LMS/LEH/S05069

Record of Decision for DOE Areas at the Laboratory for Energy-Related Health Research University of California, Davis

September 2009

U.S. DEPARTMENT OF ENERGY | Office of Legacy Management

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Acronyms and Abbreviations

ARAR(s)	applicable or relevant and appropriate requirement(s)
ATSDR	Agency for Toxic Substances and Disease Registry
bgs	below ground surface
C-14	carbon-14
CCR	*Code of California Regulations*
CEQA	California Environmental Quality Act
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980
CFR	*Code of Federal Regulations*
cm	centimeter(s)
cm/s	centimeters per second
Co-60	cobalt-60
COC(s)	constituent(s) of concern
COPC(s)	constituent(s) of potential concern
COPEC(s)	constituent(s) of potential ecological concern
Cs-137	cesium-137
D&M	Dames & Moore
DOE	U.S. Department of Energy
DSCSOC	Davis South Campus Superfund Oversight Committee
DSS	Domestic Septic System
DTSC	California Department of Toxic Substances Control
EDPs	Eastern Dog Pens
EPA	U.S. Environmental Protection Agency
EPC	exposure point concentration
ft	foot or feet
HDPE	high-density polyethylene
HEAST	Health Effects Assessment Summary Tables, U.S. Environmental Protection Agency
HHRA	human health risk assessment
HQ	hazard quotient
HSU	hydrostratigraphic unit
IRIS	Integrated Risk Information System, U.S. Environmental Protection Agency
LEHR	Laboratory for Energy-related Health Research

LFI	limited field investigation
LOAEL	lowest observed adverse effects level
LOEC	lowest observed effects concentration
LTS&M	long-term surveillance and maintenance
MCL	maximum contaminant level
mg/kg	milligram(s) per kilogram
mrem/year	millirem per year
NCEA	National Center for Environmental Assessment
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NEPA	National Environmental Policy Act
NESHAPs	National Emission Standards for Hazardous Air Pollutants
NOAEL	no observable adverse effects level
NRC	U.S. Nuclear Regulatory Commission
NUFT	Non-Isothermal Unsaturated Flow and Transport
O&M	operations and maintenance
OEHHA	Office of Environmental Health Hazard Assessment, California Environmental Protection Agency
PAH(s)	polycyclic aromatic hydrocarbon(s)
pCi/g	picocuries per gram
Ra/Sr	radium/strontium
Ra-226	radium-226
RAOs	Remedial Action Objectives
ROD	Record of Decision
RWQCB	Regional Water Quality Control Board
Sr-90	strontium-90
SWERA	Site-Wide Ecological Risk Assessment
SWRCB	State Water Resources Control Board
SWT	Southwest Trenches
TMV	toxicity, mobility, or volume
TRV	toxicity reference value
UC Davis	University of California, Davis
UCL	upper confidence limit
UCOP	University of California Office of the President
UMTRCA	Uranium Mill Tailings Radiation Control Act

USC	*United States Code*
UTL	upper tolerance limit
WA	Weiss Associates
WDPs	Western Dog Pens
µg/kg	microgram(s) per kilogram

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1.0 Declaration

1.1 Site Name and Location

This Record of Decision (ROD) documents the U.S. Department of Energy's (DOE) and the U.S. Environmental Protection Agency's (EPA) selection of remedial action pursuant to Section 120 of the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) for the Laboratory for Energy-related Health Research (LEHR) Federal Facility located within the LEHR/Old Campus Landfill (EPA Superfund Site Identification No. CA2890190000), at the University of California, Davis (UC Davis) in Solano County, California (Figure 1-1).

The LEHR Federal Facility is defined in a Federal Facility Agreement signed in 1999 by DOE and EPA, with the California Department of Public Health (DPH) (formerly the California Department of Health Services) and the Central Valley Regional Water Quality Control Board (RWQCB) joining as signatories in 1999, and Department of Toxic Substances Control (DTSC) joining in 2000. It comprises the land and improvements located within the former LEHR Facility boundary shown in Figure 1-2, including the following areas:

- All LEHR buildings (see Section 2.5.2 for list of buildings)
- Cobalt-60 (Co-60) Irradiation Field
- Radium/Strontium (Ra/Sr) Treatment Systems area
- Seven septic tanks (including leach fields and dry wells)
- Southwest Trenches (SWT) area
- Western Dog Pens (WDPs) area
- Eastern Dog Pens (EDPs) area
- DOE Disposal Box
- Areas where contamination originating from the areas listed above has come to be located, excluding areas assigned to UC Davis, by a Memorandum of Agreement between the Regents of the University of California and DOE (DOE 2009) (see Section 2.1)

1.2 Statement of Basis and Purpose

This ROD presents the facts and analysis supporting the selection of a final remedy for the site specified above in accordance with CERCLA, as amended by the Superfund Amendments and Reauthorization Act of 1986 and the National Oil and Hazardous Substances Contingency Plan (NCP). This decision is based on the Administrative Record for the site. DOE and EPA Region 9, with input from the State of California and the public, jointly selected the final remedy for each of the areas defined above, using the evaluation criteria contained in the NCP. The State of California DTSC, the Central Valley RWQCB, and the Department of Public Health, Radiologic Health Branch, were involved with the identification of state requirements that are applicable or relevant and appropriate to the site and have had an opportunity to review and comment on this ROD.

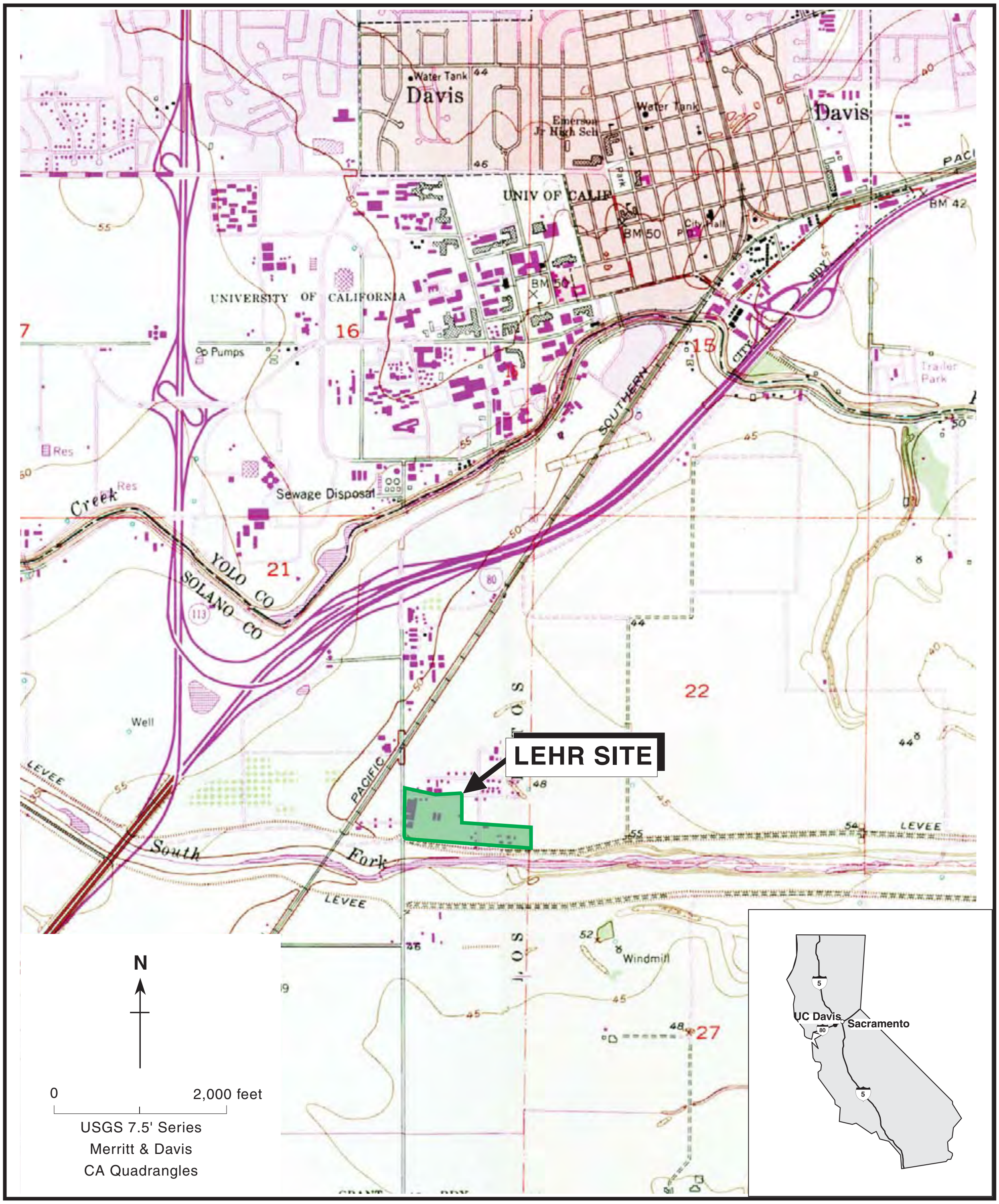

Figure 1−1. Location of the LEHR Site, UC Davis, Solano County, California

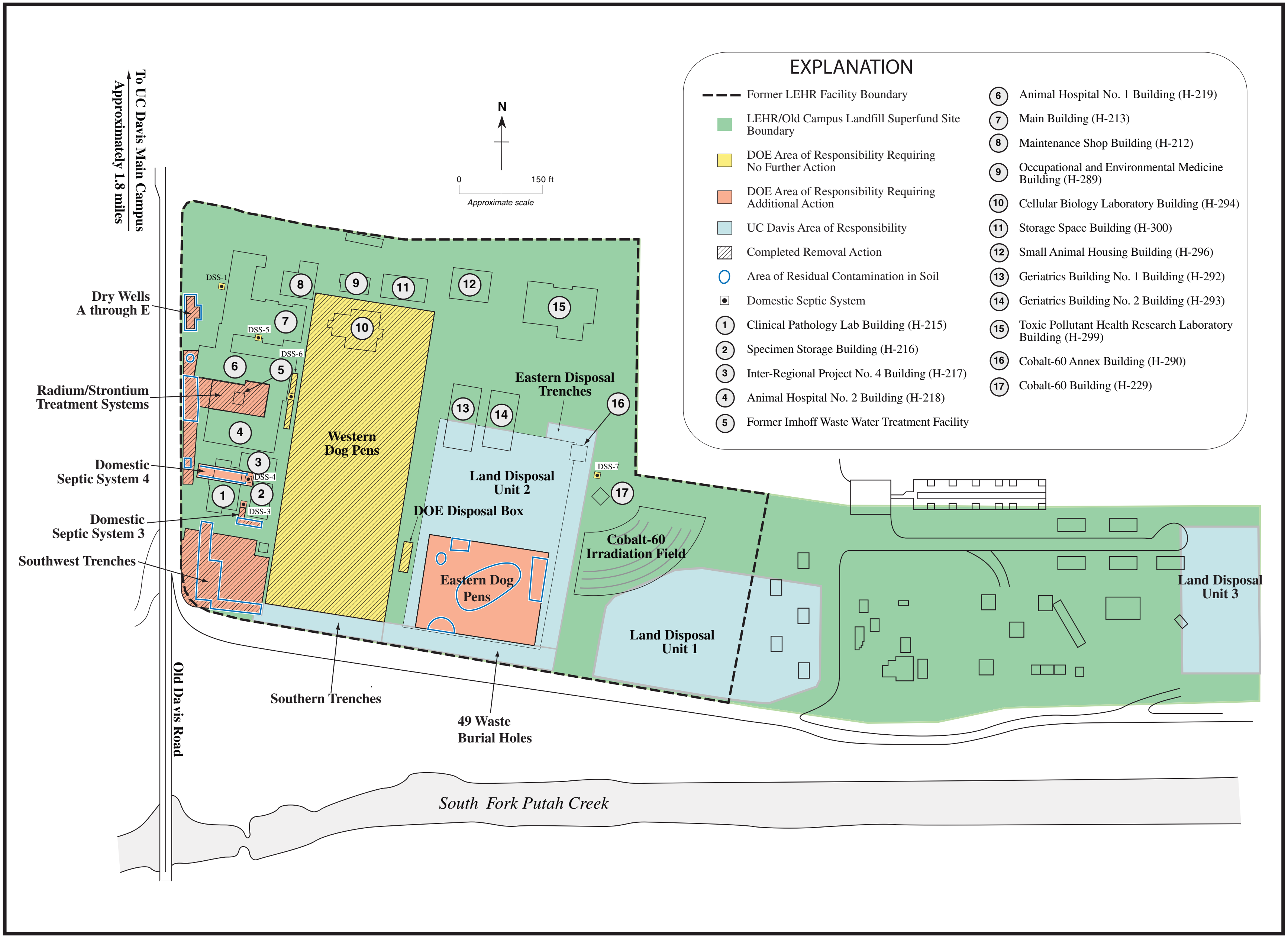

Figure 1–2. LEHR Site Features

1.3 Assessment

DOE has successfully completed removal actions at the DOE areas of the LEHR Federal Facility and has thereby significantly reduced impacts to human health and the environment. However, residual contaminants remain at the site at concentrations that prevent its unrestricted use, or that have the potential to impact groundwater quality above background concentrations in the future.

1.3.1 Description of Selected Remedy

A number of alternatives to clean up the residual contamination were evaluated in the DOE Areas Feasibility Study (WA 2008a). The preferred alternatives were presented in a Proposed Plan issued by DOE in October 2008 (DOE 2008).

The selected remedies for the DOE areas are as follows:

- Long-term groundwater monitoring with contingent remediation and a Soil Management Plan at the Ra/Sr Treatment Systems area, Domestic Septic System (DSS) 3, Dry Wells A−E, and the SWT area.
- Long-term groundwater monitoring with contingent remediation, land-use restriction prohibiting residential use, and a Soil Management Plan at DSS 4.
- Implementation of a Soil Management Plan at the EDPs area.
- No further action at DSS 1, DSS 5, DSS 6, DSS 7, WDPs, and DOE Disposal Box areas.

The major components of these selected remedies, other than the no further action remedy, are as follows:

- Groundwater monitoring to detect any changes in contaminant concentrations that could impact human health or the environment. If groundwater monitoring indicates that impacts to groundwater have occurred due to constituents of concern (COCs) remaining in soil, DOE will evaluate remedial options and determine whether remediation is appropriate in accordance with CERCLA and Applicable or Relevant and Appropriate Requirements (ARARs).
- Land-use controls, also known as institutional controls, to prevent exposure where an unacceptable risk to human health potentially remains (Figure 1−3). The land-use control components of the selected remedy include the development and implementation of a Soil Management Plan to specify controls that would apply to activities that disturb the subsurface, a prohibition against destruction of or tampering with selected groundwater monitoring wells, the requirement that access be provided for the purpose of sampling and maintaining monitoring wells and conducting contingent remediation, and a prohibition against residential use at the DSS 4 area. The land-use controls will be recorded. Land-use controls will be maintained until the concentrations of hazardous substances in the soil are at levels that allow for unrestricted use and exposure.

Significant or fundamental changes to the remedies would be evaluated and documented in an Explanation of Significant Differences or an amendment to this ROD.

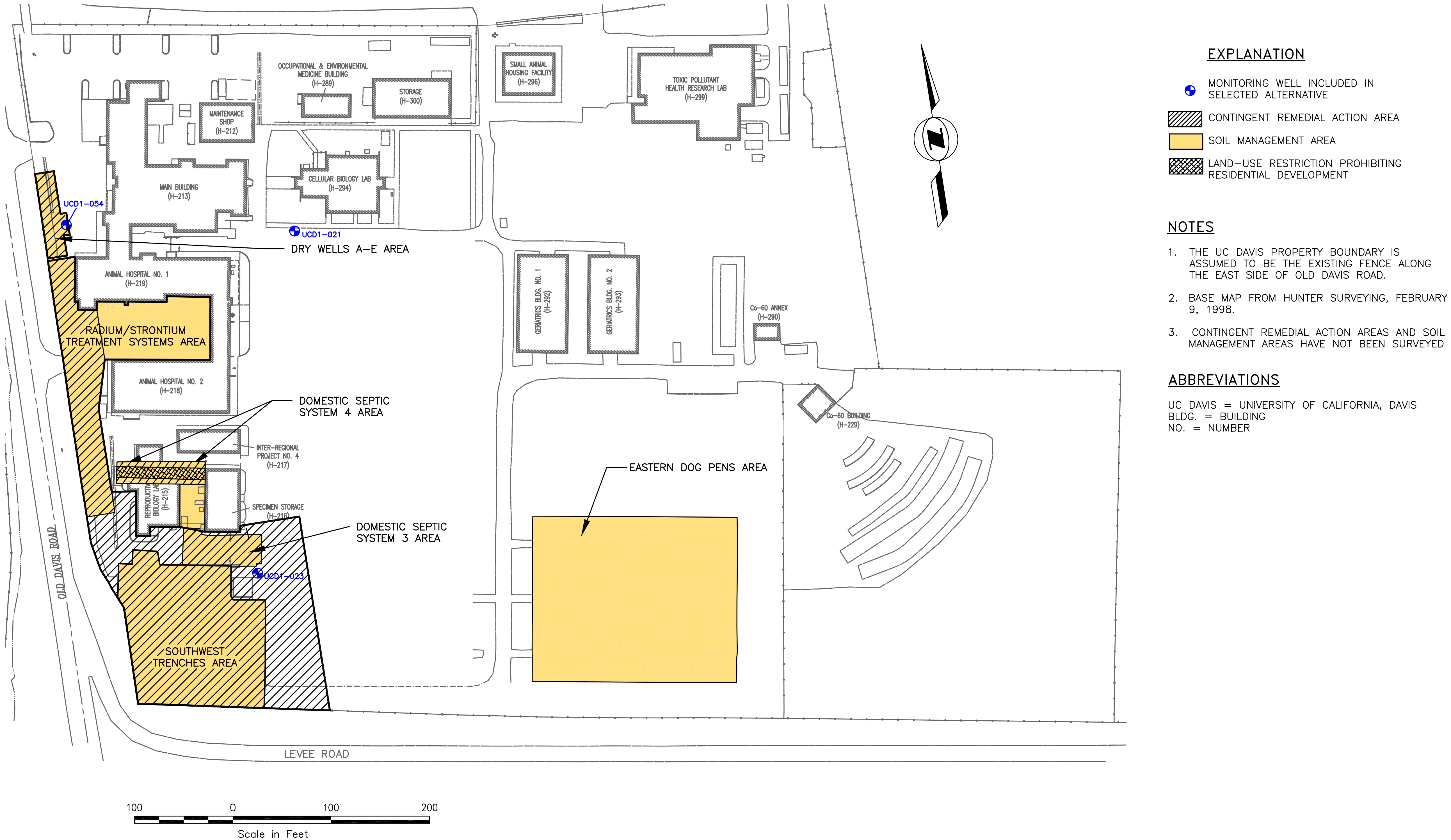

Figure 1–3. Land-Use Control Components of the Selected Remedy

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1.3.2 Statutory Determinations

The selected remedies protect human health and the environment, comply with federal and state requirements, and are cost-effective. Because principal-threat wastes have been removed from the site in early removal actions, and only low-threat contamination remains at the site, alternatives that present treatment as a principal element of the remedy were not appropriate. However, the selected remedies will result in contaminants remaining on site above levels that allow for unrestricted use; therefore, a statutory review will be conducted every 5 years after the adoption of this ROD to ensure that the remedies remain protective of human health and the environment.

Implementation of land-use covenants will be required at each DOE area addressed in this ROD due to hazardous materials, hazardous wastes, or hazardous substances that will remain in these areas at levels that render the LEHR Federal Facility not suitable for unrestricted use of the land. Land-use covenants are necessary to protect present or future human health, safety, or the environment as a result of the presence on the land of hazardous materials as defined by state statutes. Any contaminated soil or materials brought to the surface by any means will be managed in accordance with a Soil Management Plan approved by DOE and EPA to ensure that the exposure pathway remains closed. For the DSS 4 area, it is necessary to prevent residential use of the property to ensure protection of human health. DOE and EPA have concluded that the LEHR Federal Facility, if remediated to the goals presented in this ROD and subject to restrictions in the land-use covenants described in this ROD, will not present an unacceptable threat to human safety or the environment. The Regents of the University of California, the current property owner, has agreed to sign and record land-use covenants for the selected remedies. For properties subject to the land-use covenants, the property owner has agreed to refrain from any activity that would interfere with the operation of the selected remedies and shall not permit any such activity by others. All uses and development of the property will preserve the integrity of the selected remedies. The State of California and EPA will have reasonable right of entry and access to the properties for inspection, monitoring, and other activities associated with the selected remedies and consistent with the purposes of the land-use covenant. The land-use covenants will neither limit nor affect EPA's or the State of California's right of entry or access provided in federal or state statutes and regulations.

1.4 Compliance Checklist

The following information required by the NCP is included in the noted sections of the "Decision Summary" portion of this ROD. Additional information can be found in the Administrative Record for this site (see Section 2.3).

- COCs and their respective concentrations (Sections 2.5, 2.13.1.2, 2.13.2.2, 2.13.3.2, 2.13.4.2, 2.13.5.2, and 2.13.6.2)
- Baseline risk represented by the COCs (Sections 2.5, 2.13.1.2, 2.13.2.2, 2.13.3.2, 2.13.4.2, 2.13.5.2, and 2.13.6.2)
- Cleanup standards established for COCs and the basis for these standards (Table 2−7 and Table 2−8)
- Use of permanent solutions and alternative treatment or resource recovery technologies to the extent practicable (Sections 2.13.1.8, 2.13.2.8, 2.13.3.8, 2.13.5.8, and 2.13.6.8)

- How source materials constituting principal-threat wastes are addressed (Section 2.13)
- Current and reasonably anticipated future land-use assumptions and current and potential beneficial uses of groundwater (Section 2.6)
- Potential land and groundwater uses that will be available as a result of the selected remedies (Sections 2.6, 2.13.1.5, 2.13.2.5, 2.13.3.5, 2.13.4.5, 2.13.5.5, and 2.13.6.5)
- Estimated capital, annual operations and maintenance costs, and the number of years over which the remedy cost estimates are projected (Table 2–11 through Table 2–16)
- Cost-effectiveness of the selected remedies (Table 2–11 through Table 2–16)
- Protectiveness of human health and the environment of the selected remedies (Sections 2.13.1.8, 2.13.2.8, 2.13.3.8, 2.13.4.8, 2.13.5.8, and 2.13.6.8)
- Compliance of the selected remedies with federal and state requirements that are applicable, relevant, and appropriate to the site (Appendix A)
- Key factors that led to selecting the remedy (Sections 2.13.1.7, 2.13.2.7, 2.13.3.7, 2.13.4.7, 2.13.5.7, and 2.13.6.7)
- Commitment to further analysis and selection of additional response measures within an appropriate time frame to ensure protectiveness of human health and the environment (Section 2.10.2)

1.5 Authorizing Signatures

Each representative of the undersigned party certifies that he or she is fully authorized to enter into the terms and conditions of this agreement and legally bind such party to this agreement.

IT IS SO AGREED:

David W. Geiser Deputy Director Office of Legacy Management U.S. Department of Energy	10/16/09 Date
Michael M. Montgomery Assistant Director Federal Facilities and Site Cleanup Branch U.S. Environmental Protection Agency Region 9	12/10/09 Date

1.6 State Agencies' Signatures

The undersigned agencies had an opportunity to review and comment on this Record of Decision, and their comments were addressed.

Pamela C. Creedon
Executive Officer
California Regional Water Quality Control Board
Central Valley Region

Date 11-12-09

Richard Hume
Supervising Hazardous Substances Engineer I
Brownfields Environmental and Restoration Program
California Environmental Protection Agency
Department of Toxic Substances Control

Date 11/24/2009

Gary W. Butner
Chief
California Department of Public Health
Radiologic Health Branch

Date 12/1/09

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2.0 Decision Summary

2.1 Site Name, Location, and Description

LEHR is a former research facility operated by DOE at UC Davis (Figure 1–1 and Figure 1−2). The following terminology is used in this ROD and other documents contained in the LEHR Administrative Record to refer to various areas of the site:

- LEHR Site—As defined in the Federal Facility Agreement, the area referred to on the National Priorities List as "LEHR/Old Campus Landfill."
- DOE areas—Portions of the LEHR Federal Facility (defined in Section 1.1) areas where CERCLA or California groundwater protection standards are exceeded (i.e., the SWT area, the Ra/Sr Treatment Systems area, DSSs 3 and 4, Dry Wells A–E, and the EDPs area) (Figure 1−2).
- UC Davis areas—Portions of the LEHR Site that include Landfill Disposal Units 1, 2, and 3; the 49 waste burial holes; the eastern and southern disposal trenches; and groundwater (Figure 1−2).

LEHR is located immediately east of Old Davis Road, about 2,500 feet (ft) south of U.S. Interstate 80 in Solano County, California, in the southeast quarter of Section 21, Township 8 North, Range 2 East, Mount Diablo Base and Meridian (Figure 1−1). The former LEHR facility (Figure 1−2) is located on the southern portion of Solano County Assessor's Parcel Number 110-05-04. It is approximately 1.5 miles south of the city of Davis, in the southeast portion (South Campus Area) of the UC Davis campus.

The LEHR/Old Campus Landfill was placed on the National Priorities List (Superfund Site Identification No. CA2890190000) in May 1994 because contamination at the site was considered to pose significant risk to human health and/or the environment.

DOE is the lead agency responsible for the remediation of the environmental impacts associated with past activities at the LEHR Federal Facility portion of the LEHR/Old Campus Landfill. DOE is remediating the site with support from EPA Region 9, and the State of California's DTSC, the Central Valley RWQCB, and the Department of Public Health, Radiologic Health Branch. The remediation is funded by DOE Office of Legacy Management.

The site is presently occupied by the UC Davis Center for Health and the Environment, which conducts toxicology, epidemiology, radiation biology, and radiochemistry research. Site facilities currently consist of 16 buildings, including a main administration and office building, two former animal hospitals, a laboratory, and support buildings (Figure 1−2). Former facilities include radioactive wastewater treatment systems, an indoor/outdoor Co-60 irradiation field, a radioactive waste burial area, and outdoor dog pens. Presently inactive campus landfill units and numerous disposal sites (i.e., trenches and holes) were used to dispose of waste from campus activities and are being evaluated by UC Davis.

From 1958 to 1988, research at LEHR focused on the long-term health effects of low-level radiation on laboratory animals. The research projects were funded primarily by DOE. Disposal of chemical and radioactive laboratory and campus waste resulted in soil and groundwater contamination at LEHR.

DOE and the Regents of the University of California entered into a Memorandum of Agreement to allocate responsibility for environmental restoration of the LEHR/Old Campus Landfill Superfund Site (DOE 2009). Under this agreement, DOE is responsible for environmental restoration of environmental impacts associated with the LEHR Federal Facility, and UC Davis is responsible for environmental restoration of Old Campus Landfill areas, including but not limited to, Land Disposal Units 1, 2, and 3; the 49 waste burial holes; the UC Davis disposal trenches; and site groundwater impacts not associated with DOE's activities (Figure 1−2) (DOE 2009).

2.1.1 Areas Requiring No Action or No Further Action

DOE released all of the LEHR buildings to UC Davis for unrestricted use in compliance with DOE Order 5400.5, *Radiation Protection of the Public and the Environment,* and accelerated site cleanup by completing several removal actions that successfully addressed principal environmental threats at the LEHR Federal Facility. Following the removal actions, risks to human health and the environment were estimated for the DOE Disposal Box, DSS 1, DSS 5, DSS 6, DSS 7, and WDP areas in the *Site-Wide Risk Assessment* (Weiss 2005). Human health and ecological risk characterizations were performed to examine the strengths and weaknesses of lines of evidence indicating whether constituents of potential concern (COPCs) pose significant risks (WA 2005; BBL 2006). A groundwater risk characterization was included in the human health risk characterization document (WA 2005). As documented in their approval of *Site-Wide Risk Assessment, Volume I Human Health Risk Assessment (Part B Risk Characterization for DOE Areas)* (WA2005), the remedial project managers made a risk management decision that the risks were insignificant and no further action is required at the following areas of the LEHR Federal Facility:

- DSSs areas other than DSSs 3 and 4;
- DOE Disposal Box; and
- WDPs.

Similarly, based on DOE's compliance with DOE Order 5400.5 for release of property for unrestricted use (62 FR 51844–51845), no action or no further action is required at:

- All LEHR buildings (including the Imhoff Wastewater Treatment Facility demolished in 1995) (see Section 2.4.1); and
- Co-60 irradiation field (no identified contamination and no potential for contamination based on historical use).

These areas and their disposition are shown on Figure 1−2 and are discussed further in Sections 2.2 and 2.4.

2.1.2 Areas Requiring Additional Action

The following areas of the LEHR Federal Facility require additional action because they contain contaminants that present potential excess cancer risks of above 1 in 1 million (see Section 2.7 for discussion of risk) or have the potential to impact groundwater quality within the next

500 years by increasing contaminant concentrations in groundwater above background concentrations:

- Ra/Sr Treatment Systems area;
- DSSs 3 and 4 and Dry Wells A–E;
- SWT area; and
- EDPs area.

No ecological risks were identified in these areas (BBL 2006).

2.2 Site History and Enforcement Activities

As shown on Figure 2−1, the U.S. Atomic Energy Commission first sponsored radiological studies on laboratory animals at UC Davis in the early 1950s. Initially situated on the main campus, LEHR was relocated to its present location in 1958 (Figure 1−1). Research at LEHR through the late 1980s was focused on health effects from chronic exposure to radionuclides, primarily strontium-90 (Sr-90) and radium-226 (Ra-226), using beagles as research subjects. Other related research was conducted at the site concurrently with these long-term studies. In the early 1970s, a Co-60 irradiator facility was constructed at the site to study the effects of chronic exposure to gamma radiation on humans, again using beagles.

A campus landfill with two waste burial units that were used from the 1940s until the mid-1960s is located at the site (Figure 1−2). Several low-level radioactive-waste burial areas were also present at the site, and campus and LEHR research waste was buried in these areas until 1974 in accordance with regulations in effect at the time. The principal environmental threats posed by contaminant releases associated with LEHR activities have been mitigated during several removal actions conducted at the site since 1996.

All DOE-funded research activities at LEHR had ceased by 1988, and in the same year, pursuant to a Memorandum of Agreement between DOE and the University of California, DOE's Office of Energy Research initiated activities to close out the research program at LEHR.

In May 1994, EPA added the site to the National Priorities List. In 1995, DOE demolished the Imhoff Wastewater Treatment Facility (Figure 1−2) as a voluntary removal action, and by 1997, DOE had completed building decontamination and decommissioning (62 FR 51844–51845). In 1997, a second Memorandum of Agreement divided the responsibility for environmental remediation between DOE and the Regents of the University of California (DOE 1997). By December 1999, DOE entered into a Federal Facility Agreement with EPA, RWQCB, DPH, and DTSC, whereby DOE is responsible for the remediation of the Ra/Sr Treatment Systems; a waste burial area known as the DOE Disposal Box; on-site domestic septic tanks, associated leach fields, and dry wells; DOE disposal trenches; and the former Dog Pens (EPA 1999). Under a separate agreement with EPA and the state agencies, UC Davis is responsible for remediation of three landfills, disposal trenches located south and east of Landfill No. 2, 49 waste holes, an old wastewater treatment plant, groundwater impacted by the site, and surface water and storm water runoff impacted by UC Davis.

Since entering into the Federal Facility Agreement in 1999, DOE conducted additional soil and groundwater characterization and removal of contaminated underground tanks, trench structures,

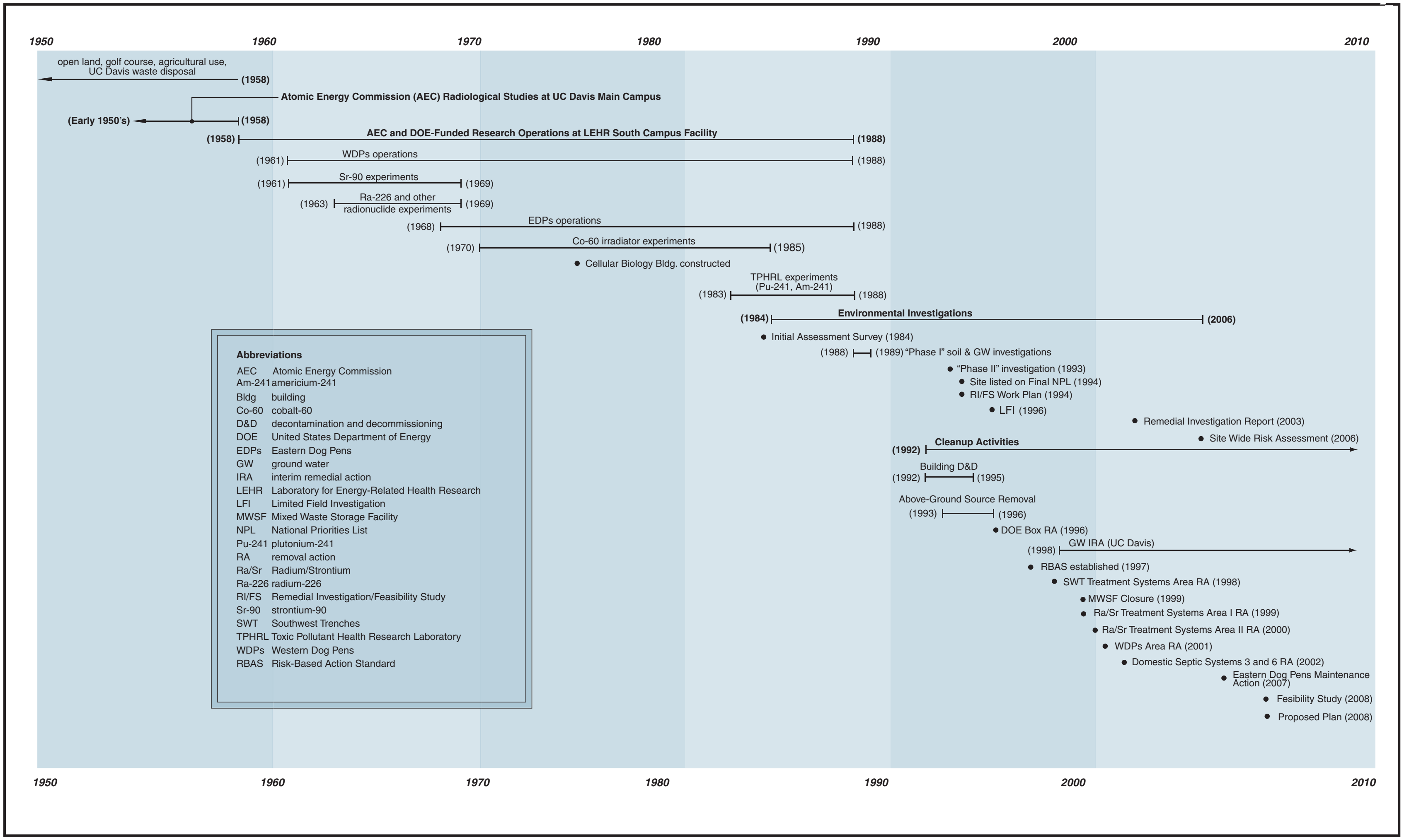

Figure 2−1. Timeline of Operation and Cleanup Activities at the LEHR Federal Facility and contaminated soil at the site in accordance with the requirements of Section 300.415 (b)(4)(I) of the NCP, as discussed in Section 2.4.1. Removal actions at the DOE areas were completed in 2002.

