate.

## 4.6.6.4.2 Data Representativeness

The locations of soil and concrete samples used in the risk estimate are shown in Figure 4.6-2. The results are presented in Table 4.6-1. The sampling was a combination of discretionary and random grid based sampling. Sample coverage for Hg, Cr-VI, copper and barium was extensive and well positioned to characterize releases from the tank and leach lines. Sample coverage for other analytes was limited, but positioned to be representative of the releases from the tank and leach lines.

## 4.6.6.5 Relation of Concentrations of Contaminants of Potential Concern to Site Operations

Current COPCs in soil at Domestic Septic System No. 6 are at or below natural background levels. Impacts from site operations were mitigated by the removal action.

## 4.6.7 Ground Water Impacts

In addition to evaluation of human health risk resulting from soil contamination, potential ground water impacts from contaminants remaining in the soil at Domestic Septic Tank No. 6 were evaluated and are presented in the RI (WA, 2003b). An evaluation of DI WET results is presented in Appendix C. Potential impacts to ground water at Domestic Septic Tank No. 6 are summarized in Table 4.6-4.

Hg was the only constituent detected in soil above background in the Domestic Septic System No. 6 confirmation and DL soil samples. DI WET results indicated that aluminum and mercury may impact ground water above their MCLs. Cr-VI was detected in downgradient wells UCD1-21 and UCD2-7 at concentrations above background and the MCL. Hg has not been detected in downgradient wells UCD1-20, UCD1-21, and UCD2-7 (Figure 2-3).

Based on modeling, localized impact on ground water may exceed background and the MCL from Hg in Domestic Septic System No. 6 soil. However, the impact from Hg will not occur in the

next 500 years. Therefore, Hg does not require further evaluation in conformance with the ground water COPC evaluation process illustrated in Figure 1-2.

Therefore, as shown on Table 4.6-5, only aluminum and Cr-VI is retained for further evaluation as a COPGWC.

## 4.6.7.1 Risk Characterization of Constituents of Potential Ground Water Concern

## 4.6.7.1.1 Percentage and Spatial Distribution of Samples Exceeding Background

## 4.6.7.1.1.1 Aluminum

No spatial information is available for aluminum concentrations in soil because aluminum was not analyzed in soil samples. Two DI WET samples were collected at 6.0 feet bgs and 11 feet bgs beneath the first point of perforation on the northeast leach line and two additional DI WET samples were collected at 6.0 feet bgs and 11 feet bgs beneath the first point of perforation on the southeast leach line. All four of the DI WET sample concentrations were above the MCL. The DI WET data were not compared to background because aluminum has not been analyzed in background well samples.

## 4.6.7.1.1.2 Hexavalent Chromium

All 42 hexavalent chromium soil sample results were below background (1.3 mg/kg) at Domestic Septic System No. 6. Hexavalent chromium appears to be randomly distributed in soil throughout the area.

## 4.6.7.1.2 Degradation and Decay of Contaminants of Potential Concern

Aluminum and Cr-VI are not expected to undergo significant degradation or decay.

## 4.6.7.1.3 Uncertainty

Similar to human health risk estimates, evaluation of ground water impacts is subject to uncertainties, such as analytical bias and data representativeness, discussed below.

## 4.6.7.1.3.1 Analytical Issues

## 4.6.7.1.3.1.1 Aluminum

No analytical issues were identified with the DI WET analysis of aluminum.

## 4.6.7.1.3.1.2 Hexavalent Chromium

Twenty-two of 42 hexavalent chromium results were qualified. Fifteen results were qualified due to matrix spike recovery failure, which is likely due to soil chemistry in the matrix spike sample. This matrix effect is not considered an analytical accuracy issue.

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Nine samples were qualified because their results were between the method detection limit and the quantitation limit. This qualification indicates individual results may be less precise than results above the quantitation limit, but it does not indicate a positive or negative bias.

## 4.6.7.1.3.2 Data Representativeness

Domestic Septic System No. 6 soil sampling consisted of random grid, discretionary and soil boring samples collected at depths ranging from 3.7 ft bgs to 41 ft bgs. Soil sample coverage was extensive, and covers the lateral and vertical extent of the known potential source areas. The samples were collected and analyzed according to Superfund risk assessment data quality standards. The data are sufficient for characterizing the soil column at Domestic Septic System No. 6. No data gaps were identified.

## 4.6.7.1.4 Relation of Concentrations of Contaminants of Potential Ground Water Concern to Site Operations

Aluminum and/or aluminum-bearing compounds may have been used in LEHR operations and released to the Domestic Septic System via sink and/or floor drains.

Cr-VI is potentially associated with LEHR operations, since chromic acid and other chromium-bearing chemicals may have been used or disposed at the Site.

## 4.6.8 Risk Characterization Summary and Recommendations Regarding Contaminants of Concern at the Domestic Septic System No. 6 Area

Risk characterization findings and recommended COCs at Domestic Septic System No. 6 are summarized below and presented in Table 4.6-6. The recommended COCs include constituents that are considered to have potential risks to human health or may have potential impact on the ground water at the Site.

## 4.6.8.1 Human Health

Because the cumulative risk at Domestic Septic System No. 6 is below the point of departure of  $10^{-6}$  for all receptors, no data quality issues affect the estimate, and the estimate is based on data that is likely to be representative of the contamination in the area, no COPCs are recommended for further evaluation in the Feasibility Study.

## 4.6.8.2 Ground Water

## 4.6.8.2.1 Aluminum

DI WET results suggest that aluminum may have the potential to impact ground water at the site. No ground water data are available to compare aluminum in downgradient wells to background. Aluminum may have been used in LEHR operations and could have been inadvertently disposed at Domestic Septic System No. 6, but there are no indications that a significant mass of aluminum was released during LEHR operations. No soil data are available to evaluate the spatial distribution of aluminum in soil or to estimate attenuation factors. Both of the DI WET samples were above the

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MCL and no significant analytical accuracy issues were identified. Since there appears to be a moderately low likelihood of significant ground water impacts from aluminum at this site, ground water monitoring is recommended.

## 4.6.8.2.2 Hexavalent Chromium

Cr-IV has been detected in ground water in a well downgradient of Domestic Septic System No. 6 in concentrations slightly exceeding background and the MCL. Modeling results indicate the time to ground water impact is zero years and the existing Cr-VI concentrations in soil have impacted ground water above background and the MCL. Soil sample coverage was extensive, and covers the lateral and vertical extent of the known potential source areas. Various forms of chromium were potentially used at LEHR and could have been inadvertently disposed at Domestic Septic Tank No. 5. No significant analytical accuracy issues were identified with the data. Since residual Cr-VI concentrations are below background in soil, no future impacts to ground water are expected. Therefore, Cr-VI should be excluded from further evaluation in the Feasibility Study and ground water monitoring is not recommended.



Figure 4.6-1. Domestic Septic System No. 6 Features



Figure 4.6-2. Domestic Septic System No. 6 Area Sample Locations and Depths 4108-142-DSS6.ai

Constituent	Number of Samples	Number of Samples > Background <sup>1</sup>	Number of Samples > PRG <sup>2</sup>	Maximum Concentration	Sample Identification	Depth (ft)
Metals				mg/kg		
Antimony	6	1	0	1.9	SSD3C004A/B	3.75
Arsenic	6	4	6	9.3	LEHR-S-T603	13
Barium	6	3	0	221	LEHR-S-T602	8
Copper	6	2	0	75.2	SSD6C001A/B	4
Chromium	16	11	0	166	SSD6F027	3
Iron	6	0	6	43,200	LEHR-S-T603	13
Lead	16	1	$0^{4}$	9.6	SSD6C004A/B	3.75
Manganese	6	0	0	709	LEHR-S-T603	13
Mercury	44	34	9	101	SSD6C012	4
Molybdenum	6	3	0	0.41	SSD6C001A/B	4
Nickel	6	3	0	274	SSD6C03A/B	3.25
Silver	6	2	0	1	SSD6C004A/B	3.75
Thallium	6	2	0	2	SSD6C004A/B	3.75
Vanadium	6	3	0	84.8	LEHR-S-T603	13
Zinc	6	5	0	179	SSD6C001A/B	4
Radionuclides				pCi/g		
Actinium-228	6	1	0	0.67	LEHR-S-T603	13
Bismuth-212	6	1	0	0.45	LEHR-S-T602	8
Bismuth-214	6	3	0	0.61	LEHR-S-T602	8
Cesium-137 <sup>5</sup>	6	0	0	0.0549	SSD6C001A/B	4
Lead-210	6	1	6	1.75	SSD6C004A/B	3.75
Lead-214	6	4	0	0.75	LEHR-S-T602	8
Potassium-40	6	0	6	12.8	SSD6C001A/B	4
Radium-226	6	0	6	0.56	LEHR-S-T603	13
Radium-228	3	0	3	0.64	LEHR-S-T601	
Strontium-90	6	2	0	0.211	SSD6C001A/B	4
Thallium-208	6	2	0	0.242	LEHR-S-T602	8
Thorium-228	3	0	3	0.499	SSD6C002A/B	3.25
Thorium-232	3	0	0	0.429	SSD6C003A/B	3.25
Tritium	6	1	3	2.3	LEHR-S-T602	8
Uranium-233/234	3	2	0	0.737	SSD6C001A/B	4
SVOCs				μg/kg		
Benzo(a)anthracene	6	N/A	2	14,400	SSD6C001A/B	4
Benzo(a)pyrene	6	N/A	2	788	SSD6C001A/B	4
Benzo(b)fluoranthene	6	N/A	2	8,330	SSD6C001A/B	4
Benzo(k)fluoranthene	6	N/A	$1^{3}$	7,000	SSD6C001A/B	4
Chrysene	6	N/A	$1^{3}$	10,800	SSD6C001A/B	4
Dibenzo(a,h)anthracene	6	N/A	3	2,980	SSD6C001A/B	4
Indeno(1,2,3-cd)pyrene	6	N/A	1	1,260	SSD6C001A/B	4

Table 4.6-1.	Analytes Detected above Background in Soil/Waste at the Domestic Septic System
	No. 6 Area Prior to Removal Actions

#### Notes

Data from the Remedial Investigation Report (WA, 2003b). Contaminant data includes data collected from all depth intervals instead of the 0-10 ft interval used in the risk estimate.

## Table 4.6-1.Analytes Detected above Background in Soil/Waste at the Domestic Septic System<br/>No. 6 Area Prior to Removal Actions (continued)

>	greater than
µg/kg	micrograms per kilogram
ft	feet
mg/kg	milligrams per kilogram
N/A	not applicable
pCi/g	picoCuries per gram
PRG	preliminary remediation goal
SVOCs	semi-volatile organic compounds
US EPA	United States Environmental Protection Agency

<sup>&</sup>lt;sup>1</sup>Lowest site-specific background Lowest background concentration is the lower of the shallow (0-4 ft) and the deep (4-40 ft) soil background screening values for vertically stratified analytes.

<sup>&</sup>lt;sup>2</sup>Chemical PRGs for residential soil are from US EPA Region 9 PRGs table, dated October 1, 2002. Radionuclide PRGs for residential soil are from Radionuclide Toxicity and PRGs for Superfund, dated April 14, 2003 (US EPA, http://epa-prgs.orrl.gov/radionuclides/ download/rad\_master\_prg\_table.xls).

<sup>&</sup>lt;sup>3</sup>Lead, benzo(k)fluoranthene and chrysene were evaluated against California-modified PRGs.

Table 4.6-2	Summary of Sampling Results Used in the	e Risk Estimate at the Domestic Septic System No. 6 Area

List 1 COPC	Units	Total Samples	Number of Detections	Number of Detections > Background Concentration Range <sup>1</sup>		Background Screening Concentration <sup>2</sup>	ID of Sample with Highest Concentration	Depth of Sample with Highest Concentration (ft)
Metals								
Arsenic	mg/kg	2	2	0	4.5 - 9.2	9.6	LEHR-S-T602	8
Radionuclides								
Lead-210	pCi/g	2	2	0	1.05 - 1.5	1.6	CSD6C001	6
Potassium-40	pCi/g	2	2	0	6.02 - 12.1	14	LEHR-S-T602	8
Radium-226	pCi/g	2	2	0	0.251 - 0.35	0.75	LEHR-S-T602	8
Radium-228	pCi/g	1	1	0	0.307 - 0.307	0.64	CSD6C001	6
Thorium-228	pCi/g	1	1	0	0.234 - 0.234	0.74	CSD6C001	6

Notes

Source: COPC data from the HHRA Risk Estimate, Appendix A (UC Davis, 2005). <sup>1</sup>The concentration ranges for metals and radionuclides include non-detects. <sup>2</sup>The background screening concentrations are the unstratified background screening values in Appendix B of the HHRA Risk Estimate.

Abbreviations

greater than > constituent of potential concern COPC feet ft Human Health Risk Assessment identification (number) HHRA ID milligrams per kilogram mg/kg pCi/g picoCuries per gram

Table 4.6-3. Human Health Risks to On-Site Resident by Exposure Route for Contaminants of Potential Concern at the Domestic Septic System No. 6 Area

	CANCER RISK BY EXPOSURE ROUTE												
List 1 COPC	EPC <sup>1</sup> (0-10 ft)	Soil Ingestion	Soil Dermal Exposure	Above-Ground Plant Ingestion <sup>2</sup>	Below-Ground Plant Ingestion <sup>2</sup>	External Radiation	Dust Inhalation	Total Cancer Risk	Statistical Background Comparison <sup>3</sup>	List 2 Cancer Risk <sup>4</sup>			
Arsenic	9.2	2.E-05	1.E-06	1.E-04	3.E-05	-	2.E-08	2.E-04	Pass	-			
Lead-210	1.5	1.E-07	-	2.E-07	-	4.E-08	2.E-10	3.E-07	Pass	-			
Potassium-40	12	2.E-08	-	5.E-07	-	7.E-05	1.E-12	7.E-05	Pass	-			
Radium-226	0.35	2.E-08	-	5.E-08	-	2.E-05	6.E-11	2.E-05	Pass	-			
Radium-228	0.31	1.E-08	-	3.E-08	-	9.E-06	2.E-10	9.E-06	Pass	-			
Thorium-228	0.23	7.E-10	-	5.E-11	-	1.E-06	4.E-11	1.E-06	Pass	-			
TOTAL								<b>3.E-04</b>		-			
				HAZARD Q	UOTIENT BY EXPOSI	URE ROUTE							
List 1 COPC	EPC <sup>1</sup>	Soil Ingestion	Soil Dermal Exposure	Above-Ground Plant Ingestion	Below-Ground Plant Ingestion	External Radiation	Dust Inhalation	Non-Cancer Hazard Index	Statistical Background Comparison <sup>3</sup>	List 2 Non-Cancer Hazard Risk <sup>4</sup>			
Arsenic	9.2	3.9E-01	3.3E-02	2.1E+00	2.6E-01	-	-	2.8E+00	Pass	_			
TOTAL								2.8E+00		-			

List 1 COPC	$EPC^1$	Soil Ingestion	Soil Dermal Exposure	Above-Ground Plant Ingestion	Below-Ground Plant Ingestion	External Radiation	Dust Inhalation	Non-C
Arsenic	9.2	3.9E-01	3.3E-02	2.1E+00	2.6E-01	-	-	
TOTAL								2

Notes

Source Data from HHRA Risk Estimate, Tables 7 and 8. Statistical Background Comparison from Appendix B (UC Davis, 2005). The non-cancer risk is for a resident child; for cancer risk it is an age-adjusted adult. Rounding may affect the total List 2 cancer risk values shown in the last column. Determination of whether the risk is greater than ten percent of total List 2 cancer risk is based on unrounded values. <sup>1</sup>The 95% upper confidence limit on the mean of the exposure point concentration; chemical concentrations are in milligrams per kilogram and radionuclide concentrations are in picoCuries per gram. <sup>2</sup>For radionuclides, plant ingestion is not subdivided into above-ground and below-ground plants.

<sup>3</sup>Based on Wilcoxon Rank Sum test or other statistical comparisons, as shown in Appendix B of the HHRA Risk Estimate.

<sup>4</sup>Dashes indicate that constituent was not identified as a List 2 COPC, since it was identified to be statistically equivalent to background.

-	not calculated
COPC	constituent of potential concern
EPC	exposure point concentration
ft	feet
HHRA	Human Health Risk Assessment

Table 4.6-4. Summary of Potential Impacts of Designated-Level Constituents of Potential Concern in the Domestic Septic System 6 Area Soil on Ground Water

Designated-Level Constituent of Potential Concern	Confirmation Sampling			Designated-Level Sampling		Soil	NUFT Model Soil Result		Downgradient Ground Water		Ground Water Background		Ground	Тар	Time to Peak at
	Maximum (mg/kg)	Depth of Maximum (ft)	95% UCL (mg/kg)	Maximum (mg/kg) <sup>1</sup>	Depth of Maximum (ft)	Background Value (mg/kg)	Background Ground Water Goal (mg/kg)	MCL Ground Water Goal (mg/kg)	Concentration <sup>2</sup> (µg/l) HSU-1 HSU-2		Concen (µ HSU-1	tration <sup>3</sup> g/l) HSU-2	Water MCL (µg/l)	Water PRG (µg/l)	Ground Water Goal Level (years)
Aluminum <sup>4</sup>	N/A	N/A	N/A	$52,100^{5}$	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	200	36,000	N/A
Hexavalent Chromium Mercury <sup>7</sup>	0.362 <b>8</b>	4.4 7	N/A <b>0.66</b>	0.467 <b>6.7</b>	6 20	1.3 3.94/0.25/0.63 <sup>8</sup>	0.638	0.809	19 – <b>66</b> < 0.20	15.0 - 110 <0.10 - <0.4 <sup>9</sup>	39 < 0.20	0.2	50° 11	110 11	0 1,780

Notes

<sup>1</sup>µg/L for DI WET results.

<sup>2</sup>Range of available data for nearby downgradient HSU-1 wells UCD1-020 and UCD1-021, and HSU-2 well UCD2-7. <sup>3</sup>Based on data from HSU-1 well UCD1-18, and HSU-2 wells UCD2-17 and UCD2-37.

<sup>4</sup>Aluminum is a designated-level COC because the DI WET result is above the MCL. No data are available for soil or downgradient ground water. No NUFT modeling has been done.

<sup>5</sup>Based on DI WET results.

<sup>6</sup>MCL for total chromium.

<sup>7</sup>Assumed to be mercuric chloride.

<sup>8</sup>First value is a concentration for 0 to 4 ft below ground surface, second is for greater than 4 ft below ground surface and third is a consolidated concentration (all depths)

<sup>9</sup>One outlier was excluded from well UCD2-7. All other samples were non-detects. Although the highest detection limits for other samples demonstrate that the Mercury concentrations at well UCD2-7 are not greater than background. Bold type indicates soil concentration is above background and above NUFT result for ground water impact at background levels, or ground water concentration is above background.

Boxed type indicates soil concentration is above background and above NUFT result for ground water impact at the MCL, or DI WET concentration or ground water concentration is above the MCL.

<	denotes analyte concentrations below the detection limit
μg/l	micrograms per liter
COC	constituent of concern
DI WET	deionized water waste extraction test
ft	feet
MCL	California Maximum Contaminant Level for ground water (November 2002)
mg/kg	milligrams per kilogram
N/A	not applicable or not available
NUFT	Non-Isothermal, Unsaturated Flow and Transport model
PRG	preliminary remediation goal (US EPA, 2002a for radionuclides; US EPA, 2002b for others)
UCL	upper confidence limit on the true mean based on sample data
US EPA	United States Environmental Protection Agency

#### Summary of Designated-Level Ground Water Constituents of Potential Concern at Domestic Septic System No. 6 Area Table 4.6-5. Retained as Constituents of Potential Ground Water Concern

	0	0	6	4
Designated-Level Constituent of Potential Concern	Are the DL COPCs ground water concentrations above site background? <sup>1</sup>	Are the DL COPC soil concentrations above soil background and the NUFT soil results? <sup>2</sup>	Will the DL COPC impact ground water above background levels in the next 500 years?	Retained as COPGWC in risk
	If yes, enter ✓ in ④	If yes, enter ✓ in ④ If yes, go to ⑤		$\sqrt{-V_{ec}}$
	If no, go to 🛛	If no, stop and enter $\times$ below	If no, stop and enter $\times$ below	· - 103
Aluminum	Yes <sup>3</sup>	N/A	N/A	✓
Hexavalent Chromium	Yes	-	-	✓
Mercury	No	Yes	×	-

#### Notes

<sup>1</sup>See Table 4.6-4. Compare downgradient ground water concentration to ground water background concentration. Results below detection limits are presumed to be below site background. <sup>2</sup>The lower of background and MCL goals. <sup>3</sup>Based on DI WET results.

×	not retained as a COPGWC
$\checkmark$	retained as a COPGWC
-	skip
COPC	constituent of potential concern
COPGWC	constituent of potential ground water concern
DI WET	deionized water waste extraction test
DL	designated-level
MCL	California Maximum Contaminant Level for ground water (November 2002)
N/A	not available
NUFT	Non-Isothermal, Unsaturated Flow and Transport

Table 4.6-6. Summary of Major Factors Driving Risk and Recommendations for Future Action at Domestic Septic System No. 6 Area

Driver COPC	Total Cancer Risk	Spatial Distribution	95UCL Background Contribution	95UCL Site Contribution	Historically Used at the Site	Time for Attenuation to Risk Endpoint <sup>1</sup> (years)	Above Ground Water Background or MCL	Uncertainty	Recommended Act
Human Health Receptor									
None	N/A	N/A	N/A	N/A	N/A	N/A	N/A	<ul><li>No data quality issues.</li><li>Representative.</li></ul>	N/A
Ground Water								representation of	
Aluminum	N/A	N/A	N/A	N/A	Yes	N/A	>bkgd >MCL	• Unknown vertical and horizontal distribution.	Monitoring
								Unknown attenuation factor	
			27/1			27/4		between source and ground water.	
Hexavalent Chromium	N/A	Random	N/A	N/A	No	N/A	>MCL, >bkgd	• Twenty-two of 42 samples qualified.	No Further Action

**Notes** <sup>1</sup>The time for the site concentration of a radionuclide to decay to a risk endpoint.

Abbreviations

95UCL	95 percent upper confidence limit on the mean
>	greater than
bkgd	background
COPC	constituent of potential concern
DI WET	deionized water waste extraction test
EPC	exposure point concentration
MCL	California Maximum Contaminant Level for ground water (February 2003)
N/A	not applicable

ion

## Basis for Recommendation

## N/A

- DI WET results suggest a potential impact above MCL and background.
- No ground water data are available.
- Residual soil concentrations are below background. on

## 4.7 Domestic Septic System No. 7

Figure 4.7-1 shows the Domestic Septic System No. 7 features.

## 4.7.1 Area Description

Domestic Septic System No. 7 was installed adjacent to the Co-60 Field to receive wastes from the Co-60 irradiator building. This tank was reportedly never used.

## 4.7.2 Pre-Removal Action Contaminant Distribution

Before Domestic Septic System No. 7 could be placed into use, the Co-60 Building was connected to the new sanitary sewer (WA, 2001c). The limited data available for this system suggest that no constituents are present at levels significantly above background levels. It is believed that Domestic Septic Tank No. 7 was demolished in place, possibly during installation of the sanitary sewer line at the Co-60 Building.

## 4.7.3 Removal Action Activities

No removal action was conducted at Domestic Septic System No. 7.

## 4.7.4 Post-Removal Action Contaminant Distribution

Three soil samples were collected from the suspected former location of Domestic Septic Tank No. 7 during the Limited Field Investigation conducted in 1996. All of the chemical and radionuclide concentrations above their respective backgrounds are summarized in Table 4.7-1. Of the 169 analytes, fourteen were detected above background.

## 4.7.5 Summary of Risk Estimate Data

As noted above, samples were collected from Domestic Septic System No. 7 during the 1996 Limited Field Investigation. This investigation is summarized in Table 6-8 of the RI (WA, 2003b). The data set was evaluated and redacted to exclude information associated with samples collected at depths greater than ten ft bgs. Table 4.7-2 provides a summary of sample data used in the Tier 2 risk estimate. The sample locations for all data used in the risk estimate are presented in Figure 4.7-2.

## 4.7.5.1 Quality of Site Data

The data set for the Domestic Septic System No. 7 area included 336 analytical results. Four of these results, or 1.2%, were rejected from the total data set ("R"-qualified). Sample results are rejected when a data validation expert reviewing laboratory data finds evidence of serious deficiencies in the ability to analyze a sample and meet QC criteria. The "R" qualifier indicates that the data cannot be used to verify whether the analyte was present in or absent from the sample. "R"-qualified results were not used in the risk estimate. After "R"-qualified data were removed from the total data set, the final risk estimate data set contained 332 results. Fourteen of the results, or 4.2%, had "J" qualifiers, which indicate that an analyte was positively identified in the sample, but the analytical result is an approximation of the analyte concentration in the sample. Data with "J" qualifiers were used in developing risk estimates. A total of 70 records, or 21%, had "UJ" qualifiers, which mean that an analyte was not detected, but the detection limit is approximate. Data with "UJ" qualifiers were included in the risk estimate and were treated as a non-detection of an analyte.

Fourteen of the 332 final records from the Domestic Septic System No. 7 area were used to generate the Tier 2 human health risk estimate. Four of the fourteen results had "J" qualifiers, and none had "UJ" qualifiers.

## 4.7.6 Risk Characterization—Domestic Septic System No. 7

Consistent with the HHRA Risk Estimate, as discussed in Section 2.2, this risk characterization uses the terms "List 1" and "List 2". List 2 identifies constituents that failed the statistical comparison to background, which may be indicative of a release to the environment. Table 4.7-3, in the first column, provides the List 1 COPCs identified in the HHRA Risk Estimate. The last column of Table 4.7-3 provides only List 2 COPCs and their risk values. The values provided are not corrected for decay. A subset (shown in bold-type) of List 2 contains COPCs that have a risk of at least 10<sup>-6</sup> or contribute more than ten percent of the total excess cumulative cancer risk in the Domestic Septic System No. 7 area.

Specifically, this subset consists of Pb-210 for the hypothetical on-site resident. Pb-210 is identified in this risk characterization as the List 2 driver COPC, since it represents potential site-related risks and is the best candidate for further evaluation in the Feasibility Study. Pb-210 is the focus of the risk characterization discussions that follow. None of the receptors evaluated for this area showed non-cancer hazard quotients above the point of departure of one.

## 4.7.6.1 Exposure Assessment

The exposure assessment for List 2 driver COPCs at the Domestic Septic System No. 7 area includes:

- The spatial distribution of the List 2 driver COPCs;
- Risk from COPC concentrations attributed to site background versus prior site activities; and
- Exposure intake estimates.

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A conceptual site model illustrating exposure pathways and potential human receptors for all DOE areas is provided as Figure 2-1.

## 4.7.6.1.1 Spatial Distribution of Contaminants of Potential Concern

Figure 4.7-3 shows the spatial distribution of sample results for Pb-210. The Pb-210 sample concentrations appeared to indicate less than 10<sup>-6</sup> risk. Sampling at the Domestic Septic System No. 7 area consisted of two discretionary samples collected at one soil boring location as shown in Figure 4.7-2. The samples, LEHR-S-428 and LEHR-S-429, were collected at 7 ft bgs and 9.5 ft bgs, respectively.

## 4.7.6.1.1.1 Lead-210 Distribution

As shown in Figure 4.7-3, both of the reported Pb-210 sample results were below the detection limit and  $10^{-6}$  risk, but above the site background screening value. Nothing can be concluded about the relative distribution of Pb-210 concentrations in Domestic Septic System No. 7, because the samples were collected at the same location laterally, and only 2.5 ft apart vertically.

## 4.7.6.1.2 Degradation and Decay of Contaminants of Potential Concern

The methodology for calculating radionuclide decay is described in detail in Appendix B.

## 4.7.6.1.2.1 Lead-210

Pb-210 (22.3-yr half-life) is naturally occurring and is part of the uranium-decay series, where it is derived from Ra-226 (1,600-yr half-life) and ultimately U-238. These parent isotopes have been characterized at Domestic Septic System No. 7, and found to be at levels consistent with site background. Thus, the decay of the parent isotope will replenish Pb-210 at background concentrations, and any Pb-210 that has been released at levels above background will attenuate over time.

The Pb-210 decay estimate for Domestic Septic System No. 7 is shown in Figure 4.7-4. The Pb-210 site EPC is below the  $10^{-6}$  risk level for the on-site resident.

The decay calculation result may be impacted by data quality deficiencies in the maximum reported Pb-210 concentration. The data quality deficiencies are described below in Section 4.7.6.4.1.1.

## 4.7.6.1.3 Background Evaluation

## 4.7.6.1.3.1 Detections above Site Background

The number of analytical results that were greater than both the detection limits and the background screening levels are reported in Table 4.7-2 for the List 1 COPCs. The one COPC that is a List 2 driver, Pb-210, was not detected above background in any samples. The remainder of the List 1 COPCs were detected above background in zero to two samples.

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## 4.7.6.1.3.2 Parent-Daughter Activity Concentration Relationships

The concentration of Pb-210 at the Domestic Septic System No. 7 area was compared to the concentration of its longer-lived parent, Ra-226, in Appendix E (Figure E-5). As shown, the concentrations of these isotopes appear to be in secular equilibrium when quantified analytical errors are taken into account. This is evidence that the concentration of Pb-210 at the site is due to decay of Ra-226 rather than to a release of Pb-210, because any shorter-lived daughter isotope will have a concentration approximately equal to that of its longer-lived parent isotope, in the absence of excess input of the daughter. The apparent elevated concentration of Pb-210 at the site relative to background, therefore, is probably due to analytical limitations rather than to a release. The concentration of Ra-226, which was measured at much higher precision than was Pb-210, is demonstrably below background concentrations. Therefore, the Ra-226 results suggest that the Ra-226/Pb-210 decay series is not impacting the site.

## 4.7.6.1.3.3 Comparison of Risk Attributed to Background versus Site Activities

Table 4.7-4 presents statistics, including EPCs, for the sample results for Pb-210 at both the site and in the background. The background EPC was calculated using the same method used to calculate the site EPCs (Section 2.2.3.3.1). Table 4.7-4 also presents the decay-corrected EPCs. EPCs can be used to derive relative contributions of risk because risk is directly proportional to the EPC. At Domestic Septic System No. 7, however, the relative contributions from site activities and background cannot be accurately quantified. This is due to serious data quality deficiencies in the reported Pb-210 data, as described in Section 4.7.6.4.1.1. In addition, the site EPC is the highest-measured concentration, and is therefore not comparable to the background EPC, which is the 95% UCL.

## 4.7.6.2 Toxicity Assessment

Toxicity values for COPCs in the Domestic Septic System No. 7 area were taken from US EPA guidance as discussed in Section 2.2.4. The toxicity values used for these COPCs are appropriate for this evaluation and make use of the best available information.

## 4.7.6.3 Risk Estimate

Table 4.7-3 summarizes the risk estimate information for the hypothetical future on-site resident. It shows that Pb-210 risk is primarily due to plant ingestion (56%) and soil ingestion (33%), with a secondary contribution from external radiation (11%). Dust inhalation does not contribute significant Pb-210 risk. The estimated risks may be impacted by data quality deficiencies in the reported Domestic Septic System No. 7 Pb-210 data. The data quality deficiencies are described in Section 4.7.6.4.1.1 below.

## 4.7.6.4 Uncertainty

Risk estimates are values that have uncertainties associated with them, as discussed in Section 2.2.6. The objective of this section is to discuss the major sources of uncertainty that are specific to this refined assessment of Domestic Septic System No. 7. These include data coverage and analytical issues.

### 4.7.6.4.1 Analytical Issues

## 4.7.6.4.1.1 Lead-210

The Domestic Septic System No. 7 EPC was based on a data set containing two sample results that had marginal data quality. Both of the Pb-210 results had high detection limits and counting errors. The results were  $4.1 \pm 9.1$  pCi/g (Sample LEHR-S-428) and  $3.2 \pm 7.1$  pCi/g (Sample LEHR-S-429) with detection limits of 12 pCi/g and 9.8 pCi/g, respectively. Based on the total error for sample LEHR-S-428, its concentration could range from less than zero to 13.2 pCi/g.

The Pb-210 data are not sensitive or accurate enough to determine whether Pb-210 was released at Domestic Septic System No. 7. The lowest detection limit was more than six times the background screening value of 1.6 pCi/g, and the lowest counting error was more than four times the background screening value.

The  $10^{-6}$  risk threshold corresponds to a Domestic Septic System No. 7 EPC value of 4.6 pCi/g. The risk could be above or below  $10^{-6}$  with almost equal probability, based on the results for samples LEHR-S-428 and LEHR-S-429 of 4.1 ±9.1 pCi/g and 3.2 ±7.1 pCi/g, respectively. No conclusion can be drawn whether Pb-210 at Domestic Septic System No. 7 poses greater than or less than  $10^{-6}$  risk.

The  $10^{-5}$  risk threshold corresponds to a Domestic Septic System No. 7 EPC value of 46 pCi/g. Based on the sample detection limits (12 pCi/g and 9.8 pCi/g), it is possible to conclude with reasonable certainty that the risk at the soil boring location is less than  $10^{-5}$ .

## 4.7.6.4.2 Data Representativeness

The locations and depth range of both samples collected in the Domestic Septic System No. 7 area are shown in Figure 4.7-2. Sample coverage was limited at Domestic Septic System No. 7, because it was reportedly never used. Sampling consisted of a single discretionary soil boring with samples collected at 7 ft and 9.5 ft bgs. Other septic systems at the Site had the highest levels of contamination in the leach fields and inside the tanks. No leach field or tank was identified or sampled in the Domestic Septic System No. 7 area.

## 4.7.6.5 Relation of Concentrations of Contaminants of Potential Concern to Site Operations

Pb-210 is a naturally occurring isotope that is associated with LEHR operations, since it is a daughter product of Ra-226. However, Pb-210 should not have been released at Domestic Septic System No. 7, because Domestic Septic System No. 7 was reportedly never used.

## 4.7.7 Ground Water Impacts

In addition to evaluation of human health risk resulting from soil contamination, potential ground water impacts from contaminants remaining in the soil at Domestic Septic Tank No. 7 were evaluated and are presented in the RI (WA, 2003b). No List 2 driver COPCs were identified in the area.

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## 4.7.7.1 Risk Characterization of Constituents of Potential Ground Water Concern

Based on the limited soil sample data and historical information indicating that Domestic Septic Tank No. 7 had never been operated, ground water impacts are not anticipated for Domestic Septic System No. 7, and no ground water modeling has been conducted.

## 4.7.8 Risk Characterization Summary and Recommendations Regarding Contaminants of Concern at Domestic Septic System No. 7

Risk characterization findings and recommended COCs at Domestic Septic System No. 7 are summarized below and presented in Table 4.7-5.

### 4.7.8.1 Human Health

Pb-210 was found in the Domestic Septic System No. 7 area in concentrations exceeding site background. The concentrations correspond to a decay-corrected cancer risk to the on-site resident of 7 x  $10^{-7}$ , which is below the CERCLA point of departure. However, the Pb-210 data used to estimate that risk is of poor quality and may underestimate the risk. Because of the operational history indicating that no discharge or release occurred at Domestic Septic System No. 7, it is most likely that the presence of Pb-210 is an artifact of analytical imprecision. Therefore, Pb-210 should not be retained as a COC in the Feasibility Study.

## 4.7.8.2 Ground Water

Based on the limited soil sample data and historical information about Domestic Septic System No. 7, ground water impacts are not anticipated for Domestic Septic System No. 7.



Figure 4.7-1. Domestic Septic System No. 7 Features



Figure 4.7-2. Domestic System No. 7 Area Sample Locations and Depths 4108-142-DSS7.ai



Figure 4.7-3. Lead-210 Spatial Analysis, Domestic Septic System No. 7 Area

4108-142-DSS7\_Pb-210.ai



Figure 4.7-4. Decay of Lead-210 at Domestic Septic System No. 7 Area

## Table 4.7-1. Analytes Detected above Background in Soil at the Domestic Septic System No. 7 Area

Constituent	Units	Number of Samples	Number of Samples > Background <sup>1</sup>	Number of Samples > PRG <sup>2</sup>	Maximum Concentration	Depth (ft)
Cobalt-60	mg/kg	3	2	0	0.009	7
Formaldehyde	mg/kg	3	1	1	2.2	12
Gross Alpha	pCi/g	3	2	0	9.9	9.5
Gross Beta	pCi/g	3	1	0	17.3	9.5
Lead-210	pCi/g	3	3	0	5.5	12
Manganese	mg/kg	3	1	1	790	7
Mercury	mg/kg	3	1	1	0.35	9.5
Molybdenum	mg/kg	3	3	0	0.51	7 and 9.5
Nickel	mg/kg	3	3	0	250	7 and 9.5
Nitrate	mg/kg	3	1	0	120	9.5
Radium-226	pCi/g	3	1	1	0.85	12
Strontium-90	pCi/g	3	3	0	0.45	12
Uranium-235	pCi/g	3	2	0	0.1	7
Zinc	mg/kg	3	1	0	110	12

#### Notes

Data from the Remedial Investigation Report (WA, 2003b).

Contaminant data includes data collected from all depth intervals instead of the 0-10 ft interval used in the risk estimate.

<sup>1</sup>Lowest site-specific background. Lowest background concentration is the lower of the shallow (0-4 ft) and the deep (4-40 ft) soil background screening values for vertically stratified analytes.

<sup>2</sup>Chemical PRGs for residential soil are from US EPA Region 9 PRGs table, dated October 1, 2002. Radionuclide PRGs for residential soil are from Radionuclide Toxicity and PRGs for Superfund, dated April 14, 2003 (US EPA, http://epa-prgs.orrl.gov/radionuclides/ download/rad\_master\_prg\_table.xls).

>	greater than
ft	feet
mg/kg	milligrams per kilogram
pCi/g	picoCuries per gram
PRG	preliminary remediation goal
US EPA	United States Environmental Protection Agency

## Table 4.7-2.Summary of Sampling Results Used in the Risk Estimate at the Domestic Septic<br/>System No. 7 Area

List 1 COPC	Total Samples	Number of Detections	Number of Detections > Background	Concentration Range <sup>1</sup>	Background Screening Concentration <sup>2</sup>	ID of Sample with Highest Concentration	Depth of Sample with Highest Concentration (ft)
Metals				mg/kg	mg/kg		
Arsenic	2	2	0	8.2 - 8.6	9.6	LEHR-S-429	9.5
Radionuclides				pCi/g	pCi/g		
Lead-210	2	0	0	3.2 - 4.1	1.6	LEHR-S-428	7
Potassium-40	2	2	0	11.2 - 12.4	14	LEHR-S-428	7
Radium-226	4	4	0	0.48 - 0.75	0.75	LEHR-S-429	9.5
Strontium-90	2	2	2	0.26 - 0.27	0.056	LEHR-S-429	9.5

#### Notes

Source: COPC data from the HHRA Risk Estimate, Appendix A (UC Davis, 2005).

<sup>1</sup>The concentration ranges for metals and radionuclides include non-detects.

<sup>2</sup>The background screening concentrations are the unstratified background screening values in Appendix B of the HHRA Risk Estimate.

>	greater than
COPC	constituent of potential concern
ft	feet
HHRA	Human Health Risk Assessment
ID	identification (number)
mg/kg	milligrams per kilogram
pCi/g	picoCuries per gram

Table 4.7-3. Human Health Risks to On-Site Resident by Exposure Route for Contaminants of Potential Concern in the Domestic Septic System No. 7 Area

CANCER RISK BY EXPOSURE ROUTE										
List 1 COPC	EPC <sup>1</sup> (0-10 ft)	Soil Ingestion	Soil Dermal Exposure	Above-Ground Plant Ingestion <sup>2</sup>	Below-Ground Plant Ingestion <sup>2</sup>	External Radiation	Dust Inhalation	Total Cancer Risk	Statistical Background Comparison <sup>3</sup>	List 2 Cancer Risk <sup>4</sup>
Arsenic	8.6	2.E-05	1.E-06	9.E-05	3.E-05	-	1.E <b>-</b> 08	1.E-04	Pass	-
Lead-210	4.1	3.E-07	-	5.E-07	-	1.E-07	5.E-10	9.E-07	Fail	9.0E-07
Potassium-40	12	2.E-08	-	5.E-07	-	7.E-05	1.E-12	7.E-05	Pass	-
Radium-226	0.75	4.E-08	-	1.E-07	-	5.E-05	1.E-10	5.E-05	Pass	-
Strontium-90	0.27	1.E-09	-	3.E-08	-	3.E-08	3.E-13	6.E-08	Fail	6.E-08
TOTAL								3.E-04		1.E-06
			]	HAZARD QUOTIEN	T BY EXPOSURE ROU	ТЕ				
List 1 COPC	EPC <sup>1</sup>	Soil Ingestion	Soil Dermal Exposure	Above-Ground Plant Ingestion	Below-Ground Plant Ingestion	External Radiation	Dust Inhalation	Non-Cancer Hazard Index	Statistical Background Comparison <sup>3</sup>	List 2 Non-Cancer Hazard Risk <sup>4</sup>
Arsenic	8.6	3.7E-01	3.1E-02	2.0E+00	2.4E-01	-	-	2.6E+00	Pass	-
TOTAL								2.6E+00		-

Notes

Source Data from HHRA Risk Estimate, Tables 7 and 8. Statistical Background Comparison from Appendix B (UC Davis, 2005).

The non-cancer risk is for a resident child; for cancer risk it is an age-adjusted adult.

List 2 constituents shown in **bold-type** text contribute at least 10<sup>6</sup>, or greater than 10%, to the excess cumulative cancer risk. Rounding may affect the total List 2 cancer risk values shown in the last column. Determination of whether the risk is greater than ten percent of total List 2 cancer risk is based on unrounded values.

<sup>1</sup>The 95% upper confidence limit on the mean of the exposure point concentration; chemical concentrations are in milligrams per kilogram and radionuclide concentrations are in picoCuries per gram.

<sup>2</sup>For radionuclides, plant ingestion is not subdivided into above-ground and below-ground plants.

<sup>3</sup>Based on Wilcoxon Rank Sum test or other statistical comparisons, as shown in Appendix B of the HHRA Risk Estimate.

<sup>4</sup>Dashes indicate that constituent was not identified as a List 2 COPC, since it was identified to be statistically equivalent to background.

#### Abbreviations

- not calculated COPC constituent of potential concern EPC exposure point concentration ft feet HHRA Human Health Risk Assessment

# Table 4.7-4.Data Summary—Comparison of Exposure Point Concentrations to Site Background at the Domestic Septic System No. 7<br/>Area (Human Health)

Analyte	Detections	Samples	Min Detect	Max Detect	Min Detection Limit	Max Detection Limit	Average <sup>1</sup>	Standard Deviation <sup>1</sup>	Distribution	95UCL <sup>1</sup>	EPC	Decay- Corrected EPC <sup>2</sup>
Site (0 to 10 ft)			pCi/g	pCi/g	pCi/g	pCi/g	pCi/g	pCi/g		pCi/g	pCi/g	pCi/g
Lead-210	0	2	N/A	N/A	9.8	12	3.65	0.64	Non-parametric	N/A <sup>3</sup>	4.1 <sup>4</sup>	3.4
Background (0 t	o 10 ft)											
Lead-210	6	26	0.703	2.49	0.209	5.08	0.719	0.697	Non-parametric	0.95	0.95	0.95

#### Notes

Source: COPC data from Appendix A from HHRA Risk Estimate (UC Davis, 2005). 95UCL calculations for background concentrations and decay corrections added."

<sup>1</sup>Negative concentration values were set to zero and concentrations below the detection limit were used to determine the 95UCL, average, and standard deviation for radionuclides. Same as 95UCL calculation procedure used in HHRA Risk Estimate (UC Davis, 2005).

<sup>2</sup>The EPC was decay-corrected to April 2005 (see Figure 4.7-4 and Appendix A).

<sup>3</sup>95UCL was not calculated because of insufficient number of samples.

<sup>4</sup>Maximum reported concentration (4.1 pCi/g) was below the detection limit (12 pCi/g).

95UCL	95 percent upper confidence limit on the mean
EPC	exposure point concentration
ft	feet
HHRA	Human Health Risk Assessment
max	maximum
min	minimum
N/A	not applicable
pCi/g	picoCuries per gram
Table 4.7-5. Summary of Major Factors Driving Risk and Recommendations for Future Action at Domestic Septic System No. 7 Area

Driver COPC	Total Cancer Risk <sup>1</sup>	Spatial Distribution	Background Contribution <sup>2</sup>	Above- Background Contribution <sup>3</sup>	Historically Used at the Site	Time for Attenuation to Risk Endpoint <sup>4</sup> (years)	Level of Ground Water Impact	Uncertainty	Recommended Act
On-Site Resident Lead-210	<7E-7 <sup>5</sup>	Undetermined	N/A	N/A	No	$< 0^{6}$	N/A	• Characterization/EPC uncertain due to limited samples (two) with marginal data quality	No Further Action
Ground Water None							_	_	-

Notes

<sup>1</sup>For radionuclides, values are decay-corrected to April 2005 (see Figure 4.7-4 and Appendix B). <sup>2</sup>The background contribution is the proportion of the site EPC that can be attributed to the background EPC (see Table 4.7-4).

<sup>3</sup>The above-background contribution is the proportion of the site EPC that is greater than the background EPC.

<sup>4</sup>The time for attenuation to risk endpoint is the time, from April 2005, for the site EPC of a radionuclide to decay to either the background EPC or the concentration equivalent to a risk of 10<sup>-6</sup>, whichever is greater.

<sup>5</sup>The decay-corrected risk is estimated at 7 x  $10^{-7}$ , however the data quality issues affected this estimate and may underestimate the risk. <sup>6</sup>As of April 2005, the site concentration is less than the concentration equivalent to risk of  $10^{-6}$ .

#### Abbreviations

< less than COPC constituent of potential concern EPC exposure point concentration not applicable N/A

ion	Basis for Recommended Action	
n	<ul> <li>No evidence of release.</li> <li>Decay-corrected risk is likely below 1E-6.</li> </ul>	

# 4.8 Dry Wells A-E

Figure 4.8-1 shows the Dry Wells A-E features.

# 4.8.1 Area Description

Dry Wells A-E were discovered during the 1999 Radium/Strontium Treatment Area I removal action. Dry Wells A-E features were found to consist of a leach system containing five dry wells (A-E), a distribution box and piping (Figure 4.8-1). Dry Wells A-E were not connected to any domestic septic tanks when they were discovered in 1999. According to historical records, all of the domestic septic tank influent and effluent lines were cut and capped in 1971. This leach system is believed to have received waste water from Domestic Septic Tank Nos. 1 and 5, based on distribution pipe locations identified during field investigation and existing site maps. The dry wells were designed to discharge waste water to soil beneath a depth of about six ft.

# 4.8.2 Pre-Removal Action Contaminant Distribution

During the 1999 removal action, investigation samples were collected from Dry Wells A-E, and are summarized in Table 4.8-1. The maximum Ra-226 and Cs-137 concentrations and the majority of the highest metals concentrations were reported in a sample (CWRSC024) collected in soil 9.5 ft bgs at the southwestern edge of Dry Well D.

# 4.8.3 Removal Action Activities

In 1999, after the investigation samples indicated metal contamination at the southwestern edge of Dry Well D, the upper portions of Dry Wells A-E were removed to depths ranging from 8 to 20 ft bgs. Excavation in the vicinity of Dry Wells A, B, C, and E reached a depth of eight ft bgs. Dry Well D was excavated to a depth of 20 ft bgs, the maximum reach of the excavator. Gravel was observed to the maximum excavation depth, indicating that Dry Well D is at least 20 ft deep. A distribution box was located approximately one ft bgs and measured four ft wide by four ft long by three ft high. The distribution box was removed and the area was excavated to a depth of approximately 5.5 ft. The soil and rock were containerized and shipped off site for disposal. The concrete removed from this area was pulverized and also shipped off site for disposal. Following excavation and waste removal, the area was backfilled and compacted using an excavator with a compaction wheel. The lower portions of the dry wells were not removed.

# 4.8.4 Post-Removal Action Contaminant Distribution

Soil samples were collected in the Dry Wells A-E area during the 2001 Domestic Septic Systems investigation (after the completion of removal action activities in 1999). Soil samples were

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collected at 10, 20, 30, and 40 ft bgs from a borehole located approximately two ft from the axis of each dry well. The sample results are summarized in the RI (WA, 2003b). Of the 173 analytes, 24 were detected at concentrations greater than their respective backgrounds and four were detected above their respective PRGs.

At Dry Well A, cadmium, Cs-137, Hg and silver were detected at concentrations greater than their respective background concentrations. The Hg concentrations of 1.2 and 1.7 mg/kg were over four times greater than the background concentration of 0.248 mg/kg. The maximum reported cadmium concentration of 0.54 mg/kg was only 0.03 mg/kg above background. Silver was detected at 7 mg/kg, and Cs-137 was detected at 0.191±0.0078 pCi/kg.

At Dry Well B, cadmium, Cs-137, manganese, Hg and silver were detected at concentrations greater than their respective background concentrations. Hg was detected at concentrations above background in three of four samples. The maximum reported Hg concentration of 0.49 mg/kg was less than two times the background concentration. Maximum cadmium, Cs-137, manganese and silver concentrations were all less than two times their background.

At Dry Well C, barium, cadmium, lead, manganese, Hg and silver were detected in concentrations greater than their respective background levels. Hg was detected in concentrations above background in all four samples. The maximum reported Hg concentration of 1.5 mg/kg was over six times the background concentration. Silver was detected at concentrations above background in three of four samples. The maximum reported barium concentration of 608 mg/kg was over two times background. Maximum cadmium, manganese and lead concentrations were all less than 1.5 times their background concentrations.

A total of four soil borings were drilled surrounding Dry Well D to determine if the 1999 removal action successfully removed contamination near the sample collected at the southwestern edge of Dry Well D. All of the borings were drilled within two ft of the axis of the dry well.

Lead and manganese were detected in concentrations greater than their respective background values in samples collected from boring D-1, drilled southeast of the center of Dry Well D. Manganese was detected above background in all three samples. The maximum reported manganese concentration of 1,010 mg/kg is less than 1.5 times the background concentration. The maximum reported lead concentration, 9.9 mg/kg, was slightly above the background concentration of 9.5 mg/kg.

Hg and silver were detected in concentrations greater than their respective background values in samples collected from borings D-2 and D-3, drilled southeast and southwest, respectively, of the center of Dry Well D. Hg was detected above background in four of six samples at 10 and 15 ft bgs. The maximum reported Hg concentration of 1.4 mg/kg is over five times the background concentration. Silver was detected above background in three of six samples. The Hg concentration of 1.5 mg/kg was over six times the background concentration, at a depth between 38 and 42 ft.

At Dry Well E, Hg and silver were detected at concentrations greater than their respective background levels. The maximum reported Hg concentration of 0.45 mg/kg was less than two times the background concentration. The maximum reported silver concentration was 6.7 mg/kg.

# 4.8.5 Summary of Risk Estimate Data

Data used in the human health risk estimate were collected during various investigations and sampling events that were conducted at the Dry Wells A-E. Information used in the risk estimate included data from the:

- Limited Field Investigation;
- Data Gaps Investigation;
- 1999 Radium/Strontium Treatment Systems Area I removal action; and
- 2001 Domestic Septic System Investigation.

These various investigations are summarized in Table 6-8 of the RI, and details of the 2001 Domestic Septic System Investigation are presented in Appendix B of the same report (WA, 2003b). Although all radionuclide waste from the LEHR operations was being treated in the Radium/Strontium Treatment Systems at the time that Dry Wells A-E were installed, there is a potential that a wide variety of radionuclide and chemical lab waste were improperly discharged into these systems. Samples collected in the areas of the Dry Wells A-E were therefore analyzed for a broad suite of chemicals and radionuclides.

The confirmation sample data were combined with prior characterization data that were determined to be representative of post-removal conditions. The combined data set was then evaluated in the risk estimate. Table 4.8-2 provides a summary of all data used in the Tier 2 risk estimate. The sample locations for all data used in the risk estimate are presented in Figure 4.8-2.

Any contaminant releases in the Dry Wells A-E area were considered to be subsurface only for the purposes of the risk estimate, since:

- Leach system process information and observations of the dry wells during removal action excavations indicated that any potential contaminant releases would have occurred below a depth of six ft;
- Contamination control practices were employed during the removal action to prevent surface contamination; and
- All of the excavations were backfilled with clean fill.

As a result, the risk estimate did not evaluate surface soil exposure to potential receptors, except the hypothetical site resident. Surface soil exposures for the hypothetical site resident were developed using EPCs derived from the zero- to ten-ft data set to be conservative.

# 4.8.5.1 Quality of Site Data

The data set for the Dry Wells A-E area included 1,712 analytical results. None of these results were rejected from the total data set ("R"-qualified). Ninety-eight of the results, or 5.7%, had "J" qualifiers, which indicate that an analyte was positively identified in the sample, but the analytical result is an approximation of the analyte concentration in the sample. Data with "J" qualifiers were used in developing risk estimates. A total of one hundred sixty-one records, or 9.4%,

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had "UJ" qualifiers, which mean that an analyte was not detected but the detection limit is approximate. Data with "UJ" qualifiers were included in the risk estimate, and were treated as a non-detection of an analyte.

Eighty of the 1,712 final records from the Dry Wells A-E area were used to generate the Tier 2 human health risk estimate. Six of the 80 results had "J" qualifiers, and none had "UJ" qualifiers.

## 4.8.6 Risk Characterization—Dry Wells A-E

Consistent with the HHRA Risk Estimate, as discussed in Section 2.2, this risk characterization uses the terms "List 1" and "List 2". List 2 identifies constituents that failed the statistical comparison to background, which may be indicative of a release to the environment. Table 4.8-3 through Table 4.8-6, in the first column, provide the List 1 COPCs identified in the HHRA Risk Estimate. The last column of Table 4.8-3 through Table 4.8-6 provides only List 2 COPCs and their risk values. The values provided are not corrected for decay. A subset (shown in bold-type) of List 2 contains COPCs that have a risk of at least 10<sup>-6</sup> or contribute more than ten percent of the total excess cumulative cancer risk in the Dry Wells A-E area.

Specifically, this subset consists of:

- Arsenic (for cancer and non-cancer risk), Ra-226, and Th-228 for the hypothetical on-site resident;
- Ra-226 and Th-228 for the outdoor research worker;
- Ra-226 and Th-228 for the indoor research worker; and
- Arsenic, Ra-226, and Th-228 for the construction worker.

The constituents in this subset are identified in the risk characterization as List 2 driver COPCs, since these COPCs represent potential site-related risks, and are the best candidates for further evaluation in the Feasibility Study. These COPCs are the focus of the risk characterization discussions that follow.

Because of the subsurface release conditions discussed above, the only open exposure pathway in the risk estimate for the indoor and outdoor researcher at Dry Wells A-E was external radiation, based on an EPC developed using the 0- to 10-ft data set. The risk estimate approach likely overestimates the risk to indoor and outdoor researchers, since the radiation attenuation provided by several ft of imported fill overlying the potentially contaminated soil was not accounted for. Future movement of the contaminated soil to the surface may increase the risk to the outdoor researcher and other receptors, but the levels would be less than the hypothetical residential exposure, due to shortened exposure durations and the lack of plant ingestion.

#### 4.8.6.1 Exposure Assessment

The exposure assessment for List 2 driver COPCs at the Dry Wells A-E area includes:

- The spatial distribution of the List 2 driver COPCs with figures showing sample locations;
- Further evaluation of risk from COPC concentrations attributed to site background versus prior site activities; and
- A discussion of the exposure intake estimates and their effect on the overall risk estimate.

A conceptual site model illustrating exposure pathways and potential human receptors for all DOE areas is provided as Figure 2-1.

# 4.8.6.1.1 Spatial Distribution of Contaminants of Potential Concern

Figure 4.8-3 through Figure 4.8-5 show the spatial distribution of sample results for arsenic, Ra-226, and Th-228, respectively.

None of the samples contained Ra-226 concentrations corresponding to a risk greater than  $10^{-4}$ , and none of the samples contained Th-228 concentrations corresponding to a risk greater than  $10^{-5}$ . Sample results for arsenic, however, did correspond to a risk above  $10^{-4}$ .

Sampling at Dry Wells A-E covers the entire area except Dry Well E (Figure 4.8-1 and Figure 4.8-2). Samples were collected at Dry Well E, but at depths below the zero- to ten-ft soil horizon used in the risk estimate. The sample locations were not part of a random grid, but represent discretionary sampling performed within the potential areas of contamination.

# 4.8.6.1.1.1 Arsenic Distribution

The spatial analysis of arsenic samples is presented in Figure 4.8-3. Arsenic was detected in all of the samples. One sample, located between the distribution box and Dry Well C, had an arsenic concentration of 10.8 mg/kg that was above the site background screening value of 9.6 mg/kg. The estimated cancer risk to a hypothetical on-site resident for this slightly elevated arsenic concentration is between  $10^{-4}$  and  $10^{-3}$ , and the non-cancer hazard quotient is above one.

The remaining twelve samples had arsenic concentrations below the background screening value. All of the estimated cancer risks associated with these samples are between  $10^{-4}$  and  $10^{-3}$  for the hypothetical on-site resident. All of the non-cancer hazard quotients are above one for the resident. Construction worker cancer risks are uniformly below  $10^{-6}$ .

The spatial distribution of arsenic at Dry Wells A-E does not appear to indicate localized areas of contamination.

# 4.8.6.1.1.2 Radium-226 Distribution

The spatial analysis of Ra-226 samples is presented in Figure 4.8-4. Ra-226 was detected in all of the samples and all of the results were below the background screening value. Ra-226 is a List 2 driver COPC for the hypothetical on-site resident, outdoor research worker, indoor research worker, and construction worker. The estimated risks associated with all of the sample results are

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between  $10^{-5}$  and  $10^{-4}$  for both the hypothetical on-site resident and outdoor research worker. All of the sample results indicate risks ranging from  $10^{-6}$  and  $10^{-5}$  for the indoor research worker. The risks to the construction worker are between  $10^{-6}$  and  $10^{-4}$ .

There may be slightly higher Ra-226 concentrations near the distribution box and lower concentrations near Dry Wells A, B, and C. However, the range of concentrations only spans  $0.43\pm0.22$  pCi/g to  $0.675\pm0.0911$  pCi/g. This apparent localized difference in sample concentration is not likely large enough to indicate any significant spatial variability.