In 2005, DOE transferred ownership of all of DOE's LEHR buildings and associated utilities to UC Davis. Title to the buildings and utilities was transferred to the Regents of the University of California by a quitclaim deed, effective July 1, 2005. UC Davis requested, and the California Department of Health Services granted, an amendment to their Broadscope Radioactive Materials License No.1334-57, to cover buildings released by DOE. In 2009, DOE and the Regents of the University of California established a Memorandum of Agreement (DOE 2009) which:

- Assigned to DOE the responsibility for remediation of groundwater impacts from DOE areas;
- Allows DOE to implement land-use restrictions in accordance with the Proposed Plan and this ROD; and
- Provides DOE and its agents reasonable access to the DOE areas for the purpose of conducting long-term monitoring, maintenance, and contingent remediation.

2.3 Community Participation

A Proposed Plan was made available to the public in October 2008 (DOE 2008). This document, as well as other documents related to the cleanup of DOE areas at LEHR, can be found in the Administrative Record online at http://www.lm.doe.gov/land/sites/ca/lehr/lehr.htm and at the Information Repository located at the Yolo County Library in Davis, California. A notice of availability of the Proposed Plan and other site documents was published in the *Davis Enterprise* on October 10 and 23, 2008. A public comment period on the Proposed Plan extended from October 15 to November 17, 2008. In addition, a public meeting was held in Davis on October 23, 2008, to present the Proposed Plan to the community. At this meeting, the community was provided the opportunity to comment on the Proposed Plan. DOE's responses to the comments received during this period and at the community meeting are included in a "Responsiveness Summary" in Section 3.0 of this document.

A local community group known as the Davis South Campus Superfund Oversight Committee has participated in the project since 1995. Representatives of this community group have attended most remedial project manager meetings held since 1995.

2.4 Scope and Role of Response Action

2.4.1 Past Response Actions

As shown on Figure 2−1, prior to entering into the Federal Facility Agreement in 1999, DOE conducted a building assessment; decontamination and decommissioning of aboveground structures; and the following investigations and removal actions:

- In 1975, gravel and curbing were removed from 64 pens in the WDPs.
- In 1984, Rockwell International conducted an Initial Assessment Survey to obtain data and perform an initial characterization of the nature and extent of radioactive and chemical contamination at the LEHR site. Surface and subsurface investigations were

conducted in all the DOE potential source areas except the DSS and DOE Box areas (Rockwell 1984).

- From late 1987 through 1988, Wahler Associates conducted investigations to determine potential low-level radioactive sources at the LEHR Federal Facility. Surface and subsurface investigations were conducted in the SWT, Ra/Sr Treatment Systems area, WDP and EDP areas, and the vicinity of the DOE Box. The first groundwater investigation at the LEHR site was conducted in 1987 (Wahler 1989).
- In 1988, DOE signed a Memorandum of Agreement with UC Davis that allowed UC Davis to use some of the LEHR buildings for non-DOE research. On September 8, 1988, UC Davis corresponded with the California Department of Health Services to amend their Broadscope Radioactive Materials License No. 1334-57 to include the following buildings: Maintenance Shop (H-212), Main Building (H-213), Reproductive Biology Laboratory (H-215), Inter-Regional Project No. 4 (H-217), Occupational and Environmental Medicine Building (H-289), Co-60 Annex (H-290), Geriatrics Building Number 1 (H-292), Geriatrics Building Number 2 (H-293), Cellular Biology Laboratory (H-294), Small Animal Housing (H-296), Toxic Pollutant Health Research Laboratory (H-299) and Storage Space (H-300). With the amendment of their State of California Broadscope Radioactive Materials License, UC Davis has accepted responsibility for any future release of these buildings.
- Between 1989 and 1993, Dames and Moore (D&M) conducted several investigations to evaluate the potential source areas at the LEHR site (D&M 1991; D&M 1993).
- In 1995, Pacific Northwest National Laboratory conducted surface and subsurface investigations in the SWT and at DSS 2. Surface and subsurface investigations were conducted in all of the DOE potential source areas except for the DSS and DOE Box areas.
- In 1995, DOE demolished the Imhoff Wastewater Treatment Facility (Figure 1−2) as a voluntary removal action.
- In 1995–96, concrete pedestals and wooden barrels were removed from the EDPs and WDPs and disposed of as low-level radioactive waste at Hanford (WA 1997b).
- In 1996, IT Corporation conducted a Limited Field Investigation (LFI) to collect data necessary to evaluate whether sources associated with the LEHR Federal Facility potentially pose an unacceptable threat to human health and the environment. The LFI included investigations of the SWT area, Ra/Sr Treatment Systems area, and DSSs 1 and 7 (WA 1997b).
- In 1996, IT Corp. also removed the WDP and EDP pedestals and collected soil and gravel data during the removal activities (WA 1997b).
- From 1996 to 1999, Weiss Associates (WA) conducted several data gaps investigations to collect additional data on the DSSs, WDPs, and EDPs (WA 1998a; WA 1998b; and WA 1999).
- Between August and September 1996, the Agency for Toxic Substances and Disease Registry (ATSDR) collected four composite samples each of Putah Creek fish, sediments, and water to determine if the LEHR site activities had impacted the creek. The fish, sediment, and water samples were analyzed for radionuclides, metals, pesticides, and semivolatile organic compounds (ATSDR 1997).

- Before entering into the Federal Facility Agreement in 1999, DOE decommissioned, decontaminated, and released for unrestricted use four of the 17 buildings associated with the LEHR Federal Facility (Figure 1−2) that did not meet the release criteria of DOE Order 5400.5 for unrestricted use (Animal Hospital 1 building, Animal Hospital 2 building, Specimen Storage building, Co-60 building) (Figure 1−2). A notice of certification of the radiological condition of this real property was published in the *Federal Register* on October 3, 1997 (62 FR 51844–51845).

  Ongoing groundwater monitoring of selected wells has occurred since 1990. In 1997, the Memorandum of Agreement between DOE and the Regents of the University of California transferred responsibility for groundwater and surface water sampling from DOE to UC Davis. Groundwater analytical results, proposed monitoring plan changes, and the rationale for these changes are presented in annual water monitoring reports (D&M 1999, D&M 2000; URS 2001).

These actions were conducted outside of the scope of the Federal Facility Agreement. The LFI and subsequent investigations conducted from 1996 to 1999 (after the LEHR Federal Facility was placed on the National Priorities List), including a time-critical removal action at the DOE Disposal Box area in 1996 and a non-time-critical removal action at the SWT area in 1998, were performed in accordance with NCP requirements.

After entering into the Federal Facility Agreement in 1999, DOE completed the following removal actions that successfully addressed principal environmental threats at the site:

- A non-time-critical removal action in the Ra/Sr Treatment Systems area in 1999 and 2000. DSS 2, parts of DSS 1, and parts of the DSS 5 leach field were removed during the removal action at the Ra/Sr Treatment Systems area (Figure 1−2).
- A non-time-critical removal action in the WDPs area in 2001.
- A non-time-critical removal action in the DSS 3 and 6 areas in 2002.

These removal actions were conducted in compliance with the requirements of Section 300.415 (b)(4)(I) of the NCP, which mandates the development and approval of an Engineering Evaluation/Cost Analysis prior to conducting a removal action. In 2007, DOE also conducted a non-CERCLA maintenance action that consisted of the removal and disposal of concrete from the EDPs.

A risk assessment at the DOE Disposal Box conducted after the completion of the removal action in this area (WA 2005) showed that no risk to human health, ecological receptors, or groundwater quality remained in the area; hence, no further action is required in the DOE Disposal Box. A risk assessment performed after the four non-time-critical removal actions in the SWT, Ra/Sr Treatment Systems, DSS 1, 2, 3, 5, 6, and WDPs areas showed that excess risk to human health from contaminants in all of these areas, except for the SWT area, was reduced to below 1 in 1 million (WA 2005), and ecological risks were insignificant after the removal actions (BBL 2006). Risks to human health were above 1 in 1 million at the DSS 4 and the EDPs (WA 2005), but ecological risks were insignificant (BBL 2006). Risks to groundwater remain at the SWT, Ra/Sr Treatment Systems, the Dry Wells, and DSS 3 and 4 areas and require additional action as discussed in Section 2.7.2. No further action is required at the WDPs and DSSs 1, 2, 5, and 6.

2.4.2 Future Response Actions

As a result of prior voluntary removal actions, actions conducted in compliance with the NCP, and building decontamination activities conducted in compliance with DOE Order 5400.5, the mass of residual contamination in the DOE areas is very low, and site risks are either at or below state and federal human health risk thresholds for current and projected site use as a research facility (WA 2005). As discussed in Section 2.7.2, site risks are also below the level of concern for all ecological receptors (BBL 2006). However, under a hypothetical residential land-use scenario, risk estimates discussed in Section 2.7.1 suggest that residual soil contamination in some areas could pose a risk to an on-site resident. Groundwater fate and transport modeling also indicate that residual soil contamination could impact groundwater. The areas where such risks remain are the SWT area, the Ra/Sr Treatment Systems area, DSS 3, DSS 4, Dry Wells A–E, and the EDPs (WA 2005).

The selected response actions for each of these areas are summarized in Table 2−1 and described in Section 2.13, and the components of each alternative are detailed in Section 2.10. The selected remedies for all areas except the DSS 4 combine groundwater monitoring/contingent remediation to detect and prevent future contaminant migration with the implementation of a Soil Management Plan to prevent exposure to contaminated subsurface soils. Additional restrictions prohibiting residential land use will be implemented at the DSS 4. These actions will be undertaken in compliance with the requirements of the NCP and in accordance with the Federal Facility Agreement discussed in Section 2.2 above.

Table 2−1. Selected Remedies for Each DOE Area

DOE Area	No Action/No Further Action	Long-Term Groundwater Monitoring/Contingency Remediation	Land-Use Restrictions	
			Soil Management Plan	No Residential Use
DSS 1	✓			
DSS 3		✓	✓	
DSS 4		✓	✓	✓
DSS 5	✓			
DSS 6	✓			
DSS 7	✓			
DOE Disposal Box	✓			
Dry Wells A–E		✓	✓	
EDPs			✓	
Ra/Sr Treatment Systems		✓	✓	
SWT		✓	✓	
WDPs	✓			

DSS Domestic Septic System
EDPs Eastern Dog Pens
Ra/Sr radium/strontium
SWT Southwest Trenches

In addition to future action to be undertaken by DOE, UC Davis is in the process of evaluating remedies for the landfills and existing groundwater contamination. Soil contamination remaining at the EDPs will be considered in the evaluation of options for this area and in the selection of a final remedy by EPA.

No further actions will be taken at the buildings, DSS 1, DSS 5, DSS 6, DSS 7, WDPs, and DOE Disposal Box areas as shown in Table 2−1 and discussed in Section 2.4.1. Contaminant concentrations have been reduced at these areas to levels acceptable for unrestricted use under CERCLA and ARARs.

2.5 Site Characteristics

2.5.1 Conceptual Site Model

The overall conceptual site model for the DOE areas is shown in Figure 2−2. The model depicts the areas with residual contamination and underlying groundwater resources.

2.5.2 Site Overview

LEHR is situated on the southern portion of a flat 15-acre parcel (Solano County Assessor's Parcel Number 110-05-04) owned by the Regents of the University of California. The LEHR site is located in Solano County, California, in the southeast quarter of Section 21, Township 8 North, Range 2 East, Mount Diablo Base and Meridian (Figure 1−1). The site is approximately 1.5 miles south of the City of Davis and is bounded by UC Davis research facilities, private farmland, and the South Fork of Putah Creek. The southern boundary of the LEHR site is the northern levee of the South Fork of Putah Creek.

The South Fork of Putah Creek is the only surface water body near the LEHR site. In 1872, Putah Creek was redirected to what is now called the "South Fork" to divert floodwaters away from the City of Davis and the UC Davis main campus. The South Fork channel is separated from LEHR by a levee. The South Fork of Putah Creek is a losing stream (i.e., recharges groundwater). The creek is typically bordered by dense vegetation and small trees within and adjacent to the channel. Federal flood maps indicate that the 100-year floodplain is confined within the Putah Creek levees at the southern LEHR boundary.

LEHR and its vicinity are in the Putah Plain of the Sacramento Valley (DWR 1978), which consists of alluvial fan deposits associated with Putah Creek. These alluvial deposits are approximately 180 ft thick and consist primarily of silt and clay with localized, interfingered, coarse-grained sediments (DWR 1978). Beneath LEHR, the sediments are nearly flat-lying and overlie the Tehama Formation, which consists of silts and clays with discontinuous lenses of coarse sands and gravel and is the principal water-bearing geologic unit on the west side of the Sacramento Valley.

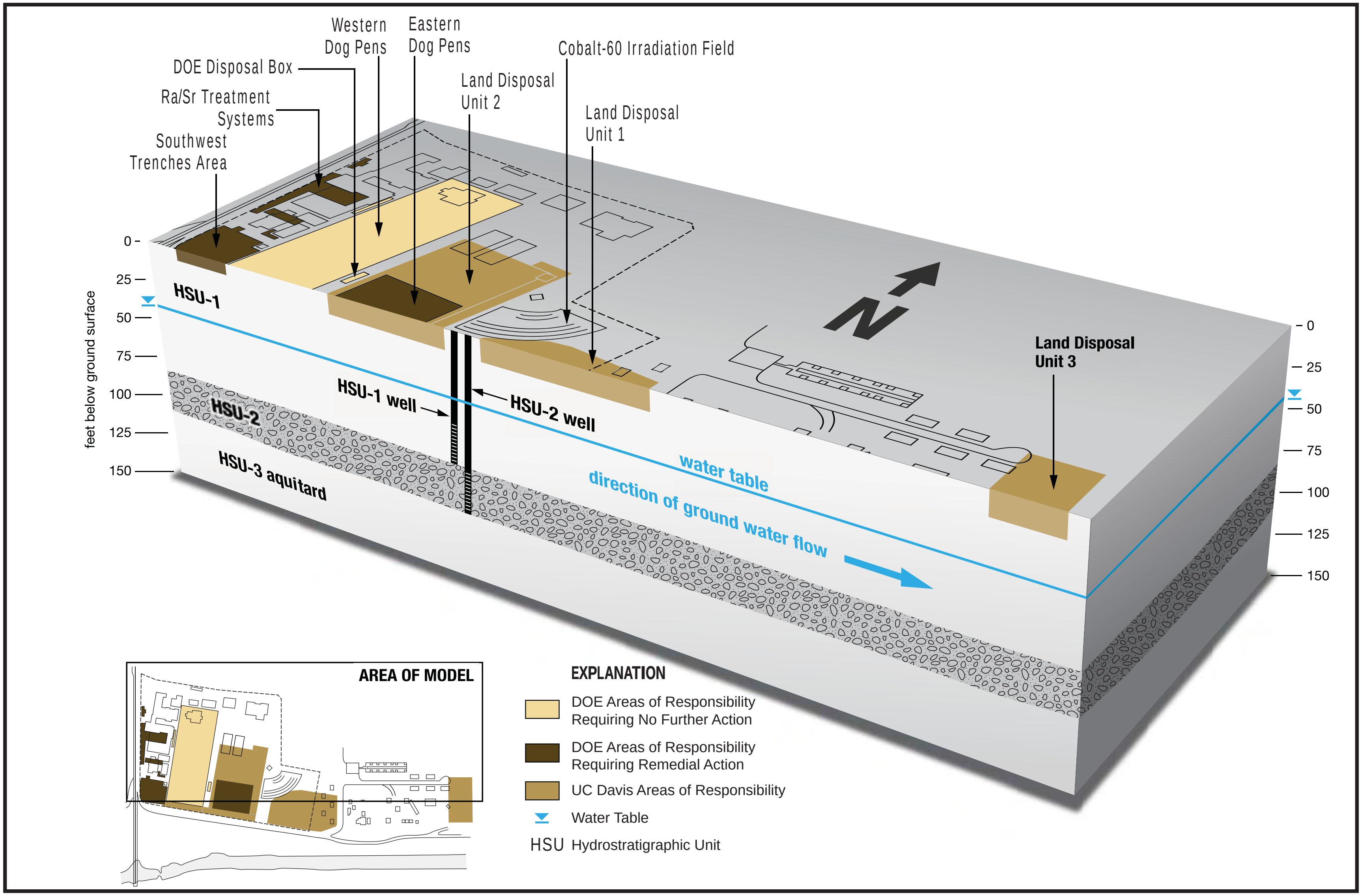

Figure 2–2. Conceptual Site Model for DOE Areas

In the vicinity of the LEHR site, groundwater generally flows east toward the Sacramento River (D&M 1993). 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 groundwater, which has historically ranged from 15 to 65 ft below ground surface (bgs). The vadose zone consists primarily of unsaturated clay and silt with lesser amounts of interbedded sand and gravel. HSU-1 extends from the bottom of the vadose zone to a depth of approximately 76 to 88 ft bgs. This unit is lithologically similar to 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. HSU-3 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).

The HSU-1 lateral gradient across the LEHR site typically ranges from 0.01 to 0.04 ft/ft, predominantly to the northeast. Representative values of HSU-1 horizontal hydraulic conductivity are between 1×10^{-4} and 1×10^{-7} centimeter per second (cm/s) (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, although it can occasionally be east-southeast. Based on pumping tests, hydraulic conductivity in HSU-2 ranges from 0.26 to 0.43 cm/s (D&M 1997).

Available data for HSU-3 and HSU-4 are insufficient to evaluate lateral gradient magnitude and direction, or hydraulic conductivity ranges.

Structures at the site include 16 of the 17 original buildings used for DOE-funded research shown on Figure 1−2, laboratory and support buildings, and areas of former animal-handling facilities that were used by DOE (Figure 1−2): Maintenance Shop (H-212); Main Building (H-213); Clinical Pathology (formerly Reproductive Biology) Laboratory (H-215); Specimen Storage (H-216); Inter-regional Project No. 4 (H-217); Animal Hospital No. 2 (H-218); Animal Hospital No. 1 (H-219); Co-60 Building (H-229); Occupational and Environmental Medicine Building (H-289); Co-60 Annex (H-290); Geriatrics Building No. 1 (H-292); Geriatrics Building No. 2 (H-293); Cellular Biology Laboratory (H-294); Small Animal Housing (H-296); Toxic Pollutant Health Research Laboratory (H-299); Storage Space (H-300); cobalt-60 irradiation field; and the former dog pen areas. The Former Imhoff Wastewater Treatment Facility shown on Figure 1−2 was demolished by DOE in 1995. The following subsurface features, mainly associated with disposal and treatment of waste generated at the laboratories, supported the facilities: southwest trenches; the Sr-90 and Ra-226 leach fields and the Ra-226 waste tanks; seven septic tanks; Imhoff storage tanks; and the DOE Disposal Box (Figure 1−2). The LEHR site, including the buildings, is currently used for academic research.

There are no known archeological or cultural resources at or beneath the LEHR site.

2.5.3 Sampling Strategy

Prior to 1994, investigations were conducted at the LEHR DOE areas to determine if soil and groundwater were contaminated. Soil samples were collected from exploratory trenches and soil borings. Monitoring wells were installed, and groundwater samples were collected. Sludge and liquid grab samples were collected from the radium and strontium tanks and domestic septic system tanks. Beginning in 1994, sampling was conducted according to CERCLA data quality standards. Between 1996 and 2002, removal actions were conducted in various DOE areas. After each removal action, confirmation soil samples were collected from excavation floors and sidewalls using statistically designed random grid sampling plans. Discretionary soil samples were also collected to supplement the removal action confirmation data. Soil boring samples were collected at DOE areas to characterize the vertical extent of COPCs.

Area-specific details of previous investigations are presented in the Site Characteristics sections for individual DOE areas.

2.5.4 Sources of Contamination

Buried laboratory waste and subsurface discharges of treated laboratory wastewater were the primary sources of contamination at the LEHR DOE areas. Site characterization data indicated that contamination was released from the buried waste to the soil.

All of the buried waste and wastewater treatment systems and associated contaminated soil were excavated and disposed of off site during removal actions that occurred between 1996 and 2002. Only limited amounts of residual contamination currently remain in the DOE areas. The residual contamination is a minor threat to groundwater resources and human health. The infiltration of surface and rain water can potentially move some of the residual contaminants through the vadose zone to groundwater.

2.5.5 Types of Contamination and Affected Media

This ROD addresses soil contamination only. Two types of soil COCs are addressed:

- COCs that may potentially impact groundwater in the future (groundwater COCs; discussed in Section 2.5.7).
- COCs that may potentially impact human health (human health COCs; discussed in Section 2.7.1).

The types of contamination and affected media are discussed in the Site Characteristics sections for each individual DOE area. All the human health COCs for the DOE areas are carcinogens.

There are no Resource Conservation and Recovery Act hazardous wastes in DOE areas.

2.5.6 Location of Contamination and Routes of Migration

Researchers and students working at the site, construction workers conducting work at the site, and visitors to the site can become exposed to residual contamination through incidental ingestion of soil, dermal contact with soil, and inhalation of soil particulates dispersed in air.

Discussions of the location of contamination and known or potential routes of migration are presented in the Site Characteristics sections for individual DOE areas.

2.5.7 Groundwater Contamination

The site is underlain by river- and creek-deposited alluvial sediments. Two layers of alluvium are important to DOE areas of the site. The first unit of alluvium, identified as HSU-1, extends from ground surface to approximately 80 ft bgs and consists of sandy/silty clay with occasional sand layers. The second unit of alluvium, HSU-2, consists of sand and gravel located approximately 80 to 135 ft bgs (Figure 2−2).

Groundwater within HSU-1 is not used because of low yield and poor natural water quality (high dissolved solids). Some site contamination has impacted groundwater in this unit. However, this impact is limited and is predicted to remain on site. HSU-2 is a high-yield aquifer that is used for local agricultural and domestic water supplies.

The water table at the site varies seasonally from approximately 20 to 60 ft bgs. Additional deeper water-bearing units of alluvial deposits are present but have not been affected by DOE activities.

Groundwater near the site generally flows to the northeast. A number of nearby domestic and irrigation wells draw water from HSU-2. UC Davis monitored these wells and determined that they are not impacted by site contaminants. Additionally, UC Davis maintains a network of monitoring wells on and around the site to monitor water quality.

Contaminants that have impacted or could impact HSU-1 groundwater are listed in Table 2−2. Based on very conservative screening, vadose zone modeling, and characterization process, DOE determined that these soil contaminants were a potential concern to groundwater due to estimates of future migration.

The screening approach, vadose zone model, and the characterization process are discussed below. Based on conservative contaminant loading estimates, DOE concluded that residual contamination has extremely limited potential to migrate off site in groundwater. The contaminant loading estimates are also discussed below.

2.5.7.1 Groundwater Contaminant Screening

Soil sample data for detected analytes in each DOE area were screened on the basis of remedial project manager–established thresholds for detection frequency, background comparison, transport potential (K_d), biodegradation and/or decay (WA 2001a; WA 2001b; WA 2003). Analytes showing concentrations above these thresholds were evaluated using the contaminant transport model described below.

Table 2−2. Summary of Contaminant Loading Estimates for Soil to Groundwater Contaminant Migration

Area	COC	Estimated Mass (kilograms)	Impact at Groundwater Goal[1]			Impact at Groundwater Background[2]		
			Goal (µg/L or pCi/L)	Affected Area[3] (acres)	Diameter (ft)	Background (µg/L or pCi/L)	Affected Area[3] (acres)	Diameter (ft)
Ra/Sr TS	Nitrate	400	10,000	3.6[8]	446	25,000	1.3[8]	269
	Carbon-14	1.9E-7	2,000[4]	0.038	46	3.5	1.5	290
	Radium-226	1.2E-6	5	0.010	23	1.14	0.042	48
DSS 3	Formaldehyde	5.7	100[5]	5.1	531	<50[9]	20	1,061
	Molybdenum	4.9	180[6]	0.026	38	14.9	0.31	131
	Nitrate	92	10,000	0.83[8]	214	25,000	0.30[8]	129
DSS 4	Selenium	0.027	50	0.0020	10	5.67	0.018	31
Dry Wells A-E	Chromium	6.0	50	0.12	81	25	0.24	114
	Hexavalent Chromium	0.025	50	5.0E-04	5.3	39.4	6.3E-04	5.9
	Mercury	0.18	2	0.032	42	0.1	0.63	187
	Molybdenum	0.092	180[6]	4.8E-04	5.2	14.9	5.8E-03	18
	Silver	2.7	100[7]	0.060	58	5	1.2	257
	Cesium-137	1.4E-10	200[4]	1.2E-06	0.26	1	2.4E-04	3.6
	Strontium-90	1.1E-10	8	9.8E-04	7.4	1.7	0.0046	16
SWT	Nitrate	270	10,000	2.4[8]	365	25,000	0.88[8]	220
	Carbon-14	5.6E-7	2,000[4]	0.11	79	3.5	4.5	498

Notes

These calculations do not predict maximum concentrations.

[1]Groundwater concentration does not exceed groundwater goal (California MCL Title 22 *Code of California Regulations* [CCR] Sections 64431, 64441, and 64443, unless otherwise noted).

[2]Groundwater concentration does not exceed site background (concentrations in groundwater from upgradient HSU-1 well UCD1-018 [WA 2005]).

[3]Area within HSU-1 aquifer.

[4]Goal is based on the derived limit for drinking water from the 4 millirem per year federal MCL for beta particles and photon emitters (EPA 2000).

[5]Formaldehyde goal is based on the California Department of Public Health Notification Level of 100 µg/L (California Health and Safety Code Section 116455).

[6]Goal is based on the EPA Region 9 regional screening level for tap water (EPA Region 9 2009).

[7]Goal is based on the California secondary MCL for drinking water (Title 22 CCR Section 64449).

[8]The estimated area of impact for nitrate at the MCL is greater than at background because the MCL is below background.

[9]Not detected in background well. One-half the detection limit (<50 µg/L) used in area and diameter calculation.

µg/L   micrograms per liter
pCi/L   picocuries per liter

2.5.7.2 Vadose Zone Modeling

A one-dimensional numerical model code was used to simulate contaminant transport from surface and shallow subsurface DOE area sources through the vadose zone. Vadose zone transport simulations were performed using the Non-Isothermal Unsaturated Flow and Transport (NUFT) (Nitao 1998) computer program developed and validated by Lawrence Livermore National Laboratory. The results of vadose zone modeling were used to estimate the time required for residual contaminants in soil to migrate through the vadose zone and to determine soil cleanup levels protective of groundwater quality (designated levels). Because of the one-dimensional nature of the NUFT model, the mass of contamination and the volume of contaminated groundwater that might be produced from residual vadose zone contamination were not modeled. Estimates of these impacts are discussed below.

Initial vadose zone model development and parameter selection/justification was presented in the *Draft Final One-Dimensional Vadose Zone Modeling for the Laboratory for Energy-Related Health Research* (WA 1997a) report. This report documented the basic modeling approach and parameter selection process that was used in subsequent simulations. Modeling refinements that increased site-specific versatility and simulation efficiency were documented in the *Final Work Plan for Removal Actions in the Southwest Trenches, Ra/Sr Treatment Systems, and Domestic Septic System Areas* (WA 2000).

The modeled designated levels were determined according to the *Designated Level Methodology for Waste Classification and Cleanup Level Determination* (CRWQCB 1989). The primary hydrogeologic parameters and their supporting assumptions are:

- Depth to groundwater: The smallest seasonal depth to the water table (20 ft) during years of above-average precipitation at the site was used in the model.
- Infiltration: 10.8 cm/year corresponding to 25 percent of the mean annual precipitation rate was used. The infiltration was assigned to the model at a constant rate, resulting in continuous vertical flux toward the water table. The infiltration rate represents a reasonable maximum in an area with high evapotranspiration rates that reverse the direction of infiltration flux throughout most of the year.
- Dispersion: No dispersion was used for any of the COCs.
- Dilution: A thin aquifer thickness at the bottom of the model was used to represent the top of the water table as a receptor. Dilution is therefore negligible, and this assumption results in an overestimate of the concentrations of COCs in groundwater.

2.5.7.3 Characterization of Contaminants with Potential to Impact Groundwater

If downgradient groundwater monitoring data showed concentrations above background, or if modeling results indicated impact above groundwater goals within 500 years, a detailed groundwater risk characterization was performed (WA 2005). Spatial distribution, presence in groundwater, predicted impact timing/magnitude, analytical uncertainty, sample data representativeness, and other factors were evaluated. The risk characterization used multiple lines of evidence to evaluate uncertainties and identify the final groundwater COCs that are the basis of remedial action decisions.

2.5.7.4 Contaminant Loading Estimates for Soil to Groundwater Contaminant Migration

In addition to the groundwater COC identification process, DOE made conservative estimates of the potential diameter and area of impact in HSU-1 for individual COCs (contaminant loading). Estimates of the area and diameter of groundwater contamination that would result if the entire mass of a COC in soil were to be immediately transferred into the shallowest water-bearing unit were calculated and presented in the DOE Areas Feasibility Study (WA 2008a). These calculations do not predict maximum concentrations. The resulting plume was assumed evenly distributed over an area in HSU-1 at concentrations equal to the groundwater goals (i.e., the California maximum contaminant level [MCL] for drinking water or the site background concentration). No degradation was assumed. The procedures involved in this calculation included estimating the mass of contamination in the vadose zone and the resulting groundwater plume area and diameter for each COC in the DOE areas. The estimated masses of COCs in the vadose zone, estimated groundwater plume areas, and plume diameters are shown in Table 2−2. The actual areas of groundwater impacts are expected to be markedly less due to the dilution and dispersion of all constituents, and the degradation of formaldehyde and nitrate.

2.6 Current and Potential Site Uses

2.6.1 Land Uses

UC Davis currently operates the Center for Health and the Environment at the former LEHR facility. Research activities at the Center for Health and the Environment include the study of toxic and carcinogenic agents and occupational health (UC Davis 2003). These activities are likely to continue in the foreseeable future.

The site is designated as “Urban and Built-up Land” by the State of California Department of Conservation Farmland Mapping and Monitoring Program (UC Davis 2003). Specific land uses on the site and in the adjacent areas are under the control of UC Davis. The UC Davis Long-Range Development Plan (UC Davis 2003), which presents the land-use plans throughout the 2015–2016 academic year, designates the LEHR site as “Academic/Administrative Low Density” and “Support Services.” It is expected that the uses of the site after 2016 will continue to be consistent with the Long-Range Development Plan and will include academic and support services.

DOE’s selected remedies for the DOE areas do not conflict with the Long-Range Development Plan. The selected remedies require the implementation of a Soil Management Plan at the DOE areas and prohibit residential use of the DSS 4 area. The Soil Management Plan will set out requirements that prevent exposure to subsurface contaminants and will not significantly constrain UC Davis’s land-use options. The land-use restriction at the DSS 4 area, prohibiting residential use of this area, is consistent with the anticipated land use of the site as nonresidential.

Privately owned property and land owned by the Regents of the University of California surround LEHR. Rural residences and croplands are located to the south, east, and northeast of the site. Most of the surrounding land in the general vicinity is used for agriculture; major crops include fruits, nuts, and grains. Recreational land uses in this area primarily involve fishing and swimming along nearby Putah Creek. The population within a 2-mile radius of the site is estimated to be about 5,000, based on 2008 US Census data for Yolo and Solano Counties. The majority of this population resides within the southern portion of the city of Davis.

2.6.2 Groundwater Uses

Groundwater at the site is not currently used for drinking water; however, the aquifer below the site is designated as a potential source of drinking water (CRWQCB 2007). Irrigation and domestic wells are located within 1 mile of the site (Table 2−3). The nearest well is about 1,100 ft south of LEHR.

Table 2−3. Summary of Off-Site Wells Within 1 Mile of the LEHR Site

Well Type	Direction from LEHR	Approximate Distance[1] (ft)
Agricultural	south-southwest	1,100
Domestic	south-southwest	1,600
Domestic	south	1,500
Agricultural	south	1,300
Domestic	southeast	1,900
Agricultural	southeast	1,900
Agricultural	east	2,600
Agricultural	east-northeast	4,400

[1]Shortest distance from LEHR Site boundary (Figure 1−1)

UC Davis is responsible for remediation of groundwater contamination beneath the LEHR site; however, DOE's selected remedy includes groundwater monitoring to ensure that soil contamination is not impacting groundwater beneath the DOE areas or beyond. Minimal impact is anticipated from the groundwater monitoring activity, as most of the monitoring wells needed for the monitoring program are presently installed, and installation of additional wells will be coordinated with UC Davis. If contingent remediation is required, it will be evaluated for consistency with all requirements, including UC Davis's future use of the site.

2.7 Summary of Site Risks

This section summarizes the process and results of the baseline risk assessment conducted for the LEHR Federal Facility to evaluate risks to human and ecological receptors that may be exposed to contaminants in soil, air, surface water, or groundwater from the LEHR Federal Facility if no remedial actions were implemented.

2.7.1 Human Health Risk Assessment

The human health risk assessment (HHRA) for DOE areas consisted of a Risk Estimate (UC Davis 2004a) and Risk Characterization (WA 2005). Risks to human health were estimated using exposure assumptions and contaminant toxicity data. The Risk Characterization characterized the risk values from the Risk Estimate with respect to multiple lines of evidence to identify uncertainties and characterize risks to provide the basis for risk management decisions for remedial action.

2.7.1.1 Identification of Constituents of Concern

The baseline HHRA Risk Estimate was conducted in two tiers. The first tier, the Tier 1 screening assessment, consisted of comparing area-specific maximum concentrations for each constituent and medium to EPA risk-based screening levels (EPA-ORNL 2002, EPA 2002). Constituents with concentrations that exceeded screening levels were considered COPCs and were quantitatively evaluated in a Tier 2 estimation of risks to persons who may be exposed to contaminants at the site.

Exposure point concentrations were determined for each COPC at the Tier 2 stage of the Risk Estimate by evaluating the statistical distribution and calculating the 95 percent upper confidence limit (95% UCL) on the mean concentration. The lower of the 95% UCL or maximum detected concentration was used as the representative exposure point concentration for estimating risk. The mathematical formulas and statistical procedures used to determine exposure point concentrations are described in detail in Sections 6.1 and 6.2 of the Risk Estimate (UC Davis 2004a).

Because metals and radionuclides may be naturally occurring, statistical tests described below were conducted concurrently with the Tier 1 and 2 analyses to determine whether the constituents were present above site background concentrations in each DOE area.

Risks were estimated for all complete pathways and receptors of concern whether or not the COPC was above background. COPCs with estimated risks above 1 in 1 million that were found in concentrations that statistically exceeded background were evaluated in the Risk Characterization as discussed in Section 2.7.1.4. COPCs with concentrations statistically equivalent or below the site background concentrations were not considered for remedial action.

Multiple lines of evidence and associated uncertainties were evaluated in the Risk Characterization to recommend COCs for remedial action decisions. Table 2−4 summarizes the statistical information for COCs that are statistically above background and that by the multiple lines of evidence were determined to present human health risks above 1 in 1 million.

Table 2−4. Statistical Summary of Human Health Constituents of Concern, Soil

DOE Area	COC	Frequency of Detection	Units	Mean (mg/kg or pCi/g)	95% UCL (mg/kg or pCi/g)	Max (mg/kg or pCi/g)	EPC (mg/kg or pCi/g)	Statistical Basis of EPC
Domestic Septic System No. 4								
	Benzo(a)anthracene	3/6	mg/kg	0.86	64 [2]	3.8	3.8	Max
	Benzo(a)pyrene	3/6	mg/kg	0.61	27 [2]	2.4	2.4	Max
	Benzo(b)fluoranthene	3/6	mg/kg	0.65	40[2]	2.7	2.7	Max
	Benzo(k)fluoranthene	3/6	mg/kg	0.46	10[2]	1.5	1.5	Max
	Dibenzo(a,h)anthracene	2/6	mg/kg	0.30	37[2]	1.1	1.1	Max
	Indeno(1,2,3-cd)pyrene	2/6	mg/kg	0.43	0.86	1.5	0.86	95% UCL
Southwest Trenches								
	Strontium-90	31/68	pCi/g	0.54	0.94	16	0.94	95% UCL
Eastern Dog Pens								
	Dieldrin	13/37	mg/kg	0.0091	0.019	0.22	0.019	95% UCL
	Strontium-90	23/68	pCi/g	0.37	0.62	8.3	0.62[1]	95% UCL

Notes

Source data from HHRA, Tables 2 and 3 (UC Davis 2004). The soil depth interval used to evaluate human exposure was 0−10 ft bgs.

[1]EPC (exposure point concentration) became 0.33 pCi/g after EDPs maintenance action was completed in 2007.

[2]The 95% UCL is significantly higher than the maximum concentration due to large standard deviation (large variation between lowest and highest concentration) and a low number of samples. The 95% UCL was not used to establish the EPC.

EPC exposure point concentration
Max maximum

Human health COCs at DSS 4 consist of six polycyclic aromatic hydrocarbon compounds with maximum concentrations in soil ranging from 1.1 milligrams per kilogram (mg/kg) to 3.8 mg/kg, and detection frequencies ranging from 33 percent to 50 percent of samples collected. Sr-90, the only human health COC in the SWT area, was detected in 46 percent of soil samples and had a maximum concentration of 16 picocuries per gram (pCi/g). Dieldrin and Sr-90 are human health COCs in the EDPs area. Dieldrin was detected in 35 percent of EDPs area soil samples, with a maximum concentration of 0.22 mg/kg. The maximum detected concentration of Sr-90 in EDPs area soil was 8.3 pCi/g, and Sr-90 was detected in 34 percent of samples collected. Soil is the only medium that contains human health COCs in DOE areas. The Ra/Sr Treatment System, DSS 3, and Dry Wells A–E areas have no human health COCs.

2.7.1.1.1 Background Comparison Statistics

Statistical comparisons of COPCs to site background were reported in Appendix B of the Risk Estimate (UC Davis 2004a). Soil samples collected from uncontaminated areas in the LEHR site vicinity provide a reference data set for soil background. It was assumed that the soil background concentration for organic chemicals is zero, although the existing background data showed that pesticides are present in soils at LEHR from their regional agricultural use. Metals and radionuclides are known to be naturally occurring and were compared to background.

The background soil data were initially evaluated for potential depth stratification, where due to ambient conditions, surface background soils (0 to 0.5 ft bgs) have statistically significant different concentrations than subsurface background soils (0.5 to 10 ft bgs). For constituents with concentrations in background surface soils that were different from concentrations in background subsurface soils, site surface soil data were compared to background surface soil data only. For all other constituents, data from both soil depth ranges were compared to the full set of background data from 0 to 10 ft bgs.

Most of the background to on-site comparisons were performed using the Mann-Whitney test (also known as the Wilcoxon rank-sum test), a nonparametric alternative to the Student’s t-test with type I decision error (alpha) equal to 0.05. The Mann-Whitney statistical comparison was performed when both background and site data sets had a frequency of detection greater than 50 percent and sample size greater than five samples. In these background comparisons, one-half the detection limit was used for a nondetect result of nonradiological constituents. For radionuclides, the resulting estimated value below the detection limit was used for nondetect results. The Mann-Whitney test determined whether concentrations in the on-site data set are statistically greater than, the same as, or less than background.

If the on-site or background data sets frequency of detection was lower than 50 percent, or their sample set was fewer than five, then the maximum on-site concentration was compared to the background upper tolerance limit (UTL). The UTLs used in this evaluation are the 80 percent lower confidence limit of the 95th percentile from the background data (WA 1998b). If the maximum on-site concentration exceeded the UTL, the constituent was considered to be above background (UC Davis 2004a). If the maximum on-site concentration was equal to or below the UTL, or not detected in any on-site samples, it was considered below background.

2.7.1.2 Exposure Assessment

As part of the Tier 2 Risk Estimate, potential exposures to persons using the LEHR site and surrounding area were evaluated based on a conceptual site model involving research facility land use and potential future residential land use. The conceptual site model identified primary sources of contamination, their release mechanisms, secondary sources and affected media, exposure routes, and potential receptors. Contaminated soil is the primary source in DOE areas. Release mechanisms include fugitive dust emissions from soil, direct contact with soil, infiltration/percolation through soil, and storm water runoff over soil. Secondary sources/affected media include air, plants, groundwater, surface water, fish, and sediments. Exposure routes include inhalation, ingestion, dermal contact, and external radiation. Persons identified in the HHRA that may become exposed to DOE-areas contamination are on-site indoor research workers, on-site outdoor research workers, construction workers, hypothetical future on-site residents, trespassers, and off-site residents. Details of the conceptual site model are presented in Section 4.0 of the HHRA (UC Davis 2004a).

Potentially complete exposure pathways identified for on-site indoor researchers are inhalation of fugitive dust, surface soil ingestion, and subsurface soil external radiation (radionuclides only). On-site outdoor researchers were assumed exposed to surface soil dermal contact in addition to the same exposures as on-site indoor researchers. Construction workers were assumed exposed to fugitive dust inhalation and subsurface soil ingestion, dermal contact, and external radiation. Open exposure pathways for hypothetical future on-site residents were assumed to include:

- Fugitive dust inhalation;
- Ingestion, dermal contact, and external radiation from contaminated subsurface soil;
- Ingestion of home-grown produce;
- Groundwater ingestion;
- Surface water ingestion and dermal contact;
- Ingestion of fish from Putah Creek; and
- Sediment ingestion and dermal contact.

The open exposure pathways identified for on-site trespassers are inhalation of fugitive dust, surface soil ingestion and dermal contact, subsurface soil external radiation, surface water ingestion and dermal contact, ingestion of fish from Putah Creek, sediment ingestion, and sediment dermal contact. The open exposure pathway identified for off-site residents is ingestion of groundwater that could become impacted by contaminants migrating from DOE areas soil. Details of exposure specific to each DOE area are presented in the area-specific discussions in Section 2.13.

Fate and transport models were used to estimate exposure point concentrations in fugitive dust, plant tissue, and fish tissue. Fate and transport modeling details are presented in Section 6.3 and Appendix D of the HHRA (UC Davis 2004a). Indoor and outdoor air fate and transport modeling was conducted for volatile organic compounds in the HHRA, but these calculations do not apply to DOE areas because these areas do not have volatile organic compound contamination.

Exposure point concentrations for soil, groundwater, surface water and sediments were determined directly from sample data without fate and transport modeling.

2.7.1.3 Toxicity Assessment

A toxicity assessment was conducted as part of the Tier 2 Risk Estimate. Carcinogenic toxicity data relevant to DOE areas COCs in soil are summarized in Table 2−5. The DOE areas do not have noncarcinogen COCs. Ingestion and inhalation slope factors apply to all of the COCs. Sr-90 has individual slope factors for food, water, and soil ingestion. Sr-90 is a radioactive isotope classified as a known human carcinogen (Class A). The chemical COCs are classified as probable human carcinogens with sufficient evidence of carcinogenicity in animals and inadequate or no evidence of carcinogenicity in humans (Class B2). Slope factors are not available for dermal exposure. Dermal slope factors were extrapolated from oral values for chemical COCs in the HHRA. Sr-90 is the only COC with external radiation toxicity.

2.7.1.4 Risk Characterization

COPCs identified in the Risk Estimate were subjected to a risk characterization process that took into account multiple lines of evidence to develop a list of COCs to be evaluated in the Feasibility Study.

COPCs identified in the Risk Estimate to pose risks greater than 1 in 1 million were screened out from the Risk Characterization if their concentrations were statistically at or below the site background. The statistical background comparison procedure is described in Section 2.7.1.1.1 above and the statistical results are presented in the HHRA Risk Estimate (UC Davis 2004a). The COPCs that were statistically above the site background were then evaluated using a systematic risk characterization process in accordance with *EPA Risk Assessment Guidelines for Superfund* (EPA 1989*)*. As documented in the *Site-Wide Risk Assessment, Volume 1: Human Health Risk Assessment (Part B Risk Characterization for DOE Areas)* (WA 2005), factors including data quality, contribution of background concentrations, spatial distribution, degradation, and radioactive decay were evaluated for each COPC.

The conclusions of the risk characterization process serve as the basis for risk management decisions for the DOE areas after EPA and state regulatory agency approval of the document. According to these risk management decisions, existing risks due to DOE releases were deemed acceptable at the WDPs, DSS 1, DSS 3, DSS 5, DSS 6, DSS 7, Dry Wells A–E, the DOE Disposal Box, and the Ra/Sr Treatment Systems areas. Residual risks requiring remedial alternatives were identified in the DSS 4, SWT, and EDP areas, as discussed below.

Table 2−6 presents human health risks by exposure route for the COPCs evaluated in the Risk Characterization along with the risk management decisions for each of the COPCs. Table 2−6 includes Ra-226 in the WDPs that was identified below site background and was screened out in the Risk Characterization based on background test results. This COPC is included due to the relatively high upper bound of the Ra-226 data set range at a concentration of 5.11 pCi/g in one sample (SSDP0015) collected in the WDPs area on December 8, 1994. Human health risks for Ra-226 in the WDPs were calculated using a surface soil exposure point concentration (EPC) of 0.47 pCi/g and a subsurface soil EPC of 0.55 pCi/g and range from 2 in 10,000 for on–site researcher to 1 in 1 million for the on-site construction worker. Because the elevated Ra-226 concentration in the sample appears to be isolated, and the result was not replicated in subsequent samples collected in the same location or in other samples collected in the vicinity, the result from sample SSDP0015 was determined to be an outlier.

Table 2−5. Data Summary of Cancer Toxicity

Pathway: Ingestion, Dermal

Constituent of Concern	Oral Cancer Slope Factor	Dermal Cancer Slope Factor	Slope Factor Units	Weight of Evidence/ Cancer Guideline Description	Source	Date
Benzo(a)anthracene[1]	7.30E-01	7.30E-01	(mg/kg-day)$^{-1}$	B2	NCEA	10/2/2002
Benzo(a)pyrene[1]	7.30E+00	7.30E+00	(mg/kg-day)$^{-1}$	B2	IRIS	8/16/2002
Benzo(b)fluoranthene[1]	7.30E-01	7.30E-01	(mg/kg-day)$^{-1}$	B2	NCEA	10/2/2002
Benzo(k)fluoranthene[1]	1.20E+00	1.20E+00	(mg/kg-day)$^{-1}$	B2	OEHHA	4/15/2003
Dibenzo(a,h)anthracene[1]	4.10E+00	4.10E+00	(mg/kg-day)$^{-1}$	B2	OEHHA	4/15/2003
Indeno(1,2,3-cd)pyrene[1]	1.20E+00	1.20E+00	(mg/kg-day)$^{-1}$	B2	OEHHA	4/15/2003
Dieldrin	1.60E+01	1.60E+01	(mg/kg-day)$^{-1}$	B2	IRIS	8/19/2002
Strontium-90 + decay chain						
food	9.50E-11	NA	pCi^{-1}	A	HEAST	4/16/2001
water	7.40E-11	NA	pCi^{-1}	A	HEAST	4/16/2001
soil	1.40E-10	NA	pCi^{-1}	A	HEAST	4/16/2001

Pathway: Inhalation

Constituent of Concern	Unit Risk	Units	Inhalation Cancer Slope Factor	Units	Weight of Evidence/ Cancer Guideline Description	Source	Date
Benzo(a)anthracene	2.10E-01	$(mg/m^3)^{-1}$	7.30E-01	(mg/kg-day)$^{-1}$	B2	NCEA	10/10/2002
Benzo(a)pyrene	2.10E+00	$(mg/m^3)^{-1}$	7.30E+00	(mg/kg-day)$^{-1}$	B2	NCEA	10/10/2002
Benzo(b)fluoranthene	2.10E-01	$(mg/m^3)^{-1}$	7.30E-01	(mg/kg-day)$^{-1}$	B2	NCEA	10/10/2002
Benzo(k)fluoranthene	1.10E-01	$(mg/m^3)^{-1}$	3.90E-01	(mg/kg-day)$^{-1}$	B2	OEHHA	4/15/2003
Dibenzo(a,h)anthracene	1.20E+00	$(mg/m^3)^{-1}$	4.20E+00	(mg/kg-day)$^{-1}$	B2	OEHHA	12/6/2002
Indeno(1,2,3-cd)pyrene	1.10E-01	$(mg/m^3)^{-1}$	3.90E-01	(mg/kg-day)$^{-1}$	B2	OEHHA	12/6/2002
Dieldrin	4.60E+00	$(mg/m^3)^{-1}$	1.60E+01	(mg/kg-day)$^{-1}$	B2	IRIS	8/19/2002
Sr-90 + decay chain	NA	NA	1.13E-10	pCi^{-1}	A	HEAST	4/16/2001

Pathway: External (Radiation)

Constituent of Concern	Cancer Slope Factor	Units	Weight of Evidence/Cancer Guideline Description	Source	Date
Strontium-90 + decay chain	1.96E-08	(year-pCi/g)$^{-1}$	A	HEAST	4/16/2001

Notes

[1] Referred to as polycyclic aromatic hydrocarbon (PAH) in text.

Abbreviations

AHuman carcinogen
B2 Probable human carcinogen—Indicates sufficient evidence in animals and inadequate or no evidence in humans
HEAST Health Effects Assessment Summary Tables, U.S. Environmental Protection Agency
IRIS Integrated Risk Information System, U.S. Environmental Protection Agency
mg/m^3 milligram per cubic meter
NA not applicable
NCEA National Center for Environmental Assessment
OEHHA Office of Environmental Health Hazard Assessment, California Environmental Protection Agency
PAH polycyclic aromatic hydrocarbon
pCi picocurie

Table 2−6. Human Health Risks by Exposure Route for Contaminants in Soil at the DOE Areas

			Cancer Risk by Exposure Route							
DOE Area	**Receptor/Constituent**	**EPC[1] (0–10 ft) (mg/kg or pCi/g)**	**Soil Ingestion**	**Soil Dermal Exposure**	**Aboveground Plant Ingestion[2]**	**Belowground Plant Ingestion[2]**	**External Radiation**	**Dust Inhalation**	**Total Cancer Risk**	**Risk Management Decision[5]**
DOE Disposal Box	**On-Site Resident**									
	Lead-210	0.95	2.E-07	–	4.E-07	–	3.E-08	1.E-10	6.E-07	NFA [6]
	Thorium-228	0.68	6.E-09	–	5.E-10	–	5.E-06	1.E-10	5.E-06	NFA [7]
								Total Risk	**6.E-06**	
	On-Site Outdoor Researcher									
	Thorium-228	0.68	–	–	–	–	2.E-06	–	2.E-06	NFA [7]
								Total Risk	**2.E-06**	
Domestic Septic System 1	–	–	–	–	–	–	–	–	**<1.E-06**	–
Domestic Septic System 3	**On-Site Resident**									
	Aroclor 1254	0.13	4.E-07	1.E-07	4.E-07	6.E-08	–	5.E-12	1.E-06	NFA [8,9]
	Cesium-137	0.015	8.E-11	–	4.E-10	–	3.E-07	2.E-15	3.E-07	NFA [6,10]
	Lead-210	0.85	3.E-07	–	5.E-07	–	3.E-08	1.E-10	8.E-07	NFA [10]
								Total Risk	**2.E-06**	
Domestic Septic System 4	**On-Site Resident**									
	Benzo(a)anthracene	3.8	4.E-06	1.E-06	9.E-06	1.E-06	–	3.E-10	2.E-05	COC [9]
	Benzo(a)pyrene	2.4	3.E-05	7.E-06	3.E-05	5.E-06	–	2.E-09	7.E-05	COC [9]
	Benzo(b)fluoranthene	2.7	3.E-06	8.E-07	3.E-06	5.E-07	–	2.E-10	7.E-06	COC [9]
	Benzo(k)fluoranthene	1.5	3.E-06	7.E-07	3.E-04	5.E-05	–	7.E-11	4.E-04	COC [9]
	Dibenzo(a,h)anthracene	1.1	7.E-06	2.E-06	4.E-06	6.E-07	–	5.E-10	1.E-05	COC [9]
	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	COC [9]
	Lead-210	2.5	4.E-07	–	8.E-07	–	8.E-08	3.E-10	1.E-06	NA [9,17]
								Total Risk	**5.E-04**	
	On-Site Construction Worker									
	Benzo(a)pyrene	2.4	8.E-07	3.E-07	–	–	–	7.E-10	1.E-06	COC [9]
	Dibenzo(a,h)anthracene	1.1	2.E-07	8.E-08	–	–	–	2.E-10	3.E-07	NA [6]
								Total Risk	**1.E-06**	

Table 2−6 (continued). Human Health Risks by Exposure Route for Contaminants in Soil at the DOE Areas

			Cancer Risk by Exposure Route							
DOE Area	**Receptor/Constituent**	**EPC[1] (0–10 ft) (mg/kg or pCi/g)**	**Soil Ingestion**	**Soil Dermal Exposure**	**Aboveground Plant Ingestion[2]**	**Belowground Plant Ingestion[2]**	**External Radiation**	**Dust Inhalation**	**Total Cancer Risk**	**Risk Management Decision[5]**
Domestic Septic System 5	–	–	–	–	–	–	–	–	**<1.E-06**	–
Domestic Septic System 6	–	–	–	–	–	–	–	–	**<1.E-06**	–
Domestic Septic System 7	**On-Site Resident**									
	Lead-210	4.1	3.E-07	–	5.E-07	–	1.E-07	5.E-10	9.E-07	NA[11,12]
								Total Risk	**9.E-07**	
Dry Wells A through E	**On-Site Resident**									
	Arsenic	8.8	2.E-05	1.E-06	1.E-04	3.E-05	–	1.E-08	2.E-04	NFA[10]
	Radium-226	0.63	1.E-07	–	3.E-07	–	4.E-05	1.E-10	4.E-05	NFA[10]
	Thorium-228	0.73	7.E-09	–	5.E-10	–	6.E-06	1.E-10	6.E-06	NFA[7,13]
								Total Risk	**2.E-04**	
	On-Site Outdoor Researcher									
	Radium-226	0.63	–	–	–	–	2.E-05	–	2.E-05	NFA[10]
	Thorium-228	0.73	–	–	–	–	3.E-06	–	3.E-06	NFA[10]
								Total Risk	**2.E-05**	
	On-Site Indoor Researcher									
	Radium-226	0.63	–	–	–	–	4.E-06	–	4.E-06	NFA[10]
	Thorium-228	0.73	–	–	–	–	6.E-07	–	6.E-07	NFA[12]
								Total Risk	**5.E-06**	
	On-Site Construction Worker									
	Arsenic	8.8	6.E-07	5.E-08	–	–	–	5.E-09	7.E-07	NFA[10]
	Radium-226	0.63	2.E-09	–	–	–	1.E-06	2.E-12	1.E-06	NFA[10]
	Thorium-228	0.73	2.E-09	–	–	–	9.E-07	2.E-11	9.E-07	NFA[12]
								Total Risk	**3.E-06**	

Table 2−6 (continued). Human Health Risks by Exposure Route for Contaminants in Soil at the DOE Areas

			Cancer Risk by Exposure Route							
DOE Area	**Receptor/Constituent**	**EPC[1] (0–10 ft) (mg/kg or pCi/g)**	**Soil Ingestion**	**Soil Dermal Exposure**	**Aboveground Plant Ingestion[2]**	**Belowground Plant Ingestion[2]**	**External Radiation**	**Dust Inhalation**	**Total Cancer Risk**	**Risk Management Decision[5]**
Eastern Dog Pens	**On-Site Resident**									
	Dieldrin	0.019	5.E-07	9.E-08	2.E-06	2.E-07	–	4.E-11	3.E-06	COC[9]
	Lead-210	0.67	1.E-06	–	2.E-06	–	2.E-08	1.E-10	3.E-06	NA[10]
	Strontium-90	0.33[3]	4.E-08	–	1.E-06	–	5.E-08	5.E-13	1.E-06	COC[14]
								Total Risk	**7.E-06**	
Radium/Strontium Treatment Systems	**On-Site Resident**									
	Strontium-90	0.25	2.E-08	–	5.E-07	–	4.E-08	4.E-13	6.E-07	NFA[6]
	Thorium-228	0.59	3.E-08	–	2.E-09	–	5.E-06	1.E-10	5.E-06	NFA[7,13]
								Total Risk	**6.E-06**	
	On-Site Outdoor Researcher									
	Thorium-228	0.59	–	–	–	–	2.E-06	–	2.E-06	NFA[7,13]
								Total Risk	**2.E-06**	
Southwest Trenches	**On-Site Resident**									
	Cesium-137	0.054	2.E-09	–	8.E-09	–	1.E-06	9.E-15	1.E-06	NFA[12]
	Lead-210	1.3	2.E-06	–	4.E-06	–	5.E-08	2.E-10	6.E-06	NFA[15]
	Strontium-90	0.94	1.E-07	–	3.E-06	–	2.E-07	2.E-12	3.E-06	COC[9]
	Thorium-228	0.59	5.E-08	–	4.E-09	–	5.E-06	2.E-10	5.E-06	NFA[7,13]
								Total Risk	**2.E-05**	
	On-Site Outdoor Researcher									
	Cesium-137	0.054	–	–	–	–	4.E-07	–	4.E-07	NFA[12]
	Thorium-228	0.53, 0.59[4]	9.E-09	–	–	–	2.E-06	5.E-11	2.E-06	NFA[7,13]
								Total Risk	**2.E-06**	

Table 2−6 (continued). Human Health Risks by Exposure Route for Contaminants in Soil at the DOE Areas

			Cancer Risk by Exposure Route							
DOE Area	**Receptor/Constituent**	**EPC[1] (0–10 ft) (mg/kg or pCi/g)**	**Soil Ingestion**	**Soil Dermal Exposure**	**Aboveground Plant Ingestion[2]**	**Belowground Plant Ingestion[2]**	**External Radiation**	**Dust Inhalation**	**Total Cancer Risk**	**Risk Management Decision[5]**
Western Dog Pens[21]	**On-Site Resident**									
	Lead-210	1.2	2.E-06	–	4.E-06	–	4.E-08	3.E-10	6.E-06	NFA [16]
	Radium-226	0.55	2.E-06	–	4.E-06	–	6.E-05	3.E-10	7.E-05	NFA [19, 20]
	Strontium-90	0.43	5.E-08	–	1.E-06	–	8.E-08	9.E-13	1.E-06	NFA [16,17]
	Thorium-228	0.61	5.E-08	–	4.E-09	–	6.E-06	2.E-10	6.E-06	NFA [7,18]
	Uranium-238	0.71	2.E-07	–	3.E-08	–	1.E-06	2.E-10	1.E-06	NFA [15]
								Total Risk	**1.E-05**	
	On-Site Outdoor Researcher									
	Radium-226	0.47, 0.55 [4]	6.E-08	–	–	–	2.E-05	4.E-11	2.E-05	NFA [19, 20]
	Thorium-228	0.68, 0.61 [4]	6.E-09	–	–	–	3.E-06	8.E-11	3.E-06	NFA [7,18]
	Uranium-238	0.71	–	–	–	–	4.E-07	–	4.E-07	NFA [6]
								Total Risk	**3.E-06**	
	On-Site Construction Worker									
	Radium-226	0.55	5.E-08	–	–	–	1.E-06	4.E-12	1.E-06	NFA [19, 20]
	Thorium-228	0.61	1.E-08	–	–	–	9.E-07	2.E-11	9.E-07	NFA [6,18]
								Total Risk	**9.E-07**	

Abbreviations

–	Not applicable
EPC	exposure point concentration
NA	no action
NFA	no further action
UTL	upper tolerance limit

Table 2−6 (continued). Human Health Risks by Exposure Route for Contaminants in Soil at the DOE Areas

Notes

Source data from HHRA, Tables 7 and 8 (UC Davis 2004a). Constituent/risks are presented here if the constituent is present above site background. Constituent/risks are presented here if they contribute at least a factor of 1 in 1 million, or greater than 10%, to the excess cumulative cancer risk for a DOE area and receptor. Only exposure pathways for contaminants in soil at the DOE areas are presented here. Exposures to groundwater and surface water contaminants are not included, as they are being addressed by the UC Davis Feasibility Study.

[1] The 95 percent upper confidence limit on the mean or maximum sample concentration; chemical concentrations are expressed in milligrams per kilogram, and radionuclide concentrations are expressed in picocuries per gram.

[2] Homegrown produce. For radionuclides, plant ingestion is not subdivided into aboveground and belowground produce.

[3]EPC after Eastern Dog Pens maintenance action.

[4]EPC for surface soil (0 to 0.5 ft bgs) and subsurface soil (0 to 10 ft bgs) used to determine risks.

[5]The primary basis for risk management decisions is included as footnotes 6 through 18 here for each constituent and presented in detail in the *Site-Wide Risk Assessment, Volume 1: Human Health Risk Assessment (Part B Risk Characterization for DOE Areas)* (WA 2005), and the *Former Western Dog Pens Backfill Risk Assessment* (WA 2007).

[6]Risk is below 1 in 1 million.

[7]Contaminant will quickly decay below background based on its concentration and radioactive decay rate.

[8]Contamination detected only in tank-contents samples.

[9] Spatial analysis indicated a risk is localized in a small area.

[10]Constituent concentrations are generally below background.

[11] No evidence of contamination release.

[12] Decay-corrected risk is below 1 in 1 million.

[13] Risk is near 1 in 1 million (marginal).

[14]Majority of risk is due to site releases.

[15] No correlation with site activities.

[16] Risk values may be due to analytical uncertainty.

[17]Constituent risk will quickly decline below 1 in 1 million due to radioactive decay.

[18] Risk is based on concentrations found in clean fill and Southwest Trenches area overburden soil.

[19] Statistical test results indicate constituent is below background.

[20] Detected radium-226 results from samples collected in the Western Dog Pens ranged from 0.16 to 5.11 pCi/g. The majority of radium-226 sample results in the Western Dog Pens were below the UTL, and radium-226 was below background according to the statistical test results. Risks were calculated using a surface soil EPC of 0.47 pCi/g and a subsurface soil EPC of 0.55 pCi/g. The elevated radium-226 result of 5.11 pCi/g in sample SSDP0015 collected on 12/8/1994 appears to be isolated, and the result was not replicated in subsequent samples collected in the same location or in other samples collected in the vicinity. The radium-226 result from sample SSDP0015 was identified as an outlier.

[21] Western Dog Pens EPC values and risks are from the *Former Western Dog Pens Backfill Risk Assessment* (WA 2007).

The risk characterization results indicate that hypothetical future on-site residents may be exposed to risks exceeding 1 in 1 million at DSS 4, SWT, and EDP areas. On-site construction workers may be exposed to risks at 1 in 1 million at DSS 4.

Benzo(a)pyrene is the only COC for hypothetical on-site construction workers at DSS 4. The estimated risk for an on-site construction worker is 1 in 1 million, primarily due to potential ingestion of subsurface soil, with a secondary contribution from dermal exposure. Carcinogenic risks to hypothetical future on-site residents from individual chemicals at DSS 4 range from 4 in 1 million for indeno(1,2,3-cd)pyrene to 4 in 10,000 for benzo(k)fluoranthene. The sum of cancer risks to a residential receptor across COCs at DSS 4 is 5 in 10,000. Residential risks at DSS 4 are primarily due to soil ingestion and plant ingestion, with secondary contributions from dermal exposure. The risk characterization (WA 2005) shows that risk at DSS 4 is localized in the near vicinity of shallow leach trenches. Although a small number of samples were collected at DSS 4 (six samples), a conclusion was reached in the risk characterization that these data were representative due to discretionary sampling at the most likely hot spots.

Sr-90 was estimated to pose a risk of 3 in 1 million to hypothetical future on-site residents in the SWT area, primarily due to plant ingestion, with secondary contributions from external radiation and soil ingestion. DOE concluded in the risk characterization that risks from localized Sr-90 in soil remain at the SWT area. Analytical uncertainty issues were identified for some of the Sr-90 data. These uncertain data likely resulted in a small overestimate of the exposure point concentration and human health risk.

Sr-90 and dieldrin were estimated to pose risks of 1 in 1 million and 3 in 1 million, respectively, to hypothetical future on-site residents in the EDPs area. The risk sum across COCs in the EDPs is 4 in 1 million. Risks posed by Sr-90 and dieldrin were primarily due to plant ingestion, with a secondary contribution to dieldrin risk from soil ingestion. DOE concluded in the risk characterization that localized risks remain, due to Sr-90 and dieldrin in soil at the SWT area. Six of the 68 Sr-90 samples collected in the EDPs area were identified in the risk characterization as not meeting CERCLA data quality standards. These data may have resulted in a small overestimation of exposure point concentration and human health risk for Sr-90 in the EDPs area.

Future development activities, including infrastructure replacement, could bring contamination located in subsurface soil to the surface. Risks estimated for construction workers and hypothetical future on-site residents were based on complete exposure pathways for subsurface soil, and account for the possibility of bringing subsurface contamination to the surface. Risks estimated for on-site researchers and trespassers are based on exposure to existing surface soil and do not account for future soil disturbance. The potential risks from exposure to contaminants in subsurface soil are controlled by the land-use restrictions included in the selected alternatives that require management of potentially contaminated soil during site development activities. The details of soil management under the selected alternatives are discussed in Section 2.10.3.

2.7.2 Ecological Risk Assessment

The Site-Wide Ecological Risk Assessment (SWERA) followed a two-tiered approach (BBL 2006). In Tier 1, the problem formulation was presented, and a conservative screen of the data identified constituents of potential ecological concern (COPECs). In Tier 2, the COPECs were evaluated in more detail through a refinement of the problem formulation, an exposure and effects assessment, a characterization of risk, and an uncertainty analysis. The problem formulation conducted in both tiers of the risk assessment was a formal process that developed and evaluated preliminary hypotheses concerning the likelihood and causes of ecological effects that may have occurred, or may occur, from human activities. The exposure assessment assessed the potential for exposure to chemical stressors (i.e., site-related chemicals) by evaluating the co-occurrence of the stressors and the ecological receptors.

The effects assessment identified toxicological effects data (e.g., sediment quality guidelines, water quality criteria, and toxicity reference values) that were used as benchmarks to compare to site COPEC concentrations. In the risk characterization phase of the assessment, the results of the exposure and effects assessments were combined to estimate risk to the receptors and the assessment endpoints identified in the problem formulation. An uncertainty analysis was also conducted to identify any inputs to the risk assessment that might over- or underestimate risk. Finally, risks were interpreted and conclusions were reported. The SWERA concluded that residual contamination in soil at the DOE areas presents no significant risks to ecological receptors (UC Davis 2004b; BBL 2006). The results of the ecological risk assessment for each DOE area are summarized below.

2.7.2.1 DOE Disposal Box

The Tier 2 risk estimate identified only selenium, vanadium, and zinc as the COPECs to be evaluated. A summary of the potential risk for assessment endpoints at the DOE Disposal Box is as follows.

Plants: Protect/maintain plant productivity or development under conditions of chronic exposure—Selenium, vanadium, and zinc were the COPECs evaluated for plants. Hazard quotients (HQs) using the low plant toxicity benchmark based on lowest observed effects concentration (LOEC) for selenium and zinc were just slightly above one and are unlikely to represent concentrations that would result in adverse effects. The HQ for vanadium was higher (HQ=34), but the area concentrations were similar to background concentrations and were unlikely to pose a significantly increased risk to plants. Therefore, it was concluded that risk to plants at the DOE Disposal Box is acceptable.

Soil invertebrates: Protect/maintain soil invertebrate community function and structure under conditions of chronic exposure—For all compounds that could be evaluated quantitatively and were greater than background, no LOEC-based low HQs were greater than one. Therefore, it was concluded that risk to soil invertebrates at the DOE Disposal Box is *de minimis*.

Herbivorous mammals (Botta's pocket gopher): Protect/maintain persistence and reproductive success of herbivorous mammal populations under conditions of chronic exposure—Only selenium and vanadium had no observable adverse effects level (NOAEL)-based HQs slightly greater than one. Because the HQs based on the NOAEL were low, it was assumed that the potential for risk is low. Additionally, background risk is similar to the risk estimated for the site area. Therefore, it was concluded that risk to herbivorous mammals at the DOE Disposal Box is acceptable.

Herbivorous birds (rock dove): Protect/maintain persistence and reproductive success of herbivorous bird populations under conditions of chronic exposure—For all compounds that could be evaluated quantitatively and were greater than background, no NOAEL-based HQs were greater than one. Therefore, it was concluded that risk to herbivorous birds at the DOE Disposal Box is *de minimis*.

Insectivorous mammals (ornate shrew): Protect/maintain persistence and reproductive success of insectivorous mammal populations under conditions of chronic exposure—For all compounds that could be evaluated quantitatively and had concentrations greater than background, no NOAEL-based HQs were greater than one. Therefore, it was concluded that risk to insectivorous mammals at the DOE Disposal Box is *de minimis*.

Insectivorous birds (American robin,): Protect/maintain persistence and reproductive success of insectivorous bird populations under conditions of chronic exposure—For all compounds that could be evaluated quantitatively and had concentrations greater than background, no NOAEL-based HQs were greater than one. Therefore, it was concluded that risk to insectivorous birds at the DOE Disposal Box is *de minimis*.

Special-status insectivorous birds (California horned lark): Protect/maintain persistence and reproductive success of individual special-status insectivorous birds under conditions of chronic exposure—For all compounds that could be evaluated quantitatively and had concentrations greater than background, no NOAEL-based HQs were greater than one. Therefore, it was concluded that risk to special-status insectivorous birds at the DOE Disposal Box is *de minimis*.

Carnivorous mammals (coyote): Protect/maintain persistence and reproductive success of carnivorous mammal populations under conditions of chronic exposure—For all compounds that could be evaluated quantitatively and had concentrations greater than background, no NOAEL-based HQs were greater than one for the coyote. Therefore, it was concluded that risk to carnivorous mammals at the DOE Disposal Box is *de minimis*.

Carnivorous birds (red-tailed hawk): Protect/maintain persistence and reproductive success of carnivorous bird populations under conditions of chronic exposure—For all compounds that could be evaluated quantitatively and had concentrations greater than background, no NOAEL-based HQs were greater than one for the red-tailed hawk. Therefore, it was concluded that risk to carnivorous birds at the DOE Disposal Box is *de minimis*.

Special-status carnivorous birds (northern harrier): Protect/maintain persistence and reproductive success of individual carnivorous birds under conditions of chronic exposure—For all compounds that could be evaluated quantitatively and had concentrations greater than background, no NOAEL-based HQs were greater than one for the northern harrier. Therefore, it was concluded that risk to special-status carnivorous birds at the DOE Disposal Box is *de minimis*.

The risk evaluation indicates that potential risk to all the identified assessment endpoints exposed to the DOE Disposal Box is acceptable. This conclusion is further supported by the fact that the risk evaluation was based on highly conservative exposure assumptions regarding the receptors' potential use of the area for foraging, as the area does not currently support habitat for these receptors. Based on this evaluation, it was recommended that the DOE Disposal Box does not require any further evaluation from an ecological perspective.

2.7.2.2 DSSs and Dry Wells

The Tier 2 risk estimate for the DSS 1, DSS 3, DSS 4, DSS 5, DSS 6, DSS 7, and Dry Wells A−E areas identified chromium, manganese, selenium, thallium, vanadium, and zinc as the COPECs to be evaluated. A summary of the potential risk for assessment endpoints at the DSS and Dry Wells A–E areas is as follows.