# 4.8.6.1.1.3 Thorium-228 Distribution

The Th-228 spatial analysis is shown in Figure 4.8-5. Two samples located near Dry Well C had concentrations above the background screening value. The concentrations found above background were  $0.771\pm0.339$  pCi/g and  $0.764\pm0.297$  pCi/g and the background screening value is 0.74 pCi/g. These two sample results are only slightly above background.

The estimated risk associated with all of the sample results is between  $10^{-6}$  and  $10^{-5}$  for the hypothetical on-site resident and outdoor research worker. All of the sample results indicate risks below  $10^{-6}$  for the indoor research worker and construction worker.

The concentration range of Th-228 at Dry Wells A-E was  $0.604\pm0.309$  pCi/g to  $0.771\pm0.297$  pCi/g, which indicates very little variability. It is difficult to conclude whether the two results exceeding background located near Dry Well C represent a localized area of elevated Th-228 concentration. The two results above background are not significantly elevated above the rest of the data.

# 4.8.6.1.2 Degradation and Decay of Contaminants of Potential Concern

The methodology for calculating radionuclide decay is described in detail in Appendix B.

# 4.8.6.1.2.1 Radium-226

Ra-226 (1,600-yr half-life) was used extensively in experiments at the LEHR site, and could have been released at Dry Wells A-E due to improper disposal. Ra-226 is also naturally occurring and is part of the uranium-decay series, where it is derived from U-238. Natural uranium will replenish Ra-226 at background concentrations.

The Ra-226 decay estimate for Dry Wells A-E is shown in Figure 4.8-6. Based on the half-life of Ra-226, the site EPC should decay to within 1% of the background EPC in less than 6,000 years. The Ra-226 EPC is not expected to decay to concentrations equivalent to the risks of  $10^{-6}$  for the on-site resident, outdoor researcher or indoor researcher receptors, because these concentrations are less than the background concentration. The site EPC will decay to a concentration equivalent to a risk of  $10^{-6}$  for the on-site construction worker receptor in 36 years.

### 4.8.6.1.2.2 Thorium-228

Th-228 (half-life of 1.9 yrs) is naturally occurring and is part of the thorium-decay series, where it is derived from its primordial Th-232 parent (half-life of  $1.4 \times 10^{10}$  yrs). The decay estimate for Th-228 at the Dry Wells A-E is shown in Figure 4.8-7.

Based on the Th-228 half-life, the site EPC should decay to within 1% of the background EPC in approximately five years. The Th-238 EPC is not expected to decay to concentrations equivalent to the risks of  $10^{-6}$  for the on-site resident or outdoor researcher, because these concentrations are less than the background concentration. The site EPC is less than the concentration equivalent to a risk of  $10^{-6}$  for both the on-site indoor researcher and on-site construction worker receptors.

# 4.8.6.1.3 Background Evaluation

## 4.8.6.1.3.1 Detections above Site Background

The number of analytical results that were greater than both the detection limits and the background screening levels are reported in Table 4.8-2 for the List 1 COPCs. The three COPCs that are the List 2 drivers, arsenic, Ra-226 and Th-228 were detected above background in one, zero and two samples, respectively. The remainder of the List 1 COPCs were detected above background in zero to four samples.

# 4.8.6.1.3.2 Parent-Daughter Activity Concentration Relationships

The concentration of Ra-226 at the Dry Wells A-E area was compared to the concentration of its shorter-lived daughter, Pb-210, in Appendix E (Figure E-6). As shown, the concentrations of these isotopes appear to be in secular equilibrium when quantified analytical errors are taken into account. This is evidence that the concentration of Ra-226 at the site is not due to a release. Any shorter-lived daughter isotope will eventually reach a concentration approximately equal to that of its longer-lived parent isotope, but the relatively long half-life of Ra-226, compared to the relatively short history of the site, would preclude the present equilibrium concentration with Pb-210 had there been a release of Ra-226. The apparent elevated concentration of Ra-226 at the site relative to background, therefore, is probably due to analytical limitations rather than to a release.

The concentration of Th-228 at the Dry Wells A-E area was compared to the concentration of its longer-lived parent, Th-232, in Appendix E (Figure E-7). As shown, the concentrations of these isotopes appear to be in secular equilibrium when quantified analytical errors are taken into account. This is evidence that the concentration of Th-228 at the site is due to decay of Th-232 rather than to a release of Th-228, because any shorter-lived daughter isotope will have a concentration approximately equal to that of its longer-lived parent isotope, in the absence of excess input of the daughter. The apparent elevated concentration of Th-228 at the site relative to background, therefore, is probably due to analytical limitations rather than to a release.

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4.8.6.1.3.3 Comparison of Risk Attributed to Background versus Site Activities

Table 4.8-7 presents statistics, including EPCs, for the sample results of the List 2 driver COPCs at both the site and in the background. The background EPCs were calculated using the same method used to calculate the site EPCs (Section 2.2.3.3.1). Table 4.8-7 also presents decay-corrected EPCs for radionuclides. EPCs can be used to derive relative contributions of risk because risk is directly proportional to the EPC.

Figure 4.8-8 to Figure 4.8-11 graphically illustrate the site risks to each receptor from each List 2 driver COPC, and the relative contributions to those risks from the background. These risks and proportions have been corrected for decay for the radionuclides.

The background contribution to the arsenic risk is 88%. The background contribution to the Ra-226 risk is 89%. The background contribution to the Th-228 risk is 94%.

Although the site EPC is above the background EPC for arsenic and the HHRA Risk Estimate background-screening results indicated arsenic was above background at Dry Wells A-E, natural arsenic stratification has not been addressed. Natural arsenic concentrations in LEHR soil are known to increase with depth, and the Dry Wells A-E samples were collected from a deeper soil interval than the background samples. The arsenic background samples were collected at ground surface and four ft bgs. The arsenic samples at Dry Wells A-E were collected between 5 and 10 ft bgs. Because natural arsenic concentrations are vertically stratified, and no arsenic background samples have been collected within the same depth range as Dry Wells A-E samples, a background data gap exists. No background arsenic data are available from the same depth interval to determine whether arsenic is above or below background in the Dry Wells A-E area.

# 4.8.6.2 Toxicity Assessment

Toxicity values for COPCs in the Dry Wells A-E area were taken from US EPA guidance as discussed in Section 2.2.4. The toxicity values used for these COPCs are appropriate for this evaluation and make use of the best available information.

# 4.8.6.3 Risk Estimate

Table 4.8-3 summarizes the risk estimate information for the hypothetical future on-site resident. This table shows that arsenic risk is primarily due to plant ingestion (86%), with a secondary contribution from soil ingestion (13%) and minimal contribution from dermal exposure (1%). External radiation is the only exposure route that contributes significant resident risk for Ra-226 and Th-228.

Table 4.8-4 and Table 4.8-5 summarize the risk estimate information for the outdoor and indoor researchers. Based on the assumption that current conditions will persist, the risk estimate bases the outdoor and indoor researcher's risk solely on external radiation. Most of the List 2 risk for outdoor and indoor researchers is from Ra-226 (87%). Th-228 contributes 13% to the outdoor and indoor researcher's List 2 risk. Due to radiological decay, the Th-228 risk should decline to background levels in 2010. However, the Ra-226 risk will not decline to background levels for several thousand years.

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Table 4.8-6 summarizes the risk estimate information for the construction worker. This table shows that arsenic risk is primarily due to soil ingestion (91%), with a secondary contribution from soil dermal exposure (8%), and a minimal contribution from dust inhalation (1%). External radiation is the only exposure route that contributes significant construction worker risk for Ra-226 and Th-228.

## 4.8.6.4 Uncertainty

Risk estimates are values that have uncertainties associated with them, as discussed in Section 2.2.6. The objective of this section is to discuss the major sources of uncertainty that are specific to this refined assessment of Dry Wells A-E. These include data coverage and analytical issues.

# 4.8.6.4.1 Analytical Issues

## 4.8.6.4.1.1 Arsenic

The arsenic data set was composed of reasonably good quality data. All of the reported sample concentrations were above their detection limits. Ten of the thirteen samples were not qualified during data validation. Three samples were qualified due to matrix duplicate imprecision, which is assigned when the relative percent difference between a sample concentration and its matrix duplicate is above the control limit. Matrix duplicate precision is determined in the laboratory by analyzing the same sample twice. Because the qualifications are due to precision rather than accuracy, and qualifiers were applied to only 23% of the data, the EPC accuracy and estimated risk were not likely affected. The data qualifications did not indicate a high or low bias.

# 4.8.6.4.1.2 Radium-226

No accuracy issues were identified for the Ra-226 results. All of the reported sample concentrations were above their detection limits and the counting errors were relatively small. None of the data were qualified during data validation.

# 4.8.6.4.1.3 Thorium-228

No accuracy issues were identified for the Th-228 results. The reported concentrations were above the detection limits and the counting errors were relatively small. None of the data were qualified during data validation.

# 4.8.6.4.2 Data Representativeness

In 1999, discretionary soil samples were collected in the Dry Wells A-E area while the removal action was conducted. In 2001, additional discretionary soil samples were collected around Dry Well D. Soil boring samples were collected in 2001, next to each of the dry wells, to characterize deep subsurface soil. The 1999 and 2001 samples were collected at depths ranging from five ft bgs to forty ft bgs. Only samples collected at depths less than or equal to ten ft bgs were used in the risk estimate. No surface soil samples (0 to 0.5 ft bgs) were collected in Dry Wells A-E, because the contamination was released to subsurface soil and the contaminant chemical characteristics and subsurface physical conditions were unlikely to result in surface contamination

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(i.e., upward volatile compound diffusion, shallow water table fluctuation). Clean surface fill was placed in the excavated areas after the removal action.

As shown in Figure 4.8-2, subsurface soil samples are located in the vicinity of Dry Wells A, B, C, and D, and around the distribution box and piping. No samples were collected between zero and ten ft bgs near Dry Well E. Five samples were collected at Dry Well E between 12 and 40 ft bgs, where contamination was thought most likely to be found. All of the arsenic, Ra-226 and Th-228 results for Dry Well E soil boring samples were below their respective background screening values.

Arsenic was analyzed in Dry Wells A, B, C, and D samples (Figure 4.8-3), but Ra-226 and Th-228 were not analyzed in the samples collected around Dry Well D (Figure 4.8-4 and Figure 4.8-5). Without Ra-226 and Th-228 data near Dry Wells D and E, a data gap appears to exist in the southern portion of Dry Wells A-E areas. Ra-226 and Th-228 were analyzed in Dry Wells D and E samples collected between 12 and 40 ft bgs, and all of these results were below their respective background screening values.

Ra-226 and Th-228 data showed little variance. The range of Ra-226 concentrations was  $0.43 \pm 0.22 \text{ pCi/g}$  to  $0.675\pm 0.0911 \text{ pCi/g}$ , and the range of Th-228 concentrations was  $0.604\pm 0.309 \text{ pCi/g}$  to  $0.771\pm 0.339 \text{ pCi/g}$ .

## 4.8.6.5 Relation of Concentrations of Contaminants of Potential Concern to Site Operations

Arsenic is a naturally occurring element in soil at the LEHR site. Based on historical information, arsenic was not used in research or released to the environment. The spatial analysis did not indicate any area of localized contamination. Arsenic concentrations in Dry Wells A-E soil may be attributable to natural conditions. Soil background data show that natural arsenic concentrations increase with depth. However, no background arsenic samples were collected from the same depth interval as the Dry Wells A-E samples, indicating a data gap in the arsenic background data. Due to this data gap, the Dry Wells A-E arsenic data has not been compared to natural arsenic concentrations in LEHR soil.

Ra-226 was used extensively in research experiments at LEHR. Aqueous waste from Ra-226 experiments was processed at the Radium/Strontium Treatment Systems area. Domestic Septic Tank Nos. 1 and 5, which are believed to have discharged to Dry Wells A-E, were not intended to receive Ra-226 waste. However, Ra-226 waste may have been disposed into the Domestic Septic Systems and the associated dry wells. The spatial analysis indicated no Ra-226 concentrations above the background screening value. The distribution of Dry Wells A-E Ra-226 data is shifted slightly towards the high end of the background distribution, but still lies within the background distribution range. It is difficult to conclude whether Ra-226 concentrations at Dry Wells A-E are natural or due to site operations.

Based on historical information, Th-228 concentrations included in the risk estimate are likely attributed to site conditions and not related to site activities. This isotope is a naturally occurring radionuclide, and there are no records indicating it was released at the Site. The spatial analysis indicated two samples with Th-228 concentrations slightly above background near Dry Well C (Figure 4.8-5). Because these two samples with concentrations above background are located adjacent to each other, they appear to indicate a localized area of contamination. However, the entire

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Th-228 data set only spans a concentration range of  $0.604\pm0.309$  pCi/g to  $0.771\pm0.339$  pCi/g, which does not indicate that the results with concentrations above background are significantly elevated above the rest of the data. There is no conclusive evidence of a Th-228 release at the Dry Wells A-E area.

# 4.8.7 Ground Water Impacts

In addition to evaluation of human health risk resulting from soil contamination, potential ground water impacts from contaminants remaining in the soil at Dry Wells A-E were evaluated and are presented in the RI (WA, 2003b).

# 4.8.7.1 Risk Characterization of Constituents of Potential Ground Water Concern

Based on preliminary DL analysis conducted to identify COPCs associated with Dry Wells A-E that could potentially impact ground water, Cr-VI, chromium, Hg, molybdenum, silver, Cs-137, and Sr-90 were evaluated as constituents of potential concern. Because the maximum concentrations of all of these COPCs were detected at depths typically below the water table (i.e., 30 ft bgs or greater), "equilibrium soil concentrations" were calculated using the ground water background levels, MCLs and representative partitioning coefficients ( $K_d$ ) for these COPCs. The results of these calculations and comparisons of the equilibrium soil concentrations with the maximum concentrations detected in the Dry Wells A-E area are presented in Table 4.8-8.

As shown on Table 4.8-9, all of these COPCs are present at concentrations that could result in localized ground water impact above background. In addition, the maximum Cr-VI, total chromium, Hg, and silver concentrations could also result in ground water impact above MCLs as shown in Table 4.8-8. However, based on one year of ground water monitoring results for well UCD1-54 (Figure 2-3), none of these COPCs, except possibly Cs-137, has impacted ground water. In HSU-1, chromium and Cr-VI have been detected in ground water downgradient of Drywells A-E above background and MCLs in UCD2-7 and above background in UCD2-36.

In conformance with the ground water COPC evaluation process illustrated in Figure 1-2, all of the COPCs are retained for further evaluation as a COPGWC.

# 4.8.7.1.1 Percentage and Spatial Distribution of Samples Exceeding Background

The data presented here is discussed in detail in the Remedial Investigation report.

# 4.8.7.1.1.1 Hexavalent Chromium

Hexavalent chromium was above background in two of 32 soil sample results (6%) in the Dry Wells A-E area. The two elevated samples were collected next to Dry Wells C and E and had hexavalent chromium concentrations of 1.62 mg/kg and 1.37 mg/kg, respectively. The elevated concentrations were only slightly above the background screening value of 1.3 mg/kg. The lateral spatial distribution appears random, but hexavalent chromium concentrations appear to increase slightly with depth. The highest detected concentration was located at 32 ft bgs, and the next highest concentration was located at 40 ft bgs.

## 4.8.7.1.1.2 Chromium

Total chromium was above background in one of 41 soil sample results (2.4%) in the Dry Wells A-E area. The elevated sample (245 mg/kg) was collected next to Dry Well C at a depth of 40 ft bgs. The background screening value for chromium is 181 mg/kg. The lateral and vertical spatial distribution appears random. With the exception of one elevated result at 40 ft bgs, the chromium concentration profile does not appear to vary significantly throughout the total depth explored (5 ft to 40 ft bgs). The chromium background study results indicated that chromium concentrations decrease with depth. Dry Wells A-E chromium data do not reflect the expected natural decrease in chromium concentration with depth. Deep Dry Wells A-E area soil is likely contaminated with chromium.

# 4.8.7.1.1.3 Mercury

Mercury was above background in nine of 41 soil sample results (22%) in the Dry Wells A-E area. Samples with elevated mercury results were located next to Dry Wells A, C and D. Mercury was below the background screening value (0.63 mg/kg) at Dry Wells B and E and the distribution box and piping.

The highest reported mercury concentration was 5.3 mg/kg in sample SSSTC007 located at Dry Well D at a depth of 20 ft bgs. Four of the elevated concentrations were located below 30 ft bgs. The background study results indicated that mercury concentrations decrease with depth. Dry Wells A-E mercury concentrations do not reflect the expected natural decrease in concentrations with depth. The data indicate mercury contamination in deep subsurface soil.

# 4.8.7.1.1.4 Molybdenum

Twenty-nine of 37 molybdenum results (78%) were above background in the Dry Wells A-E area. Elevated concentrations were found in soil samples collected at all of the Dry Wells A-E area features. The highest molybdenum concentration was 1.3 mg/kg in sample SSDWC033 collected next to Dry Well D at a depth of 40 ft bgs. The vertical profile of molybdenum concentrations is uniform between 5 ft and 20 ft bgs and then increases slightly with depth down to 40 ft bgs. Molybdenum contamination is present throughout the subsurface soil column.

# 4.8.7.1.1.5 Silver

Silver was above background in 28 of 41 soil sample results (68%) at the Dry Wells A-E area. Elevated concentrations were found in soil samples collected at all of the Dry Wells A-E area features except the piping. The highest silver concentration was 53.8 mg/kg in sample SSDWC013 collected next to Dry Well C at a depth of 40 ft bgs. Twelve of the elevated results (6.4 mg/kg to 53.8 mg/kg) were more than an order of magnitude above the background screening value for silver (0.55 mg/kg). The vertical profile of silver concentrations is uniform between 5 ft and 20 ft bgs, and then decreases between 20 ft and 40 ft bgs. The exception in this vertical profile is the maximum concentration, which stands out as a single elevated result located at 40 ft bgs. Based on the soil concentrations, silver contamination is present in deep subsurface soil. However, most of the silver contamination is located in the vadose zone (<20 ft bgs).

### 4.8.7.1.1.6 Cs-137

Sixteen of 32 Cs-137 results (50%) were above background in the Dry Wells A-E area. Elevated concentrations were found in soil samples collected at each dry well. Cs-137 was below background in soil samples collected at the distribution box and piping. The highest Cs-137 concentration was  $0.191\pm0.0078$  pCi/g in sample SSDWC008 collected next to Dry Well A at a depth of 40 ft bgs. The vertical profile of Cs-137 concentrations is lowest at 20 ft bgs, and higher at the top and bottom of the soil column. The two highest Cs-137 concentrations ( $0.161\pm0.0163$  pCi/g and  $0.191\pm0.0078$  pCi/g were in soil samples located at 40 ft bgs.

# 4.8.7.1.1.7 Sr-90

Sr-90 was above background in thirteen of 28 soil sample results (46%) at the Dry Wells A-E area. Elevated concentrations were found in soil samples collected at Dry Wells A, B, C, E, and the distribution box. Sr-90 was below background (0.056 pCi/g) in soil samples collected at Dry Well D. The highest Sr-90 concentration was  $0.176\pm0.0132$  pCi/g in sample SSDWC013 collected next to Dry Well C at a depth of 40 ft bgs. The vertical profile of Sr-90 concentrations appears nearly uniform in the vertical plane throughout the total depth explored (5 ft to 40 ft bgs).

# 4.8.7.1.2 Degradation and Decay of Contaminants of Potential Concern

Cr-VI, chromium, Hg, molybdenum, and silver are not expected to undergo significant degradation.

Cs-137 has a half-life of 30.07 yrs, and is not a naturally occurring radionuclide. It is a fission product that will not be replenished by a parent isotope. Sr-90 has a half-life of 28.79 yrs, and is not naturally occurring.

# 4.8.7.1.3 Uncertainty

Similar to human health risk estimates, evaluation of ground water impacts is subject to uncertainties, such as analytical bias and data representativeness, discussed below.

# 4.8.7.1.3.1 Analytical Issues

# 4.8.7.1.3.1.1 Hexavalent Chromium

Nineteen of 32 hexavalent chromium results were qualified. Fifteen results were qualified due to matrix spike recovery failure, which is likely due to soil chemistry in the matrix spike sample. Matrix spike recovery failure is not reflective of analytical accuracy issues for hexavalent chromium.

Six samples were qualified due to contamination detected in the laboratory method blank. Laboratory contamination can cause false positive detection and may cause an overall positive bias in the data set. It should be noted that two of the samples were qualified for a combination of matrix spike recovery failure and laboratory contamination.

# 4.8.7.1.3.1.2 Chromium

Eighteen of 41 chromium results were qualified. Fourteen of the chromium results were qualified due to matrix spike recovery failure. A matrix spike consists of adding a known quantity of analyte to a sample and determining the percent recovered by the analytical method. Matrix spike recovery failure may indicate the sample matrix is interfering with quantitative accuracy for this analyte.

Four samples were qualified due to field duplicate imprecision, which does not indicate a high or low bias. However, the highest value among field duplicate pairs is selected for DOE areas data. The field duplicate selection process does cause DOE areas data to be biased high.

# 4.8.7.1.3.1.3 Mercury

None of the 41 mercury results were qualified during data validation. All but three of the results were detected above the quantitation limit. No analytical issues were identified for mercury.

# 4.8.7.1.3.1.4 Molybdenum

Thirty-one of the 37 molybdenum results were qualified during data validation.

All 31 of the qualified results were qualified because the reported concentrations were between the method detection limit and the quantitation limit. These results are not as accurate as results that are above the quantitation limit, but the qualifications do not indicate a positive or negative bias. Eleven samples were also qualified due to contamination detected in the laboratory method blank. Laboratory contamination can cause false positive detection and may cause an overall positive bias in the data set.

# 4.8.7.1.3.1.5 Silver

Twenty-one of the 41 silver results were qualified during data validation. Fourteen of the silver results were qualified due to matrix spike recovery failure, which may indicate the sample matrix is interfering with quantitative accuracy for this analyte.

Nine results were qualified because the reported concentrations were between the method detection limit and the quantitation limit. These results are not as accurate as results that are above the quantitation limit, but the qualifications do not indicate a positive or negative bias. It should be noted that two samples were qualified for both matrix spike recovery failure and detection below the quantitation limit.

# 4.8.7.1.3.1.6 Cesium-137

None of the 32 Cs-137 results were qualified during data validation. Fourteen of the results (44%) were below the laboratory detection limit. Four of the samples (13%) had detection limits above the background screening value of 0.012 pCi/g. Radiological analytical results below the detection limit are still reported as semi-quantitative results by the analytical laboratory and were

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compared to the background screening value. These background comparisons were less reliable than situations where lower relative detection limits have been achieved.

# 4.8.7.1.3.1.7 Strontium-90

Eight of the 28 Sr-90 results were qualified due to expired initial calibration of the laboratory instrumentation. Sr-90 initial calibrations are performed annually. The continuing calibration check, which consists of measuring a National Institute of Science and Technology-traceable standard, showed that the calibration was within control limits for these samples. In addition, all of the other QC parameters (holding time, blanks, relative error ratio, laboratory control samples, matrix spikes and field duplicates) were within control limits for these samples. Because the control limits were met and the data qualifications were due to a calibration procedure that is only required annually, the Sr-90 data are likely very accurate. The data qualifications do not indicate a high or low bias for these data.

# 4.8.7.1.3.2 Data Representativeness

Dry Wells A-E area sampling consisted of discretionary grab samples and soil boring samples collected at depths ranging from 5 ft to 40 ft bgs. Soil samples were collected at all of the Dry Wells A-E features. Samples were not collected away from the features to determine the lateral extent of contamination. Some of the contaminants are likely present in soil below the maximum depth explored (40 ft bgs). The highest concentrations of chromium, molybdenum, silver, Cs-137, and Sr-90 were found at 40 ft bgs.

# 4.8.7.1.4 Relation of Concentrations of Contaminants of Potential Ground Water Concern to Site Operations

Cr-VI and chromium are potentially associated with LEHR operations, since chromic acid and other chromium-bearing chemicals may have been used or disposed at the Site. Mercury, molybdenum, and silver are likely to have been used in LEHR operations. Sr-90 was one of the primary research isotopes used at LEHR, and Cs-137 was also used in research at the Site.

# 4.8.8 Risk Characterization Summary and Recommendations Regarding Contaminants of Concern at the Dry Wells A-E Area

Risk characterization findings and recommended COCs at Dry Wells A-E are summarized below and presented in Table 4.8-10. The recommended COCs include constituents that are considered to have potential risks to human health or may have potential impact on the ground water at the site.

# 4.8.8.1 Human Health—On-Site Resident

# 4.8.8.1.1 Arsenic

Arsenic is a naturally occurring element and is not known or suspected to have been used at LEHR. The risk estimate indicates that the arsenic cancer risk is  $2 \times 10^{-4}$  and the non-cancer risk is

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2.6 for the hypothetical on-site resident. Spatial analysis shows that arsenic in the soil is randomly distributed. Only one sample had a concentration above background. The arsenic risk attributed to site activities, based on the one sample exceeding background, is estimated at 12%. The risk attributed to background arsenic concentrations is estimated at about 88%. Arsenic concentrations at Dry Wells A-E are not likely to have been associated with site operations, and are likely an artifact of ambient site conditions; thus the constituent should not be retained as a COC for the residential receptor based on its cancer and non-cancer risk.

# 4.8.8.1.2 Radium-226

Ra-226 was detected at Dry Wells A-E in concentrations corresponding to a risk of 4 x  $10^{-5}$  for the on-site resident. All of the sampling results for Ra-226 were below the background screening value. The distribution of Ra-226 in the area appears to be random, despite a minor increase in concentrations near the distribution box. Ra-226 is a naturally occurring isotope, which was also used in LEHR operations. Eighty-nine percent of the Ra-226 risk is likely attributable to background, and 11% is from site activities for this receptor. Ra-226 concentrations are consistent with background, thus this constituent should not be retained and evaluated in the Feasibility Study as a COC.

# 4.8.8.1.3 Thorium-228

Th-228 was used in research activities at LEHR and was found at slightly elevated concentrations in two samples in the Dry Wells A-E area. The Th-228 concentrations correspond to risk in excess of  $10^{-6}$  for the resident. Its random distribution and slight elevation are not suggestive of a release. The decay-corrected List 2 cancer risk associated with the Th-228 concentrations is  $4 \times 10^{-6}$  for the on-site resident. A large fraction of the risk (94%) is attributable to background concentrations of the Th-228 in the soil, and the concentrations attributed to site activities should decay to within 1% of the background EPC in approximately five years.

The Th-228 distribution does not suggest a release; therefore, this constituent should not be retained and evaluated in the Feasibility Study as a COC.

# 4.8.8.2 Human Health—On-Site Outdoor Researcher

# 4.8.8.2.1 Radium-226

Ra-226 was detected Dry Wells A-E in concentrations corresponding to a risk of  $2 \times 10^{-5}$  to the outdoor research worker. All of the sampling results for Ra-226 were below the background screening value. The distribution of Ra-226 in the area appears to be random, despite a minor increase in concentrations near the distribution box. Ra-226 is a naturally occurring isotope, which was also used in LEHR operations. Eighty-nine percent of the Ra-226 risk is likely attributable to background, and 11% is from site activities for this receptor. This constituent should not be retained and evaluated in the Feasibility Study as a COC for this receptor.

# 4.8.8.2.2 Thorium-228

Th-228 was detected at the Dry Wells A-E at decay-corrected concentrations corresponding to risk in excess of  $2x10^{-6}$  for the outdoor research worker. As discussed above, it was found at

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slightly elevated concentrations in two samples in the Dry Wells A-E area. Its random distribution and slight elevation are not suggestive of a release. As discussed above, a large fraction of the risk (94%) is attributable to background concentrations of the Th-228 in the soil, and the site contribution is likely to decay to near background level within five years. Th-228 should not be retained as a COC for the outdoor researcher and evaluated in the Feasibility Study.

# 4.8.8.3 Human Health—On-Site Indoor Researcher

# 4.8.8.3.1 Radium-226

Ra-226 was detected at Dry Wells A-E in concentrations corresponding to a risk of 4 x  $10^{-6}$  for the indoor research worker. Eighty-nine percent of the Ra-226 risk is likely attributable to background, and 11% is from site activities for this receptor. Ra-226 should not be retained as a COC for the indoor researcher and evaluated in the Feasibility Study.

## 4.8.8.3.2 Thorium-228

The List 2 cancer risk associated with the Th-228 concentrations is below the  $10^{-6}$  risk for the on-site indoor researcher, and therefore, should be excluded from evaluation in the Feasibility Study as a COC.

# 4.8.8.4 Human Health—On-Site Construction Worker

### 4.8.8.4.1 Arsenic

Arsenic is a naturally occurring element, and is not known or suspected to have been used at LEHR. The risk estimate indicates that the arsenic cancer risk is  $7 \times 10^{-7}$  and the non-cancer risk is  $1 \times 10^{-1}$  for the on-site construction worker. Spatial analysis shows that arsenic in the soil is randomly distributed. Only one sample had a concentration above background. The arsenic risk attributed to site activities, based on the one sample exceeding background, is estimated at 12%. The risk attributed to background arsenic concentrations is estimated at about 88%. Arsenic concentrations at Dry Wells A-E are not likely to have been associated with site operations, and are likely an artifact of ambient site conditions; thus the constituent should not be retained as a COC for the on-site construction worker based on its cancer and non-cancer risk.

# 4.8.8.4.2 Radium-226

Ra-226 was detected at Dry Wells A-E in concentrations corresponding to a risk of  $1 \times 10^{-6}$  for the construction worker. Eighty-nine percent of the Ra-226 risk is likely attributable to background, and 11% is from site activities for this receptor. Ra-226 should not be retained as a COC for the construction worker and evaluated in the Feasibility Study.

# 4.8.8.4.3 Thorium-228

Th-228 was detected at Dry Wells A-E at concentrations that accounted for more than 10% of the total cancer risk for the construction worker. However, the List 2 cancer risk associated with the Th-228 concentrations is below the  $10^{-6}$  risk for the on-site construction worker, and therefore should be excluded from evaluation in the Feasibility Study as a COC.

# 4.8.8.5 Ground Water

Several COCs are present at concentrations that could result in localized ground water impact above background and MCLs at Dry Wells A-E. These include Cr-VI, total chromium, Hg, silver, molybdenum, Cs-137 and Sr-90. All of these constituents should be retained as COCs and evaluated in the Feasibility Study.



Figure 4.8-1. Domestic Septic System Dry Wells A-E Area Features







Figure 4.8-3. Arsenic Spatial Analysis, Domestic Septic System Dry Wells A-E Area

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Figure 4.8-5. Thorium-228 Spatial Analysis, Domestic Septic System Dry Wells A-E Area



Figure 4.8-6. Decay of Radium-226 at Dry Wells A-E Area



Figure 4.8-7. Decay of Thorium-228 at Dry Wells A-E Area



Figure 4.8-8. Cancer Risk for On-Site Resident from Site Activities and Background, Dry Wells A-E Area



Cancer Risk for On-Site Outdoor Researcher from Site Activities and Background, Dry Wells A-E Area Figure 4.8-9.

Figures



Figure 4.8-10. Cancer Risk for On-Site Indoor Researcher from Site Activities and Background, Dry Wells A-E Area



Figure 4.8-11. Cancer Risk for Construction Worker from Site Activities and Background, Dry Wells A-E Area

Analyte	Total Samples	Number of Samples > Bkgd	Number of Samples > Bkgd and Residential PRGs <sup>1</sup>	Number of Samples > Bkgd and Industrial PRGs <sup>1</sup>	Maximum Conc.	Bkgd for > 4 ft bgs	Residential PRG <sup>1</sup>	Industrial PRG <sup>1</sup>
Metals					(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)
Barium	29	1	0	0	608	294	5,400	67,000
Cadmium	29	3	0	0	0.68	0.51	37	450
Chromium	29	4	1	0	245	125	210	450
Chromium VI	29	14	0	0	1.62	1.3	30	64
Lead	29	3	0	0	9.9	9.5	$150^{(2)}$	750
Manganese	29	6	0	0	1,010	750	1,800	19,000
Mercury	29	16	0	0	1.7	0.248	23	310
Molybdenum	29	24	0	0	1.3	0.26	390	5,100
Selenium	29	7	0	0	1.9	1.2	390	5,100
Silver	29	22	0	0	53.8	0.55	390	5,100
Vanadium	29	6	0	0	89.9	80.3	550	7,200
Zinc	29	3	0	0	96.5	93.1	23,000	100,000
Radionuclides					(pCi/g)	(pCi/g)	(pCi/g)	(pCi/g)
Actinium-228	20	3	0	0	0.695	0.642	732	1,180
Americium-241	20	1	0	0	0.0149	0.014	1.87	5.68
Bismuth-212	20	2	0	0	0.449	0.434	22,600	36,600
Bismuth-214	20	3	0	0	0.587	0.54	8,190	13,200
Cesium-137	20	13	3	0	0.191	0.00695	0.0597	0.11
Lead-210	20	1	1	1	2.23	8.85	0.15	1.23
Lead-212	20	5	0	0	0.772	0.684	3,640	6,070
Lead-214	20	7	0	0	0.639	0.581	46,300	74,800
Radium-228	20	2	2	0	0.695	0.655	0.26	8.4
Strontium-90	20	10	0	0	0.176	0.056	0.231	10.7
Thallium-208	20	2	0	0	0.227	0.223	22,600	36,500
Thorium-234	20	8	0	0	0.971	0.78	1,330	3,250

Table 4.8-1.Analytes Detected above Background in Soil/Waste at Dry Wells A-E (Domestic<br/>Septic System Nos. 1 and 5 Leach Field) Area Prior to Removal Actions

#### Notes

Data from the Remedial Investigation Report (WA, 2003b).

Contaminant data includes data collected from all depth intervals instead of the 0-10 ft interval used in the risk estimate. <sup>1</sup>Chemical PRGs are from US EPA Region 9 PRGs Table, dated October 1, 2002. Radionuclide PRGs are from Radionuclide Toxicity and PRGs for Superfund, dated April 14, 2003 (US EPA, <u>http://epa-prgs.ornl.gov/radionuclides/download/rad\_master\_prg\_</u> <u>table\_pci.xls</u>). The industrial PRGs for radionuclides are for "outdoor worker soil." California-modified PRGs are shown in brackets.

>	greater than
bkgd	background
bgs	below ground surface
conc.	concentration
ft	feet
mg/kg	milligrams per kilogram
pCi/g	picoCuries per gram
PRG	preliminary remediation goal
US EPA	United States Environmental Protection Agency

Table 4.8-2.	Summary of Sampling Results Use	d in the Risk Estimate at the Do	omestic Septic System Dry Wells A-E Area

List 1 COPC	Units	Total Samples	Number of Detections	Number of Detections > Background	Concentration Range <sup>1</sup>	Background Screening Concentration <sup>2</sup>	ID of Sample with Highest Concentration	Depth of Sample with Highest Concentration (ft)
Metals								
Arsenic	mg/kg	13	13	1	5.9 - 10.8	9.6	SSSTC006	5
Radionuclides								
Cesium-137	pCi/g	10	7	4	-0.00613 - 0.0775	0.012	SSSTC006	5
Lead-210	pCi/g	10	5	0	0.235 - 1.3	1.6	LEHR-S-T1A03(7.5)	7.5
Potassium-40	pCi/g	10	10	0	9.6 - 12.9	14	SSSTC010	8
Radium-226	pCi/g	10	10	0	0.43 - 0.675	0.75	SSSTC005	6
Radium-228	pCi/g	7	7	3	0.568 - 0.673	0.64	SSSTC006	5
Thorium-228	pCi/g	7	7	2	0.604 - 0.771	0.74	SSSTC006	5

Notes

Source: COPC data from the HHRA Risk Estimate, Appendix A (UC Davis, 2005). <sup>1</sup>The concentration ranges for metals and radionuclides include non-detects.

<sup>2</sup>The background screening concentrations are the unstratified background screening values in Appendix B of the HHRA Risk Estimate.

>	greater than
COPC	constituent of potential concern
ft	feet
HHRA	Human Health Risk Assessment
ID	identification (number)
mg/kg	milligrams per kilogram
pCi/g	picoCuries per gram

# Table 4.8-3. Human Health Risks to On-Site Resident by Exposure Route for Contaminants of Potential Concern in the Dry Wells A-E Area

CANCER RISK BY EXPOSURE ROUTE											
EPC <sup>1</sup>	Soil Ingestion	Soil Dermal Exposure	Above-Ground Plant Ingestion <sup>2</sup>	Below-Ground Plant Ingestion <sup>2</sup>	External Radiation	Dust Inhalation	Total Cancer Risk	Statistical Background Comparison <sup>3</sup>	List 2 Cancer Risk <sup>4</sup>		
8.8	2.E-05	1.E-06	1.E-04	3.E-05	-	1.E-08	2.E-04	Fail	2.E-04		
0.034	1.E-10	-	7.E-10	-	7.E-07	5.E-15	7.E-07	Pass	-		
0.87	2.E-07	-	4.E-07	-	3.E-08	1.E-10	6.E-07	Pass	-		
12	7.E-08	-	2.E-06	-	8.E-05	1.E-12	8.E-05	Pass	-		
0.63	1.E-07	-	3.E-07	-	4.E-05	1.E-10	4.E-05	Fail	4.E-05		
0.65	7.E-08	-	2.E-07	-	2.E-05	4.E-10	2.E-05	Pass	-		
0.73	7.E-09	-	5.E-10	-	6.E-06	1.E-10	6.E-06	Fail	6.E-06		
							<b>3.E-04</b>		2.E-04		
			HAZARD QUOTIENT	BY EXPOSURE ROUTE							
EPC <sup>1</sup>	Soil Ingestion	Soil Dermal Exposure	Above-Ground Plant Ingestion	Below-Ground Plant Ingestion	External Radiation	Dust Inhalation	Non-Cancer Hazard Index	Statistical Background Comparison <sup>3</sup>	List 2 Non-Cancer Hazard Risk <sup>4</sup>		
8.8	3.7E-01	3.1E-02	2.0E+00	2.4E-01	-	-	2.6E+00	Fail	2.6E+00		
							2.6E+00		2.6E+00		
	EPC <sup>1</sup> 8.8 0.034 0.87 12 0.63 0.65 0.73 EPC <sup>1</sup> 8.8	EPC <sup>1</sup> Soil Ingestion         8.8       2.E-05         0.034       1.E-10         0.87       2.E-07         12       7.E-08         0.63       1.E-07         0.65       7.E-08         0.73       7.E-09         EPC <sup>1</sup> Soil Ingestion         8.8       3.7E-01	$EPC^1$ Soil Ingestion       Soil Dermal Exposure         8.8       2.E-05       1.E-06         0.034       1.E-10       -         0.87       2.E-07       -         12       7.E-08       -         0.63       1.E-07       -         0.65       7.E-08       -         0.73       7.E-09       -         EPC <sup>1</sup> Soil Ingestion       Soil Dermal Exposure         8.8       3.7E-01       3.1E-02	EPC <sup>1</sup> Soil Ingestion         Soil Dermal Exposure         Above-Ground Plant Ingestion <sup>2</sup> 8.8         2.E-05         1.E-06         1.E-04           0.034         1.E-10         -         7.E-10           0.87         2.E-07         -         4.E-07           12         7.E-08         -         2.E-06           0.63         1.E-07         -         3.E-07           0.65         7.E-08         -         2.E-07           0.65         7.E-08         -         2.E-07           0.73         7.E-09         -         5.E-10           HAZARD QUOTIENT I           EPC <sup>1</sup> Soil Ingestion         Soil Dermal Exposure         Above-Ground Plant Ingestion           8.8         3.7E-01         3.1E-02         2.0E+00	CANCER RISK BY EXPOSURE ROUTE $EPC^1$ Soil IngestionSoil Dermal ExposureAbove-Ground Plant Ingestion2Below-Ground Plant Ingestion28.82.E-051.E-061.E-043.E-050.0341.E-10-7.E-10-0.872.E-07-4.E-07-127.E-08-2.E-06-0.631.E-07-3.E-07-0.657.E-08-2.E-07-0.737.E-09-5.E-10-HAZARD QUOTIENT BY EXPOSURE ROUTEEPC1Soil IngestionSoil Dermal ExposureAbove-Ground Plant IngestionBelow-Ground Plant Ingestion8.83.7E-013.1E-022.0E+002.4E-01	EPC <sup>1</sup> Soil Ingestion         Soil Dermal Exposure         Above-Ground Plant Ingestion <sup>2</sup> Below-Ground Plant Ingestion <sup>2</sup> External Radiation           8.8         2.E-05         1.E-06         1.E-04         3.E-05         -           0.034         1.E-10         -         7.E-10         -         7.E-07           0.87         2.E-07         -         4.E-07         -         3.E-08           12         7.E-08         -         2.E-06         -         8.E-05           0.63         1.E-07         -         3.E-07         -         4.E-05           0.65         7.E-08         -         2.E-07         -         4.E-05           0.65         7.E-08         -         2.E-07         -         4.E-05           0.73         7.E-09         -         5.E-10         -         6.E-06           HAZARD QUOTIENT EXPOSURE ROUTE           EPC <sup>1</sup> Soil Ingestion         Soil Dermal Exposure         Above-Ground Plant Ingestion         Below-Ground Plant Ingestion         Below-Ground Plant Ingestion         External Radiation           8.8         3.7E-01         3.1E-02         2.0E+00         2.4E-01         -	EPC <sup>1</sup> Soil Ingestion         Soil Dermal Exposure         Above-Ground Plant Ingestion <sup>2</sup> Below-Ground Plant Ingestion <sup>2</sup> External Radiation         Dust Inhalation           8.8         2.E-05         1.E-06         1.E-04         3.E-05         -         1.E-08           0.034         1.E-10         -         7.E-10         -         7.E-07         5.E-15           0.87         2.E-07         -         4.E-07         -         3.E-08         1.E-10           12         7.E-08         -         2.E-06         -         8.E-05         1.E-10           0.63         1.E-07         -         3.E-07         -         4.E-10         -         1.E-10           0.65         7.E-08         -         2.E-07         -         4.E-05         1.E-10           0.65         7.E-09         -         5.E-10         -         6.E-06         1.E-10           0.73         7.E-09         -         5.E-10         -         6.E-06         1.E-10           EPC <sup>1</sup> Soil Ingestion         Soil Dermal Exposure         Above-Ground Plant Ingestion         Below-Ground Plant Ingestion         Setternal Radiation         Dust Inhalation           8.8         3.7E-01	EPC <sup>1</sup> Soil Ingestion         Soil Dermal Exposure         Above-Ground Plant Ingestion <sup>2</sup> Below-Ground Plant Ingestion <sup>2</sup> External Radiation         Dust Inhalation         Total Cancer Risk           8.8         2.E-05         1.E-06         1.E-04         3.E-05         -         1.E-08         2.E-04           0.034         1.E-10         -         7.E-07         5.E-15         7.E-07           0.87         2.E-07         -         4.E-07         -         3.E-08         1.E-10         6.E-07           12         7.E-07         -         3.E-07         -         8.E-05         1.E-10         4.E-07           0.63         1.E-07         -         2.E-07         -         8.E-05         1.E-10         4.E-05           0.65         7.E-08         -         2.E-07         -         4.E-05         1.E-10         4.E-05           0.65         7.E-08         -         2.E-07         -         2.E-05         4.E-10         2.E-05           0.73         7.E-09         -         2.E-07         -         3.E-04         2.E-05         3.E-10         3.E-04           Evert         HZZARD QUOTIENT EVENDEUE         Evertal Radiation         Dust Inh	CANCER RISK BY EXPOSURE ROUTEEPC1Soil IngestionSoil Dermal ExposureAbove-Ground Plant Ingestion2Below-Ground Plant Ingestion2External RadiationDust InhalationTotal Cancer RiskStatistical Background Comparison38.82.E-051.E-061.E-043.E-05-1.E-082.E-04Fail0.0341.E-10-7.E-10-7.E-075.E-157.E-07Pass0.872.E-07-4.E-07-3.E-081.E-106.E-07Pass127.E-08-2.E-066-8.E-051.E-128.E-05Pass0.631.E-07-3.E-07-4.E-051.E-104.E-05Fail0.657.E-08-2.E-07-2.E-061.E-104.E-05Pass0.657.E-08-2.E-07-2.E-054.E-102.E-05Pass0.657.E-09-5.E-10-6.E-061.E-104.E-05Pass0.657.E-09-2.E-07-2.E-054.E-102.E-05PassInternation of the second plantExternal Radiation0.6E-06FailInternation6.E-061.E-104.E-05PassInternation2.E-054.E-102.E-05PassInternation1.E-101.E-101.E-101.E-10Internation1.E-101.E-101.E-101.E-10 <t< td=""></t<>		

Notes

Source Data from HHRA Risk Estimate, Tables 7 and 8. Statistical Background Comparison from Appendix B (UC Davis, 2005).

The non-cancer risk is for a resident child; for cancer risk it is an age-adjusted adult.

List 2 constituents shown in **bold-type** text contribute at least 10<sup>6</sup>, or greater than 10%, to the excess cumulative cancer risk. Rounding may affect the total List 2 cancer risk values shown in the last column. Determination of whether the risk is greater than ten percent of total List 2 cancer risk. values.

<sup>1</sup>The 95% upper confidence limit on the mean of the exposure point concentration; chemical concentrations are in milligrams per kilogram and radionuclide concentrations are in picoCuries per gram.

<sup>2</sup>For radionuclides, plant ingestion is not subdivided into above-ground and below-ground plants.

<sup>3</sup>Based on Wilcoxon Rank Sum test or other statistical comparisons, as shown in Appendix B of the HHRA Risk Estimate.

<sup>4</sup>Dashes indicate that constituent was not identified as a List 2 COPC, since it was identified to be statistically equivalent to background.

#### Abbreviations

not calculated

- COPC constituent of potential concern EPC exposure point concentration

HHRA Human Health Risk Assessment

# Table 4.8-4.Human Health Risks to On-Site Outdoor Researcher by Exposure Route for Contaminants of Potential Concern at the<br/>Dry Wells A-E Area

## **CANCER RISK BY EXPOSURE ROUTE**

List 1 COPC	EPC <sup>1</sup>	External Radiation	Total Cancer Risk	Statistical Background Comparison <sup>2</sup>	List 2 Cancer Risk <sup>3</sup>
Arsenic	8.8	_	0.E+00	Fail	0.E+00
Cesium-137	0.034	3.E-07	3.E-07	Pass	-
Lead-210	0.87	1.E-08	1.E-08	Pass	-
Potassium-40	12	3.E-05	3.E-05	Pass	-
Radium-226	0.63	2.E-05	2.E-05	Fail	2.E-05
Radium-228	0.65	1.E-05	1.E-05	Pass	-
Thorium-228	0.73	<b>3.E-06</b>	<b>3.E-06</b>	Fail	<b>3.E-06</b>
TOTAL			6.E-05		2.E-05

#### Notes

Source Data from HHRA Risk Estimate, Tables 7 and 8. Statistical Background Comparison from Appendix B (UC Davis, 2005).

The non-cancer risk is for a resident child; for cancer risk it is an age-adjusted adult.

List 2 constituents shown in **bold-type** text contribute at least  $10^{-6}$ , or greater than 10%, to the excess cumulative cancer risk.

<sup>1</sup>The 95% upper confidence limit on the mean of the exposure point concentration; chemical concentrations are in milligrams per kilogram and radionuclide concentrations are in picoCuries per gram.

<sup>2</sup>Based on Wilcoxon Rank Sum test or other statistical comparisons, as shown in Appendix B of the HHRA Risk Estimate.

<sup>3</sup>Dashes indicate that constituent was not identified as a List 2 COPC, since it was identified to be statistically equivalent to background.

-	not calculated
COPC	constituent of potential concern
EPC	exposure point concentration
HHRA	Human Health Risk Assessment

# Table 4.8-5.Human Health Risks to On-Site Indoor Researcher by Exposure Route for Contaminants of Potential Concern at the<br/>Dry Wells A-E Area

## **CANCER RISK BY EXPOSURE ROUTE**

List 1 COPC	EPC <sup>1</sup>	External Radiation	Total Cancer Risk	Statistical Background Comparison <sup>2</sup>	List 2 Cancer Risk <sup>3</sup>
Arsenic	8.8	-	0.E+00	Fail	0.E+00
Cesium-137	0.034	6.E-08	6.E-08	Pass	-
Lead-210	0.87	3.E-09	3.E-09	Pass	-
Potassium-40	12	7.E-06	7.E-06	Pass	-
Radium-226	0.63	<b>4.E-06</b>	<b>4.E-06</b>	Fail	4.E-06
Radium-228	0.65	2.E-06	2.E-06	Pass	-
Thorium-228	0.73	6.E-07	6.E-07	Fail	6.E-07
TOTAL			1.E-05		5.E-06

#### Notes

Source Data from HHRA Risk Estimate, Tables 7 and 8. Statistical Background Comparison from Appendix B (UC Davis, 2005).

List 2 constituents shown in **bold-type** text contribute at least  $10^{-6}$ , or greater than  $10^{\%}$ , to the excess cumulative cancer risk.

<sup>1</sup>The 95% upper confidence limit on the mean of the exposure point concentration; chemical concentrations are in milligrams per kilogram and radionuclide concentrations are in picoCuries per gram.

<sup>2</sup>Based on Wilcoxon Rank Sum test or other statistical comparisons, as shown in Appendix B of the HHRA Risk Estimate.

<sup>3</sup>Dashes indicate that constituent was not identified as a List 2 COPC, since it was identified to be statistically equivalent to background.

-	not calculated
COPC	constituent of potential concern
EPC	exposure point concentration
HHRA	Human Health Risk Assessment

Table 4.8-6.Human Health Risks to On-Site Construction Worker by Exposure Route for Contaminants of Potential Concern at the<br/>Dry Wells A-E Area

List 1 COPC	EPC <sup>1</sup>	Soil Ingestion	Soil Dermal Exposure	External Radiation	Dust Inhalation	Total Cancer Risk	Statistical Background Comparison <sup>2</sup>	List 2 Cancer Risk <sup>3</sup>
Arsenic	8.8	6.E-07	5.E-08	-	5.E-09	7.E-07	Fail	7.E-07
Cesium-137	0.034	5.E-12	-	2.E-08	8.E-17	2.E-08	Pass	-
Lead-210	0.87	8.E-09	-	7.E-10	2.E-12	9.E-09	Pass	-
Potassium-40	12	2.E-09	-	2.E-06	3.E-14	2.E-06	Pass	-
Radium-226	0.63	2.E-09	-	1.E-06	2.E-12	1.E-06	Fail	1.E <b>-</b> 06
Radium-228	0.65	5.E-09	-	6.E-07	4.E-12	6.E-07	Pass	-
Thorium-228	0.73	2.E-09	-	9.E-07	2.E-11	9.E-07	Fail	9.E-07
TOTAL						5.E-06		3.E-06

#### **CANCER RISK BY EXPOSURE ROUTE**

#### HAZARD QUOTIENT BY EXPOSURE ROUTE

List 1 COPC	EPC <sup>1</sup>	Soil Ingestion	Soil Dermal Exposure	External Radiation	Dust Inhalation	Non-Cancer Hazard Index	Statistical Background Comparison <sup>3</sup>	List 2 Non- Cancer Hazard Risk <sup>4</sup>
Arsenic	8.8	9.5E-02	8.5E-03	-	-	1.0E-01	Fail	1.0E-01
TOTAL						1.0E-01		1.0E-01

#### Notes

Source Data from HHRA Risk Estimate, Tables 7 and 8. Statistical Background Comparison from Appendix B (UC Davis, 2005).

The non-cancer risk is for a resident child; for cancer risk it is an age-adjusted adult.

List 2 constituents shown in **bold-type** text contribute at least 10<sup>-6</sup>, or greater than 10%, to the excess cumulative cancer risk.

<sup>1</sup>The 95% upper confidence limit on the mean of the exposure point concentration; chemical concentrations are in milligrams per kilogram and radionuclide concentrations are in picoCuries per gram.

<sup>2</sup>Based on Wilcoxon Rank Sum test or other statistical comparisons, as shown in Appendix B of the HHRA Risk Estimate.

<sup>3</sup>Dashes indicate that constituent was not identified as a List 2 COPC, since it was identified to be statistically equivalent to background.

-	not calculated	EPC	exposure point concentration
COPC	constituent of potential concern	HHRA	Human Health Risk Assessment
## Table 4.8-7.Data Summary—Comparison of Exposure Point Concentrations to Site Background at the Dry Wells A-E Area (Human Health)

Analyte	Detections	Samples	Min Detect	Max Detect	Min Detection Limit	Max Detection Limit	Average <sup>1</sup>	Standard Deviation <sup>1</sup>	Distribution	95UCL <sup>1</sup>	EPC	Decay- Corrected EPC <sup>2</sup>
Site (0 to 10	) ft)		mg/kg or pCi/g	mg/kg or pCi/g	mg/kg or pCi/g	mg/kg or pCi/g	mg/kg or pCi/g	mg/kg or pCi/g		mg/kg or pCi/g	mg/kg or pCi/g	mg/kg or pCi/g
Arsenic	13	13	5.9	10.8	0.56	2.4	8.13	1.34	Normal	8.8	8.8	N/A
Radium-226	5 10	10	0.43	0.675	0.0298	0.3	0.590	.0700	Normal	0.63	0.63	0.63
Thorium-22	8 7	7	0.604	0.771	0.162	0.408	0.687	0.0634	Normal	0.73	0.73	0.53
Background	d (0 to 10 ft)											
Arsenic	11	11	6.4	8.6	2	2	7.345	0.763	Lognormal	7.76	7.76	N/A
Radium-226	5 32	37	0.347	0.83	0.0228	0.56	0.521	0.144	Normal	0.56	0.56	0.56
Thorium-22	8 48	48	0.266	0.66	0.058	0.379	0.475	0.105	Normal	0.50	0.50	0.50

#### Notes

Source: COPC data from Appendix A from HHRA Risk Estimate (UC Davis, 2005). 95UCL calculations for background concentrations and decay corrections added.

<sup>1</sup>Negative concentration values were set to zero and concentrations below the detection limit were used to determine the 95UCL, average, and standard deviation for radionuclides. Half of the detection limit was used when chemicals were not detected. Same as 95UCL calculation procedure used in HHRA Risk Estimate (UC Davis, 2005).

<sup>2</sup>The EPC was decay-corrected to April 2005 (see Figures 4.8-6, 4.8-7 and Appendix A).

95UCL	95 percent upper confidence limit on the mean
COPC	constituent of potential concern
EPC	exposure point concentration
ft	feet
HHRA	Human Health Risk Assessment
max	maximum
min	minimum
mg/kg	milligrams per kilogram
N/A	not applicable or not available
pCi/g	picoCuries per gram

Table 4.8-8. Summary of Potential Impacts of Designated-Level Constituents of Potential Concern in Dry Wells A-E Area Soil on Ground Water

	Soil Sampling Results			Equilibrium Soil	Concentration	Downgradient		Ground Water Background		Ground Water	Tap Water	Time to Peak
Potential Concern	Maximum (mg/kg	Depth of Maximum	(mg/kg or pCi/g)	BackgroundMCLGround Water GoalGround Water Goal		Ground (	$(\mu g/l \text{ or } pCi/l)^1$		Concentration <sup>3</sup> (µg/l or pCi/l)		$\begin{array}{c c} PRG & a \\ V \\ (\mu g/l \text{ or } & L \end{array}$	at Ground Water Goal
	or $pCi/g)^1$	(ft)		(mg/kg or pCi/g)	(mg/kg or pCi/g)	HSU-1 HSU-2		HSU-1	HSU-2	pCi/l)	pCi/l)	Level (years)
Cesium-137	0.191	38-42	$0.00695/0.012^5$	0.1	20	<1.92 – <b>2.15</b>	<-4.2 - <1.21 [ND] /	1	2.6	200	1.57	0
							<-0. <u>92 -</u> <2.3 [ND]					
Chromium	245	38-42	125/181 <sup>5</sup>	0.475	0.950	3.0 - 5.6	16.5 - <b>120</b> / 12.6 - <b>40.1</b>	25	27.1	50	110	0
Hexavalent Chromium	1.62	30-34	1.3	0.749	0.950	< 5.4 - 7.35	15.5 - <b>110</b> / <6.0 - <b>25.0</b>	39.4	20	50	110	0
Mercury <sup>6</sup>	5.3	16-20	$0.25/0.63^5$	0.00520	0.572	<0.037 - <0.066	< 0.10 - < 0.4 /	0.10	0.2	2	11	0
							<0.1 - <0.2 [ND] <sup>7</sup>					
Molybdenum	1.3	38-42	<0.26	0.30	3.60	3.2 - 7.11	$1.1 - 5^{8,9} / < 1.4 - 2.6^{8,10}$	14.9	5 <sup>8</sup>	NE	180	0
Silver	53.8	38-42	0.55	0.0415	0.830	< 0.72 - 3.2	$0.08 - <1 / 0.04 - <4^{11}$	5	$1.7^{11}$	100	180	0
Strontium-90	0.176	38-42	0.056	0.0595	0.280	< 0.379 - 0.51	<-0.8 - <0.78 [ND] /	1.7	0.28 <sup>12</sup>	8	0.644	0
							$< 0.237 - < 0.909 [ND]^{12, 13}$					

#### Notes

<sup>1</sup>Cesium-137 and strontium-90 in pCi/g or pCi/l; all others in mg/kg or µg/l.

<sup>2</sup> Range of data from downgradient HSU-1 well UCD1-054, and HSU-2 wells UCD2-7 and UCD2-36.

<sup>3</sup>Based on data from HSU-1 well UCD1-18, and HSU-2 wells UCD2-17 and UCD2-37.

<sup>4</sup>Dry Wells A-E Area contamination is currently in direct contact with water table.

<sup>5</sup>First value is a concentration greater than 4 ft below ground surface and second is a consolidated concentration (all depths).

<sup>6</sup>Assumed to be mercuric chloride.

<sup>7</sup>One outlier was excluded from well UCD2-7. All other samples were non-detects. Although the highest detection limits were greater than background, the lowest detection limits for other samples demonstrate that the mercury concentrations at well UCD2-7 are not greater than background. <sup>8</sup>Measurements of molybdenum in samples collected before 1993 were excluded here because those data are significantly less reliable than the measurements of molybdenum in later samples.

<sup>9</sup>Four outliers, all non-detects, were also excluded.

<sup>10</sup>One outlier, a non-detect, was also excluded.

<sup>11</sup>Measurements of silver in samples collected before 1997 were excluded here because those data are significantly less reliable than are the measurements of silver in later samples. Outliers were also excluded.