Plants: Protect/maintain plant productivity or development under conditions of chronic exposure—Manganese, selenium, thallium, vanadium, and zinc were identified as the COPECs to be evaluated for plants. LOEC-based low HQs for all COPECs except vanadium were just slightly above one and are unlikely to represent concentrations that would result in adverse effects. The HQ for vanadium was higher (HQ=36), but the area concentrations were similar to background concentrations and are unlikely to pose a significantly increased risk to plants. In addition, the spatial distribution of elevated concentrations is minimal (i.e., four or fewer locations for all COPECs). Therefore, it was concluded that risk to plants at the DSSs and Dry Well A–E areas is acceptable.

Soil invertebrates: Protect/maintain soil invertebrate community function and structure under conditions of chronic exposure—Chromium was the only COPEC to be evaluated for invertebrates, and the concentration was elevated at DSS 4 only. Although the LOEC-based low HQ for invertebrates was elevated, given the uncertainty and conservatism associated with the benchmark and the limited spatial extent of benchmark exceedances, it was concluded that risk to soil invertebrates at the DSSs and Dry Wells A–E areas is acceptable.

Herbivorous mammals (Botta’s pocket gopher): Protect/maintain persistence and reproductive success of herbivorous mammal populations under conditions of chronic exposure—Only vanadium and selenium had NOAEL-based HQs slightly greater than one for the Botta’s pocket gopher. Because the NOAEL-based HQs were low (1.1 for vanadium and 2.2 for selenium), and the HQs based on the lowest observed adverse effects level (LOAEL) were well below one, it was assumed that the potential for risk is low. Additionally, background risk was similar to the risk estimated for the site areas, and the spatial analysis of risk showed that only two locations were elevated for vanadium and four for selenium. Therefore, it was concluded that risk to herbivorous mammals at the DSSs and Dry Wells A–E areas is acceptable.

Herbivorous birds (rock dove): Protect/maintain persistence and reproductive success of herbivorous bird populations under conditions of chronic exposure—For all compounds that could be evaluated quantitatively and had concentrations greater than background, no NOAEL-based HQs were greater than one. Therefore, it was concluded that risk to herbivorous birds at the DSSs and Dry Wells A–E areas is *de minimis*.

Insectivorous mammals (ornate shrew): Protect/maintain persistence and reproductive success of insectivorous mammal populations under conditions of chronic exposure—For all compounds that could be evaluated quantitatively and had concentrations greater than background, no NOAEL-based HQs were greater than one. Therefore, it was concluded that risk to insectivorous mammals at the DSSs and Dry Wells A–E areas is *de minimis*.

Insectivorous birds (American robin): Protect/maintain persistence and reproductive success of insectivorous bird populations under conditions of chronic exposure—For all compounds that could be evaluated quantitatively and had concentrations greater than background, no NOAEL-based HQs were greater than one. Therefore, it was concluded that risk to insectivorous birds at the DSSs and Dry Wells A–E areas is *de minimis*.

Special-status insectivorous birds (California horned lark): Protect/maintain persistence and reproductive success of individual special-status insectivorous birds under conditions of chronic exposure—For all compounds that could be evaluated quantitatively and had concentrations greater than background, no NOAEL-based HQs were greater than one. Therefore, it was concluded that risk to special-status insectivorous birds at the DSSs and Dry Wells A–E areas is *de minimis*.

Carnivorous mammals (coyote): Protect/maintain persistence and reproductive success of carnivorous mammal populations under conditions of chronic exposure—For all compounds that could be evaluated quantitatively and had concentrations greater than background, no NOAEL-based HQs were greater than one for the coyote. Therefore, it was concluded that risk to carnivorous mammals at the DSSs and Dry Wells A–E areas is *de minimis*.

Carnivorous birds (red-tailed hawk): Protect/maintain persistence and reproductive success of carnivorous bird populations under conditions of chronic exposure—For all compounds that could be evaluated quantitatively and had concentrations greater than background, no NOAEL-based HQs were greater than one for the red-tailed hawk. Therefore, it was concluded that risk to carnivorous birds at the DSSs and Dry Wells A–E areas is *de minimis*.

Special-status carnivorous birds (northern harrier): Protect/maintain persistence and reproductive success of individual special-status carnivorous birds under conditions of chronic exposure—For all compounds that could be evaluated quantitatively and were greater than background, no NOAEL-based HQs had concentrations greater than one for the northern harrier. Therefore, it was concluded that risk to carnivorous birds at the DSSs and Dry Wells A−E areas is *de minimis*.

The risk evaluation indicates that potential risk to all the identified assessment endpoints exposed to the DSSs and Dry Wells A−E areas is acceptable. This conclusion is further supported by the fact that the risk evaluation was based on highly conservative exposure assumptions regarding the receptors' potential use of the site areas for foraging, as the site areas do not currently support habitat for these receptors and is likely to support only patchy habitat in the future. Based on the evaluation provided here, it was recommended that no further evaluation of ecological resources at the DSSs and Dry Wells A–E areas is warranted.

2.7.2.3 EDPs

The Tier 2 risk estimate identified only chromium as the COPEC to be evaluated. A summary of the potential risk for assessment endpoints at the EDPs is as follows.

Plants: Protect/maintain plant productivity or development under conditions of chronic exposure—No HQ for chromium could be calculated for plants because no toxicity benchmark was available. While this is an uncertainty, the area and background concentrations of chromium are similar (area exposure point concentration [EPC] = 166 mg/kg and background EPC = 151 mg/kg). It was concluded that risk to plants from the EDPs is acceptable.

Soil invertebrates: Protect/maintain soil invertebrate community function and structure under conditions of chronic exposure—For all compounds that could be evaluated quantitatively and had concentrations greater than background, only total chromium exceeded a toxicity benchmark. While the magnitude of the LOEC-based low HQ was high, background exposure provides a similarly elevated HQ. Therefore, it was concluded that risk to soil invertebrates from the EDPs is acceptable.

Herbivorous mammals (Botta's pocket gopher): Protect/maintain persistence and reproductive success of herbivorous mammal populations under conditions of chronic exposure—For all COPECs that could be evaluated quantitatively and had concentrations greater than background, no NOAEL-based HQs were greater than one. Therefore, it was concluded that risk to herbivorous mammals at the EDPs is *de minimis*.

Herbivorous birds (rock dove): Protect/maintain persistence and reproductive success of herbivorous bird populations under conditions of chronic exposure—For all compounds that could be evaluated quantitatively and had concentrations greater than background, no NOAEL-based HQs were greater than one. Therefore, it was concluded that risk to herbivorous birds at the EDPs is *de minimis*.

Insectivorous mammals (ornate shrew): Protect/maintain persistence and reproductive success of insectivorous mammal populations under conditions of chronic exposure—For all compounds that could be evaluated quantitatively and had concentrations greater than background, only the NOAEL-based HQ for total chromium exceeded one. However, the magnitude of HQ is very low (HQ = 1.1) and is unlikely to represent a potential risk. Therefore, it was concluded that risk to insectivorous mammals at the EDPs is acceptable.

Insectivorous birds (American robin): Protect/maintain persistence and reproductive success of insectivorous bird populations under conditions of chronic exposure—For all compounds that could be evaluated quantitatively and had concentrations greater than background, only chromium had HQs that exceeded one. The magnitude of the NOAEL-based HQs was low for the American robin (HQ = 2.2). The LOAEL-based HQ was also slightly greater than one (HQ = 1.2). However, background concentrations of chromium resulted in similar risk estimates. Therefore, it was concluded that risk to insectivorous birds at the EDPs is acceptable.

Special-status insectivorous birds (California horned lark): Protect/maintain persistence and reproductive success of individual special-status insectivorous birds under conditions of chronic exposure—As with the robin, the only NOAEL-based HQ to exceed one was for chromium. The magnitude of the NOAEL-based HQs was low for the California horned lark (HQ = 1.1) and the LOAEL-based HQ was less than one. In addition, background concentrations of chromium resulted in similar risk estimates. It was concluded that risk to special-status insectivorous birds at the EDPs is acceptable.

Carnivorous mammals (coyote): Protect/maintain persistence and reproductive success of carnivorous mammal populations under conditions of chronic exposure—For all compounds that could be evaluated quantitatively and had concentrations greater than background, no NOAEL-based HQs were greater than one for the coyote. Therefore, it was concluded that risk to carnivorous mammals at the EDPs is *de minimis*.

Carnivorous birds (red-tailed hawk): Protect/maintain persistence and reproductive success of carnivorous bird populations under conditions of chronic exposure—For all compounds that could be evaluated quantitatively and had concentrations greater than background, no NOAEL-based HQs were greater than one for the red-tailed hawk. Therefore, it was concluded that risk to carnivorous birds at the EDPs is *de minimis*.

Special-status carnivorous birds (northern harrier): Protect/maintain persistence and reproductive success of individual special-status carnivorous birds under conditions of chronic exposure—For all compounds that could be evaluated quantitatively and had concentrations greater than background, no NOAEL-based HQs were greater than one for the northern harrier. Therefore, it was concluded that risk to special-status carnivorous birds at the EDPs is *de minimis*.

The risk evaluation indicates that potential risk to all the identified assessment endpoints exposed to the EDPs is acceptable. This conclusion is supported by the fact that the risk evaluation was based on highly conservative exposure assumptions regarding the receptors' potential use of the area for foraging. Based on this evaluation, it was recommended that no further evaluation of ecological resources at the EDPs is warranted.

2.7.2.4 Radium/Strontium Treatment Systems

The Tier 2 risk estimate identified only cadmium, selenium, vanadium, and zinc as the COPECs to be evaluated. A summary of the potential risk for assessment endpoints at the Ra/Sr Treatment Systems area is as follows.

Plants: Protect/maintain plant productivity or development under conditions of chronic exposure—Selenium, vanadium, and zinc were identified as the COPECs to be evaluated for plants. HQs using the low plant toxicity benchmark for selenium and zinc are just slightly above one and are unlikely to represent concentrations that would result in adverse effects. The HQ for vanadium is higher (HQ=32), but the area concentrations are similar to background concentrations and are unlikely to pose a significantly increased risk to plants. Therefore, it was concluded that risk to plants at the Ra/Sr Treatment Systems area is acceptable.

Soil invertebrates: Protect/maintain soil invertebrate community function and structure under conditions of chronic exposure—For all compounds that could be evaluated quantitatively and had concentrations greater than background, no NOAEL HQs were greater than one. Therefore, it was concluded that risk to soil invertebrates at the Ra/Sr Treatment Systems area is *de minimis*.

Herbivorous mammals (Botta's pocket gopher): Protect/maintain persistence and reproductive success of herbivorous mammal populations under conditions of chronic exposure—Only selenium and vanadium had NOAEL-based HQs slightly greater than one. Because the HQs based on the NOAEL-based toxicity reference values (TRVs) were low, it was assumed that the potential for risk is low. Additionally, background risk is similar to the risk estimated for the site area. Therefore, it was concluded that risk to herbivorous mammals at the Ra/Sr Treatment Systems area is acceptable.

Herbivorous birds (rock dove): Protect/maintain persistence and reproductive success of herbivorous bird populations under conditions of chronic exposure—For all compounds that could be evaluated quantitatively and had concentrations greater than background, no NOAEL-based HQs were greater than one. Therefore, it was concluded that risk to herbivorous birds at the Ra/Sr Treatment Systems area is *de minimis*.

Insectivorous mammals (ornate shrew): Protect/maintain persistence and reproductive success of insectivorous mammal populations under conditions of chronic exposure—For the ornate shrew, cadmium, vanadium, and zinc had NOAEL-based HQs equal to or less than five. LOAEL-based HQs for these compounds were very low. Because the HQs based on the NOAEL-based TRVs were low, it was assumed that the potential for risk is low. Additionally, background risk is either greater than or similar to the risk estimated for the site area. Therefore, it was concluded that risk to insectivorous mammals at the Ra/Sr Treatment Systems area is acceptable.

Insectivorous birds (American robin): Protect/maintain persistence and reproductive success of insectivorous bird populations under conditions of chronic exposure—For the American robin, only cadmium, selenium, and zinc had NOAEL-based HQs slightly above one. Because the HQs based on the NOAEL-based TRVs were low, it was assumed that the potential for risk is unlikely. Additionally, background risk is either greater than or similar to the risk estimated for the site area. Based on this evaluation, it was concluded that risk to insectivorous birds at the Ra/Sr Treatment Systems area is acceptable.

Special-status insectivorous birds (California horned lark): Protect/maintain persistence and reproductive success of individual special-status insectivorous birds under conditions of chronic exposure—For all compounds that could be evaluated quantitatively and had concentrations greater than background, no NOAEL-based HQs were greater than one. Based on this information, it was concluded that risk to special-status insectivorous birds at the Ra/Sr Treatment Systems area is *de minimis*.

Carnivorous mammals (coyote): Protect/maintain persistence and reproductive success of carnivorous mammal populations under conditions of chronic exposure—For all compounds that could be evaluated quantitatively and had concentrations greater than background, no NOAEL-based HQs were greater than one for the coyote. Therefore, it was concluded that risk to carnivorous mammals at the Ra/Sr Treatment Systems area is *de minimis*.

Carnivorous birds (red-tailed hawk): Protect/maintain persistence and reproductive success of carnivorous bird populations under conditions of chronic exposure—For all compounds that could be evaluated quantitatively and had concentrations greater than background, no NOAEL-based HQs were greater than one. Therefore, it was concluded that risk to carnivorous birds at the Ra/Sr Treatment Systems area is *de minimis*.

Special-status carnivorous birds (northern harrier): Protect/maintain persistence and reproductive success of individual special status carnivorous birds under conditions of chronic exposure—For all compounds that could be evaluated quantitatively and had concentrations greater than background, no NOAEL-based HQs were greater than one for the northern harrier. Therefore, it was concluded that risk to special-status carnivorous birds at the Ra/Sr Treatment Systems area is *de minimis*.

The risk evaluation indicates that potential risk to all the identified assessment endpoints exposed to the Ra/Sr Treatment Systems area is acceptable. This conclusion is further supported by the fact that the risk evaluation was based on highly conservative exposure assumptions regarding the receptors' potential use of the area for foraging, as the area does not currently support habitat for these receptors and is likely to support only poor quality, patchy habitat in the future. Based on the assessment provided here, no further evaluation was recommended for the Ra/Sr Treatment Systems area for ecological receptors.

2.7.2.5 Southwest Trenches

The Tier 2 risk estimate for the SWTs identified antimony, selenium, vanadium, and zinc as the COPECs to be evaluated. A summary of the potential risk for assessment endpoints at the SWTs is as follows.

Plants: Protect/maintain plant productivity or development under conditions of chronic exposure—Vanadium and zinc were identified as the COPECs to be evaluated for plants. HQs using the low plant toxicity benchmark for zinc are just slightly above one and are unlikely to represent concentrations that would result in adverse effects. The HQ for vanadium is higher (HQ=33), but the area concentrations are similar to background concentrations and are unlikely to pose a significantly increased risk to plants. In addition, the spatial distribution of elevated concentrations is minimal (i.e., three locations for vanadium and one for zinc). Therefore, it was concluded that risk to plants at the SWTs is acceptable.

Soil invertebrates: Protect/maintain soil invertebrate community function and structure under conditions of chronic exposure—For all compounds that could be evaluated quantitatively and had concentrations greater than background, no NOAEL-based HQs were greater than one. Therefore, it was concluded that risk to soil invertebrates at the SWTs is *de minimis*.

Herbivorous mammals (Botta's pocket gopher): Protect/maintain persistence and reproductive success of herbivorous mammal populations under conditions of chronic exposure—Only vanadium had NOAEL-based HQs slightly greater than one for the Botta's pocket gopher. Because the HQs based on the NOAEL-based TRVs were low, and the LOAEL-based HQ was well below one, it was assumed that the potential for risk is low. Additionally, background risk is similar to the risk estimated for the area, and the spatial analysis of risk showed that only three locations had elevated concentrations of vanadium. Therefore, it was concluded that risk to herbivorous mammals at the SWTs is acceptable.

Herbivorous birds (rock dove): Protect/maintain persistence and reproductive success of herbivorous bird populations under conditions of chronic exposure—For all compounds that could be evaluated quantitatively and had concentrations greater than background, no NOAEL-based HQs were greater than one. Therefore, it was concluded that risk to herbivorous birds at the SWTs is *de minimis*.

Insectivorous mammals (ornate shrew): Protect/maintain persistence and reproductive success of insectivorous mammal populations under conditions of chronic exposure—For the ornate shrew, antimony, selenium, vanadium, and zinc had NOAEL-based HQs above one. HQs ranged from 2.5 for selenium to 7.6 for zinc. LOAEL-based HQs for these compounds were all well below one. Because the HQs based on the NOAEL-based TRVs were low, it was assumed that the potential for risk is unlikely. Additionally, background risk for selenium was greater than risk in the site area, and risk for vanadium and zinc was similar to the risk estimated for the site area. While the background HQ for antimony is greater than the HQ in the site area, the spatial analysis of antimony showed that antimony concentration was elevated in only a single isolated location. Likewise, the spatial distribution of elevated concentrations of selenium, vanadium, and zinc is minimal (i.e., two locations for selenium, three locations for vanadium, and one for zinc). Therefore, it was concluded that risk to insectivorous mammals at the SWTs is acceptable.

Insectivorous birds (American robin): Protect/maintain persistence and reproductive success of insectivorous bird populations under conditions of chronic exposure—For the American robin, only vanadium and zinc had NOAEL-based HQs above one. Because the HQs based on the NOAEL-based TRVs were low, it was assumed that the potential for risk is unlikely. Additionally, background risk for both compounds is barely distinguishable from risk estimated for the site area. In addition, the spatial distribution of elevated concentrations is minimal (i.e., three locations for vanadium and one for zinc). Based on this information, it was concluded that risk to insectivorous bird species at the SWTs is acceptable.

Special-status insectivorous birds (California horned lark) Protect/maintain persistence and reproductive success of individual special-status insectivorous birds under conditions of chronic exposure—For the horned lark, only vanadium and zinc had NOAEL-based HQs above one. Because the HQs based on the NOAEL-based TRVs were low, it was assumed that the potential for risk is unlikely. Additionally, background risk for both constituents is barely distinguishable from risk estimated for the site area. In addition, the spatial distribution of elevated concentrations is minimal (i.e., three locations for vanadium and one for zinc). Based on this information, it was concluded that risk to special-status insectivorous bird species at the SWTs is acceptable.

Carnivorous mammals (coyote): Protect/maintain persistence and reproductive success of carnivorous mammal populations under conditions of chronic exposure—For all compounds that could be evaluated quantitatively and had concentrations greater than background, no NOAEL-based HQs were greater than one for the coyote. Therefore, it was concluded that risk to carnivorous mammals at the SWTs is *de minimis*.

C**arnivorous birds (red-tailed hawk): Protect/maintain persistence and reproductive success of carnivorous bird populations under conditions of chronic exposure—**For all compounds that could be evaluated quantitatively and had concentrations greater than background, no NOAEL-based HQs were greater than one for the red-tailed hawk. Therefore, it was concluded that risk to carnivorous birds at the SWTs is *de minimis*.

Special-status carnivorous birds (northern harrier): Protect/maintain persistence and reproductive success of individual special-status carnivorous birds under conditions of chronic exposure—For all compounds that could be evaluated quantitatively and had concentrations greater than background, no NOAEL-based HQs were greater than one for the northern harrier. Therefore, it was concluded that risk to special-status carnivorous birds at the SWTs is *de minimis*.

The risk evaluation indicates that potential risk to all the identified assessment endpoints exposed to the SWTs area is acceptable. This conclusion is further supported by the fact that the risk evaluation was based on highly conservative exposure assumptions regarding the receptors' potential use of the SWTs area for foraging, as the area does not currently support habitat for these receptors and is likely to support only patchy habitat in the future. Based on the evaluation, it was recommended that no further evaluation of ecological resources at the SWTs is warranted.

2.7.2.6 WDPs

The Tier 2 risk estimate identified only selenium, vanadium, and zinc as the COPECs to be evaluated. A summary of the potential risk for assessment endpoints at the WDPs follows.

Plants: Protect/maintain plant productivity or development under conditions of chronic exposure—Selenium, vanadium, and zinc were identified as the COPECs to be evaluated for plants. HQs using the low plant toxicity benchmark for selenium and zinc are just slightly above one and are unlikely to represent concentrations that would result in adverse effects. The HQ for vanadium is higher (HQ=32), but the area concentrations are similar to background concentrations and are unlikely to pose a significantly increased risk to plants. In addition, vanadium concentration at the area was elevated above background in only one location. Therefore, it was concluded that risk to plants at the WDPs is acceptable.

Soil invertebrates: Protect/maintain soil invertebrate community function and structure under conditions of chronic exposure—For all compounds that could be evaluated quantitatively and had concentrations greater than background, no LOEC-based low HQs were greater than one. Therefore, it was concluded that risk to soil invertebrates at the WDPs is *de minimis*.

Herbivorous mammals (Botta's pocket gopher): Protect/maintain persistence and reproductive success of herbivorous mammal populations under conditions of chronic exposure—Only selenium and vanadium had NOAEL-based HQs slightly greater than one for the Botta's pocket gopher. Because the HQs based on the NOAEL-based TRVs were low, and the LOAEL-based HQs were well below one, it was assumed that the potential for risk is low. Additionally, background risk is similar to the risk estimated for the site area. Therefore, it was concluded that risk to herbivorous mammals at the WDPs is acceptable.

Herbivorous birds (rock dove): Protect/maintain persistence and reproductive success of herbivorous bird populations under conditions of chronic exposure—For all compounds that could be evaluated quantitatively and had concentrations greater than background, no NOAEL-based HQs were greater than one. Therefore, it was concluded that risk to herbivorous birds at the WDPs is *de minimis*.

Insectivorous mammals (ornate shrew): Protect/maintain persistence and reproductive success of insectivorous mammal populations under conditions of chronic exposure—For the ornate shrew, selenium, vanadium, and zinc had NOAEL-based HQs greater than one but low in magnitude (i.e., <8). LOAEL-based HQs for these constituents did not exceed one.

Because the HQs based on the NOAEL-based TRVs were low, and the LOAEL-based HQs were below one, it was assumed that the potential for risk is low. Additionally, background risk from vanadium and zinc is similar to the risk estimated for the site area. Therefore, it was concluded that risk to insectivorous mammals at the WDPs is acceptable.

Insectivorous birds (American robin): Protect/maintain persistence and reproductive success of insectivorous bird populations under conditions of chronic exposure—For the American robin, selenium, vanadium, and zinc had NOAEL-based HQs slightly above one. Because the HQs based on the NOAEL-based TRVs were low, and the LOAEL-based HQs were well below one, it was assumed that the potential for risk is low. Additionally, background risk is similar to the risk estimated for the site area; for vanadium and zinc they are nearly identical. Based on this information, it was concluded that risk to insectivorous bird species at the WDPs is acceptable.

Special-status insectivorous birds (California horned lark): Protect/maintain persistence and reproductive success of individual special-status insectivorous birds under conditions of chronic exposure—For the horned lark, selenium, vanadium, and zinc had NOAEL-based HQs slightly above one. Because the HQs based on the NOAEL-based TRVs were low, and the LOAEL-based HQs were well below one, it was assumed that the potential for risk is low. Additionally, background risk is similar to the risk estimated for the site area; for vanadium and zinc they are nearly identical. Based on this information, it was concluded that risk to special-status insectivorous birds at the WDPs is acceptable.

Carnivorous mammals (coyote): Protect/maintain persistence and reproductive success of carnivorous mammal populations under conditions of chronic exposure—For all compounds that could be evaluated quantitatively and had concentrations greater than background, no NOAEL-based HQs were greater than one for the coyote. Therefore, it was concluded that risk to carnivorous mammals at the WDPs is *de minimis*.

Carnivorous birds (red-tailed hawk): Protect/maintain persistence and reproductive success of carnivorous bird populations under conditions of chronic exposure—For all compounds that could be evaluated quantitatively and had concentrations greater than background, no NOAEL-based HQs were greater than one for the red-tailed hawk. Therefore, it was concluded that risk to carnivorous birds at the WDPs is *de minimis*.

Special-status carnivorous birds (northern harrier): Protect/maintain persistence and reproductive success of individual special-status carnivorous birds under conditions of chronic exposure—For all compounds that could be evaluated quantitatively and had concentrations greater than background, no NOAEL-based HQs were greater than one for the northern harrier. Therefore, it was concluded that risk to special-status carnivorous birds at the WDPs is *de minimis*.

The risk evaluation indicates that potential risk to all the identified assessment endpoints exposed to the WDPs area is either acceptable or *de minimis*. This conclusion is further supported by the fact that the risk evaluation was based on highly conservative exposure assumptions regarding the receptors' potential use of the WDPs for foraging, as the area does not currently support habitat for these receptors and is likely to support only poor quality, patchy habitat in the future. In addition, for each of the COPECs evaluated, concentrations above background were only found in one or two locations. Based on the evaluation provided here, it was recommended that the WDPs area does not require further evaluation of ecological receptors.

2.7.3 Basis for Action

The response actions selected in this ROD are necessary to protect public health and the environment from actual or threatened releases of hazardous substances from this site. The baseline risk assessment evaluated potential present and future public health and ecological risks associated with environmental contamination from the LEHR Federal Facility using the assumption that no cleanup or remediation activities would take place at the site. The risk assessment provides the basis for implementing a remedial action and identifies the potential exposure pathways that need to be addressed. Selection of a remedial action was based in part on the extent to which it can reduce human and ecological risks, including risks to groundwater quality.

2.8 Remedial Action Objectives

As determined by DOE and the regulatory agencies, the Remedial Action Objectives (RAOs) for the site are to:

- Prevent human contact with contamination in soil that poses an excess cumulative cancer risk greater than the upper bound of the range of 1 in 1 million to 1 in 10,000. Any risk greater than 1 in 1,000,000 requires investigation to determine if remedial action is necessary.
- Mitigate potential future impacts to groundwater.
- Minimize threats to the environment, including but not limited to, sensitive habitats and critical habitats of species protected under the state and federal Endangered Species Acts.
- Comply with all ARARs.
- Minimize impact to UC Davis research activities at the site, as specified in the Memorandum of Agreement between DOE and the Regents of the University of California.

Table 2−7 and Table 2−8 present numerical remediation goals for residual contaminant concentrations in soils that would meet the first two of the above RAOs, respectively. The goals presented in Table 2−7 were developed to address the risks identified in the human health risk assessment as exceeding a 1 in 1 million risk due to exposure to residual contaminants. The groundwater quality goals (Table 2−8) were developed in conformance with the RWQCB Central Valley Region's guidance document *Designated-Level Methodology for Waste Classification and Cleanup Level Determination* (CRWQCB 1989). These remediation goals represent contaminant concentrations in soil that, based on modeling, would not impact groundwater above groundwater background or water quality goals. Removal actions completed by DOE were based on these remediation goals. However, in some areas (DSS 4, EDP, SWT) residual soil contamination exceeding these goals remains, and groundwater monitoring beneath and downgradient of these areas of contamination will continue until it can be shown that the wastes no longer pose a threat to water quality.

Table 2−7. Remediation Goals for the Protection of Human Health

DOE Area	Receptor/COC	EPC[1] (mg/kg or pCi/g)	Remediation Goal[2] (mg/kg or pCi/g)
Domestic Septic System 4	**On-Site Resident**		
	Benzo(a)anthracene	3.8	0.2
	Benzo(a)pyrene	2.4	0.03
	Benzo(b)fluoranthene	2.7	0.4
	Benzo(k)fluoranthene	1.5	0.004
	Dibenzo(a,h)anthracene	1.1	0.1
	Indeno(1,2,3-cd)pyrene	0.86	0.2
	On-Site Construction Worker		
	Benzo(a)pyrene	2.4	2
Southwest Trenches	**On-Site Resident**		
	Strontium-90+daughter	0.94	0.3
Eastern Dog Pens	**On-Site Resident**		
	Dieldrin	0.019	0.006
	Strontium-90+daughter	0.33[3]	0.3

Notes

[1]Maximum concentration or 95% UCL on the mean for soil located between 0 and 10 ft bgs; chemical concentrations are in milligrams per kilogram, and radionuclide concentrations are in picocuries per gram.

[2]RAOs based on 1 in 1 million risk, determined using one significant figure total cancer risk; chemical concentrations are in milligrams per kilogram, and radionuclide concentration is in picocuries per gram.

[3]EPC after EDPs maintenance action.

Table 2−8. Remediation Goals for the Protection of Groundwater

DOE Area	COC in Soil[1]	Maximum Soil Concentration (mg/kg or pCi/g)	Background Remediation Goal[2] (mg/kg or pCi/g)	MCL Remediation Goal[3] (mg/kg or pCi/g)
Domestic Septic System 3	Formaldehyde	2.2	0.00378	0.0151[5]
	Molybdenum	2.5	<0.26[4]	3.11[6]
	Nitrate	106	36[4]	36[4]
Domestic Septic System 4	Selenium	2.0[7]	4.0	35
Dry Wells A–E Area	Chromium	245	181[4]	181[4]
	Hexavalent Chromium	1.62	1.3[4]	1.3[4]
	Mercury	5.3	0.63[4]	0.63[4]
	Molybdenum	1.3	0.30	3.6 [6]
	Silver	53.8	0.55[4]	0.83
	Cesium-137	0.191	0.1	20 [8]
	Strontium-90	0.176	0.0595	0.28
Radium/Strontium Treatment Systems	Nitrate	304	36[4]	36[4]
	Carbon-14	2.41	0.13[4]	2.34[8,9]
	Radium-226	1.72[10]	0.752[4]	1.9
Southwest Trenches	Nitrate	909	36[4]	36[4]
	Carbon-14	5.84	0.13[4]	0.292[8, 9]

Notes

[1] Vadose zone soil contaminant with potential to impact groundwater.

[2] Soil concentration predicted by transport modeling above which groundwater impacts above site background are possible.

[3] Soil concentration predicted by transport modeling above which groundwater impacts above California drinking water MCL may occur, unless noted.

[4] The calculated remediation goal is below soil background. Soil background was selected as the remediation goal. Calculated remediation goals are presented in the *Risk Characterization for DOE areas* (WA 2005).

[5] Based on the California Department of Public Health Notification Level of 100 µg/L (California Health & Safety Code 116455).

[6] Based on EPA Region 9, preliminary remediation goal for tap water (EPA Region 9 2009).

[7] Residual selenium soil concentrations exceeded soil background in 23% of the samples collected, and modeling suggests that selenium concentrations in the soil are unlikely to impact groundwater at levels exceeding the remediation goals. However, selenium was retained as a COC due to its presence (one result) in a downgradient HSU-1 well at a concentration slightly above groundwater background.

[8] Based on the four millirem per year federal MCL for beta particles and photon emitters (EPA 2000).

[9] The different MCL remediation goals for Ra/Sr Treatment Systems and SWT areas reflect the observed vertical distribution of contamination in these areas.

[10] The sample containing the maximum radium-226 result in the Ra/Sr Treatment Systems area was re-collected and reanalyzed. The reported maximum value is the average of the initial result (1.81 pCi/g) and re-collected sample result (1.63 pCi/g).

2.9 Additional Requirements for Protection of Groundwater Quality

In addition to developing a list of contaminants of concern that were evaluated in the Feasibility Study report (WA 2008a) , the remedial project managers identified an additional suite of constituents in soil at the DOE areas that should be identified in the ROD as requiring future monitoring. This suite of soil contaminants was identified in the risk characterization as having very low, but possible, groundwater impacts in the future. These constituents are listed in Table 2−9.

Table 2−9. Constituents to be Monitored due to Potential Impact on Groundwater Quality

Area	Constituents of Potential Concern to be Monitored
Domestic Septic System 1	Aluminum
Domestic Septic System 3	Aluminum, Silver
Domestic Septic System 4	Aluminum, Chromium, Nickel
Domestic Septic System 5	Aluminum
Domestic Septic System 6	Aluminum
Domestic Septic System 7	None
Dry Wells A–E Area	None
Radium/Strontium Treatment Systems	Americium-241
Southwest Trenches	Mercury, Zinc
Western Dog Pens	None
Eastern Dog Pens	alpha-Chlordane, gamma-Chlordane, Dieldrin
DOE Disposal Box	None

These constituents were identified by evaluating sample data representative of post-removal-action conditions to determine potential for groundwater impacts. The following summary of uncertainties associated with constituents listed in Table 2−9 provides the rationale for collecting additional data to ensure that unanticipated impacts do not occur:

- Although there was no indication of a release, aluminum was selected for monitoring at DSS 1, DSS 3, DSS 4, DSS 5, and DSS 6 because deionized water waste extraction test (DI WET) results from soil samples from these areas suggested the possibility of groundwater impacts at concentrations above the MCL and background. Downgradient groundwater data have not yet been collected for aluminum. Monitoring is intended to verify whether modeling predictions are correct.
- Modeling suggests that silver at DSS 3 will impact groundwater above the MCL and background. However, soil sample data at DSS 3 did not conclusively indicate the presence of elevated silver concentrations, and silver was not detected in groundwater samples from downgradient wells. Monitoring is intended to verify whether modeling predictions are correct.
- Chromium concentrations in soil at DSS 4 were found to be slightly above background in localized shallow soil and downgradient groundwater. The elevated soil concentrations did not extend down the soil column, and the groundwater concentrations were below MCLs. However, modeling results suggest native chromium concentrations and the concentrations detected in DSS 4 soil will impact groundwater at levels significantly above background and the MCL. Monitoring was selected for chromium to verify model predictions.
- Nickel concentrations in soil were localized near the site features at DSS 4 and slightly above background, but below background and the MCL in downgradient groundwater. Nickel DI WET results did not indicate significant leaching. However, the potential for nickel to impact local groundwater has not been modeled, and monitoring was selected to confirm that no impacts to groundwater would occur from the slightly elevated concentrations.

- Americium-241 was identified to be slightly above background in a small localized volume of soil from the Ra/Sr Treatment Systems Area. Americium-241 was detected infrequently and with high analytical uncertainty in groundwater samples collected downgradient of the Ra/Sr Treatment Systems Area. Modeling suggests americium-241 will decay before reaching groundwater. Monitoring was selected to determine whether the detections of americium-241 in downgradient groundwater were due to impact or analytical error.
- Elevated concentrations of mercury are present in soil at the SWTs area, but mercury is not currently impacting downgradient groundwater. Modeling suggests that mercury could impact groundwater above background and the MCL. Although current monitoring data do not indicate mercury impact, monitoring was selected in case the predicted impact occurs.
- Elevated concentrations of zinc were detected in a small volume of SWTs area soil. Downgradient groundwater concentrations were below background and the MCL. Modeling suggested zinc could currently be impacting groundwater above background. Zinc was selected for monitoring to address the differences between existing data and modeling.
- Alpha-chlordane, gamma-chlordane, and dieldrin are present in shallow soil at the WDPs area. Modeling suggests that alpha-chlordane and gamma-chlordane will not impact groundwater above the MCL and analytical detection limit. Dieldrin was screened out during the groundwater risk estimate. These constituents have been detected historically in groundwater, but they are not currently present. Alpha-chlordane, gamma-chlordane, and dieldrin were retained for monitoring to confirm current conditions.

A monitoring plan for these constituents and a process for evaluating the need for such continued monitoring will be included in the Remedial Design Report. The monitoring results and the need for continued monitoring will be evaluated and reported during the 5-year reviews. If constituents listed in Table 2−9 are detected in groundwater, response actions will be evaluated and implemented in accordance with CERCLA and ARARs. Since these constituents were not evaluated in the Feasibility Study, their possible future remediation is not addressed in this ROD.

2.10 Remedial Technology Summary

Cleanup technologies and alternatives have been developed to address contaminants remaining in the DOE areas. A remedial alternative consists of one or more cleanup technologies assembled to address specific conditions in a release area. Eight cleanup approaches were identified to address the forms of contamination at the site, including a No Action/No Further Action approach. The cleanup approaches are presented in Sections 2.10.1 through 2.10.8. The assembly of cleanup technologies into alternatives is presented in Section 2.10.9. The complete evaluation of cleanup technologies and alternatives is presented in the Feasibility Study report (WA 2008a).

2.10.1 No Action and No Further Action

As required by EPA guidance, No Further Action and No Action alternatives were developed to determine the potential effects associated with leaving residual contamination in place without monitoring or controls. No Further Action (which may include monitoring) applies to the areas that have undergone removal actions. No Action applies to the areas that have not undergone removal actions.

2.10.2 Long-Term Groundwater Monitoring and Contingent Remedial Action

Under this option, some residual concentrations of contaminants remain in soil above remediation goals. The contaminants may migrate from soil into groundwater. However, based on the conservative assumptions used in developing these goals, it is not considered likely that residual soil concentrations are high enough to raise contaminant levels in groundwater above site background or drinking water MCLs.

The purpose of long-term groundwater monitoring is to ensure that if contaminants begin to impact groundwater, remedial action will be taken to prevent the degradation of water quality. DOE believes that the likelihood that contingent remediation will be necessary is low, since most of the contaminants have been removed, and current monitoring data do not show impacts to groundwater quality.

Groundwater monitoring would include performing sufficient sampling to establish background/baseline conditions and criteria for determining if a contingent remedy is needed. A process for establishing background/baseline condition values would be detailed in the Remedial Design Report. Long-term monitoring would consist of collecting groundwater samples from wells located in HSU-1 close to the area with residual contamination. HSU-1 groundwater is not used due to the aquifer's inadequate yield and the poor natural quality of the water. The HSU-2 aquifer located directly below HSU-1 has a higher yield, and the water in this aquifer is used for domestic and agricultural purposes. Groundwater monitoring at HSU-1 would detect contaminants in the aquifer before they reach groundwater in HSU-2. Thus, the probability of public exposure to contaminated groundwater under this option is extremely low.

Where necessary, new monitoring wells will be installed under this option. DOE would evaluate the locations of these wells and monitoring requirements during the remedial action/remedial design phase. Results from monitoring new and existing wells would be evaluated and presented in annual water monitoring reports and in 5-year reviews.

Sampling would be conducted within 60 days of the report of analysis, and more frequent sampling as defined in the compliance monitoring component of the Remedial Design Report would occur at the specific area for at least 1 year if:

- Concentrations of COCs identified in Table 2−8 not currently present above background in groundwater were detected above site background concentrations; or
- Concentrations of COCs identified in Table 2−8 currently present in groundwater showed an upward trend in concentration.

Four consecutive groundwater sample results that exceed background levels or show a distinct increasing concentration trend above baseline conditions (hereafter referred to as groundwater impact) will trigger an evaluation of remedial cleanup technologies and identification of a cleanup remedy, if necessary. The background comparison and trend analysis will be performed according to *Methods for Evaluating the Attainment of Cleanup Standards, Volume 2: Ground Water* (EPA 1992), or equivalent methodology agreed upon by EPA and the RWQCB. If groundwater monitoring indicates that impacts to groundwater have occurred due to COCs remaining in soil, DOE will evaluate remedial options and determine whether remediation is appropriate in accordance with CERCLA and ARARs, including the evaluation and corrective action requirements of Title 27 *Code of California Regulations*.

Monitoring well locations, compliance monitoring requirements (e.g. frequency, analytical methods), and procedures for evaluating remedial options if groundwater impacts occur will be included in the Remedial Design Report. Requirements preventing the destruction or disturbance of monitoring wells will be established as land-use covenants implemented as discussed in Section 2.10.3.

2.10.3 Land-Use Restrictions

Land-use restrictions are physical, administrative, or legal mechanisms used to limit exposure to residual contamination, and they are often applied when a site is not remediated to a level that would allow for its unrestricted use. Land-use restrictions could include deed restrictions, covenants, easements, zoning ordinances, and groundwater use restrictions. Land-use restrictions could be used in coordination with other technologies—for instance, with asphalt caps to ensure the integrity of the cap area and prohibit site development activities that might affect cap performance.

Land-use restrictions would be required to:

- Prevent exposure to contaminated soil.
- Prevent improper disposal of contaminated soils.
- Maintain the integrity of all present and future monitoring wells for alternatives requiring storm water monitoring.

Land-use controls would be maintained until the concentrations of contaminants in the soil are at levels that allow unrestricted use.

Due to the potential elevated risk of a hypothetical resident in the DSS 4 area, DOE would establish a land-use covenant prohibiting residential land use in this area if residual contamination is left in place. For the purpose of this ROD, residential use includes, but is not limited to, single-family or multifamily residences, childcare facilities, and any type of educational purpose for children under the age of 21. For alternatives requiring capping, a land-use restriction would be used to prevent development that would disturb or adversely affect performance of the cap. Events that would trigger the land-use restrictions (e.g., excavation, change in land use, zoning changes) would be identified at the remedial design phase and included in the land-use covenants.

If residual contamination is left in place, DOE would require a Soil Management Plan to address residual chemical and radionuclide soil contamination for all DOE areas, except areas where No Action or No Further Action was identified. The Soil Management Plan would be required any time soil-disturbing activities may bring subsurface contaminants to the surface. The Soil Management Plan would be maintained and updated during 5-year reviews and would provide management requirements for the reuse and disposal of soil in DOE areas. The plan would comply with the substantive requirements of DOE Order 435.1, *Radioactive Waste Management,* which specifies requirements for managing DOE radioactive waste. The contents of the Soil Management Plan would include:

- Introduction, background, purpose
- Scope and applicability
- Roles and responsibilities
- Nature and extent of residual contamination
- Identification of other required plans, permits, and documentation
- Soil management procedures
- Sampling and analysis procedures
- Waste characterization and disposal
- Reporting and recordkeeping
- Audits and 5-year reviews

The general requirements for this plan would be documented in land-use covenants discussed below.

The lateral extent of the areas subject to land-use restrictions would be confirmed by a survey. The vertical extent would be defined at the remedial design phase and included in the land-use covenants. Land-use covenants would be specified during the remedial design, and the land-use restrictions (including the Soil Management Plan) would be incorporated into the remedial design. Within 90 days of ROD signature, DOE would prepare and submit to EPA for review and approval a draft Remedial Design Report containing the plan for all implementation and maintenance actions, including periodic inspections.

After the Remedial Design Report is approved, land-use covenants would be drafted by DTSC with input from EPA; signed by the University of California and DTSC, listing EPA as a third-party beneficiary; and recorded by the Recorder Division of the Solano County Department of the Assessor/Recorder. Land-use restrictions would be implemented by the University of California as agreed upon in a Memorandum of Agreement between DOE and the Regents of the University of California (DOE 2009). Although DOE may transfer the implementation of land-use restrictions to the University of California by agreement, DOE shall retain ultimate responsibility under CERCLA for remedy integrity, including maintaining, reporting on, and enforcing the land-use restrictions. A Land-use Covenant Report would be submitted annually to EPA and DTSC. As long as contamination requiring the implementation of a Soil Management Plan and/or land-use restrictions remains in place, DOE shall continue to conduct 5-year reviews to ensure that the selected remedy remains protective.

2.10.4 Asphalt Cap

Generally, residual contaminants in the DOE areas are located in soil above the water table. Surface water infiltration is the primary mechanism for migration of these contaminants to groundwater. An asphalt cap would divert surface water from the contaminated soil area and prevent infiltration. An asphalt cap would consist of a thick plastic liner overlain by 8 inches of compacted gravel and 4 inches of asphalt pavement. The liner and pavement would be sloped to direct storm water runoff away from the area. The asphalt cap would be inspected periodically and repaired as necessary.

2.10.5 Removal and Off-Site Disposal

This option would consist of excavating all contaminated soil regardless of depth, and disposing of it in an appropriately permitted off-site facility. All soil containing contaminants at concentrations above cleanup goals would be removed and disposed of. Confirmation samples would be collected from excavation floors and sidewalls prior to filling the excavation with clean soil or low-strength concrete. Excavated soil classified as low-level radioactive waste would be transported by truck and disposed of at a permitted facility outside of California. Other soil would be disposed of at a Class II industrial waste landfill located within 50 miles of the site.

2.10.6 Removal and On-Site Treatment by Phytoremediation

This option would involve removing soil to achieve the cleanup goals and treating a portion of the contaminated soil on site. Phytoremediation would treat nitrate in contaminated soil by planting crops that remove nitrate through root uptake and convert the nitrate to nitrogen gas. On-site phytoremediation would be accomplished by spreading contaminated soil over the former WDPs and planting annual crops of warm-season grass. A plastic liner would be installed under the contaminated soil to prevent contact with surface soil in the treatment area. The grass crop would be seeded in spring and regularly trimmed through early fall. The trimmings would be properly disposed of off-site. When monitoring data indicate that remediation is complete, confirmation samples would be collected to verify that concentrations are below the cleanup goals.

2.10.7 Limited Removal and Off-Site Disposal

This option would involve removing soil that is accessible with conventional excavation equipment and disposing of it in an appropriately permitted off-site facility. The lateral excavation limits would include soil with concentrations above the cleanup goals, but excavation would be terminated approximately 20 ft bgs regardless of the presence of deeper contamination.

2.10.8 In Situ Bioremediation

This option would treat nitrate in place using a process called anaerobic microbial denitrification. To initiate this process, a benign nutrient solution (e.g., molasses) would be injected into the subsurface until complete soil saturation is achieved in the vicinity of the nitrate contamination. Over time, naturally occurring microorganisms would reduce the nitrate to nitrogen gas. A treatment system consisting of several injection wells connected to a solution tank and metered delivery pump would be installed. Clustered piezometers and monitoring wells would be used to measure the level of soil saturation, nutrient concentration, and nitrate concentration at various distances away from the injection wells. When monitoring data indicate that remediation is complete, confirmation samples would be collected to verify that concentrations are below the cleanup goals.

2.10.9 Assembly of Alternatives

The cleanup options described above were assembled into alternatives comprising one or more cleanup methods to meet all RAOs and ARARs for a particular area. The list of alternatives for each area is provided in Table 2−10.

2.11 National Environmental Policy Act (NEPA) Integration

Section II.E of the DOE Secretarial Policy Statement on NEPA (Public Law 91-190) requires that when DOE remedial actions under CERCLA trigger the procedures set forth in NEPA, the procedural and documentation requirements of NEPA and CERCLA are integrated. Integration is to be accomplished by conducting environmental review under NEPA and CERCLA concurrently to avoid duplication, conflicting analyses, and delays in implementing remedial action on procedural grounds. The potential environmental impacts of each alternative are evaluated in compliance with the requirements of DOE's NEPA Implementing Procedures (Title 10 *Code of Federal Regulations* Part 1021 [10 CFR 1021]), Section II.E of the Secretarial Policy Statement on NEPA (issued June 1994), and the Council of Environmental Quality Regulations for Implementing the Procedural Provisions of NEPA (40 CFR 1500–1508).

Each remedial alternative presented in this ROD was reviewed and evaluated for potential environmental impacts, including:

- Purpose and need for action
- Proposed actions and alternatives
- Alternatives not carried forward for analysis
- Affected environment, including:
  - — Aesthetics and scenic values
  - — Air quality
  - — Biological resources
  - — Floodplains
  - — Geology/soils
  - — Hydrogeology
  - — Land use
  - — Noise
  - — Socioeconomic conditions
  - — Water resources (from storm water runoff)
  - — Wetlands
- Environmental considerations not affected by any of the alternatives
- Potential environmental impacts
- Mandatory finding of significance
- Mitigation measures

None of the selected alternatives was found to have a significant impact on the environment (WA 2008a).

Table 2−10. Cleanup Technologies and Alternatives for Each DOE Area

Cleanup Technology	Ra/Sr Treatment Systems							DSS 3							DSS 4				Dry Wells A–E					SWT							EDPs		
	Alternatives[1, 2]																																
	1	2	3	4a	4b	4c	5	1	2	3	4a	4b	4c	5	1	2	3	4	1	2	3	4a	4b	1	2	3	4a	4b	4c	5	1	2	3
No Further Action/No Action	✓							✓							✓				✓					✓							✓		
Long-Term Groundwater Monitoring/Contingency Remediation		✓	✓			✓	✓		✓	✓			✓	✓		✓	✓			✓	✓		✓		✓	✓			✓	✓			
Land-Use Restrictions:																																	
Soil Management Plan		✓			✓	✓	✓		✓			✓	✓	✓		✓	✓	✓		✓			✓		✓			✓	✓	✓		✓	
Limit Development (cap protection)			✓							✓							✓				✓					✓							
No Residential Use																✓	✓	✓															
Well Protection		✓	✓			✓	✓		✓	✓			✓	✓		✓	✓			✓	✓		✓		✓	✓			✓	✓			
Capping			✓							✓							✓				✓					✓							
Removal and Off-Site Disposal				✓							✓											✓					✓						✓
Removal and On-Site Treatment					✓							✓																✓					
Limited Removal and Off-Site Disposal						✓							✓					✓					✓						✓				
In Situ Bioremediation							✓							✓																✓			

Notes

[1]Alternatives were numbered based on the primary approach they represent. Variations of an approach were lettered. Alternative numbers are sequential for each area and are not necessarily the same from area to area. Blue highlighting denotes DOE's selected remedy.

[2]Only alternatives evaluated in the Feasibility Study are presented. As discussed in Section 2.7.1.4 and presented in Table 2-6, risks from residual contamination in soil at DSS 1, DSS 5, DSS 6, DSS 7, WDPs, and DOE Disposal Box were determined to be acceptable (WA 2005) and required either No Action or No Further Action. These areas are therefore not included in this table.

2.12 Termination of Routine Environmental Reporting

After the adoption of this ROD, the preparation of the reports discussed in this section will be terminated.

DOE and EPA agree that monitoring air emissions from the site and reporting the monitoring data for compliance with the National Emission Standards for Hazardous Air Pollutants (NESHAPs) of Section 112 of the Clean Air Act (40 CFR Part 61, 10 CFR 20.101–108, NESHAPs for Radionuclides) will cease once the ROD is adopted. Reporting indicates that radiation-associated windblown fugitive dust (the only source of air emissions) has been at least two orders of magnitude below the 10 millirem (mrem)/year standard (WA 2008b). Given these results, DOE and EPA conclude that the site is not a significant source of radionuclides in air emissions.

DOE will also cease to prepare and issue to the public the Annual Site Environmental Report once the ROD is adopted. The Annual Site Environmental Report summarizes the environmental impacts of DOE's operations at active sites and is required by DOE Order 231.1 for certain DOE offices. The Office of Legacy Management is excluded from the requirement to issue an Annual Site Environmental Report under this order.

2.13 Area-Specific Decisions

Remedial action decisions are addressed separately for each DOE area in the following sections. The topics discussed for each area include an assessment of the area, a description of alternatives, a comparative analysis of alternatives, a selected remedy, statutory determinations, common elements, distinguishing features, and expected outcomes of each alternative. Table 2−10 shows the alternatives and selected remedies for each DOE area. The selected remedies are also summarized in Table 2−1.

None of the DOE areas contain "principal-threat waste" as defined by the NCP and EPA's *Guide to Principal Threat and Low-level Threat Wastes* (EPA 1991). All of the liquid waste, highly toxic waste, and mobile source materials were removed during removal actions conducted under the NCP. Residual contamination remaining in the DOE areas presents a "low-level threat" (EPA 1991). The selected alternatives address this low-level threat.

Under CERCLA Section 121 and the NCP, DOE and EPA must select remedies that protect human health and the environment, comply with ARARs, are cost-effective, and use permanent solutions and alternative treatment technologies or resource recovery technologies to the maximum extent practicable. In addition, CERCLA includes a preference for remedies that permanently and significantly reduce the volume, toxicity, or mobility of hazardous wastes as a principal element and are biased against off-site disposal of untreated wastes. A discussion of how the selected remedies for each DOE area meet these statutory requirements is presented for each area.

In DOE's judgment, the selected remedies addressed in this ROD are cost-effective. In making this determination, the following definition was used: "A remedy shall be cost-effective if its costs are proportional to its overall effectiveness" (NCP 300.430[f][1][ii][D]). Alternatives that satisfied the threshold criteria (i.e., protect human health and the environment and comply with ARARs) were evaluated by assessing three of the five balancing criteria in combination (long-term effectiveness and permanence; reduction in toxicity, mobility and volume through treatment; and short-term effectiveness). Overall effectiveness was then compared to estimated costs to evaluate cost-effectiveness. The relationship of the overall effectiveness of the selected remedial alternatives was determined to be proportional to their costs and thus represent reasonable value.

All of the selected remedies achieve compliance with ARARs. Tables A−1 through A−3 in Appendix A present the federal and state ARARs that apply to each remedy.

DOE and EPA, in consultation with the agencies of the State of California who are signatories to the Federal Facility Agreement, have determined that the selected remedies comply with federal and state requirements and are cost-effective. The Feasibility Study contains a discussion of other alternatives that were analyzed for permanence and alternative technologies but were not selected. Of those alternatives that protect human health and the environment and comply with ARARs, DOE and the regulatory agencies have determined that the selected remedies provide the best balance of trade-offs when compared across the five balancing criteria and two modifying criteria of the NCP §300.430(f)(1)(i)(B) and (C), respectively.
NCP §300.430(f)(1)(ii)(E) provides that the balancing shall emphasize the factors of "long-term effectiveness" and "reduction of toxicity, mobility, or volume through treatment," and shall consider the preference for treatment and bias against off-site disposal. However, alternatives that include additional treatment have not been selected for any DOE areas at LEHR, since all of the principal-threat waste has been removed from all of the DOE areas, and only low-threat residual contamination requires additional action.

Modifying criteria should also be considered in making this determination. The selected remedies also consider state and community acceptance, the statutory preference for treatment as a principal element, and a bias against off-site treatment and disposal.

2.13.1 Ra/Sr Treatment Systems Area

2.13.1.1 Area Characteristics

The location of the Ra/Sr Treatment Systems area is shown in Figure 1−2. This area was used to treat and discharge wastewater generated by LEHR research operations. Two separate treatment systems treated aqueous waste generated during the Ra-226 and Sr-90 experiments. The Ra-226 treatment system consisted of one subsurface 14,400-gallon tank, an effluent distribution box, three dry wells, and two leach trenches. The Sr-90 treatment system consisted of a series of nine adjoining subsurface tanks and an ion exchange column, referred to as the Imhoff Wastewater Treatment Facility shown on Figure 1−2; and a leach field and associated piping. The ion exchange column was used to remove Sr-90 from wastewater prior to discharge. The primary release mechanism for contaminants from the treatment systems was subsurface infiltration/percolation of wastewater from the leach fields and dry wells into the soil.

In 1992, approximately 40,000 gallons of low-level radioactive liquid and sludge waste were removed from the Ra-226 septic tank and Sr-90 tanks as part of the facility decontamination and decommissioning activities conducted by DOE (WA 2003). This waste was solidified and disposed of at the DOE Hanford Site. The Imhoff Waste Water Treatment Facility was demolished in 1995, and all associated waste was properly disposed of off site. In 1999 and 2000, the Ra/Sr Treatment Systems tanks, leach fields, dry wells, associated piping, and surrounding contaminated soil were excavated and disposed of off site. Thus, all of the liquid waste, highly toxic waste, and mobile source materials were removed from the Ra/Sr Treatment Systems area during the removal actions conducted in 1992, 1995, 1999, and 2000.

Human health risk information for the Ra/Sr Treatment Systems area is discussed in Section 2.7.1. Ecological risks are provided in Section 2.7.2. The conceptual site model is shown in Figure 2−3, and contaminants remaining in subsurface soil are provided in Table 2−8. Receptors identified in the risk assessment with potential for exposure to residual contamination in subsurface soil are construction workers, hypothetical future on-site residents, and terrestrial biota. Exposure mechanisms include incidental ingestion of subsurface soil and ingestion of plants that take up contamination from subsurface soil, dermal contact, external radiation, and dust inhalation for construction workers performing subsurface work in the area. On-site researchers and trespassers may also be exposed to potential risks from contaminants in subsurface soil during soil-disturbing activities conducted as part of maintenance work, infrastructure replacement, or future development. However, because of the limited areal extent of residual contamination and its low estimated risk (less than 1 in 1 million for a residential receptor), these potential exposures are not expected to be significant.

As shown in the conceptual site model (Figure 2−3), residual subsurface soil contamination (nitrate) has migrated to HSU-1 groundwater, and ingestion of contaminated groundwater is a potentially complete exposure pathway. Conclusive groundwater monitoring data are not currently available to determine whether Ra-226 or carbon-14 (C-14) have impacted HSU-1. Groundwater samples need to be collected in HSU-1 close to the areas with residual Ra-226 and C-14 contamination to make this determination. Residual soil contamination in the area between Animal Hospital No. 1 and Animal Hospital No. 2 buildings shown on Figure 1−2 does not present risk to groundwater (WA 2005).

2.13.1.2 Assessment of the Ra/Sr Treatment Systems Area

A sitewide risk assessment found no significant human health or ecological risk associated with residual contamination in the area (WA 2005; BBL 2006). Modeling calculations suggest that nitrate, Ra-226, and C-14 have potential to impact a small area of groundwater in HSU-1 beneath this location (Table 2−2).

2.13.1.3 Description of Alternatives for the Ra/Sr Treatment Systems Area

The following remedial alternatives shown in Table 2−10 were developed in the Feasibility Study as potential response actions for the residual nitrate, Ra-226, and C-14:

- Alternative 1—No Further Action
- Alternative 2—Long-Term Groundwater Monitoring/Contingency Remediation/Land-Use Restrictions
- Alternative 3—Capping/Long-Term Groundwater Monitoring/Land-Use Restrictions
- Alternative 4a—Removal and Off-Site Disposal
- Alternative 4b—Removal and On-Site Treatment/Land-Use Restrictions

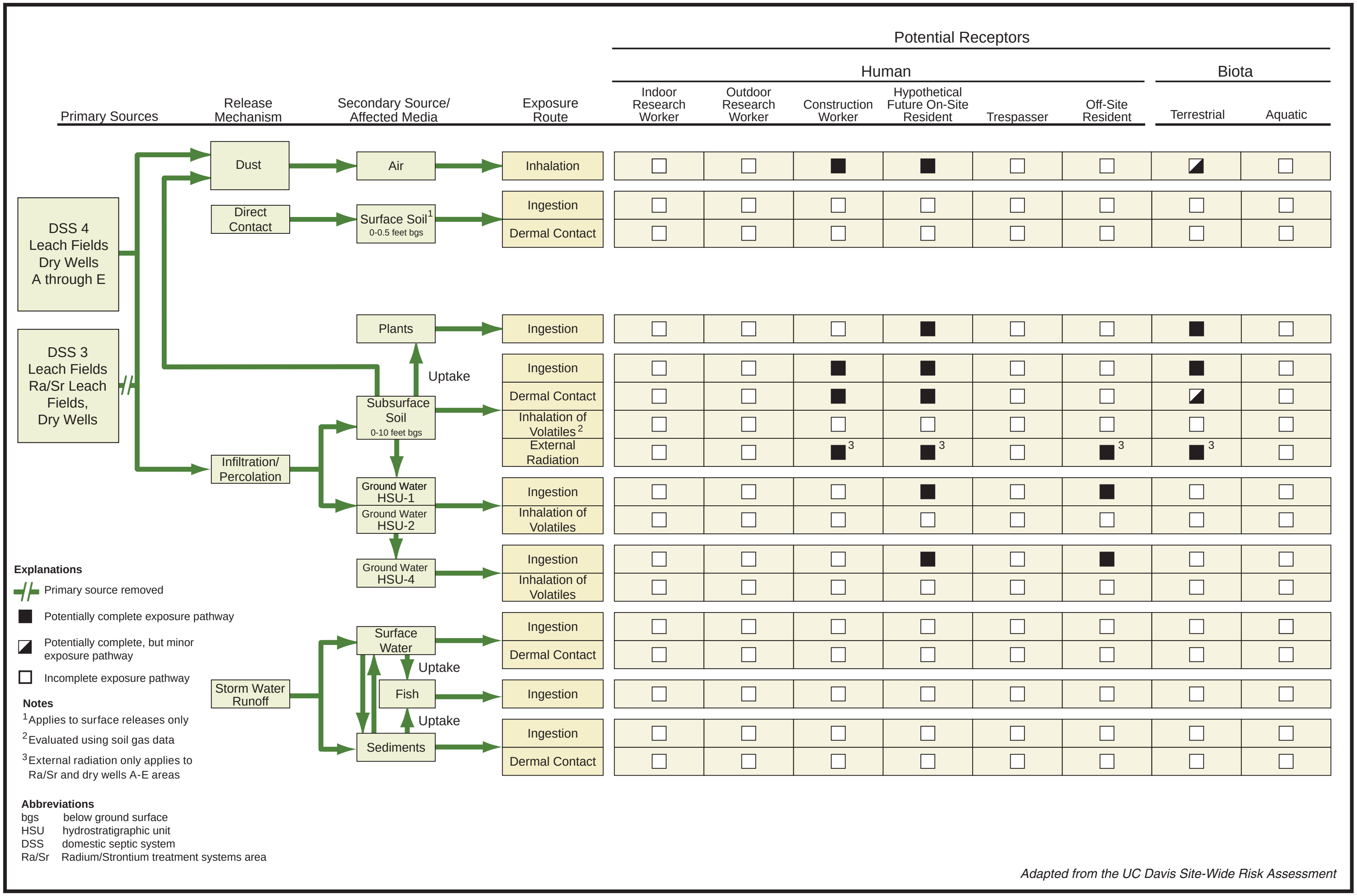

Figure 2−3. Conceptual Site Model for the Radium/Strontium Treatment Systems, Domestic Septic Systems 3 and 4, and Dry Wells A through E

- Alternative 4c—Limited Removal and Off-Site Disposal/Long-Term Groundwater Monitoring/Land-Use Restrictions
- Alternative 5—In Site Bioremediation/Long-Term Groundwater Monitoring/Land-Use Restrictions

2.13.1.4 Common Elements and Distinguishing Features of Each Alternative for the Ra/Sr Treatment Systems Area

Alternatives 2 and 3 rely on groundwater monitoring to ensure compliance with the state's Anti-Degradation Policy and Basin Plan and land-use restrictions to prevent exposure to subsurface soil contamination that could be brought to the surface in the future. Under Alternatives 4a and 4b, all of the contamination that could impact groundwater is excavated, and no groundwater monitoring is included. Under Alternative 4c, residual contamination is excavated down to 20 ft and followed by long-term groundwater monitoring. Alternative 5 consists of bioremediation to treat residual nitrate contamination, and the other residual contaminants are left in place and monitored for groundwater impacts. All of these alternatives (except the No Further Action alternative) meet ARARs.

The long-term reliability of Alternatives 2 and 3 is similar in that both alternatives rely on monitoring to meet ARARs, and if monitoring indicates the need, the implementation of contingent remedial action to achieve compliance. Alternative 3 adds a capping element to prevent surface water infiltration. Periodic cap repair is anticipated in Alternative 3. The alternatives in which all residual contaminants are removed (4a and 4b) have the highest long-term reliability; however, this is achieved at a significantly higher cost than the alternatives that rely on monitoring and land-use restrictions. Alternative 4c removes residual contaminants to a depth of 20 ft, which makes it somewhat less reliable than those that remove all of the waste. The bioremediation in Alternative 5 only addresses the nitrate contamination and does not address other COCs.

Groundwater monitoring under Alternatives 2, 3, 4c, and 5 will generate small quantities of purge water (less than 1,000 gallons per year) and a small volume of drill cuttings during well installation. Excavation of contaminated soils under Alternative 4a would generate about 4,000 to 7,000 cubic yards of waste to be disposed of off-site. The amount of contaminated soil that would require disposal under Alternative 4b is 350 to 450 cubic yards. Limited excavation under Alternative 4c would yield about 1,500 to 2,000 cubic yards of contaminated soil requiring off-site disposal. Alternative 5 is estimated to generate a small volume of contaminated soil from drill cuttings from well installation.

The schedule for implementation of each of the alternatives is short (less than one year), but the estimated time to reach cleanup levels varies. Alternatives 2, 3, and 4c have an indefinite operation time frame. Under Alternatives 4a, 4b, and 5, cleanup levels are predicted to be met in less than 5 years. Monitoring for C-14 and Ra-226 is indefinite under Alternative 5.

The estimated capital, operations and maintenance, periodic, and total present worth costs for the alternatives and the number of years over which the cost estimates are projected are presented in Table 2−11. The 2008 discount rate of 2.8 percent for federal facilities was used to determine costs (Office of Management and Budget, Circular A-94 Appendix C).

2.13.1.5 Expected Outcomes of Each Alternative for the Ra/Sr Treatment Systems Area

Available land-use options under each of the alternatives would remain consistent with the UC Davis Long-Range Development Plan designation as "Academic/Administrative Low Density" and "Support Services." The alternatives containing land-use restrictions (all, except Alternative 4a) would constrain UC Davis's development options to a limited degree for the duration of the implementation of each of these alternatives. The areas used for phytoremediation under Alternative 4b would be unavailable for development for the duration of the remediation process. Development in the vicinity of monitoring wells may require abandonment and relocation of the existing wells (Alternatives 2, 3, 4c, and 5). Alternative 4a would allow the most flexibility in development after implementation (1 year).

The aquifer beneath the site is designated as a potential source of drinking water (CRWQCB 2007). Under Alternative 2, monitoring continues until contaminants no longer pose any threat to groundwater quality. The performance period is uncertain. If groundwater impacts are observed, an effective contingent remedy will be selected and implemented. Based on the low mass of COCs in the Ra/Sr Treatment Systems area, a contingent remedy would likely reduce the COC concentrations to groundwater standards within 3 years of implementation. The same is true for Alternatives 3, 4c, and 5. Alternative 5 is expected to achieve groundwater standards for nitrate in 3 years. Alternatives 4a and 4b are expected to meet groundwater standards for all COCs in one year.

2.13.1.6 Summary of Comparative Analysis of Alternatives for the Ra/Sr Treatment Systems Area

As discussed below, each remedial alternative was evaluated against the seven NCP criteria shown in Table 2−11.

Overall Protection of Human Health and the Environment—Excess human health risk associated with residual contamination in the Ra/Sr Treatment Systems area is less than 1 in 1 million. Further removal or treatment will not significantly improve protectiveness of human health. Alternative 2 would require monitoring of groundwater in HSU-1 near the area of residual contamination. Remediation could be implemented if residual Ra-226 and C-14 were discovered to be migrating to groundwater in HSU-1. Monitoring data indicate that nitrate has reached HSU-1 groundwater, but current nitrate impacts are insufficient to warrant selecting a remedy. Remediation of Ra-226 and C-14 at such an early stage would prevent contaminants from reaching HSU-2, thereby protecting the quality of groundwater in this aquifer. A Soil Management Plan would prevent improper disposal of contaminated soil or exposure to residual contaminants. Alternatives 4a, 4b, and 4c reduce uncertainty of the future fate and transport of residual contaminants; however, these alternatives present risks of exposure to contaminants during construction and waste shipment and have high costs. All the alternatives except Alternative 1 provide approximately the same level of protectiveness to human health and the environment. Alternative 1 is not protective because it does not monitor shallow groundwater.

Compliance with ARARs—All the alternatives except Alternative 1 comply with ARARs. Alternative 1 does not comply with ARARs because it does not ensure compliance with California's water quality protection requirements.