<sup>12</sup>Measurements of strontium-90 using analysis-method 901.1 were excluded here because those data are significantly less reliable than are those measurements of strontium-90 using other methods.

<sup>13</sup>Although concentrations of strontium-90 were reported greater than background concentrations, all of the strontium-90 results at wells UCD2-7 and UCD2-36 were non-detects. There is no evidence that site concentrations of strontium-90 are greater than background concentrations. **Bold type** indicates soil concentration is above background and above NUFT result for ground water impact at background levels, or ground water concentration is above background.

Boxed type indicates soil concentration is above background and above NUFT result for ground water impact at the MCL, or ground water concentration is above the MCL.

<	denotes analyte concentrations below the detection limit
μg/l	micrograms per liter
ft	feet
MCL	California Maximum Contaminant Level for ground water (November 2002)
mg/kg	milligrams per kilogram
ND	not detected in any samples
NE	none established
NUFT	Non-Isothermal, Unsaturated Flow and Transport model
pCi/g	picoCuries per gram
pCi/l	picoCuries per liter
PRG	preliminary remediation goal (US EPA, 2002a for radionuclides; US EPA, 2002b for others)
US EPA	United States Environmental Protection Agency

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# Table 4.8-9. Summary of Designated-Level Ground Water Constituents of Potential Concern at Dry Wells A-E Area Retained as Constituents of Potential Ground Water Concern

	0	0	6	4	
Designated-Level Constituent of Potential Concern	Are the DL COPCs ground water concentrations above site background? <sup>1</sup>	Are the DL COPC soil concentrations above soil background and the NUFT soil results? <sup>2</sup>	Will the DL COPC impact ground water above background levels in the next 500 years?	Retained as COPGWC in risk	
	If yes, enter ✓ in ④	If yes, go to <b>S</b>	If yes, enter ✓ in ④	$\sqrt{-V_{ex}}$	
	If no, go to <b>2</b>	If no, stop and enter $\times$ below	If no, stop and enter $\times$ below	v = 105	
Hexavalent Chromium	No	Yes	Yes	✓	
Chromium	No	Yes	Yes	✓	
Mercury	No	Yes	Yes	✓	
Molybdenum	No	Yes	Yes	✓	
Silver	No	Yes	Yes	✓	
Cesium-137	Yes	-	-	✓	
Strontium-90	No	Yes	Yes	✓	

#### Note

<sup>1</sup>See Table 4.8-8. Compare downgradient ground water concentration to ground water background concentration. Results below detection limits are presumed to be below site background. <sup>2</sup>The lower of background and MCL goals.

×	not retained as a COPGWC
$\checkmark$	retained as a COPGWC
-	skip
COPC	constituent of potential concern
COPGWC	constituent of potential ground water concern
DL	designated-level
NUFT	Non-Isothermal, Unsaturated Flow and Transport

Driver COPC /COPGWC	Total Cancer Risk <sup>1</sup>	Spatial Distribution	Background Contribution <sup>2</sup>	Above- Background Contribution <sup>3</sup>	Historically Used at the Site	Time for Attenuation to Risk Endpoint <sup>4</sup> (years)	Level of Ground Water Impact		Uncertainty	Recommended Action	Basis for Recommendation
On-Site Resident											
Arsenic <sup>5</sup>	2.E-04	Random	88%	12%	No	N/A	N/A	•	Good data quality. Non-gridded sampling.	No Further Action	• Only one sample above background.
Radium-226	4.E-05	Random	89%	11%	Yes	5,825	N/A	•	Good data quality. Non-gridded sampling	No Further Action	• Concentrations consistent with background.
Thorium-228	4.E-06	Random	94%	6%	Yes	4.9	N/A	•	Good data quality. Non-gridded sampling.	No Further Action	<ul><li>Current risk is marginal.</li><li>Will decay to background in less than 5 years.</li></ul>
<b>On-Site Outdoor Research</b>	ner								i ton graded campring.		
Radium-226	2.E-05	Random	89%	11%	Yes	5,825	N/A	•	Good data quality. Non-gridded sampling	No Further Action	• Concentrations likely below background.
Thorium-228	2.E-06	Random	94%	6%	Yes	4.9	N/A	•	Good data quality. Non-gridded sampling.	No Further Action	• Concentrations likely below background.
<b>On-Site Indoor Researche</b>	r										
Radium-226	4.E-06	Random	89%	11%	Yes	5,825	N/A	•	Good data quality. Non-gridded sampling.	No Further Action	Concentrations likely below background.
Thorium-228	4.E-07	Random	94%	6%	Yes	$<\!\!0^{6}$	N/A	•	Good data quality. Non-gridded sampling.	No Further Action	• Decay-corrected risk is below 1E-6.
<b>On-Site Construction Wor</b>	rker										
Arsenic	7.E-07	Random	88%	12%	No	N/A	N/A	•	Good data quality. Non-gridded sampling.	No Further Action	• Concentrations likely below background.
Radium-226	1.E-06	Random	89%	11%	Yes	36	N/A	•	Good data quality. Non-gridded sampling.	No Further Action	• Concentrations likely below background.
Thorium-228	7.E-07	Random	94%	6%	Yes	$< 0^{6}$	N/A	•	Good data quality. Non-gridded sampling.	No Further Action	• Decay-corrected risk is below 1E-6.
Ground Water									0 1 0		
Chromium	N/A	Localized	N/A	N/A	Yes	N/A	>MCL, >bkgd	•	Good data quality. Non-gridded sampling.	Evaluate in FS	• Existing deeper soil contamination.
Hexavalent Chromium	N/A	Localized	N/A	N/A	No	N/A	>MCL, >bkgd	•	Good data quality. Non-gridded sampling	Evaluate in FS	• Existing deeper soil contamination.
Mercury	N/A	Localized	N/A	N/A	Yes	N/A	>MCL, >bkgd <sup>7</sup>	•	Good data quality.	Evaluate in FS	• Existing deeper soil contamination.
Molybdenum	N/A	Localized	N/A	N/A	No	N/A	>bkgd	•	Good data quality.	Evaluate in FS	• Existing deeper soil contamination.
Silver	N/A	Localized	N/A	N/A	Yes	N/A	>MCL, >bkgd	•	Good data quality.	Evaluate in FS	• Existing deeper soil contamination.
Cesium-137	N/A	Localized	N/A	N/A	Yes	N/A	bkgd	•	Good data quality.	Evaluate in FS	• Existing deeper soil contamination.
Strontium-90	N/A	Localized	N/A	N/A	Yes	N/A	bkgd	•	Non-gridded sampling. Good data quality. Non-gridded sampling.	Evaluate in FS	• Existing deeper soil contamination.

Table 4.8-10. Summary of Major Factors Driving Risk and Recommendations for Future Action at Dry Wells A-E Area

Notes

<sup>1</sup>For radionuclides, values are decay-corrected to April 2005 (see Figure 4.8-6, Figure 4.8-7 and Appendix B). <sup>2</sup>The background contribution is the proportion of the site EPC that can be attributed to the background EPC (see Table 4.8-7 and Figure 4.8-8 through Figure 4.8-11). <sup>3</sup>The above-background contribution is the proportion of the site EPC that is greater than the background EPC (see Figure 4.8-8 through Figure 4.8-11).

 Table 4.8-10.
 Summary of Major Factors Driving Risk and Recommendations for Future Action at Dry Wells A-E Area (continued)

<sup>4</sup>The time for attenuation to risk endpoint is the time, from April 2005, for the site EPC of a radionuclide to decay to either the background EPC or the concentration equivalent to a risk of 10<sup>-6</sup>, whichever is greater. <sup>5</sup>Non-cancer hazard index is 2.6. <sup>6</sup>As of April 2005, the site EPC is less than the concentration equivalent to a risk of 10<sup>-6</sup>.

<sup>7</sup>Not detected in downgradient well. Impact is based on modeling.

Abbreviations

>	greater than
<	less than
bkgd	background
COPC	constituent of potential concern
COPGWC	constituent of potential ground water concern
EPC	exposure point concentration
FS	Feasibility Study
MCL	California Maximum Contaminant Level for ground water (November 2002)
N/A	not applicable

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## 5. EASTERN DOG PENS RISK CHARACTERIZATION

#### 5.1 Area Description

The Eastern Dog Pens were used to house beagles used in LEHR radiation research. Following a 30-day indoor holding period, irradiated beagles were moved outside to the outdoor dog pens (Goldman, 1997; DOE-archived records). Feces were removed from each pen daily, and urine percolated into the gravel floor of the dog pens (Ballard, 1997; Goldman, 1997; Hinz, 1997; DOE-archived records). The gravel was removed periodically and disposed in the Southwest Trenches (Hinz, 1997) and possibly disposed off-site (Ballard, 1997).

The Eastern Dog Pens were constructed on top of portions of UC Davis Landfill No. 2. According to aerial photographs, Rows K and L of the Eastern Dog Pens were constructed by May 1968. The final row, Row M, was completed by March 1970 (Figure 5-1).

Due to the co-location of the Eastern Dog Pens and Landfill No. 2, UC Davis plans to characterize risk associated with both areas and address the resulting COCs in the UC Davis Feasibility Study.

## 5.1.1 Pre-Removal Action Contaminant Distribution

Previous investigations at the Eastern Dog Pens include a 1984 Initial Assessment Survey, 16 composite samples collected in 1987-1988, and sample data collected in 1990 and 1996. None of the data from these investigations were collected under work plans prepared in accordance with the requirements of CERCLA, and therefore are not used in the DOE Areas RI (WA, 2003b) to characterize the contaminant distribution in the Eastern Dog Pens. Soil from the upper two ft of the Eastern Dog Pens area was collected during a 1999 investigation and analyzed in accordance with CERCLA data quality standards. The results are presented in Table 5-1 and discussed in Section 5.1.3 below.

## 5.1.2 Removal Action Activities

No CERCLA removal actions have been conducted at the Eastern Dog Pens. As part of the site decommissioning process, in 1996, DOE removed the chain-link pen partitions and concrete pedestals. The concrete pedestals were packaged and shipped to the DOE Hanford site for disposal as low-level radioactive waste. In 1999, the interior chain-link fencing was shipped off site for recycling (WA, 2000a). Currently, the perimeter chain-link fence, concrete curbs, gravel and three asphalt aisles remain.

#### 5.1.3 Contaminant Distribution

The nature and extent of known contamination in the Eastern Dog Pens is based on investigations conducted in 1996 as part of site decommissioning activities, and in 1999, as presented in the *Technical Memorandum: Investigative Results for the Former Eastern Dog Pens* (WA, 1999b). The 1999 samples were analyzed for 58 constituents. Seven pesticides and two PCBs were detected. Sr-90, chromium, and Cr-VI were detected at concentrations statistically above background (WA, 2003b).

#### 5.1.4 Future Land Use

Future use of the LEHR site by UC Davis will be consistent with the "Academic/Administrative Low Density" land use designation of the area contained in Section 3.8.1 of the UC Davis 2003 *Long Range Development Plan* (UC Davis, 2003).

Because the Eastern Dog Pens overlie Landfill No. 2, DOE and UC Davis plan to evaluate CERCLA remedial alternatives for both areas in the UC Davis Feasibility Study. Thus, the CERCLA Record of Decision will dictate future land use for this area.

#### 5.2 Summary of Risk Estimate Data

Data used in the human health risk estimate were collected during various investigations and sampling events that were conducted at the Eastern Dog Pens. Information used in the risk estimate included data from the:

- 1996 Investigation (IT Corp., 1997); and
- 1999 Investigation (WA, 1999b).

During these investigations, soil, gravel and concrete samples were collected from the upper two ft of the area at the locations shown in Figure 5-2, and did not include material from the underlying landfill. Results from 1996 were not included in the *DOE Areas Remedial Investigation Report*, since they were not collected under the CERCLA RI/FS Work Plan or other quality assurance protocols. However, they were included in the HHRA Risk Estimate at the request of the US EPA, since they provide additional data on contaminant distribution at the Site. Available information indicates that these samples were collected in soil adjacent to the removed concrete pedestals. Table 5-2 provides a summary of the sample data used in the Tier 2 risk estimate. The sample locations for all data used in the risk estimate are presented in Figure 5-2.

## 5.2.1 Quality of Site Data

The data set for the Eastern Dog Pens area included 2,340 analytical results. None of these results were rejected from the total data set ("R"-qualified). One hundred thirty of the results, or

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5.6%, had "J" qualifiers, which indicate that an analyte was positively identified in the sample, but the analytical result is an approximation of the analyte concentration in the sample. Data with "J" qualifiers were used in developing risk estimates. A total of five records, or 0.2%, had "UJ" qualifiers, which mean that an analyte was not detected, but the detection limit is approximate. Data with "UJ" qualifiers were included in the risk estimate, and were treated as a non-detection of an analyte.

Three hundred ninety-two of the 2,340 final records from the Eastern Dog Pens area were used to generate the Tier 2 human health risk estimate. Ten of the 392 results had "J" qualifiers, and four results had "UJ" qualifiers.

## 5.3 Risk Characterization—Eastern Dog Pens

Consistent with the HHRA Risk Estimate, as discussed in Section 2.2, this risk characterization uses the terms "List 1" and "List 2". List 2 identifies constituents that failed the statistical comparison to background, which may be indicative of a release to the environment. Table 5-3, in the first column, provides the List 1 COPCs identified in the HHRA Risk Estimate. The last column of Table 5-3 provides only List 2 COPCs and their risk values. The values provided are not corrected for decay. A subset (shown in bold-type) of List 2 contains COPCs that have a risk of at least 10<sup>-6</sup> or contribute more than ten percent of the total excess cumulative cancer risk in the Eastern Dog Pens area. None of the COPCs had hazard quotients above 1.

Specifically, this subset consists of dieldrin, Pb-210, Sr-90 and its daughter product. The constituents in this subset are identified in the risk characterization as List 2 driver COPCs, since these COPCs present potential site-related risks.

The only receptor with List 2 carcinogenic risks estimated to be above  $10^{-6}$  is the hypothetical on-site resident (cumulative risk of 8 x  $10^{-6}$ ). The cancer risks for the hypothetical outdoor researcher, construction worker, and trespasser are estimated to be below  $10^{-6}$ . Table 5-3 shows the risks by exposure route for the hypothetical on-site resident.

#### 5.3.1 Exposure Assessment

The exposure assessment for List 2 driver COPCs at the Eastern Dog Pens area includes:

- The spatial distribution of the List 2 driver COPCs;
- Risk from COPC concentrations attributed to site background versus prior site activities; and
- Exposure intake estimates.

A conceptual site model illustrating exposure pathways and potential human receptors for all DOE areas is provided as Figure 2-1.

#### 5.3.1.1 Spatial Distribution of Contaminants of Potential Concern

Figure 5-3 through Figure 5-5 show the spatial distribution of sample results for dieldrin, Pb-210 and Sr-90, respectively. Section 2.2.3.1 describes the symbols used in the spatial distribution maps. All references to risk refer to cancer risk to a hypothetical on-site resident.

#### 5.3.1.1.1 Dieldrin Distribution

The spatial analysis of dieldrin concentrations is presented in Figure 5-3. Only one sample (Sample ID SSDP0338, located in surface soil [0-0.5 ft] near the northeastern corner of the dog pens [Figure 5-2]) has a concentration in the  $10^{-5}$  to  $10^{-4}$  risk range. Dieldrin was not detected in subsurface soil at the same location (two ft bgs in Sample SSDP0340). One sample had a concentration in the  $10^{-5}$  risk range (Sample ID SSDP0345) and is surrounded by samples showing risks below  $10^{-6}$ . Concentrations detected above the site background occur most frequently in the northeast quarter of the Eastern Dog Pens area.

#### 5.3.1.1.2 Lead-210 Distribution

The spatial analysis of Pb-210 samples is presented in Figure 5-4. At two sample locations, the concentration of Pb-210 was below the detection limit and below  $10^{-5}$ , risk but above the site background. All of the positive results were below site background. No particular hot spots are present and Pb-210 concentration appears randomly distributed, suggesting that Pb-210 was either released from a distant source or disseminated by natural processes.

#### 5.3.1.1.3 Strontium-90 Distribution

The spatial analysis of Sr-90 sample data is shown in Figure 5-5. At four locations, the Sr-90 concentrations correspond to a risk range between  $10^{-4}$  and  $10^{-5}$ , and, at five locations, the Sr-90 concentrations correspond to a risk range between  $10^{-5}$  and  $10^{-6}$ . Samples with concentrations indicating risk above  $10^{-5}$  are either from the 1996 pedestal data set or concrete samples. As discussed in Section 5.3.4.1.2, the 1996 data may not be representative of site conditions, since they were not collected under the CERCLA RI/FS Work Plan or other quality assurance protocols. Regardless, the selection of the 1996 pedestal and most of the 1998 concrete sample locations was based on elevated surface radiation scans, and likely represent a reasonable upper bound for residual Sr-90 concentrations in the pens.

#### 5.3.1.2 Degradation and Decay of Contaminants of Potential Concern

The methodology for calculating radionuclide decay is described in detail in Appendix B.

## 5.3.1.2.1 Lead-210

Pb-210 (22.3-yr half-life) is naturally occurring and is part of the uranium-decay series, where it is derived from Ra-226 (1,600-yr half-life) and ultimately U-238. These parent isotopes have been characterized at the Eastern Dog Pens and found to be at levels consistent with site background. Thus, the decay of the parent isotope will replenish Pb-210 at background concentrations and any Pb-210 that has been released at levels above background will attenuate over time.

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The Pb-210 decay estimate for the Eastern Dog Pens is shown in Figure 5-6. The Pb-210 site EPC is currently below the background EPC.

#### 5.3.1.2.2 Strontium-90

Sr-90 has a half-life of 28.79 years and is not naturally occurring. The Sr-90 decay estimate for the Eastern Dog Pens is shown in Figure 5-7. The Sr-90 site EPC will decay to below the  $10^{-6}$  risk level for residential receptors in about 26 years.

#### 5.3.1.3 Background Evaluation

#### 5.3.1.3.1 Detections above Site Background

The number of analytical results that were greater than both the detection limits and the background screening levels are shown in Table 5-2 for the List 1 COPCs. As shown, dieldrin, Cs-137, Pb-210, Ra-226, Sr-90 and Th-228 were detected above the background screening value in one or more samples.

#### 5.3.1.3.2 Parent-Daughter Activity Concentration Relationships

The concentration of Pb-210 at the Eastern Dog Pens area was compared to the concentration of its longer-lived parent, Ra-226, in Appendix E (Figure E-8). As shown, the concentrations of these isotopes appear to be in secular equilibrium when quantified analytical errors are taken into account. This is evidence that the concentration of Pb-210 at the site is due to decay of Ra-226 rather than to a release of Pb-210, because any shorter-lived daughter isotope will have a concentration approximately equal to that of its longer-lived parent isotope, in the absence of excess input of the daughter. The apparent elevated concentration of Pb-210 at the site relative to background, therefore, is probably due to analytical limitations rather than to a release. The concentration of Ra-226, which was measured at much higher precision than was Pb-210, is demonstrably below background concentrations. Therefore, the Ra-226 results suggest that the Ra-226/Pb-210 decay series is not impacting the site.

#### 5.3.1.3.3 Comparison of Risk Attributed to Background versus Site Activities

Table 5-4 presents statistics, including EPCs, for the sample results of the List 2 driver COPCs at both the site and in the background. The background EPCs were calculated using the same method used to calculate the site EPCs (Section 2.2.3.3.3). Table 5-4 also presents decay-corrected EPCs for radionuclides. EPCs can be used to derive relative contributions of risk because risk is directly proportional to the EPC.

None of the dieldrin risk can be attributed to background, because the background concentration of dieldrin was assumed to be equal to zero. All of the Pb-210 risk can be attributed to background, because its site EPC is less than its respective background EPC.

The observation that the Pb-210 site risk is below the background risk does not contradict the earlier conclusion in the HHRA Risk Estimate that Pb-210 failed the statistical background comparison and is therefore qualified to be a List 2 COPC (Table 5-3). Unlike the background comparison in the HHRA Risk Estimate for some of the other COPCs, Pb-210 was not compared to

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background using the WRS test, which compares the means of two data sets. Following the specifications in the HHRA work plan, the WRS test was used only if more than 50% of the results in both compared data sets were above the analytical detection limits. This requirement was not satisfied because in only 11 of 45 samples (24%) from the site, and 6 of 26 samples (23%) from the background, was Pb-210 above the detection limit (Table 5-4). Instead of comparing the mean site concentration to mean background concentration using the WRS test, the HHRA Risk Estimate compared the highest measured site concentration to the background screening value. This latter comparison is significantly different from a comparison of mean concentrations. Therefore, the conclusion that Pb-210 failed the statistical background comparison does not contradict the conclusion that the background concentrations contribute all of the site risk.

Although the rule in the HHRA work plan that restricted the WRS test to data sets with at least 50% detections, as discussed in Section 2.2.3.3.2, the WRS test can still provide useful results for uncensored radiological data when a large fraction of the data are below the detection limit. Under these conditions, Pb-210 passed the WRS background comparison test, supporting the conclusion that its site concentration EPC is less than its background screening level is not in opposition to this finding. The highest-measured concentration,  $2 \pm 2.8 \text{pCi/g}$  (Sample LEHR-S-376, Table 5-2), was below its analytical detection limit of 3.9 pCi/g. The background screening value of 1.6 pCi/g (Table 5-2) is well within the high sample's uncertainty range. Furthermore, of the 45 samples analyzed for Pb-210, none of the 11 detected samples exceeded the background UTL (Table 5-2). The highest result that was above the detection limit was only 1.62 ±1.68 pCi/g.

Figure 5-8 graphically illustrates the site risks to the on-site residential receptor from Sr-90, and the relative contribution to that risk from the background. In addition to presenting site and background risk contributions based on the HHRA Risk Estimate data, Figure 5-8 also shows the risks and relative risk contributions based on a redacted data set, which excludes data for samples collected in concrete. Concrete is not an exposure medium for residential receptors. The background contribution to the Sr-90 risk including concrete samples is 14%. The background contribution to the Sr-90 risk excluding concrete samples is 22%. Data presented in Figure 5-8 are corrected for decay.

## 5.3.2 Toxicity Assessment

Toxicity values for COPCs in the Eastern Dog Pens area were taken from US EPA guidance as discussed in Section 2.2.4. The toxicity values used for these COPCs are appropriate for this evaluation and make use of the best available information.

#### 5.3.3 Risk Estimate

Table 5-3 summarizes the risk estimate information for the hypothetical future on-site resident. It indicates that dieldrin, Pb-210, and Sr-90 comprise the List 2 driver COPCs, and shows that the pathway driving risk for all of these COPCs is above-ground plant ingestion.

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As discussed in Section 5.3.1.1.3, many of the higher Sr-90 concentrations were detected in concrete. Testing of the concrete indicates that the Sr-90 is "fixed" to the concrete, suggesting that it is immobile and unavailable for plant uptake. Recalculation of the EPC without the concrete sample results lowers the EPC from 0.62 to 0.39 pCi/g, corresponds to a risk of  $1 \times 10^{-6}$ .

#### 5.3.4 Uncertainty

Risk estimates are values that have uncertainties associated with them. The objective of this section is to discuss the major sources of uncertainty that are specific to this refined assessment of the Eastern Dog Pens. These include data coverage and analytical issues.

#### 5.3.4.1 Analytical Uncertainty

#### 5.3.4.1.1 Lead-210

Twenty percent of Pb-210 soil samples collected in the Eastern Dog Pens had detection limits greater than the background screening value. Most of the samples also had counting errors in excess of 50% of the reported value.

High detection limits and counting errors associated with the Pb-210 data generate uncertainty in the EPC value and the resulting risk. This uncertainty could lead to either an overestimate or underestimate of the true risk. However, the EPC would have to be more than 1.4 times higher than the calculated in the HHRA Risk Estimate EPC in order to exceed the background EPC.

#### 5.3.4.1.2 Strontium-90

As illustrated by Figure 5-5, six of the 68 samples collected in the Eastern Dog Pens did not meet Superfund data quality standards for risk assessment. These samples all have elevated concentrations with a corresponding risk range of  $10^{-5}$  to  $10^{-4}$ . No work plan was prepared for field sampling and no documentation exists to verify whether proper decontamination procedures were followed when the six samples were collected. The selection of these sample locations was based on available documentation and on radiation survey information collected in the field. Thus, the apparent high bias of the six 1996 samples may be an artifact of the sample locations or the undocumented procedures.

## 5.3.4.2 Data Representativeness

The locations and depth ranges of samples collected in the Eastern Dog Pens are shown in Figure 5-2. Twenty-two surface (0 to 0.5 ft bgs) and 78 subsurface (zero to ten ft bgs) samples were collected. Six of the samples were collected from concrete curbing. The concrete samples were collected between rows M and L near the western border of the Eastern Dog Pens. Fifty percent of the sample locations were selected based on elevated field radiation survey measurements. Non-concrete samples were focused primarily on the areas covered with gravel and surrounded by concrete curbs. Samples were less frequent in the asphalt-covered areas. No samples were collected from the asphalt-covered area of row L and only two samples (one surface and one subsurface) were

collected within the asphalt-covered area of row M. Five surface and five subsurface samples were collected from within the asphalt-covered area of row K. The deepest Eastern Dog Pens sample was collected at 3.87 ft bgs. Deeper samples were not collected since waste associated with the underlying UC Davis Landfill Unit Number 2 was encountered in the subsurface at depths as shallow as two ft bgs. The Eastern Dog Pens sample coverage is generally less comprehensive than other DOE areas at the Site. However, available Eastern Dog Pens characterization results are generally consistent with the more thoroughly characterized Western Dog Pens, suggesting that the Eastern Dog Pens. Dieldrin is not a chemical with documented site use and its mechanism for release remains an uncertainty. Possible sources for the dieldrin include buried material in Landfill No. 2 or an uncharacterized surface release at or near the Eastern Dog Pens.

## 5.3.5 Relation of Concentrations of Contaminants of Potential Concern to Site Operations

Dieldrin is not a documented or suspected chemical used in LEHR operations.

Pb-210 is a naturally occurring isotope that is associated with LEHR operations, since it is a daughter product of Ra-226, which was widely used at the Site. The spatial distribution data discussed in Section 5.3.1.1.2 indicates that elevated levels of Pb-210 are infrequent and randomly distributed, suggesting that the concentrations of Pb-210 are not a result of localized site releases.

Sr-90 was used extensively in experiments at LEHR and its EPC in Table 5-4 appears to indicate that Site operations have resulted in Sr-90 contamination.

## 5.4 Ground Water Impacts

In addition to evaluation of human health risk resulting from soil contamination, potential ground water impacts from contaminants remaining in the soil at the Eastern Dog Pens were evaluated and are presented in the RI (WA, 2003b). A summary of this evaluation is presented in Table 5-5.

## 5.4.1 Risk Characterization of Constituents of Potential Ground Water Concern

Potential impact to ground water was evaluated by comparing results from the 1999 soil investigation for Sr-90, Hg, Cr-VI, dichlorodiphenyl dichloroethane (DDD), dichlorodiphenyl dichloroethylene (DDE). dichlorodiphenyl trichloroethane (DDT), alpha-chlordane, gamma-chlordane, dieldrin, and Aroclor 1254 with vadose zone modeling results. Ground water data from downgradient wells UCD1-13 and UCD2-39 were also compared to background. Sr-90 has been detected in concentrations below background in downgradient well UCD1-13 (Figure 2-3). Concentrations of Cr-VI in the same well exceeded background and the MCL. Hg has not been detected in ground water from either background well UCD1-18 or downgradient well UCD1-13. DDD, DDE, DDT and Aroclor 1254 have never been detected in downgradient well UCD1-13. Alpha-chlordane, gamma-chlordane, and dieldrin have been detected infrequently in well UCD1-13 at concentrations up to 0.016, 0.016 and 0.094 µg/l, respectively. Only Cr-VI has been detected downgradient of the EDPs in concentrations above background in HSU-2 based on results from UCD2-39.

Modeling results indicate that ground water impacts from Sr-90 in Eastern Dog Pens soil is very unlikely. Based on the DL modeling, Hg in Eastern Dog Pens soil may impact ground water above the MCL. Modeling results indicate that any impact to ground water from the pesticides and Aroclor 1254 detected in soil would be expected to be several orders of magnitude below the MCLs.

Ground water impact from Hg in Eastern Dog Pens soil is estimated to only occur after several thousand years. Modeling results indicate that any impact to ground water from the pesticides and Aroclor 1254 detected in soil would not occur for thousands of years.

Based on the process for evaluating DL COPCs illustrated in Figure 1-2, and shown on Table 5-6, Cr-VI, alpha-chlordane, gamma-chlordane, and dieldrin are retained as COPGWCs for further evaluation.

#### 5.4.1.1 Percentage and Spatial Distribution of Samples Exceeding Background

#### 5.4.1.1.1 Hexavalent Chromium

All thirty-nine hexavalent chromium soil sample results were below background (1.3 mg/kg) at the Eastern Dog Pens. Hexavalent chromium appears to be uniformly below background in soil throughout the lateral and vertical extent of the area.

#### 5.4.1.1.2 Alpha-Chlordane

Alpha-chlordane was detected in twelve of 36 sample results (33%) in the Eastern Dog Pens area. The detected concentrations ranged from 0.38  $\mu$ g/kg to 47.8  $\mu$ g/kg. Alpha-chlordane contamination was more frequently detected in the eastern half of the Eastern Dog Pens. The highest detected concentrations was located near the southeast corner of the area and was surrounded by a cluster of detected concentrations. Alpha-chlordane was not detected in any of the samples collected in the northwest quarter of the area. Three samples located in the southwest quarter of the area, near the western border, had some of the highest detected concentrations. Eastern Dog Pens samples were collected from ground surface down to 3.87 ft bgs. Alpha-chlordane was detected at all sample depths. The concentrations appear to attenuate slightly with depth.

## 5.4.1.1.3 Gamma-Chlordane

Gamma-chlordane was detected in twelve of 36 sample results (33%) in the Eastern Dog Pens area. The detected concentrations ranged from  $0.4 \,\mu g/kg$  to  $43.4 \,\mu g/kg$ . The lateral and vertical contaminant distribution was identical to alpha-chlordane. As expected, alpha- and gamma-chlordane are consistently co-located.

## 5.4.1.1.4 Dieldrin

Dieldrin was detected in thirteen of 37 sample results (35%) in the Eastern Dog Pens area. The detected concentrations ranged from 0.76  $\mu$ g/kg to 223  $\mu$ g/kg. Dieldrin contamination was more frequently detected in the eastern half of the Eastern Dog Pens, but not necessarily co-located with

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alpha- and gamma-chlordane. The highest and most frequently detected dieldrin concentrations were located in the northeast corner of the area. Dieldrin was not detected in any of the samples collected in the southwest quarter of the area. The two highest dieldrin concentrations, 223  $\mu$ g/kg and 41.4  $\mu$ g/kg, were in samples collected at zero ft and three ft bgs, respectively. The rest of the detected dieldrin concentrations appear randomly distributed with depth down to the maximum depth explored of 3.87 ft bgs.

#### 5.4.1.2 Degradation and Decay of Contaminants of Potential Concern

Cr-VI, alpha-chlordane, gamma-chlordane and dieldrin are not expected to undergo significant degradation or decay.

#### 5.4.1.3 Uncertainty

Similar to human health risk estimates, evaluation of ground water impacts is subject to uncertainties, such as analytical bias and data representativeness, discussed below.

#### 5.4.1.3.1 Analytical Issues

#### 5.4.1.3.1.1 Hexavalent Chromium

Eighteen of 39 hexavalent chromium results were qualified due to matrix spike recovery failure, which is likely due to soil chemistry in the matrix spike sample. This matrix effect does not necessarily indicate an analytical accuracy issue for the hexavalent chromium data. No significant analytical issues were found.

#### 5.4.1.3.1.2 Alpha-Chlordane

Seven of 36 alpha-chlordane results were qualified because their concentrations were between the method detection limit and the quantitation limit. This qualification indicates individual results may be less precise than results above the quantitation limit, but it does not indicate a positive or negative bias. No significant analytical issues were found.

#### 5.4.1.3.1.3 Gamma-Chlordane

Six of 36 gamma-chlordane results were qualified because their concentrations were between the method detection limit and the quantitation limit. This qualification does not indicate a positive or negative bias. No significant analytical issues were found.

#### 5.4.1.3.1.4 Dieldrin

Nine of 37 dieldrin results were qualified because their concentrations were between the method detection limit and the quantitation limit. This qualification does not indicate a positive or negative bias. No significant analytical issues were found.

#### 5.4.1.3.2 Data Representativeness

The Eastern Dog Pens soil samples were collected from the upper two ft and do not include material from the landfill underneath the Eastern Dog Pens.

## 5.4.1.4 Relation of Concentrations of Contaminants of Potential Ground Water Concern to Site Operations

Cr-VI is potentially associated with LEHR operations, since chromic acid and other chromium-bearing chemicals may have been used or disposed at the Site. Although it has been detected in the nearest downgradient wells in concentrations exceeding background at the MCL, modeling indicates that the impact is not associated with the Eastern Dog Pens Cr-VI soil concentrations. Modeling results show that the residual Cr-VI at the Eastern Dog Pens will have no impact on local ground water.

Alpha- and gamma-chlordane were used extensively in the Eastern Dog Pens for flea control. There is no documented use of dieldrin at LEHR and it was not detected in soil in the Western Dog Pens, which had a nearly identical operational history.

As with Cr-VI, based on modeling results and the depth and nature of waste in UC Davis Landfill Disposal Unit 2 and disposal trenches, the chlordane and dieldrin detected in well UCD1-13 may be from these areas, rather than from surface soil in the Eastern Dog Pens.

# 5.5 Risk Characterization Summary and Recommendations Regarding Contaminants of Concern at the Eastern Dog Pens Area

Risk characterization findings and recommended COCs at the Eastern Dog Pens are summarized below and presented in Table 5-7. The recommended COCs include constituents that are considered to have potential risks to human health or may have potential impact on the ground water at the Site. As discussed above, additional risk characterization of the Eastern Dog Pens and Landfill No. 2 is planned by UC Davis and will affect the final findings and recommendations for action in this area.

## 5.5.1 Human Health—On-Site Resident

#### 5.5.1.1 Dieldrin

Dieldrin is not a chemical with known or suspected use at LEHR. The risk estimate indicates that the dieldrin cancer risk is  $3 \times 10^{-6}$ . Spatial analysis shows that dieldrin in soil is mainly localized in the northeast quarter of the area and no point concentrations exceed a risk of  $10^{-4}$ . Only one sample had a concentration in the  $10^{-5}$  to  $10^{-4}$  risk range, and one sample had a concentration in the  $10^{-5}$  to  $10^{-4}$  risk range, and one sample had a concentration in the  $10^{-5}$  to  $10^{-4}$  risk range. Dieldrin should be retained as a COC for this receptor.

#### 5.5.1.2 Lead-210

Pb-210 is naturally occurring and part of the uranium-238 decay series. The risk estimate indicates that the Pb-210 cancer risk is  $3 \times 10^{-6}$ . The Pb-210 EPC for the Eastern Dog Pens is less than the background EPC, indicating that the risk associated with Pb-210 background is greater than the site risk. Pb-210 concentrations appear randomly distributed; suggesting that risk throughout the area is due to natural Pb-210 concentrations. The random distribution indicates Pb-210 is uniformly below  $10^{-5}$ . Based on these findings, Pb-210 should not be retained as a COC for this receptor.

#### 5.5.1.3 Strontium-90

Sr-90 was one of the primary research isotopes used at LEHR and it is present in the Eastern Dog Pens soil and concrete. Four locations show a concentration corresponding to a risk range of  $10^{-4}$  and  $10^{-5}$ , and five have a risk between  $10^{-5}$  to  $10^{-6}$ . These locations are clustered between Rows M and L in the northwestern part of the area. The risk estimate indicates that the Sr-90 cancer risk to the on-site resident is 2 x  $10^{-6}$ . The majority (86%) of risk associated with Sr-90 is attributable to site concentrations. Therefore, Sr-90 should be retained as a COC for this receptor.

## 5.5.2 Ground Water

#### 5.5.2.1 Alpha- and Gamma-Chlordane

Alpha- and gamma-chlordane were used extensively in the Eastern Dog Pens Area and detected in Eastern Dog Pens soil samples and infrequently, at or slightly above detection limits in ground water samples from downgradient well UCD1-13 (Figure 2-3). Specifically, alpha- and gamma-chlordane have only been detected above the detection limit in two out of 32 samples collected in UCD1-13. The highest detected concentration above the detection limit for alpha- and gamma-chlordane was 0.016 µg/L (or 16 parts per trillion) in May 1998. These concentrations of alpha- and gamma-chlordane in ground water, if present, are about two orders-of-magnitude lower than the total chlordane MCL of 2  $\mu$ g/L. Well UCD1-13 has not been sampled for chlordane or other pesticides since 1999. Modeling indicates that the soil concentrations will not impact ground water and that the ground water concentrations did not likely originate from the Eastern Dog Pens soils. Soil sampling covered the extent of the Eastern Dog Pens area. The spatial analysis indicated that localized areas of alpha- and gamma-chlordane contamination were present in soil. No significant analytical accuracy issues were identified with these data. Alpha- and gamma-chlordane should not be retained as COCs, but should included in the ground water monitoring program to address the uncertainty associated with the model predictions and to confirm the presence of chlordane in well UCD1-13.

## 5.5.2.2 Dieldrin

There is no documented use of dieldrin at LEHR, but it was detected in Eastern Dog Pens soil samples. The spatial analysis indicated that localized areas of dieldrin contamination were present in soil. Dieldrin was detected above the MCL in ground water samples from downgradient well UCD1-13 (Figure 2-3). However, no positive detections (detection limits ranged from  $0.02-0.09 \mu g/L$ ) of dieldrin have been reported in this well since 1997. Modeling indicates that the

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existing soil concentrations in the Eastern Dog Pens will not impact ground water and that the ground water concentrations did not likely originate from the Eastern Dog Pens soils. Soil sampling covered the extent of the Eastern Dog Pens area. No significant analytical accuracy issues were identified with the data. Dieldrin should not be retained as a COC. It should, however, be included in the ground water monitoring program to address the uncertainty associated with the model predictions and to confirm the presence of dieldrin in well UCD-13.

#### 5.5.2.3 Hexavalent Chromium

Cr-VI concentrations in the nearest downgradient wells in HSU-1 and HSU-2 slightly exceeded background and the MCL. Eastern Dog Pens Cr-VI soil concentrations are below background. Modeling results indicate that hexavalent chromium in soil will not impact ground water above background or the MCL. Soil sampling was discretionary and covered the lateral and vertical extent of the Eastern Dog Pens area, but was not as extensive as sampling in the Western Dog Pens area. Cr-VI was potentially associated with LEHR operations. No significant analytical accuracy issues were identified with the data. No impact on local ground water is likely to result from Cr-VI in the area soil. Cr-VI should not be retained as a COC in the FS and ground water monitoring is not recommended.



Figure 5-1.Eastern Dog Pens Features







#### Figure 5-4. Lead-210 Spatial Analysis, Eastern Dog Pens Area





Figure 5-6. Decay of Lead-210 at Eastern Dog Pens Area



Figure 5-7. Decay of Strontium-90 at Eastern Dog Pens Area



Figure 5-8. Cancer Risk for On-Site Resident from Site Activities and Background, Eastern Dog Pens Area

Constituent	Total No. of Samples	Min. and Max. of Detections	Background <sup>1</sup>	Statistical Comparison with Background <sup>2</sup>	PRG <sup>3</sup>
Radionuclides		pCi/g	pCi/g		pCi/g
Cesium-137	37	0.0048-0.191	0.102	Pass Q	0.0597
Radium-226	37	0.355-0.734	0.752	Pass	0.0124
Strontium-90	37	0.023-0.164	0.056	Fail Q	0.231
Thorium-228	37	0.225-1.54	0.627	Pass	0.154
Thorium-230	37	0.288-1.26	1.04	Pass	3.49
Thorium-232	37	0.234-1.39	0.63	Pass	3.1
Thorium-234	37	0.357-0.89	0.78	Pass	1,330
Metals		mg/kg	mg/kg		mg/kg
Total Chromium	37	90.7-251	199	Fail	210
Hexavalent	37	0.077-0.673	1.3	Fail Q	30
Chromium					
Mercury	37	0.09-14.6	3.94	Pass Q	23
Pesticides/PCBs		μg/kg	μg/kg		μg/kg
4,4'-DDD	37	$0.82 - 3.3^4$	N/A	N/A	2,400
4,4'-DDE	37	$0.3 - 3.6^4$	N/A	N/A	1,700
4,4'-DDT	37	$0.48-5.8^4$	N/A	N/A	1,700
Chlordane-alpha +	37	$0.78-91.2^4$	N/A	N/A	1,600
gamma					
Dieldrin	37	$0.76-223^4$	N/A	N/A	30
Endrin	37	6.2	N/A	N/A	18
Endrin Ketone	37	2.7 5	N/A	N/A	NE
PCB-1254	37	24.3-54.9 <sup>4</sup>	N/A	N/A	220
PCB-1260	37	$6.9^{4}$	N/A	N/A	220
Inorganics		mg/kg	mg/kg		mg/kg
Nitrate	37	0.351-10.1	36	Pass Q	NE

#### Table 5-1. Analytes Detected above Background in Soil at the Eastern Dog Pens Area

#### Notes

Data from the Remedial Investigation Report (WA, 2003b).

Contaminant data includes data collected from all depth intervals instead of the 0-10 foot interval used in the risk estimate.

<sup>1</sup>Site-specific background levels (WA, 2000b).

<sup>2</sup>Using WRS with previously approved parameters; "Pass" indicates Eastern Dog Pens distribution statistically does not exceed the background distribution; "Q" indicates result is qualified due to insufficient data for WRS test based on Noether calculation. <sup>3</sup>Chemical PRGs for residential soil from US EPA Region 9 PRGs table, dated October 1, 2002. Radionuclide PRGs for residential soil

from Radionuclide Toxicity and PRGs for Superfund, dated April 14, 2003 US EPA, http://epa-prgs.orrl.gov/radionuclides/ download/rad\_master\_prg\_table.xls.

<sup>4</sup>Any values below reporting limits are estimated values. Most of the concentrations for pesticides are below reporting limits.

μg/kg	micrograms per kilogram	NE	none established
DDD	dichlordiphenyl dichlor	No.	Number
DDE	dichlordiphenyl ethylene	PCB	polychlorinated biphenyl
DDT	dichlordiphenyl trichlor	pCi/g	picoCuries per gram
Max.	maximum	PRG	preliminary remediation goal
mg/kg	milligrams per kilogram	Q	qualified
Min.	minimum	US EPA	United States Environmental Protection Agency
Min.	not available	US EPA	United States Environmental Protection Agency
N/A		WRS	Wilcoxon Rank Sum

#### Summary of Sampling Results Used in the Risk Estimate at the Eastern Dog Pens Table 5-2. Area

List 1 COPC	Total Samples	Number of Detections	Number of Detections > Background	Concentration Range <sup>1</sup>	Background Screening Concentration <sup>2</sup>	ID of Sample with Highest Concentration	Depth of Sample with Highest Conc.(ft)
<b>Pesticides/PCBs</b>				mg/kg	mg/kg		
Dieldrin	37	13	13	0.00076 - 0.223	0	SSDP0338DL1	0
Radionuclides				pCi/g	pCi/g		
Cesium-137	45	33	24	-0.01 - 0.191	0.012	SSDP0320	3.17
Lead-210	45	11	0	-0.8 - 2	1.6	LEHR-S-376	0
Potassium-40	45	45	0	5.21 - 13.9	14	SSDP0316	1.39
Radium-226	74	67	5	-0.38 - 1.68	0.75	CSDP0002	0
Radium-228	39	39	0	0.306 - 0.618	0.64	SSDP0316	1.39
Strontium-90	68	22	15	-0.125 - 8.3	0.056	CSDP0005R	0
Thorium-228	39	39	1	0.207 - 1.54	0.74	SSDP0328	2.1

#### Notes

Source: COPC data from the HHRA Risk Estimate, Appendix A (UC Davis, 2005). <sup>1</sup>The concentration ranges for radionuclides include non-detects. The concentration ranges for pesticides/PCBs do not include non-

detects. <sup>2</sup>The background screening concentrations are the unstratified background screening values in Appendix B of the HHRA Risk Estimate. Abbreviations

>	greater than
Conc.	concentration
COPC	constituent of potential concern
ft	feet
HHRA	Human Health Risk Assessment
ID	identification (number)
mg/kg	milligrams per kilogram
PCBs	polychlorinated biphenyls
pCi/g	picoCuries per gram

## Table 5-3. Human Health Risks to On-Site Resident by Exposure Route for Contaminants of Potential Concern at the Eastern Dog Pens Area

				CANCE	R RISK BY EXPO	<b>DSURE ROUTE</b>				
List 1 COPC	EPC <sup>1</sup>	Soil Ingestion	Soil Dermal Exposure	Above-Ground Plant Ingestion <sup>2</sup>	Below-Ground Plant Ingestion <sup>2</sup>	External Radiation	Dust Inhalation	List 1 Cancer Risk	Statistical Background Comparison <sup>3</sup>	List 2 Cancer Risk <sup>4</sup>
Dieldrin	0.019	5.E-07	9.E-08	2.E-06	2.E-07	-	4.E-11	3.E-06	Fail	3.E-06
Cesium-137	0.048	2.E-09	-	8.E-09	-	1.E-06	9.E-15	1.E-06	Pass	-
Lead-210	0.67	1.E-06	-	2.E-06	-	2.E-08	1.E-10	<b>3.E-06</b>	Fail	<b>3.E-06</b>
Potassium-40	12	6.E-07	-	1.E-05	-	9.E-05	2.E-12	1.E-04	Pass	-
Radium-226	0.53	7.E-07	-	2.E-06	-	4.E-05	2.E-10	4.E-05	Pass	-
Radium-228	0.50	4.E-07	-	1.E-06	-	2.E-05	4.E-10	2.E-05	Pass	-
Strontium-90+Daughter	0.62	7.E-08	-	2.E-06	-	1.E-07	1.E-12	<b>2.E-06</b>	Fail	<b>2.E-06</b>
Thorium-228	0.53	4.E-08	-	3.E-09	-	5.E-06	2.E-10	5.E-06	Pass	-
TOTAL								2.E-04		<b>8.E-06</b>
				HAZARD (	QUOTIENT BY EX	<b>XPOSURE ROUTE</b>				
List 1 COPC	EPC <sup>1</sup>	Soil Ingestion	Soil Dermal Exposure	Above-Ground Plant Ingestion	Below-Ground Plant Ingestion	External Radiation	Dust Inhalation	List 1 Non-Cancer Hazard Index	Statistical Background Comparison <sup>3</sup>	List 2 Non-Cancer Hazard Index <sup>4</sup>
Dieldrin	0.019	4.9E-03	1.4E-03	1.8E-02	9.8E-04	-	1.0E-07	2.5E-02	Fail	2.5E-02
TOTAL								2.5E-02		2.5E-02

Notes

Source Data from HHRA Risk Estimate, Tables 7 and 8. Statistical Background Comparison from Appendix B (UC Davis, 2005).

The non-cancer risk is for a resident child; the cancer risk is for an age-adjusted adult.

List 2 constituents shown in **bold-type** text contribute at least 10<sup>-6</sup>, or greater than 10%, to the excess cumulative cancer risk. Rounding may affect the total List 2 cancer risk values shown in the last column. Determination of whether the risk is greater than ten percent of total List 2 cancer risk is based on unrounded values.

<sup>1</sup>The 95% upper confidence limit on the mean of the exposure point concentration; chemical concentrations are in milligrams per kilogram and radionuclide concentrations are in picoCuries per gram.

<sup>2</sup>For radionuclides, plant ingestion is not subdivided into above-ground and below-ground plants.

<sup>3</sup>Based on Wilcoxon Rank Sum test or other statistical comparisons, as shown in Appendix B of the HHRA Risk Estimate.

<sup>4</sup>Dashes indicate that constituent was not identified as a List 2 COPC, since it was identified to be statistically equivalent to background.

#### Abbreviations

- not calculated COPC constituent of potential concern EPC exposure point concentration HHRA Human Health Risk Assessment

## Table 5-4. Data Summary—Comparison of Exposure Point Concentrations to Site Background at the Eastern Dog Pens Area

Analyte	Detections	Samples	Min Detect	Max Detect	Min Detection Limit	Max Detection Limit	Average <sup>1</sup>	Standard Deviation <sup>1</sup>	Distribution	95UCL <sup>1</sup>	EPC	Decay- Corrected EPC <sup>2</sup>
Site (0 to 10 f	t)		mg/kg or pCi/g	mg/kg or pCi/g	mg/kg or pCi/g	mg/kg or pCi/g	mg/kg or pCi/g	mg/kg or pCi/g		mg/kg or pCi/g	mg/kg or pCi/g	mg/kg or pCi/g
Dieldrin	13	37	0.00076	0.223	0.0034	0.0181	0.0091	0.037	Non-parametric	0.019	0.019	N/A
Lead-210	11	45	0.356	1.33	0.0656	3.9	0.57	0.43	Non-parametric	0.67	0.67	$N/A^3$
Strontium-90	22	68	0.023	8.3	0.0143	0.84	0.37	1.2	Non-parametric	0.62	0.62	0.53
Background (	0 to 10 ft)											
Dieldrin	3	53	0.00005	0.00051	0.0034	0.0043	0.00027	0.00023	N/A	$0^4$	$0^4$	N/A
Lead-210	6	26	0.703	2.49	0.209	5.08	0.719	0.697	Non-parametric	0.95	0.95	0.95
Strontium-90	12	38	0.0166	0.313	0.0158	0.89	0.0601	0.105	Non-parametric	0.089	0.089	0.076

Notes

Source: COPC data from Appendix A from HHRA Risk Estimate (UC Davis, 2005). 95UCL calculations for background concentrations and decay corrections added.

<sup>1</sup>Negative concentrations values were set to zero and concentrations below the detection limit were used to determine the 95UCL, average, and standard deviation for radionuclides. Same as 95UCL calculation procedure used in HHRA Risk Estimate (UC Davis, 2005).

<sup>2</sup>The EPC was decay-corrected to April 2005 (see Figures 5-6, 5-7 and Appendix A).

<sup>3</sup>The site EPC is less than the background EPC, so the changes in the site EPC over time are unknown due to simultaneous replenishment and decay.

<sup>4</sup>Background dieldrin EPC assumed equal to zero.

95UCL	95 percent upper confidence limit on the mean
COPC	constituent of potential concern
EPC	exposure point concentration
ft	feet
HHRA	Human Health Risk Assessment
max	maximum
min	minimum
mg/kg	milligrams per kilogram
N/A	not applicable
pCi/g	picoCuries per gram

Designated-Level	Inve	stigation Sampl	ing	Soil Background	NUFT So	NUFT Soil Result		Ground Water Concentration <sup>2</sup>		Ground Water		Tap Water	Time to Peak at
Constituent of Potential Concern	Maximum Detection (mg/kg or pCi/g) <sup>1</sup>	Depth of Maximum (ft)	95% UCL (mg/kg or pCi/g)	Value (mg/kg or pCi/g)	Background Water Goal (mg/kg or pCi/g)	MCL Water Goal (mg/kg or pCi/g)	(μg/l	or pCi/l) <sup>1</sup>	Concent (µg/l or	ration <sup>3</sup> pCi/l)	MCL (µg/l or pCi/l)	PRG (µg/l or pCi/l)	Goal Level (years)
							HSU-1	HSU-2	HSU-1	HSU-2			
<b>Radionuclides</b> Strontium-90	0.164	0	NC	0.056	NC	1.72E+15	1.07 ±0.35	< -0.574 - < 0.135 [ND] <sup>4</sup>	N/A	28 <sup>4</sup>	8	0.02	No impact expected
Metals													
Hexavalent Chromium	0.673	2	NC	1.3	2.56	NC	73	5 <b>- 27.0</b>	39	20	50 <sup>5</sup>	110	No impact expected
Mercury <sup>6</sup>	14.6	0	0.94	3.94/0.63 <sup>7</sup>	NC	0.94	< 0.20	<0.043 - <0.20[ND]	< 0.20	0.2	2	11	6,420
<b>Pesticides</b> 4,4'-DDD	0.0033	0	NC	0	NC	4,900	< 0.02	<0.0073 - < 0.10 /	< 0.02	<0.10	0.28	0.28	No impact expected
4,4'-DDE	0.0036	2	NC	0	NC	24,400	< 0.02	< 0.02 - 0.10 / < 0.004 - < 0.10 / < 0.02 - < 0.10	< 0.02	< 0.10	0.20	0.2	No impact expected
4,4'-DDT	0.0058	0	NC	0	NC	9,890	< 0.02	< 0.02 < 0.10 /	< 0.02	< 0.10	0.20	0.2	No impact expected
alpha-Chlordane	0.0478	0	NC	0	NC	110,000	< 0.01 – <b>0.016</b>	0.0026 - <0.053 / < 0.0099 - <0.050	< 0.01	< 0.050	0.05	0.19	No impact expected
gamma-Chlordane	0.0434	0	NC	0	NC	2.45E+7	< 0.01 - 0.0071	<0.0026 - <0.053 / < 0.0099 - <0.050	< 0.01	< 0.050	0.05	0.19	No impact expected
Dieldrin	0.223	0	NC	0	NC	25,000	< 0.02 – <b>0.03</b>	< 0.002 - <0.10 /	< 0.02	< 0.10	0.0042	0.0042	No impact expected
Aroclor 1254	0.0549	0	NC	0	NC	10,100	< 0.2	< 0.02 - <0.10 < 0.05 - <1.0 / < 0.05 - <1.0	< 0.02	<1.0	0.50	0.034	No impact expected

#### Potential Impacts on Ground Water of Designated-Level Constituents of Potential Concern in Eastern Dog Pens Area Soil Table 5-5.

Notes

<sup>1</sup>Strontium-90 in pCi/g or pCi/l, all others in mg/kg or μg/l. <sup>2</sup>Range of data from downgradient HSU-1 well UCD1-13, and HSU-2 well UCD2-39. <sup>3</sup>Based on concentrations in ground water from upgradient HSU-1 well UCD1-18, and HSU-2 wells UCD2-17 and UCD2-37.

<sup>4</sup>Measurements of strontium-90 using EPA Method 901.1 were excluded because those data are significantly less reliable than are those measurements of strontium-90 using other methods.

<sup>5</sup>MCL for total chromium.

<sup>6</sup>Assumed to be mercuric chloride.

<sup>7</sup>First value is a concentration for 0 to 4 ft below ground surface, second is consolidated concentration (all depths).

Bold type indicates soil concentration is above background and above NUFT result for ground water impact at background levels, or ground water concentration is above background.

Boxed type indicates soil concentration is above background and above NUFT result for ground water impact at the MCL, or ground water concentration is above the MCL.

<	denotes analyte concentrations below the detection limit	NC	not calculated
μg/l	micrograms per liter	ND	no detections in any samples
DDD	dichlordiphenyl dichloroethane	NUFT	Non-Isothermal, Unsaturated Flow and Transport model
DDE	dichlordiphenyl dichloroethylene	pCi/g	picoCuries per gram
DDT	dichlordiphenyl trichloroethane	pCi/l	picoCuries per liter
ft	feet	PRG	preliminary remediation goal (US EPA, 2002a for radionuclides; US EPA, 2002b for others)
MCL	Maximum Contaminant Level for ground water (primary)	UCL	upper confidence limit on the true mean based on sample data
mg/kg	milligrams per kilogram	US EPA	United States Environmental Protection Agency
N/A	not applicable or not available		

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# Table 5-6.Summary of Designated-Level Ground Water Constituents of Potential Concern at Eastern Dog Pens Area Retained as<br/>Constituents of Potential Ground Water Concern

	0	0	Θ	4
Designated-Level Constituent of Potential Concern	Are the DL COPCs ground water concentrations above site background? <sup>1</sup>	Are the DL COPC soil concentrations above soil background and the NUFT soil results? <sup>2</sup>	Will the DL COPC impact ground water above background levels in the next 500 years?	Retained as COPGWC in risk characterization? ✓ = Yes
	If yes, enter ✓ in ❹	If yes, go to <b>S</b>	If yes, enter ✓ in ④	
	If no, go to <b>2</b>	If no, stop and enter $\times$ below	If no, stop and enter $\times$ below	
Strontium-90	No	×	-	-
Hexavalent Chromium	Yes	-	-	$\checkmark$
Mercury	No	Yes	×	-
4,4'-DDD	No	×	-	-
4,4'-DDE	No	×	-	-
4,4'-DDT	No	×	-	-
alpha-Chlordane	Yes	-	-	$\checkmark$
gamma-Chlordane	Yes	-	-	$\checkmark$
Dieldrin	Yes	-	-	✓
Aroclor 1254	No	×	-	-

#### Note

<sup>1</sup>See Table 5-5. Compare downgradient ground water concentration to ground water background concentration. Results below detection limits are presumed to be below site background. <sup>2</sup>The lower of background and MCL goals.

×	not retained as a COPGWC
$\checkmark$	retained as a COPGWC
-	skip
COPC	constituent of potential concern
COPGWC	constituent of potential ground water concern
DDD	dichlordiphenyl dichlor
DDE	dichlordiphenyl ethylene
DDT	dichlordiphenyl trichlor
DL	designated-level
NUFT	Non-Isothermal, Unsaturated Flow and Transport

#### Summary of Major Factors Driving Risk and Recommendations for Future Action at Eastern Dog Pens Area Table 5-7.

Driver COPC / COPGWC	Total Cancer Risk <sup>1</sup>	Spatial Distribution	Background Contribution <sup>2</sup>	Above- Background Contribution <sup>3</sup>	Historically Used at the Site	Time for Attenuation to Risk Endpoint <sup>4</sup> (years)	Level of Ground Water Impact	Uncertainty	Recommended Action <sup>5</sup>	Basis for Recommendation
On-Site Resident	25.06	Teelined	00/	1000/	Var	NT/ A	NI/A		Eveluete in ES	
Dielarin	3E-00	Localized	0%	100%	Yes	1N/A	IN/A	• None.	Evaluate in FS	• Spatial analysis shows localized risk.
Lead-210	3E-06	Random	100%	0%	No	$< 0^{6}$	N/A	• Characterization/EPC uncertain due to high detection limits and counting errors.	No Further Action	<ul><li>Maximum detected concentration below background screening value.</li><li>Site EPC below background EPC.</li></ul>
Strontium-90	2E-06 (1E-6) <sup>7</sup>	Localized	14% (22%) <sup>7</sup>	$\frac{86\%}{(78\%)^7}$	Yes	26	N/A	• Six of 68 samples did not meet CERCLA data quality standards.	Evaluate in FS	• Majority of risk is due to site releases.
Ground water										
alpha-Chlordane	N/A	Localized	N/A	N/A	Yes	N/A	>bkgd	• Seven of 36 results qualified.	Monitoring	<ul> <li>Modeling suggests source other than EDPs.</li> <li>Modeling suggests that residual soil concentrations will not result in future impact.</li> <li>Possible release</li> </ul>
gamma-Chlordane	N/A	Localized	N/A	N/A	Yes	N/A	>bkgd	• Six of 36 results qualified.	Monitoring	<ul> <li>Modeling suggests source other than EDPs.</li> <li>Modeling suggests that residual soil concentrations will not result in future impact.</li> <li>Possible release.</li> </ul>
Dieldrin	N/A	Localized	N/A	N/A	No	N/A	>bkgd	• Nine of 37 results qualified.	Monitoring	<ul> <li>Modeling suggests source other than EDPs.</li> <li>Modeling suggests that residual soil concentrations will not result in future impact.</li> <li>Possible release.</li> </ul>
Hexavalent Chromium	N/A	Random	N/A	N/A	Yes	N/A	>MCL, >bkgd	• Eighteen of 39 results qualified.	No Further Action	Residual soil concentrations below background.

Notes

<sup>1</sup>For radionuclides, values are decay-corrected to April 2005 (see Figure 5-6, Figure 5-7 and Appendix B). <sup>2</sup>The background contribution is the proportion of the site EPC that can be attributed to the background EPC (see Table 5-4 and Figure 5-8).

<sup>3</sup>The above-background contribution is the proportion of the site EPC that is greater than the background EPC (see Figure 5-8).

<sup>4</sup>The time for attenuation to risk endpoint is the time, from April 2005, for the site EPC of a radionuclide to decay to either the background EPC or the concentration equivalent to a risk of 10<sup>-6</sup>, whichever is greater.

<sup>5</sup>The recommended action is independent of the UC Davis risk characterization for Landfill No. 2 and the Eastern Dog Pens.

<sup>6</sup>The site EPC is less than the background EPC.

<sup>7</sup>Values in parentheses are the risk and relative risk contributions from Sr-90 if the samples taken from concrete are excluded from the analysis.

>	greater than
<	less than
bkgd	background
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
COPC	constituent of potential concern
COPGWC	constituent of potential ground water concern
EDPs	Eastern Dog Pens
EPC	exposure point concentration
FS	Feasibility Study
MCL	California Maximum Contaminant Level (primary) for ground water (November 2002)
N/A	not applicable

## 6. RADIUM/STRONTIUM TREATMENT SYSTEMS AREA RISK CHARACTERIZATION

## 6.1 Area Description

Waste water from dog cages in Animal Hospital Nos. 1 and 2 was treated at the adjacent Radium/Strontium Treatment Systems (Figure 6-1). The subsurface release of treated waste water associated with these systems has impacted deeper soil. In 1999 and 2000, DOE removed the treatment tanks, associated piping and surrounding soil as a CERCLA non-time critical removal action (WA, 2002a).

The Ra-226 Treatment System consisted of two septic tanks (combined capacity of 14,400 gallons), each with two compartments separated by a weir, and an effluent distribution box feeding three dry wells and two leach trenches via distribution pipelines. Additionally, effluent piping from Domestic Septic Tank No. 2 was connected to this distribution box. Three Ra-226 dry wells were installed to facilitate subsurface infiltration of waste water. These dry wells, each with a diameter of about 2.5 ft, consisted of open boreholes filled with gravel between the depths of about 6 and 40 ft bgs (WA, 1998a). Because the infiltration capacity of the original dry well system was frequently exceeded, cobble-lined leach trenches were added in 1965. The southern leach trench extended south from the dry wells and was about 140 ft long, 3 ft wide and 14 ft deep. The northern leach trench extended north from the dry wells and was about 40 ft long, 3 ft wide and 14 ft deep.

The Sr-90 Treatment System consisted of a series of nine interconnected "Imhoff" tanks (Tanks A through I), and a leach field (WA, 1998a). The tanks were concrete and coated with a plastic material. The total capacity of these tanks was 46,000 gallons. In 1962, Building H-214 was built over a portion of the original leach field (along the eastern side of the tank). To enhance infiltration capacity, a second leach field was constructed to augment the original field.

In 1992, the remaining contents of the Ra-226 septic tanks were homogenized, pumped, solidified and shipped for disposal as low-level radioactive waste to DOE's Hanford site in Washington state (CWM, 1992). In 1991 and 1992, the majority of liquids and sludge remaining in the Sr-90 Imhoff tanks were removed, solidified, and also disposed at Hanford as low-level radioactive waste. After 1992, all of the tanks accumulated water, through possible rainwater infiltration. Approximately 12 cu yds of sludge and debris were left in Tank A in 1992, and ultimately removed during the CERCLA removal action as discussed below.

#### 6.1.1 Pre-Removal Action Contaminant Distribution

The contaminants at the Radium/Strontium Treatment Systems area were identified during environmental investigations and site characterization activities. Information regarding investigations performed at the Radium/Strontium Treatment Systems area may be found in:

- Draft Final Engineering Evaluation/Cost Analysis (EE/CA) (WA, 1998a); and
- Final Site Characterization Summary Report (WA, 1997b).

Three constituents, Ra-226, Sr-90, and nitrate, were either consistently detected at the Radium/Strontium Treatment Systems area or were associated with past operations and/or releases to the environment. Table 6-1 provides a summary of the pre-removal action constituents detected at the Radium/Strontium Treatment Systems area.

## 6.1.2 Removal Action Activities

A removal action was conducted at the Radium/Strontium Treatment Systems area beginning in May 1999 and ending in November 2000. The action was performed in accordance with the *Final Work Plan for Removal Actions in the Southwest Trenches, Ra/Sr Treatment Systems, and Domestic Septic System Areas* (WA, 2000b). In 1999, Domestic Septic Tank No. 2, associated piping, three upper dry well structures (zero to ten ft bgs), and two leach trenches and three cobble-filled dry wells were removed to an average depth of 42 ft. In 2000, the Ra-226 and Sr-90 tanks, associated influent piping, and leach fields were removed. The lower portions of the dry wells were filled with lowstrength concrete to eight ft bgs and all excavations were backfilled with approximately 3,300 cu yd of clean soil and compacted to grade.

## 6.1.3 Post-Removal Action Contaminant Distribution

Throughout the removal action, screening samples were collected to guide the extent of soil excavation. To delineate the lateral and vertical extent of contamination of the leach fields and piping, soil samples were collected from the dry well excavation boundaries. The screening samples were analyzed for Ra-226, Sr-90 and nitrate. Following removal of subsurface structures and surrounding soil, confirmation samples were collected from the excavation sidewalls and floor to verify that the cleanup criteria for all COCs were met. A total of 70 confirmation samples and eight duplicate samples (total of 78 samples) were collected at depths between one and 42 ft bgs. The excavation confirmation samples were analyzed for radionuclides, pesticides/PCBs, metals, VOCs, SVOCs and nitrate.

All of the 78 confirmation samples were analyzed for 28 pesticides and PCBs, 68 SVOCs and 33 VOCs. Of the 28 pesticides and PCBs, four constituents, 4,4'-DDT, alpha-chlordane, gamma-chlordane and heptachlor, were reported above the detection limit. The maximum detected concentrations for these four constituents were all found in a sample collected from the excavation surrounding the influent piping to the Ra-226 Tank. The maximum detected concentrations for 4,4'DDT, alpha-chlordane, gamma-chlordane and heptachlor were 133, 277, 346 and 52.2  $\mu$ g/kg,

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respectively. Of the 68 SVOCs, di-n-butyl-phthalate was detected at 380  $\mu$ g/kg in one sample collected from the excavation surrounding the influent piping to the Ra-226 Tank. Of the 33 VOCs, three constituents, 2-butanone (methyl ethyl ketone), acetone and toluene, were reported above the detection limit. The maximum concentration of 2-butanone (132  $\mu$ g/kg) was found near the Domestic Septic Tank No. 2 excavation at ten ft bgs. The maximum acetone concentration at 44.8  $\mu$ g/kg was detected in a sample collected at Dry Well No. 3 at 42.5 ft bgs. The maximum toluene concentration (263  $\mu$ g/kg) was detected in a sample collected from the location of the former Sr-90 Tank at ten ft bgs.

The maximum Ra-226 concentration (1.81 pCi/g) was detected in a sample collected 42.5 ft bgs near the bottom of Dry Well No. 2. The sample with the maximum Sr-90 concentration was collected five ft bgs near the former location of the influent piping for the Sr-90 Tank. The maximum mercury concentrations were detected in samples collected at depths of 1 and 5.5 ft in the southern leach trench, approximately 20 ft and 140 ft south of Dry Well No. 3, respectively. The sample with the maximum Cr-VI concentration was collected from the Sr-90 leach field, under the former location of the strontium effluent pipe, at a depth of seven ft. The maximum nitrate concentration was detected at 20 ft bgs in the sidewall of the Dry Well No. 2 excavation.

An evaluation of the confirmation sample data for compliance with DLs required to achieve ground water protection identified Cr-VI, nitrate, mercury, C-14, and Cs-137 as COCs requiring additional evaluation. Thirteen additional soil borings were advanced to the water table, soil samples were collected at various depths, and samples were analyzed for each one of the five COCs to determine the vertical distribution of these constituents. The additional data suggested that Cs-137 in the Radium/Strontium Treatment Systems area presents no threat to ground water. Ground water impact resulting from Cr-VI, mercury and C-14 in Radium/Strontium Treatment Systems area soil was found to be possible, but likely to be very localized and below MCLs. Nitrate was found to potentially impact ground water locally above background and/or the MCL.

Additional information on the post-removal action sampling and analysis is presented in the *Final Radium/Strontium Treatment Systems Area Removal Action Confirmation Report* (WA, 2002a).

## 6.1.4 Future Land Use

Future use of the Radium/Strontium Treatment Systems area by UC Davis will be consistent with the "Academic/Administrative Low Density" land use designation of the area contained in Section 3.8.1 of the UC Davis 2003 *Long Range Development Plan* (UC Davis, 2003). The western portion of the Radium/Strontium Treatment Systems area (identified as Area I in Figure 6-1) is currently paved and is used as a parking area and access road for the adjacent buildings. Area II (Figure 6-1) is unpaved and not currently used or landscaped.
#### 6.2 Summary of the Risk Estimate

The confirmation sample data were combined with backfill characterization data. None of the prior characterization sample results were used since they represented removed soil. The combined data set was then evaluated in the risk estimate. Table 6-2 provides a summary of all data used in the Tier 2 risk estimate. The sample locations for all data used in the risk estimate are presented in Figure 6-2.

As discussed in Section 6.1, the Radium/Strontium Treatment Systems area is considered a subsurface release area in the risk estimate since:

- Process information and observations during the removal action indicated that all releases of hazardous material occurred below a depth of four ft;
- Contamination control practices employed during removal action prevented surface contamination; and
- All of the excavations were backfilled with clean fill to depths of at least three ft.

As a result, the risk estimate did not evaluate surface soil exposure to potential receptors except the hypothetical site resident. In this case, surface soil exposures were developed using EPCs derived from the zero- to ten-ft data set.

#### 6.2.1 Quality of Site Data

Data quality procedures common to evaluations of all DOE areas and site background at LEHR are discussed in Section 2.2.

The total data set for the Radium/Strontium Treatment Systems area included 13,934 results. Fifty-four of these results, or 0.4%, were rejected from the total data set ("R"-qualified). Sample results are rejected when a data validation expert reviewing laboratory data finds evidence of serious deficiencies in the ability to analyze a sample and meet QC criteria. The "R" qualifier indicates that the data cannot be used to verify whether the analyte was present in or absent from the sample. "R"-qualified results were not used in the risk estimate. After "R"-qualified data were removed from the total data set, the final risk estimate data set contained 13,880 results. Five-hundred eleven of the results, or 3.7%, had "J" qualifiers, which indicate that an analyte was positively identified in the sample, but the analytical result is an approximation of the analyte concentration in the sample. Data with "J" qualifiers were used in developing risk estimates. A total of 889 records, or 6.4%, had "UJ" qualifiers, which means that an analyte was not detected, but the detection limit is approximate. Data with "UJ" qualifiers were included in the risk estimate and were treated as a non-detection of an analyte.

A total of 910 of the 13,880 final records from the Radium/Strontium Treatment Systems area were used to generate the Tier 2 human health risk estimates. A total of 18 of the 910 results had "J" qualifiers and 23 results had "UJ" qualifiers.

### 6.3 Risk Characterization—Radium/Strontium Treatment Systems Area

Consistent with the HHRA Risk Estimate, as discussed in Section 2.2, this risk characterization uses the terms "List 1" and "List 2". List 2 identifies constituents that failed the statistical comparison to background, which may be indicative of a release to the environment. Table 6-3 and Table 6-4, in the first column, provide the List 1 COPCs identified in the HHRA Risk Estimate. The last column of Table 6-3 and Table 6-4 provides only risk values for List 2 COPCs. The values provided are not corrected for decay. A subset (shown in bold-type) of List 2 contains COPCs that have a risk of at least 10<sup>-6</sup> or contribute more than ten percent of the total excess cumulative cancer risk in the Radium/Strontium Treatment Systems area.

Specifically, this subset consists of Sr-90 and Th-228 for the hypothetical on-site resident, and Th-228 for the outdoor research worker. This subset is identified in this risk characterization as comprising the List 2 driver COPCs, since these COPCs represent potential site-related risks. These COPCs are the focus of the risk characterization discussions that follow. None of the receptors evaluated for this area showed non-cancer hazard quotients above the point of departure of one.

Carcinogenic risks estimated in the HHRA Risk Estimate were below  $1 \times 10^{-6}$  for all receptors except hypothetical on-site residents and outdoor research workers. List 2 cumulative carcinogenic risks to hypothetical future on-site residents and outdoor research workers were estimated to be 6 x  $10^{-6}$  and 2 x  $10^{-6}$ , respectively. The risk characterization for the Radium/Strontium Treatment Systems area focuses on these two receptors.

Because of the subsurface release conditions discussed above, the exposure pathway for the outdoor researcher is limited to external radiation based on an EPC developed using the zero- to ten-ft data set. This approach will likely overestimate the risk to the outdoor researcher, since the radiation attenuation provided by several ft of imported fill overlying the contaminated soil was not accounted for. Future movement of the contaminated soil to the surface may increase the risk to the outdoor researcher and other receptors, but the levels would be less than the hypothetical-residential exposure due to shortened exposure durations and the lack of plant ingestion.

#### 6.3.1 Exposure Assessment

The exposure assessment for List 2 driver COPCs at the Radium/Strontium Treatment Systems area includes:

- The spatial distribution of the List 2 driver COPCs;
- Risk from COPC concentrations attributed to site background versus prior site activities; and
- Exposure intake estimates and their effect on the overall risk estimate.

A conceptual site model illustrating exposure pathways and potential human receptors for all DOE areas is provided as Figure 2-1.

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#### 6.3.1.1 Spatial Distribution of Contaminants of Potential Concern

Figure 6-3 and Figure 6-4 show the spatial distribution of post-removal action sample results for Sr-90 and Th-228, respectively. A visual comparison of the site data to the background and benchmarks (e.g.,  $10^{-6}$  and  $10^{-5}$ ) should identify data anomalies and trends that may have significance in the risk characterization and Feasibility Study. Section 2.2.3.1 contains the description of symbols used in the spatial distribution maps.

None of the sample results were greater than the concentrations corresponding to risks of  $10^{-5}$  for either of the driver COPCs. Sampling at the Radium/Strontium Treatment Systems area comprised samples collected at depths ranging from one to 42.5 ft. Only samples collected between one and ten ft bgs were used in the risk estimate. As previously discussed in Section 6.2, no surface soil samples were used in the risk estimate (Figure 6-2). Random grid, hot spot, and vertical profile samples were collected within the potential areas of contamination.

#### 6.3.1.1.1 Strontium-90 Distribution

The Sr-90 spatial analysis is shown in Figure 6-3. None of the samples analyzed indicated a risk above  $10^{-5}$  to a residential receptor. Twenty-five of the 90 sample results had concentrations above background, and only ten indicated a risk greater than  $10^{-6}$ . The ten samples, with a risk range between  $10^{-5}$  and  $10^{-6}$ , were clustered in the location of the leach field to the former Sr-90 treatment tank, between Animal Hospital Nos. 1 and 2.

All samples throughout the Ra-226 leach field, Ra-226 tank, Domestic Septic Tank No. 2 and Sr-90 tank areas had Sr-90 concentrations corresponding to a risk below  $10^{-6}$ . Sr-90 concentrations were below background in all of the samples collected from the southern half of the Ra-226 leach field. Three samples in the northern half of the Ra-226 leach field had Sr-90 concentrations above background, but with a corresponding risk below  $10^{-6}$ . About half of the samples located near or beneath the former Sr-90 tank had concentrations above background, but with a corresponding risk below  $10^{-6}$ .

#### 6.3.1.1.2 Thorium-228 Distribution

The Th-228 spatial analysis is shown in Figure 6-4. For both the on-site resident and outdoor researcher, the measured concentrations correspond to risks in the 10<sup>-6</sup> to the 10<sup>-5</sup> range for all samples. Nine of the 85 samples had concentrations above background. Six of these samples were clustered in the location of the former Sr-90 treatment tank and Sr-90 leach field, between Animal Hospital Nos. 1 and 2. Five of these samples are co-located with samples that show elevated concentrations of Sr-90.

All samples throughout the Ra-226 leach trenches, except for two, had concentrations below background. The samples in the Sr-90 leach field and Sr-90 tank area with concentrations above background do appear to indicate a localized area of contamination, particularly because five of these samples are located in areas of elevated Sr-90 concentrations. Based on the spatial distribution of these data, Th-228 concentrations appear to exceed background and the 10<sup>-6</sup> risk in the location of the former Sr-90 treatment tanks and leach field.

#### 6.3.1.2 Degradation and Decay of Contaminants of Potential Concern

The methodology for calculating radionuclide decay is described in detail in Appendix B.

#### 6.3.1.2.1 Strontium-90

Sr-90 has a half-life of 28.79 years and is not naturally occurring. The Sr-90 decay estimate for the Radium/Strontium Treatment Systems area is shown in Figure 6-5. The site EPC is less than the concentration equivalent to a risk of  $10^{-6}$  for the residential receptor.

#### 6.3.1.2.2 Thorium-228

Th-228 (half-life of 1.9 yrs) is naturally occurring and is part of the thorium-decay series, where it is derived from the primordial Th-232 parent, which has a half-life of  $1.4 \times 10^{10}$  yrs. The decay estimate for Th-228 at the Radium/Strontium Treatment Systems area is shown in Figure 6-6. Based on the Th-228 half-life, the site EPC should decay to within 1% of the background EPC in approximately 3.5 years.

### 6.3.1.3 Background Evaluation

### 6.3.1.3.1 Detections above Site Background

The number of analytical results that were greater than both the detection limits and the background screening levels are reported in Table 6-2. The two COPCs that are the List 2 drivers, Sr-90 and Th-228, were detected above background in 25 and 9 samples, respectively.

#### 6.3.1.3.2 Parent-Daughter Activity Concentration Relationships

The concentration of Th-228 at the Radium/Strontium Treatment Systems area was compared to the concentration of its longer-lived parent, Th-232, in Appendix E (Figure E-9). As shown, the concentrations of these isotopes appear to be in secular equilibrium when quantified analytical errors are taken into account. This is evidence that the concentration of Th-228 at the site is due to decay of Th-232 rather than to a release of Th-228, because any shorter-lived daughter isotope will have a concentration approximately equal to that of its longer-lived parent isotope, in the absence of excess input of the daughter. The apparent elevated concentration of Th-228 at the site relative to background, therefore, is probably due to analytical limitations rather than to a release.

#### 6.3.1.3.3 Comparison of Risk Attributed to Background versus Site Activities

Table 6-5 presents statistics, including EPCs, for the sample results of the List 2 driver COPCs at both the site and in the background. The background EPCs were calculated using the same method used to calculate the site EPCs (Section 2.2.3.3.3). Table 6-5 also presents decay-corrected EPCs. EPCs can be used to derive relative contributions of risk because risk is directly proportional to the EPC.

Figure 6-7 graphically illustrates the site risks to both receptors from both List 2 driver COPCs, and the relative contribution to those risks from the background. These risks and proportions have been corrected for decay. As shown in Figure 6-7, the background contribution to the Sr-90 risk is 34%. The background contribution to the Th-228 risk is 97%.

#### 6.3.2 Toxicity Assessment

Toxicity values for COPCs in the Radium/Strontium Treatment Systems area were taken from US EPA guidance, as discussed in Section 2.2.4. The toxicity values used for these COPCs are appropriate for this evaluation and make use of the best available information.

### 6.3.3 Risk Estimate

Table 6-3 summarizes the risk estimate information for the hypothetical future on-site resident. It shows that Sr-90 risk is driven primarily by above-ground plant ingestion (89%), with secondary contributions from external radiation (7%) and soil ingestion (4%). Th-228 risk is driven by external radiation, with no significant contributions from the other exposure pathways.

Table 6-4 summarizes the risk estimate information for the outdoor researcher. The risk estimate bases the outdoor researcher's risk solely on external radiation and indicates that nearly all of the risk is from Th-228. The Th-228 EPC (0.59 pCi/g) was only slightly above the background EPC (0.50 pCi/g) when samples were last collected in 2000; the concentration should be nearly equal to background in approximately 3.5 years, based on the decay half-life (1.9 yrs).

#### 6.3.4 Uncertainty

Risk estimates are values that have uncertainties associated with them, as discussed in Section 2.2.6. The objective of this section is to discuss the major sources of uncertainty that are specific to this refined assessment of the Radium/Strontium Treatment Systems area. These include data coverage and analytical issues.

#### 6.3.4.1 Analytical Issues

#### 6.3.4.1.1 Strontium-90

All of the Sr-90 samples in the Radium/Strontium Treatment Systems area data set were collected after the analytical method was improved in 1997. However, twelve Sr-90 results were "J" qualified and twenty were "UJ" qualified due to expired initial calibration of the laboratory instrumentation. Sr-90 initial calibrations are performed annually. The continuing calibration check, which consists of measuring a National Institute of Science and Technology-traceable standard, showed that the calibration was within control limits for these samples. In addition, all of the other QC parameters (holding time, blanks, relative error ratio, laboratory control samples, matrix spikes and field duplicates) were within control limits for these samples. Because the control limits were met and the data qualifications were due to a calibration procedure that is required annually, the Sr-90 data are likely very accurate. The data qualifications do not indicate a high or low bias for these data.

#### 6.3.4.1.2 Thorium-228

The histogram of Th-228 and Th-232 data for the Radium/Strontium Treatment Systems area (Figure 6-8) indicates a general positive shift in the Th-228 concentration relative to Th-232 that may or may not be due to contamination. Th-228 and its parent, Th-232, are part of the thorium decay series. Because Th-228 has a short half-life (1.9 yrs), naturally-occurring Th-228 it is expected to be in secular equilibrium (i.e., have the same concentration) with its parent, Th-232, which is much longer-lived (half-life of  $1.4 \times 10^{10}$  years). As shown in Figure 6-8, however, the Th-228 frequency distribution is generally shifted to the right of Th-232.

The soil background histogram for these isotopes is shown in Figure 6-9. The background histogram shows Th-228 and Th-232 in reasonable equilibrium. A comparison of Figure 6-9 and Figure 6-8 indicates Th-228 data from the Radium/Strontium Treatment Systems area have a slight positive distribution shift from background, and Th-232 data from the area have a slight negative shift from background. The last two bins of the Th-228 histogram for the Radium/Strontium Treatment Systems area (Figure 6-8) suggest a slight tail.

Histograms of contaminated soil data when compared to the reference background data distribution usually show an extended tail or bimodal distributions, but general distribution shifts are unexpected. It is possible that the distribution shift is due to overall analytical drift observed in Figure 6-8. The background samples and Radium/Strontium Treatment Systems area samples were collected and analyzed during different time periods. Temporal analytical drift would also explain the observation that the Th-228 data are biased slightly positive and the Th-232 data are biased slightly negative. Yet, no data quality qualifications were found during data validation and no analytical methodology changes occurred between collecting the background samples and the Radium/Strontium Treatment Systems area samples. Analytical drift is a possible explanation for the overall distribution shifts, but no confirming evidence is available to support that explanation. It is also possible that the overall distribution shift is due to natural variability in the Site soil.

#### 6.3.4.2 Data Representativeness

Soil boring samples were collected in the Radium/Strontium Treatment Systems area to characterize the Site prior to removal actions that were conducted in 1999 and 2000. Since all of these sample represented removed soil, the results were properly removed from the data used in the risk estimate. Random grid, discretionary grab samples, and soil boring samples were collected after the treatment tanks, leach fields and associated contamination were removed by excavation. The samples were collected at depths ranging from one ft bgs to 42.5 ft bgs. Only samples collected at depths less than or equal to ten ft bgs were used in the risk estimate. As previously discussed in Section 6.2, no surface soil samples (0 to 0.5 ft bgs) were collected in the Radium/Strontium Treatment Systems area, because the contamination was released to subsurface soil and the contaminant chemical characteristics and subsurface physical conditions were unlikely to result in surface contamination (i.e., no upward volatile compound diffusion, no shallow water table fluctuation).

Subsurface soil sample coverage was extensive, and covers all of the known potential source areas. Figure 6-2 shows the soil samples collected from one to ten ft bgs. There were no samples collected near the southern end of the Ra-226 leach field and below the former Ra-226 tank between

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0.5 and 10 ft bgs. Removal action confirmation samples were collected in these areas, but these samples are not shown, because the excavation was more than ten ft deep. No significant residual contamination was present in these deeper samples.

The data used to determine risk estimates were representative of site conditions at the time they were collected. The data coverage was extensive, and the samples were collected and analyzed according to Superfund risk assessment data quality standards. Due to radiological decay, some of the radionuclide data, such as Th-228 data, is not representative of current site conditions. Decay corrections for short-lived isotopes should be considered in formulating decisions for remedial action in this area.

### 6.3.5 Relation of Concentrations of Contaminants of Potential Concern to Site Operations

Sr-90 was used extensively in experiments at LEHR, and Sr-90 waste was treated and discharged to subsurface soil via the Sr-90 leach field. The elevated Sr-90 concentrations in the Sr-90 leach field are a result of discharges from the leach field to surrounding subsurface soil (Figure 6-1). In addition to the leach field releases, the former Sr-90 treatment tank may have released some Sr-90 contamination to underlying soil and the near vicinity. As shown in Figure 6-3, about half of the samples in the vicinity of the former Sr-90 tank were above background. The data do not appear to indicate a Sr-90 release in the Ra-226 leach trenches. None of the Sr-90 data are above the background screening value in the southern Ra-226 leach trench. Two samples were above background in the northern Ra-226 leach trench, but the sample concentrations correspond to a risk below 10<sup>-6</sup>. The data are consistent with operational history that indicates Sr-90 waste was handled separately from Ra-226 waste.

Available information indicates that Th-228 was used as a source material to generate thoron (radon-220) in experiments at LEHR. Records indicate that this material was carefully managed and no releases are suspected. However, Th-228 concentrations in the Sr-90 leach field appear to indicate that a small release occurred. As discussed in the spatial analysis, a cluster of Th-228 results were above the background screening value in the vicinity of the former Sr-90 treatment tank and leach field. Five of the elevated Th-228 results were co-located with elevated Sr-90 results. The highest Th-228 result was approximately 1.5 times the background screening value and the general sample distribution is slightly shifted above the background sample distribution. Given the short half-life of Th-228 (1.9 yrs), the concentration of Th-228 in the Radium/Strontium Treatment Systems area has likely declined since samples were last collected in 2000 and will approach natural levels in approximately 3.5 years.

#### 6.4 Ground Water Impacts

In addition to evaluation of human health risk resulting from soil contamination, potential ground water impacts from contaminants remaining in the soil at the Radium/Strontium Treatment Systems area were evaluated and are presented in the RI (WA, 2003b). These impacts are summarized in Table 6-6.

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### 6.4.1 Risk Characterization of Constituents of Potential Ground Water Concern

Residual soil contaminants identified in the post-removal action confirmation samples and in follow-up analyses described in the *DOE Areas Remedial Investigation Report* (WA, 2003b) were identified as potential DL COPCs. These constituents include Am-241, C-14, Cs-137, Ra-226, Th-228, Cr-VI, Hg, nitrate, cadmium and zinc. Table 6-6 summarizes these constituents and their potential impact on ground water.

Ground water data collected from the one downgradient HSU-1 well (UCD1-21) and two downgradient HSU-2 wells (UCD2-7 and UCD2-36) (Figure 2-3) nearest to the Radium/Strontium Treatment Systems area were compared to ground water background. Cr-VI has been detected in the HSU-1 and HSU-2 downgradient wells (UCD1-21 and UCD2-7) in concentrations exceeding background and the MCL. Cr-VI exceeds background in ground water from downgradient well UCD2-36. Hg, cadmium, zinc and Cs-137 were either not detected or were detected at levels below background in ground water from downgradient wells. Nitrate concentrations exceeding background and the MCL (as high as 64 mg/l) have been detected in downgradient wells UCD1-21, UCD2-7 and UCD2-36. C-14 concentration in ground water from downgradient well UCD1-21 has ranged from 105±63 to 177±69 picoCuries per liter (pCi/l), above the ground water background value of 3.5 pCi/l, but well below the MCL of 2,000 pCi/l. C-14 periodically exceeded background in UCD2-36 but is below background in UCD2-7. The ground water sample data show low or non-detectable levels of Ra-226 and Am-241 in downgradient well UCD1-21 and in background well UCD1-18. Ground water results for the nearest downgradient well (UCD1-21) indicate the highest concentrations of Ra-226 and Am-241 may exceed those in background well UCD1-18. No Th-228 ground water data are available for these wells.

Based on the vadose zone modeling results, it is very unlikely that the low concentrations of Cs-137, Am-241, and Th-228 detected in the Radium/Strontium Treatment Systems area ground water and/or soil samples would elevate ground water concentrations of these constituents above background or the MCL. Modeling results indicate that C-14 remaining in the Radium/Strontium Treatment Systems area soil could potentially reach ground water at concentrations above background and the MCL, but any impact would be highly localized. Modeling results indicate that Ra-226 remaining in the Ra-226 seepage trench/dry well area could potentially impact local ground water above background, but below the MCL. Modeling results indicate that migration of Hg, cadmium and zinc remaining in area soil could potentially increase the concentrations of these constituents in ground water above background, and locally above MCLs. Modeling results indicate that nitrate remaining in the area soil could impact ground water at concentrations above the 25.1 mg/l background and the 10 mg/l MCL.

Estimated peak concentrations of Hg, cadmium, and zinc in ground water will not occur for over 5,000 years. Nitrate impacts are estimated to occur in the next ten years. C-14 is expected to impact ground water in fifteen years, whereas the Ra-226 impact is current due to the depth of the localized Ra-226.

Based on the DL COPC evaluation process illustrated in Figure 1-2 and as shown in Table 6-7, only Cr-VI, nitrate, Am-241, C-14 and Ra-226 should be retained for further evaluation as COPGWCs.

#### 6.4.1.1 Percentage and Spatial Distribution of Samples Exceeding Background

Spatial distribution of ground water COPCs is documented in the *DOE Areas Remedial Investigation Report* (WA, 2003b).

#### 6.4.1.1.1 Americium-241

Five out of 101 (5%) of the Am-241 soil sample results exceeded background in the Radium/Strontium Treatment Systems area. Three of the elevated samples were located in the vicinity of the Sr-90 and Ra-226 treatment tanks and Sr-90 leach field. These three samples were located randomly in the soil column and had random lateral distribution across the area. The remaining two elevated samples were collected from the same soil boring in the Ra-226 leach trench at 25 and 29 ft bgs. These two elevated samples appear to represent a localized cluster of Am-241 contamination, but their concentrations (0.028 pCi/g and 0.033 pCi/g) were only about twice the background screening value (0.014 pCi/g). The Am-241 concentrations in all five elevated samples ranged from between  $0.0256\pm0.0117$  pCi/g and  $0.0847\pm0.0185$  pCi/g. These data indicate that Am-241 concentrations in the Radium/Strontium Treatment Systems area are low and mostly random in spatial distribution. A small area of localized low-level Am-241 contamination may be present in the Ra-226 leach trench between 25 and 29 ft bgs.

#### 6.4.1.1.2 Carbon-14

Only six out of 103 soil sample results (6%) exceeded background for C-14 in the Radium/Strontium Treatment Systems area. The elevated results were located in the Ra-226 leach trench at depths ranging between 5.5 and 13.5 ft bgs. Two of the samples had relatively high concentrations ( $2.38\pm0.115$  pCi/g and  $2.41\pm0.112$  pCi/g) compared to background (0.13 pCi/g). The two elevated samples (SSRSC019 and SSRSC020) were clustered at the southern end of the Ra-226 leach trench (SSRSC019 shown in Figure 6-2). Soil boring samples were collected at these two sample locations at depths ranging from 13 to 33.5 ft bgs. C-14 concentrations were consistent with background in the soil boring samples. C-14 concentrations in the other four elevated sample results were significantly lower ( $0.173\pm0.0606$  pCi/g to  $0.404\pm0.0634$  pCi/g) and randomly distributed across the Ra-226 leach trench. These data suggest that any residual C-14 is limited in extent and is not actively releasing C-14 to ground water.

#### 6.4.1.1.3 Radium-226

The spatial distribution of above-background Ra-226 is limited. Only five out of 106 (5%) of the Radium/Strontium Treatment Systems area soil samples exceeded background. The samples with elevated concentrations were located at depths ranging between 15 ft bgs and 42.5 ft bgs. Three of the samples were located below the southern Ra-226 leach trench, and two were inside the southern and middle dry wells. Deeper soil samples were collected below each of these locations and their results were below background. The extent and mass of Ra-226 appears limited to depths below 15 ft bgs in the vicinity of the former southern leach trench and dry wells.

#### 6.4.1.1.4 Hexavalent Chromium

All 99 hexavalent chromium results were below background (1.3 mg/kg) in the Radium/Strontium Treatment Systems area. Hexavalent chromium appears to be uniformly below background throughout the lateral and vertical extent of the area.

#### 6.4.1.1.5 Nitrate

A significant fraction of the nitrate results exceeded background (29 of 126, or 23%) in the Radium/Strontium Treatment Systems area. The elevated results ranged from 36.1 mg/kg to 304 mg/kg and were clustered in the vicinity of the three dry wells, Domestic Septic Tank No. 2 and the northern Ra-226 leach trench. The background concentration for nitrate in LEHR soil is 36 mg/kg. Nitrate was below background throughout the southern Ra-226 leach trench, Sr-90 leach field, and Sr-90 and Ra-226 treatment tank areas. Most of the nitrate contamination is distributed vertically between four and 20 ft bgs. However, two of three samples collected at 42.5 ft bgs had nitrate concentrations above background. Intervals from one to three ft bgs and 21 to 29 ft bgs were below background. The area of nitrate contamination appears to be approximately twenty-five ft wide with a small leg extending north along the northern Ra-226 leach trench, and 20 ft deep with potential deeper contamination.

#### 6.4.1.2 Degradation and Decay of Contaminants of Potential Concern

Cr-VI, alpha-chlordane, gamma-chlordane, and dieldrin are not expected to undergo significant degradation or decay.

Am-241 and C-14 are not naturally occurring isotopes and have half-lives of 432.7 and 5,730 years, respectively. Ra-226 has a half-life of 1,600 years. Ra-226 is naturally occurring and is part of the uranium-decay series, where it is derived from U-238. Decay of natural uranium will replenish Ra-226 at background concentrations.

# 6.4.1.3 Uncertainty

The objective of this section is to discuss the major sources of uncertainty that are specific to the assessment of the Radium/Strontium Treatment Systems area.

# 6.4.1.3.1 Analytical Issues

# 6.4.1.3.1.1 Americium-241

No significant data quality issues were identified for the Am-241 soil results. There is no history of analytical methodology problems or changes that would impact Am-241 data quality or accuracy. Three of the results were qualified due to high relative percent difference between the sample and its field duplicate. Field duplicate imprecision is an indication of variability in sample collection. Differences in field duplicate soil sample concentrations are usually due to collecting the sample from slightly different locations. Two soil samples cannot be collected from the exact same location and concentrations in soil can vary significantly with position. Although these samples and their field duplicate concentrations were variable relative to one another, all three of the qualified results were below background. It should be noted that the higher concentration between a sample

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and its field duplicate is used for background comparisons and evaluations of DOE areas data. Data issues associated with downgradient ground water results from UCD1-21 were identified, as discussed in Section 6.5.2.3.

#### 6.4.1.3.1.2 Carbon-14

Three of the C-14 results were qualified due to high relative percent difference between a sample and its field duplicate. All three of these qualified results were below background. As noted above for Am-241, the higher concentration between a sample and its field duplicate is used for background comparisons. No significant data quality issues were identified for the C-14 results.

### 6.4.1.3.1.3 Hexavalent Chromium

Thirty-eight of the 99 hexavalent chromium results were qualified. Twenty-eight results were qualified due to matrix spike recovery failure, which is likely due to soil chemistry in the matrix spike sample. Hexavalent chromium spike solution can change its valiancy when it is added to a sample. If the spiked hexavalent chromium changes states during sample preparation, the analytical instrument will not detect it.

Eight samples were qualified due to contamination detected in the laboratory method blank. Laboratory contamination can cause false positive detection, and may cause an overall positive bias in a data set. Seven samples were qualified due to expired holding time, which can affect sample accuracy and cause a negative bias. Two samples were qualified due to field duplicate imprecision. It should be noted that twenty samples were qualified for more than one reason. Accuracy issues were identified with 38% the hexavalent chromium data.

#### 6.4.1.3.1.4 Nitrate

Nineteen of the 126 nitrate results were qualified during data validation. Eighteen of these results were qualified due to expired holding time. All of the holding time-qualified samples had detected concentrations that were below background. Samples can lose nitrate after the holding time is expired, which can give these data a negative bias. One sample was qualified because the result was between the method detection limit and the quantitation limit. This result is not as accurate as results that are above the quantitation limit, but the qualification does not indicate a positive or negative bias.

### 6.4.1.3.1.5 Radium-226

No significant data quality issues were identified for the Ra-226 results. All but two of the 106 results were above the detection limit. The Ra-226 counting error values were relatively low. Three of the results were qualified due to high relative percent difference between field duplicates. One of the qualified field duplicate results was above background. The results for this field duplicate pair were 0.87  $\pm 0.24$  pCi/g and 0.045  $\pm 0.098$  pCi/g with detection limits of 0.15 pCi/g and 0.18 pCi/g, respectively. Because the higher result from field duplicate pairs is always selected for use in DOE areas data evaluations, the data may have a positive bias.

#### 6.4.1.3.2 Data Representativeness

Radium/Strontium Treatment Systems area sampling consisted of random grid, discretionary grab samples, and soil boring samples collected at depths ranging from one ft bgs to 42.5 ft bgs. Soil sample coverage was extensive, and covers the lateral and vertical extent of the known potential source areas. The samples were collected and analyzed according to Superfund risk assessment data quality standards. The data are sufficient for characterizing the soil column in the Radium/Strontium Treatment Systems area. No data gaps were identified.

### 6.4.1.4 Relation of Concentrations of Contaminants of Potential Ground Water Concern to Site Operations

Cr-VI is potentially associated with LEHR operations, since chromic acid and other chromium-bearing chemicals may have been used or disposed at the Site. Although it has been detected in the nearest downgradient wells (UCD1-21) in concentrations exceeding background at the MCL, modeling indicates that the impact is not associated with the Radium/Strontium Treatment Systems area Cr-VI soil concentrations. The residual Cr-VI at the Radium/Strontium Treatment Systems area is currently at background levels and will have no impact on local ground water.

Modeling results suggest that the nitrate in well UCD1-21 may be attributed in part to the nitrate present in soils in the Radium/Strontium Treatment Systems area. Likewise, modeling indicated that the Am-241 impacts to ground water may be associated with other sources.

C-14 was used at LEHR. As discussed earlier, the concentrations of C-14 detected above background in the Radium/Strontium Treatment Systems area soil were highly localized at the southern end of the radium leach trench. C-14 concentration in soil beneath this potential release were consistent with background, suggesting that ground water impacts may be originating in other locations not related to the Site's operations.

Ra-226 is associated with site operations, and the impacts are likely to be associated with releases in the leach trench and dry wells.

# 6.5 Risk Characterization Summary and Recommendations Regarding Contaminants of Concern at the Radium/Strontium Treatment Systems Area

Risk characterization findings and recommended COCs at the Radium/Strontium Treatment Systems area are summarized below and presented in Table 6-8. The recommended COCs include constituents that are considered to have potential risks to human health or may have potential impact on the ground water at the Site.

#### 6.5.1 Human Health—On-Site Resident and Outdoor Researcher

#### 6.5.1.1 Strontium-90

Sr-90 was one of the primary research isotopes used at LEHR, and it is present in the Radium/Strontium Treatment Systems area soil. The risk estimate indicates that Sr-90 presents a potential risk to the on-site resident only. As shown in Table 6-8, the decay-corrected Sr-90 List 2 cancer risk is  $5 \times 10^{-7}$  for this receptor. Sr-90 concentrations at the Radium/Strontium Treatment Systems area account for approximately ten percent of the overall cancer risk to the on-site resident in this area. Locations of elevated Sr-90 concentrations are clustered in the proximity of a leach field associated with the former Sr-90 treatment tank located between Animal Hospitals Nos. 1 and 2. This spatial distribution of Sr-90 appears to be indicative of a release from the former Sr-90 leach field. However, the very limited site risk (5 x  $10^{-7}$ ) justifies the exclusion of Sr-90 from further evaluation in the Feasibility Study.

#### 6.5.1.2 Thorium-228

Th-228 was used in research activities at LEHR, and was found at elevated concentrations in the Radium/Strontium Treatment Systems area. Its co-location with elevated Sr-90 concentrations is suggestive of a release. The decay-corrected List 2 cancer risk associated with the Th-228 concentrations is 4 x 10<sup>-6</sup> for the on-site resident, and 2 x 10<sup>-6</sup> for the outdoor researcher. The majority of the Th-228 risk (97%) is attributable to background concentrations of the Th-228 in the soil (Figure 6-7), and Th-228 will decay to background levels in approximately 3.5 years, given this rapid attenuation to background and current marginal risk, Th-228 should not be included as a COC in the Feasibility Study.

# 6.5.2 Ground Water

#### 6.5.2.1 Hexavalent Chromium

Cr-VI was detected in ground water in concentrations exceeding background and the MCL; however, residual soil concentrations of Cr-VI are at background levels and no future impacts are expected within 500 years. Therefore, Cr-VI should be eliminated as a COC and ground water monitoring is not recommended.

#### 6.5.2.2 Nitrate

Nitrate found in ground water was confirmed by modeling to have originated from the Radium/Strontium Treatment Systems area. Nitrate should be retained as a COC and evaluated in the Feasibility Study.

#### 6.5.2.3 Americium-241

Am-241 was reported above the detection limit in two of the nine ground water samples collected historically from downgradient well UCD1-21, which was monitored between August 1994

and May 1999. The two detected activities were  $0.036 \pm 0.041$  pCi/L (MDA = 0.033 pCi/L) collected on February 15, 1996 and  $0.039 \pm 0.034$  pCi/L (MDA = 0.029 pCi/L) collected on February 24, 1997. Based on the fact that the sample counting errors approach or exceed 100% of the reported value and that the overall detection frequency of Am-241 is low, it is likely that Am-241 is not present in ground water above background. The modeling results indicate that Am-241 in the vadose zone will decay far below detectable levels before reaching ground water. Soil sampling effectively canvassed the lateral and vertical extent of Am-241 in the Radium/Strontium Treatment Systems area. Only 5% of the Am-241 soil results were above background and the spatial distribution was predominately random. Two of the soil sample results may indicate a small, localized area of soil contamination because they were located in the same borehole and had concentrations approximately twice the background value. No significant analytical accuracy issues were identified with the soil data. Am-241 should be monitored in the downgradient wells but it should not be retained as a COC.

# 6.5.2.4 Carbon-14

C-14 is currently found in downgradient ground water in HSU-1 and HSU-2, but modeling suggests that it may impact local ground water at concentrations exceeding background and the MCL in the future. Elevated soil concentrations are limited in extent and mass. C-14 should be retained as a COC.

# 6.5.2.5 Radium-226

Ra-226 may be present in downgradient in HSU-1 monitoring well UCD1-21 and modeling confirms that soil concentrations of Ra-226 remaining in the area soil may elevate ground water above background. The elevated soil concentrations are limited in extent and mass. Ra-226 should be retained as a COC.



Figure 6-1. Radium/Strontium Treatment Systems Area Features



Figure 6-2. Radium/Strontium Treatment Systems Area Sample Locations and Depths



Figure 6-3. Strontium-90 Spatial Analysis, Radium/Strontium Treatment Systems Area



Figure 6-4. Thorium-228 Spatial Analysis, Radium/Strontium Treatment Systems Area



Figure 6-5. Decay of Strontium-90 at the Radium/Strontium Treatment Systems Area



Figure 6-6. Decay of Thorium-228 at the Radium/Strontium Treatment Systems Area



Figure 6-7. Cancer Risk to the On-Site Resident and Outdoor Researcher from Site Activities and Background, Radium/Strontium Treatment Systems Area



Figure 6-8. Histogram of Thorium-228 and Thorium-232, Radium/Strontium Treatment Systems Area





Analyte	Maximum Concentration	Location of Maximum Concentration	Depth (ft bgs)	Date	Background <sup>1</sup>
Radionuclides	(pCi/g)				(pCi/g)
Actinium-228	0.93	SB-4	25-27	August 1996	0.014
Bismuth-214	6.52	SB-1	18-20	August 1996	0.54
Cesium-137	6.2	SB-13	N/A	October 1987	0.102/0.00695
Carbon-14	16	SB-5	6.5-8	August 1996	0.13
Gross Alpha	185	Ra-226 DB	9.5	August 1996	7.42/8.85
Gross Beta	156	Ra-226 DB	9.5	October 1987	15
Lead-212	0.94	SB-5	19-20	August 1996	0.691/0.684
Lead-214	7.73	SB-1	18-20	August 1996	0.55/0.581
Potassium-40	17.24	SB-28	10.0	March 1990	14
Radium-226	206	Ra-226 Tank	N/A	March 1989	0.75
Strontium-90	18,600	Sr-90 Tank A	N/A	September 1997	0.056
Thallium-208	0.25	SB-5	19-20	August 1996	0.204/0.223
Thorium-228	2.1	Beneath Ra Tank B	N/A	March 1992	0.627/0.771
Thorium-232	1.66	Beneath Ra Tank B	N/A	March 1992	0.63/0.8
Thorium-234	1.41	SB-5	19.20	August 1996	0.78
Tritium	1.15	Ra-226 DB	9.5	August 1996	1.2
Uranium-235	0.15	SB-2	15-17	August 1996	0.038
Metals	(mg/kg)			-	(mg/kg)
Beryllium	2.40	SB-26	10.0	March 1990	0.564/0.924
Chromium VI	7	SB-24	25.0	March 1990	1.3
Cobalt	38.4	SB-23	0.5	March 1990	31
Copper	160	SB-5	23-25	August 1996	48.8/61.8
Lead	19.3	Well UCD1-22	5.0	October 1990	9.5
Manganese	870	SB-4	29-31	August 1996	750
Vanadium	75	SB-5	13-15/28.5-30	August 1996	66.8/80.3
Zinc	120	SB-22	5	March 1990	72.4/93.1
VOCs (mg/kg)	(mg/kg)				(mg/kg)
Methylene Chloride	0.044	SB-28	10	March 1990	N/A
SVOCs	164	SB-3	7-10	August 1996	N/A
Pesticides (mg/kg)	(mg/kg)			-	(mg/kg)
DDD	0.0003	SB-5	23-25	August 1996	N/A
DDT	0.0018	SB-5	23-25	August 1996	N/A
Others (mg/kg)	(mg/kg)			e	(mg/kg)
Nitrate (as N)	736	SB-28	15.0	March 1990	36

Table 6-1.	Analytes	Detected	above	Background	in	Soil/Waste	at	the	Radium/Strontium
	Treatmen	t Systems .	Area Pri	ior to Remova	l Ac	ctions			

#### Notes

Data from the Remedial Investigation Report (WA, 2003b).

Contaminant data includes data collected from all depth intervals instead of the 0-10 ft interval used in the risk estimate. <sup>1</sup>Lowest background concentration is the lower of the shallow (0-4 ft) and the deep (4-40 ft) soil background screening values for vertically stratified analytes.

#### Abbreviations

bgs	below ground surface
DB	distribution box
DDD	dichlordiphenyl dichlor
DDT	dichlordiphenyl trichlor
ft	feet

# Table 6-1.Analytes Detected above Background in Soil/Waste at the Radium/Strontium<br/>Treatment Systems Area Prior to Removal Actions (continued)

mg/kg N/A	milligrams per kilogram not available (location/depth) or not applicable (background level)
pCi/g	picoCuries per gram
Ra	radium
SB	soil boring
Sr	strontium
SVOCs	semi-volatile organic compounds
VOCs	volatile organic compounds

	~	P	8					
List 1 COPC	Units	Total Samples	Number of Detections	Number of Detections > Background	Concentration Range <sup>1</sup>	Background Screening Concentration <sup>2</sup>	ID of Sample with Highest Concentration	Depth of Sample with Highest Concentration (ft)
Metals								
Arsenic	mg/kg	79	79	1	3.6 - 10	9.6	SSRSC032	4.5
Radionuclides								
Carbon-14	pCi/g	85	16	5	-0.0616 - 2.38	0.13	SSRSC019	8
Cesium-137	pCi/g	85	43	28	-0.00315 - 0.612	0.012	SSRSC072	6
Lead-210	pCi/g	85	21	0	-0.203 - 1.13	1.6	SSRSC070	7
Potassium-40	pCi/g	85	84	1	0 - 14.4	14	SSRSC043	5
Radium-226	pCi/g	85	85	0	0.376 - 0.697	0.75	SSRSC037	10
Radium-228	pCi/g	85	85	2	0.325 - 0.677	0.64	SSRSC062	8
Strontium-90	pCi/g	90	41	25	-0.0153 - 2.18	0.056	SSRSC043	5
Thorium-228	pCi/g	85	85	9	0.314 - 1.12	0.74	SSRSC076,	2, 7
							SSRSC070	
Uranium-238	pCi/g	85	85	6	0.324 - 0.825	0.65	SSRSC048	10

# Table 6-2. Summary of Sampling Results Used in the Risk Estimate at the Radium/Strontium Treatment Systems Area

#### Notes

Source: COPC data from the HHRA Risk Estimate, Appendix A (UC Davis, 2005).

<sup>1</sup>The concentration ranges for metals and radionuclides include non-detects.

<sup>2</sup>The background screening concentrations are the unstratified background screening values in Appendix B of the HHRA Risk Estimate.

#### Abbreviations

>	greater than
COPC	constituent of potential concern
ft	feet
HHRA	Human Health Risk Assessment
ID	identification (number)
mg/kg	milligrams per kilogram
pCi/g	picoCuries per gram

Human Health Risks to On-Site Resident by Exposure Route for Contaminants of Potential Concern at the Radium/Strontium Treatment Systems Area Table 6-3.

				C	ANCER RISK BY	EXPOSURE ROUT	Έ			
List 1 COPC	EPC <sup>1</sup>	Soil Ingestion	Soil Dermal Exposure	Above-Ground Plant Ingestion <sup>2</sup>	Below-Ground Plant Ingestion <sup>2</sup>	External Radiation	Dust Inhalation	Total Cancer Risk	Statistical Background Comparison <sup>3</sup>	List 2 Cancer Risk <sup>4</sup>
Arsenic	7.8	2.E-05	1.E-06	9.E-05	3.E-05	-	1.E-08	1.E-04	Pass	-
Carbon-14	0.12	3.E-12	-	8.E-10	-	2.E-13	2.E-11	8.E-10	Fail	8.E-10
Cesium-137	0.044	1.E-09	-	5.E-09	-	1.E-06	7.E-15	1.E-06	Pass	-
Lead-210	0.54	7.E-07	-	1.E-06	-	2.E-08	9.E-11	2.E-06	Pass	-
Potassium-40	11	4.E-07	-	9.E-06	-	8.E-05	2.E-12	9.E-05	Pass	-
Radium-226	0.54	5.E-07	-	1.E-06	-	4.E-05	1.E-10	4.E-05	Pass	-
Radium-228	0.53	3.E-07	-	9.E-07	-	2.E-05	4.E-10	2.E-05	Pass	-
Strontium-90+Daughter	0.25	2.E-08	-	5.E-07	-	4.E-08	4.E-13	6.E-07	Fail	6.E-07
Thorium-228	0.59	3.E-08	-	2.E-09	-	5.E-06	1.E-10	5.E-06	Fail	<b>5.E-06</b>
Uranium-238	0.5	8.E-08	-	2.E-08	-	7.E-07	9.E-11	8.E-07	Pass	-
TOTAL								3.E-04		6.E-06
				HAZ	ARD QUOTIENT	BY EXPOSURE RC	DUTE			
List 1 COPC	EPC <sup>1</sup>	Soil Ingestion	Soil Dermal Exposure	Above-Ground Plant Ingestion	Below-Ground Plant Ingestion	External Radiation	Dust Inhalation	Non-Cancer Hazard Index	Statistical Background Comparison <sup>3</sup>	List 2 Non-Cancer Hazard Index <sup>4</sup>
Arsenic	7.8	0.33	0.028	1.8	0.22	-	-	2.4	Pass	_
TOTAL								2.4		0

Notes

Source Data from HHRA Risk Estimate, Tables 7 and 8. Statistical Background Comparison from Appendix B (UC Davis, 2005).

The non-cancer risk is for a resident child; the cancer risk is for an age-adjusted adult.

List 2 constituents shown in **bold-type** text contribute at least 10<sup>-6</sup>, or greater than 10%, to the excess cumulative cancer risk values shown in the last column. Determination of whether the risk is greater than 10%, to the excess cumulative cancer risk. Rounding may affect the total List 2 cancer risk values shown in the last column. values.

<sup>1</sup> The 95% upper confidence limit on the mean of the exposure point concentration; chemical concentrations are in milligrams per kilogram and radionuclide concentrations are in picoCuries per gram.

<sup>2</sup> For radionuclides, plant ingestion is not subdivided into above-ground and below-ground plants.

<sup>3</sup> Based on Wilcoxon Rank Sum test or other statistical comparisons, as shown in Appendix B of the HHRA Risk Estimate.

<sup>4</sup> Dashes indicate that the constituent was not identified as a List 2 COPC, since it was identified to be statistically equivalent to background.

#### Abbreviations

not calculated COPC constituent of potential concern exposure point concentration EPC HHRA Human Health Risk Assessment

# Table 6-4.Human Health Risks to On-Site Outdoor Researcher by Exposure Route for Contaminants of Potential Concern at the<br/>Radium/Strontium Treatment Systems Area

List 1 COPC	$EPC^1$	External Radiation <sup>2</sup>	Total Cancer Risk	Statistical Background Comparison <sup>3</sup>	List 2 Cancer Risk <sup>4</sup>
Arsenic	7.8	-	-	Pass	-
Carbon-14	0.12	7.E-14	7.E-14	Fail	7.E-14
Cesium-137	0.044	4.E-07	4.E-07	Pass	-
Lead-210	0.54	7.E-09	7.E-09	Pass	-
Potassium-40	11	3.E-05	3.E-05	Pass	-
Radium-226	0.54	2.E-05	2.E-05	Pass	-
Radium-228	0.53 9.E-06		9.E-06	Pass	-
Strontium-90+Daughter	0.25	2.E-08	2.E-08	Fail	2.E-08
Thorium-228	0.59	<b>2.E-06</b>	<b>2.E-06</b>	Fail	<b>2.E-06</b>
Uranium-238	0.5	3.E-07	3.E-07	Pass	-
TOTAL			6.E-05		<b>2.E-06</b>
		HAZARD QUOTIENT	BY EXPOSURE ROUTE		
List 1 COPC	EPC <sup>1</sup>	External Radiation <sup>2</sup>	Non-Cancer Hazard Index	Statistical Background Comparison <sup>3</sup>	List 2 Non-Cancer Hazard Index <sup>4</sup>
Arsenic	7.8	-	-	Pass	-
TOTAL			0.0		0

#### **CANCER RISK BY EXPOSURE ROUTE**

#### Notes

Source Data from HHRA Risk Estimate, Tables 7 and 8. Statistical Background Comparison from Appendix B (UC Davis, 2005).

List 2 constituents shown in **bold-type** text contribute at least  $10^{-6}$ , or greater than 10%, to the excess cumulative cancer risk.

<sup>1</sup> The 95% upper confidence limit on the mean of the exposure point concentration; chemical concentrations are in milligrams per kilogram and radionuclide concentrations are in picoCuries per gram.

<sup>2</sup>External radiation was the only open exposure pathway for on-site outdoor researchers in the Radium/Strontium Treatment Systems area.

<sup>3</sup> Based on Wilcoxon Rank Sum test or other statistical comparisons, as shown in Appendix B of the HHRA Risk Estimate.

<sup>4</sup> Dashes indicate that constituent was not identified as a List 2 COPC, since it was identified to be statistically equivalent to background.

# Table 6-4.Human Health Risks to On-Site Outdoor Researcher by Exposure Route for Contaminants of Potential Concern at the<br/>Radium/Strontium Treatment Systems Area (continued)

Abbreviations

-	not calculated
COPC	constituent of potential concern
EPC	exposure point concentration
HHRA	Human Health Risk Assessment

# Table 6-5.Data Summary—Comparison of Exposure Point Concentrations to Site Background at the Radium/Strontium Treatment<br/>Systems Area

Analyte	Detections	Samples	Min Detect	Max Detect	Min Detection Limit	Max Detection Limit	Average <sup>1</sup>	Standard Deviation <sup>1</sup>	Distribution	95UCL <sup>1</sup>	EPC	Decay- Corrected EPC <sup>2</sup>
Site (0 to 10 ft)			pCi/g	pCi/g	pCi/g	pCi/g	pCi/g	pCi/g		pCi/g	pCi/g	pCi/g
Strontium-90	41	90	0.0151	2.18	0.0124	0.22	0.18	0.42	Non-parametric	0.25	0.25	0.22
Thorium-228	85	85	0.314	1.12	0.045	0.674	0.56	0.15	Normal	0.59	0.59	0.52
Background (0	to 10 ft)											
Strontium-90	12	38	0.0166	0.313	0.0158	0.89	0.0601	0.105	Non-parametric	0.089	0.089	0.076
Thorium-228	48	48	0.266	0.66	0.058	0.379	0.475	0.105	Normal	0.50	0.50	0.50

#### Notes

Source: COPC data from Appendix A from HHRA Risk Estimate (UC Davis, 2005). 95UCL calculations for background concentrations and decay corrections added."