Table 2−11. Comparative Analysis of Alternatives for the Radium/Strontium Treatment System

Evaluation Criteria	Effectiveness				Implementability					Costs[1] (Capital, O&M, Periodic, Total Cost)	Cost-Effective[2]
	Overall Protection of Public Health and the Environment	**Compliance with ARARs**	**Long-Term Effectiveness**	**Reduction of TMV**	**Short-Term Effectiveness**	**Technical Feasibility**	**Administrative Feasibility**	**Availability of Services and Materials**	**Regulatory Acceptance**	**Community Acceptance**		
Alternative 1: No action	Removal actions have successfully addressed the principal threats to public health and the environment. This alternative does not address future groundwater protection.	This alternative may not comply with the state's Anti-Degradation Policy and Basin Plan.	Not effective due to localized known groundwater impacts that will not be monitored. Lacks management controls to confirm effectiveness. Human health risk less than 1 in 1 million.	None. Principal-threat waste removed.	No short-term risks to the public.	N/A	N/A	N/A	Unacceptable	Unacceptable	$0 $0 $0 **$0** Years: 0	☐
Alternative 2: Long-term groundwater monitoring, contingent remedial action, and land-use restrictions	Protects the beneficial use of groundwater by monitoring groundwater near the source area. If monitoring shows that contaminants are impacting existing groundwater quality, remedial action may be implemented. Soil Management Plan will mitigate remaining low-level threat.	Compliant	Effective due to the negligible mass and toxicity of residual contaminants in soil. Includes monitoring and management controls to confirm effectiveness. Human health risk less than 1 in 1 million.	None. Principal-threat waste removed.	No short-term risks to the public and environment. Ongoing effectiveness will be confirmed by long-term groundwater monitoring.	Uses standard monitoring techniques currently deployed at the site. Site development could limit access to areas requiring future remedial action.	Standard records management and database activities required. Land-use restrictions may be a component of future remedial action, if required.	Relies on standard services and materials.	Acceptable	Acceptable	$108,000 $133,000 $11,000 **$252,000** Years: 30	☒
Alternative 3: Asphalt/HDPE cap, long-term groundwater monitoring, and land-use restrictions	Protects beneficial use of groundwater through surface capping and monitoring groundwater near the source area.	Compliant	Effective due to the negligible mass and toxicity of residual contaminants in soil. Cap will reduce the flux of contaminants to groundwater, if maintained. Includes monitoring and management controls to confirm effectiveness. Human health risk less than 1 in 1 million.	None. Principal-threat waste removed.	Minor short-term risks to the public and environment are associated with the manufacture, transport, and installation of asphalt. The risk of a fatality from implementing this alternative is approximately 0. Cap may restrict site development and aesthetics. Time to deploy is rapid since the cap relies on established engineering design and materials. Predicted to be protective in approximately one year.	Relies on established engineering design and materials.	Standard records management and database activities required. Land-use restrictions require approval by UCOP.	Relies on standard services and materials.	Acceptable	Acceptable	$462,000 $155,000 $38,000 **$655,000** Years: 30	☒

Table 2−11 (continued). Comparative Analysis of Alternatives for the Radium/Strontium Treatment System

Evaluation Criteria	Effectiveness					Implementability					Costs[1] (Capital, O&M, Periodic, Total Cost)	Cost-Effective[2]
	Overall Protection of Public Health and the Environment	**Compliance with ARARs**	**Long-Term Effectiveness**	**Reduction of TMV**	**Short-Term Effectiveness**	**Technical Feasibility**	**Administrative Feasibility**	**Availability of Services and Materials**	**Regulatory Acceptance**	**Community Acceptance**		
Alternative 4a: Removal and off-site disposal	Protects beneficial use of groundwater by removing the contaminated soil. Local risk reduction offset by the transfer of risk to the disposal site, and short-term risks from transportation accidents and vehicular air emissions.	Compliant	Effective, since virtually all residual contamination is removed. Risk transferred to disposal site, but contaminant levels are low and should be easily controlled in a permitted facility. Human health risk less than 1 in 1 million.	None.	Discernable short-term risks to the public are associated with the transport of contaminated soil to off-site disposal facilities. Traffic fatality risk = 1.17×10^{-2}. Emissions fatality risk = 2.58×10^{-3}. Potential radiation dose to maximally exposed member of public = 0.43 mrem/yr. Localized noise and vibration impacts will persist for months during the remedial action. Air monitoring, dust control, and personal protective equipment are required. Predicted to be protective in approximately one year. Time to complete is uncertain and may exceed one year due to the depth and techniques required to excavate the contaminated soil.	The use of large-diameter augers to conduct mass excavation has not been conducted at LEHR at the scale proposed and may fail to remove all contaminated soil, and/or extend the project's schedule and costs.	Standard records management and database activities required.	Relies on standard services and materials. Suitable landfill space is expected to remain available during the remedial action.	Acceptable	Acceptable	\$3,335,000–\$5,052,000 \$0 \$0 **\$3,335,000–\$5,052,000** Years: 1	☐
Alternative 4b: Removal, on-site treatment, and land-use restrictions	Protects beneficial use of groundwater by removing the contaminated soil and treating it in a lined treatment cell and disposing of soil containing added radioactivity at permitted landfills. Local risk reduction offset by the transfer of risk to the disposal site, and short-term risks from transportation accidents, vehicular air emissions, and on-site treatment operations. Soil Management Plan will mitigate any low-level threat remaining in the treatment cell.	Compliant	Effective, since virtually all residual contamination is removed and treated or disposed. Risk transferred to disposal site, but contaminant levels are low and should be easily controlled in a permitted facility. Human health risk less than 1 in 1 million.	Reduces TMV of nitrate low-level threat to negligible quantities by on-site treatment. Does not treat carbon-14 or radium-226 low-level threat.	Discernable short-term risks to the public are associated with the transport of contaminated soil to off-site disposal facilities. Traffic fatality risk = 1.88×10^{-3}. Emissions fatality risk = 4.14×10^{-4}. Potential radiation dose to maximum exposed member of public = 0.24 mrem/yr. Localized noise and vibration impacts will persist for months during the remedial action. Air monitoring, dust control, and personal protective equipment are required. Time to complete removal action is uncertain due to the depth and techniques required to excavate the contaminated soil. Predicted to be protective in approximately 4 years.	The use of large-diameter augers to conduct mass excavation has not been conducted at LEHR at the scale proposed and may fail to remove all contaminated soil, and/or extend the project's schedule and costs.	Standard records management and database activities required.	Relies on standard services and materials. Suitable landfill space is expected to remain available during the remedial action. On-site treatment requires the use of the Western Dog Pens area.	Acceptable	Acceptable	\$2,135,000–\$3,006,000 \$95,000 \$139,000 **\$2,369,000–\$3,240,000** Years: 4	☐

Table 2−11 (continued). Comparative Analysis of Alternatives for the Radium/Strontium Treatment System

Evaluation Criteria	Effectiveness				Implementability					Costs[1] (Capital, O&M, Periodic, Total Cost)	Cost-Effective[2]
	Overall Protection of Public Health and the Environment	Compliance with ARARs	Long-Term Effectiveness	Reduction of TMV	Short-Term Effectiveness	Technical Feasibility	Administrative Feasibility	Availability of Services and Materials	Regulatory Acceptance	Community Acceptance		
Alternative 4c: Limited removal, off-site disposal, long-term groundwater, monitoring and land-use restrictions	Protects beneficial use of groundwater by removing some contaminated soil and monitoring groundwater near the source area. Soil Management Plan will mitigate remaining low-level threat.	Compliant	Effective reduction in mass and toxicity due to partial removal of residual contaminants in soil. Risk transferred to disposal site, but contaminant levels are low and should be easily controlled in a permitted facility. Human health risk less than 1 in 1 million.	None. Principal threat waste removed.	Discernable short-term risks to the public are associated with the transport of contaminated soil to off-site disposal facilities. Traffic fatality risk = 7.89×10^{-3}. Emissions fatality risk = 1.74×10^{-3}. Potential radiation dose to maximum exposed member of public = 0.43 mrem/yr. Localized noise and vibration impacts will persist for several weeks during the remedial action. Air monitoring, dust control, and personal protective equipment are required. Predicted to be protective in approximately one year.	Utilizes standard excavation and disposal techniques.	Standard records management and database activities required.	Relies on standard services and materials. Suitable landfill space is expected to remain available during the remedial action.	Acceptable	Acceptable	$1,953,000–$2,354,000 $133,000 $11,000 **$2,097,000–$2,498,000** Years: 30	☐
Alternative 5: In situ bioremediation, long-term groundwater monitoring, and land-use restrictions	Protects beneficial use of groundwater by treating nitrate-contaminated soil and monitoring groundwater near the source area. Soil Management Plan will mitigate remaining low-level threat.	Compliant	Effective due to the negligible mass and toxicity of residual contaminants in soil. Includes pilot test, monitoring and management controls to confirm effectiveness. Human health risk less than 1 in 1 million.	Reduces TMV of nitrate low-level threat to negligible quantities. Does not reduce TMV of carbon-14 and radium-226 low-level threat. Could mobilize and distribute contamination to a wider area.	Minor short-term risks to the public and environment are associated with the installation and operation of a bioremediation system. The risk of a fatality from implementing this alternative is approximately 0. The treatment system may interfere with site activities or development. Time to deploy can be rapid, since the system relies on established engineering design and materials. Predicted to be protective in approximately 3 years.	A site-specific pilot test is required to confirm technical feasibility.	Standard records management and database activities required.	Relies on standard services and materials.	Acceptable	Acceptable	$703,000 $324,000 $192,000 **$1,219,000** Years: 3	☒

Notes
[1]Net present value.
[2]Relevant Considerations for Cost-Effectiveness Determination: (1) Human health risks below 1 in 1 million. (2) COCs in soil that may impact groundwater include nitrate, carbon-14, and radium-226.
Cost-Effectiveness Summary: Alternatives 1, 4A, 4B, and 4C are not considered to be cost-effective. While Alternative 5 potentially provides more reduction of TMV, Alternatives 2 and 3 are considered most cost-effective.

Abbreviations
HDPE high-density polyethylene
mrem/yr millirem per year
N/A not applicable
O&M operations and maintenance
TMV toxicity, mobility, or volume
UCOP University of California Office of the President

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Long-Term Effectiveness—The removal actions in 1999 and 2000 permanently removed most of the contaminants in the Ra/Sr Treatment Systems area. Given the limited mass of residual contamination remaining in the soil, all the alternatives are likely to be effective in mitigating long-term risk. Alternative 1 may be effective, but verifying effectiveness under this alternative is not possible.

Reduction in Toxicity, Mobility, or Volume through Treatment—Alternatives 2, 3, 4a, and 4c do not include treatment, so this criterion is not satisfied, but these alternatives reduce or manage contamination through other means. Residual nitrate contamination is treated under Alternatives 4b and 5; however, residual C-14 and Ra-226 are not. The injection of the nutrient solution in Alternative 5 has the potential to mobilize and distribute residual contamination to a wider area.

Short-Term Effectiveness—Short-term effectiveness would be attained under alternatives 4a and 4b through the removal of all residual contamination. Alternatives 2, 3, 4c, and 5 would be effective because the monitoring of area groundwater would detect contaminant migration and trigger further action to protect HSU-2, and land-use restriction would ensure proper management of residual contamination to limit potential exposure. Alternatives 2, 3, 4a, and 4c are predicted to protect human health and the environment in approximately one year. Alternatives 4b and 5 are predicted to achieve protectiveness in 4 and 3 years, respectively. The protectiveness of Alternatives 4a, 4b, and 4c is offset by risks associated with construction, operation of heavy equipment, and transportation of waste for off-site disposal. Alternatives 2, 3, and 5 pose only small risks from construction and operation of heavy equipment**.**

Implementability—Alternative 2 is readily implementable because it only involves installing a monitoring well and modifying the existing monitoring program. Alternatives 3 and 5 involve more implementation work because of cap construction and in situ treatment system installation, respectively. Alternatives 4a, 4b, and 4c are implementable, but they present challenges due to safety and environmental impacts associated with large-scale earth-moving operations.

Cost—Alternative 1 costs nothing. The present worth cost for Alternative 2 is $0.3 million. Contingent remediation costs associated with Alternative 2 are currently unknown. The estimated cost of Alternative 3 is $0.7 million. Alternatives 4a, 4b, and 4c are markedly more expensive, with estimated costs ranging from $2.0 million to $5.1 million. The estimated cost for Alternative 5 is $1.2 million.

2.13.1.7 Selected Remedy for the Ra/Sr Treatment Systems Area

The selected remedy for the Ra/Sr Treatment Systems area, Alternative 2, consists of implementing land-use controls and long-term groundwater monitoring. Groundwater monitoring will be conducted near the source area to confirm groundwater protection. If groundwater monitoring indicates that groundwater impacts as defined in Section 2.10.2 have occurred due to COCs listed in Table 2−8 remaining in soil, DOE will evaluate remedial options and determine whether remediation is appropriate in accordance with CERCLA and ARARs.

Land-use controls will consist of deed restrictions or covenants that require the implementation of a Soil Management Plan for any soil-disturbing activities. The Soil Management Plan will provide management requirements for the reuse and disposal of area soils. The covenants will be drafted by DTSC, with input from EPA, and will be signed by the University of California and DTSC. EPA will be named as a third-party beneficiary. The covenants will be recorded with the Recorder Division of the Solano County Department of the Assessor/Recorder. Land-use controls will be maintained until the concentrations of hazardous substances in the soil are at levels that allow for unrestricted use and exposure.

Alternative 2 was selected because removal actions at the Ra/Sr Treatment Systems area successfully eliminated the majority of the contamination, and residual contamination can be monitored and managed at a reasonable cost. Alternative 2 is protective of human health and the environment, is easy to implement, does not involve risk associated with the transportation of waste for disposal, and is about one-tenth the cost of Alternatives 4a, 4b, and 4c. If DOE's evaluation of monitoring data indicates the need for a contingent remedy, DOE would be responsible for proposing, designing, and implementing an alternative remedy. Alternative 3 could reduce the potential for groundwater impact, but at more than twice the cost. Alternative 5 has a significantly higher cost and might increase the area and likelihood of potential groundwater impact. Alternative 1 does not monitor groundwater for possible future impacts and therefore is unacceptable.

2.13.1.8 Statutory Determinations for the Ra/Sr Treatment Systems Area

Protection of Human Health and the Environment

Groundwater monitoring near the source area will serve to confirm groundwater protection. If monitoring indicates that residual contaminants are impacting groundwater quality, remedial action could be undertaken. If groundwater monitoring indicates that impacts to groundwater have occurred due to COCs listed in Table 2−8 remaining in soil, DOE will evaluate remedial options and determine whether remediation is appropriate in accordance with CERCLA and ARARs. Land-use controls will prevent exposure to residual contaminants in the soil.

Compliance with ARARs

The selected remedy complies with the ARARs presented in Tables A−1 through A−3 in Appendix A.

Cost-Effectiveness

All the alternatives evaluated except Alternative 1 (No Action) satisfied the threshold criteria of protection of human health and the environment and compliance with ARARs. The long-term effectiveness and permanence; reduction in toxicity, mobility, and volume through treatment; and short-term effectiveness of each of the alternatives were then compared to estimated costs to evaluate cost-effectiveness. These criteria are summarized in Table 2−11. Alternatives 4a, 4b, and 4c were deemed not cost-effective, as they provide only incremental risk reduction at a cost that ranges from approximately $2 million to $5 million, which far exceeds the costs of Alternative 2. While Alternative 5 potentially provides more reduction of toxicity, mobility, and volume through treatment of nitrate, it costs approximately $1.2 million to implement and does not address the potential low-level threat from C-14 and Ra-226 remaining in the soil. Alternatives 2 and 3 are considered most cost-effective, and the cost of Alternative 2 ($0.3 million) is estimated to be less than half the cost of Alternative 3.

Utilization of Permanent Solutions and Alternative Treatment Technologies to the Maximum Extent Practicable

DOE removed contaminated soils and contaminant sources during prior remedial actions undertaken at the Ra/Sr Treatment Systems area, thereby removing all principal-threat waste. Residual Ra-226, C-14, and nitrate concentrations present in the vadose zone are of limited mass. Groundwater monitoring will continue until DOE can show that residual soil contaminants no longer pose a threat to water quality.

Of the alternatives that are protective of human health and the environment and comply with ARARs, DOE has determined that the selected remedy provides the best balance of trade-offs in terms of the five balancing criteria. The selected remedy also considers the statutory preference for treatment as a principal element, bias against off-site treatment and disposal, and State and community acceptance.

The selected remedy satisfies the criteria for long-term effectiveness by leaving no principal-threat wastes or contaminant sources in soil. Since only residual contamination remains in the area, the selected remedy does not present short-term risks different from those of the other treatment alternatives. There are no special implementability issues that set the selected remedy apart from any of the other alternatives evaluated. The implementability of the selected remedy is higher than that of Alternatives 3, 4, and 5, which require significant construction activities to implement.

Preference for Treatment as a Principal Element

EPA expects the use of treatments that address principal threats posed by a site, wherever practicable, and engineering controls for wastes that pose a relatively low long-term threat (40 CFR 300.430 [a][1][iii][A] and [B]). No principal-threat waste remains at the Ra/Sr Treatment Systems area; therefore, monitoring and land-use controls are appropriate remedies.

5-Year Review Requirements

Although risk to human health from residual contamination remaining at the Ra/Sr Treatment Systems area is less than 1 in 1 million, residual contaminants in the soil have the potential to impact groundwater quality beneath the site. To ensure that the selected remedy is protective of the environment, reviews will be scheduled for the Ra/Sr Treatment Systems area within 5 years of the adoption of this ROD. The effectiveness of the Soil Management Plan and the land-use restrictions will be evaluated during these reviews. An assessment will be conducted to determine whether disturbance permits or equivalent processes established in the Soil Management Plan and/or land-use covenants are sufficiently protective, and whether contaminated soil has been brought to the surface without proper risk management controls. Revisions to the Soil Management Plan and land-use restriction will made as necessary to ensure the continued protectiveness of the selected remedy. Five-year reviews will continue as long as contamination requiring the implementation of the Soil Management Plan and/or land-use restrictions remains in place.

2.13.2 DSS 3 Area

2.13.2.1 Area Characteristics

DSS 3 was installed to treat sewage from LEHR facilities. The sewage was treated in a septic tank prior to being discharged via subsurface leach lines. DSS 3 was taken out of service in 1971 when the LEHR facilities were connected to the UC Davis wastewater treatment plant.

In 2002, DOE excavated the DSS 3 distribution box, pipes, leach field, and surrounding contaminated soil and disposed of the excavated waste off site. No septic tank was found during the removal action. Samples were collected from the excavation floors and sidewalls, and the excavations were backfilled with clean soil. All of the liquid waste, highly toxic waste, and mobile source materials were removed from DSS 3 during the 2002 removal action. Limited amounts of nitrate, formaldehyde, and molybdenum remain in subsurface soil (Table 2−8).

The contaminant release mechanism, affected media, and exposure routes at DSS 3 are identical to those at the Ra/Sr Treatment Systems area (Figure 2−3). The primary source of contamination at DSS 3 was wastewater discharged in the subsurface, and the primary release mechanism was infiltration/percolation in subsurface soil. The only notable difference between DSS 3 and the Ra/Sr Treatment Systems area is that DSS 3 wastewater was discharged through shallow horizontal leach lines; DSS 3 had no dry wells. Open exposure pathways for construction workers, hypothetical future on-site residents, off-site residents, on-site researchers, trespassers and terrestrial biota are the same as at the Ra/Sr Treatment Systems area. No current impacts to HSU-1 have been identified in the monitoring data. However, modeling results suggest that impacts may occur in a localized area due to residual nitrate, formaldehyde, and molybdenum in the soil (WA 2005). Exposure to contamination in groundwater at DSS 3 is unlikely for a hypothetical future on-site or off-site resident.

2.13.2.2 Assessment of the DSS 3 Area

A sitewide risk assessment identified no significant human health or ecological risk at DSS 3 after the removal action (WA 2005; BBL 2006). Conservative screening modeling results suggest that nitrate, formaldehyde, and molybdenum could impact a small area of on-site groundwater in HSU-1 (Table 2−2).

2.13.2.3 Description of Alternatives for the DSS 3 Area

The DSS 3 remedial alternatives (Table 2−10) were identical to those evaluated for the Ra/Sr Treatment Systems area (see Section 2.13.1.3), except that any detection of formaldehyde would trigger more frequent monitoring of groundwater. Increased monitoring requirements would be defined in the remedial design document.

2.13.2.4 Common Elements and Distinguishing Features of Each Alternative for the DSS 3 Area

The common elements and distinguishing features of each alternative are identical to those identified for the Ra/Sr Treatment Systems area (Section 2.13.1.5), except that the estimated volumes of contaminated soil for each alternative are as follows: 6,500 cubic yards under Alternative 4a, 2,000 cubic yards under Alternative 4b, and 1,500 cubic yards under Alternative 4c.

2.13.2.5 Expected Outcomes of Each Alternative

The expected outcomes for the alternatives are identical to those identified for the Ra/Sr Treatment Systems area (Section 2.13.1.5).

2.13.2.6 Summary of Comparative Analysis of Alternatives for the DSS 3 Area

The comparison of alternatives based on the NCP criteria was identical to that performed for the Ra/Sr Treatment Systems area (Section 2.13.1.6). The comparative analysis is summarized in Table 2−12.

2.13.2.7 Selected Remedy for the DSS 3 Area

The selected remedy for DSS 3, Alternative 2, consists of implementing land-use controls and long-term groundwater monitoring. This remedy addresses uncertainties associated with future impacts to groundwater posed by residual contamination at DSS 3 by employing monitoring near the source area to confirm long-term effectiveness and protection. If groundwater monitoring indicates that impacts to groundwater have occurred due to COCs listed in Table 2−8 remaining in soil, DOE will evaluate remedial options and determine whether remediation is appropriate in accordance with CERCLA and ARARs.

In addition to monitoring, land-use controls will be implemented. Land-use controls will consist of deed restrictions or covenants that require the implementation of a Soil Management Plan for any soil-disturbing activities. The Soil Management Plan will provide strict management requirements for reuse and disposal of area soils. The covenants will be drafted by DTSC, with input from EPA, and will be signed by the University of California and DTSC. EPA will be named as a third-party beneficiary. The covenants will be recorded with the Recorder Division of the Solano County Department of the Assessor/Recorder. Land-use controls will be maintained until the concentrations of hazardous substances in the soil are at such levels to allow for unrestricted use and exposure.

Alternative 2 was selected for the DSS 3 area for the same reasons as those identified in Section 2.13.1.7.

2.13.2.8 Statutory Determination for the DSS 3 Area

Protection of Human Health and the Environment

The selected remedy addresses uncertainties associated with future impacts to groundwater by employing groundwater monitoring near the source area to confirm long-term effectiveness and protection. If groundwater monitoring indicates that groundwater impacts as defined in Section 2.10.2 have occurred due to COCs listed in Table 2−8 remaining in soil, DOE will evaluate remedial options and determine whether remediation is appropriate in accordance with CERCLA and ARARs.

Compliance with ARARs

The selected remedy complies with ARARs presented in Tables A−1 through A−3 in Appendix A. Although contaminant concentrations in this area's groundwater are not currently in compliance with ARARs, the selected remedy is designed to ensure compliance with ARARs by using natural attenuation and dispersion to mitigate the transport of residual soil contaminants to groundwater or reduce contaminant concentrations in groundwater to background in a reasonable time frame. As noted above, if residual contamination is observed to have the potential to impact groundwater quality, additional remedial measures may be required.

Cost-Effectiveness

All the alternatives evaluated except Alternative 1 (No Action) satisfied the threshold criteria of protection of human health and the environment and compliance with ARARs. The long-term effectiveness and permanence; reduction in toxicity, mobility, and volume through treatment; and short-term effectiveness of each of the alternatives were then compared to estimated costs to evaluate cost-effectiveness. These criteria are summarized in Table 2−12. Alternatives 4a, 4b, and 4c were deemed not cost-effective, as they provide only incremental risk reduction at costs that range from approximately $2 million to over $4 million, which far exceeds the costs of Alternatives 2 and 3.

While Alternative 5 potentially provides more reduction of toxicity, mobility, and volume through treatment of nitrate and formaldehyde, it costs over $1 million to implement and does not address the potential low-level threat from molybdenum remaining in the soil. Alternatives 2 and 3 are considered more cost-effective (under $1 million), and Alternative 2 is the most cost-effective at an estimated cost of $0.2 million, which is less than half the estimated cost of Alternative 3 (about $0.5 million).

Utilization of Permanent Solutions and Alternative Treatment Technologies to the Maximum Extent Practicable

DOE has removed all source material from the DSS 3 area. Residual formaldehyde contamination in soil is believed to be degrading naturally as it reaches groundwater. Residual contamination of molybdenum and nitrate is of low mass and is not likely to reach groundwater. Long-term monitoring of groundwater in the area for these contaminants will confirm that these constituents do not present a threat to existing groundwater quality.

Of those alternatives that are protective of human health and the environment and comply with ARARs, DOE has determined that the selected remedy provides the best balance of trade-offs in terms of the five balancing criteria. The selected remedy also considers the statutory preference for treatment as a principal element, bias against off-site treatment and disposal, and State and community acceptance.

The selected remedy satisfies the criteria for long-term effectiveness by leaving no principal-threat wastes or contaminant sources in soil. Since only residual contamination remains in the area, the selected remedy does not present short-term risks different from those of the other treatment alternatives. There are no special implementability issues that set the selected remedy apart from any of the other alternatives evaluated. The implementability of the selected remedy is higher than that of Alternatives 3, 4, and 5, which require significant construction activities to implement.

Table 2−12. Comparative Analysis of Alternatives for the Domestic Septic System No. 3

Evaluation Criteria	**Effectiveness**					**Implementability**					**Costs[1] (Capital, O&M, Periodic, Total Cost)**	**Cost-Effective[2]**
	Overall Protection of Public Health and the Environment	**Compliance with ARARs**	**Long-Term Effectiveness**	**Reduction of TMV**	**Short-Term Effectiveness**	**Technical Feasibility**	**Administrative Feasibility**	**Availability of Services and Materials**	**Regulatory Acceptance**	**Community Acceptance**		
Alternative 1: No action	Removal actions have successfully addressed the principal threats to public health and the environment. This alternative does not address future groundwater protection.	May not comply with the state's Anti-Degradation Policy. This area is a possible source of contaminants currently present in groundwater.	Not effective due to localized known groundwater impacts that will not be monitored. Lacks management controls to confirm effectiveness. Human health risk less than 1 in 1 million.	None. Principal threat waste removed.	No short-term risks to the public.	N/A	N/A	N/A	Unacceptable	Unacceptable	$0 $0 $0 **$ 0** Years: 0	☐
Alternative 2: Long-term groundwater monitoring, contingent remedial action, and land-use restrictions	Protects the beneficial use of groundwater by monitoring groundwater near the source area. If monitoring shows that contaminants are impacting existing groundwater quality, remedial action may be implemented. Soil Management Plan will mitigate remaining low-level threat.	Compliant	Effective due to the negligible mass and toxicity of residual contaminants in soil. Includes monitoring and management controls to confirm effectiveness. Human health risk less than 1 in 1 million.	None. Principal-threat waste removed.	No short-term risks to the public and environment. Ongoing effectiveness will be confirmed by long-term groundwater monitoring.	Utilizes standard monitoring techniques currently deployed at the site. Site development could limit access to areas requiring future remedial action.	Standard records management and database activities required. Land-use restrictions may be a component of future remedial action, if required.	Relies on standard services and materials.	Acceptable	Acceptable	$108,000 $107,000 $11,000 **$226,000** Years: 30	☒
Alternative 3: Asphalt/ HDPE cap, long-term groundwater monitoring, and land-use restrictions	Protects beneficial use of groundwater through surface capping, and monitoring groundwater near the source area.	Compliant	Effective due to the negligible mass and toxicity of residual contaminants in soil. Cap will reduce the flux of contaminants to groundwater, if maintained. Includes monitoring and management controls to confirm effectiveness. Human health risk less than 1 in 1 million.	None. Principal-threat waste removed.	Minor short-term risks to the public and environment are associated with the manufacture, transport, and installation of asphalt. The risk of a fatality from implementing this alternative is approximately 0. Cap may restrict site development and aesthetics. Time to deploy is rapid, since the cap relies on established engineering design and materials. Predicted to be protective in approximately one year.	Relies on established engineering design and materials.	Standard records management and database activities required. Land-use restrictions require approval by UCOP.	Relies on standard services and materials.	Acceptable	Acceptable	$327,000 $129,000 $18,000 **$474,000** Years: 30	☒
Alternative 4a: Removal and off-site disposal	Protects beneficial use of groundwater by removing the contaminated soil. Local risk reduction offset by the transfer of risk to the disposal site, and short-term risks from transportation accidents and vehicular air emissions.	Compliant	Effective, since virtually all residual contamination is removed. Risk transferred to disposal site, but contaminant levels are low and should be easily controlled in a permitted facility. Human health risk less than 1 in 1 million.	None	Discernable short-term risks to the public are associated with the transport of contaminated soil to off-site disposal facilities. Traffic fatality risk = 1.05×10^{-2}. Emissions fatality risk = 2.31×10^{-3}. Potential radiation dose to maximally exposed member of public = 0.21 mrem/yr. Localized noise and vibration impacts will persist for months during the remedial action. Air monitoring, dust control, and personal protective equipment are required. Predicted to be protective in approximately 1 year. Time to complete is uncertain and may exceed one year due to the depth and techniques required to excavate the contaminated soil.	The use of large-diameter augers to conduct mass excavation has not been conducted at LEHR at the scale proposed and may fail to remove all contaminated soil, and/or extend the project's schedule and costs.	Standard records management and database activities required.	Relies on standard services and materials. Suitable landfill space is expected to remain available during the remedial action.	Acceptable	Acceptable	$4,562,000 $0 $0 **$4,562,000** Years: 1	☐

Table 2–12 (continued). Comparative Analysis of Alternatives for the Domestic Septic System No. 3

Evaluation Criteria	Effectiveness					Implementability					Costs[1] (Capital, O&M, Periodic, Total Cost)	Cost-Effective[2]
	Overall Protection of Public Health and the Environment	Compliance with ARARs	Long-Term Effectiveness	Reduction of TMV	Short-Term Effectiveness	Technical Feasibility	Administrative Feasibility	Availability of Services and Materials	Regulatory Acceptance	Community Acceptance		
Alternative 4b: Removal, on-site treatment, and land-use restrictions	Protects beneficial use of groundwater by removing the contaminated soil and treating it in a lined treatment cell and disposing of soil containing added radioactivity at permitted landfills. Local risk reduction offset by the transfer of risk to the disposal site, and short-term risks from transportation accidents, vehicular air emissions, and on-site treatment operations. Soil Management Plan will mitigate any low-level threat remaining in the treatment cell.	Compliant	Effective, since virtually all residual contamination is removed and treated or disposed of. Risk transferred to disposal site, but contaminant levels are low and should be easily controlled in a permitted facility. Human health risk less than 1 in 1 million.	Reduces TMV of nitrate low-level threat to negligible quantities by on-site treatment. Does not treat formaldehyde or molybdenum low-level threat.	Discernable short-term risks to the public are associated with the transport of contaminated soil to off-site disposal facilities. Traffic fatality risk = 8.71×10^{-3}. Emissions fatality risk = 1.92×10^{-3}. Potential radiation dose to maximally exposed member of public = 0.21 mrem/yr. Localized noise and vibration impacts will persist for months during the remedial action. Air monitoring, dust control, and personal protective equipment are required. Time to complete removal action is uncertain due to the depth and techniques required to excavate the contaminated soil. Predicted to be protective in approximately 4 years.	The use of large-diameter augers to conduct mass excavation has not been conducted at LEHR at the scale proposed and may fail to remove all contaminated soil, and/or extend the project's schedule and costs.	Standard records management and database activities required.	Relies on standard services and materials. Suitable landfill space is expected to remain available during the remedial action. On-site treatment requires the use of the Western Dog Pens area.	Acceptable	Acceptable	$4,243,000 $95,000 $139,000 **$4,477,000** Years: 4	☐
Alternative 4c: Limited removal, off-site disposal, long-term groundwater monitoring and land-use restrictions	Protects beneficial use of groundwater by removing some contaminated soil and monitoring groundwater near the source area. Soil Management Plan will mitigate remaining low-level threat.	Compliant	Effective reduction in mass and toxicity due to partial removal of residual contaminants in soil. Risk transferred to disposal site, but contaminant levels are low and should be easily controlled in a permitted facility. Human health risk less than 1 in 1 million.	None.	Discernable short-term risks to the public are associated with the transport of contaminated soil to off-site disposal facilities. Traffic fatality risk = 6.05×10^{-3}. Emissions fatality risk = 1.33×10^{-3}. Potential radiation dose to maximally exposed member of public = 0.21 mrem/yr. Localized noise and vibration impacts will persist for several weeks during the remedial action. Air monitoring, dust control, and personal protective equipment are required. Predicted to be protective in approximately one year.	Utilizes standard excavation and disposal techniques.	Standard records management and database activities required.	Relies on standard services and materials. Suitable landfill space is expected to remain available during the remedial action.	Acceptable	Acceptable	$2,046,000 $107,000 $11,000 **$2,164,000** Years: 30	☐
Alternative 5: In situ bioremediation, long-term groundwater monitoring and land-use restrictions	Protects beneficial use of groundwater by treating nitrate and formaldehyde-contaminated soil and monitoring groundwater concentration trends of COCs near the source area. Soil Management Plan will mitigate remaining low-level threat.	Compliant	Effective due to the negligible mass and toxicity of residual contaminants in soil. Includes pilot test, monitoring and management controls to confirm effectiveness. Human health risk less than 1 in 1 million.	Reduces TMV of nitrate and formaldehyde low-level threat to negligible quantities. Does not treat and may increase the mobility of molybdenum.	Minor short-term risks to the public and environment are associated with the installation and operation of a bioremediation system. The risk of a fatality from implementing this alternative is approximately 0. The treatment system may interfere with site activities or development. Time to deploy can be rapid, since the system relies on established engineering design and materials. Predicted to be protective in approximately 3 years.	A site-specific pilot test is required to confirm technical feasibility.	Standard records management and database activities required.	Relies on standard services and materials.	Acceptable	Acceptable	$722,000 $412,000 $197,000 **$1,331,000** Years: 30	☒

Notes
[1]Net present value.
[2]Relevant Considerations for Cost-Effectiveness Determination: (1) Human health risks below 1 in 1 million. (2) Constituents of concern in soil that may impact groundwater include formaldehyde, molybdenum, and nitrate.
Cost-Effectiveness Summary: Alternatives 1, 4a, 4b, and 4c are not considered to be cost-effective. While Alternative 5 potentially provides more reduction of TMV, Alternatives 2 and 3 are considered most cost-effective.

Abbreviations
HDPE high-density polyethylene
N/A not applicable
O&M operations and maintenance
TMV toxicity, mobility, or volume
UCOP University of California Office of the President

Preference for Treatment as a Principal Element

EPA expects the use of treatment to address principal threats posed by a site, wherever practicable, and engineering controls for wastes that pose a relatively low long-term threat (40 CFR 300.430[a][1][iii][A] and [B]). No principal-threat waste remains at the DSS 3 area; therefore, monitoring and land-use controls are appropriate remedies.

5-Year Review Requirements

Although residual contamination at DSS 3 does not pose unacceptable excess risk to human health, the remedy selected for the DSS 3 area results in hazardous substances remaining on site at levels that may potentially impact groundwater quality. To ensure that the selected remedy continues to be protective of the environment, a review of the selected remedial action will be conducted within 5 years of the adoption of this ROD. The effectiveness of the Soil Management Plan and the land-use restrictions will be evaluated during these reviews. An assessment will be conducted to determine whether disturbance permits or equivalent processes established in the Soil Management Plan and/or land-use covenants are sufficiently protective, and whether contaminated soil has been brought to the surface without proper risk management controls. Revisions to the Soil Management Plan and land-use restriction will be made as necessary to ensure the continued protectiveness of the selected remedy. Five-year reviews will continue as long as contamination requiring the implementation of land-use restrictions remains in place.

2.13.3 DSS 4 Area

2.13.3.1 Area Characteristics

DSS 4 was installed to treat LEHR sewage and was taken out of service with the other DSSs in 1971. The remedial approach taken by DOE at DSS 4 differs from that applied to DSS 3 and the Ra/Sr Treatment Systems area in that a removal action has not been performed at DSS 4. The septic tank, distribution box, and piping remain at the DSS 4 area, and the leach field extends beneath Building H-215 (Figure 1−2). Polycyclic aromatic hydrocarbons (PAHs) and selenium are present in subsurface soil surrounding the DSS 4 leach line and may be present beneath Building H-215. The extent of PAH contamination beneath the building has not been fully characterized.

The PAHs at DSS 4 are believed to originate from a tar-composite pipe used in the leach system. Tar, which contains PAHs, was a common component of leach and drain pipes at the time DSS 4 was installed. The quantity of PAHs that can be released from pipe material is small. PAH partitioning coefficients between soil and water indicate that they adhere strongly to the surface of soil particles and do not tend to migrate. The PAH concentrations are based on samples collected from subsurface soil located very close to the tar-composite pipe. PAHs are not present in soil at the ground surface or within a few feet of the pipe, suggesting that PAHs at DSS 4 are limited to a small volume of subsurface soil.

DSS 4 has the same conceptual site model as DSS 3 and the Ra/Sr Treatment Systems area (Figure 2−3). The primary source of contamination at DSS 4 was wastewater discharged from leach lines, and the primary release mechanism was infiltration/percolation in subsurface soil. Subsurface soil exposure pathways are potentially completed at DSS 4 for construction workers, hypothetical future on-site residents, off-site residents, and terrestrial biota. The exposure routes for subsurface soils are dermal contact for construction workers, hypothetical future on-site residents, and terrestrial biota; and ingestion of contaminated groundwater for hypothetical future on- and off-site residents. On-site researchers and trespassers may also be exposed to potential risks from contaminants in subsurface soil during soil-disturbing activities conducted as part of maintenance work, infrastructure replacement, or future development. The area of subsurface soil contamination is localized and can be managed to prevent exposure.

Selenium migration from subsurface soil to groundwater is possible. In February 1997, selenium concentration was slightly above background in one groundwater sample collected from downgradient well UCD1-024. Subsequent samples from downgradient wells UCD1-020 and UCD1-024 have contained selenium concentrations below background.

2.13.3.2 Assessment of the DSS 4 Area

A sitewide risk assessment indicated that the risk for a hypothetical on-site resident is greater than 1 in 10,000, and the risk for on-site construction workers is 1 in 1 million due to PAHs in subsurface soil (Table 2−6). PAH toxicity data are summarized in Table 2−5. Contamination in the DSS 4 area poses no significant ecological risk (BBL 2006). Selenium is the only COC for groundwater at DSS 4. Its potential extent predicted by modeling is provided in Table 2−2.

2.13.3.3 Description of Alternatives for the DSS 4 Area

Remedial alternatives developed for PAHs and selenium at DSS 4 are as follows:

- Alternative 1—No Action
- Alternative 2—Long-Term Groundwater Monitoring/Contingency Remediation/Land-Use Restrictions
- Alternative 3—Capping/Long-Term Groundwater Monitoring/Land-Use Restrictions
- Alternative 4—Limited Removal and Off-Site Disposal (does not remove contaminated soil located below Building H-215)/Land-Use Restrictions

2.13.3.4 Common Elements and Distinguishing Features of Each Alternative for the DSS 4 Area

Alternatives 2 and 3 rely mainly on groundwater monitoring to ensure compliance with the state’s Anti-Degradation Policy and Basin Plan and on land-use restrictions to prevent exposure to subsurface soil contamination that could be brought to the surface. Alternative 3 includes a capping component to prevent surface water infiltration. Alternative 4 is expected to remove the contamination, except under Building H-215. Contamination under Building H-215 would be addressed with a land-use restriction requiring additional characterization and potential remediation if the building were to be demolished. All of these alternatives (except the No Action alternative) meet ARARs.