<sup>1</sup>Negative concentration values were set to zero and concentrations below the detection limit were used to determine the 95UCL, average and standard deviation for radionuclides. Same as 95UCL calculation procedure used in HHRA Risk Estimate (UC Davis, 2005).

<sup>2</sup>The EPC was decay-corrected to April 2005 (see Figures 6-5, 6-6 and Appendix A).

#### Abbreviations

95UCL	95 percent upper confidence limit on the mean
COPC	constituent of potential concern
EPC	exposure point concentration
ft	feet
HHRA	Human Health Risk Assessment
max	maximum
min	minimum
pCi/g	picoCuries per gram

	Investigation	n and Confirmation	n Sampling	Designated-L	evel Sampling		NUFT Mode	el Soil Result	Do	wngradient	Ground	d Water			
Designated-Level Constituent of	Maximum	Depth of	95% UCL	Maximum	Depth of	Soil Background Value	Background Ground	MCL (or PRG)	Ground Wa (µ٤	ater Concentration <sup>2</sup> /l or pCi/l)	Backg Concer (µg/l o	ground ntration <sup>3</sup> r pCi/l)	Ground Water MCL	Tap Water PRG	Time to Peak at Ground Water
Concern	Concentration (mg/kg or pCi/g) <sup>1</sup>	Maximum Concentration (ft)	(mg/kg or pCi/g)	Concentration (mg/kg or pCi/g)	Maximum Concentration (ft)	(mg/kg or pCi/g)	Water Goal (mg/kg or pCi/g)	Ground Water Goal (mg/kg or pCi/g)	HSU-1	HSU-2	HSU-1	HSU-2	(µg/l or pCi/l)	(µg/l or pCi/l)	Goal Level (years)
Confirmation Sampling DL COCs															
Hexavalent Chromium	0.841	7	0.31	0.614	12	1.3	0.719	0.912	36 – <b>66</b>	15.0 - <b>110</b> / <6.0 - <b>25.0</b>	39.4	20	$50^{4}$	110	500
Mercury <sup>5</sup>	2	1, 5.5	0.66	1.2	7.5	3.94/0.25/	0.0116	1.23	< 0.20	<0.10 - <0.47 /	0.10	0.2	2	11	5,004
Nitroto (og NI)	204	20	24.4	120	20.5	0.63°	4.05	1 72	56.000 64.000	<0.10 - <0.20 [ND]	25 144	4 220	10.000	10.000	10
Millale (as N)	304	20	34.4	132	29.5	50	4.03	1.75	26,000 - 64,000	<b>5,000 - <u>57,400</u></b> / 3 240 - <b>11 000</b>	23,144	4,229	10,000	10,000	10
Cesium-137	0.612	6	0.05	0.664	16	0.102/ 0.00695/	2.77	554	ND	<-4.2 - <1.21 [ND] / <-0.92 - <2.3 [ND]	ND	2.6	200	15.7	No impact expected
Carbon-14 <sup>8</sup>	2.41	13.5	0.20	0.076	18.5	0.012°	0.004	2.34	< 7.2	<-3.82 - <6.85 [ND] / <-7.6 - <b>16.3</b> <sup>9</sup>	3.5	7.4 <sup>9</sup>	2,000	1.29	15
Other DL COCs															
Americium-241	0.0847	8	N/A	N/A	N/A	0.014	4.75 E+07	1.34 E+09	< 0.034 – <b>0.039</b>	<-0.024 - <0.036 [ND] /	0.0155	0.125	NE	0.458	No impact
Codmium	14	6	N/A	NI/A	N/A	0.51	0.122	0.617	< 1.0	<-0.04/1 - <0.144 [ND]	1.0	1.0	5	18	expected
Caulifium	1.4	0	1N/A	11/74	IN/A	0.31	0.122	0.017	< 1.0	<0.3 - <2 [ND] / <0.060 - <1.1 [ND]	1.0	1.0	5	10	0,504
Radium-226	1.72	42.5	N/A	N/A	N/A	0.752	0.43	1.90	< 0.12 <b>- 2.38</b>	<0.017 - 2.02 /	1.14	2.4	5	8.16 E-	0
Thorium-228	1.12	7	N/A	N/A	N/A	0.627/0.77/ 0.74 <sup>6</sup>	N/A	greater than pure	N/A	<0.151 - 1.89 <sup>10</sup> N/A <sup>11</sup>	NE	N/A <sup>12</sup>	NE	04 0.159	No impact expected
Zinc	360	25	N/A	N/A	N/A	72.4/93.1/87 <sup>6</sup>	1.57	constituent 262	2.7 - 5.3	<0.3 - <b>30</b> / 0.55 - <20 <sup>13</sup>	30	20	5,000	11,000	5,419

# Table 6-6. Summary of Potential Impact on Ground Water of Designated-Level Constituents of Potential Concern in Radium/Strontium Treatment Systems Area Soils

#### Notes

Source: Data from Remedial Investigation Report (WA, 2003b). HSU-2 background data added.

<sup>1</sup>Hexavalent chromium, mercury, nitrate, cadmium, and zinc in mg/kg or µg/l, all others in pCi/g or pCi/l.

<sup>2</sup>Range of available data for nearby downgradient HSU-1 well UCD1-021, and HSU-2 wells UCD2-7 and UCD2-36.

<sup>3</sup>Based on data from HSU-1 well UCD1-18, and HSU-2 wells UCD2-17 and UCD2-37.

<sup>4</sup>MCL for total chromium.

<sup>5</sup>Assumed to be mercuric chloride.

<sup>6</sup>First value is a concentration for 0 to 4 ft below ground surface, second is for greater than 4 ft below ground surface and third is a consolidated concentration (all depths).

<sup>7</sup>One outlier was excluded from well UCD2-7. All other samples were non-detects. Although the highest detection limits were greater than background, the lowest detection limits for other samples demonstrate that the Mercury concentrations at well UCD2-7 are not greater than background. <sup>8</sup>Assumed to be methanol.

<sup>9</sup>Measurements of carbon-14 in samples collected before 1998 were excluded here because those data are significantly less reliable than are the measurements of carbon-14 in later samples. Outliers were also excluded.

<sup>10</sup>Outliers were excluded.

<sup>11</sup>Thorium-228 was not analyzed in samples from either well UCD2-7 or UCD2-36.

<sup>12</sup>Thorium-228 was not analyzed in samples from either well UCD2-17 or UCD2-37.

<sup>13</sup>One outlier was excluded from well UCD2-7. Although the highest detection limits are greater than background, the detection limits and concentrations in other samples demonstrate that the concentration of zinc at well UCD2-7 is not greater than background. **Bold type** indicates soil concentration is above background and above NUFT result for ground water impact at background levels, or ground water concentration is above background.

Boxed type indicates soil concentration is above background and above NUFT result for ground water impact at the MCL, or ground water concentration is above the MCL.

#### Abbreviations

< denotes analyte concentrations below the detection limit

μg/l micrograms per liter

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Table 6-6.Summary of Potential Impact on Ground	Water of Designated-Level Constituents of Potential Concern in Ra	adium/Strontium Treatment Systems Area Soil (conti
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COC	constituent of concern
DL	designated-level
ft	feet
MCL	California Maximum Contaminant Level (primary) for ground water (November 2002)
mg/kg	milligrams per kilogram
N	nitrogen
N/A	not applicable or not available
ND	not detected at a range of detection limits
NE	not established
NUFT	Non-Isothermal, Unsaturated Flow and Transport model
pCi/g	picoCuries per gram
pCi/l	picoCuries per liter
PRG	preliminary remediation goal (US EPA, 2002a for radionuclides; US EPA, 2002b for others)
UCL	upper confidence limit on the true mean based on sample data
US EPA	United States Environmental Protection Agency

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nued)

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# Table 6-7.Summary of Designated-Level Ground Water Constituents of Potential Concern at Radium/Strontium Treatment Systems<br/>Area Retained as Constituents of Potential Ground Water Concern

	0	0	6	4	
Designated-Level Constituent of Potential Concern	Are the DL COPCs ground water concentrations above site background? <sup>1</sup>	Are the DL COPC soil concentrations above soil background and the NUFT soil results? <sup>2</sup>	Will the DL COPC impact ground water above background levels in the next 500 years?	Retained as COPGWC in risk characterization?	
	If yes, enter ✓ in ④	If yes, go to 🕄	If yes, enter ✓ in ④		
	If no, go to <b>2</b>	If no, stop and enter $\times$ below	If no, stop and enter $\times$ below	$\mathbf{v} = \mathbf{r} \mathbf{e} \mathbf{s}$	
Cadmium	No	Yes	×	-	
Hexavalent Chromium	Yes	-	-	$\checkmark$	
Mercury	No	Yes	×	-	
Nitrate (as N)	Yes	-	-	$\checkmark$	
Zinc	No	Yes	×	-	
Americium-241	Yes	-	-	$\checkmark$	
Cesium-137	No	×	-	-	
Carbon-14	No	Yes	Yes	$\checkmark$	
Radium-226	Yes	-	-	$\checkmark$	
Thorium-228	N/A	N/A	N/A	-	

#### Note

<sup>1</sup>See Table 6-6. Compare downgradient ground water concentration to ground water background concentration. Results below detection limits are presumed to be below site background. <sup>2</sup>The lower of background and MCL goals.

#### Abbreviations

×	not retained as a COPGWC
$\checkmark$	retained as a COPGWC
-	skip
COPC	constituent of potential concern
COPGWC	constituent of potential ground water concern
DL	designated-level
MCL	California Maximum Contaminant Level (primary) for ground water (November 2002)
Ν	nitrogen
N/A	not applicable
NUFT	Non-Isothermal, Unsaturated Flow and Transport

Table 0-0. Summary	of Major Pa	CIOIS DITVIII	g KISK and KC	commendatio		Action at Raun		timent systems Area	
Driver COPC / COPGWC	Total Cancer Risk <sup>1</sup>	Spatial Distribution	Background Contribution <sup>2</sup>	Above- Background Contribution <sup>3</sup>	Historically Used at the Site	Time for Attenuation to Risk Endpoint <sup>4</sup> (years)	Level of Ground Water Impact	Uncertainty	Recommended Acti
<b>On-Site Resident</b> Strontium-90	5E-7	Localized	34%	66%	Yes	<05	N/A	• No apparent bias in data.	No Further Actior
Thorium-228	4E-6	Localized	97%	3%	Yes	3.5	N/A	<ul><li>Possible analytical drift.</li><li>Representative if corrected for radiological decay.</li></ul>	No Further Action
<b>On-Site Outdoor Researche</b>	er								
Thorium-228	2E-6	Localized	97%	3%	Yes	3.5	N/A	<ul> <li>Possible analytical drift.</li> <li>Representative if corrected for radiological decay.</li> </ul>	No Further Action
Ground Water									
Hexavalent Chromium	N/A	Random	N/A	N/A	Yes	N/A	>MCL, >bkgd	• None.	No Further Actior
Nitrate (as N)	N/A	Localized	N/A	N/A	Yes	N/A	>MCL, >bkgd	• None.	Evaluate in FS

Yes

Yes

Yes

N/A

N/A

N/A

uncertainty.

• Good data quality. • Representative.

(positive bias). Representative.

• Representative soil data.

• Three results were qualified

• Good soil sample data quality. • High ground water sample

>bkgd<sup>6</sup>

>MCL, >bkgd

>bkgd

Table 6-8 Summary of Major Factors Driving Risk and Recommendations for Future Action at Radium/Strontium Treatment Systems Area

N/A

N/A

N/A

#### Notes

Americium-241

Carbon-14

Radium-226

<sup>1</sup>For radionuclides, values are decay-corrected to April 2005 (see Figure 6-5, Figure 6-6 and Appendix B).

<sup>2</sup>The background contribution is the proportion of the site EPC that can be attributed to the background EPC (see Table 6-5 and Figure 6-7).

N/A

N/A

N/A

<sup>3</sup>The above-background contribution is the proportion of the site EPC that is greater than the background EPC (see Figure 6-7).

Random

Localized

Random

<sup>4</sup>The time for attenuation to risk endpoint is the time, from April 2005, for the site EPC of a radionuclide to decay to either the background EPC or the concentration equivalent to a risk of 10<sup>-6</sup>, whichever is greater. <sup>5</sup>As of April 2005, the site EPC is less than the concentration equivalent to a risk of 10<sup>-6</sup>.

<sup>6</sup>Based on limited, low quality ground water monitoring data. The majority of historical ground water monitoring data suggest that Americium-241 concentrations are below background. See Section 6.5.2.3.

Abbreviations

greater than > less than < bkgd background COPC constituent of potential concern constituent of potential ground water concern COPGWC EPC exposure point concentration Feasibility Study FS MCL California Maximum Contaminant Level for ground water (February 2003) Ν nitrogen N/A not applicable

N/A

N/A

N/A

on	Basis for Recommendation
1 • • 1 •	Limited constituent risk. Total site risk will be below 1E-06 in 3.5 years. Decay to background in 3.5 years. Marginal current risk.
l ●	Decay to background in 3.5 years. Marginal current risk.
	Residual soil concentrations are below background. Confirmed presence in Area I and in ground water. Modeling suggests that residual soil concentrations are several orders of magnitude below levels that would result in future impact. Modeled maximum ground water concentration not expected for 5,400 years. High uncertainty in ground water monitoring data. Possible release. Limited extent and mass. Modeling suggests impacts above background and MCL in 15 years. Limited extent and mass. Downgradient ground water above background. Modeling suggests impact currently above background

Monitoring

Evaluate in FS

Evaluate in FS

# 7. SOUTHWEST TRENCHES RISK CHARACTERIZATION

### 7.1 Area Description

The Southwest Trenches area (Figure 7-1) is located in the southwest corner of the Site. The area is relatively flat, unpaved, and occupies approximately one-half of an acre (22,000 square ft). Between the late 1950s and early 1970s, low-level radioactive waste, fecal material, and laboratory wastes generated from operations at LEHR were reportedly disposed in shallow pits and trenches at the Southwest Trenches area (Figure 7-1) (D&M, 1993). During that time period, LEHR research focused on studying the health effects from chronic exposure to Ra-226 and Sr-90. Disposal practices consisted of placing laboratory waste in trenches excavated at the Site. Along with laboratory waste, the trenches were filled with gravel and animal waste from outdoor dog pens. Laboratory waste consisted of syringes, vials, glass jars with unknown liquids and solids, animal bones, and other types of material. In addition to containing waste burial trenches, part of the area referred to as the Southwest Trenches was used for applying chlordane to dogs for flea control. Additionally, a chemical storage shed in the southwest corner of the area was reportedly used to store chlordane (Figure 7-1).

# 7.1.1 Pre-Removal Action Contaminant Distribution

A limited field investigation conducted at the Southwest Trenches area in 1996 by IT Corporation revealed elevated (above background) levels of Ra-226, Sr-90, Cs-137, chlordane, Cr-VI, Hg, and nitrate. All of these constituents, with the exception of Cs-137, were considered "driver COCs" and their concentrations were used during removal action activities to guide the extent of the excavation limits. The distributions of these constituents are summarized below. Additional information regarding previous investigations and site background conditions at the Southwest Trenches area may be found in:

- Limited Field Investigation Work Plan for the Laboratory for Energy-Related Health Research (IT Corp., 1996);
- Draft Final Engineering Evaluation/Cost Analysis for the Southwest Trenches, Radium-226/Strontium-90 Treatment Systems, and Domestic Septic System Areas for the DOE Areas at the Laboratory for Energy-Related Health Research Site (WA, 1998a);
- Final Site Characterization Summary Report for the U.S. Department of Energy Areas at the Laboratory for Energy-Related Health Research (WA, 1997b); and
- DOE Areas Remedial Investigation Report (WA, 2003b).

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The extent of the Ra-226 concentrations above background appeared to be confined to solid waste and soil within, and immediately below, the disposal trenches and pits (WA, 1997b). The highest Sr-90 soil concentration was collected from beneath the largest disposal trench, T-6, and the lateral extent of Sr-90 contamination in the Southwest Trenches area did not appear to correlate with the waste disposal areas (WA, 1997b). The maximum reported chlordane soil concentration was found at a depth of 3.5 ft bgs in the southwest corner of the Site near the suspected chlordane storage area (Figure 7-1). The maximum reported nitrate concentration was found at 14.4 ft bgs beneath former Disposal Pit No. 2 (Figure 7-1). The investigation data suggested that the nitrate contamination was laterally confined to the area within and surrounding the disposal trenches and pits. The nitrate contamination did not appear to be vertically confined to the soil immediately beneath the waste trenches. The maximum reported pre-removal action Cr-VI concentration was detected in a surface soil sample collected from boring SB-19 (WA, 1997b). The maximum reported pre-removal action Hg concentration was detected at three ft bgs along the southern edge of the Southwest Trenches area. The Cr-VI and Hg data did not show any obvious contaminant distribution trends. The maximum reported Cs-137 concentration (23 pCi/g) was detected at a depth of 0.5 ft bgs, and far exceeded all other investigative sample results.

Table 7-1 provides a summary of the pre-removal action constituents and their concentrations. The data summarized is limited to the List 2 COPCs carried forward from the risk estimate. The sample locations for all data used in the risk estimate are presented in Figure 7-2.

# 7.1.2 Removal Action Activities

Removal action activities at the Southwest Trenches began in May 1998 and were completed by November 1998. The work was conducted in accordance with the *Final Work Plan for Removal Actions in the Southwest Trenches, Ra/Sr Treatment Systems, and Domestic Septic System Areas for the Laboratory for Energy-Related Health Research* (WA, 2000b), and is summarized in the *Final Southwest Trenches Area 1998 Removal Action Confirmation Report for the Laboratory for Energy-Related Health Research* (WA, 2001b).

The removal action approach included surface soil characterization sampling, followed by excavation and removal of the shallow soil contaminated with chlordane. Following removal of 450 cu yds of chlordane-contaminated soil, grid-based trenching was employed to determine the locations of the waste disposal cells.

After the characterization and removal of surface soil, waste disposal cells were excavated in three distinct areas: the northern excavation area, the western excavation area, and the southern excavation area. In the northern excavation area, 217 cu yds of waste including gravel, syringes, and several glass jars were removed. Approximately 466 cu yds of waste consisting predominantly of gravel mixed with glass jars, vials, syringes and other laboratory refuse were removed from the western excavation area, which comprised two parallel 10 to 12 ft deep trenches and a smaller shallow disposal pit (Figure 7-1). In the southern excavation area, 190 cu yds of waste were removed. The waste in this area was not commingled with gravel; instead, isolated pockets of mostly labware in a soil matrix were discovered.
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After completion of all excavation activities in the area, approximately 1,700 cu yds of imported clean soil were used to backfill the excavations. Prior to backfilling site excavations, confirmation samples were collected from the excavation sidewalls and floor to verify that the cleanup criteria for all COCs were met. A total of 63 samples and seven duplicate samples were collected between two and 13 ft bgs, and analyzed for a full suite of COCs consisting of radionuclides, pesticides/PCBs, metals, VOCs, SVOCs and nitrate.

## 7.1.3 Post-Removal Action Contaminant Distribution

After the completion of removal action activities confirmation samples were collected from the Southwest Trenches area and evaluated. The results of this evaluation are discussed in detail in a removal action confirmation report (WA, 2001b) and the Remedial Investigation (WA, 2003b).

## 7.1.4 Future Land Use

Future use of the Southwest Trenches area by UC Davis will be consistent with the "Academic/Administrative Low Density" land use designation of the area contained in Section 3.8.1 of the UC Davis 2003 *Long Range Development Plan* (UC Davis, 2003).

## 7.2 Summary of Risk Estimate Data

Data used in the human health risk estimate were collected during various investigations and sampling events that were conducted at the Southwest Trenches area. The data set was evaluated and redacted to exclude information associated with samples collected in locations that were subsequently excavated. The final data set used to estimate risk at the Southwest Trenches area reflected the post-removal action conditions of the area. Information used in the risk estimate included data from the:

- Limited field investigation conducted in 1996 (IT Corp., 1996);
- Post-removal action confirmation sampling; and
- Ground water-related soil sampling.

Additionally, eighteen soil samples and ten cobble samples were collected at the subsurface cobble trenches located in the eastern portion of the Site. The soil and cobble samples collected at the cobble trenches were excluded from the data set used in the risk estimate, since there is no evidence that the cobble trenches were associated with disposal practices or releases of hazardous substances. Because no significant contamination was found in these samples, inclusion of data associated with the cobble trenches would have decreased the EPCs used in the risk estimate, rendering the estimate less conservative. Table 7-2 provides a summary of sample data used in the Tier 2 risk estimate. The sample locations for all data used in the risk estimate are presented in Figure 7-2.

## 7.2.1 Quality of Site Data

Data quality procedures and analytical methodology changes that were common across DOE areas at LEHR were discussed in Section 2. Soil background data quality was also discussed in Section 2.

The total data set generated in the Southwest Trenches area included 12,621 results. Thirtytwo of these results, or 0.3%, were rejected from the total data set ("R"-qualified). Sample results are rejected when a data validation expert reviewing laboratory data finds evidence of serious deficiencies in the ability to analyze a sample and meet QC criteria. The "R" qualifier indicates that the data cannot be used to verify whether the analyte was present in or absent from the sample. "R"-qualified results were not used in the risk estimate. After "R"-qualified data were removed from the total data set, the final risk estimate data set contained 12,589 results. Five-hundred fifty-one of the results, or 4.4%, had "J" qualifiers, which indicate that an analyte was positively identified in the sample, but the analytical result is an approximation of the analyte concentration in the sample. Data with "J" qualifiers were used in developing risk estimates. A total of 1,473 records, or 11.7%, had "UJ" qualifiers, which mean that an analyte was not detected, but the detection limit is approximate. Data with "UJ" qualifiers were included in the risk estimate and were treated as a non-detection of an analyte.

A total of 1,026 of the 12,589 final records from the Southwest Trenches area were used to generate the Tier 2 human health risk estimates. A total of 94 of the 1,026 results had "J" qualifiers and 25 results had "UJ" qualifiers.

# 7.3 Risk Characterization—Southwest Trenches

Consistent with the HHRA Risk Estimate, as discussed in Section 2.2, this risk characterization uses the terms "List 1" and "List 2". List 2 identifies constituents that failed the statistical comparison to background, which may be indicative of a release to the environment. Table 7-3 and Table 7-4, in the first column, provide the List 1 COPCs identified in the HHRA Risk Estimate. The last column of Table 7-3 and Table 7-4 provides only List 2 COPCs and their risk values. The values provided are not corrected for decay. A subset (shown in bold-type) of List 2 contains COPCs that have a risk of at least 10<sup>-6</sup> or contribute more than ten percent of the total excess cumulative cancer risk in the Southwest Trenches area.

Specifically, this subset consists of Cs-137, Pb-210, Sr-90, and Th-228 for the hypothetical on-site resident, and Cs-137 and Th-228 for the outdoor research worker. This subset is identified in this risk characterization as the List 2 driver COPCs, since these COPCs represent potential site-related risks and are the best candidates for further evaluation in the Feasibility Study. These COPCs are the focus of the risk characterization discussions that follow. None of the receptors evaluated for this area showed non-cancer hazard quotients above the point of departure of one.

Carcinogenic risks estimated in the HHRA Risk Estimate were below  $1 \times 10^{-6}$  for all receptors except hypothetical on-site residents and outdoor research workers. Receptors with estimated cumulative risks below  $10^{-6}$  are not the focus of this risk characterization, since they are

below the CERCLA point of departure for risk. Estimated cumulative carcinogenic risks to hypothetical future on-site residents and outdoor research workers were estimated in the HHRA Risk Estimate to be  $2 \times 10^{-5}$  and  $3 \times 10^{-6}$ , respectively. The risk characterization for the Southwest Trenches area focuses on these two receptors.

# 7.3.1 Exposure Assessment

The exposure assessment for List 2 driver COPCs at the Southwest Trenches area includes:

- The spatial distribution of the List 2 driver COPCs with figures showing sample locations;
- Further evaluation of risk from COPC concentrations attributed to site background versus prior site activities; and
- A discussion of the exposure intake estimates and their effect on the overall risk estimate.

A conceptual site model illustrating exposure pathways and potential human receptors for all DOE areas is provided as Figure 2-1.

# 7.3.1.1 Spatial Distribution of Contaminants of Potential Concern

Figure 7-3 through Figure 7-8 show the spatial distribution of post-removal action sample results for: Sr-90, Cs-137, Pb-210 and its parent isotope Ra-226; and Th-228 and its parent isotope, Th-232.

Sampling at the Southwest Trenches area was focused on the shallow chlordane excavation area, former waste burial trenches, and around the wash-down pad and former chemical storage area (Figure 7-1 and Figure 7-2). The sample locations were not part of an overall random grid, but represent a combination of random grid, hot spot, and vertical profile sampling performed within the potential areas of contamination.

# 7.3.1.1.1 Strontium-90 Distribution

The Sr-90 spatial analysis is shown in Figure 7-3. Only one sample (Sample ID SSDTC020, located near the southern boundary) had a measured concentration that corresponded to the  $10^{-5}$  to  $10^{-4}$  risk range. It is surrounded by non-detect samples with concentrations below background, indicating a very limited extent of contamination. Although 18 samples had concentrations within the  $10^{-6}$  to  $10^{-5}$  risk range, ten of those sample results are from the 1996 data set, which, as described in Section 7.3.4.1.3, has a positive bias for reported concentrations. Apart from these suspect results:

- Sample concentrations were below background throughout most of the central waste burial areas.
- Only three samples that are not from the suspect 1996 data set and that are outside of the northern waste burial area had concentrations that correspond to a risk greater than 10<sup>-6</sup>.

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The northern quarter of the northern waste burial area has four closely clustered samples with concentrations in the  $10^{-6}$  to  $10^{-5}$  risk range. Two other samples in the northern waste burial area had concentrations in the  $10^{-6}$  to  $10^{-5}$  risk range.

Based on the spatial distribution of these data, Sr-90 concentrations exceed both background and the concentration equivalent to a risk of  $10^{-6}$  in areas located in the northernmost and southern waste burial areas. Based on the 1996 data, sample concentrations may also exceed background and  $10^{-6}$  risk in the southwest and southeast corners of the area, and near the former wash-down pad.

#### 7.3.1.1.2 Cesium-137 Distribution

The Cs-137 spatial analysis is shown in Figure 7-4. Only one sample location had a concentration above the concentration equivalent to a risk of  $10^{-5}$ , and one other sample had a concentration between  $10^{-6}$  and  $10^{-5}$  risk. These two adjacent samples were located at depths of six ft. Samples collected at the same locations, but at a depth of nine ft, were below background. Additionally, the two high-concentration samples were surrounded by sample data indicating less than  $10^{-6}$  risk. Otherwise, the Cs-137 sample results indicate that the risk is uniformly below  $10^{-6}$ .

## 7.3.1.1.3 Lead-210 Distribution

The Pb-210 spatial analysis is shown in Figure 7-5. Only one Pb-210 sample had a concentration above both background and the detection limit. Most of the reported concentrations were below the sample detection limit, and had high levels of quantitative uncertainty. This uncertainty is discussed in Section 7.3.4.1.1. The locations of low and high concentrations appear evenly distributed across the sampled area, and do not indicate that any portions of the Site contain consistently high or low apparent risk.

In order to reduce the uncertainty of the spatial distribution analysis for Pb-210, its parent isotope (Ra-226) was also evaluated. Ra-226 analytical accuracy is superior, and its concentration should be in equilibrium with Pb-210. Ra-226 is the likely source of any potential Pb-210 contamination at LEHR. Ra-226 was used extensively in LEHR experiments and available information indicates that Pb-210 was not used at LEHR. Pb-210 will be in secular equilibrium with Ra-226, which means that the Ra-226 and Pb-210 concentrations should be the same for a given sample. Specifically, Pb-210 (22.3-yr half-life) and intermediate progeny have relatively short half-lives compared to Ra-226 (1,600-yr half-life). Short-lived progeny can only decay (emit activity) as fast as they are generated by the parent, unless an alternative progeny source exists. Thus, it is reasonable to assume that a sample's Pb-210 concentration will be strongly correlated to its Ra-226 concentration in the Southwest Trenches area, unless Pb-210 was released independently.

The Ra-226 spatial analysis is shown in Figure 7-6. Based on a comparison of Figure 7-5 and Figure 7-6, all of the Pb-210 concentrations that are above background are co-located with Ra-226 concentrations that are below background. If we accept that the concentrations of Pb-210 are related to the Ra-226 found in the Southwest Trenches area, then Pb-210 will not be replenished to concentrations greater than background.

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#### 7.3.1.1.4 Thorium-228 Distribution

The Th-228 spatial analysis is shown in Figure 7-7. Five sample locations had concentrations above background and all of those were below the concentration equivalent to a risk of  $10^{-5}$ . The concentrations exceeding background appear randomly located throughout the former waste burial trenches. Although available information indicates that Th-228 was used as a source material to generate thoron (radon-220) in experiments at LEHR, this material was carefully managed and no releases are suspected. Th-228 (half-life of 1.9 yrs) is naturally occurring and is part of the thorium-decay series, where it is derived from the primordial Th-232 parent, which has a half-life of 1.4 x  $10^{10}$  yrs. Soil Th-232 concentrations in the Southwest Trenches area are statistically equivalent to background, as determined in the HHRA Risk Estimate soil background evaluation and as shown in Figure 7-8. Based on the long parent half-life and short progeny half-life, it is clear that Th-228 will quickly come into equilibrium with the natural background levels of Th-232 in the Southwest Trenches area.

## 7.3.1.2 Degradation and Decay of Contaminants of Potential Concern

The methodology for calculating radionuclide decay is described in detail in Appendix B.

## 7.3.1.2.1 Cesium-137

Cs-137 has a half-life of 30.07 years and is not a naturally occurring radionuclide. It is a fission product that will not be replenished by a parent isotope.

The Cs-137 decay estimate for the Southwest Trenches area is shown in Figure 7-11. Based on the Cs-137 half-life, the site EPC has already decayed to a risk below  $10^{-6}$  for both the residential receptors and the on-site outdoor researcher.

## 7.3.1.2.2 Lead-210

Pb-210 (22.3-yr half-life) is naturally occurring and is part of the uranium-decay series, where it is derived from Ra-226 (1,600-yr half-life) and ultimately U-238. These parent isotopes have been characterized at the Southwest Trenches area and found to be at levels consistent with site background. Thus, the decay of the parent isotope will replenish Pb-210 at background concentrations and any Pb-210 that has been released at levels above background will attenuate over time.

The Pb-210 decay estimate for the Southwest Trenches area is shown in Figure 7-12. The Pb-210 site EPC will decay to within 1% of the background EPC in approximately 110 years.

#### 7.3.1.2.3 Strontium-90

Sr-90 has a half-life of 28.79 yrs and is not naturally occurring. The Sr-90 decay estimate for the Southwest Trenches area is shown in Figure 7-13. The Sr-90 site EPC will decay to a concentration equivalent to a risk of  $10^{-6}$  for the on-site residential receptor in approximately 43 years.

## 7.3.1.2.4 Thorium-228

Th-228 (half-life of 1.9 yrs) is naturally occurring and is part of the thorium-decay series, where it is derived from the primordial Th-232 parent, which has a half-life of  $1.4 \times 10^{10}$  yrs. The decay estimate for Th-228 at the Southwest Trenches area is shown in Figure 7-14. Based on the Th-228 half-life, the site EPC should decay to within 1% of the background EPC in approximately 1.4 years. The Th-228 EPC is not expected to decay to the concentrations equivalent to the risks of  $10^{-6}$  for the on-site resident or outdoor researcher, because these concentrations are less than the background concentration.

# 7.3.1.3 Background Evaluation

# 7.3.1.3.1 Detections above Site Background

The number of analytical results that were greater than both the detection limits and the background screening levels are reported in Table 7-2 for the List 1 COPCs. The four COPCs that are the List 2 drivers, Cs-137, Pb-210, Sr-90 and Th-228, were detected above background in 9, 1, 25 and 5 samples, respectively. The remainder of the List 1 COPCs were detected above background in 0 to 57 samples.

# 7.3.1.3.2 Parent-Daughter Activity Concentration Relationships

The concentration of Pb-210 at the Southwest Trenches area was compared to the concentration of its longer-lived parent, Ra-226, in Appendix E (Figure E-10). As shown, the concentrations of these isotopes appear to be in secular equilibrium when quantified analytical errors are taken into account. This is evidence that the concentration of Pb-210 at the site is due to decay of Ra-226 rather than to a release of Pb-210, because any shorter-lived daughter isotope will have a concentration approximately equal to that of its longer-lived parent isotope, in the absence of excess input of the daughter. The apparent elevated concentration of Pb-210 at the site relative to background, therefore, is probably due to analytical limitations rather than to a release. The concentration of Ra-226, which was measured at much higher precision than was Pb-210, is demonstrably below background concentrations. Therefore, the Ra-226 results suggest that the Ra-226/Pb-210 decay series is not impacting the site.

The concentration of Th-228 at the Southwest Trenches area was compared to the concentration of its longer-lived parent, Th-232, in Appendix E (Figure E-11). As shown, the concentrations of these isotopes appear to be in secular equilibrium when quantified analytical errors are taken into account. This is evidence that the concentration of Th-228 at the site is due to decay of Th-232 rather than to a release of Th-228, because any shorter-lived daughter isotope will have a concentration approximately equal to that of its longer-lived parent isotope, in the absence of excess input of the daughter. The apparent elevated concentration of Th-228 at the site relative to background, therefore, is probably due to analytical limitations rather than to a release.

# 7.3.1.3.3 Comparison of Risk Attributed to Background versus Site Activities

Table 7-5 presents statistics, including EPCs, for the sample results of the List 2 driver COPCs at both the site and in the background. The background EPCs were calculated using the same method used to calculate the site EPCs (Section 2.2.3.3.). Table 7-5 also presents

decay-corrected EPCs. EPCs can be used to derive relative contributions of risk because risk is directly proportional to the EPC.

Figure 7-15 and Figure 7-16 graphically illustrate the site risks to each receptor from each List 2 driver COPC, and the relative contributions to those risks from the background. These risks and proportions have been corrected for decay. The background contribution to the Cs-137 risk is 71%. The background contribution to the Pb-210 risk is 77%. The background contribution to the Sr-90 risk is 9%.

## 7.3.2 Toxicity Assessment

Toxicity values for COPCs in the Southwest Trenches area were taken from US EPA guidance, as discussed in Section 2.2.4. The toxicity values used for these COPCs are appropriate for this evaluation and make use of the best available information.

# 7.3.3 Risk Estimate

Table 7-3 summarizes the risk estimate information for the hypothetical future on-site resident. It shows that Cs-137, Pb-210, Sr-90, and Th-228 are the List 2 driver COPCs. In addition, the table shows that the pathway driving the risk estimate is external radiation for Cs-137 and Th-228, while plant ingestion drives Pb-210 and Sr-90. The cumulative risk for the hypothetical resident is  $2 \times 10^{-5}$ . Of this total, 39% is contributed by Pb-210 and 33% by Th-228.

Table 7-4 summarizes the risk estimate information for the outdoor researcher. It shows that Cs-137 and Th-228 are the List 2 driver COPCs. In addition, the table shows that only Th-228 presents a risk that exceeds 1 x  $10^{-6}$ , and that the pathway driving the risk estimate is external radiation. The cumulative risk for the outdoor researcher is 3 x  $10^{-6}$ . Of this total, 83% is contributed by Th-228 and 17% by Cs-137.

## 7.3.4 Uncertainty

Risk estimates are values that have uncertainties associated with them, as discussed in Section 2.2.6. The objective of this section is to discuss the major sources of uncertainty that are specific to this refined assessment of the Southwest Trenches area. These include data coverage and analytical issues.

## 7.3.4.1 Analytical Issues

## 7.3.4.1.1 Cesium-137

The analytical quality, as well as the consistency of the sample results with known releases at the Site, are good. It is expected that the resulting risk estimates are reasonable and conservative.

## 7.3.4.1.2 Lead-210

A large fraction of Pb-210 soil data collected in the Southwest Trenches area had detection limits and counting error values that were greater in magnitude than the background screening values. These large detection limits and counting errors were also greater than the concentrations equivalent to the risks of 10<sup>-6</sup>. Some of the data with high detection limits and errors were from sample that were analyzed before a CRDL of 0.5 pCi/g was established. Later data that met the established CRDL had acceptable accuracy for background comparisons. Lowering the CRDL improved the accuracy, because the counting error was reduced in the process. The detection limit and counting error are both inversely proportional to the count time and sample aliquot volume, which are the parameters used to improve the CRDL.

Although the new CRDL was established, the laboratory was not always able to achieve it due to high background counts. Background counts are due to radiation from sources other than the sample, which the laboratory cannot always prevent. High background counts have caused failure to meet the CRDL, because the detection limit is proportional to the background count standard deviation. Background counts also increase the counting error, because counting error is proportional to the square root of background counts.

Fourteen out of the fifteen Southwest Trenches area Pb-210 results that were above the background screening value also had counting errors and/or detection limits that were greater than background and concentrations equivalent to risks of  $10^{-6}$  and  $10^{-5}$  to the on-site resident. Because of the counting error, individual samples do not provide an accurate representation of Pb-210 risk at locations within the Southwest Trenches area. Collectively, these data carry a large amount of uncertainty. It is not possible to conclude whether Pb-210 concentrations were above background or a concentration corresponding to a risk of  $10^{-5}$ . However, it is possible to conclude that Pb-210 concentrations were below  $10^{-4}$  risk. The highest possible concentration (10.8 pCi/g = 5.31 pCi/g + 5.49 pCi/g error) was below the concentration equivalent to a risk of  $10^{-4}$  (22 pCi/g).

These data uncertainties likely result in an overestimate of the Pb-210 EPC. The analysis of Ra-226 concentrations discussed in Section 7.3.1.1.3 indicated that Pb-210 would not be replenished at levels above background by radioactive decay. Thus, its concentrations, if elevated, will gradually decay to background levels.

# 7.3.4.1.3 Strontium-90

Fourteen of the Sr-90 samples located in the Southwest Trenches area were collected during the Limited Field Investigation in 1996. LEHR samples collected and analyzed in 1996 are suspected to have false positive results due to analytical interference described in Section 2.2.6. Because the true concentrations in these samples may be lower than the reported concentrations, the sample results may overestimate the true level of risk in the Southwest Trenches area. As shown in Figure 7-3, most of these samples were collected in areas outside of the waste burial trenches. All of these sample results were above background, and 10 of 14 samples indicated risk above 10<sup>-6</sup>. As a group, these data are clearly shifted above the rest of the Southwest Trenches area data. The rest of the Southwest Trenches area samples are located within the waste burial trenches where Sr-90– contaminated materials were removed. The 1996 data are shifted above the rest of the Southwest Trenches area data without being located in areas of former contamination. These samples may have

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the false positive analytical bias as described in Section 2.2.6.1 or they may be indicative of site contamination. Although these data do not likely provide an accurate risk estimate, they can be used to show that the risk is below a target level in the areas they represent. The actual risk at these sample locations can be no more than  $10^{-5}$ , and may be below  $10^{-6}$  or background.

These data uncertainties likely result in an overestimate of the Sr-90 EPCs.

# 7.3.4.1.4 Thorium-228

Figure 7-9 is a histogram of Th-228 and Th-232 concentrations in the Southwest Trenches area. For contrast, Figure 7-10 contains a histogram of Th-228 and Th-232 background concentrations. The histograms indicate that Th-228 data is slightly shifted above Th-232 in the Southwest Trenches area, while the background distributions do not show a shift. Based on the apparently random spatial distribution of Th-228 (Figure 7-7) in the Southwest Trenches area and the uniformly shifted Th-228 data, it appears contamination could be uniformly distributed throughout the Southwest Trenches area. However, the Th-228 shift could also be due to changes in accuracy of the analytical methods between the time the background samples were collected and when the Southwest Trenches area samples were collected. A similar question regarding analytical accuracy of Th-228 measurements was raised for the Radium/Strontium Treatment Systems area (Section 6.3.4.1.2).

As shown in Figure 7-9, the Th-228 shift is small. With only a slight amount of apparent contamination, a half-life of 1.9 yrs, and no parent source of contamination, any risk posed by Th-228 will quickly disappear.

## 7.3.4.2 Data Representativeness

The representativeness of the data used in this assessment is effected by the spatial data coverage. Two soil intervals, 0 to 0.5 ft and zero to ten ft, were evaluated in the HHRA Risk Estimate. The coverage within the deeper soil interval is extensive for the 0.6-acre site, and covers the known potential source areas (Figure 7-1 and Figure 7-2). However, the coverage for the shallow horizon (0 to 0.5 ft) consists of only six samples. Because the majority of the area was excavated and backfilled with clean fill, it is expected that surface concentrations would generally be less than subsurface concentrations. Therefore, any risk estimates based on the zero to ten ft interval will be conservative.

# 7.3.5 Relation of Concentrations of Contaminants of Potential Concern to Site Operations

Th-228 and Ra 226 are naturally occurring, but may also be present due to their use at LEHR. Th-228 was used in LEHR experiments, and the parent isotope of Pb-210, Ra-226, was used extensively in LEHR experiments. There are no records that indicate either of these isotopes was directly released at the Site, and it is likely that Th-228 and Pb-210 concentrations included in the risk estimate are not related to site activities. The spatial distribution data discussed in Sections 7.3.1.1.3 and 7.3.1.1.4 indicate that elevated levels of Th-228 and Pb-210 are randomly distributed, suggesting that the concentrations of these COPCs are not a result of site releases.

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Sr-90 and Cs-137 are not naturally occurring. Sr-90 was one of the primary research isotopes used at LEHR, and Cs-137 was also used in research at the Site.

## 7.4 Ground Water Impacts

In addition to evaluation of human health risk resulting from soil contamination, potential ground water impacts from contaminants remaining in the soil at the Southwest Trenches area were evaluated and are presented in the RI (WA, 2003b). A summary of this evaluation is presented in Table 7-6.

## 7.4.1 Risk Characterization of Constituents of Potential Ground Water Concern

Based on all data representative of soil remaining in the area, Cr-VI, Hg, nitrate, zinc, Am-241, C-14, Cs-137, Sr-90, and tritium were evaluated as DL COPCs. Of these constituents, only Hg and C-14 were detected in downgradient wells (UCD1-4 and UCD1-23 [Figure 2-3]) in concentrations exceeding background. Nitrate has been detected above background in downgradient well UCD1-24 and may reflect historic releases from the Southwest Trenches area or other areas. There are no HSU-2 monitoring wells less than 500 ft downgradient of the Southwest Trench areas that are not impacted by other source areas. Analytical data from monitoring well UCD2-15, located within the Southwest Trenches area (Figure 2-3), indicates that Cr-VI, nitrate, and C-14 are present above background.

Modeling confirms that Hg, nitrate, C-14, and tritium concentrations remaining in the Southwest Trenches soils may impact ground water in concentrations exceeding their MCLs. Based on modeling results, zinc is expected to impact ground water in concentrations exceeding background, but not the MCL.

The impact of Hg and C-14 soil concentrations is expected to occur in 5,000 and ten years, respectively. Impacts of all of the remaining constituents are currently occurring or are estimated to occur in ten years or less.

Based on the DL COPC evaluation process illustrated in Figure 1-2 and as shown in Table 7-7, Cr-VI, Hg, nitrate, zinc, C-14, and tritium were retained for further evaluation as COPGWCs.

#### 7.4.1.1 Percentage and Spatial Distribution of Samples Exceeding Background

#### 7.4.1.1.1 Hexavalent Chromium

All 118 hexavalent chromium soil sample results were below background at the Southwest Trenches area. Hexavalent chromium appears to be uniformly below background in soil throughout the lateral and vertical extent of the area. Soil sampling was extensive in the Southwest Trenches area.

## 7.4.1.1.2 Mercury

Mercury was above background in forty-four of 118 soil sample results (37%) in the Southwest Trenches area. Elevated mercury results appear more frequently in the northern third of the area and less frequently near the center. Three clusters of elevated mercury samples appear located along the southern extent of sampling. However, this clustering pattern appears to be an artifact of sample depth. Mercury concentrations in the Southwest Trenches area attenuate sharply below 6 ft bgs. Studies of ambient mercury concentrations at LEHR have shown marked depth stratification. The background screening concentration for mercury in shallow soil (0 to 4 ft bgs) is 3.94 mg/kg, and the background concentration in deep soil (>4 ft bgs) is 0.248 mg/kg (WA, 2003b). Only three of the Southwest Trenches area samples had mercury concentrations above the shallow soil screening concentration. These three samples were located at depths between three ft and four ft bgs.

Samples near the center of the Site were collected at deeper depths than samples in the northern third and southern perimeter. Mercury concentrations are significantly higher at shallow depths and uniformly below one mg/kg between seven ft bgs and the total depth explored (29 ft bgs).

## 7.4.1.1.3 Nitrate

Nitrate was above background in 114 of 456 soil sample results (25%) in the Southwest Trenches area. The elevated results were clustered in the central portion of the Southwest Trenches area and cover the northern half of waste burial trenches W-8 and W-10. Nitrate was mostly below background in samples collected on the north, east and south sides of the nitrate-contaminated area.

In the central portion of the Southwest Trenches area, maximum nitrate concentrations are present at twelve ft bgs. Shallow samples collected between ground surface and two ft bgs and deep samples collected between 21 ft and 30 ft bgs were mostly below the background screening value of 36 mg/kg. The nitrate concentration increases rapidly with depth starting at three ft bgs, peaks sharply at twelve ft bgs and declines rapidly to near background levels at 18.5 ft bgs (WA, 2003b).

# 7.4.1.1.4 Zinc

Eight of 89 soil sample results (9%) were above background for zinc in the Southwest Trenches area. The background screening concentration is 87 mg/kg. All but one of the elevated samples was collected from soil boring samples below 14 ft bgs. The study of background soil samples at LEHR indicated that natural zinc concentrations increase slightly with depth. A plot of Southwest Trenches area and background zinc concentrations in soil versus depth is shown in Figure 7-17. Based on the plot, five of the deep samples are above the range of background concentrations. These five samples were located below Trench T-1 (Figure 7-1). One sample collected at three ft bgs had a zinc concentration of 150 mg/kg. This shallow, elevated zinc concentration was located in the southernmost waste burial trench, and is surrounded by samples that were below background. It is unlikely that this sample represents a significant area of contamination. Based on the zinc spatial distribution, zinc contamination is likely present below Trench T1.

## 7.4.1.1.5 Carbon-14

Thirty-seven out of 105 soil sample results (35%) exceeded background for C-14 in the Southwest Trenches area. Most of the soil samples from the southernmost disposal trench (Figure 7-1) had elevated C-14 concentrations. A few samples containing slightly elevated C-14 concentrations are located at or near disposal trench T-3 (Figure 7-1). The four highest detected concentrations ( $1.01\pm0.129$  pCi/g to 5.84±0.25 pCi/g) were located between 2 ft and 3.5 ft bgs. C-14 concentrations were below 1 pCi/g between 4 ft and 44 ft bgs.

## 7.4.1.1.6 Tritium

Tritium was above background in 10 of 72 soil sample results (14%) in the Southwest Trenches area. A cluster of five elevated tritium concentrations is located near the northern end of waste burial trench T-3 (Figure 7-1). These five samples had the highest tritium concentrations ( $2.45\pm0.648$  to  $2.93\pm0.678$  pCi/g) in the Southwest Trenches area. The other five elevated samples were located randomly throughout the Southwest Trenches area.

The samples containing elevated tritium concentrations were collected between 3 ft and 12 ft bgs. Shallow samples collected between ground surface and two ft bgs and deeper samples collected between 13 ft and 29 ft bgs were all below the background screening value of 1.2 pCi/g. The northern cluster of samples with elevated tritium concentrations were collected between 4 ft and 10 ft bgs.

## 7.4.1.2 Degradation and Decay of Contaminants of Potential Concern

Cr-VI, Hg, nitrate and zinc are not expected to undergo significant degradation. The NUFT model accounts for the radioactive decay of tritium and C-14, and indicates that the attenuation will not fully mitigate future impacts to ground water.

# 7.4.1.3 Uncertainty

Similar to human health risk estimates, evaluation of ground water impacts is subject to uncertainties, such as analytical bias and data representativeness, discussed below.

## 7.4.1.3.1 Analytical Issues

## 7.4.1.3.1.1 Hexavalent Chromium

Forty-three of the 118 hexavalent chromium results were qualified. Seventeen samples were qualified due to contamination detected in the laboratory method blank. Laboratory contamination can cause false positive detection and may cause an overall positive bias in the data set. Twenty-six samples were qualified due to expired holding time, which can affect sample accuracy and cause a negative bias. The laboratory contamination and holding time issues affected 36% of the hexavalent chromium data.

#### 7.4.1.3.1.2 Mercury

Thirty-eight of the 118 mercury results were qualified. Nineteen of the mercury results were qualified due to matrix spike recovery failure. Eighteen samples were qualified due to low matrix spike recovery and one sample was qualified due to high matrix spike recovery. A matrix spike consists of adding a known quantity of analyte to a sample and determining the percent recovered by the analytical method. Matrix spike recovery failure may indicate the sample matrix is interfering with quantitative accuracy for this analyte.

Three samples were qualified due to field duplicate imprecision, which does not indicate a high or low bias. However, the highest value among field duplicate pairs was used for site characterization to ensure a conservative bias. Sixteen samples were qualified due to laboratory duplicate imprecision, which does not result in high or low bias.

## 7.4.1.3.1.3 Nitrate

Seventy-one of the 456 nitrate results were qualified during data validation. Fifty of these results were qualified due to expired holding time. Samples could lose nitrate after the holding time is expired, which can cause a negative bias in the data.

Seventeen samples were qualified due to contamination detected in the laboratory method blank. Laboratory contamination can cause false positive detection, and may cause an overall positive bias in a data set.

Six of the nitrate results were qualified due to low matrix spike recovery. A matrix spike consists of adding a known quantity of analyte to a sample and determining the percent recovered by the analytical method. Poor matrix spike recovery may indicate the sample matrix is interfering with quantitative accuracy.

Two samples were qualified due to field duplicate imprecision, which does not indicate a high or low bias. However, the highest value among field duplicate pairs was selected for site characterization. Two samples were qualified due to laboratory duplicate imprecision, which does not result in high or low bias.

It should be noted that six samples were qualified for both expired holding time and failed matrix spike recovery. All but one of the double-qualified results were above the background screening value of 36 mg/kg.

## 7.4.1.3.1.4 Zinc

None of the 89 zinc results were qualified during data validation. All of the results were detected above the quantitation limit. No analytical issues were identified for zinc.

#### 7.4.1.3.1.5 Tritium

None of the 72 tritium results were qualified during data validation. Sixty-one of the results (85%) were below the laboratory detection limit. All of the detection limits were below the background screening value of 1.2 pCi/g. No analytical issues were identified for tritium.

## 7.4.1.3.1.6 Carbon-14

None of the one-hundred five C-14 results were qualified during data validation. Sixty-seven of the results (64%) were below the laboratory detection limit. Sixty of the samples (57%) had detection limits above the background screening value of 0.13 pCi/g. Radiological analytical results below the detection limit are still reported as semi-quantitative results by the analytical laboratory, and were compared to the background screening value. The background comparison was less reliable than situations where lower relative detection limits have been achieved.

## 7.4.1.3.2 Data Representativeness

Southwest Trenches area sampling consisted of random grid, discretionary grab samples, and soil boring samples collected at depths ranging from ground surface to 44 ft bgs. Soil sample coverage was extensive, and covers the lateral and vertical extent of the areas containing buried waste and other known or potential source areas. The samples were collected and analyzed according to Superfund risk assessment data quality standards. The data are sufficient for characterizing the soil column in the Southwest Trenches area. No data gaps were identified.

# 7.4.1.4 Relation of Concentrations of Contaminants of Potential Ground Water Concern to Site Operations

Cr-VI is potentially associated with LEHR operations, since chromic acid and other chromium-bearing chemicals may have been used or disposed at the Site. Mercury was also used at LEHR. Zinc was present at significant concentrations (730 mg/kg) in buried waste removed from the Southwest Trenches (Table 7-1). Nitrate is a likely artifact of biological waste disposed in the Southwest Trenches area.

Tritium and C-14 were used at LEHR and were present in buried waste removed from the Southwest Trenches area (WA, 2003b).

# 7.5 Risk Characterization Summary and Recommendations Regarding Contaminants of Concern at the Southwest Trenches Area

Risk characterization findings and recommended COCs at the Southwest Trenches area are summarized below and presented in Table 7-8. The recommended COCs include constituents that are not considered to have potential risks to human health, but that may have potential impact on the ground water at the Site.

Consistent with the HHRA Risk Estimate, the hypothetical future resident and the outdoor researcher are the populations with the highest estimated risk levels at the Southwest Trenches area.

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As discussed in Section 7.3.4, the current risk estimates for the driver COPCs are very conservative. The inclusion of background risk in the EPCs consistently elevates the List 2 exposure point risks by more than 50%, except for Sr-90.

Th-228 and Pb-210 concentrations included in the risk estimate contribute approximately 55% (for the on-site resident) to 66.67% (for the on-site researcher) of the total site-related risk. Given the fact that these isotopes are naturally occurring radionuclides, and the analytical results for Th-228 and Pb-210 samples have an apparent high analytical bias, their inclusion in the risk estimate is likely to overestimate the site risk.

## 7.5.1 Human Health—On-Site Resident

#### 7.5.1.1 Cesium–137

Cs-137 was used in research activities at LEHR and was present in waste material buried in the Southwest Trenches area. The decay-corrected Cs-137 cancer risk is  $9 \times 10^{-7}$ . The majority of the Cs-137 risk present at the Site (71%) is related to the background concentration, not to site activities. Spatial analysis shows that Cs-137 in soil is mainly localized in the southern portion of the Site, and no point concentrations exceed a risk of  $10^{-4}$ . Based on these findings, it is recommended that Cs-137 not be identified as a COC for this receptor.

#### 7.5.1.2 Lead-210

Lead-210 is naturally occurring and is part of the uranium-238 decay series. As such, it is derived from the decay of naturally occurring uranium-238 and its progeny, which includes Ra-226. Although Pb-210 is not a documented LEHR research isotope, it would have been produced by decay of Ra-226 and Rn-222, which are known to have been used at LEHR. However, there is no evidence that Pb-210 was released or disposed in the area, since the waste material removed from the Southwest Trenches area had Pb-210 concentrations that were consistent with site background. Ra-226 and U-238 concentrations in the site soil are at background levels, so Pb-210 would not be replenished at levels above background by radioactive decay of these isotopes. The risk estimate indicates that the Pb-210 cancer risk is  $6 \times 10^{-6}$ . The majority (77%) of risk associated with Pb-210 is attributable to background. Analytical bias in reporting the lead concentration values also overestimates the risk to human health from Pb-210. The Pb-210 appears to be randomly distributed, and few sample results exceeded the analytical detection limits. Based on these findings, Pb-210 should not be retained as a COC for this receptor.

## 7.5.1.3 Strontium-90

Sr-90 was one of the primary research isotopes used at LEHR and it was present in relatively high concentrations (16,700 pCi/g) in buried waste material removed from the Southwest Trenches. Ambient background levels are very low and are mainly an artifact of global fallout from above-ground weapons testing. The risk estimate indicates that the Sr-90 cancer risk is  $3 \times 10^{-6}$ . The majority (91%) of risk associated with Sr-90 is attributable to site activities. The spatial distribution data for Sr-90 indicates localized areas of contamination that may be related to past site releases. Therefore, Sr-90 should be retained as a COC for this receptor.

## 7.5.1.4 Thorium-228

Th-228 was used in research activities at LEHR, but was not present at elevated concentrations in waste material removed from the Southwest Trenches area, and the random spatial distribution of this isotope is not indicative of a release. The risk estimate indicates that the decay-corrected cancer risk from Th-228 is  $4 \times 10^{-6}$ . The majority (98%) of risk associated with Th-228 is attributable to background. This COPC has a relatively short half-life (1.9 yrs), and the site EPC will diminish to within one percent of the background EPCs in approximately 1.4 years. Therefore, Th-228 should not be retained as a COC for this receptor.

## 7.5.2 Human Health—On-Site Outdoor Researcher

## 7.5.2.1 Cesium-137

Cs-137 was used in research activities at LEHR, and was present in waste material buried in the Southwest Trenches area. The risk estimate indicates that the decay-corrected cancer risk is  $4 \times 10^{-7}$ . The majority of the Cs-137 risk present at the Site (71%) is related to the background concentration, not to site activities. Spatial analysis shows that Cs-137 in soil is mainly localized in the southern portion of the Site and no point concentrations exceed  $10^{-5}$ . The total Cs-137 risk in the Southwest Trenches area is below the CERCLA point of departure; therefore, it is recommended that Cs-137 not be retained as a COC for this receptor.

## 7.5.2.2 Thorium-228

Th-228 was used in research activities at LEHR, but was not present at elevated concentrations in waste material removed from the Southwest Trenches area. The random spatial distribution of this isotope is not indicative of a release. The risk estimate indicates that the decay-corrected cancer risk from Th-228 is  $2 \times 10^{-6}$ . The majority (98%) of risk associated with Th-228 is attributable to background. This COPC has a relatively short half-life (1.9 yrs), and has undergone radioactive decay since sample analysis was conducted. Due to decay, the site EPC will diminish to within one percent of the background EPC in approximately 1.4 years. Therefore, Th-228 should not be retained as a COC for this receptor.

# 7.5.3 Ground Water

## 7.5.3.1 Hexavalent Chromium

Cr-VI concentrations in HSU-1 ground water have been below background and the MCL, but concentrations in HSU-2 ground water have been above background and the maximum was equal to the MCL of 50  $\mu$ g/l. Southwest Trenches area Cr-VI soil concentrations are below background. Modeling results indicate that Cr-VI will impact ground water slightly above background and the MCL. Soil sampling was extensive and covered the lateral and vertical extent of the Southwest Trenches area. Cr-VI was potentially associated with LEHR operations. Cr-VI should not be retained as a COC. Additionally, ground water monitoring is not recommended for this area since all residual Cr-VI soil concentrations are below background.