Alternatives 2 and 3 include groundwater monitoring and have similar levels of reliability. Periodic cap repair is anticipated in Alternative 3. Under Alternative 4, all contaminants are removed, thereby making this the most reliable, except for potential contamination that would remain in the soil under Building H-215 that will not be excavated unless the building is demolished.

Groundwater monitoring under Alternatives 2 and 3 will generate small quantities of purge water (less than 1,000 gallons per year) and a small volume of soil from drill cuttings generated during well installation. Under Alternative 4, about 13 cubic yards of soil would be excavated for off-site disposal. The amount of potentially PAH-contaminated soil that would be excavated from under Building H-215 is unknown.

Alternatives 2 and 3 have indefinite operation time frames. Alternative 4 is predicted to reach PAHs and selenium cleanup levels within one year, except for potential PAH contamination below Building H-215.

The estimated capital, operations and maintenance, periodic, and total present worth costs for the alternatives and the number of years over which the cost estimates are projected are presented in Table 2−13. The 2008 discount rate of 2.8 percent for federal facilities from the Office of Management and Budget, Circular A-94 Appendix C, was used to determine costs.

2.13.3.5 Expected Outcomes of Each Alternative

Available land-use options under each of the alternatives would remain consistent with the UC Davis Long-Range Development Plan designation as “Academic/ Administrative Low Density” and “Support Services.” All the alternatives contain land-use restrictions and would constrain UC Davis’s development options to a limited degree for the duration of the implementation of each of these alternatives. The need for access to monitoring wells would preclude construction in the well locations. Alternative 4 would allow the most flexibility in development after it is implemented (one year).

The aquifer beneath the site is designated as a potential source of drinking water (CRWQCB 2007). Under Alternative 2, monitoring continues until selenium no longer poses any threat to groundwater quality. The performance period is uncertain. If groundwater impacts are observed, an effective contingent remedy will be selected and implemented. Based on the low mass of COCs in the DSS 4 area, a contingent remedy would likely reduce the COC concentrations to groundwater standards within 3 years of implementation. The same is true for Alternative 3. Alternative 4 is expected to meet groundwater standards for selenium in one year.

2.13.3.6 Summary of Comparative Analysis of Alternatives for the DSS 4 Area

The comparison of alternatives based on NCP criteria is shown in Table 2−13 and discussed below.

Overall Protection of Human Health and the Environment—Alternatives 2, 3, and 4 are protective of human health and the environment; Alternative 1 is not. The land-use restrictions in Alternatives 2, 3, and 4 protect human health by managing access to contaminated subsurface soil and prohibiting residential development. Selenium is managed under Alternatives 2 and 3 through long-term groundwater monitoring. Accessible PAHs and selenium are removed under Alternative 4.

Compliance with ARARs—The selected remedy complies with the ARARs presented in Tables A−1 through A−3 in Appendix A.

Long-Term Effectiveness—Alternative 1 is not effective because it does not address the human health risk. Alternatives 2, 3, and 4 are effective because potential human health risk is addressed through land-use restrictions (i.e., no residential development). In Alternative 3, cap effectiveness could diminish if the cap is neglected. Alternative 4 offers good long-term effectiveness by permanently removing most of the selenium and all of the accessible PAHs, but it leaves inaccessible PAHs below Building H-215.

Reduction in Toxicity, Mobility, or Volume through Treatment—None of the alternatives meet EPA's definition of treatment.

Short-Term Effectiveness—Alternatives 2, 3, and 4 are predicted to protect human health and groundwater quality within one year. Basic protection will be achieved through land-use restrictions and groundwater monitoring. Capping and excavation provide some additional short-term effectiveness. Alternative 1 is not effective due to unaddressed human health risk.

Implementability—Alternative 2, 3, and 4 are readily implementable.

Cost—Alternative 1 costs nothing. Alternative 2 costs slightly less than Alternatives 3 and 4.

2.13.3.7 Selected Remedy for the DSS 4 Area

The selected remedy for DSS 4, Alternative 2, consists of land-use restrictions and long-term groundwater monitoring. If groundwater monitoring indicates that impacts to groundwater have occurred due to COCs listed in Table 2−8 remaining in soil, DOE will evaluate remedial options and determine whether remediation is appropriate in accordance with CERCLA and ARARs.

A residential property restriction and a restriction on soil removal documented in a Soil Management Plan will protect the public from exposure to PAHs by preventing residential and construction worker exposure to subsurface soil contamination. The Soil Management Plan will provide strict management requirements for reuse and disposal of area soils. The Soil Management Plan will specify that sampling must be conducted to delineate the extent of contamination under Building H-215 if it is demolished. The sample results shall be used to determine whether additional remediation is required. The deed restriction and covenant will be drafted by DTSC, with input from EPA, and will be signed by the University of California and DTSC. EPA will be named as a third-party beneficiary. The restrictions and covenants will be recorded with the Recorder Division of the Solano County Department of the Assessor/Recorder, and will include a survey map and/or a legal description defining the exclusion areas where residential risk is greater than 1 in 1 million and references to site characterization data pertaining to the land-use restriction. These restrictions will be maintained until the concentration of hazardous substances in the soil are at levels that allow for unrestricted use and exposure.

Table 2−13. Comparative Analysis of Alternatives for Domestic Septic System No. 4

Evaluation Criteria	Effectiveness: Overall Protection of Public Health and the Environment	Effectiveness: Compliance with ARARs	Effectiveness: Long-Term Effectiveness	Effectiveness: Reduction of TMV	Effectiveness: Short-Term Effectiveness	Implementability: Technical Feasibility	Implementability: Administrative Feasibility	Implementability: Availability of Services and Materials	Implementability: Regulatory Acceptance	Implementability: Community Acceptance	Costs[1] (Capital, O&M, Periodic, Total Cost)	Cost-Effective[2]
Alternative 1: No action	Residual soil contaminants pose a risk to hypothetical site residents. The risk to construction workers falls within the acceptable CERCLA risk range but slightly exceeds 1×10^{-6}. This alternative does not address future groundwater protection.	This alternative may not comply with the state's Anti-Degradation Policy and Basin Plan.	Not effective due to localized known groundwater impacts that will not be monitored and the potential risk to hypothetical site residents and construction workers. Hypothetical site resident risk $= 5 \times 10^{-4}$. Construction worker risk = 1 in 1 million.	None. Contamination is low-level threat.	No short-term risks to the public. Residential receptors do not currently occupy the site. No construction projects are currently planned in the DSS 4 area.	N/A	N/A	N/A	Unacceptable	Unacceptable	$0 $0 $0 **$0** Years: 0	☐
Alternative 2: Long-term groundwater monitoring, contingent remedial action, and land-use restrictions	Prevents site residential and construction worker exposure to subsurface soil contamination by implementing land-use restrictions that prevent residential use and unsafe worker exposure. Manages potential future loss of beneficial use of groundwater by monitoring groundwater near the source area. If deemed not protective of groundwater in the future, other remedial actions may be undertaken.	Compliant.	Effective in protecting human health if land-use restrictions are maintained. Human health risk less than 1 in 1 million. Effective in protecting groundwater due to the negligible mass and toxicity of residual contaminants in soil. Includes monitoring and management controls to confirm effectiveness of groundwater protection.	None. Contamination is low-level threat.	No short-term risks to the public and environment. Ongoing effectiveness will be confirmed by long-term groundwater monitoring.	Uses standard monitoring techniques currently deployed at the site. Site development could limit access to areas requiring future remedial action.	Standard records management and database activities required. Land-use restrictions require approval by the UCOP. Additional land-use restrictions may be a component of future remedial action, if required.	Relies on standard services and materials.	Acceptable	Acceptable	$158,000 $96,000 $11,000 **$265,000** Years: 30	☒
Alternative 3: Asphalt/ HDPE cap, long-term groundwater monitoring, and land-use restrictions	Prevents site resident exposure to subsurface soil contamination by implementing land-use restrictions that prevent residential use and unsafe worker exposure. Deed restrictions prevent disturbances of the cap. The physical barrier and development restrictions provided by the cap mitigate direct worker exposure to the underlying contaminants. Protects beneficial use of groundwater by installation of a cap to limit infiltration of surface water, and monitoring groundwater near the source area.	Compliant.	Effective in protecting human health if land-use restrictions are maintained. Human health risk less than 1 in 1 million. Effective in protecting groundwater due to the negligible mass and toxicity of residual contaminants in soil. Cap will reduce the flux of contaminants to groundwater, if maintained. Includes monitoring and management controls to confirm effectiveness of groundwater protection.	None. Contamination is low-level threat.	Minor short-term risks to the public and environment are associated with the manufacture, transport, and installation of asphalt. The risk of a fatality from implementing this alternative is approximately 0. Cap may restrict site development and aesthetics. Time to deploy is rapid, since the cap relies on established engineering design and materials. Predicted to be protective in approximately one year.	Relies on established engineering design and materials.	Standard records management and database activities required. Land-use restrictions require approval by UCOP.	Relies on standard services and materials.	Acceptable	Acceptable	$302,000 $118,000 $18,000 **$438,000** Years: 30	☒

Table 2–13 (continued). Comparative Analysis of Alternatives for Domestic Septic System No. 4

Evaluation Criteria	Effectiveness					Implementability					Costs[1] (Capital, O&M, Periodic, Total Cost)	Cost-Effective[2]
	Overall Protection of Public Health and the Environment	Compliance with ARARs	Long-Term Effectiveness	Reduction of TMV	Short-Term Effectiveness	Technical Feasibility	Administrative Feasibility	Availability of Services and Materials	Regulatory Acceptance	Community Acceptance		
Alternative 4: Removal, off-site disposal, and land-use restrictions	Protects beneficial use of groundwater by removing the accessible contaminated soil and disposing of it. Soil Management Plan will mitigate the low-level threat from inaccessible contaminated soil remaining on site. Local risk reduction is offset by the transfer of risk to the disposal site, and short-term risks from transportation accidents and vehicular air emissions. Prevents residential receptor exposure to currently inaccessible subsurface soil contamination (beneath Building H-215) by implementing land-use restrictions that prevent residential land use.	Compliant.	Effective for accessible contamination. Risk transferred to disposal site, but contaminant mass is small and should be easily controlled in a permitted facility. Effectiveness of land-use restrictions for inaccessible contamination depends on continued future implementation. Human health risk less than 1 in 1 million.	None. Contamination is low-level threat.	Minor short-term risks to the public are associated with the transport of contaminated soil to off-site disposal facilities. Traffic fatality risk = 8.2×10^{-6}. Emissions fatality risk = 1.8×10^{-6}. Localized noise will persist for a few weeks during the remedial action. Air monitoring, dust control, and personal protective equipment are required. Predicted to be protective in approximately 1 year.	Utilizes standard excavation and disposal techniques.	Standard records management and database activities required.	Relies on standard services and materials. Suitable landfill space is expected to remain available during the remedial action.	Acceptable	Acceptable	$547,000 $0 $0 **$547,000** Years: 1	☒

Notes
[1]Net present value.
[2]Relevant Considerations for Cost-Effectiveness Determination: (1) Human health risks to on-site residents and on-site workers are 5 in 10,000 (total risk) and 1 in 1 million (Benzo[a]pyrene), respectively. (2) The COC in soil that may impact groundwater is selenium.
Cost-Effectiveness Summary: Alternative 1 is not considered to be cost-effective. Alternative 2, 3, and 4 are considered cost-effective.

Abbreviations
HDPE high-density polyethylene
N/A not applicable
O&M operations and maintenance
TMV toxicity, mobility, or volume
UCOP University of California Office of the President

2.13.3.8 Statutory Determination for the DSS 4 Area

Protection of Human Health and the Environment

The selected remedy protects the public from exposure to PAHs in the soil at DSS 4 by implementing land-use restrictions to prevent residential and construction worker exposure to subsurface soil contamination. Selenium present in soil is not expected to impact groundwater quality; however, the monitoring aspect of the remedy manages the potential future loss of beneficial use of groundwater by implementing a groundwater monitoring program to detect potential selenium impacts. If groundwater monitoring indicates that groundwater impacts as defined in Section 2.10.2 have occurred due to COCs listed in Table 2−8 remaining in soil, DOE will evaluate remedial options and determine whether remediation is appropriate in accordance with CERCLA and ARARs.

Compliance with ARARs

The selected remedy complies with ARARs presented in Tables A−1 through A−3 in Appendix A. The groundwater monitoring program is designed to confirm whether selenium impacts are continuing, and provide data to assess whether additional remedial measures are required. If groundwater monitoring indicates that impacts to groundwater have occurred due to COCs listed in Table 2−8 remaining in soil, DOE will evaluate remedial options and determine whether remediation is appropriate in accordance with CERCLA and ARARs.

Cost-Effectiveness

All the alternatives evaluated except Alternative 1 (No Action) satisfied the threshold criteria of protection of human health and the environment and compliance with ARARs. Long-term effectiveness and permanence; reduction in toxicity, mobility, and volume through treatment; and short-term effectiveness of each of the alternatives were then compared to estimated costs to evaluate cost-effectiveness. These criteria are summarized in Table 2−13. Alternatives 2, 3, and 4 are considered cost-effective (under $1 million), and Alternative 2 is considered the most cost-effective at an estimated cost of $0.3 million, which is less than half of the estimated cost of Alternatives 3 and 4 (approx. $0.4 million and $0.5 million, respectively).

Utilization of Permanent Solutions and Alternative Treatment Technologies to the Maximum Extent Practicable

The residual contamination at DSS 4 is not considered to be principal-threat waste. The negligible mass and toxicity of residual selenium in soil is not expected to impact groundwater quality based on modeling results. The long-term groundwater monitoring program would be used to evaluate any potential impacts. If groundwater monitoring indicates that impacts to groundwater have occurred due to COCs listed in Table 2−8 remaining in soil, DOE will evaluate remedial options and determine whether remediation is appropriate in accordance with CERCLA and ARARs.

Of those alternatives that are protective of human health and the environment and comply with ARARs, DOE has determined that the selected remedy provides the best balance of trade-offs in terms of the five balancing criteria. The selected remedy also considers the statutory preference for treatment as a principal element, bias against off-site treatment and disposal, and State and community acceptance.

The selected remedy satisfies the criteria for long-term effectiveness by leaving no principal-threat wastes or contaminant sources in soil. Since only residual contamination remains in the area, and it is not expected to migrate, the selected remedy does not present short-term risks different from those of the other treatment alternatives. There are no special implementability issues that set the selected remedy apart from any of the other alternatives evaluated. The implementability of the selected remedy is higher than that of Alternatives 3 and 4, which require significant construction or excavation activities to implement.

Preference for Treatment as a Principal Element

EPA expects the use of treatment to address principal threats posed by a site, wherever practicable, and engineering controls for wastes that pose a relatively low long-term threat [40 CFR 300.430(a)(A)(iii)(A) and (B)]. No principal-threat waste remains at the DSS 4 area; therefore, monitoring and land-use controls are appropriate remedies.

5-Year Review Requirements

Because the remedies selected for the DSS 4 area result in hazardous substances remaining on-site at levels above those allowed for unrestricted use, a review of the selected remedial action will be conducted within 5 years of the adoption of this ROD. The effectiveness of the Soil Management Plan and the land-use restrictions will be evaluated during these reviews.

An assessment will be conducted to determine whether disturbance permits or equivalent processes established in the Soil Management Plan and/or land-use covenants are sufficiently protective, and whether contaminated soil has been brought to the surface without proper risk management controls. Revisions to the Soil Management Plan and land-use restriction will made as necessary to ensure the continued protectiveness of the selected remedy. Five-year reviews will continue as long as contamination requiring the implementation of the Soil Management Plan and/or land-use restrictions remains in place.

2.13.4 DSS Leach Field (Dry Wells A–E) Area

2.13.4.1 Area Characteristics

Dry wells A–E (Figure 1−2) consisted of buried concrete surface casings and open boreholes filled with gravel and cobbles. A distribution box was connected to the dry wells, but no septic tank connections were found. Based on existing site maps, it is believed that the dry wells were connected to domestic septic tanks 1 and 5, and are therefore likely to have been operated between 1962 and 1970 along with the DSSs (WA 2003).

In 1999, DOE excavated the dry wells, distribution box, and interconnected piping. The excavation extended to 8 ft bgs at Dry Wells A, B, C, and E, and 20 ft bgs at Dry Well D. Gravel was still present in the excavation floor at Dry Well D.

In 2001, soil samples were collected at each dry well to determine if the removal action was successful and to characterize the nature and extent of contamination in deeper soil. Sample depths ranged from 10 to 40 ft bgs. The soil sample results indicated elevated levels of chromium, hexavalent chromium, mercury, molybdenum, silver, Cs-137, and Sr-90.

The Dry Wells A–E area has the same conceptual site model (Figure 2−3) as DSS 3, DSS 4, and the Ra/Sr Treatment Systems area. Potentially complete exposure pathways are present for subsurface soil, but the principal concern at Dry Wells A–E is protection of groundwater quality. The primary source of contamination was wastewater discharged from the dry wells. The primary release mechanism was infiltration/percolation.

Although residual contamination was detected in subsurface soil, results of groundwater samples collected in 2004 at HSU-1 well UCD1-054, located immediately downgradient of the Dry Wells area, indicated that contaminants had not impacted groundwater.

2.13.4.2 Assessment of the Dry Wells A–E Area

During the development of a sitewide risk assessment conducted after the removal action, DOE found no significant human health or ecological risk at the Dry Wells area (WA 2005). Chromium, hexavalent chromium, mercury, molybdenum, silver, Cs-137, and Sr-90 were identified as potential groundwater contaminants (Table 2−8). The area of potential impact predicted by modeling is provided in Table 2−2.

In 2004, HSU-1 well UCD1-054 was installed immediately downgradient of the former Dry Wells area to determine if contaminants were impacting groundwater quality. Results of the quarterly groundwater sampling conducted in 2004 showed that the potential contaminants identified had not impacted groundwater quality.

2.13.4.3 Description of Alternatives for the Dry Wells A–E Area

Remedial alternatives developed for the Dry Wells A–E area are as follows:

- Alternative 1—No Further Action
- Alternative 2—Long-Term Groundwater Monitoring/Contingency Remediation/Land-Use Restrictions
- Alternative 3—Capping/Long-Term Groundwater Monitoring/Land-Use Restrictions
- Alternative 4a—Removal and Off-Site Disposal
- Alternative 4b—Limited Removal and Off-Site Disposal/Long-Term Groundwater Monitoring/Land-Use Restrictions

2.13.4.4 Common Elements and Distinguishing Features of Each Alternative for the Dry Wells A–E Area

Alternatives 2, 3, and 4b rely on groundwater monitoring to ensure compliance with the state's Anti-Degradation Policy and Basin Plan and land-use restrictions to prevent exposure to subsurface soil contamination that could be brought to the surface in the future. Alternative 3 adds a capping component, and Alternative 4b removes residual contamination down to 20 ft but leaves contaminants in deeper soil. Alternative 4a is expected to remove all of the contamination that could impact groundwater. All of these alternatives (except the No Further Action alternative) meet ARARs.

The long-term reliability of Alternatives 2 and 3 is similar in that both alternatives rely on monitoring to ensure that ARARs are met for the duration of the remedy. Periodic cap repair is anticipated in Alternative 3. The monitoring component of Alternative 4b is similar to that of Alternative 2. The alternative where all residual contaminants are removed (4a) has the highest long-term reliability; however, this is achieved at a significantly higher cost than the alternatives that rely on monitoring and land-use restrictions. Alternative 4b removes residual contaminants to a depth of 20 ft, which makes it somewhat less reliable than those that remove all of the waste.

Groundwater monitoring under Alternatives 2, 3, and 4b will generate small quantities of purge water (less than 1,000 gallons per year) and a small volume of soil from drill cuttings generated during well installation. Excavation of contaminated soils under Alternative 4a would generate about 600 cubic yards of waste to be disposed of off site. The amount of contaminated soil that would require disposal under Alternative 4b is about 270 cubic yards.

The schedule for implementation of each of the alternatives is short (less than one year), but the estimated time to reach cleanup levels varies. Alternative 4a is predicted to reach cleanup levels within 1 year. Alternatives 2, 3, and 4b have indefinite operation time frames.

The estimated capital, operations and maintenance, periodic, and total present worth costs for the alternatives and the number of years over which the cost estimates are projected are presented in Table 2−14. The 2008 discount rate of 2.8 percent for federal facilities from the Office of Management and Budget, Circular No. A-94 Appendix C, was used to determine costs.

2.13.4.5 Expected Outcomes of Each Alternative

Available land-use options under each of the alternatives would remain consistent with the UC Davis Long-Range Development Plan designation as “Academic/ Administrative Low Density” and “Support Services.” The alternatives containing land-use restrictions (all, except Alternative 4a) would constrain UC Davis’s development options to a limited degree for the duration of the implementation of each of these alternatives. The need to access monitoring wells would preclude construction in the well locations. Alternative 4a would allow the most flexibility in development after it is implemented (1 year).

The aquifer beneath the site is designated as a potential source of drinking water (CRWQCB 2007). Under Alternatives 2, 3, and 4b, monitoring continues until contaminants no longer pose any threat to groundwater quality. The performance period is uncertain. If groundwater impacts are observed, an effective contingent remedy will be selected and implemented. Alternative 4a is expected to meet groundwater standards for all COCs in one year.

Table 2−14. Comparative Analysis of Alternatives for the Domestic Septic Systems Leach Field (Dry Wells A–E)

Evaluation Criteria	Effectiveness					Implementability					Costs[1] (Capital, O&M, Periodic, Total Cost)	Cost-Effective[2]
	Overall Protection of Public Health and the Environment	Compliance with ARARs	Long-Term Effectiveness	Reduction of TMV	Short-Term Effectiveness	Technical Feasibility	Administrative Feasibility	Availability of Services and Materials	Regulatory Acceptance	Community Acceptance		
Alternative 1: No action	This alternative does not address future groundwater protection.	This alternative may not comply with the State's Anti-Degradation Policy and Basin Plan.	Not effective due to localized known groundwater impacts that will not be monitored. Lacks management controls to protect groundwater. Human health risk less than 1 in 1 million.	None. Principal-threat waste removed.	No short-term risks to the public. Current groundwater monitoring is showing no significant impacts.	N/A	N/A	N/A	Unacceptable	Unacceptable	$0 $0 $0 **$0** Years: 0	☐
Alternative 2: Long-term groundwater monitoring, contingent remedial action and land-use restrictions	Protects the beneficial use of groundwater by monitoring groundwater near the source area. If deemed not protective in the future, remedial action may be implemented. Soil Management Plan will mitigate remaining low-level threat.	Compliant.	Effective due to the limited mass of contaminants in the vadose zone and the inclusion of monitoring and management controls to initiate future remedial actions if necessary. Human health risk less than 1 in 1 million.	None. Principal-threat waste removed.	No short-term risks to the public and environment. Current groundwater monitoring is showing no significant impacts. Ongoing effectiveness will be confirmed by long-term groundwater monitoring.	Uses standard monitoring techniques currently deployed at the Site. Site development could limit access to areas requiring future remedial action.	Standard records management and database activities required. Land-use restrictions may be a component of future remedial action, if required.	Relies on standard services and materials.	Acceptable	Acceptable	$10,000 $130,000 $11,000 **$151,000** Years: 30	☒
Alternative 3: Asphalt /HDPE cap, long-term groundwater monitoring, and land-use restrictions	Protects beneficial use of groundwater by limiting surface water infiltration through surface capping, and monitoring groundwater near the source area. Deed restrictions will mitigate disturbances of the cap.	Compliant.	Effective due to the limited mass of contaminants in the vadose zone. Additionally, cap will reduce the flux of contaminants to groundwater, if maintained. Includes monitoring and management controls to confirm effectiveness. Human health risk less than 1 in 1 million.	None. Principal-threat waste removed.	Minor short-term risks to the public and environment are associated with the manufacture, transport, and installation of asphalt. The risk of a fatality from implementing this alternative is approximately 0. Cap may restrict site development and aesthetics. Time to deploy is rapid, since the cap relies on established engineering design and materials. Predicted to be protective in approximately one year.	Relies on established engineering design and materials.	Standard records management and database activities required. Land-use restrictions require approval by UCOP.	Relies on standard services and materials.	Acceptable	Acceptable	$241,000 $152,000 $19,000 **$412,000** Years: 30	☒
Alternative 4a: Remove and dispose of soil above the cleanup goals	Protects beneficial use of groundwater by removing the contaminated soil and disposing of it at permitted landfills. Local protection offset by the transfer of risk to the disposal site, and short-term risks from transportation accidents and vehicular air emissions.	Compliant.	Effective, since virtually all residual contamination is removed. Risk transferred to disposal site but contaminant levels are low and should be easily controlled in a permitted facility. Human health risk less than 1 in 1 million.	None.	Discernable short-term risks to the public are associated with the transport of contaminated soil to off-site disposal facilities. Traffic fatality risk = 2.58×10^{-3}. Emissions fatality risk = 5.67×10^{-4}. Potential radiation dose to maximally exposed member of public = 0.057 mrem/yr. Localized noise and vibration impacts will persist for weeks during the remedial action. Air monitoring, dust control, and personal protective equipment are required. Predicted to be protective in approximately 1 year.	The use of large-diameter augers to conduct dry well excavation has been successfully conducted at LEHR.	Standard records management and database activities required.	Relies on standard services and materials. Suitable landfill space is expected to remain available during the remedial action.	Acceptable	Acceptable	$1,201,000 $0 $0 **$1,201,000** Years: 1	☐

Table 2–14 (continued). Comparative Analysis of Alternatives for the Domestic Septic Systems Leach Field (Dry Wells A–E)

Evaluation Criteria	Effectiveness					Implementability					Costs[1] (Capital, O&M, Periodic, Total Cost)	Cost-Effective[2]
	Overall Protection of Public Health and the Environment	Compliance with ARARs	Long-Term Effectiveness	Reduction of TMV	Short-Term Effectiveness	Technical Feasibility	Administrative Feasibility	Availability of Services and Materials	Regulatory Acceptance	Community Acceptance		
Alternative 4b: Limited Removal, off-site disposal, long-term groundwater monitoring, and land-use restrictions	Protects beneficial use of groundwater by removing some contaminated soil and monitoring groundwater near the source area. Soil Management Plan will mitigate the low-level threat from contaminated soil remaining on-site.	Compliant.	Effective due to the limited mass of contaminants in the vadose zone. Additional mass reduction due to partial removal of residual contaminants in soil. Risk transferred to disposal site, but contaminant levels are low and should be easily controlled in a permitted facility. Human health risk less than 1 in 1 million.	None. Principal-threat waste removed.	Discernable short-term risks to the public are associated with the transport of contaminated soil to off-site disposal facilities. Traffic fatality risk = 1.10×10^{-3}. Emissions fatality risk = 2.43×10^{-4}. Potential radiation dose to maximally exposed member of public = 0.024 mrem/yr. Localized noise and vibration impacts will persist for a few weeks during the remedial action. Air monitoring, dust control, and personal protective equipment are required. Predicted to be protective in approximately one year.	Uses standard excavation and disposal techniques.	Standard records management and database activities required.	Relies on standard services and materials. Suitable landfill space is expected to remain available during the remedial action.	Acceptable	Acceptable	$708,000 $130,000 $11,000 **$849,000** Years: 30	☐

Notes

[1]Net present value.

[2]Relevant Considerations for Cost-Effectiveness Determination: (1) Human health risks below 1 in 1 million. (2) COCs in soil that may impact groundwater include chromium, hexavalent chromium, mercury, molybdenum, silver, cesium-137, and strontium-90.

Cost-Effectiveness Summary: Alternatives 1, 4A, and 4B are not considered to be cost-effective. While Alternative 3 is considered cost-effective, Alternative 2 provides a potentially more effective result.

Abbreviations

HDPE high-density polyethylene
mrem/yr millirem per year
N/A not applicable
O&M operations and maintenance
TMV toxicity, mobility, or volume
UCOP University of California Office of the President

2.13.4.6 Summary of Comparative Analysis of Alternatives for the Dry Wells A–E Area

The comparison of alternatives based on NCP criteria is shown in Table 2−14 and discussed below.

Overall Protection of Human Health and the Environment—Alternatives 2, 3, 4a, and 4b are protective of human health and the environment. The human health risk is less than 1 in 1 million, and groundwater monitoring data indicate that the released contaminants are not impacting groundwater quality. Alternative 1 cannot be considered protective because it does not provide for monitoring of groundwater quality.

Compliance with ARARs—The selected remedy complies with the ARARs presented in Tables A−1 through A−3 in Appendix A.

Long-Term Effectiveness—Long-term effectiveness should be easily achievable under Alternatives 2, 3, 4a, or 4b. Thirty-three years after the dry wells were abandoned, none of the released contaminants are currently impacting groundwater quality.

Reduction in Toxicity, Mobility, or Volume through Treatment—The alternatives do not meet EPA's definition of treatment.

Short-Term Effectiveness—Alternatives 2, 3, 4a, and 4b are predicted to protect groundwater quality within one year. Alternatives 2, 3, 4a, and 4b are equally effective because the contaminants are not moving into groundwater at a significant rate. In Alternative 4a, the excavation safety issues and waste shipment risks far outweigh the benefit of protecting groundwater quality. Alternative 1 is not effective because it does not monitor groundwater.

Implementability—Alternative 2 is easy to implement because it involves modifying only the existing monitoring program. Alternatives 3 and 4b involve more effort because they include cap construction and excavation, respectively. Alternative 4a is difficult to implement because of excavation safety issues and the need for large equipment to remove contaminants below a depth of 20 ft.

Cost—Alternative 1 costs nothing. Alternative 2 costs $0.2 million, and Alternative 3 costs $0.4 million. Alternatives 4a and 4b are more expensive, with estimated costs ranging from $0.8 million to $1.2 million.

2.13.4.7 Selected Remedy for the Dry Wells A–E Area

The selected remedy for Dry Wells A–E, Alternative 2, consists of land-use restrictions and long-term groundwater monitoring. If groundwater monitoring indicates that groundwater impacts as defined in Section 2.10.2 have occurred due to COCs listed in Table 2−8 remaining in soil, DOE will evaluate remedial options and determine whether remediation is appropriate in accordance with CERCLA and ARARs.

In addition to monitoring, land-use controls will be implemented. Land-use controls will consist of deed restrictions or covenants that require the implementation of a Soil Management Plan for any soil-disturbing activities. The Soil Management Plan will provide strict management requirements for the reuse and disposal of area soils. The covenants will be drafted by DTSC, with input from EPA, and will be signed by the University of California and DTSC. EPA will be named as a third-party beneficiary. The covenants will be recorded with the Recorder Division of the Solano County Department of the Assessor/Recorder. Land-use controls will be maintained until the concentrations of hazardous substances in the soil are at levels that allow for unrestricted use and exposure.

Alternative 2 was selected because the human health risk is less than 1 in 1 million, and the residual contaminants are not significantly impacting groundwater quality. Alternatives 3, 4a, and 4b offer no significant improvements over, and are more costly than, Alternative 2.

2.13.4.8 Statutory Determinations—Dry Wells A–E Area

Protection of Human Health and the Environment

The selected remedy protects the public from risk associated with residual contamination by implementation of land-use restrictions. With respect to groundwater, the selected remedy addresses uncertainties associated with the predictions of the future impacts by implementing a groundwater monitoring program. Based on plume size estimates, additional remedial measures are not expected; however, if groundwater monitoring indicates that impacts to groundwater have occurred due to COCs listed in Table 2−8 remaining in soil, DOE will evaluate remedial options and determine whether remediation is appropriate in accordance with CERCLA and ARARs.

Compliance with ARARs

The selected remedy complies with ARARs presented in Tables A−1 through A−3 in Appendix A. If monitoring shows that residual soil contamination is impacting groundwater quality, remediation will be undertaken.

Cost-Effectiveness

All the alternatives evaluated except Alternative 1 (No Action) satisfied the threshold criteria of protection of human health and the environment and compliance with ARARs. The long-term effectiveness and permanence; reduction in toxicity, mobility, and volume through treatment; and short-term effectiveness of each of the alternatives were then compared to estimated costs to evaluate cost-effectiveness. These criteria are summarized in Table 2−14.

Alternatives 4a and 4b were deemed not cost-effective, as they provide only incremental risk reduction at a cost of over $1 million. While Alternative 3 is considered to be cost-effective at approximately $0.4 million, Alternative 2 provides a potentially more effective result at an estimated cost of less than $0.2 million.

Utilization of Permanent Solutions and Alternative Treatment Technologies to the Maximum Extent Practicable

No principal-threat wastes remain at the Dry Wells. Groundwater modeling results indicate that, with the exception of silver, none of the residual contaminants at the Dry Wells area are expected to impact groundwater quality above the MCL (or the preliminary remediation goal if no MCL was available) over more than 1 acre. Predicted plume sizes for hexavalent chromium, molybdenum, Cs-137, and Sr-90 are much less than 1 acre in area. Given the limited area of contamination, the long-term impact of residual contamination is expected to be insignificant. However, collection of groundwater data until DOE can show that residual soil contaminants no longer pose a threat to water quality allows continued long-term evaluation of groundwater impacts.

Of the alternatives that are protective of human health and the environment and comply with ARARs, DOE has determined that the selected remedy provides the best balance of trade-offs in terms of the five balancing criteria. The selected remedy also considers the statutory preference for treatment as a principal element, bias against off-site treatment and disposal, and State and community acceptance.

The selected remedy satisfies the criteria for long-term effectiveness by leaving no principal-threat wastes or contaminant sources in soil. Since only residual contamination remains in the area, the selected remedy does not present short-term risks different from the other treatment alternatives. There are no special implementability issues that set the selected remedy apart from any of the other alternatives evaluated. The implementability of the selected remedy is higher than that of Alternatives 3 and 4, which require significant construction or excavation activities to implement.

Preference for Treatment as a Principal Element

EPA expects the use of treatment to address principal threats posed by a site, wherever practicable, and engineering controls for wastes that pose a relatively low long-term threat (40 CFR 300.430[a][A][iii][A] and [B]). No principal-threat waste remains at the Dry Wells area; therefore, monitoring and land-use controls are appropriate remedies.

5-Year Review Requirements

Although residual contamination at the Dry Wells area does not pose unacceptable excess risk to human health, the remedy selected for the area results in hazardous substances remaining on site at levels that may potentially impact groundwater quality. To ensure that the selected remedy continues to be protective of the environment, a review of the selected remedial action will be conducted within 5 years of the adoption of this ROD. The effectiveness of the Soil Management Plan and the land-use restrictions will be evaluated during these reviews. An assessment will be conducted to determine whether disturbance permits or equivalent processes established in the Soil Management Plan and/or land-use covenants are sufficiently protective, and whether contaminated soil has been brought to the surface without proper risk management controls. Revisions to the Soil Management Plan and land-use restriction will be made as necessary to ensure the continued protectiveness of the selected remedy. Five-year reviews will continue as long as contamination requiring the implementation of the Soil Management Plan and/or land-use restrictions remains in place.

2.13.5 SWT Area

2.13.5.1 Area Characteristics

Between the late 1950s and early 1970s, low-level radioactive waste, animal waste, and laboratory wastes from LEHR research activities were reportedly disposed of in shallow pits and trenches in the SWT area (Figure 1−2) (D&M 1993). Part of the SWT area was also used for chemical storage and treating dogs for fleas. Specifically, a storage shed in the southwest corner of the SWT area apparently contained chlordane for treating dogs nearby (WA 2003).

In 1998, DOE excavated the trenches, pits, and surrounding contaminated soil. DOE also excavated shallow chlordane-impacted soil in the former chemical storage area. Samples were collected from the excavation floors and sidewalls, and the excavations were backfilled with uncontaminated soil. The sample results indicated that only small amounts of residual contamination remain in subsurface soil.