## 7.5.3.2 Mercury

Hg has been detected sporadically in ground water in concentrations exceeding background, but below the MCL. Although Hg was detected in elevated concentrations in a downgradient well in 1995, it has not otherwise been detected above the detection limit. Soil sampling was extensive throughout the lateral and vertical extent of the operational area. Mercury concentrations are randomly distributed in shallow soil (zero to four ft bgs) throughout the area, but slightly elevated mercury concentrations were detected in deeper soil samples (4 to 25 ft bgs). Mercury was used in LEHR operations. Modeling indicated that Hg in Southwest Trenches area soil might impact ground water at concentrations exceeding background and the MCL. The predicted time to impact is approximately 5,000 years from present. The uncertainty evaluation indicated that 1% of the data may be biased high and 15% of the data may be biased low due to analytical accuracy issues. Hg should not be retained as a COC because current data indicate that Hg is not impacting ground water, and the predicted impact from soil is more than 500 years from present. However, due to the presence of elevated Hg concentrations in soil, it should be included in the ground water monitoring program to ensure that the model predictions are appropriate.

# 7.5.3.3 Nitrate

Nitrate concentrations in ground water have been above background and the MCL. Modeling suggests that nitrate in soil may elevate ground water concentrations above background and the MCL in approximately 10 years. Nitrate was associated with LEHR operations. Soil sampling was extensive throughout the lateral and vertical extent of the operational area. A localized area of nitrate soil contamination was found in the center of the Southwest Trenches area between 3 and 18.5 ft bgs. The uncertainty evaluation indicated that 4% of the data may be biased high and 12% of the data may be biased low due to analytical accuracy issues. Nitrate should be retained as a COC.

# 7.5.3.4 Zinc

Zinc concentrations in HSU-1 ground water have been below background and the MCL. Modeling indicated zinc would be currently impacting ground water above background. Zinc was potentially associated with LEHR operations. Soil sampling was extensive throughout the lateral and vertical extent of the operational area. The spatial analysis indicated an area of elevated zinc below Trench T-1. No analytical accuracy issues were identified with the data. Zinc should not be retained as a COC because the mass of elevated concentrations is small. It should, however, be included in the ground water monitoring program.

# 7.5.3.5 Tritium

Downgradient tritium concentrations were consistent with site background. Modeling suggests that tritium would be currently impacting ground water above background and the MCL. Tritium was used in LEHR operations. Soil sampling was extensive throughout the lateral and vertical extent of the operational area. A small localized area of soil contamination was found at the north end of waste burial trench T3 between 3 and 12 ft bgs. No analytical accuracy issues were identified with the data. Tritium should not be retained as a COC because the mass and extent of tritium in soil is limited and it was not detected above background in ground water.

## 7.5.3.6 Carbon-14

Concentrations of C-14 in a downgradient well ground water sample were above background, but below the MCL. Modeling indicates that C-14 in Southwest Trenches area soil is likely to impact ground water at levels exceeding background and the MCL in approximately 10 years. C-14 was used in LEHR operations. Soil sampling was extensive throughout the lateral and vertical extent of the operational area. Contamination was found mainly at the southernmost waste burial trench. No significant analytical accuracy issues were identified with the data. C-14 should be retained as a COC.

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Figure 7-1. Southwest Trenches Area Features 4108-142-SWT\_Features2.ai



Figure 7-2.Southwest Trenches Area Sample Locations and Depths



Figure 7-3. Strontium-90 Spatial Analysis, Southwest Trenches Area 4108-142-SWT\_Sr-90.ai



Figure 7-4. Cesium-137 Spatial Analysis, Southwest Trenches Area 4108-142-SWT\_Cs-137.ai



 Figure 7-5.
 Lead-210 Spatial Analysis, Southwest Trenches Area

 4108-142-SWT\_Pb-210.ai



Figure 7-6. Radium-226 Spatial Analysis, Southwest Trenches Area 4108-142-SWT\_Ba-226.ai



Figure 7-7. Thorium-228 Spatial Analysis, Southwest Trenches Area 4108-142--SWT-Th-228.ai



Figure 7-8. Thorium-232 Spatial Analysis, Southwest Trenches Area 4108-142-SWT\_Th-232.ai



Figure 7-9. Histogram of Thorium-228 and Thorium-232, Southwest Trenches Area



Figure 7-10. Histogram of Thorium-228 and Thorium-232, Soil Background, Southwest Trenches Area



Figure 7-11. Decay of Cesium-137 at Southwest Trenches Area



Figure 7-12. Decay of Lead-210 at Southwest Trenches Area



Figure 7-13. Decay of Strontium–90 at Southwest Trenches Area



Figure 7-14. Decay of Thorium-228 at Southwest Trenches Area



Figure 7-15. Cancer Risk for On-Site Resident from Site Activities and Background, Southwest Trenches Area



% values represent percent contribution from the site and background, decay-corrected to April 2005





Figure 7-17. Southwest Trenches Area and Background Zinc Concentrations in Soil vs. Depth

Analyte	Max Concentration	Background <sup>1</sup>	Sample No.	Matrix	Location	Depth (ft bgs)	Date
Radionuclides	(pCi/g)	(pCi/g)					
Actinium-228	<b>`</b> 5.5	0.01	S-342	Plastic Bag	T-2	3.5	July 1996
Carbon-14	117.0	0.13	S-339	Bone	T-2	6	July 1996
Cesium-137	23.0	0.102/0.007	S-350	Ground	Grid 7-9	0.5	July 1996
Potassium-40	16.7	14	S-473	Soil	SB-7	21	August 1996
Lead-214	4.3	0.55/0.581	S-342	Plastic Bag	T-2	3.5	July 1996
Radium-226	7.06	0.75	S-338	Gravel	T-2	6.5	July 1996
Strontium-90	16,700	0.056	S-340	Sludge	T-2, T-6	6.5	July 1996
Thorium-234	39.5	0.78	S-362	Wood	T-6, Pit No. 1	12	July 1996
Tritium	91.1	1.2	S-347	Gravel	T-5	1.5	July 1996
Metals	(mg/kg)	(mg/kg)					5
Arsenic	9.7	8.14/10.9	S-481	Soil	SB-8	30	August 1996
Barium	270	211/294	S-336	Soil	T-2	3.5	July 1996
Beryllium	4.80	0.564/0.924		Soil	SB-20	0.0	March 1990
Chromium VI	1.2	1.3		Soil	SB-19	0.0	March 1990
Chromium	250	199/125	S-349	Soil	T-5	4	July 1996
Cobalt	35.00	31		Soil	SB-21	10.0	March 1996
Copper	890	48.8/61.8	S-340	Sludge	Т-2	6.5	July 1996
Iron	46.000	44,000	S-352	Soil	Grid 7-9	3.5	July 1996
Lead	49	9.5	S-340	Sludge	T-2	6.5	July 1996
Manganese	1.000	750	S-357	Soil	T-6	14.4	July 1996
Mercury	5.2	3.94/0.248	S-483	Soil	SW Corner of Site	3	August 1996
Nickel	420	334/246	S-495	Soil	Wash-down Pad	3-4.5	August
Selenium	15	12	S-340	Sludge	T-2	65	July 1996
Vanadium	82	66.8/80.3	S-481	Soil	SB-8	30	August 1996
Zinc VOCs	730 (mg/kg)	72.4/93.1	S-340	Sludge	T-2	6.5	July 1996
Ethylene	1.2	N/A	S-362	Wood	T-6, Pit No. 1	12	July 1996
SVOCs (mg/kg)	30,947 (mg/kg)	N/A (mg/kg)	S-362	Wood	T-6, Pit No. 1	12	July 1996
Chlordane	2 000	$N/\Delta$		Soil	T-06	N/A	1988
DDD	0.26	N/A	S-484	Soil	Shallow soil	3.5	August
DDE	0.014	N/A	S-378	Soil	T-3	2.5	August 1996

# Table 7-1.Analytes Detected above Background in Soil/Waste at the Southwest Trenches Area<br/>Prior to Removal Actions
Analyte	Max Concentration	Background <sup>1</sup>	Sample No.	Matrix	Location	Depth (ft bgs)	Date
DDT	0.0037	N/A	S-490	Soil	Shallow soil	4	August 1996
Dieldrin	0.07	N/A	S-484	Soil	Shallow soil	3	August 1996
Heptachlor	0.10	N/A	S-486	Soil	Shallow soil	3	August 1996
Endosulfan- Sulfate	0.011	N/A	S-485	Soil	Shallow soil	3	August 1996
Heptachlor epoxide	0.0013	N/A	S-490	Soil	Shallow soil	4	August 1996
Methoxychlor	0.0011	N/A	S-490	Soil	Shallow soil	4	August 1996
PCB-1260	1.0	N/A	S-340	Sludge	T-2	6.5	July 1996
Pyrene	0.033	N/A	S-333	Soil	T-1	6	July 1996
Others	(mg/kg)	(mg/kg)					-
Chloride	470	N/A	S-331	Soil	T-1	2	July 1996
Formaldehyde	530	N/A		Soil	SSL00001	0.4	June 1995
Hexanol	660	N/A		Soil	SSL00003	0.5	June 1995
Nitrate (as N)	390	36	S-357	Soil	T-6, Pit No. 2	14.4	July 1996
Nonanol	340	N/A		Soil	SSL00002	0.4	June 1995
Sulfate	5,700	N/A	S-340	Sludge	T-2, T-6	6.5	July 1996

# Table 7-1.Analytes Detected above Background in Soil/Waste at the Southwest Trenches Area<br/>Prior to Removal Actions (continued)

#### Notes

Data from the Remedial Investigation Report (WA, 2003b).

Source: D&M, 1994, and PNNL, 1995.

List includes only analytes considered as COPCs for the purpose of the risk estimates.

Contaminant data includes data collected from all depth intervals instead of the 0-10 ft interval used in the risk estimate.

<sup>1</sup>Lowest background concentration is the lower of the shallow (0-4 ft) and the deep (4-40 ft) soil background screening values for vertically stratified analytes.

bgs COPC DDD	below ground surface constituent of potential concern dichlordiphenyl dichlor
DDE	dichlordiphenyl ethylene
DDT	dichlordiphenyl trichlor
ft	feet
Max	maximum
mg/kg	milligrams per kilogram
N/A	not available (location) or not applicable (background level)
No.	number
PCB	polychlorinated biphenyl
pCi/g	picoCuries per gram
SB	soil boring
SVOC	semi-volatile organic compound
SW	southwest
Т	trench
VOC	volatile organic compound

List 1 COPC	Units	Total Samples (not including field duplicates)	Number of Detections	Number of Detections > Background	Concentration Range <sup>1</sup>	Background Screening Concentration <sup>2</sup>	Maximum Sample ID	Sample Depth (ft)
Metals								
Arsenic	mg/kg	67	67	0	5.2 - 9.5	9.6	SSDTC064	10
Iron	mg/kg	67	67	1	21,000 - 44,200	44,000	SSDTC067	8
Pesticides/PCBs								
alpha-Chlordane	µg/kg	80	54	54	0.032 - 1,700	0	LEHR-S-484	3.5
Dieldrin	µg/kg	80	6	6	0.41 - 70	0	LEHR-S-484	3.5
gamma-Chlordane	µg/kg	80	57	57	0.12 - 1,900	0	LEHR-S-484	3.5
Radionuclides								
Americium-241	pCi/g	55	5	4	0.0113 - 3.22	0.014	SSDTC090	0
Carbon-14	pCi/g	69	29	27	0.111 - 5.84	0.13	SSDTC024	3
Cesium-137	pCi/g	69	9	9	0.0219 - 1.18	0.012	SSDTC036	6
Lead-210	pCi/g	67	8	1	0.261 - 1.61	1.60	SSDTC079	8
Potassium-40	pCi/g	67	67	9	9.85 - 15.3	14	SSDTC076	5
Radium-226	pCi/g	81	72	7	0.38 - 1.11	0.75	LEHR-S-485	3
Radium-228	pCi/g	53	52	11	0.383 - 0.769	0.64	SSDTC083	8
Strontium-90	pCi/g	68	26	25	0.0498 - 15.7	0.056	SSDTC020	3
Thorium-228	pCi/g	53	53	5	0.336 - 0.894	0.74	SSDTC076	5
Tritium	pCi/g	70	10	9	0.971 - 5.2	1.2	SSDTC086	4

#### Table 7-2. Summary of Sampling Results Used in the Risk Estimate at the Southwest Trenches Area

#### Notes

Source: COPC data from the HHRA Risk Estimate, Appendix A (UC Davis, 2005). <sup>1</sup>The concentration ranges for metals and radionuclides include non-detects.

<sup>2</sup>The background screening concentrations are the unstratified background screening values in Appendix B of the HHRA Risk Estimate.

greater than
micrograms per kilogram
constituent of potential concern
feet
Human Health Risk Assessment
identification (number)
milligrams per kilogram
polychlorinated biphenyl
picoCuries per gram

Human Health Risks to On-Site Resident by Exposure Route for Contaminants of Potential Concern at the Southwest Trenches Area Table 7-3.

				CANCER F	RISK BY EXPOSURE	ROUTE				
List 1 COPC <sup>1</sup>	EPC <sup>2</sup>	Soil Ingestion	Soil Dermal Exposure	Above-Ground Plant Ingestion <sup>3</sup>	Below-Ground Plant Ingestion <sup>3</sup>	External Radiation	Dust Inhalation	Total Cancer Risk	Statistical Background Comparison <sup>4</sup>	List 2 Cancer Risk <sup>5</sup>
alpha-Chlordane	0.082	5E-08	3E-09	4E-08	6E-09	-	3E-12	1E-07	Fail	1E-07
Arsenic	7.8	2E-05	1E-06	9E-05	3E-05	-	1E-08	1E-04	Pass	-
Dieldrin	0.0053	1E-07	3E-08	4E-07	7E-08	-	1E-11	6E-07	Fail	6E-07
gamma-Chlordane	0.093	5E-08	4E-09	5E-08	7E-09	-	4E-12	1E-07	Fail	1E-07
Americium-241	0.16	3E-08	-	3E-09	-	5E-08	9E-11	8E-08	Fail	8E-08
Carbon-14	0.55	2E-11	-	1E-08	-	8E-13	2E-10	1E-08	Fail	1E-08
Cesium-137	0.054	2E-09	-	8E-09	-	1E-06	9E-15	1E-06	Fail	1E-06
Lead-210	1.3	<b>2E-06</b>	-	4E-06	-	5E-08	<b>2E-10</b>	6E-06	Fail	6E-06
Potassium-40	12	6E-07	-	2E-05	-	1E-04	2E-12	1E-04	Pass	-
Radium-226	0.62	9E-07	-	3E-06	-	5E-05	2E-10	5E-05	Pass	-
Radium-228	0.57	5E-07	-	1E-06	-	2E-05	5E-10	2E-05	Pass	-
Strontium-90+Daughter	0.94	1E-07	-	<b>3E-06</b>	-	<b>2E-07</b>	<b>2E-12</b>	3E-06	Fail	3E-06
Thorium-228	0.59	5E-08	-	4E-09	-	5E-06	<b>2E-10</b>	5E-06	Fail	5E-06
Tritium	0.66	2E-11	-	7E-09	-	0E+00	0E+00	7E-09	Pass	-
TOTAL								4E-04		2E-05
				HAZARD QU	OTIENT BY EXPOSU	<b>IRE ROUTE</b>				
List 1 COPC	EPC <sup>2</sup>	Soil Ingestion	Soil Dermal Exposure	Above-Ground Plant Ingestion	Below-Ground Plant Ingestion	External Radiation	Dust Inhalation	Non-Cancer Hazard Index	Statistical Background Comparison <sup>4</sup>	List 2 Non-Cancer Hazard Index <sup>5</sup>
alpha-Chlordane	0.08	6.0E-04	4.5E-05	5.5E-04	8.5E-05	-	1.1E-07	1.3E-03	Fail	1.3E-03
Arsenic	7.8	9.6E-02	5.4E-03	4.5E-01	1.5E-01	-	0.0E+00	7.0E-01	Pass	-
Dieldrin	0.01	3.9E-04	7.3E-05	1.2E-03	1.9E-04	-	2.8E-08	1.9E-03	Fail	1.9E-03
gamma-Chlordane	0.09	6.8E-04	5.1E-05	6.3E-04	9.6E-05	-	1.2E-07	1.5E-03	Fail	1.5E-03
TOTAL								7.0E-01		-

List 1 COPC	EPC <sup>2</sup>	Soil Ingestion	Soil Dermal Exposure	Above-Ground Plant Ingestion	Below-Ground Plant Ingestion	External Radiation	Dust Inhalation	Non-
alpha-Chlordane	0.08	6.0E-04	4.5E-05	5.5E-04	8.5E-05	-	1.1E-07	
Arsenic	7.8	9.6E-02	5.4E-03	4.5E-01	1.5E-01	-	0.0E+00	
Dieldrin	0.01	3.9E-04	7.3E-05	1.2E-03	1.9E-04	-	2.8E-08	
gamma-Chlordane	0.09	6.8E-04	5.1E-05	6.3E-04	9.6E-05	-	1.2E-07	
TOTAL								

Notes

Source Data from HHRA Risk Estimate, Tables 7 and 8. Statistical Background Comparison from Appendix B (UC Davis, 2005).

The non-cancer risk is for a resident child; the cancer risk is for an age-adjusted adult.

List 2 constituents shown in **bold-type** text contribute at least 10<sup>6</sup>, or greater than 10%, to the excess cumulative cancer risk. Rounding may affect the total List 2 cancer risk values shown in the last column. Determination of whether the risk is greater than ten percent of total List 2 cancer risk. values.

<sup>1</sup> Iron was not evaluated in the risk assessment because there is no toxicity value associated with this constituent.

<sup>2</sup>The 95% upper confidence limit on the mean of the exposure point concentration; chemical concentrations are in milligrams per kilogram and radionuclide concentrations are in picoCuries per gram.

<sup>3</sup> For radionuclides, plant ingestion is not subdivided into above-ground and below-ground plants.

<sup>4</sup> Based on Wilcoxon Rank Sum test or other statistical comparisons, as shown in Appendix B of the HHRA Risk Estimate.

<sup>5</sup> Dashes indicate that constituent was not identified as a List 2 COPC, since it was identified to be statistically equivalent to background.

#### Abbreviations

_	not calculated
GODG	not culculated
aoba	

COPC constituent of potential concern EPC

exposure point concentration HHRA Human Health Risk Assessment

Human Health Risks to On-Site Outdoor Researcher by Exposure Route for Contaminants of Potential Concern at the Southwest Trenches Area Table 7-4.

				CANCER RISK BY H	EXPOSURE ROUTE				
List 1 COPC <sup>1</sup>	$EPC (0-0.5 ft)^2$	$\frac{\text{EPC}}{(0-10 \text{ ft})^2}$	Surface Soil Ingestion	Surface Soil Dermal Exposure	Deep Soil (0-10 ft) External Radiation	Surface Soil Dust Inhalation	Total Cancer Risk	Statistical Background Comparison <sup>3</sup>	List 2 Cancer Risk <sup>4</sup>
alpha-Chlordane	0.0016	-	2E-10	5E-11	-	3E-14	3E-10	Fail	3E-10
Arsenic	8.6	-	4E-06	8E-07	-	6E-09	5E-06	Pass	-
gamma-Chlordane	0.0059	-	7E-10	2E-10	-	1E-13	9E-10	Fail	9E-10
Americium-241	3.2	0.16	7E-08	-	2E-08	3E-10	9E-08	Fail	9E-08
Carbon-14	-	0.55	-	-	3E-13	-	3E-13	Fail	3E-13
Cesium-137	-	0.054	-	-	4E-07	-	<b>4E-07</b>	Fail	4E-07
Lead-210	-	1.3E	-	-	2E-08	-	2E-08	Fail	2E-08
Potassium-40	12	12	3E-08	-	4E-05	2E-13	4E-05	Pass	-
Radium-226	0.52	0.62	1E-07	-	2E-05	4E-11	2E-05	Pass	-
Radium-228	0.46	0.57	7E-08	-	1E-05	1E-10	1E-05	Pass	-
Strontium-90+Daughter	1.4	0.94E	2E-08	-	6E-08	5E-13	8E-08	Fail	8E-08
Thorium-228	0.53	0.59	9E-09	-	<b>2E-06</b>	5E-11	<b>2E-06</b>	Fail	<b>2E-06</b>
Tritium	-	0.66b	-	-	0E+00	-	0E+00	Fail	-
TOTAL							8E-05		3E-06
				HAZARD QUOTIENT B	BY EXPOSURE ROUTE				
List 1 COPC	$EPC (0-0.5 \text{ ft})^2$		Soil Ingestion	Soil Dermal Exposure		Dust Inhalation	Non-Cancer Hazard Index	Statistical Background Comparison <sup>3</sup>	List 2 Non-Cancer Hazard Index <sup>4</sup>
alpha-Chlordane	0.0016		2.8E-06	7.4E-07	-	1.1E-09	3.5E-06	Fail	3.5E-06
Arsenic	8.6		2.5E-02	5.0E-03	_	0.0E+00	3.0E-02	Pass	-
gamma-Chlordane	0.0059		1.0E-05	2.8E-06	-	4.0E-09	1.3E-05	Fail	1.3E-05
TOTAL							0.0+00		-

List 1 COPC	$EPC (0-0.5 \text{ ft})^2$	Soil Ingestion	Soil Dermal Exposure		Dust Inhalation	Non-Cancer Ha
alpha-Chlordane	0.0016	2.8E-06	7.4E-07	-	1.1E-09	3.5E-0
Arsenic	8.6	2.5E-02	5.0E-03	-	0.0E+00	3.0E-0
gamma-Chlordane	0.0059	1.0E-05	2.8E-06	-	4.0E-09	1.3E-0
TOTAL						0.0+0

Notes

Source Data from HHRA Risk Estimate, Tables 7 and 8. Statistical Background Comparison from Appendix B (UC Davis, 2005).

The non-cancer risk is for a resident child; the cancer risk is for an age-adjusted adult.

List 2 constituents shown in **bold-type** text contribute at least 10<sup>-6</sup>, or greater than 10%, to the excess cumulative cancer risk. Rounding may affect the total List 2 cancer risk values shown in the last column. Determination of whether the risk is greater than 10%, to the excess cumulative cancer risk. values.

<sup>1</sup> Iron was not evaluated in the risk assessment because there is no toxicity value associated with this constituent.

<sup>2</sup> The 95% upper confidence limit on the mean of the exposure point concentration; chemical concentrations are in milligrams per kilogram and radionuclide concentrations are in picoCuries per gram.

<sup>3</sup>Based on Wilcoxon Rank Sum test or other statistical comparisons, as shown in Appendix B of the HHRA Risk Estimate. <sup>4</sup>Dashes indicate that constituent was not identified as a List 2 COPC, since it was identified to be statistically equivalent to background.

Abbreviations

not calculated -

COPC	constituent of potential	concern
EDC	• .	

exposure point concentration EPC ft

feet HHRA Human Health Risk Assessment

# Table 7-5.Data Summary—Comparison of Exposure Point Concentrations to Site Background at the Southwest Trenches Area<br/>(Human Health)

Analyte	Detections	Samples	Min Detect	Max Detect	Min Detection Limit	Max Detection Limit	Average <sup>1</sup>	Standard Deviation <sup>1</sup>	Distribution	UCL Calculation Method	95UCL <sup>1</sup>	EPC	Decay- Corrected EPC <sup>2</sup>
Site (0 to 10 f	ft)		pCi/g	pCi/g	pCi/g	pCi/g	pCi/g	pCi/g			pCi/g	pCi/g	pCi/g
Cesium-137	9	69	0.0219	1.18	0.00542	0.054	0.025	0.142	Non-parametric	Student's	0.054	0.054	0.048
Lead-210	8	67	0.261	1.61	0.194	7.51	1.07	0.954	Non-parametric	Student's	1.3	1.3	1.24
Strontium-90	26	68	0.0498	15.7	0.0227	0.5	0.542	1.95	Non-parametric	Student's	0.94	0.94	0.80
Thorium-228	53	53	0.336	0.894	0.0544	0.387	0.566	0.118	Normal	Student's	0.59	0.59	0.51
Background	(0 to 10 ft)												
Cesium-137	43	75	0.00532	0.275	0.00386	0.065	0.031	0.0435	Non-parametric	Student's	0.039	0.039	0.034
Lead-210	6	26	0.703	2.49	0.209	5.08	0.719	0.697	Non-parametric	Student's	0.95	0.95	0.95
Strontium-90	12	38	0.0166	0.313	0.0158	0.89	0.0601	0.105	Non-parametric	Student's	0.089	0.089	0.076
Thorium-228	48	48	0.266	0.66	0.058	0.379	0.475	0.105	Normal	Student's	0.50	0.50	0.50

#### Notes

Source: COPC data from Appendix A from HHRA Risk Estimate (UC Davis, 2005). 95UCL calculations for background concentrations and decay corrections added.

<sup>1</sup>Negative concentration values were set to zero and concentrations below the detection limit were used to determine the 95UCL, average, and standard deviation for radionuclides. Same as 95UCL calculation procedure used in HHRA Risk Estimate (UC Davis, 2005).

<sup>2</sup>The EPC was decay-corrected to April 2005 (see Figures 7-11 through 7-14, and Appendix A).

95UCL	95 percent upper confidence limit on the mean
COPC	constituent of potential concern
EPC	exposure point concentration
ft	feet
HHRA	Human Health Risk Assessment
max	maximum
min	minimum
pCi/g	picoCuries per gram

	Investig	ation and Cont Sampling	firmation	Designat Sam	ed-Level pling	Soil	NUFT S	oil Result			Ground	d Water	Ground Water	Tap Water	Time to Peak at
Constituent of Concern	Maximum (mg/kg or pCi/g) <sup>1</sup>	Depth of Maximum (ft)	95 UCL (mg/kg or pCi/g) <sup>1</sup>	Maximum (mg/kg or pCi/g) <sup>1</sup>	Depth of Maximum (ft)	Background Value (mg/kg or pCi/g) <sup>1</sup>	Background Water Goal (mg/kg or pCi/g) <sup>1</sup>	MCL Water Goal (mg/kg or pCi/g) <sup>1</sup>	Area Ground Water Concentration <sup>2</sup> (µg/l or pCi/l) <sup>1</sup>		Background Concentration <sup>3</sup> $(\mu g/l \text{ or } pCi/l)^1$ M $(\mu pl)$		$\begin{array}{c} \text{MCL} \\ (\mu g/l \text{ or } \\ \text{pCi/l})^1 \end{array}$	$\frac{PRG}{(\mu g/l \text{ or } pCi/l)^1}$	Ground Water Goal Level (years)
									HSU-1	HSU-2	HSU-1	HSU-2			
Confirmation Sampling DL COCs															
Mercury <sup>4</sup>	6.1	4	0.98	N/A	N/A	3.94/0.25/ 0.63 <sup>5</sup>	0.0265	2.74	< 0.20 - <b>0.61</b>	<0.10 - < <u>0.4 [ND]</u>	0.38	0.2	2	11	5,000
Nitrate (as N)	909	12	125.1	822	12.5	36	4.05	1.70	1,340 - 11,040	830 - <b>10,000</b>	27,431	4,229	10,000	10,000	10
Carbon-14 <sup>6</sup>	$5.84^{7}$	3	0.54	<b>0.85</b> <sup>7</sup>	10	0.13	0.000511	0.292	< 20.0 <b>- 370</b>	<-3.12 - <b>18.4</b> <sup>8</sup>	< 50	7.4 <sup>8</sup>	2,000	1.29	10
Cesium-137	1.18	6	0.05	0.00718	20	$0.102/0.00695/0.012^5$	7.04E+09	8.95E+11	ND	<-7 - <5.1%	ND	2.6	20	3.64	No impact expected
Tritium <sup>10</sup>	5.2	4	0.76	0.35	30	1.2	0.0193	3.51	ND	$< -341 - 290^{11,12}$	965	12711	20,000	43	0
Other DL COCs Americium-241	1.61	11	N/A	N/A	N/A	0.014	greater than pure	greater than pure	< 0.027 - < 0.081	<-0.004 - <0.009 [ND]	0.016	0.125	NE	0.458	No impact expected
Hexavalent	1.06	4	N/A	N/A	N/A	1.3	constituent 0.638	constituent 0.809	6 – 23	<4.0 - <b>50</b>	39.4	20	50	110	0
Strontium-90	22.3	14.5	N/A	N/A	N/A	0.056	4,561	21,215	0.25 - < 1.6	<-0.5 – <b>0.39</b> <sup>13, 14</sup>	1.7	$0.28^{13}$	8.0	0.852	No impact expected
Zinc	200	29	N/A	N/A	N/A	72.4/93.1/ 87 <sup>5</sup>	1.57	262.2	< 0.3 - 13.4	<0.3 - <30 <sup>15</sup>	30	20	5,000	11,000	0

#### Table 7-6. Summary Evaluation of Potential Impact on Ground Water of Designated-Level Constituents of Potential Concern in Southwest Trenches Area Soil

#### Notes

<sup>1</sup>Mercury, nitrate, hexavalent chromium, and zinc in mg/kg and µg/l; all others in pCi/g or pCi/l.

<sup>2</sup>Range of data from Southwest Trenches area HSU-1 well UCD1-4, downgradient HSU-1 well UCD1-23, and HSU-2 well UCD2-15.

<sup>3</sup>Based on concentrations in ground water from upgradient HSU-1 well UCD1-18, and HSU-2 wells UCD2-17 and UCD2-37.

<sup>4</sup>Assumed to be mercuric chloride.

<sup>5</sup>First value is a concentration for 0 to 4 ft below ground surface, second is for greater than 4 ft below ground surface and third is a consolidated concentration (all depths).

<sup>6</sup>Assumed to be methanol.

<sup>7</sup>The maximum carbon-14 concentrations were detected in samples, which appear to be located in the UC Davis trench disposal area.

<sup>8</sup>Measurements of carbon-14 in samples collected before 1998 were excluded here because those data are significantly less reliable than are the measurements of carbon-14 in later samples.

<sup>9</sup>One outlier was excluded from well UCD2-15. All other samples were non-detects. Although the highest detection limits are greater than background, the lower detection limits for other samples demonstrate that the cesium-137 concentrations at well UCD2-15 are not greater than background. <sup>10</sup>Assumed to be water.

<sup>11</sup>Measurements of tritium using analysis-method LAL0066 were excluded here because those data are significantly less reliable than are the measurements of tritium using other analytical methods. Outliers were also excluded.

<sup>12</sup>Although some samples yielded tritium measurements higher than the background concentration, the frequency distribution of tritium in well UCD2-15 is very near the frequency distribution of tritium in the background wells. As such, the HSU-2 area ground water concentrations are interpreted to be consistent with site background.

<sup>13</sup>Measurements of strontium-90 using analysis-method 901.1 were excluded here because those data are significantly less reliable than are those measurements of strontium-90 using other methods.

<sup>14</sup>Although the highest measurement of strontium-90 in the samples from well UCD2-15 were greater than the background, that highest measurement appears to be merely the upper end of a frequency distribution very similar to the frequency distribution of the background samples. <sup>15</sup>One outlier was excluded from well UCD2-15. Although the highest detection limits are greater than background, the detection limits and concentrations in other samples demonstrate that the concentration of zinc at well UCD2-15 is not greater than background. **Bold type** indicates soil concentration is above background and above NUFT result for ground water impact at background levels, or ground water concentration is above background.

Boxed type indicates soil concentration is above background and above NUFT result for ground water impact at the MCL, or ground water concentration is above the MCL.

95UCL	95 percent upper confidence limit on the mean	Ν	nitrogen
<	denotes analyte concentrations below the detection limit	N/A	not applicable or not available
μg/l	micrograms per liter	ND	not detected
COC	constituent of concern	NE	none established
DL	designated-level	NUFT	Non-Isothermal, Unsaturated Flow and Transport model
ft	feet	pCi/g	picoCuries per gram
MCL	California Maximum Contaminant Level for ground water (November 2002)	pCi/l	picoCuries per liter
mg/kg	milligrams per kilogram	PRG	preliminary remediation goal (US EPA, 2002a for radionuclides; US EPA, 2002b for others)

# Table 7-7.Summary of Designated-Level Ground Water Constituents of Potential Concern at Southwest Trenches Area Retained as<br/>Constituents of Potential Ground Water Concern

	0	0	Θ	4	
Designated-Level Constituent of Potential Concern	Are the DL COPCs ground water concentrations above site background? <sup>1</sup>	Are the DL COPC soil concentrations above soil background and the NUFT soil results? <sup>2</sup>	Will the DL COPC impact ground water above background levels in the next 500 years?	Retained as COPGWC in risk characterization?	
	If yes, enter ✓ in ④	If yes, go to <b>9</b>	If yes, enter ✓ in ❹	$\sqrt{-V_{ec}}$	
	If no, go to <b>2</b>	If no, stop and enter $\times$ below	If no, stop and enter $\times$ below	· - 105	
Hexavalent Chromium	Yes	-	-	$\checkmark$	
Mercury	Yes	-	-	$\checkmark$	
Nitrate (as N)	No	Yes	Yes	$\checkmark$	
Zinc	No	Yes	Yes	$\checkmark$	
Americium-241	No	×	-	-	
Carbon-14	Yes	-	-	$\checkmark$	
Cesium-137	No	×	-	-	
Strontium-90	No	×	-	-	
Tritium	No	Yes	Yes	✓	

#### Notes

<sup>1</sup>See Table 7-6. Compare downgradient ground water concentration to ground water background concentration. Results below detection limits are presumed to be below site background. <sup>2</sup>The lower of background and MCL goals.

×	not retained as a COPGWC
$\checkmark$	retained as a COPGWC
-	skip
COPC	constituent of potential concern
COPGWC	constituent of potential ground water concern
DL	designated-level
MCL	California Maximum Contaminant Level for ground water (November 2002)
Ν	nitrogen
NUFT	Non-Isothermal, Unsaturated Flow and Transport

Driver COPC / COPGWC	Total Cancer Risk <sup>1</sup>	Spatial Distribution	Background Contribution <sup>2</sup>	Above- Background Contribution <sup>3</sup>	Historically Used at the Site	Time for Attenuation to Risk Endpoint <sup>4</sup> (years)	Level of Ground Water Impact	Uncertainty	Recommended Action	Basis for Recommendation
On-Site Resident										
Cesium-137	9E-07	Localized	71%	29%	Yes	$< 0^{5}$	N/A	<ul><li>Good data quality.</li><li>Representative.</li></ul>	No Further Action	• Decay-corrected risk is below 1E-6.
Lead-210	6E-06	Random	77%	23%	No	110	N/A	<ul> <li>Analytical issues lead to likely over-estimate.</li> <li>Representative.</li> </ul>	No Further Action	• No correlation with site activities.
Strontium-90	3E-06	Localized	9%	91%	Yes	43	N/A	<ul><li>Suspected false positive results.</li><li>Representative.</li></ul>	Evaluate in FS	• Localized distribution is indicative of a release.
Thorium-228	4E-06	Random	98%	2%	No	1.4	N/A	<ul><li>Possible analytical drift.</li><li>Representative.</li></ul>	No Further Action	<ul><li>Marginal current risk.</li><li>Will decay to background in less than two years.</li></ul>
<b>On-Site Outdoor Resear</b>	rcher							-		
Cesium-137	4E-07	Localized	71%	29%	Yes	<05	N/A	<ul><li>Good data quality.</li><li>Representative.</li></ul>	No Further Action	• Decay-corrected risk is below 1E-6.
Thorium-228	2E-06	Random	98%	2%	No	1.4	N/A	<ul><li>Possible analytical drift.</li><li>Representative.</li></ul>	No Further Action	<ul><li>Marginal current risk.</li><li>Will decay to background in less than two years.</li></ul>
<b>Ground Water</b>										
Hexavalent Chromium	N/A	Random	N/A	N/A	Yes	N/A	> MCL, > bkgd	• High percentage of qualified data.	No Further Action	• Residual soil concentrations are below background.
Mercury	N/A	Random	N/A	N/A	Yes	N/A	>MCL, >bkgd	<ul> <li>Laboratory contamination and holding time issues effect 36% of the data.</li> <li>Representative</li> </ul>	Monitoring	<ul> <li>Modeling suggests impacts above background and MCL after 500 years.</li> <li>Elevated soil concentrations.</li> </ul>
Nitrate (as N)	N/A	Localized	N/A	N/A	Yes	N/A	>MCL, >bkgd	<ul> <li>Seventy-one of 456 results qualified.</li> <li>Representative</li> </ul>	Evaluate in FS	• Likely to impact ground water.
Zinc	N/A	Localized	N/A	N/A	No	N/A	>bkgd	<ul> <li>Good data quality.</li> <li>Bepresentative.</li> </ul>	Monitoring	<ul> <li>Limited mass.</li> <li>Area ground water concentration is below background.</li> </ul>
Carbon-14	N/A	Localized	N/A	N/A	Yes	N/A	>MCL, >bkgd	<ul> <li>Good data quality.</li> <li>Representative</li> </ul>	Evaluate in FS	<ul> <li>Currently impacting ground water above background.</li> </ul>
Tritium	N/A	Localized	N/A	N/A	Yes	N/A	>MCL, >bkgd	<ul><li>Good data quality.</li><li>Representative.</li></ul>	No Further Action	• Area ground water concentration is consistent with background.

Table 7-8. Summary of Major Factors Driving Risk and Recommendations for Future Action at Southwest Trenches Area

#### Notes

<sup>1</sup>For radionuclides, values are decay-corrected to April 2005 (see Figure 7-11 through Figure 7-14, and Appendix B).

<sup>2</sup>The background contribution is the proportion of the site EPC that can be attributed to the background EPC (see Table 7-5 and Figure 7-15 and Figure 7-16).

<sup>3</sup>The above-background contribution is the proportion of the site EPC that is greater than the background EPC (see Figure 7-15 and Figure 7-16). <sup>4</sup>The time for attenuation to risk endpoint is the time, from April 2005, for the site EPC of a radionuclide to decay to either the background EPC or the concentration equivalent to a risk of 10<sup>-6</sup>, whichever is greater.

<sup>5</sup>As of April 2005, the site EPC is less than the concentration equivalent to a risk of 10<sup>-6</sup>.

#### Abbreviations

>	greater than	EPC
<	less than	FS
bkgd	background	MCI
COPC	constituent of potential concern	Ν
COPGWC	constituent of potential ground water concern	N/A

exposure point concentration Feasibility Study California Maximum Contaminant Level for ground water (February 2003) nitrogen not applicable

- Limited mass and extent.

# 8. WESTERN DOG PENS RISK CHARACTERIZATION

### 8.1 Area Description

Beagles that had been exposed to radioactive substances were housed outside in two dog pens identified as the Eastern and Western Dog Pens. The Western Dog Pens (Figure 8-1) contained 320 individual concrete pens lined with gravel up to one ft in depth in the western section. These pens were constructed in phases between 1958 and 1968. The pen construction details were generally consistent between these development phases, except that pen rows A through D contained sub-grade, cobble-filled trenches oriented in an east-west direction. Construction drawings indicated that these trenches contained a water line, but their full purpose has not been determined. In 1975, 64 pens (Rows A and B) were removed during construction of the Cellular Biology Laboratory (Figure 8-1). The gravel and interior curbing for Rows A and B were removed, but the outer-most perimeter curbing was left in place.

# 8.1.1 Pre-Removal Action Contaminant Distribution

Pre-removal action investigations in the Western Dog Pens include:

- 1984, Initial Assessment Survey (Rockwell, 1984);
- 1987-1988, Investigation to determine the type and extent of soil contamination (Wahler, 1989);
- February through March 1990, Investigation to determine the type and extent of soil contamination (D&M, 1993);
- October 1990, Ground water investigation (D&M, 1993);
- December 1994, Soil contamination investigation (D&M, 1994);
- June through July 1996, Soil contamination investigation associated with the removal of the dog pen pedestals (WA, 1997b);
- October 1997, Data gaps investigation (WA, 1998b); and
- February through March 1998, Gravel and soil contamination investigation (WA, 1998b).

Sample locations are shown on Figure 8-2 through Figure 8-6. A statistical evaluation of the pre-removal action soil analyses was presented in the *Draft Technical Memorandum: Statistical Comparison of Western Dog Pens Soil Data with Risk-Based Target Levels* (WA, 1999a), and the results are summarized in Table 8-1. The statistical evaluation of analytical data is summarized in

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the RI (WA, 2003b). Data collected during the 1994 investigation and the 1997/1998 investigation were included in the statistical evaluation and are discussed below.

The maximum reported concentration of Ra-226 at  $5.11\pm0.94$  pCi/g was detected in the 5.75 ft bgs sample from a boring collected during the 1994 investigation from pen G-22 near the center of the Western Dog Pens (SBL-5). However, no subsurface samples collected during the 1997/1998 investigation, including one collected at the same location and depth as the SBL-5 sample, had Ra-226 concentration greater than background. The maximum reported concentration of Sr-90, 0.712 pCi/g, was detected in a sample (SSDP0263) collected from 25 ft bgs from pen G-22. The investigation data did not show any relationship of Sr-90 concentration with depth.

The maximum reported Hg concentration of 3.7 mg/kg was detected in surface soil in pen H-29. The investigation data showed that Hg concentrations attenuated sharply with depth. The maximum Cr-VI concentration of 1.02 mg/kg was detected in surface soil sample SSDP0285 from pen C-15. The investigation data did not show a relationship of Cr-VI concentration with depth. A surface soil sample from pen E-7 (LEHR-SS-DP-141) had the maximum detected concentration of alpha- plus gamma-chlordane at 2,186 µg/kg. Chlordane concentrations attenuated markedly with depth and were below the detection limit in all of the soil samples collected from greater than two ft bgs.

The maximum reported concentrations of Ra-226 and Sr-90 detected in the gravel prior to the 2001 removal action were 1.94 pCi/g and 3.59 pCi/g, respectively (Table 8-2). These were detected in a sample collected from pen C-32 (Figure 8-2). The concrete curbing sample with the maximum reported Ra-226 concentration of 3.67 pCi/g was also collected from pen C-32 (Figure 8-2).

In addition to the statistical evaluation of soil data, concrete curb and gravel samples were collected and analyzed. Table 8-2 presents a summary of the analytical results for the concrete curb and gravel samples collected from the Western Dog Pens investigations prior to the removal action.

# 8.1.2 Removal Action Activities

The above-ground dog pen structures were dismantled and removed in 1995 and 1996. The concrete pedestals and wooden barrels used to house the dogs were disposed as low-level radioactive waste at Hanford. In 2001, a removal action was conducted to remove the remaining curbing and gravel in 256 pens, including the eight asphalt aisles separating the rows of dog pens and the chain-link fence that enclosed the entire area. The removal action was conducted according to the *Dog Pens Removal Action Work Plan* (WA, 2001a) and is described in detail in the *Final Western Dog Pens Area Removal Action Confirmation Report* (WA, 2002c).

### 8.1.3 Post-Removal Action Contaminant Distribution

Following the removal action, soil samples were collected from the excavation area and analyzed to confirm that concentrations of Ra-226 and Sr-90 in the soil were below the screening criteria. A total of 199 screening samples (not including field duplicates) were collected and

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analyzed. One hundred eighty-three samples were collected from the pens, 12 samples were collected beneath the cobble trenches, 16 samples were collected beneath the former dog pen perimeter curbing surrounding the Cellular Biology Building and 21 field duplicates were collected. Of the 199 samples analyzed, none were above the screening levels for Ra-226 and Sr-90.

In addition to screening sampling conducted during the removal action, random-based and discretionary hot-spot confirmation samples were collected after the removal action using a random grid-based sampling design. Thirty-three confirmation samples and five field duplicates were collected between 0.5 and 3 ft bgs. The confirmation sampling included 24 soil samples (including three field duplicates), one soil and one cobble sample collected at random locations from each of the four cobble trenches, five cobble samples (including one field duplicate) collected from these trenches and four soil samples collected at the soil/cobble interface.

The random grid did not identify any confirmation sample locations in Aisle 3, where stockpiles containing chlordane-impacted soil from the Southwest Trenches area were stored. Therefore, discretionary samples were collected from Aisle 3 to verify that no residual chlordane remained after the asphalt removal. Five surface soil samples (including one field duplicate) were collected from four random locations within Aisle 3 and shipped off site for chlordane analyses only.

With the exception of the Aisle 3 samples, all of the confirmation samples were analyzed for Ra-226, Sr-90, Cr-VI, total mercury and chlordane. The maximum reported Sr-90 concentration, 0.491±0.0334 pCi/g, was detected in a soil sample collected at a depth of 1.5 ft bgs from Pen I-28 (Figure 8-1). The maximum reported mercury concentration, 5.1 mg/kg, was detected in a soil sample collected 1.5 ft bgs in Pen I-22 (Figure 8-1). There was no mercury concentration distribution trend observed in the confirmation data (WA, 2002c).

Data obtained from cobble samples showed a maximum reported concentration of Ra-226, 0.664±0.09 pCi/g, detected in a sample collected two ft bgs beneath Pen D-21 (Figure 8-1). Three soil samples collected from the cobble trenches located within the first three rows had Cr-VI concentrations of 0.5 mg/kg, 0.465 mg/kg, and 0.357 mg/kg, respectively.

The maximum reported alpha- plus gamma-chlordane ( $873 \mu g/kg$ ) and total chlordane concentrations (2,120 µg/kg) were found in a sample (SSWDC033) collected from the eastern side of Aisle 3 (Figure 8-4). Samples with the second- and third-highest alpha- plus gamma-chlordane concentrations (SSWDC023 and SSWDC029), 333 µg/kg and 244 µg/kg, respectively, were collected beneath the cobble trenches. The locations of these samples were resampled for chlordane on December 13 and 18, 2001 to confirm the reported elevated concentrations. Additional samples were also collected around each sample location to determine the vertical and lateral extents of contamination. A sample was collected one ft below each of the original locations. Samples were also collected five lateral ft from the sample collected from the eastern side of Aisle 3 (SSWDC033) in all four compass directions, and five ft east and west from the other two locations (SSWDC023 and SSWDC029).

The resampling showed no alpha- plus gamma-chlordane above the detection limit of  $1.9 \,\mu$ g/kg near the eastern side of Aisle 3. A sample collected five ft north of the samples collected in the cobble trenches had an alpha- plus gamma-chlordane concentration of  $1,529 \,\mu$ g/kg. All of the other samples collected at or in the vicinity of the original sample location had alpha- plus gamma-

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chlordane concentrations that were significantly lower than the original concentration. Another sample collected at sample location SSWDC029 showed an alpha- plus gamma-chlordane concentration of 214  $\mu$ g/kg, slightly lower than the concentration of 244  $\mu$ g/kg originally detected at this location. The samples collected to the east and west of this location had similar alpha- plus gamma-chlordane concentrations. All of the samples collected beneath the original sample locations showed that chlordane concentrations attenuated with depth.

### 8.1.4 Future Land Use

Future use of the Western Dog Pens area by UC Davis will be consistent with the "Academic/Administrative Low Density" land use designation of the area contained in Section 3.8.1 of the UC Davis 2003 *Long Range Development Plan* (UC Davis, 2003).

### 8.2 Summary of Risk Estimate Data

Data used in the human health risk estimate were collected during various investigations and sampling events that were conducted at the Western Dog Pens, as discussed in Section 8.1.1 above. Confirmation sample data were combined with prior characterization data that were determined to be representative of post-removal conditions. The combined data set was then evaluated in the risk estimate. Table 8-3 provides a summary of all data used in the Tier 2 risk estimate. The sample locations for all data used in the risk estimate are presented in Figure 8-2 through Figure 8-6.

# 8.2.1 Quality of Site Data

Data quality procedures common to evaluations of all DOE areas and site background are discussed in Section 2. The total data set for the Western Dog Pens area included 10,267 results. Nineteen of these results, or 0.2%, were rejected from the total data set ("R"-qualified). Sample results are rejected when a data validation expert reviewing laboratory data finds evidence of serious deficiencies in the ability to analyze a sample and meet QC criteria. The "R" qualifier indicates that the data cannot be used to verify whether the analyte was present in or absent from the sample. "R"-qualified results were not used in the risk estimate. After "R"-qualified data were removed from the total data set, the final risk estimate data set contained 10,248 results. There were 464 results, or 4.5%, with "J" qualifiers, which indicate that an analyte was positively identified in the sample, but the analytical result is an approximation of the analyte concentration in the sample. Data with "J" qualifiers were used in developing risk estimates. A total of 254 records, or 2.5%, had "UJ" qualifiers, which mean that an analyte was not detected, but the detection limit is approximate. Data with "UJ" qualifiers were included in the risk estimate and were treated as non-detection of an analyte.

A total of 1,929 of the 10,248 final records from the Western Dog Pens area were used to generate the Tier 2 human health risk estimate. A total of 93 of the 1,929 results had "J" qualifiers, and four results had "UJ" qualifiers.

### 8.3 Risk Characterization—Western Dog Pens

Consistent with the HHRA Risk Estimate, as discussed in Section 2.2, this risk characterization uses the terms "List 1" and "List 2". List 2 identifies constituents that failed the statistical comparison to background, which may be indicative of a release to the environment. Table 8-4 through Table 8-7, in the first column, provide the List 1 COPCs identified in the HHRA Risk Estimate. The last column of Table 8-4 through Table 8-7 provides only List 2 COPCs and their risk values. The values provided are not corrected for decay. A subset (shown in bold-type) of List 2 contains COPCs that have a risk of at least 10<sup>-6</sup> or contribute more than ten percent of the total excess cumulative cancer risk in the Western Dog Pens area.

Specifically, this subset consists of Pb-210, Th-228, and U-238 for the hypothetical on-site resident; Pb-210 and Th-228 for the indoor researcher, and Th-228 for the outdoor researcher and construction worker. This subset is identified in this risk characterization as the List 2 driver COPCs, since these COPCs represent potential site-related risks. These COPCs are the focus of the risk characterization discussions that follow. None of the receptors evaluated for this area showed non-cancer hazard quotients above the point of departure of one.

### 8.3.1 Exposure Assessment

The exposure assessment for List 2 driver COPCs at the Western Dog Pens includes:

- The spatial distribution of the List 2 driver COPCs;
- Risk from COPC concentrations attributed to site background versus prior site activities; and
- Exposure intake estimates.

A conceptual site model illustrating exposure pathways and potential human receptors for all DOE areas is provided as Figure 2-1.

#### 8.3.1.1 Spatial Distribution of Contaminants of Potential Concern

Figure 8-7 and Figure 8-8 show the spatial distribution of sample results for Pb-210 and U-238, respectively. None of the samples had concentrations greater than the concentrations equivalent to the risks of  $10^{-4}$  for any of the driver COPCs.

Sampling at the Western Dog Pens is extensive and covers the entire area (Figure 8-2 through Figure 8-6). The sample locations were not exclusively part of an overall random grid, but represent a combination of random-grid and discretionary sampling.

#### 8.3.1.1.1 Lead-210 Distribution

The spatial plot of Pb-210 samples is presented in Figure 8-7. The spatial map indicates that there are several locations where Pb-210 concentrations are greater than background concentrations and the concentration equivalent to a risk of  $10^{-6}$ . The majority of these high-concentration results

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are proxy results with significant uncertainty. Analytical issues affected the accuracy of the Pb-210 data, as discussed in Section 8.3.4.1.1 below.

#### 8.3.1.1.2 Thorium-228 Distribution

Five samples of imported backfill soil were collected prior to the placement of the soil in 2001 in the southern portion of the Western Dog Pens area. Th-228 was detected in all five samples. Because these samples were collected before the placement of the soil, and therefore do not have point locations that can be mapped, a map was not created for Th-228 at the Western Dog Pens. The concentrations of Th-228 in the backfill samples ranged from  $0.555\pm0.113$ \_pCi/g to  $1.02\pm0.372$  pCi/g. All but the highest-concentration sample were below the background screening value (0.74 pCi/g). The sample concentrations correspond to the risk level <10<sup>-5</sup> for the on-site resident, outdoor researcher and (in one sample) construction worker receptors; the sample concentration and risk ranges can be assumed present in soil between ground surface and approximately two ft bgs throughout the southern one-third of the Western Dog Pens area.

#### 8.3.1.1.3 Uranium-238 Distribution

The spatial plot of U-238 samples is presented in Figure 8-8. The spatial plot appears to indicate randomly distributed U-238 contamination above the background screening value and  $10^{-6}$  risk benchmark for hypothetical residential receptors.

#### 8.3.1.2 Degradation and Decay of Contaminants of Potential Concern

The methodology for calculating radionuclide decay is described in detail in Appendix B.

# 8.3.1.2.1 Lead-210

Pb-210 (22.3-yr half-life) is naturally occurring and is part of the uranium-decay series, where it is derived from Ra-226 (1,600-yr half-life) and ultimately U-238. Ra-226 detected at the Western Dog Pens area has been found to be at levels consistent with site background. U-238 concentrations at the Western Dog Pens area are currently uncertain due to analytical issues, as discussed below in Section 8.3.4.1.3. The parent isotopes are expected to replenish Pb-210 at background concentrations, and any Pb-210 that has been released at levels above background will attenuate over time.

The Pb-210 decay estimate for the Western Dog Pens area is shown in Figure 8-9. Based on the Pb-210 half-life, the Pb-210 site EPC should decay to within 1% of the background EPC in approximately 85 years. The Pb-210 EPC is not expected to decay to the concentration equivalent to the risk of  $10^{-6}$  for the on-site resident, because the latter concentration is less than the background concentration. The site EPC is already less than the concentration equivalent to a risk of  $10^{-6}$  for the on-site indoor researcher receptor.

For the indoor researcher, the concentration equivalent to a risk of  $10^{-6}$  was calculated from the EPC for shallow surface soil (0 to 0.5 ft) rather than the EPC for deep surface soil (zero to ten ft) (Table 8-6). The indoor researcher is exposed to Pb-210 by two pathways, each sourced by the two

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different soil-depth intervals. Because these two intervals have different EPCs (Table 8-6), the EPC from the interval that sources the dominant pathway (surface soil ingestion) was chosen for the calculation of the concentration equivalent to a risk of  $10^{-6}$ . This EPC is 1.3 pCi/g and the corresponding concentration equivalent to a risk of  $10^{-6}$  is 6.4 pCi/g.

#### 8.3.1.2.2 Thorium-228

Th-228 (half-life of 1.9 yrs) is naturally occurring and is part of the thorium-decay series, where it is derived from the primordial Th-232 parent, which has a half-life of  $1.4 \times 10^{10}$  years. The decay estimate for Th-228 at the Western Dog Pens area is shown in Figure 8-10. Based on the Th-228 half-life, the site EPC should decay to within 1% of the background EPC in approximately eight years. The Th-228 EPC is not expected to decay to the concentrations equivalent to the risks of  $10^{-6}$  for the on-site resident or outdoor researcher, because these concentrations are less than the background concentration. The site EPC is already less than the concentrations equivalent to a risk of  $10^{-6}$  for the on-site indoor researcher and on-site construction worker receptors.

These Th-228 decay estimates apply only to the imported fill placed in the southern portion of the Western Dog Pens area in 2001. No Th-228 sample data are available for the rest of the Western Dog Pens area.

### 8.3.1.2.3 Uranium-238

U-238 (half-life of 4.468 x  $10^9$  years) is naturally occurring and is the ultimate parent isotope of the uranium-decay series. The U-238 decay estimate for the Western Dog Pens area is shown in Figure 8-11. As shown, there is no significant attenuation of U-238 over time.

# 8.3.1.3 Background Evaluation

# 8.3.1.3.1 Detections above Site Background

The number of analytical results that were greater than both the detection limits and the background screening levels are reported in Table 8-3 for the List 1 COPCs. The three COPCs that are the List 2 drivers, Pb-210, Th-228 and U-238, were detected above background in three, one and 43 samples, respectively.

#### 8.3.1.3.2 Parent-Daughter Activity Concentration Relationships

The concentration of Pb-210 at the Western Dog Pens area was compared to the concentration of its longer-lived parent, Ra-226, in Appendix E (Figure E-12). As shown, the concentrations of these isotopes appear to be in secular equilibrium when quantified analytical errors are taken into account. This is evidence that the concentration of Pb-210 at the site is due to decay of Ra-226 rather than to a release of Pb-210, because any shorter-lived daughter isotope will have a concentration approximately equal to that of its longer-lived parent isotope, in the absence of excess input of the daughter. The apparent elevated concentration of Pb-210 at the site relative to background, therefore, is probably due to analytical limitations rather than to a release. The concentration of Ra-226, which was measured at much higher precision than was Pb-210, is demonstrably below background concentrations. Therefore, the Ra-226 results suggest that the Ra-226/Pb-210 decay series is not impacting the site.

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The concentration of Th-228 at the Western Dog Pens area was compared to the concentration of its longer-lived parent, Th-232, in Appendix E (Figure E-13). As shown, the concentrations of these isotopes appear to be in secular equilibrium when quantified analytical errors are taken into account. This is evidence that the concentration of Th-228 at the site is due to decay of Th-232 rather than to a release of Th-228, because any shorter-lived daughter isotope will have a concentration approximately equal to that of its longer-lived parent isotope, in the absence of excess input of the daughter. The apparent elevated concentration of Th-228 at the site relative to background, therefore, is probably due to analytical limitations rather than to a release.

#### 8.3.1.3.3 Comparison of Risk Attributed to Background versus Site Activities

Table 8-8 presents statistics, including EPCs, for the sample results of the List 2 driver COPCs at both the site and in the background. The background EPCs were calculated using the same method used to calculate the site EPCs (Section 2.2.3.3.3). Table 8-8 also presents decay-corrected EPCs. EPCs can be used to derive relative contributions of risk because risk is directly proportional to the EPC.

Figure 8-12 to Figure 8-15 graphically illustrate the site risks to each receptor from each List 2 driver COPC and the relative contribution to those risks from the background. These risks and proportions have been corrected for decay.

The background contribution to the Pb-210 risk is approximately 88% for the on-site resident receptor, and is approximately 84% for the indoor researcher receptor. An accurate calculation of the relative contribution to the risk may not be possible due to analytical issues with the Pb-210 data, as described in Section 8.3.4.1.1. The difference in the relative risk contributions for the different receptors is a function of the difference in EPCs for these two receptors. The Pb-210 EPC for the resident is 1.1 pCi/g (Table 8-4). The relevant Pb-210 EPC for the indoor researcher is 1.3 pCi/g, because the dominant exposure pathway for this receptor is sourced by shallow surface soil (0 to 0.5 ft) rather than deep surface soil (zero to ten ft) (Table 8-6). Because the receptors have different Pb-210 EPCs, but the background EPC is constant, the relative background contributions are different for the two receptors.

The background contribution to the Th-228 risk is 84%, but this applies only to the imported fill placed in the southern one-third of the Western Dog Pens area in 2001. No data are available to determine the relative Th-228 risk contributions for the rest of the Western Dog Pens area. The background contribution to the U-238 risk is approximately 66%, but an accurate calculation of the relative contribution to the risk may not be possible due to analytical issues with the U-238 data, as described in Section 8.3.4.1.3.

### 8.3.2 Toxicity Assessment

Toxicity values for COPCs in the Western Dog Pens area were taken from US EPA guidance, as discussed in Section 2.2.4. The toxicity values used for these COPCs are appropriate for this evaluation and make use of the best available information.

#### 8.3.3 Risk Estimate

Table 8-4 summarizes the risk estimate information for the hypothetical future on-site resident. It shows that Pb-210 risk is primarily due to plant ingestion (67%) and soil ingestion (32%), with a small secondary contribution from external radiation (1%). External radiation is the only exposure route that contributes significant risk for Th-228. U-238 risk is primarily due to external radiation (83%), with a secondary contribution from soil ingestion (17%).

Table 8-5 and Table 8-6 summarize the risk estimate information for the outdoor researcher and indoor researcher, respectively. They show that the Th-228 risk is entirely due to external radiation. Pb-210 risk for the indoor researcher is primarily due to surface soil ingestion. The indoor researcher is also potentially at risk to Pb-210, for which the dominant exposure pathway is surface soil ingestion.

Table 8-7 summarizes the risk estimate information for the construction worker. It shows that Th-228 risk is primarily due to external radiation (98%), with a small secondary contribution from soil ingestion (2%).

### 8.3.4 Uncertainty

Risk estimates are values that have uncertainties associated with them, as discussed in Section 2.2.6. The objective of this section is to discuss the major sources of uncertainty that are specific to this refined assessment of the Western Dog Pens. These include data coverage and analytical issues.

#### 8.3.4.1 Analytical Issues

#### 8.3.4.1.1 Lead-210

The detection limits in 139 of the total 173 samples (80%) were above the background screening level, and the detection limits in 137 of the total 173 samples (79%) were above the concentration equivalent to a risk of  $10^{-5}$  for the residential receptor. One hundred thirty-six of the 139 samples had results that were below the detection limit. Radiological analytical results below the detection limit are still reported as semi-quantitative results by the analytical laboratory, and were used in the risk estimate to establish the EPCs and the statistical background comparison. In the case of the Western Dog Pens, since most of Pb-210 detection limits were above both the background screening level and the concentration equivalent to a risk of  $10^{-5}$  for the residential receptor, the calculated EPCs and the background screening comparison are less reliable than situations where lower relative detection limits have been achieved.

Of the 139 Pb-210 sample results for which the detection limit was above both, the background screening value and a concentration corresponding to a risk of  $10^{-5}$  for the hypothetical residential receptor, only three were above the detection limit. These three results could be classified as usable for comparisons, but their counting error and detection limit should be taken into consideration. The three results were 4.96 ±5.43 pCi/g,  $3.84\pm3.57$  pCi/g, and  $3.3\pm2.4$  pCi/g with detection limits of 4.82 pCi/g, 2.76 pCi/g and 3 pCi/g, respectively. The counting errors and

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detection limits for these samples indicate considerable uncertainty in making comparisons with the background and risk standards. While these three samples are technically usable for the comparisons, there is a high probability of drawing a wrong conclusion from the comparisons.

For the indoor researcher, all of the Pb-210 sample results are below a concentration (6.4 pCi/g) equivalent to a risk of  $10^{-6}$ .

#### 8.3.4.1.2 Thorium-228

No accuracy issues were identified for the Th-228 results. The reported concentrations were above the detection limits and the counting errors were relatively small. None of the data were qualified during data validation.

#### 8.3.4.1.3 Uranium-238

The contract laboratory analyzed 131 of the total 137 Western Dog Pens area samples following a different analytical method than was used for the soil background samples. The methods were Environmental Physics Incorporated (EPI) Method A013 (gamma spectroscopy) for Western Dog Pens area samples and EPI method A011 (alpha spectroscopy) for background samples. The Western Dog Pens area sample detection limits and counting error values were more than an order of magnitude larger than the detection limits and counting errors for the background samples.

The method used for the background samples was sensitive and precise enough to accurately determine natural U-238 concentrations in LEHR soil. All of the background results were detected concentrations with relatively small detection limits and counting errors.

In contrast, 106 of the total 137 sample results for the Western Dog Pens area had detection limits above the background screening value (0.65 pCi/g). Seventy six of these 106 high-detection-limit analyses produced results below their detection limits. As discussed above, the resulting statistical background comparisons and EPC calculations are less reliable than in areas where lower relative detection limits have been achieved.

#### 8.3.4.2 Data Representativeness

The locations and depth ranges of samples collected in the Western Dog Pens area are shown in Figure 8-2 through Figure 8-6. Two hundred ninety-one surface and subsurface (zero to ten ft bgs) samples were collected. The sample locations were a combination of random grid and discretionary sampling.

Western Dog Pens area sampling was extensive. As shown in Figure 8-2, the majority of samples were collected within the curbed portions of the pens. The aisles were not sampled as frequently, because releases were assumed to be limited to within the pen perimeters.

As shown in Figure 8-7 and Figure 8-8, most samples were analyzed for Pb-210 and U-238. Most of the sample results showed that these isotopes were below their respective detection limits. Sample coverage is excellent for these List 2 COPCs. The Th-228 data are not representative of native soil in the Western Dog Pens area. None of the samples collected from native soil in the Western Dog Pens area were analyzed for Th-228, since it was not suspected to have been released at

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the Western Dog Pens given the operational history of the Site. The Th-228 sample data are associated with imported soil that was placed in the southern one-third of the Western Dog Pens area in 2001. This means the Western Dog Pens area Th-228 EPC and risk are only representative of imported fill, and not representative of most of the Western Dog Pens area.

#### 8.3.5 Relation of Concentrations of Contaminants of Potential Concern to Site Operations

Pb-210 is a naturally occurring isotope. However, it may also be associated with LEHR operations, since it is a daughter product of Ra-226, which was widely used at the Site.

Th-228 has been identified only in the imported backfill based on pre-placement characterization samples. The backfill came from agricultural areas with no suspected source of Th-228. As discussed above, the operational history of the Site does not indicate that Th-228 was released in the Western Dog Pens area.

U-238 is a naturally occurring isotope with no history of use or release at LEHR. Higher quality analytical data for U-238 is available for the Southwest Trenches and Radium/Strontium Treatment Systems areas. Since media in these other areas either contained waste from the Western Dog Pens (e.g., gravel), and/or from the higher concentration waste from the beagle dogs (waste sludge), and these media do not contain elevated U-238, it appears likely that the elevated U-238 reported in the Western Dog Pens area is an artifact of inaccurate analytical results.

# **8.4 Ground Water Impacts**

In addition to evaluation of human health risk resulting from soil contamination, potential ground water impacts from contaminants remaining in the soil at the Western Dog Pens area were evaluated and are presented in the RI (WA, 2003b). Table 8-9 summarizes these impacts.

#### 8.4.1 Risk Characterization of Constituents of Potential Ground Water Concern

The following DL COPCs were identified based on soil sampling results: Ra-226, alpha- and beta-chlordane and Sr-90. Ground water concentrations of these constituents were evaluated by comparing data from wells UCD2-7, UCD1-20 and UCD1-24, which are located downgradient of the Western Dog Pens. No downgradient ground water sample data are available for Sr-90.

Only Ra-226 and Cr-VI were detected in ground water at a downgradient well in concentrations above background. Ra-226 is sporadically detected in upgradient well UCD1-18 and downgradient well UCD1-20. Ra-226 has ranged from  $0.17\pm0.13$  to  $2.31\pm0.78$  pCi/l in the downgradient wells, and from  $0.27\pm0.15$  to  $1.34\pm0.62$  pCi/l in the background well. All these results are below the 5 pCi/l Ra-226 MCL. Given the shallow nature of the Ra-226 releases at the Western Dog Pens, the detection of elevated Ra-226 in well UCD1-20 is likely attributable to analytic error. Cr-VI concentrations in ground water collected from UCD2-7 routinely exceed background and

exceed the total chromium MCL of 50  $\mu$ g/l in about 20% of the samples collected between 1990 and 2000.

Modeling results indicated that Hg in the Western Dog Pens soil is the only constituent expected to impact ground water at concentrations exceeding the MCL. The estimated time required for Hg impact to occur is almost 6,000 years.

Based on the DL COPC evaluation process illustrated in Figure 1-2 and as shown in Table 8-10, Cr-VI was retained for further evaluation as a COPGWC.

#### 8.4.1.1.1 Percentage and Spatial Distribution of Samples Exceeding Background

All 297 hexavalent chromium soil sample results were below background at the Western Dog Pens area. Hexavalent chromium appears to be uniformly below background in soil throughout the lateral and vertical extent of the area. Soil sampling was extensive in the Western Dog Pens area.

#### 8.4.1.1.2 Degradation and Decay of Contaminants of Potential Concern

Hexavalent chromium is not expected to undergo significant degradation or decay.

### 8.4.1.1.3 Uncertainty

Similar to human health risk estimates, evaluation of ground water impacts is subject to uncertainties such as analytical bias and data representativeness, discussed below.

#### 8.4.1.1.4 Analytical Issues

One hundred ninety-four of the 297 hexavalent chromium results were qualified. One hundred sixty-eight results were qualified due to matrix spike recovery failure, which is likely due to soil chemistry in the matrix spike sample. Hexavalent chromium spike solution can change its valiancy when it is added to a sample. If the spiked hexavalent chromium changes states during sample preparation, the analytical instrument will not detect it.

Seventy-three samples were qualified due to contamination detected in the laboratory method blank. Laboratory contamination can cause false-positive detection, and may cause an overall positive bias in a data set. Nine samples were qualified due to expired holding time, which can affect sample accuracy and cause a negative bias. Nineteen samples were qualified due to matrix spike duplicate imprecision. It should be noted that seventy-one samples were qualified for more than one reason. Accuracy issues were identified with 26% of the hexavalent chromium data.

# 8.4.1.1.5 Data Representativeness

Hexavalent chromium soil sampling was extensive in the Western Dog Pens area and consisted of random grid, discretionary grab samples and soil boring samples collected at depths ranging from ground surface to 26 ft bgs. The majority of samples were collected within the curbed portions of the pens because releases were assumed to be limited within the pen perimeters. Hexavalent chromium sampling covered the lateral and vertical extent of the Western Dog Pens area.

The samples were collected and analyzed according to Superfund risk assessment data quality standards. No data gaps were identified.

### 8.4.1.1.6 Relation of Concentrations of Contaminants of Potential Ground Water Concern to Site Operations

Hexavalent chromium is potentially associated with LEHR operations since chromic acid and other chromium-bearing chemicals may have been used or disposed at the Site.

# 8.5 Risk Characterization Summary and Recommendations Regarding Contaminants of Concern at the Western Dog Pens Area

Risk characterization findings and recommended COCs at the Western Dog Pens are summarized below and presented in Table 8-11. The recommended COCs include constituents that are not considered to have potential risks to human health, but that may have potential impact on the ground water at the Site.

### 8.5.1 Human Health—On-Site Resident

#### 8.5.1.1 Lead-210

Pb-210 is a naturally occurring isotope. The decay-corrected cancer risk associated with the Pb-210 concentrations detected at the Western Dog Pens is  $6 \times 10^{-6}$ . Elevated Pb-210 results may have been caused by analytical errors. Approximately 12% of the Pb-210 risk appears to be attributable to site activities, while 88% appears attributable to background. Due to the marginal risk from Site releases, Pb-210 should not be retained as a COC for this receptor.

#### 8.5.1.2 Thorium-228

Th-228 is a naturally occurring isotope, and its concentrations in the Western Dog Pens area are due to natural Th-228 occurrence in the imported fill, not to site operations. Decay-corrected cancer risk for Th-228 for the on-site resident is  $6 \times 10^{-6}$ . This risk estimate is based on five samples collected in imported fill material placed in the Western Dog Pens. A large fraction (84%) of the Th-228 risk is attributed to background levels of the isotope. Based on the Th-228 half-life, the site EPC should decay to within 1% of the background screening level in approximately eight years. Thus, Th-228 should be excluded as a COC in the Feasibility Study for this receptor.

#### 8.5.1.3 Uranium-238

The U-238 risk for the on-site resident is  $1 \times 10^{-6}$ . The majority of the U-238 risk (66%) to the resident is attributable to background concentrations of U-238. Data quality issues indicate that there is moderate uncertainty associated with the data used to derive this risk. Site operational history and ancillary data from other related, more contaminated DOE areas at LEHR, strongly suggest that U-238 was not released at the Western Dog Pen Area. Based on the apparent marginal

risk and the high unlikelihood that U-238 was actually released, U-238 should be excluded as a COC in the Feasibility Study for this receptor.

#### 8.5.2 Human Health—On-Site Outdoor Researcher

#### 8.5.2.1 Thorium-228

The decay-corrected cancer risk of Th-228 for the outdoor researcher is  $3 \times 10^{-6}$ . As discussed in Section 8.5.1.2, the isotope is naturally occurring, and 84% of the Th-228 risk can be attributed to the background concentrations. Based on the Th-228 half-life, the site EPC should decay to within 1% of the background screening level in approximately eight years. Th-228 should not be retained as a COC.

### 8.5.3 Human Health—On-Site Indoor Researcher

#### 8.5.3.1 Lead-210

Pb-210 is a naturally occurring isotope. The decay-corrected risk associated with the Pb-210 concentrations detected at the Western Dog Pens is  $2 \times 10^{-7}$ , which is below the CERCLA point of departure. Approximately 27% of the Pb-210 risk appears to be attributable to site activities, while 73% appears attributable to background. Due to the low overall risk and only small fraction attributable to site activities, Pb-210 should not be retained as a COC for this receptor.

#### 8.5.3.2 Thorium-228

The decay-corrected cancer risk of Th-228 to the indoor researcher is  $6 \times 10^{-7}$ , which is below the CERCLA point of departure. Th-228 should be excluded as a COC in the Feasibility Study for this receptor.

#### 8.5.4 Human Health—On-Site Construction Worker

#### 8.5.4.1 Thorium-228

The decay-corrected cancer risk from Th-228 for the construction worker is  $7 \times 10^{-7}$ , below the CERCLA point of departure. As discussed in Section 8.5.1.2 above, the isotope is naturally occurring, and 84% of the Th-228 risk can be attributed to the background concentrations. Based on the Th-228 half-life, the site EPC should decay to within 1% of the background screening level in approximately eight years. Th-228 should be excluded as a COC in the Feasibility Study for this receptor.

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### 8.5.5 Ground Water

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Hexavalent chromium concentrations in the nearest downgradient HSU-1 wells were below background and the MCL but the HSU-2 well (UCD2-7) was above background and the MCL. The Western Dog Pens soil data were below background. Soil sampling was extensive and covered the lateral and vertical extent of the Western Dog Pens area. Therefore, hexavalent chromium should not be retained as a COC in the FS and ground water monitoring is not recommended.



### Figure 8-1. Western Dog Pens Features

4108-142-WDP\_Features.ai



Figure 8-2. Western Dog Pens Area Sample Locations and Depths

4108-142-WDP\_a.ai

# HHRA, Part B - Risk Characterization for DOE Areas

# Oakland Environmental Programs

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Figure 8-3. Western Dog Pens Area Sample Locations and Depths, Subarea A



Figure 8-4. Western Dog Pens Area Sample Locations and Depths, Subarea B 4108-142-WDP\_c.ai



Figure 8-5. Western Dog Pens Area Sample Locations and Depths, Subarea C



Figure 8-6. Western Dog Pens Area Sample Locations and Depths, Subarea D

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# EXPLANATION Proxy Result < background; risk < 1E-6 for residential receptors, risk < 1E-6 for on-site indoor researcher receptors Proxy Result < background; risk < 1E-5 for residential receptors, risk < 1E-6 for on-site indoor researcher receptors Proxy Result > background; risk < 1E-5 for residential receptors, risk < 1E-6 for on-site indoor researcher receptors Proxy Result > background; risk < 1E-4 for residential receptors, risk < 1E-6 for on-site indoor researcher receptors Positive Result < background; risk < 1E-5 for residential receptors, risk < 1E-6 for on-site indoor researcher receptors Positive Result > background; risk < 1E-4 for residential receptors, risk < 1E-6 for on-site indoor researcher receptors **Definitions/Abbreviations** > = greater than < = less than Proxy Result = Quantitative result not available (i.e., non-detected result). Non-quantitative value used as proxy. Positive Result = Detected and quantified analytical result. Notes All concentrations were below 1E-6 risk for on-site researchers. At locations where multiple samples were collected (due to sampling at depth), all risk categories are represented on the map, with smaller symbols plotted on top of larger symbols. If more than one sample falls into the same risk category at the same location, however, the symbol for that location, however, the symbol for that category can be plotted only once. Therefore, there are fewer symbols depicted on the map than there were samples collected at the site.



#### Figure 8-7. Lead-210 Spatial Analysis, Western Dog Pens Area

4108-142-WDP\_Pb-210.ai

### EXPLANATION

- Proxy Result < background; risk < 1E-6 for residential receptors



Figure 8-8. Uranium-238 Spatial Analysis, Western Dog Pens Area 4108-142-WDP\_U-238.ai



Figure 8-9. Decay of Lead-210 at Western Dog Pens Area



Figure 8-10. Decay of Thorium-228 at Western Dog Pens Area



Figure 8-11. Decay of Uranium-238 at the Western Dog Pens Area



Cancer Risk for On-Site Resident from Site Activities and Background, Western Dog Pens Area Figure 8-12.

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Figures



Figure 8-13. Cancer Risk for On-Site Outdoor Researcher from Site Activities and Background, Western Dog Pens Area


Figure 8-14. Cancer Risk for On-Site Indoor Researcher from Site Activities and Backgroun, Western Dog Pens Area



Figure 8-15. Cancer Risk for Construction Worker from Site Activities and Background, Western Dog Pens Area

Constituent	Total No. of Samples	No. above Reporting Limit	Range (Min-Max)	Background <sup>1</sup>	PRG <sup>2</sup>
Radionuclides			pCi/g	pCi/g	pCi/g
Carbon-14	200	7 (<5%)	<0.695-16.4	N/A	0.5
Cesium-137	199	44	< 0.02-0.115	$0.102/0.007^3$	0.06
Lead-210	199	18	<0.21 - 4.96	1.6	0.15
Potassium-40	198	198	4.1-16.4	14	0.11
Radium-226	200	183	<0.019-5.11	0.752	0.01
Strontium-90	200	8 (<5%)	< 0.236-0.712	0.056	0.23
Thorium-234	199	59	< 0.24-2.4	0.78	1,330
Uranium-235	198	10 (<5%)	< 0.13-0.317	0.0638	0.195
Uranium-238	169	60	< 0.24-2.4	$0.565/0.645^3$	0.74
Metals			mg/kg	mg/kg	mg/kg
Barium	30	6	<200-219	$211/294^{3}$	5,400
Total Chromium	63	63	43.9-273	$199/125^3$	210
Hexavalent Chromium	210	39	< 0.206-1.02	1.3	30
Copper	30	25	<25-46.8	$48.8/61.8^3$	3,100
Iron	30	30	21,000-46,600	44,000	23,000
Lead	30	30	4.1-10.8	9.5	400 (150)
Manganese	30	30	379-1010	750	1,800
Mercury	201	128	< 0.03-3.7	$3.94/0.248^3$	23
Nickel	30	30	62.9-318	$334/246^{3}$	1,600
Vanadium	30	30	34.7-77.5	$66.8/80.3^3$	550
Zinc	30	30	42.8-130	$72.4/93.1^3$	23,000
Pesticides			μg/kg	μg/kg	μg/kg
Alpha-BHC	197	1 (<5%)	<1.9-11	N/A	0.09
Chlordane-	197	85	<1.5-1-2,186	N/A	1,600
alpha+gamma					
Heptachlor Epoxide	197	8 (<5%)	<1.8-13.4	N/A	110
Inorganics			mg/kg	mg/kg	mg/kg
Nitrate	200	189	<0.197-59	36	ŇĔ

Table 8-1.	Statistical	Evaluation	of I	Pre-Remedial	Action	Soil	Analytical	Data	for	the	Western
	Dog Pens										

#### Notes

Data from the Remedial Investigation Report (WA, 2003b).

Contaminant data includes data collected from all depth intervals instead of the 0-10 ft interval used in the risk estimate.

<sup>1</sup>Site-specific background levels (WA, 2000b). <sup>2</sup>Chemical PRGs for residential soil are from US EPA Region 9 PRGs table, dated October 1, 2002. Radionuclide PRGs for residential soil are from Radionuclide Toxicity and PRGs for Superfund, dated April 14, 2003 (US EPA, http://epa-

prgs.orrl.gov/radionuclides/download/rad\_master\_prg\_table.xls). California-modified PRGs are shown in parentheses. <sup>3</sup>First value is for surface to 4 ft bgs soil; second value is for >4 ft bgs soil.

>	greater than
μg/kg	micrograms per kilogram
BHC	hexachloro cyclohexane
bkgd	background
ft bgs	feet below ground surface
Max	maximum
mg/kg	milligrams per kilogram
Min	minimum
N/A	not available
NE	not established

# Table 8-1.Statistical Evaluation of Pre-Remedial Action Soil Analytical Data for the Western<br/>Dog Pens (continued)

No.	number
pCi/g	picoCuries per gram
PRG	preliminary remediation goal
US EPA	United States Environmental Protection Agency

# Table 8-2.Summary of Analytical Results for the Concrete Curb and Gravel Samples from the<br/>Western Dog Pens Investigations Prior to the Removal Action

List 1 COPC <sup>1</sup>	Units	No. of Samples Analyzed	No. of Samples above Reporting Limit <sup>1</sup>	Min Conc. <sup>2</sup>	Max Conc.	Average Conc. <sup>3</sup>	Sample ID with Max Conc.	Dog Pen No. with Max Conc.
Curb Samples								
Radium-226	pCi/g	14	14	0.255	3.67	0.88	CSWDP003	C-32
Strontium-90	pCi/g	14	7	0.025	3.29	0.36	CSWDP011	Between E-30 and
								F-3
Gravel Samples								
Radium-226	pCi/g	46	38	0.086	1.94	0.625	LEHRSSDP-0072	C-32
Strontium-90	pCi/g	46	4	0.009	3.59	0.363	LEHRSSDP-0072	C-32
Uranium-238	pCi/g	46	15	0.058	1.2	0.438	LEHRSSDP-0098	H-32
Chlordane-alpha	mg/kg	46	39	0.0003	0.103	0.009	LEHRSSDP-0075	D-20
+gamma Hexavalent chromium	mg/kg	46	18	0.18	0.451	0.21	LEHRSSDP-0077	D-27

#### Notes

Source: COPC data from the HHRA Risk Estimate, Appendix A (UC Davis, 2005).

<sup>1</sup>Number of samples above reporting limit represents the number of samples greater than the "detection units" for volatile and semivolatile organic compounds, pesticides, the instrument detection limit for metals, the minimum detection limit for general chemistry, and the minimum detectable concentration for radionuclides.

<sup>2</sup>Minimum value above laboratory reporting limit.

<sup>3</sup>The average of all detected concentrations including those below the reporting limit. If the sample results were censored or negative, half the detection limit was used to calculate the average.

#### Abbreviations

Conc. Concentration

- COPC constituent of potential concern
- HHRA Human Health Risk Assessment
- ID identification (number)
- Max maximum
- mg/kg milligrams per kilogram
- Min minimum
- No. number
- pCi/g picoCuries per gram

#### Summary of Sampling Results Used in the Risk Estimate at the Western Dog Pens Area Table 8-3.

Constituent	Units	Total Samples	Number of Detections	Number of Detections > Background	Concentration Range <sup>1</sup>	Background Screening Concentration <sup>2</sup>	ID of Sample with Highest Concentration	Depth of Sample with Highest Concentration (ft)
Metals								
Arsenic	mg/kg	34	34	0	4.2 - 8.8	9.6	SSDP0059	5
Pesticides/PCBs								
1,2-Dichloroethane	mg/kg	9	1	1	0.0354 - 0.0354	0	SSIBF149DL	0.75
alpha-Chlordane	mg/kg	214	150	150	0.0004 - 1.21	0	LEHR-SS-DP-0141	1.61
gamma-Chlordane	mg/kg	214	150	150	0.0003 - 0.976	0	LEHR-SS-DP-0141	1.61
Radionuclides								
Carbon-14	pCi/g	165	4	4	-4.6 - 11.3	0.13	SSDP0045	0.5
Cesium-137	pCi/g	173	50	50	-0.031 - 0.115	0.012	LEHR-SS-DP-0132	2.92
Lead-210	pCi/g	173	18	3	-1.26 - 4.96	1.6	LEHR-SS-DP-0128	1.73
Potassium-40	pCi/g	173	173	4	0.944 - 15.3	14	SSDP0220	8
Radium-226	pCi/g	215	188	18	0.0654 - 5.11	0.75	SSDP0015	5.75
Radium-228	pCi/g	5	5	0	0.472 - 0.513	0.64	SSIBF147	0.75
Strontium-90	pCi/g	206	32	25	-0.8 - 5.66	0.056	LEHR-S-371	0
Thorium-228	pCi/g	5	5	1	0.555 - 1.02	0.74	SSIBF145	0.75
Uranium-235	pCi/g	172	8	5	-6.81 - 0.317	0.039	SSDP0230	8
Uranium-238	pCi/g	137	56	43	0 - 1.67	0.65	SSDP0282	10

**Notes** <sup>1</sup>The concentration ranges for metals and radionuclides include non-detects. The concentration ranges for pesticides/PCBs do not include non-detects. <sup>2</sup>The background screening concentrations are the unstratified background screening values in Appendix B of the HHRA Risk Estimate.

>	greater than
ft	feet
HHRA	Human Health Risk Assessment
ID	identification (number)
mg/kg	milligrams per kilogram
PCBs	polychlorinated biphenyls
pCi/g	picoCuries per gram

Table 8-4.	Human Health Risks to On-Site F	esident by Exposure Route for	Contaminants of Potential	Concern at the Western Dog Pens Area
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	CANCER RISK BY EXPOSURE ROUTE									
List 1 COPC	$EPC^{1}$ (1-10 ft)	Soil Ingestion	Soil Dermal Exposure	Above-Ground Plant Ingestion <sup>2</sup>	Below-Ground Plant Ingestion <sup>2</sup>	External Radiation	Dust Inhalation	Total Cancer Risk	Statistical Background Comparison <sup>3</sup>	List 2 Cancer Risk <sup>4</sup>
alpha-Chlordane	0.047	3.E-08	2.E-09	2.E-08	4.E-09	-	2.E-12	6.E-08	Fail	6.E-08
1,2-Dichloroethane	0.035	5.E-09	0.E+00	-	-	-	4.E-13	5.E-09	Fail	5.E-09
Arsenic	7.8	2.E-05	1.E-06	9.E-05	3.E-05	-	1.E-08	1.E-04	Pass	-
gamma-Chlordane	0.049	3.E-08	2.E-09	2.E-08	4.E-09	-	2.E-12	6.E-08	Fail	6.E-08
Carbon-14	0.61	2.E-11	-	2.E-08	-	9.E-13	4.E-10	2.E-08	Fail	2.E-08
Cesium-137	0.024	8.E-10	-	4.E-09	-	6.E-07	5.E-15	6.E-07	Fail	6.E-07
Lead-210	1.1	<b>2.E-06</b>	-	<b>4.E-06</b>	-	4.E-08	<b>2.E-10</b>	6.E-06	Fail	6.E-06
Potassium-40	12	6.E-07	-	1.E-05	-	1.E-04	2.E-12	1.E-04	Pass	-
Radium-226	0.57	1.E-06	-	3.E-06	-	6.E-05	2.E-10	6.E-05	Pass	-
Radium-228	0.51	4.E-07	-	1.E-06	-	2.E-05	5.E-10	2.E-05	Pass	-
Strontium-90	0.26	3.E-08	-	8.E-07	-	5.E-08	5.E-13	9.E-07	Fail	9.E-07
Thorium-228	0.85	7.E-08	-	5.E-09	-	8.E-06	<b>3.E-10</b>	8.E-06	Fail	8.E-06
Uranium-235	0.065	1.E-08	-	2.E-09	-	4.E-07	2.E-11	4.E-07	Fail	4.E-07
Uranium-238	0.74	<b>2.E-07</b>	-	<b>3.E-08</b>	-	1.E-06	<b>2.E-10</b>	1.E-06	Fail	1.E-06
TOTAL								4.E-04		2.E-05
				HAZARD Q	UOTIENT BY EXPOSI	URE ROUTE				
List 1 COPC	EPC <sup>1</sup>	Soil Ingestion	Soil Dermal Exposure	Above-Ground Plant Ingestion <sup>2</sup>	Below-Ground Plant Ingestion <sup>2</sup>	External Radiation	Dust Inhalation	Non-Cancer Hazard Index	Statistical Background Comparison <sup>3</sup>	List 2 Non-Cancer Hazard Risk <sup>4</sup>
alpha-Chlordane	0.047	1.2E-03	1.3E-04	1.3E-03	6.8E-05	-	1.1E-07	2.7E-03	Fail	2.7E-03
Arsenic	7.8	3.3E-01	2.8E-02	1.8E+00	2.2E-01	-	-	2.4E+00	Pass	-
gamma-Chlordane	0.049	1.2E-03	1.4E-04	1.3E-03	7.0E-05	-	1.2E-07	2.7E-03	Fail	2.7E-03
TOTAL								2.4E+00		5.4E-03

List 1 COPC	$EPC^1$	Soil Ingestion	Soil Dermal Exposure	Above-Ground Plant Ingestion <sup>2</sup>	Below-Ground Plant Ingestion <sup>2</sup>	External Radiation	Dust Inhalation	Non-C
alpha-Chlordane	0.047	1.2E-03	1.3E-04	1.3E-03	6.8E-05	_	1.1E-07	2
Arsenic	7.8	3.3E-01	2.8E-02	1.8E+00	2.2E-01	-	-	2
gamma-Chlordane	0.049	1.2E-03	1.4E-04	1.3E-03	7.0E-05	-	1.2E-07	4
TOTAL								2

Notes

Source Data from HHRA Risk Estimate, Tables 7 and 8. Statistical Background Comparison from Appendix B (UC Davis, 2005).

The non-cancer risk is for a resident child; for cancer risk it is an age-adjusted adult.

List 2 constituents shown in **bold-type** text contribute at least 10<sup>6</sup>, or greater than 10%, to the excess cumulative cancer risk. Rounding may affect the total List 2 cancer risk values shown in the last column. Determination of whether the risk is greater than ten percent of total List 2 cancer risk is based on unrounded values.

<sup>1</sup>The 95% upper confidence limit on the mean of the exposure point concentration; chemical concentrations are in milligrams per kilogram and radionuclide concentrations are in picoCuries per gram.

<sup>2</sup>For radionuclides, plant ingestion is not subdivided into above-ground and below-ground plants. <sup>3</sup>Based on Wilcoxon Rank Sum test or other statistical comparisons, as shown in Appendix B of the HHRA Risk Estimate.

<sup>4</sup>Dashes indicate that constituent was not identified as a List 2 COPC, since it was identified to be statistically equivalent to background.

-	not calculated
COPC	constituent of potential concern
EPC	exposure point concentration
ft	feet
HHRA	Human Health Risk Assessment

Human Health Risks to On-Site Outdoor Researcher by Exposure Route for Contaminants of Potential Concern at the Western Dog Pens Area Table 8-5.

List 1 COPC <sup>1</sup>	EPC <sup>2</sup> (0-0.5 ft)	EPC <sup>2</sup> (0-10 ft)	Surface Soil Ingestion	Surface Soil Dermal Exposure	Subsurface Soil External Radiation	Surface Soil Dust Inhalation	Total Cancer Risk	Statistical Background Comparison <sup>3</sup>	List 2 Cancer Risk <sup>4</sup>
alpha-Chlordane	0.17	-	2.E-08	5.E-09	-	3.E-12	3.E-08	Fail	3.E-08
Arsenic	8.2	-	4.E-06	8.E-07	-	6.E-09	5.E-06	Pass	-
gamma-Chlordane	0.21	-	2.E-08	6.E-09	-	4.E-12	3.E-08	Fail	3.E-08
Carbon-14	1.4	0.61	1.E-12	-	4.E-13	1.E-11	1.E-11	Fail	1.E-11
Cesium-137	0.031	0.024	2.E-10	-	2.E-07	2.E-15	2.E-07	Fail <sup>5</sup>	2.E-07
Lead-210	1.3	1.1	4.E-07	-	2.E-08	8.E-11	4.E-07	Fail	4.E-07
Potassium-40	12	12	3.E-08	-	4.E-05	2.E-13	4.E-05	Pass	-
Radium-226	0.54	0.57	1.E-07	-	2.E-05	5.E-11	2.E-05	Pass	-
Radium-228	-	0.51	-	-	9.E-06	-	9.E-06	Pass	-
Strontium-90	0.71	0.26	1.E-08	-	2.E-08	3.E-13	3.E-08	Fail	3.E-08
Thorium-228	-	0.85	-	-	<b>4.E-06</b>	-	<b>4.E-06</b>	Fail	4.E-06
Uranium-235	0.070	0.065	2.E-09	-	2.E-07	4.E-12	2.E-07	Fail	2.E-07
Uranium-238	0.77	0.74	2.E-08	-	4.E-07	4.E-11	4.E-07	Fail	4.E-07
TOTAL							8.E-05		5.E-06
				HAZARD QUOTIENT	BY EXPOSURE ROUTE				
List 1 COPC	EPC <sup>2</sup>	EPC <sup>2</sup>	Soil Ingestion	Soil Dermal Exposure	External Radiation	Dust Inhalation	Non-Cancer Hazard Inde:	Statistical Background	List 2 Non-Cancer Hazar

List 1 COPC	$EPC^{2}$ (0-0.5 ft)	EPC <sup>2</sup> (0-10 ft)	Soil Ingestion	Soil Dermal Exposure	External Radiation	Dust Inhalation	Non-Cancer Hazard Index	Statistical Background Comparison <sup>3</sup>	List 2 Non-Cancer Hazard Risk <sup>4</sup>
alpha-Chlordane	0.17	-	3.1E-04	8.1E-05	-	1.2E-07	3.9E-04	Fail	3.9E-04
Arsenic	8.2	-	2.4E-02	4.7E-03	-	-	2.9E-02	Pass	-
gamma-Chlordane	0.21	-	3.7E-04	9.8E-05	-	1.4E-07	4.7E-04	Fail	4.7E-04
TOTAL							3.0E-02		8.6E-04

Notes

Source Data from HHRA Risk Estimate, Tables 7 and 8. Statistical Background Comparison from Appendix B (UC Davis, 2005).

List 2 constituents shown in **bold-type** text contribute at least 10<sup>-6</sup>, or greater than 10%, to the excess cumulative cancer risk.

<sup>1</sup>1,2-dichloroethane is excluded from this list for this receptor because 1,2-dichloroethane is a subsurface contaminant and this receptor is only exposed to surface soil, as shown in Figure 2-1.

<sup>2</sup>The 95% upper confidence limit on the mean of the exposure point concentration; chemical concentrations are in milligrams per kilogram and radionuclide concentrations are in picoCuries per gram.

<sup>3</sup>Based on Wilcoxon Rank Sum test or other statistical comparisons, as shown in Appendix B of the HHRA Risk Estimate.

<sup>4</sup>Dashes indicate that constituent was not identified as a List 2 COPC, since it was identified to be statistically equivalent to background.

<sup>5</sup>Cesium-137 failed the background comparison for the 0-10 ft depth interval, but passed the background comparison for the 0-0.5 ft depth interval. Because the dominant risk from cesium-137 is from the 0-10 ft depth interval. comparison.

#### Abbreviations

not calculated COPC constituent of potential concern EPC exposure point concentration ft feet HHRA Human Health Risk Assessment

Table 8-6.	Human Health Risks to On-Site Indoor Researcher b	y Ex	posure Route	for Co	ontaminants o	of Potentia	al Concern	at the	Western 1	Dog P	ens Area
		-								<u> </u>	

List 1 COPC <sup>1</sup>	$EPC^{2}$ (0-0.5 ft)	EPC <sup>2</sup> (0-10 ft)	Surface Soil Ingestion	Subsurface Soil External Radiation	Total Cancer Risk
alpha-Chlordane	0.17	-	1.E-08	-	1.E-08
Arsenic	8.2	-	2.E-06	-	2.E-06
gamma-Chlordane	0.21	-	1.E-08	-	1.E-08
Carbon-14	1.4	0.61	7.E-13	9.E-14	8.E-13
Cesium-137	0.031	0.024	1.E-10	5.E-08	5.E-08
Lead-210	1.3	1.1	<b>2.E-07</b>	<b>4.E-09</b>	<b>2.E-07</b>
Potassium-40	12	12	2.E-08	9.E-06	9.E-06
Radium-226	0.54	0.57	7.E-08	5.E-06	5.E-06
Radium-228	-	0.51	-	2.E-06	2.E-06
Strontium-90	0.71	0.26	6.E-09	4.E-09	1.E-08
Thorium-228	-	0.85	-	<b>8.E-07</b>	<b>8.E-07</b>
Uranium-235	0.070	0.065	9.E-10	4.E-08	4.E-08
Uranium-238	0.77	0.74	1.E-08	9.E-08	1.E-07
TOTAL					2.E-05

### HAZARD QUOTIENT BY EXPOSURE ROUTE

List 1 COPC	EPC <sup>2</sup>	EPC <sup>2</sup> (0-10 ft)	Soil Ingestion	External Radiation	Non-Cancer Hazard Index
alpha-Chlordane	0.17	-	1.7E-04	-	1.7E-04
Arsenic	8.2	-	1.3E-02	-	1.3E-02
gamma-Chlordane	0.21	-	2.1E-04	-	2.1E-04
TOTAL					1.3E-02

#### Notes

Source Data from HHRA Risk Estimate, Tables 7 and 8. Statistical Background Comparison from Appendix B (UC Davis, 2005). List 2 constituents shown in **bold-type** text contribute at least 10<sup>-6</sup>, or greater than 10%, to the excess cumulative cancer risk.

<sup>1</sup>1,2-dichloroethane is excluded from this list for this receptor because 1,2-dichloroethane is a subsurface contaminant and this receptor is only exposed to surface soil, as shown in Figure 2-1.

<sup>2</sup>The 95% upper confidence limit on the mean of the exposure point concentration; chemical concentrations are in milligrams per kilogram and radionuclide concentrations are in picoCuries per gram.

<sup>3</sup>Based on Wilcoxon Rank Sum test or other statistical comparisons, as shown in Appendix B of the HHRA Risk Estimate.

<sup>4</sup>Dashes indicate that constituent was not identified as a List 2 COPC, since it was identified to be statistically equivalent to background.

<sup>5</sup>Cesium-137 failed the background comparison for the 0-10 ft depth interval, but passed the background comparison for the 0-0.5 ft depth interval. Because the dominant risk from cesium-137 is from the 0-10 ft depth interval (subsurface soil), it is correct to regard cesium-137 as failing the statistical background comparison.

#### Abbreviations

not calculated COPC constituent of potential concern EPC exposure point concentration ft feet

HHRA Human Health Risk Assessment

Statistical Background Comparison <sup>3</sup>	List 2 Cancer Risk <sup>4</sup>
Fail	1.E-08
Pass	-
Fail	1.E-08
Fail	8.E-13
Fail <sup>5</sup>	5.E-08
Fail	<b>2.E-07</b>
Pass	-
Pass	-
Pass	-
Fail	1.E-08
Fail	8.E-07
Fail	4.E-08
Fail	1.E-07
	1.E-06
Statistical Background Comparison <sup>3</sup>	List 2 Non-Cancer Hazard Risk <sup>4</sup>
Fail	1.7E-04
Pass	-
Fail	2.1E-04
	<b>3.8E-04</b>

#### Human Health Risks to On-Site Construction Worker by Exposure Route for Contaminants of Potential Concern at the Western Dog Pens Area Table 8-7.

CANCER RISK BY EXPOSURE ROUTE									
List 1 COPC	EPC <sup>1</sup> (1-10 ft)	Soil Ingestion	Soil Dermal Exposure	External Radiation	Dust Inhalation	Total Cancer Risk	Statistical Background Comparison <sup>2</sup>	List 2 Cancer Risk <sup>3</sup>	
alpha-Chlordane	0.047	8.E-10	9.E-11	-	7.E-13	9.E-10	Fail	9.E-10	
1,2-Dichloroethane	0.035	1.E-10	0.E+00	-	1.E-13	1.E-10	Fail	1.E-10	
Arsenic	7.8	5.E-07	5.E-08	-	5.E-09	6.E-07	Pass	-	
gamma-Chlordane	0.049	8.E-10	9.E-11	-	7.E-13	9.E-10	Fail	9.E-10	
Carbon-14	0.61	2.E-11	-	4.E-13	1.E-10	1.E-10	Fail	1.E-10	
Cesium-137	0.024	3.E-11	-	1.E-08	9.E-17	1.E-08	Fail	1.E-08	
Lead-210	1.1	8.E-08	-	1.E-09	5.E-12	8.E-08	Fail	8.E-08	
Potassium-40	12	2.E-08	-	2.E-06	4.E-14	2.E-06	Pass	-	
Radium-226	0.57	1.E-08	-	1.E-06	2.E-12	1.E-06	Pass	-	
Radium-228	0.51	3.E-08	-	6.E-07	5.E-12	6.E-07	Pass	-	
Strontium-90	0.26	1.E-09	-	1.E-09	1.E-14	2.E-09	Fail	2.E-09	
Thorium-228	0.85	<b>2.E-08</b>	-	<b>1.E-06</b>	<b>3.E-11</b>	1.E-06	Fail	<b>1.E-06</b>	
Uranium-235	0.065	3.E-10	-	7.E-09	2.E-13	7.E-09	Fail	7.E-09	
Uranium-238	0.74	4.E-09	-	2.E-08	2.E-12	2.E-08	Fail	2.E-08	
TOTAL						5.E-06		1.E-06	
			HAZARD	QUOTIENT BY EXPOSUR	E ROUTE				
List 1 COPC	EPC <sup>1</sup> (1-10 ft)	Soil Ingestion	Soil Dermal Exposure	External Radiation	Dust Inhalation	Non-Cancer Hazard Index	Statistical Background Comparison <sup>2</sup>	List 2 Non-Cancer Hazard Risk <sup>3</sup>	
alpha-Chlordane	0.047	2.5E-03	3.0E-04	-	6.6E-07	2.8E-03	Fail	2.8E-03	
Arsenic	7.8	8.4E-02	7.6E-03	-	-	9.2E-02	Pass	-	
gamma-Chlordane	0.049	2.6E-03	3.1E-04	-	6.8E-07	2.9E-03	Fail	2.9E-03	

List 1 COPC	$EPC^{1}$ (1-10 ft)	Soil Ingestion	Soil Dermal Exposure	External Radiation	Dust Inhalation	Non-Cancer Hazard Ind
alpha-Chlordane	0.047	2.5E-03	3.0E-04	-	6.6E-07	2.8E-03
Arsenic	7.8	8.4E-02	7.6E-03	-	-	9.2E-02
gamma-Chlordane	0.049	2.6E-03	3.1E-04	-	6.8E-07	2.9E-03
TOTAL						9.7E-02

Notes

Source Data from HHRA Risk Estimate, Tables 7 and 8. Statistical Background Comparison from Appendix B (UC Davis, 2005).

List 2 constituents shown in **bold-type** text contribute at least 10<sup>-6</sup>, or greater than 10%, to the excess cumulative cancer risk.

The 95% upper confidence limit on the mean of the exposure point concentration; chemical concentrations are in milligrams per kilogram and radionuclide concentrations are in picoCuries per gram.

<sup>2</sup>Based on Wilcoxon Rank Sum test or other statistical comparisons, as shown in Appendix B of the HHRA Risk Estimate. <sup>3</sup>Dashes indicate that constituent was not identified as a List 2 COPC, since it was identified to be statistically equivalent to background.

Abbreviations

not calculated COPC constituent of potential concern EPC exposure point concentration feet ft

HHRA Human Health Risk Assessment 5.7E-03

# Table 8-8.Data Summary—Comparison of Exposure Point Concentrations to Site Background at the Western Dog Pens Area (Human<br/>Health)

Analyte	Detections	Samples	Min Detect	Max Detect	Min Detection Limit	Max Detection Limit	Average	<sup>1</sup> Standard Deviation <sup>1</sup>	Distribution	95UCL <sup>1</sup>	EPC	Decay- Corrected EPC <sup>2</sup>
Site (0 to 10 ft)			pCi/g	pCi/g	pCi/g	pCi/g	pCi/g	pCi/g		pCi/g	pCi/g	pCi/g
Lead-210	18	173	0.269	4.96	0.0724	6.58	1.015	0.837	Non-parametric	1.1	1.1	1.1
Thorium-228	5	5	0.555	1.02	0.0556	0.427	0.660	0.201	Non-parametric	0.85	0.85	0.59
Uranium-238	56	137	0.312	1.67	0.0212	4.26	0.688	0.384	Non-parametric	0.74	0.74	0.74
Background (0	to 10 ft)											
Lead-210	6	26	0.703	2.49	0.209	5.08	0.719	0.697	Non-parametric	0.95	0.95	0.95
Thorium-228	48	48	0.266	0.66	0.058	0.379	0.475	0.105	Normal	0.50	0.50	0.50
Uranium-238	48	48	0.327	0.631	0.00359	0.036	0.469	0.070	Normal	0.49	0.49	0.49

#### Notes

Source: COPC data from Appendix A from HHRA Risk Estimate (UC Davis, 2005). 95UCL calculations for background concentrations and decay corrections added.

<sup>1</sup>Negative concentration values were set to zero and concentrations below the detection limit were used to determine the 95UCL, average, and standard deviation for radionuclides. Same as 95UCL calculation procedure used in HHRA Risk Estimate (UC Davis, 2005).

<sup>2</sup>The EPC was decay-corrected to April 2005 (see Figures 8-9 through 8-11, and Appendix A).

95UCL	95 percent upper confidence limit on the mean
COPC	constituent of potential concern
EPC	exposure point concentration
ft	feet
HHRA	Human Health Risk Assessment
max	maximum
min	minimum
pCi/g	picoCuries per gram

### Table 8-9. Potential Impact on Ground Water of Designated-Level Constituents of Potential Concern in Western Dog Pens Area Soil

Designated-Level Constituent of Potential Concern	Investigation/Con	firmation Sampling	Confirmation Sampling 95% UCL (mg/kg or pCi/g)	Soil Background Value (mg/kg or pCi/g)	NUFT Soil Result Background Water Goal (mg/kg or pCi/g)	NUFT Soil Result MCL Water Goal (mg/kg or pCi/g)	Downgradient Ground Water Concentration <sup>1</sup> (µg/l or pCi/l) <sup>3</sup>		ent centration <sup>1</sup> i/l) <sup>3</sup> Background Ground Water Concentration <sup>2</sup> (µg/l or pCi/l) <sup>3</sup>		Ground Water MCL (µg/l or pCi/l) <sup>3</sup>	Tap Water PRG (µg/l or pCi/l) <sup>3</sup>	Time to Peak at Ground Water Goal Level (years)
	Maximum $(mg/kg \text{ or } pCi/g)^3$	Depth of Maximum					HSU-1	HSU-2	HSU-1	HSU-2			
Dadianualidas		(11)											
Radionuclides	0.664	0 1	0.464	0.752	NC	NC	0.17 0.21	<0.017 2.024	0.07 1.24	2.4	5	0.002	NC
Radium-226	0.664	0 - 1	0.464	0.752	NC	INC.	0.1/-2.31	<0.017 - 2.02	0.27 - 1.34	2.4	5	0.003	NC
Strontium-90	0.491	0 - 1	0.115	0.056	NC	3.28E+18	N/A	<-0.8 - <0.78 [ND] <sup>5, 10</sup>	N/A	0.2810	8	0.02	No impact expected
Metals													
Hexavalent Chromium	1.17	0 - 1	0.26	1.3	NC	NC	19 - 37.1	15.0 - <b>110</b>	39	20	$50^{6}$	110	NC
Mercury <sup>7</sup>	5.1	0 - 1	2.46	3.94/0.25/0.63 <sup>8</sup>	NC	0.62	< 0.20	<0.10 - <0.49	< 0.20	0.2	2	$11^{11}$	5,927
Pesticides													
alpha-Chlordane	1.210	0 - 1	0.0878	0	NC	59	< 0.01	<0.005 - < 0.050	< 0.01	< 0.050	0.05	$0.19^{12}$	No impact expected
gamma-Chlordane	0.976	0 - 1	0.109	0	NC	13,200	< 0.01	<0.005 - < 0.050	< 0.01	< 0.050	0.05	0.19 <sup>12</sup>	No impact expected

#### Notes

<sup>1</sup>Range of data from downgradient HSU-1 wells UCD1-020 and UCD1-24, and HSU-2 well UCD2-7.

<sup>2</sup>Based on concentrations in ground water from upgradient HSU-1 well UCD1-18, and HSU-2 wells UCD2-17 and UCD2-37.

<sup>3</sup>Radium-226 and strontium-90 in pCi/g or pCi/l, all others in mg/kg or µg/l.

<sup>4</sup>Outliers were excluded.

<sup>5</sup>Although concentrations of strontium-90 were reported greater than background concentrations, all of the strontium-90 results at well UCD2-7 were non-detects. There is no evidence that site concentrations of strontium-90 are greater than background concentrations. <sup>6</sup>MCL for total chromium.

<sup>7</sup>Assumed to be mercuric chloride.

<sup>8</sup>First value is a concentration for 0 to 4 ft below ground surface, second is for greater than 4 ft below ground surface, and third is a consolidated concentration (all depths).

<sup>9</sup>One outlier was excluded from well UCD2-7. All other samples were non-detects. Although the highest detection limits were greater than background, the lowest detection limits for other samples demonstrate that the mercury concentrations at well UCD2-7 are not greater than background. <sup>10</sup>Measurements of strontium-90 using EPA Method 901.1 were excluded because those data are significantly less reliable than are those measurements of strontium-90 using other methods.

<sup>11</sup>Preliminary remediation goal for mercuric chloride.

<sup>12</sup>Preliminary remediation goal for total Chlordane.

Bold type indicates ground water concentration is above background.

Boxed type indicates soil concentration is above background and above NUFT result for ground water impact at the MCL, or ground water concentration is above the MCL.

<	denotes analyte concentrations below the detection limit
>	greater than
μg/l	micrograms per liter
ft	feet
MCL	California Maximum Contaminant Level for ground water
mg/kg	milligrams per kilogram
N/A	not applicable or not available
NC	not calculated
NUFT	Non-Isothermal, Unsaturated Flow and Transport model
pCi/g	picoCuries per gram
pCi/l	picoCuries per liter
PRG	preliminary remediation goal (US EPA, 2002a for radionuclides; US EPA, 2002b for others)
UCL	Upper confidence limit on the true mean based on sample data
TTO ED (	

# Table 8-10.Summary of Designated-Level Ground Water Constituents of Potential Concern at Western Dog Pens Area Retained as<br/>Constituents of Potential Ground Water Concern

	0	0	6	4	
Designated-Level Constituent of Potential Concern	Are the DL COPCs ground water concentrations above site background? <sup>1</sup>	Are the DL COPC soil concentrations above soil background and the NUFT soil results? <sup>2</sup>	Will the DL COPC impact ground water above background levels in the next 500 years?	Retained as COPGWC in risk characterization? $\checkmark = Yes$	
	If yes, enter ✓ in ❹	If yes, go to <b>B</b>	If yes, enter ✓ in ❹		
	If no, go to <b>2</b>	If no, stop and enter $\times$ below	If no, stop and enter $\times$ below	. 105	
alpha-Chlordane	No	×	-	-	
gamma-Chlordane	No	×	-	-	
Hexavalent Chromium	Yes	-	-	$\checkmark$	
Mercury	No	Yes	×	-	
Radium-226	No <sup>3</sup>	×	-	-	
Strontium-90	No	×	-	-	

#### Note

<sup>1</sup>See Table 8-9. Compare downgradient ground water concentration to ground water background concentration. Results below detection limits are presumed to be below site background. <sup>2</sup>The lower of background and MCL goals.

<sup>3</sup>Slight background exceedances in well UCD1-20 deemed to be an artifact of analytical error.

×	not retained as a COPGWC
$\checkmark$	retained as a COPGWC
-	skip
COPC	constituent of potential concern
COPGWC	constituent of potential ground water concern
DL	designated-level
MCL	California Maximum Contaminant Level for ground water
NUFT	Non-Isothermal, Unsaturated Flow and Transport

Driver COPC / COPGWC	Total Cancer Risk <sup>1</sup>	Spatial Distribution	Background Contribution <sup>2</sup>	Above- Background Contribution <sup>3</sup>	Historically Used at the Site	Time for Attenuation to Risk Endpoint <sup>4</sup> (years)	Level of Ground Water Impact	Uncertainty	Recommended Action	Basis for Recommendation
<b>On-Site Resident</b> Lead-210	6E-06	Random	88%	12%	Yes	85.1	N/A	<ul> <li>Counting errors and issue with detection limits.</li> <li>Perrocentative</li> </ul>	No Further Action	• Risk values may be due to analytical errors.
Thorium-228	6E-06	N/A <sup>5</sup>	84%	16%	No	8.1	N/A	<ul><li>Good data quality.</li><li>Representative.</li></ul>	No Further Action	<ul> <li>No operational history of use.</li> <li>Risk is based on concentrations found in clean fill soil</li> </ul>
Uranium-238	1E-06	Random	66%	34%	No	1.3 billion	N/A	<ul> <li>High detection limits affect 106 of 137 samples.</li> <li>Representative.</li> </ul>	No Further Action	<ul> <li>Uranium-238 is not found in EDPs, which had same operational history as WDPs, nor in the waste from the Southwest Trenches, which received waste from the WDPs, suggesting it is not related to site activities.</li> </ul>
<b>On-Site Outdoor Researc</b> Thorium-228	her 3E-06	N/A <sup>5</sup>	84%	16%	Yes	8.1	N/A	<ul><li>Good data quality.</li><li>Representative.</li></ul>	No Further Action	<ul><li>Decay to background in eight years.</li><li>Risk is based on concentrations found in clean fill soil.</li></ul>
<b>On-Site Indoor Research</b> Lead-210	er 2E-07	Random	73%	27%	Yes	<06	N/A	<ul> <li>Counting errors and issue with detection limits.</li> </ul>	No Further Action	• Risk is below 1E-06.
Thorium-228	6E-07	N/A <sup>5</sup>	84%	16%	Yes	$< 0^{6}$	N/A	<ul><li>Good data quality.</li><li>Representative.</li></ul>	No Further Action	<ul> <li>Risk is below 1E-6.</li> <li>Site EPC is below background EPC.</li> <li>Risk is based on concentrations found in clean fill soil.</li> </ul>
On-Site Construction Wo Thorium-228	orker 7E-07	N/A <sup>5</sup>	84%	16%	Yes	<06	N/A	<ul><li>Good data quality.</li><li>Representative.</li></ul>	No Further Action	<ul> <li>Site EPC is below background EPC.</li> <li>Risk is based on concentrations found in clean fill soil.</li> </ul>
Ground Water Hexavalent Chromium	N/A	Random	N/A	N/A	Yes	N/A	> MCL, > bkgd	• Qualified 194 of 297 results.	No Further Action	Residual soil concentrations below background

#### Summary of Major Factors Driving Risk and Recommendations for Future Action at Western Dog Pens Area Table 8-11.

<

bkgd

<sup>1</sup>For radionuclides, values are decay-corrected to April 2005 (see Figure 8-9 through Figure 8-11 and Appendix B).

<sup>2</sup>The background contribution is the proportion of the site EPC that can be attributed to the background EPC (see Table 8-8 and Figure 8-12 through Figure 8-15).

<sup>3</sup>The above-background contribution is the proportion of the site EPC that is greater than the background EPC (see Figure 8-12 through Figure 8-15).

<sup>4</sup>The time for attenuation to risk endpoint is the time, from April 2005, for the site EPC of a radionuclide to decay to either the background EPC or the concentration equivalent to a risk of 10<sup>-6</sup>, whichever is greater.

<sup>5</sup>Spatial analysis not possible due to disturbance of backfill after sampling.

 $^{6}$ As of April 2005, the site EPC is less than the concentration equivalent to a risk of  $10^{-6}$ .

#### Abbreviations

EPC exposure point concentration

- MCL California Maximum Contaminant Level for ground water
- not applicable N/A
- COPC constituent of potential concern COPGWC constituent of potential ground water concern Western Dog Pens WDPs

EDPs Eastern Dog Pens

less than

background

 $\label{eq:weissdc01} weissdc01\clients\DOE\4108\142\Risk\ Characterization\RC_fnl.doc$ 

Notes

### 9. **REFERENCES**

- Argonne National Laboratory, 2000, Development of Probabilistic RESRAD 6.0 and RESRAD-BUILD 3.0 Computer Codes, Attachment C: Parameter Distribution for Use in RESRAD and RESRAD-BUILD Computer Codes. Environmental Assessment Division, DOE, Argonne, Illinois.
- Ballard, Don, 1997, University of California at Davis (UC Davis), Personal Conversation with Alison Watts of Weiss Associates, October 8.
- California Environmental Protection Agency (Cal/EPA), 2004, Toxicity Criteria Database. Office of Environmental Health Hazard Assessment (OEHHA), (http://www.oehha.ca.gov/risk/ chemicalDB/index.asp).
- California Regional Water Quality Control Board (CRWQCB), Central Valley Region, 1989, Designated-Level Methodology for Waste Classification and Cleanup Level Determination.
- Chemical Waste Management, Inc. (CWM), 1992, Final Report for the Liquid and Sludge Removal Project at the LEHR Facility at the University of California at Davis.
- Dames & Moore (D&M), 1993, *Phase II Site Characterization Report for the LEHR Environmental Restoration*, UC Davis, February.
- D&M, 1994, Final Draft Remedial Investigation, Feasibility Study and Environmental Assessment (RI/FS-EA) Work Plan, LEHR Environmental Restoration, University of California, Davis.
- D&M, 1997, Engineering Evaluation/Cost Analysis, Ground Water Interim Remedial Action, LEHR Environmental Restoration, Davis, California, January.
- D&M, 1999, 1998 Annual Groundwater Treatment System and Water Monitoring Report.
- DOE, 1996, Memorandum, CERCLA Removal Action, Attention of Jim Littlejohn/Oakland Operations Office/ERD, July 16.
- DOE, 1997, Memorandum of Agreement (MOA) between the United States Department of Energy and the Regents of the University of California Regarding the Investigation and Remediation of the Laboratory for Energy-Related Health Research at the University of California, Davis.
- Goldman, Marvin, Former LEHR Director, UC Davis, 1997, Phone Conversation with Alison Watts of Weiss Associates, October 15.
- Hinz, Ed, 1997, Electrical Engineer, UC Davis, Personal Conversation with Alison Watts of Weiss Associates, October 8.
- IT Corporation (IT Corp.), 1996, Limited Field Investigation Work Plan for the Laboratory for Energy-Related Health Research, University of California, Davis.
- IT Corp., 1997, *DOE Disposal Box Area Closure Report*, Laboratory for Energy-Related Health Research, University of California, Davis, California.

- Pacific Northwest National Laboratory (PNNL), 1995, Data Needs for Detailed Evaluation of Presumptive Remedial Actions at the Laboratory for Energy-Related Health Research, University of California, Davis.
- Park, K.S., R.C. Sims, R.R. DuPont, W.J. Doucette, and J.E. Matthews (Park, *et al.*), 1990, Fate of PAH Compounds in Two Soil Types: Influence of Volatilization, Abiotic Loss, and Biological Activity, Environmental Toxicology Chemical, 9:187-195.
- Rockwell International (Rockwell), 1984, Initial Assessment Survey of the DOE LEHR Site of University of California, Davis, Contract No. DE-AT03-845F15160.
- Sims, R.C., Overcash M.R. (Sims and Overcash), 1989, Polynuclears in Soil–Plant Systems. Res. Rev. 1983;88:2-68.
- UC Davis, 2002, Site-Wide Risk Assessment Work Plan, LEHR/SCDS Environmental Restoration, March.
- UC Davis, 2003, Long Range Development Plan, University of California at Davis.
- UC Davis, 2005, Site-Wide Risk Assessment, Volume I: Human Health Risk Assessment, Part A Risk Estimate University of California at Davis.
- U.S. Environmental Protection Agency (US EPA), 1989, Risk Assessment Guidance for Superfund Volume 1: Human Health Evaluation Manual (Part A), Publication EPA/540/1-89/002, Office of Emergency and Remedial Response, Washington, DC, December.
- US EPA, 1991, Risk Assessment Guidance for Superfund Volume 1: Human Health Evaluation Manual (Part B, Development of Risk-Based Preliminary Remediation Goals), Publication 9285.7-01B, Office of Emergency and Remedial Response, Washington, DC, NTIS PB92-963333.
- US EPA, 1997, Annual Health Effects Assessment Summary Tables (HEAST) FY 1997. Office of Solid Waste and Emergency Response, Washington DC, EPA 540/R-94/036.
- US EPA, 1999, Region 9, California Department of Toxic Substances Control (DTSC), Central Valley Regional Water Quality Control Board (RWQCB), California Department of Health Services (DHS), and DOE, *Federal Facility Agreement under CERCLA*, Section 120, Administrative Docket Number: 99-17, In the matter of: The U.S. Department of Energy Laboratory for Energy Related Health Research (LEHR).
- US EPA, 2001, Radionuclide Table: Radionuclide Carcinogenicity Slope Factors. Office of Radiation and Indoor Air, Washington, DC.
- US EPA, 2002a, Memorandum: Distribution of OSWER of Radionuclide Preliminary Remediation Goals (PRGs), February.

US EPA, 2002b, Region IX Preliminary Remediation Goals, http://www.epa.gov/region09 /waste/sfund/prg/index.htm, 2002.

- US EPA, 2004, Integrated Risk Information System (IRIS). USEPA on-line database: (http://www.epa.gov/iris/index.html).
- Wahler, 1989, Ground Water and Soils Investigation, U. C. Davis LEHR Facility, Davis, California.

- Weiss Associates (WA), 1997a, Draft Final One-Dimensional Vadose Zone Modeling for the U.S. Department of Energy Areas at the Laboratory for Energy-Related Health Research, University of California at Davis, California, April.
- WA, 1997b, Final Site Characterization Summary Report for the U.S. Department of Energy Areas at the Laboratory for Energy-Related Health Research, University of California at Davis, California, Rev. 0, November.
- WA, 1998a, Draft Final Engineering Evaluation/Cost Analysis for the Southwest Trenches, Radium-226/Strontium-90 Treatment Systems, and Domestic Septic System Areas for the DOE Areas at the Laboratory for Energy-Related Health Research Site, University of California, Davis, Rev. E, January.
- WA, 1998b, Final Technical Report: Results of Western Dog Pens, Background and Off-Site Investigations at the Laboratory for Energy-Related Health Research, University of California, Davis, California, June.
- WA, 1999a, Draft Technical Memorandum: Statistical Comparison of Western Dog Pens Soil Data with Risk-Based Target Levels for the Laboratory for Energy-Related Health Research, University of California, Davis, June, Rev. A.
- WA, 1999b, Technical Memorandum: Investigation Results For the Former Eastern Dog Pens at the Laboratory for Energy-Related Health Research, University of California at Davis, California, September 24, Rev. 0.
- WA, 2000a, Addendum to Former Dog Pens Technical Memoranda for the Laboratory for Energy-Related Health Research, University of California, Davis, February.
- WA, 2000b, Final Work Plan for Removal Actions in the Southwest Trenches, Ra/Sr Treatment Systems, and Domestic Septic System Areas for the Laboratory for Energy-Related Health Research, University of California at Davis, California, July, Rev. 0.
- WA, 2001a, Dog Pens Removal Action Work Plan for the Laboratory for Energy-Related Health Research, University of California, Davis, June, Rev. 0.
- WA, 2001b, Final Southwest Trenches Area 1998 Removal Action Confirmation Report for the Laboratory for Energy-Related Health Research, University of California at Davis, June, Rev. 0.
- WA, 2001c, Domestic Septic Systems Investigation and Removal Action Work Plan for the Laboratory for Energy-Related Health Research, University of California, Davis, August, Rev. 0.
- WA, 2001d, Sampling and Analysis Plan for the DOE Disposal Box Area Confirmation Data Gaps at the Laboratory for Energy-Related Health Research, University of California, Davis, December, Rev. B.
- WA, 2002a, Final Radium/Strontium Treatment Systems Area Removal Action Confirmation Report, for the U.S. Department of Energy Areas at the Laboratory for Energy-Related Health Research, University of California at Davis, California, July.
- WA, 2002b, Domestic Septic Systems 3 and 6 Confirmation Report for the Laboratory for Energy-Related Health Research, University of California, Davis, September, Rev. C.

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- WA, 2002c, Final Western Dog Pens Area Removal Action Confirmation Report for the U.S. Department of Energy Areas at the Laboratory for Energy-Related Health Research, University of California at Davis, California, October, Rev. 0.
- WA, 2003a, Final Domestic Septic Systems 3 and 6, Removal Actions Confirmation Report, for the U.S. Department of Energy Areas at the Laboratory for Energy-Related Health Research, University of California at Davis, California, March, Rev. 0.
- WA, 2003b, DOE Areas Remedial Investigation Report for the U.S. Department of Energy Areas at the Laboratory for Energy-Related Health Research, University of California at Davis, California, September, Rev. 0.

## **APPENDIX** A

## SOIL RADIONUCLIDE RESULTS

# NOTE:

# Appendix A is included as a PDF file on the enclosed CD.

## **APPENDIX B**

# METHODOLOGY FOR CALCULATING RADIATION ATTENUATION TO RISK ENDPOINTS

### APPENDIX B: METHODOLOGY FOR CALCULATING RADIATION ATTENUATION TO RISK ENDPOINTS

Because radionuclides decay at known rates, it is possible to determine how much the concentration of a radionuclide has decreased after an elapsed time, by

$$C = \frac{C_s}{e^{\frac{\ln 2}{t_{1/2}} \cdot t}}$$
 [Equation B-1]

where:

C is the concentration after elapsed time t,

 $C_s$  is the starting concentration, and

 $t_{1/2}$  is the half-life, the time required for some amount of a radionuclide to decrease to one-half of that amount. The half-lives are independent of temperature, pressure, and chemical reaction and are specific for each radionuclide. The half-live values are well-established (Korea Atomic Energy Research Institute, 2005).

It is also possible to calculate how much time is required for a radionuclide to decrease to concentration C from the starting concentration  $C_s$ , by:

$$t = \frac{t_{1/2}}{\ln 2} \cdot \left( \ln C_s - \ln C \right).$$
 [Equation B-2]

Equation B-1 was used to calculate the concentrations of radionuclide COPCs as they will be in April 2005. Equation B-2 was used to calculate how long it will take for the radionuclide COPC concentrations to decrease to acceptable risk endpoints. The starting time for both types of calculations is the last date of sample collection (Table B-1). The risk endpoint for each radionuclide COPC at each area is the greater of either:

- The concentration at which the risk is  $10^{-6}$ , or
- The background concentration if the radionuclide is naturally replenished.

For those radionuclides that are naturally replenished (Pb-210, Ra-226, and Th-228) by decay of the uranium and thorium series, the natural replenishment will maintain a constant background concentration. Therefore, the values  $C_s$  and C in equations B-1 and B-2 must exclude the background concentrations. That is,  $C_s =$  (total starting concentration – background concentration), and C = (total ending concentration – background concentration). Furthermore, the site

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concentrations of these radionuclides will asymptotically approach the constant background concentration, as illustrated in Figure B-1, rather than approaching the concentration of zero. Therefore, the risk endpoint will be the concentration equivalent to a risk of  $10^{-6}$  only if that concentration is greater than the background concentration, as in Figure B-1. If the concentration equivalent to a risk of  $10^{-6}$  is less than the background concentration, the site concentration will never decrease to the concentration equivalent to a risk of  $10^{-6}$ , and the risk endpoint can only be the background concentration. In the latter case, for the purpose of the calculations, a practical *de minimis* background concentration must be used for the value of *C* in Equation B-2; because the site concentration will only asymptotically approach the background concentration (*C* cannot equal zero in the equation). The value of *C* used in these calculations is 1% of the background concentration of the time for a radionuclide to decay to both risk endpoints, although in the risk characterization, only the time to decay to the higher risk endpoint is calculated.

For those radionuclides that are not naturally replenished (Cs-137, Sr-90, and U-238), the site concentrations will asymptotically approach zero, as illustrated in Figure B-2. Because the concentration equivalent to a risk of  $10^{-6}$  is always greater than zero, that concentration is the only risk endpoint for these radionuclides.

These calculations assume that risk is directly related to the decay of the parent isotope. In some cases, daughters of the parents that are relatively long lived may be produced and may contribute risk. Specifically at LEHR, the decay of U-238 and Ra-226 would produce the relatively long-lived daughter isotopes Ra-226 and Pb-210, respectively. However, modeling using RESRAD, indicates that the added risk contributed by these daughters will be inconsequential. This is due both to the low risk presented by the daughters and the environmental attenuation mechanisms (e.g., dispersion, diffusion, advection, etc.) that take place over time. Therefore, the assumption that risk is directly related to parent decay is appropriate.

### **References Cited**

Korea Atomic Energy Research Institute, 2005, http://atom.kaeri.re.kr/.



Figure B-1. Decay of Hypothetical Radionuclide that is Naturally Replenished



Figure B-2. Decay of Hypothetical Radionuclide that is Not Naturally Replenished

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Figures

Table B-1.	Last Sample	Date for	each	Radionuclide	List 2	2 Driver	Constituent	of	Potential
	Concern at eac	ch Area							

Area	List 2 Driver COPC	Date of Last Sample
DOE Disposal Box	Lead-210	17-Apr-2002
DOE Disposal Box	Thorium-228	17-Apr-2002
Dry Wells	Thorium-228	27-Aug-1999
Dry Wells	Radium-226	27-Aug-1999
Domestic Septic System No. 3	Cesium-137	24-Jun-2002
Domestic Septic System No. 3	Lead-210	24-Jun-2002
Domestic Septic System No. 4	Lead-210	6-Sep-2001
Domestic Septic System No. 7	Lead-210	16-Aug-1996
Eastern Dog Pens	Strontium-90	4-Mar-1999
Eastern Dog Pens	Lead-210	31-Jul-1996
Radium/Strontium Treatment Area	Strontium-90	9-Nov-2000
Radium/Strontium Treatment Area	Thorium-228	9-Nov-2000
Southwest Trenches	Cesium-137	28-Oct-1999
Southwest Trenches	Lead-210	19-Oct-1998
Southwest Trenches	Strontium-90	19-Oct-1998
Southwest Trenches	Thorium-228	19-Oct-1998
Western Dog Pens	Lead-210	6-Sep-2001
Western Dog Pens	Thorium-228	6-Sep-2001
Western Dog Pens	Uranium-238	6-Sep-2001

COPC	constituent of potential concern
DOE	United States Department of Energy

## **APPENDIX C**

## SCREENING OF GROUND WATER CONSTITUENTS USING DEIONIZED WATER WASTE EXTRACTION TEST DATA

#### Analysis of Deionized Water Waste Extraction Test Results and Designated Level Screening, DOE Box Area Table C-1.

							S	tep 1		Step 2		Step 3	Step 4	
Sample ID	Constituent	DI WET Concentration (mg/l)	Ground Water Background <sup>1</sup> (mg/l)	MCL <sup>2</sup> (mg/l)	Source	DI WET Concentration >Background or MCL?	Soil Sample Count	Number of Soil Detections	Maximum Total Soil Concentration (mg/kg)	Deep (> 4 ft) Soil Background (mg/kg)	Significant <sup>3</sup> Soil Results Above Background?	Partitioning Coefficient (Kd) / Half Life Evaluation	WRS Test	Is Analyte a DL COPC?
SSDBDL09DI_WET	Hexavalent Chromium	0.014	0.0394	0.05	MCL	Pass								No
SSDBDL08DI_WET	Hexavalent Chromium	0.012	0.0394	0.05	MCL	Pass								No
SSDBDL09DI_WET	Mercury	<0.00039	0.0001	0.002	MCL	Unknown	35	35	3.9	0.248	Yes	Fail (Kd = 52 ml/g)	Fail	Yes
SSDBDL08DI_WET	Mercury	<0.00039	0.0001	0.002	MCL	Unknown	35	35	3.9	0.248	Yes	Fail (Kd = 52 ml/g)	Fail	Yes
SSDBDL09DI_WET	Molybdenum	0.0022	0.015	0.18	PRG	Pass								No
SSDBDL08DI_WET	Molybdenum	0.0034	0.015	0.18	PRG	Pass								No

#### Notes

<sup>1</sup>The ground water background concentration represents the maximum concentration detected in ground water from well UCD1-18. <sup>2</sup>Drinking water PRG used when MCL is not established.

<sup>3</sup>Soil results are considered significant enough to require further screening if maximum concentration is greater than 1.5 times background and more than 5% of the data are above background.

Abbreviations	
>	greater than
DI WET	deionized water waste extraction test
DL COPC	designated-level constituent of potential concern
ft	feet
ID	identification (number)
Kd	partitioning coefficient
MCL	maximum contaminant level
mg/kg	milligrams per kilogram
mg/l	milligrams per liter
ml/g	milliliters per gram
PRG	preliminary remediation goal
WRS	Wilcoxon Rank Sum

							S	tep 1		Step 2		Step 3	Step 4	
Sample ID	Constituent	DI WET Concentration (mg/l)	Ground Water Background <sup>1</sup> (mg/l)	MCL <sup>2</sup> (mg/l)	Source	DI WET Concentration >Background or MCL?	Soil Sample Count	Number of Soil Detections	Maximum Total Soil Concentration (mg/kg)	Deep (> 4 ft) Soil Background (mg/kg)	Significant <sup>3</sup> Soil Results Above Background?	Partitioning Coefficient (Kd) / Half Life Evaluation	WRS Test	Is Analyte a DL COPC?
SSD1DL01DI WET	Aluminum	20.8	NE	0.2	MCL	Yes	0	N/A	N/A	N/A	N/A	N/A	N/A	Yes
SSD1DL02DI WET	Aluminum	7.42	NE	0.2	MCL	Yes	0	N/A	N/A	N/A	N/A	N/A	N/A	Yes
SSD1DL01DI WET	Antimony	0.0055	0.005	0.006	MCL	Yes	6	2	1.1	1.4	No			No
SSD1DL01DI_WET	Arsenic	0.0094	0.00811	0.05	MCL	Yes	6	6	8.1	10.9	No			No
SSD1DL02DI_WET	Arsenic	0.0048	0.00811	0.05	MCL	No								No
SSD1DL01DI_WET	Barium	0.217	0.187	1.0	MCL	Yes	6	6	220	294	No			No
SSD1DL02DI_WET	Barium	0.0542	0.187	1.0	MCL	No								No
SSD1DL01DI_WET	Beryllium	0.00046	0.0015	0.004	MCL	No								No
SSD1DL01DI_WET	Cadmium	0.00032	0.001	0.005	MCL	No								No
SSD1DL02DI_WET	Cadmium	0.00031	0.001	0.005	MCL	No								No
SSD1DL01DI WET	Chromium	0.111	0.025	0.05	MCL	Yes	6	6	100	125	No			No
SSD1DL02DI_WET	Chromium	0.0283	0.025	0.05	MCL	Yes	6	6	100	125	No			No
SSD1DL01DI WET	Cobalt	0.0065	0.0018	0.73	PRG	Yes	6	6	25	31	No			No
SSD1DL02DI WET	Cobalt	0.0019	0.0018	0.73	PRG	Yes	6	6	25	31	No			No
SSD1DL01DI_WET	Copper	0.0382	0.0017	1.0	MCL	Yes	6	6	56	61.8	No			No
SSD1DL02DI WET	Copper	0.0111	0.0017	1.0	MCL	Yes	6	6	56	61.8	No			No
SSD1DL01DI WET	Iron	36.2	0.502	0.3	MCL	Yes	6	6	36,000	44,000	No			No
SSD1DL02DI WET	Iron	8.43	0.502	0.3	MCL	Yes	6	6	36,000	44,000	No			No
SSD1DL01DI WET	Lead	0.0068	0.0013	0.015	MCL	Yes	6	6	9.0	9.5	No			No
SSD1DL02DI WET	Lead	0.0044	0.0013	0.015	MCL	Yes	6	6	9.0	9.5	No			No
SSD1DL01DI WET	Magnesium	18.9	112	NE		No								No
SSD1DL02DI WET	Magnesium	12.9	112	NE		No								No
SSD1DL01DI WET	Manganese	0.207	0.0099	0.05	MCL	Yes	6	6	890	750	No			No
SSD1DL02DI WET	Manganese	0.0615	0.0099	0.05	MCL	Yes	6	6	890	750	No			No
SSD1DL02DI WET	Molybdenum	0.002	0.015	0.18	PRG	No								No
SSD1DL01DI WET	Molybdenum	0.0018	0.015	0.18	PRG	No								No
SSD1DL01DI WET	Nickel	0.169	0.0779	0.1	MCL	Yes	6	6	230	246	No			No
SSD1DL02DI WET	Nickel	0.0449	0.0779	0.1	MCL	No								No
SSD1DL02DI WET	Nitrate	0.908	25.14	10	MCL	No								No
SSD1DL01DI WET	Nitrate	0.138	25.14	10	MCL	No								No
SSD1DL01DI WET	Vanadium	0.0782	0.02	0.036	PRG	Yes	6	6	65	80.3	No			No
SSD1DL02DI WET	Vanadium	0.0317	0.02	0.036	PRG	Yes	6	6	65	80.3	No			No
SSD1DL01DI WET	Zinc	0.0676	0.03	5.0	MCL	Yes	6	6	84	93.1	No			No
SSD1DL02DI WET	Zinc	0.0269	0.03	5.0	MCL	No								No

#### Deionized Water Waste Extraction Test Results and Designated Level Screening, Domestic Septic Tank 1 Table C-2.

Notes

<sup>1</sup>The ground water background concentration represents the maximum concentration detected in ground water from well UCD1-18. <sup>2</sup>Drinking water PRG used when MCL is not established.

<sup>3</sup>Soil results are considered significant enough to require further screening if maximum concentration is greater than 1.5 times background and more than 5% of the data are above background.

>	greater than
DI WET	deionized water waste extraction test
DL COPC	designated-level constituent of potential concern
ft	feet
ID	identification (number)

 Table C-2.
 Deionized Water Waste Extraction Test Results and Designated Level Screening, Domestic Septic Tank 1 (continued)

Kd	partitioning coefficient
MCL	maximum contaminant level
mg/kg	milligrams per kilogram
mg/l	milligrams per liter
ml/g	milliliters per gram
N/A	not applicable
NE	not established
PRG	preliminary remediation goal
WRS	Wilcoxon Rank Sum

							Step 1	l		Step 2		Step 3	Step 4	
Sample ID	Constituent	DI WET Concentration (mg/l)	Ground Water Background <sup>1</sup> (mg/l)	MCL <sup>2</sup> (mg/l)	Source	DI WET Concentration >Background or MCL?	Soil Sample Count	Number of Soil Detections	Maximum Total Soil Concentration (mg/kg)	Deep (> 4 ft) Soil Background (mg/kg)	Significant <sup>3</sup> Soil Results Above Background?	Partitioning Coefficient (Kd) / Half Life Evaluation	WRS Test	Is Analyte a DL COPC?
SSD3DL04(diwet)	Aluminum	112	NE	0.2	MCL	Yes	0	N/A	N/A	N/A	N/A	N/A	N/A	Yes
SSD3DL08(diwet)	Aluminum	55.8	NE	0.2	MCL	Yes	0	N/A	N/A	N/A	N/A	N/A	N/A	Yes
SSD3DL04(diwet)	Arsenic	0.0421	0.008	0.05	MCL	Yes	18	18	11	10.9	No			No
SSD3DL08(diwet)	Arsenic	0.0311	0.008	0.05	MCL	Yes	18	18	11	10.9	No			No
SSD3DL04(diwet)	Barium	0.829	0.187	1.0	MCL	Yes	18	18	296	294	No			No
SSD3DL07(diwet)	Barium	0.507	0.187	1.0	MCL	Yes	18	18	296	294	No			No
SSD3DL04(diwet)	Beryllium	0.0021	0.0015	0.004	MCL	Yes	18	18	0.6	0.924	No			No
SSD3DL07(diwet)	Beryllium	0.0016	0.0015	0.004	MCL	Yes	18	18	0.6	0.924	No			No
SSD3DL04(diwet)	Chromium	0.424	0.025	0.05	MCL	Yes	41	41	174	125	No			No
SSD3DL08(diwet)	Chromium	0.154	0.025	0.05	MCL	Yes	41	41	174	125	No			No
SSD3DL04(diwet)	Cobalt	0.0461	0.0018	0.73	PRG	Yes	18	18	30.9	31	No			No
SSD3DL07(diwet)	Cobalt	0.0267	0.0018	0.73	PRG	Yes	18	18	30.9	31	No			No
SSD3DL04(diwet)	Copper	0.202	0.0017	1.0	MCL	Yes	41	41	59.3	61.8	No			No
SSD3DL08(diwet)	Copper	0.0972	0.0017	1.0	MCL	Yes	41	41	59.3	61.8	No			No
SSD3DL04(diwet)	Iron	180	0.502	0.3	MCL	Yes	18	18	42,400	44,000	No			No
SSD3DL08(diwet)	Iron	94.9	0.502	0.3	MCL	Yes	18	18	42,400	44,000	No			No
SSD3DL04(diwet)	Lead	0.038	0.0013	0.015	MCL	Yes	41	41	9.1	9.5	No			No
SSD3DL08(diwet)	Lead	0.0284	0.0013	0.015	MCL	Yes	41	41	9.1	9.5	No			No
SSD3DL04(diwet)	Magnesium	75.1	112	NE		No								No
SSD3DL07(diwet)	Magnesium	26	112	NE		No								No
SSD3DL04(diwet)	Manganese	1.94	0.0099	0.05	MCL	Yes	18	18	1,280	750	Yes	Fail (Kd = $65 \text{ ml/g}$ )	Pass	No
SSD3DL07(diwet)	Manganese	1.36	0.0099	0.05	MCL	Yes	18	18	1,280	750	Yes	Fail (Kd = $65 \text{ ml/g}$ )	Pass	No
SSD3DL04(diwet)	Mercury	0.0017	0.0001	0.002	MCL	Yes	45	43	4.4	0.248	Yes	Fail (Kd = $52 \text{ ml/g}$ )	Fail	Yes
SSD3DL07(diwet)	Mercury	0.0011	0.0001	0.002	MCL	Yes	45	43	4.4	0.248	Yes	Fail (Kd = 52 ml/g)	Fail	Yes
SSD3DL04(diwet)	Molybdenum	0.0034	0.015	0.18	PRG	No								No
SSD3DL07(diwet)	Molybdenum	0.0025	0.015	0.18	PRG	No								No
SSD3DL04(diwet)	Nickel	0.706	0.0079	0.1	MCL	Yes	18	18	266	246	No			No
SSD3DL07(diwet)	Nickel	0.209	0.0779	0.1	MCL	Yes	18	18	266	246	No			No
SSD3DL04(diwet)	Nitrate	2.31	25.14	10	MCL	No								No
SSD3DL08(diwet)	Nitrate	0.489	25.14	10	MCL	No								No
SSD3DL04(diwet)	Selenium	0.0065	0.0057	0.05	MCL	Yes	18	6	1.7	1.2	No			No
SSD3DL08(diwet)	Selenium	0.0033	0.0057	0.05	MCL	No								No
SSD3DL04(diwet)	Vanadium	0.33	0.02	0.036	PRG	Yes	18	18	76.7	80.3	No			No
SSD3DL08(diwet)	Vanadium	0.191	0.02	0.036	PRG	Yes	18	18	76.7	80.3	No			No
SSD3DL04(diwet)	Zinc	0.361	0.03	5.0	MCL	Yes	18	18	258	93.1	Yes	Fail (Kd = $62 \text{ ml/g}$ )	Pass	No
SSD3DL07(diwet)	Zinc	0.187	0.03	5.0	MCL	Yes	18	18	258	93.1	Yes	Fail (Kd = $62 \text{ ml/g}$ )	Pass	No

#### Deionized Water Waste Extraction Test Results and Designated Level Screening, Domestic Septic System 3 Table C-3.

#### Notes

<sup>1</sup>The ground water background concentration represents the maximum concentration detected in ground water from well UCD1-18. <sup>2</sup>Drinking water PRG used when MCL is not established.

<sup>3</sup>Soil results are considered significant enough to require further screening if maximum concentration is greater than 1.5 times background and more than 5% of the data are above background.

#### Abbreviations

greater than DI WET deionized water waste extraction test

Table C-3.Deionized Water Waste Extraction Te	Results and Designated Level Screening,	, Domestic Septic System 3 (continued)
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DL COPC	designated-level constituent of potential concern
ft	feet
ID	identification (number)
Kd	partitioning coefficient
MCL	maximum contaminant level
mg/kg	milligrams per kilogram
mg/l	milligrams per liter
ml/g	milliliters per gram
N/A	not applicable
NE	not established
PRG	preliminary remediation goal
WRS	Wilcoxon Rank Sum

Appendix C Rev. 0 9/30/05 **Tables** 

#### Table C-4. Analysis of Deionized Water Waste Extraction Test Results and Designated Level Screening, Domestic Septic System 4

							St	ep 1		Step 2		Step 3	Step 4	
Sample ID	Constituent	DI WET Concentration (mg/l)	Ground Water Background <sup>(1)</sup> (mg/l)	MCL <sup>(2)</sup> (mg/l)	Source	DI WET Concentration >Background or MCL?	Soil Sample Count	Number of Soil Detections	Maximum Total Soil Concentration (mg/kg)	Deep (> 4 ft) Soil Background (mg/kg)	Significant <sup>(3)</sup> Soil Results Above Background?	Partitioning Coefficient (Kd) / Half Life Evaluation	WRS Test	Is Analyte a DL COPC?
SSD4DL02DI_WET	Aluminum	20.3	NE	0.2	MCL	Yes	0	N/A	N/A	N/A	N/A	N/A	N/A	Yes
SSD4DL01DI_WET	Aluminum	10.5	NE	0.2	MCL	Yes	0	N/A	N/A	N/A	N/A	N/A	N/A	Yes
SSD4DL02DI WET	Arsenic	0.0095	0.00811	0.05	MCL	Yes	7	7	8.9	10.9	No			No
SSD4DL01DI WET	Arsenic	0.0069	0.00811	0.05	MCL	No								No
SSD4DL02DI WET	Barium	0.18	0.187	1.0	MCL	No								No
SSD4DL01DI WET	Barium	0.106	0.187	1.0	MCL	No								No
SSD4DL02DI WET	Beryllium	0.00033	0.0015	0.004	MCL	No								No
SSD4DL01DI WET	Beryllium	0.00022	0.0015	0.004	MCL	No								No
SSD4DL02DI WET	Cadmium	0.00037	0.001	0.005	MCL	No								No
SSD4DL02DI WET	Chromium	0.0923	0.025	0.05	MCL	Yes	13	13	319	125	Yes	Fail (Kd = $19 \text{ ml/g}$ )	Fail	Yes
SSD4DL01DI WET	Chromium	0.0658	0.025	0.05	MCL	Yes	13	13	319	125	Yes	Fail (Kd = $19 \text{ ml/g}$ )	Fail	Yes
SSD4DL02DI WET	Cobalt	0.008	0.0018	0.73	PRG	Yes	7	7	24.3	31	No			No
SSD4DL01DI WET	Cobalt	0.004	0.0018	0.73	PRG	Yes	7	7	24.3	31	No			No
SSD4DL02DI WET	Copper	0.046	0.0017	1.0	MCL	Yes	7	7	64.6	61.8	No			No
SSD4DL01DI WET	Copper	0.0226	0.0017	1.0	MCL	Yes	7	7	64.6	61.8	No			No
SSD4DL02DI WET	Iron	34.4	0.502	0.3	MCL	Yes	7	7	39,400	44,000	No			No
SSD4DL01DI WET	Iron	18.7	0.502	0.3	MCL	Yes	7	7	39,400	44,000	No			No
SSD4DL02DI WET	Lead	0.0101	0.0013	0.015	MCL	Yes	14	14	20.1	9.5	Yes	Fail (Kd = $900 \text{ ml/g}$ )	Fail	Yes
SSD4DL01DI WET	Lead	0.0049	0.0013	0.015	MCL	Yes	14	14	20.1	9.5	Yes	Fail (Kd = $900 \text{ ml/g}$ )	Fail	Yes
SSD4DL02DI WET	Magnesium	21	112	NE		No								No
SSD4DL01DI WET	Magnesium	13.8	112	NE		No								No
SSD4DL02DI WET	Manganese	0.226	0.0099	0.05	MCL	Yes	7	7	655	750	No			No
SSD4DL01DI WET	Manganese	0.087	0.0099	0.05	MCL	Yes	7	7	655	750	No			No
SSD4DL02DI WET	Molybdenum	0.0019	0.015	0.18	PRG	No								No
SSD4DL01DI_WET	Molybdenum	0.0014	0.015	0.18	PRG	No								No
SSD4DL02DI WET	Nickel	0.175	0.0779	0.1	MCL	Yes	7	7	405	246	Yes	Fail (Kd = 65 ml/g)	Fail	Yes
SSD4DL01DI WET	Nickel	0.0943	0.0779	0.1	MCL	Yes	7	7	405	246	Yes	Fail (Kd = $65 \text{ ml/g}$ )	Fail	Yes
SSD4DL02DI WET	Nitrate	1.14	25.14	10	MCL	No								No
SSD4DL01DI WET	Nitrate	0.24	25.14	10	MCL	No								No
SSD4DL02DI_WET	Vanadium	0.0674	0.02	0.036	PRG	Yes	7	7	74.5	80.3	No			No
SSD4DL01DI WET	Vanadium	0.0472	0.02	0.036	PRG	Yes	7	7	74.5	80.3	No			No
SSD4DL01DI WET	Zinc	0.0916	0.03	5.0	MCL	Yes	7	7	144	93.1	Yes	Fail (Kd = $62 \text{ ml/g}$ )	Pass	No
SSD4DL02DI_WET	Zinc	0.0829	0.03	5.0	MCL	Yes	7	7	144	93.1	Yes	Fail (Kd = $62 \text{ ml/g}$ )	Pass	No

#### Notes

<sup>1</sup>The ground water background concentration represents the maximum concentration detected in ground water from well UCD1-18. <sup>2</sup>Drinking water PRG used when MCL is not established. Secondary MCL is used if no primary MCL is available or if the secondary MCL is lower than the primary MCL. <sup>3</sup>Soil results are considered significant enough to require further screening if maximum concentration is greater than 1.5 times background and more than 5% of the data are above background.

>	greater than
DI WET	deionized water waste extraction test
DL COPC	designated-level constituent of potential concern
ft	feet
ID	identification (number)
Kd	partitioning coefficient

 Table C-4.
 Analysis of Deionized Water Waste Extraction Test Results and Designated Level Screening, Domestic Septic System 4 (continued)

MCL	maximum contaminant level
mg/kg	milligrams per kilogram
mg/l	milligrams per liter
ml/g	milliliters per gram
N/A	not applicable
NE	not established
PRG	preliminary remediation goal
WRS	Wilcoxon Rank Sum

Appendix C Rev. 0 9/30/05 **Tables** 

Гable С-5.	Analysis of Deionized Water	Waste Extraction T	est Results and Designated	Level Screening,	Domestic Septic Tank 5
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							Ste	ep 1		Step 2		Step 3	Step 4	
Sample ID	Constituent	DI WET Concentration (mg/l)	Ground Water Background <sup>(1)</sup> (mg/l)	MCL <sup>(2)</sup> (mg/l)	Source	DI WET Concentration >Background or MCL?	Soil Sample Count	Number of Soil Detections	Maximum Total Soil Concentration (mg/kg)	Deep (> 4 ft) Soil Background (mg/kg)	Significant <sup>(3)</sup> Soil Results Above Background?	Partitioning Coefficient (Kd) / Half Life Evaluation	WRS Test	Is Analyte a DL COPC?
SSD5DL01DI_WET	Aluminum	60.7	NE	0.2	MCL	Yes	0	N/A	N/A	N/A	N/A	N/A	N/A	Yes
SSD5DL02DI_WET	Aluminum	41.8	NE	0.2	MCL	Yes	0	N/A	N/A	N/A	N/A	N/A	N/A	Yes
SSD5DL01DI_WET	Arsenic	0.0217	0.0081	0.05	MCL	Yes	1	1	8.6	10.9	No			No
SSD5DL02DI_WET	Arsenic	0.0166	0.0081	0.05	MCL	Yes	1	1	8.6	10.9	No			No
SSD5DL01DI_WET	Barium	0.404	0.187	1.0	MCL	Yes	1	1	213	294	No			No
SSD5DL02DI_WET	Barium	0.329	0.187	1.0	MCL	Yes	1	1	213	294	No			No
SSD5DL01DI WET	Beryllium	0.00095	0.0015	0.004	MCL	No								No
SSD5DL02DI WET	Beryllium	0.00074	0.0015	0.004	MCL	No								No
SSD5DL02DI WET	Cadmium	0.00043	0.001	0.005	MCL	No								No
SSD5DL01DI WET	Cadmium	0.00038	0.001	0.005	MCL	No								No
SSD5DL01DI WET	Chromium	0.28	0.025	0.05	MCL	Yes	1	1	110	125	No			No
SSD5DL02DI WET	Chromium	0.191	0.025	0.05	MCL	Yes	1	1	110	125	No			No
SSD5DL02DI WET	Cobalt	0.0155	0.0018	0.73	PRG	Yes	1	1	24.4	31	No			No
SSD5DL01DI WET	Cobalt	0.0136	0.0018	0.73	PRG	Yes	1	1	24.4	31	No			No
SSD5DL01DI WET	Copper	0.0741	0.0017	1.0	MCL	Yes	1	1	49.6	61.8	No			No
SSD5DL02DI WET	Copper	0.0688	0.0017	1.0	MCL	Yes	1	1	49.6	61.8	No			No
SSD5DL01DI WET	Iron	91.2	0.502	0.3	MCL	Yes	1	1	40,300	44,000	No			No
SSD5DL02DI WET	Iron	70.4	0.502	0.3	MCL	Yes	1	1	40,300	44,000	No			No
SSD5DL01DI WET	Lead	0.0128	0.0013	0.015	MCL	Yes	1	1	8.4	9.5	No			No
SSD5DL02DI WET	Lead	0.0125	0.0013	0.015	MCL	Yes	1	1	8.4	9.5	No			No
SSD5DL02DI WET	Magnesium	46.6	112	NE		No								No
SSD5DL01DI WET	Magnesium	28.9	112	NE		No								No
SSD5DL02DI WET	Manganese	0.481	0.0099	0.05	MCL	Yes	1	1	719	750	No			No
SSD5DL01DI WET	Manganese	0.458	0.0099	0.05	MCL	Yes	1	1	719	750	No			No
SSD5DL01DI WET	Molybdenum	0.0042	0.015	0.18	PRG	No								No
SSD5DL02DI WET	Molybdenum	0.002	0.015	0.18	PRG	No								No
SSD5DL01DI WET	Nickel	0.374	0.0779	0.1	MCL	Yes	1	1	237	246	No			No
SSD5DL02DI WET	Nickel	0.339	0.0779	0.1	MCL	Yes	1	1	237	246	No			No
SSD5DL02DI WET	Nitrate	0.213	25.14	10	MCL	No								No
SSD5DL01DI WET	Nitrate	0.157	25.14	10	MCL	No								No
SSD5DL01DI WET	Selenium	0.005	0.00567	0.05	MCL	No								No
SSD5DL01DI WET	Vanadium	0.177	0.02	0.036	PRG	Yes	1	1	65.8	80.3	No			No
SSD5DL02DI WET	Vanadium	0.129	0.02	0.036	PRG	Yes	1	1	65.8	80.3	No			No
SSD5DL01DI WET	Zinc	0.175	0.03	5.0	MCL	Yes	1	1	82.3	93.1	No			No
SSD5DL02DI_WET	Zinc	0.133	0.03	5.0	MCL	Yes	1	1	82.3	93.1	No			No

#### Notes

<sup>1</sup>The ground water background concentration represents the maximum concentration detected in ground water from well UCD1-18. <sup>2</sup>Drinking water PRG used when MCL is not established. Secondary MCL is used if primary MCL is not available or if secondary MCL is lower than the primary MCL <sup>3</sup>Soil results are considered significant enough to require further screening if maximum concentration is greater than 1.5 times background and more than 5% of the data are above background.

### Abbreviations

greater than > DI WET deionized water waste extraction test

DL COPC designated-level constituent of potential concern Table C-5.Analysis of Deionized Water Waste Extraction Test Results and Designated Level Screening, Domestic Septic Tank 5 (continued)

ft	feet
ID	identification (number)
Kd	partitioning coefficient
MCL	maximum contaminant level
mg/kg	milligrams per kilogram
mg/l	milligrams per liter
ml/g	milliliters per gram
N/A	not applicable
NE	not established
PRG	preliminary remediation goal
WRS	Wilcoxon Rank Sum

Appendix C Rev. 0 9/30/05 **Tables**
						Step 1			Step 2			Step 3	Step 4	
Sample ID	Constituent	DI WET Concentration (mg/l)	Ground Water Background <sup>(1)</sup> (mg/l)	MCL <sup>(2)</sup> (mg/l)	Source	DI WET Concentration >Background or MCL?	Soil Sample Count	Number of Soil Detections	Maximum Total Soil Concentration (mg/kg)	Deep (> 4 ft) Soil Background (mg/kg)	Significant <sup>(3)</sup> Soil Results Above Background?	Partitioning Coefficient (Kd) / Half Life Evaluation	WRS Tes	t Is Analyte a DL COPC?
SSD6DL06(diwet)	Hexavalent	0.028	0.0394	0.05	MCL	No								No
SSD6DL21(diwet)	Hexavalent	0.055	0.0394	0.05	MCL	Yes	42	24	0.467	1.3	No			No
SSD6DL21(diwet)	Aluminum	52.1	NE	0.2	MCL	Yes	0	N/A	N/A	N/A	N/A	N/A	N/A	Yes
SSD6DL01(diwet)	Aluminum	38	NE	0.2	MCL	Yes	0	N/A	N/A	N/A	N/A	N/A	N/A	Yes
SSD6DL26(diwet)	Aluminum	9.08	NE	0.2	MCL	Yes	0	N/A	N/A	N/A	N/A	N/A	N/A	Yes
SSD6DL06(diwet)	Aluminum	2.87	NE	0.2	MCL	Yes	0	N/A	N/A	N/A	N/A	N/A	N/A	Yes
SSD6DL21(diwet)	Arsenic	0.0191	0.008	0.05	MCL	Yes	3	3	9.3	10.9	No			No
SSD6DL01(diwet)	Arsenic	0.0145	0.008	0.05	MCL	Yes	3	3	9.3	10.9	No			No
SSD6DL06(diwet)	Arsenic	0.009	0.008	0.05	MCL	Yes	3	3	93	10.9	No			No
SSD6DL26(diwet)	Arsenic	0.0082	0.008	0.05	MCL	Yes	3	3	93	10.9	No			No
SSD6DL20(diwet)	Barium	0.43	0.187	1.0	MCL	Yes	26	26	290	294	No			No
SSD6DL21(diwet)	Barium	0.403	0.187	1.0	MCL	Yes	26	26	290	294	No			No
SSD6DL26(diwet)	Barium	0.0965	0.187	1.0	MCI	No	20	20	290	291				No
SSD6DL20(diwet)	Barium	0.0387	0.187	1.0	MCI	No								No
SSD6DL00(diwet)	Berullium	0.0007	0.0015	0.004	MCL	No								No
SSD6DL21(diwet)	Deryllium	0.00076	0.0015	0.004	MCL	No								No
SSD0DL01(diwet)	Cadminum	0.00070	0.0013	0.004	MCL	INO No								INU No
SSD0DL21(diwet)	Cadmium	0.00067	0.001	0.005	MCL	INO No								INO No
SSD0DL01(diwet)	Cadmium	0.00033	0.001	0.005	MCL	INO No								INO No
SSD0DL20(diwet)	Cadmium	0.00028	0.001	0.005	MCL	INO Na								INO Nu
SSD6DL06(diwet)	Cadmium	0.00024	0.001	0.005	MCL	INO V					 N I			INO N
SSD6DL21(diwet)	Chromium	0.264	0.025	0.05	MCL	Yes	3	3	113	125	No			No
SSD6DL01(diwet)	Chromium	0.207	0.025	0.05	MCL	Yes	3	3	113	125	No			No
SSD6DL26(diwet)	Chromium	0.0492	0.025	0.05	MCL	Yes	3	3	113	125	No			No
SSD6DL06(diwet)	Chromium	0.0156	0.025	0.05	MCL	No								No
SSD6DL21(diwet)	Cobalt	0.0176	0.0018	0.73	PRG	Yes	3	3	25.9	31	No			No
SSD6DL01(diwet)	Cobalt	0.0169	0.0018	0.73	PRG	Yes	3	3	25.9	31	No			No
SSD6DL26(diwet)	Cobalt	0.0035	0.0018	0.73	PRG	Yes	3	3	25.9	31	No			No
SSD6DL06(diwet)	Cobalt	0.00071	0.0018	0.73	PRG	No								No
SSD6DL21(diwet)	Copper	0.0871	0.0017	1.0	MCL	Yes	42	42	57.5	61.8	No			No
SSD6DL01(diwet)	Copper	0.0682	0.0017	1.0	MCL	Yes	42	42	57.5	61.8	No			No
SSD6DL26(diwet)	Copper	0.0217	0.0017	1.0	MCL	Yes	42	42	57.5	61.8	No			No
SSD6DL06(diwet)	Copper	0.008	0.0017	1.0	MCL	Yes	42	42	57.5	61.8	No			No
SSD6DL21(diwet)	Iron	85.8	0.502	0.3	MCL	Yes	3	3	43,200	44,000	No			No
SSD6DL01(diwet)	Iron	66.9	0.502	0.3	MCL	Yes	3	3	43,200	44,000	No			No
SSD6DL26(diwet)	Iron	17.4	0.502	0.3	MCL	Yes	3	3	43,200	44,000	No			No
SSD6DL06(diwet)	Iron	5.55	0.502	0.3	MCL	Yes	3	3	43,200	44,000	No			No
SSD6DL21(diwet)	Lead	0.0152	0.0013	0.015	MCL	Yes	3	3	8.1	9.5	No			No
SSD6DL01(diwet)	Lead	0.0124	0.0013	0.015	MCL	Yes	3	3	8.1	9.5	No			No
SSD6DL26(diwet)	Lead	0.0039	0.0013	0.015	MCL	Yes	3	3	8.1	9.5	No			No
SSD6DL06(diwet)	Lead	0.002	0.0013	0.015	MCL	Yes	3	3	8.1	9.5	No			No
SSD6DL21(diwet)	Magnesium	31.9	112	NE		No								No

## Table C-6. Analysis of Deionized Water Waste Extraction Test Results and Designated Level Screening, Domestic Septic System 6

							Ste	ep 1		Step 2		Step 3	Step 4	
Sample ID	Constituent	DI WET Concentration (mg/l)	Ground Water Background <sup>(1)</sup> (mg/l)	MCL <sup>(2)</sup> (mg/l)	Source	DI WET Concentration >Background or MCL?	Soil Sample Count	Number of Soil Detections	Maximum Total Soil Concentration (mg/kg)	Deep (> 4 ft) Soil Background (mg/kg)	Significant <sup>(3)</sup> Soil Results Above Background?	Partitioning Coefficient (Kd) / Half Life Evaluation	WRS Test	s Analyte a DL COPC?
SSD6DL01(diwet)	Magnesium	27.3	112	NE		No								No
SSD6DL26(diwet)	Magnesium	13.3	112	NE		No								No
SSD6DL06(diwet)	Magnesium	8.29	112	NE		No								No
SSD6DL21(diwet)	Manganese	0.568	0.0099	0.05	MCL	Yes	3	3	709	750	No			No
SSD6DL01(diwet)	Manganese	0.492	0.0099	0.05	MCL	Yes	3	3	709	750	No			No
SSD6DL26(diwet)	Manganese	0.127	0.0099	0.05	MCL	Yes	3	3	709	750	No			No
SSD6DL06(diwet)	Manganese	0.0373	0.0099	0.05	MCL	Yes	3	3	709	750	No			No
SSD6DL21(diwet)	Mercury	0.00033	0.0001	0.002	MCL	Yes	63	61	8.0	0.248	Yes	Fail (Kd = $52 \text{ ml/g}$ )	Fail	Yes
SSD6DL01(diwet)	Mercury	0.00019	0.0001	0.002	MCL	Yes	63	61	8.0	0.248	Yes	Fail (Kd = $52 \text{ ml/g}$ )	Fail	Yes
SSD6DL26(diwet)	Mercury	0.000066	0.0001	0.002	MCL	No								No
SSD6DL01(diwet)	Molybdenum	0.0013	0.015	0.18	PRG	No								No
SSD6DL21(diwet)	Molybdenum	0.0013	0.015	0.18	PRG	No								No
SSD6DL21(diwet)	Nickel	0.427	0.0779	0.1	MCL	Yes	3	3	211	246	No			No
SSD6DL01(diwet)	Nickel	0.364	0.0779	0.1	MCL	Yes	3	3	211	246	No			No
SSD6DL26(diwet)	Nickel	0.0925	0.0779	0.1	MCL	Yes	3	3	211	246	No			No
SSD6DL06(diwet)	Nickel	0.0298	0.0779	0.1	MCL	No								No
SSD6DL01(diwet)	Nitrate	0.152	25.14	10	MCL	No								No
SSD6DL21(diwet)	Vanadium	0.165	0.02	0.036	PRG	Yes	3	3	84.8	80.3	No			No
SSD6DL01(diwet)	Vanadium	0.126	0.02	0.036	PRG	Yes	3	3	84.8	80.3	No			No
SSD6DL26(diwet)	Vanadium	0.0466	0.02	0.036	PRG	Yes	3	3	84.8	80.3	No			No
SSD6DL06(diwet)	Vanadium	0.0243	0.02	0.036	PRG	Yes	3	3	84.8	80.3	No			No
SSD6DL21(diwet)	Zinc	0.22	0.03	5.0	MCL	Yes	3	3	94.6	93.1	No			No
SSD6DL01(diwet)	Zinc	0.167	0.03	5.0	MCL	Yes	3	3	94.6	93.1	No			No
SSD6DL06(diwet)	Zinc	0.0186	0.03	5.0	MCL	No								No
SSD6DL26(diwet)	Zinc	0.016	0.03	5.0	MCL	No								No

#### Analysis of Deionized Water Waste Extraction Test Results and Designated Level Screening, Domestic Septic System 6 (continued) Table C-6.

**Notes** The ground water background concentration represents the maximum concentration detected in ground water from well UCD1-18.

<sup>2</sup>Drinking water PRG used when MCL is not established.

<sup>3</sup>Soil results are considered significant enough to require further screening if maximum concentration is greater than 1.5 times background and more than 5% of the data are above background.

#### Abbreviations

>	greater than
DI WET	deionized water waste extraction test
DL COPC	designated-level constituent of potential concern
ft	feet
ID	identification (number)
Kd	partitioning coefficient
MCL	maximum contaminant level
mg/kg	milligrams per kilogram
mg/l	milligrams per liter
ml/g	milliliters per gram
N/A	not applicable
NE	not established
PRG	preliminary remediation goal
WRS	Wilcoxon Rank Sum

## **APPENDIX D**

# HEXAVALENT CHROMIUM BACKGROUND STUDY (2004)

## APPENDIX D: 2004 HEXAVALENT CHROMIUM BACKGROUND STUDY

## **Data Summary**

Twenty soil samples plus two field duplicates were collected from the established LEHR background locations on March 29, 2004 and analyzed by General Engineering Laboratory for hexavalent chromium. Analysis was performed using EPA SW-846 method 7196A, a colorimetric technique. The data were validated according to the National Functional Guidelines for Inorganic Data Review (US EPA, 2004) and standard operating procedure 21.1 of the LEHR Quality Assurance Project Plan (WA, 2000c). No data validation qualifiers were assigned to these data. However, due to color interference, matrix spike recovery data were not initially available for these samples. Matrix spike analysis was re-run using samples that were non-detect and not showing color interference to ensure quantification within the calibrated range. The matrix spike results ranged from 0% to 57% recovery. Although the matrix spike recoveries were low, they likely reflect soil chemistry conditions for trivalent and hexavalent chromium in the samples. It is important to note that the average total chromium concentration in background samples has been 122 mg/kg and the average hexavalent chromium concentration has been below 1 mg/kg. The hexavalent chromium spike solution likely began changing valence to trivalent upon delivery to the samples. With enough time, the majority of the spiked hexavalent chromium would likely become trivalent in these nondetect samples as equilibrium with the sample soil chemistry is reached. The samples were not qualified because an apparent low bias in hexavalent chromium matrix spike recovery does not necessarily reflect a low bias in quantitation of the primary samples.

#### **Comparison with Previous Data**

Previously collected background data were reviewed for potential consolidation with the 2004 data. Background data collected in 1997 were not included due to sample preparation methodology issues documented in the DOE Areas RI Report (WA, 2003b). Background data collected in 1994 were eliminated because a different laboratory analyzed them and the distribution was conclusively shifted from the 2004 data. Data from background samples collected in 2002 by UC Davis were qualified due to laboratory contamination in the preparation batch (method blank contamination). The log-transformed histograms of 1994, 2002 and 2004 data are shown in Figure B-1. The 2002 data were retained for consolidation with the 2004 data as agreed in the July 28, 2004 meeting between LEHR remedial project managers.

#### **Statistical Analysis**

Distribution testing and histogram visual inspections were used to verify whether the 2004 background data fit a lognormal distribution. Shapiro Wilk distribution testing results were favorable for assuming a lognormal distribution. Histograms of the log-transformed data are shown in Figure B-2 and Figure B-3. Although visual inspection of the histograms did not indicate a perfect bell-shaped distribution, the distribution was not a poor fit. The background value was calculated assuming a lognormal fit.

The maximum likelihood estimator procedure (Gilbert, 1987) was used to determine the distribution mean and standard deviation because approximately one third of the data were non-detects. These statistical parameters were then used to determine the background screening value, which is the 80% lower confidence limit on the 95th quantile. The resulting background screening value based on the 2002 and 2004 data is 1.30 mg/kg.

## **References:**

- Gilbert, R.O., 1987, Statistical Methods for Environmental Pollution Monitoring, Van Nostrand Reinhold.
- US EPA, 2004b, USEPA Contract Laboratory Program, National Functional Guidelines for Inorganic Data Review, Publication 9240.1-45, Office of Emergency and Remedial Response, Washington, DC, EPA 540-R-04-004.
- WA, 2000c, Final Quality Assurance Project Plan, Final Standard Quality Procedures, for the Laboratory for Energy-Related Health Research, University of California, Davis, June, Rev. 3.



Figure D-1. Histogram of Hexavalent Chromium Log-Transformed Background Data



Figure D-2. Histogram of 2004 Hexavalent Chromium Log-Transformed Background Data

## **APPENDIX E**

## PARENT-DAUGHTER ACTIVITY RELATIONSHIPS FOR RADIUM-226/LEAD-210 AND THORIUM-232/THORIUM-228

## APPENDIX E: PARENT-DAUGHTER ACTIVITY RELATIONSHIPS FOR RADIUM-226/LEAD-210 AND THORIUM-232/THORIUM-228

This appendix presents the relative activity concentrations of radionuclide parents and daughters for samples collected in the DOE areas. Specifically, the isotopes of interest are Ra-226 and its daughter Pb-210, and Th-232 and its daughter Th-228. The samples presented are those samples collected in the background areas and at areas where one of the isotopes, either the parent or daughter, appears to be present in concentrations greater than background based on statistical comparisons (e.g. Wilcoxon Rank Sum test). These areas are DOE Disposal Box, Domestic Septic System No. 3, Domestic Septic System No. 4, Domestic Septic System No. 7, Dry Wells A-E, Eastern Dog Pens, Radium/Strontium Treatment Systems, Southwest Trenches, and Western Dog Pens areas. In none of these areas are both the parent and the daughter present in concentrations greater than background.

Figures E-1 through E-15 graphically depict the parent-daughter concentrations for all samples collected in a particular area. On the graphs, the order of the samples along the horizontal axes is alphabetical by sample name. The purpose of the graphs is to evaluate whether or not the parents and the daughters are in secular equilibrium. Secular equilibrium is the state of equal activity concentrations achieved by a relatively long-lived parent and its relatively short-lived daughter. In the case of LEHR, the half-lives for the isotopes of interest are:

Ra-226 (parent of Pb-210): 1,600 years Pb-210: 22.3 years Th-232 (parent of Th-228): 1.4 x 106 years Th-228: 1.9 years

Because the rates at which the parents Ra-226 and Th-232 decay are so much slower than the rate at which their daughters decay, the daughters can only decay as fast as the parent, and therefore the activity concentration of the daughter will equal that of the parent (secular equilibrium), assuming a closed system.

If either the parent or the daughter isotope is added to the system, however, the parent and daughter will be temporarily be out of equilibrium. Secular equilibrium will be re-established, but not until a significant length of time has passed. To illustrate, in the simple scenario where at the starting time only parent material exists, secular equilibrium will be achieved in approximately seven and a half half-lives of the daughter.

As shown by the graphs in this appendix, the relative activity concentrations of the parents and the daughters at the site appear to be in equilibrium, when quantified analytical errors are taken into account.

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Figure E-1. Concentrations of Radium-226 (parent) and Lead-210 (daughter) Measured in Samples Collected from the DOE Box Area



Figure E-2. Concentrations of Thorium-232 (parent) and Thorium-228 (daughter) Measured in Samples Collected from the DOE Box Area



Figure E-3. Concentrations of Radium-226 (parent) and Lead-210 (daughter) Measured in Samples Collected from the Domestic Septic System No. 3 Area



Figure E-4. Concentrations of Radium-226 (parent) and Lead-210 (daughter) Measured in Samples Collected from the Domestic Septic System No. 4 Area



Figure E-5. Concentrations of Radium-226 (parent) and Lead-210 (daughter) Measured in Samples Collected from the Domestic Septic System No. 7 Area



Figure E-6. Concentrations of Radium-226 (parent) and Lead-210 (daughter) Measured in Samples Collected from the Domestic Septic System Dry Wells A through E Area



Figure E-7. Concentrations of Thorium-232 (parent) and Thorium-228 (daughter) Measured in Samples Collected from the Domestic Septic System Dry Wells A through E Area



Figure E-8. Concentrations of Radium-226 (parent) and Lead-210 (daughter) Measured in Samples Collected from the Eastern Dog Pens Area



Figure E-9. Concentrations of Thorium-232 (parent) and Thorium-228 (daughter) Measured in Samples Collected from the Radium/Strontium Treatment Systems Area



Figure E-9. Concentrations of Thorium-232 (parent) and Thorium-228 (daughter) Measured in Samples Collected from the Radium/Strontium Treatment Systems Area (continued)



Figure E-10. Concentrations of Radium-226 (parent) and Lead-210 (daughter) Measured in Samples Collected from the Southwest Trenches Area



Figure E-11. Concentrations of Thorium-232 (parent) and Thorium-228 (daughter) Measured in Samples Collected from the Southwest Trenches Area

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Figure E-12. Concentrations of Radium-226 (parent) and Lead-210 (daughter) Measured in Samples Collected from the Western Dog Pens Area



Figure E-12. Concentrations of Radium-226 (parent) and Lead-210 (daughter) Measured in Samples Collected from the Western Dog Pens Area (continued)



Figure E-12. Concentrations of Radium-226 (parent) and Lead-210 (daughter) Measured in Samples Collected from the Western Dog Pens Area (continued)



Figure E-13. Concentrations of Thorium-232 (parent) and Thorium-228 (daughter) Measured in Samples Collected from the Western Dog Pens Area



Figure E-14. Concentrations of Radium-226 (parent) and Lead-210 (daughter) Measured in Samples Collected from the Background Area



Figure E-15. Concentrations of Thorium-232 (parent) and Thorium-228 (daughter) Measured in Samples Collected from the Background Area