The conceptual site model for the SWT area is shown in Figure 2−4. The primary sources of contamination were buried waste materials and pesticide-spraying operations. All of the primary sources of contamination were removed in 1998 when the buried waste, surrounding contaminated subsurface soil, and surface soil in the pesticide-spraying area were removed. Small amounts of residual contamination remain in subsurface soil.

Indoor research workers, outdoor research workers, construction workers, hypothetical future on-site residents, trespassers, off-site residents, terrestrial biota, and aquatic biota could be exposed to residual contamination from the SWT area. Hypothetical on-site residents would have the highest level of exposure if site use becomes residential. Construction workers performing work in the contaminated subsurface soil will have the highest exposure under the current land use. Research workers and trespassers would have significantly less exposure because they do not have direct contact with subsurface soil, but could be exposed to potential risks from contaminants in subsurface soil during soil-disturbing activities conducted as part of maintenance work, infrastructure replacement, or future development. However, due to the limited areal extent of residual contamination and its low estimated risk (i.e., less than 1 in 1 million for a residential receptor), these potential exposures are not expected to be significant.

Groundwater ingestion is a potentially complete pathway for off-site residents and hypothetical future on-site residents.

The pathway is open for hypothetical future on-site residents, trespassers, and aquatic biota to receive exposure from contaminated surface water, fish, and sediments due to contaminated storm water runoff. The primary source of storm water runoff contamination was removed (pesticide-spraying area), and surface soil is the only remaining source of storm water runoff contamination.

Surface soil is a potential source of dust contamination that could be inhaled by research workers and trespassers. Subsurface soil is a potential source of dust contamination for inhalation by hypothetical future on-site residents and construction workers. Terrestrial biota could also inhale dust contamination, but dust inhalation is a minor exposure pathway for these ecological receptors.

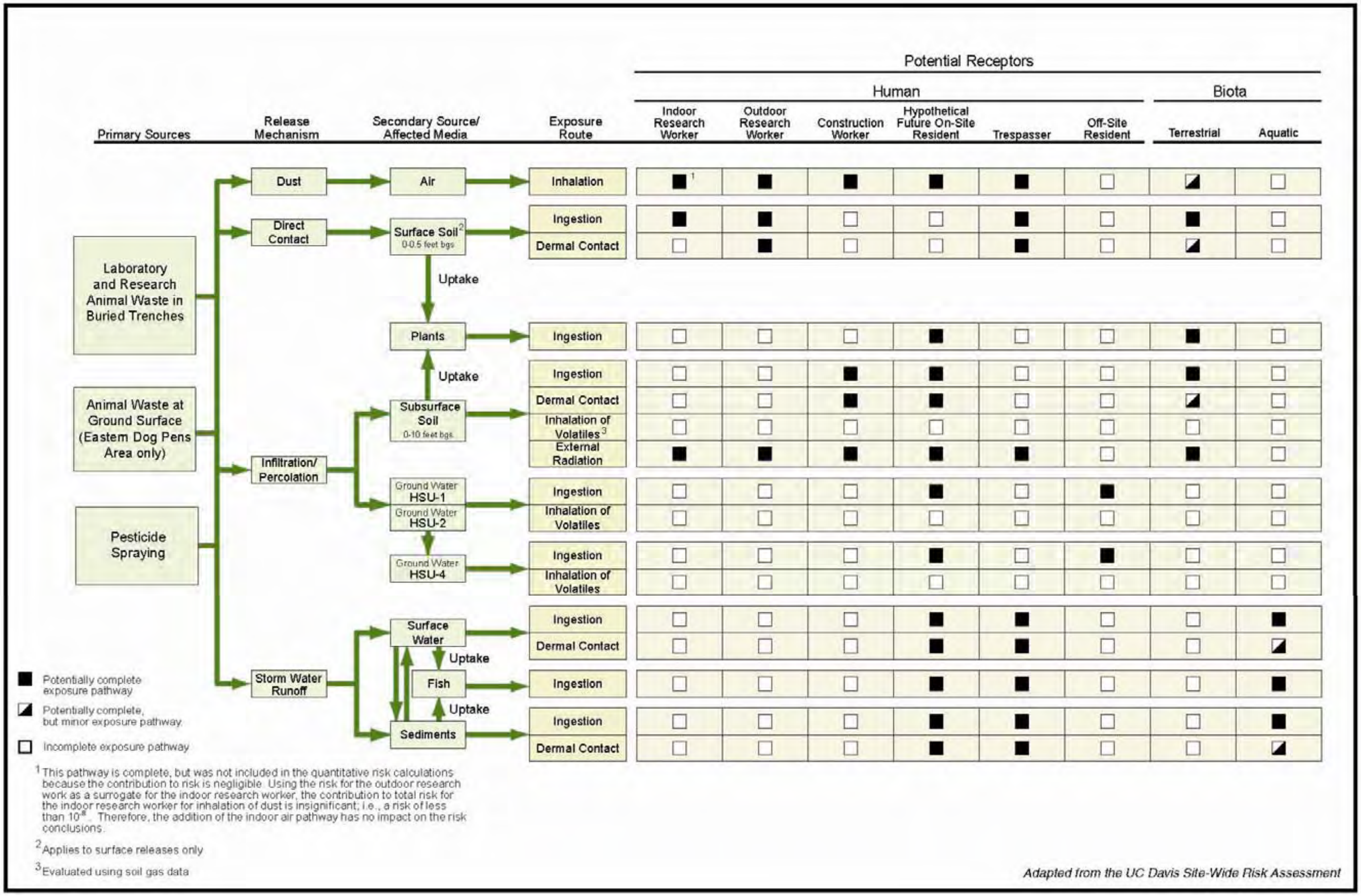

Figure 2−4. Conceptual Site Model for the Southwest Trenches Area and Eastern Dog Pens Area

2.13.5.2 Assessment of the SWT Area

A sitewide risk assessment conducted after the excavation of contaminants in the area indicated that Sr-90 was a potential concern (3 in 1 million risk) for hypothetical on-site residents (Table 2−6). Sr-90 toxicity data are summarized in Table 2−5. There were no significant risks to ecological receptors (BBL 2006). Nitrate and C-14 are predicted to impact a small area of groundwater in HSU-1 beneath the area (Table 2−2).

Strontium-90 Spatial Distribution

One sample located at 3 ft bgs near the southern boundary of the SWT area had a measured concentration that corresponded to the 1 in 100,000 to 1 in 10,000 risk range for hypothetical future on-site residents. It is surrounded by nondetect samples with concentrations below background, indicating a very limited extent of contamination. Although 18 samples had concentrations within the 1 in 1 million to 1 in 100,000 risk range, 10 of those sample results are from the 1996 data set, which has a positive bias for reported concentrations (WA 2005). 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 1 in 1 million.

The northern quarter of the northern waste burial area has four closely clustered samples located at depths ranging from ground surface to 10 ft bgs, with concentrations in the 1 in 100,000 to 1 in 10,000 risk range. Two other samples located at 10 ft bgs in the northern waste burial area had concentrations in the 1 in 1 million to 1 in 100,000 risk range. Based on the spatial distribution of these data, Sr-90 concentrations exceed both background and the concentration equivalent to a risk of 1 in 1 million in areas located in the northernmost and southern waste burial areas. Based on the 1996 data, sample concentrations may also exceed background and 1 in 1 million risk in the southwest and southeast corners of the area, and near the former wash-down pad.

Carbon-14 Spatial Distribution

Thirty-seven out of 105 soil sample results (35 percent) exceeded background for C-14 in the SWT area. Most of the soil samples along the southern boundary had elevated C-14 concentrations. A few samples containing slightly elevated C-14 concentrations are located at or near disposal trench T 3 near the SWT area northern boundary. The four highest detected concentrations (1.01 ± 0.129 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.

2.13.5.3 Description of Alternatives for the SWT Area

Remedial alternatives developed for the SWT area are as follows:

- Alternative 1—No Further Action
- Alternative 2—Long-Term Groundwater Monitoring/Contingency Remediation/Land-Use Restrictions
- Alternative 3—Capping/Long-Term Groundwater Monitoring /Land-Use Restrictions
- Alternative 4a—Removal and Off-Site Disposal
- Alternative 4b—Removal and On-Site Treatment/Land-Use Restrictions
- Alternative 4c—Limited Removal and Off-Site Disposal/Long-Term Groundwater Monitoring /Land-Use Restrictions
- Alternative 5—In Situ Bioremediation/Long-Term Groundwater Monitoring/Land-Use Restrictions

2.13.5.4 Common Elements and Distinguishing Features of Each Alternative for the SWT Area

The common elements and distinguishing features of each alternative are essentially identical to those identified for the Ra/Sr Treatment Systems area (Section 2.13.1.4), except that the estimated volumes of contaminated soil are as follows: 9,000 to 11,000 cubic yards under Alternative 4a, 4,000 to 5,500 cubic yards under Alternative 4b, and 4,000 to 4,600 under Alternative 4c.

2.13.5.5 Expected Outcomes of Each Alternative for the SWT Area

The expected outcomes for the alternatives are identical to those identified for the Ra/Sr Treatment Systems area (Section 2.13.1.5).

2.13.5.6 Summary of Comparative Analysis of Alternatives for the SWT Area

The comparison of alternatives based on NCP criteria is shown in Table 2−15 and discussed below.

Overall Protection of Human Health and the Environment—Alternatives 2, 3, 4a, 4b, 4c, and 5 are protective of human health and the environment. Alternative 1 is not. Alternative 2 would protect groundwater resources, and contingent remediation could be implemented before contaminants reach HSU-2. A Soil Management Plan will mitigate improper disposal of or exposure to residual contaminants. Alternatives 4a, 4b, and 4c would slightly improve protectiveness by removing Sr-90 human health risk and some potential groundwater impact risk, but the risk improvement may be offset by waste shipment risks and the transfer of risk to disposal site workers. Alternatives 3 and 5 do not treat Sr-90 contamination, and Alternative 5 may spread C-14 and Sr-90 contamination.

Compliance with ARARs—The selected remedy complies with the ARARs presented in Tables A−1 through A−3 in Appendix A.

Long-Term Effectiveness—All the alternatives have good long-term effectiveness, because the removal action in 1998 permanently removed most of the contaminants. Alternatives 4a and 4b could marginally improve long-term effectiveness if they successfully remove all the residual contamination.

Reduction in Toxicity, Mobility, or Volume through Treatment—Alternatives 2, 3, 4a, and 4c do not include treatment, so this criterion is not satisfied, but they reduce or manage contamination through other means. Alternatives 4b and 5 only treat nitrate. Alternative 4b will leave C-14 contamination in the SWT. Alternative 5 could spread C-14 and Sr-90.

Short-Term Effectiveness—Alternatives 2, 3, 4a, and 4c could be effective in approximately one year, and Alternatives 4b and 5 are predicted to achieve effectiveness in 4 and 3 years, respectively. Alternatives 4a, 4b, and 4c will achieve effectiveness via excavation, but with some excavation safety issues and waste shipment risks. Alternative 2 will be effective because of land-use restrictions and monitoring. Alternatives 3 and 5 may offer slight improvements because of capping and treatment, respectively. However, Alternative 5 may spread contamination.

Implementability—Alternative 2 is easy to implement because it only involves installing a well and modifying the existing monitoring program. Alternatives 3, 4a, 4b, 4c, and 5 are more difficult to implement because they add construction and maintenance issues.

Cost—Alternative 1 costs nothing, and Alternative 2 costs $0.4 million. Alternatives 3 and 5 are more expensive, with estimated costs of $0.7 million to $1.3 million, respectively. Alternatives 4a, 4b, and 4c are markedly more expensive, with estimated costs ranging from $4.6 million to $8.8 million.

2.13.5.7 Selected Remedy for the SWT Area

The selected remedy for the SWT, Alternative 2, consists of groundwater monitoring and land-use restrictions. Monitoring will address uncertainties associated with the predictions of the future impacts to groundwater quality. If groundwater monitoring indicates that groundwater impacts as defined in Section 2.10.2 have occurred due to COCs listed in Table 2−8 remaining in soil, DOE will evaluate remedial options and determine whether remediation is appropriate in accordance with CERCLA and ARARs. Land-use restrictions will consist of a Soil Management Plan to manage the reuse and disposal of area soils. Land-use controls will be maintained until the concentration of hazardous substances in the soil is at levels that allow for unrestricted use and exposure.

Alternative 2 was selected for the SWT area because it protects human health and the environment, is relatively quick and easy to implement, and is significantly less expensive than the other alternatives. Alternative 2 is sufficient because very little contamination remains in the SWT area after the 1998 removal action. Under the current land use, risk is less than 1 in 1 million. More aggressive remediation will increase costs without significantly improving protection of human health and the environment.

Table 2−15. Comparative Analysis of Alternatives for Southwest Trenches Area

Evaluation Criteria	Effectiveness					Implementability					Costs1 (Capital, O&M, Periodic, Total Cost)	Cost-Effective[2]
	Overall Protection of Public Health and the Environment	**Compliance with ARARs**	**Long-Term Effectiveness**	**Reduction of TMV**	**Short-Term Effectiveness**	**Technical Feasibility**	**Administrative Feasibility**	**Availability of Services and Materials**	**Regulatory Acceptance**	**Community Acceptance**		
Alternative 1: No action	Residual soil contaminants pose a marginal (3×10^{-6}) risk to hypothetical residential receptors. Residual soil contaminants in the vadose zone may result in a loss of beneficial use of groundwater.	This alternative may not comply with the state's Anti-Degradation Policy and Basin Plan.	Not effective due to localized known groundwater impacts that will not be monitored. Lacks management controls to confirm effectiveness. Hypothetical site resident risk = 3×10^{-6}.	None. Principal-threat waste removed.	No short-term risks to the public. Residential receptors do not currently occupy the site.	N/A	N/A	N/A	Unacceptable	Unacceptable	$0 $0 $0 **$ 0** Years: 0	☐
Alternative 2: Long-term groundwater monitoring, land-use restrictions, and contingent remedial action	Soil Management Plan will mitigate remaining low-level threat. Protects the beneficial use of groundwater by monitoring groundwater near the source area. If deemed not protective in the future, remedial action may be implemented.	Compliant.	Effective due to the negligible mass and toxicity of residual contaminants in soil. Includes monitoring and management controls to confirm effectiveness of groundwater protection. Effectiveness of land-use restrictions depends on continued future implementation. Human health risk less than 1 in 1 million.	None. Principal-threat waste removed.	No short-term risks to the public and environment. Ongoing effectiveness will be confirmed by long-term groundwater monitoring.	Utilizes standard monitoring techniques currently deployed at the site. Site development could limit access to areas requiring future remedial action.	Standard records management and database activities required. Land-use restrictions require approval by the UCOP. Additional land-use restrictions may be a component of future remedial action, if required.	Relies on standard services and materials.	Acceptable	Acceptable	$158,000 $206,000 $16,000 **$380,000** Years: 30	☒
Alternative 3: Asphalt /HDPE cap, long-term groundwater monitoring, and land-use restrictions	Mitigates marginal residential receptor risk and protects beneficial use of groundwater through surface capping and monitoring groundwater near the source area. Deed restrictions will mitigate disturbances of the cap.	Compliant.	Effective due to the negligible mass and toxicity of residual contaminants in soil. Cap will reduce the flux of contaminants to groundwater, if maintained. Includes monitoring and management controls to confirm effectiveness of groundwater protection. Effectiveness of land-use restrictions depends on continued future implementation. Human health risk less than 1 in 1 million.	None. Principal-threat waste removed.	Minor short-term risks to the public and environment are associated with the manufacture, transport, and installation of asphalt. The risk of a fatality from implementing this alternative is approximately 0. Cap may restrict site development and aesthetics. Time to deploy is rapid, since the cap relies on established engineering design and materials. Predicted to be protective in approximately one year.	Relies on established engineering design and materials.	Standard records management and database activities required. Land-use restrictions require approval by UCOP.	Relies on standard services and materials.	Acceptable	Acceptable	$450,000 $228,000 $69,000 **$747,000** Years: 30	☒
Alternative 4a: Removal and off-site disposal	Mitigates marginal residential receptor risk and protects beneficial use of groundwater by removing the contaminated soil. Local risk reduction is offset by the transfer of risk to the disposal site, and short-term risks from transportation accidents and vehicular air emissions.	Compliant.	Effective, since virtually all residual contamination is removed. Risk transferred to disposal site, but contaminant levels are low and should be easily controlled in a permitted facility. Human health risk less than 1 in 1 million.	None.	Discernable short-term risks to the public are associated with the transport of contaminated soil to off-site disposal facilities. Traffic fatality risk = 2.15×10^{-2}. Emissions fatality risk = 4.75×10^{-3}. Potential radiation dose to maximally exposed member of public = 0.43 mrem/yr. Localized noise and vibration impacts will persist for months during the remedial action. Air monitoring, dust control, and personal protective equipment are required. Predicted to be protective in approximately one year. Time to complete is uncertain and may exceed one year due to the depth and techniques required to excavate the contaminated soil.	The use of large-diameter augers to conduct mass excavation has not been conducted at LEHR at the scale proposed and may result in a failure to remove all contaminated soil or may extend the project's schedule and costs.	Standard records management and database activities required.	Relies on standard services and materials. Suitable landfill space is expected to remain available during the remedial action.	Acceptable	Acceptable	$7,271,000–$8,831,000 $0 $0 **$7,271,000–$8,831,000** Years: 1	☐

Evaluation Criteria	Effectiveness					Implementability					Costs1 (Capital, O&M, Periodic, Total Cost)	Cost-Effective[2]
	Overall Protection of Public Health and the Environment	Compliance with ARARs	Long-Term Effectiveness	Reduction of TMV	Short-Term Effectiveness	Technical Feasibility	Administrative Feasibility	Availability of Services and Materials	Regulatory Acceptance	Community Acceptance		
Alternative 4b: Removal, on-site treatment, and land-use restrictions	Mitigates marginal residential receptor risk and protects beneficial use of groundwater by removing the contaminated soil and treating it to acceptable levels or disposing of it off site. Local risk reduction offset by the transfer of risk to the disposal site, and short-term risks from transportation accidents, vehicular air emissions, and on-site treatment operations. Soil Management Plan will mitigate any low-level threat remaining in the treatment cell.	Compliant.	Effective, since virtually all residual contamination is removed and treated or disposed. Some risk transferred to disposal site, but contaminant levels are low and should be easily controlled in a permitted facility. Human health risk less than 1 in 1 million.	TMV of nitrate low-level threat reduced to negligible quantities by on-site treatment. Does not treat Sr-90 or C-14 low-level threat.	Discernable short-term risks to the public are associated with the transport of contaminated soil to off-site disposal facilities. Traffic fatality risk = 1.47 x 10^{-2}. Emissions fatality risk = 3.23 x 10^{-3}. Potential radiation dose to maximally exposed member of the public = 0.43 mrem/yr. Localized noise and vibration impacts will persist for months during the remedial action. Air monitoring, dust control, and personal protective equipment are required. Time to complete removal action is uncertain due to the depth and techniques required to excavate the contaminated soil. On-site treatment cell could rupture and release contaminants. Predicted to be protective in approximately 4 years.	The use of large-diameter augers to conduct mass excavation has not been conducted at LEHR at the scale proposed and outcomes may fail to remove all contaminated soil and/or may extend the project's schedule and costs.	Standard records management and database activities required.	Relies on standard services and materials. Suitable landfill space is expected to remain available during the remedial action. On-site treatment requires the use of the Western Dog Pens area.	Acceptable	Acceptable	$6,198,000–$7,752,000 $95,000 $139,000 **$6,432,000–$7,986,000** Years: 4	☐
Alternative 4c: Limited removal, off-site disposal, long-term groundwater monitoring, and land-use restrictions	Mitigates marginal residential receptor risk by removing soil containing Sr-90 contamination above the risk goal. Protects beneficial use of groundwater by removing some contaminated soil and monitoring groundwater near the source area. Soil Management Plan will mitigate remaining low-level threat.	Compliant.	Effective reduction in mass and toxicity due to partial removal of residual contaminants in soil. Risk transferred to disposal site, but contaminant levels are low and should be easily controlled in a permitted facility. Human health risk less than 1 in 1 million.	None. Principal-threat waste removed.	Discernable short-term risks to the public are associated with the transport of contaminated soil to off-site disposal facilities. Traffic fatality risk = 1.90 x 10^{-2}. Emissions fatality risk = 4.18 x 10^{-3}. Potential radiation dose to maximally exposed member of the public = 0.43 mrem/yr. Localized noise and vibration impacts will persist for months during the remedial action. Air monitoring, dust control, and personal protective equipment are required. Predicted to be protective in approximately one year.	Uses standard excavation and disposal techniques.	Standard records management and database activities required.	Relies on standard services and materials. Suitable landfill space is expected to remain available during the remedial action.	Acceptable	Acceptable	$4,422,000–$4,969,000 $206,000 $16,000 **$4,644,000–$5,191,000** Years: 30	☐
Alternative 5: In situ bioremediation, long-term groundwater monitoring, and land-use restrictions	Soil Management Plan will mitigate remaining low-level threat. Protects beneficial use of groundwater by treating nitrate-contaminated soil and monitoring groundwater near the source area.	Compliant.	Effective due to the negligible mass and toxicity of residual contaminants in soil. Includes pilot test, monitoring and management controls to confirm effectiveness of groundwater protection. Effectiveness of land-use restrictions depends on continued future implementation. Human health risk less than 1 in 1 million.	Reduces TMV of nitrate low-level threat to negligible quantities. Does not reduce TMV of Sr-90 or C-14 low-level threat. May mobilize some C-14 to groundwater. However, the majority of the C-14 is not co-located with nitrate.	Minor short-term risks to the public and environment are associated with the installation and operation of the bioremediation system. The risk of a fatality from implementing this alternative is approximately 0. The treatment system may interfere with site activities or development. Time to deploy can be rapid, since the system relies on established engineering design and materials. Predicted to be protective in approximately 3 years.	A site-specific pilot test is required to confirm technical feasibility.	Standard records management and database activities required. Land-use restrictions require approval by the UCOP.	Relies on standard services and materials.	Acceptable	Acceptable	$739,000 $388,000 $186,000 **$1,313,000**	☐

Notes
[1]Net present value.
[2]Relevant Considerations for Cost-Effectiveness Determination: (1) Human health risk estimated for on-site residents is 3 in 1 million (strontium-90+daughter). (2) COCs in soil that may impact groundwater include carbon-14 and nitrate.
Cost-Effectiveness Summary: Alternatives 1, 4a, 4b, 4c, and 5 are not considered to be cost-effective. While Alternative 3 is considered cost-effective, Alternative 2 provides a potentially more effective result.

Abbreviations
HDPE high-density polyethylene
mrem/yr millirem per year
N/A not applicable
O&M operations and maintenance
TMV toxicity, mobility, or volume
UCOP University of California Office of the President

2.13.5.8 Statutory Determinations for the SWT Area

Protection of Human Health and the Environment

The selected remedy protects the public from exposure to Sr-90 by implementation of land-use restrictions at the site where risk is greater than 1 in 1 million. With respect to groundwater, significant impacts are unlikely; however, the selected remedy addresses uncertainties associated with the predictions of the future impacts by implementing a groundwater monitoring program. Based on plume size estimates, additional remedial measures may not be necessary if the nitrate or C-14 contamination arrives in HSU-1; however, if groundwater monitoring indicates that impacts to groundwater have occurred due to COCs listed in Table 2−8 remaining in soil, DOE will evaluate remedial options and determine whether remediation is appropriate in accordance with CERCLA and ARARs.

Compliance with ARARs

The selected remedy complies with ARARs presented in Tables A−1 through A−3 in Appendix A. If monitoring shows that residual soil contamination is impacting groundwater quality, remediation will be considered.

Cost-Effectiveness

All the alternatives evaluated except Alternative 1 (No Action) satisfied the threshold criteria of protection of human health and the environment and compliance with ARARs. The long-term effectiveness and permanence; reduction in toxicity, mobility, and volume through treatment; and short-term effectiveness of each of the alternatives were then compared to estimated costs to evaluate cost-effectiveness. These criteria are summarized in Table 2−15. Alternatives 4a, 4b, 4c, and 5 are not considered to be cost-effective, as they provide only incremental risk reduction at costs that range from approximately $1 million to $8 million, which exceeds the estimated cost of Alternative 2, which is estimated at less than $0.5 million.

Utilization of Permanent Solutions and Alternative Treatment Technologies to the Maximum Extent Practicable

All source material has been removed, and no principal-threat waste remains in the SWT area. The results indicate that significant impacts to groundwater quality are unlikely. C-14 concentrations could exceed background over an area of up to 4.5 acres, but the 4 mrem/year federal MCL-based concentration (EPA 2000) could occupy only a little more than one-tenth of an acre. Predicted nitrate plumes range from 0.88 acre to 2.4 acres for concentrations equal to groundwater background and the California MCL, respectively. Groundwater monitoring will continue until DOE can show that residual soil contaminants no longer pose a threat to water quality.

Of the alternatives that are protective of human health and the environment and comply with ARARs, DOE has determined that the selected remedy provides the best balance of trade-offs in terms of the five balancing criteria. The selected remedy also considers the statutory preference for treatment as a principal element, bias against off-site treatment and disposal, and State and community acceptance.

The selected remedy satisfies the criteria for long-term effectiveness by leaving no principal-threat wastes or contaminant sources in soil. Since only residual contamination remains in the area, the selected remedy does not present short-term risks different from those of the other treatment alternatives. There are no special implementability issues that set the selected remedy apart from any of the other alternatives evaluated. The implementability of the selected remedy is higher than that of Alternatives 3, 4, and 5, which require significant construction activities to implement.

Preference for Treatment as a Principal Element

EPA expects the use of treatment to address principal threats posed by a site, wherever practicable, and engineering controls for wastes that pose a relatively low long-term threat (40 CFR 300.430[a][A][iii][A] and [B]). No principal-threat waste remains at the SWT area; therefore, monitoring and land-use controls are appropriate remedies.

5-Year Review Requirements

Although residual contamination at the SWT area does not pose unacceptable excess risk to human health, the remedy selected for the SWT area results in hazardous substances remaining on-site at levels that may potentially impact groundwater quality. To ensure that the selected remedy continues to be protective of the environment, a review of the selected remedial action will be conducted within 5 years of the adoption of this ROD. The effectiveness of the Soil Management Plan and the land-use restrictions will be evaluated during these reviews. An assessment will be conducted to determine whether disturbance permits or equivalent processes established in the Soil Management Plan and/or land-use covenants are sufficiently protective, and whether contaminated soil has been brought to the surface without proper risk management controls. Revisions to the Soil Management Plan and land-use restriction will be made as necessary to ensure the continued protectiveness of the selected remedy. Five-year reviews will continue as long as contamination requiring the implementation of the Soil Management Plan and/or land-use restrictions remains in place.

2.13.6 EDPs Area

2.13.6.1 Area Characteristics

Between 1968 and 1970, the EDPs were constructed and used to house dogs involved in LEHR experiments (WA 2003). The area consisted of 96 individual pens arranged in six rows separated by three asphalt-covered aisles. The pens were constructed above an inactive UC Davis land disposal unit (Figure 1−2). EPA will issue a separate ROD addressing the underlying land disposal unit.

The pens were used until research ceased in 1988. Low levels of radioactive constituents were released to the pens in the dogs’ excrement (WA 1997b). Chlordane was released to the pens to control fleas on the dogs. In 1996, aboveground features of the individual pens were removed and disposed of off-site (WA 1997b). Concrete curbs and the perimeter fence were removed and disposed of off site in 2007. Portions of the asphalt aisles, and gravel that formerly covered the dog pen floors remain.

The conceptual site model for the EDPs area is shown in Figure 2−4. The primary source of contamination was related to excreta and flea control of the research animals (dogs).

Indoor research workers, outdoor research workers, construction workers, hypothetical future on-site residents, trespassers, and terrestrial biota could be exposed to residual contamination in the EDPs area. Hypothetical on-site residents would have the highest level of exposure if site use becomes residential. Research workers, construction workers, and trespassers could also receive direct exposure from contaminated soil during maintenance work, infrastructure replacement, or future development activities.

Groundwater ingestion is not a complete exposure pathway because soil sample data, groundwater monitoring data, and predictive calculations have shown that the EDPs area contains no contaminants that could potentially impact groundwater quality (WA 2005). Storm water runoff is a complete release mechanism, but storm water from the EDPs area infiltrates in low-lying areas and does not reach Putah Creek.

2.13.6.2 Assessment of the EDPs Area

A sitewide risk assessment results indicate that dieldrin and Sr-90 in shallow soil posed small risks to hypothetical future on-site residents (Table 2−6). Dieldrin and Sr-90 toxicity data are summarized in Table 2−5. No significant risks to ecological receptors or groundwater quality were identified (BBL 2006).

Dieldrin Spatial Distribution

One sample located in surface soil (0–0.5 ft) near the northeastern corner of the EDPs area had a concentration in the 1 in 100,000 to 1 in 10,000 risk range. Dieldrin was not detected in subsurface soil at the same location (2 ft bgs). One centrally located sample within the northeast quarter of the EDPs area had a concentration in the 1 in 1 million to 1 in 100,000 risk range and is surrounded by samples showing risks below 1 in 1 million. Detected concentrations occurred most frequently in the northeast quarter of the EDPs area.

2.13.6.3 Description of Alternatives for the EDPs Area

Remedial alternatives developed for the EDPs area are as follows:

- Alternative 1—No Action
- Alternative 2—Land-Use Restrictions
- Alternative 3—Removal and Off-Site Disposal

2.13.6.4 Common Elements and Distinguishing Features of Each Alternative for the EDPs Area

Alternative 2 consists of land-use restrictions to prevent exposure to subsurface soil contamination that could be brought to the surface in the future. Alternative 3 is expected to remove all of the contamination. All alternatives (except the No Action alternative) meet ARARs.

Excavation of contaminated soils under Alternative 3 would generate about 1,500 cubic yards of waste to be disposed of off site. The alternatives will not generate treatment residuals or untreated waste.

Alternative 2 has an indefinite operation time frame. Alternative 3 is predicted to reach cleanup levels for dieldrin and Sr-90 within one year.

2.13.6.5 Expected Outcomes of Each Alternative for the EDPs Area

Available land-use options would not be affected by any of the alternatives and would remain consistent with the UC Davis Long-Range Development Plan designation as “Academic/ Administrative Low Density” and “Support Services.”

The aquifer beneath the site is designated as a potential source of drinking water (CRWQCB 2007); however, there is no risk to groundwater from any residual contaminants at the EPDs.

2.13.6.6 Summary of Comparative Analysis of Alternatives for the EDPs Area

The comparison of alternatives based on NCP criteria is shown in Table 2−16 and discussed below.

Overall Protection of Human Health and the Environment—Alternatives 2 and 3 are protective of human health and the environment; Alternative 1 is not. The human health risk is low and easily addressed by land-use restrictions (Alternative 2). A Soil Management Plan will prevent improper disposal of or exposure to residual contaminants. The risk can also be removed by excavation and off-site disposal under Alternative 3.

Compliance with ARARs—Alternatives 2 and 3 comply with the ARARs; Alternative 1 does not.

Long-Term Effectiveness—Land-use restrictions that prevent residential development (Alternative 2) are consistent with UC Davis’s long-range plans. UC Davis intends to continue using the site for academic research into the foreseeable future. Excavation and off-site disposal (Alternative 3) could permanently remove the contaminants.

Reduction in Toxicity, Mobility, or Volume through Treatment—The alternatives do not meet EPA’s definition of treatment.

Short-Term Effectiveness—Alternatives 2 and 3 are effective in the short term and are predicted to protect human health within one year. Alternative 1 will be effective in the short term if research facility land use remains unchanged. The risk to on-site workers is less than 1 in 1 million.

Implementability—Alternative 2 involves negotiations between DOE and UC Davis and the implementation of decided-upon restrictions. Alternative 3 involves shallow excavation and off-site disposal. Alternative 1 has no implementation work.

Table 2−16. Comparative Analysis of Alternatives for the Eastern Dog Pens Area

Evaluation Criteria	Effectiveness					Implementability					Costs[1] (Capital, O&M, Periodic, Total Cost)	Cost-Effective[2]
	Overall Protection of Public Health and the Environment	Compliance with ARARs	Long-Term Effectiveness	Reduction of TMV	Short-Term Effectiveness	Technical Feasibility	Administrative Feasibility	Availability of Services and Materials	Regulatory Acceptance	Community Acceptance		
Alternative 1: No action	Residual soil contaminants pose a marginal (4×10^{-6}) risk to hypothetical residential receptors. Risk is within the CERCLA acceptable risk range.	This alternative may not comply with the state's Anti-Degradation Policy and Basin Plan.	Lacks management controls to confirm effectiveness. Hypothetical site resident risk is 4 in 1 million.	None. No principal-threat waste.	No short-term risks to the public. Residential receptors do not currently occupy the site.	N/A	N/A	N/A	Unacceptable	Unacceptable	$0 $0 $0 **$0** Years: 0	☐
Alternative 2: Land-use restrictions	Mitigates low-level threat through implementation of Soil Management Plan.	Compliant.	Effectiveness of land-use restrictions depends on continued future implementation. Human health risk less than 1 in 1 million.	None. No principal-threat waste.	No short-term risks to the public. Predicted to be protective within one year.	N/A	Standard records management. Land-use restrictions require approval by the UCOP.	N/A	Acceptable	Acceptable	$50,000 $0 $0 **$50,000** Years: 1	☒
Alternative 3: Removal and off-site disposal	Mitigates marginal residential receptor risk by removing the contaminated soil. Local risk reduction is offset by the transfer of risk to the disposal site, and short-term risks from transportation accidents and vehicle air emissions.	Compliant.	Effective, since virtually all residual contamination is removed. Risk transferred to disposal site, but contaminant levels are low and should be easily controlled in a permitted facility. Human health risk less than 1 in 1 million.	None. No principal-threat waste.	Discernable short-term risks to the public are associated with the transport of contaminated materials to off-site disposal facilities. Traffic fatality risk = 8.01×10^{-3}. Emissions fatality risk = 1.76×10^{-3}. Potential radiation dose to maximally exposed member of public = 0.68 mrem/yr. Localized noise and vibration impacts will persist for weeks during the remedial action. Air monitoring, dust control, and personal protective equipment are required. Predicted to be protective in approximately one year.	Utilizes standard excavation and disposal techniques.	Standard records management and database activities required.	Relies on standard services and materials. Suitable landfill space is expected to remain available during the remedial action.	Acceptable	Acceptable	$1,626,000 $0 $0 **$1,626,000** Years: 1	☐

Notes

[1]Net present value.

[2]Relevant Considerations for Cost-Effectiveness Determination: (1) Human health risks estimated for on-site residents is 4 in 1 million (total). (2) No COCs in soil that may impact groundwater have been identified.

Cost-Effectiveness Summary: Alternatives 1 and 3 are not considered to be cost-effective.

Abbreviations

mrem/yr millirem per year
N/A not applicable
O&M operations and maintenance
UCOP University of California Office of the President
TMV toxicity, mobility, or volume

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Cost—Alternative 1 costs nothing. Alternative 2 costs $50,000. Alternative 3 is significantly more expensive, with an estimated cost of $1.6 million.

2.13.6.7 Selected Remedy for the EDPs Area

The selected remedy, Alternative 2, consisting of land-use controls, will be implemented in the EDPs area to protect the public from potential exposure to dieldrin and Sr-90. Land-use controls will consist of deed restrictions or covenants that require the implementation of a Soil Management Plan for any soil-disturbing activities. The Soil Management Plan will provide strict management requirements for the reuse and disposal of area soils. The covenants will be drafted by DTSC, with input from EPA, and will be signed by the University of California and DTSC. EPA will be named as a third-party beneficiary. The covenants will be recorded with the Recorder Division of the Solano County Department of the Assessor/Recorder.

Alternative 2 was selected for the EDPs area because the small risks to hypothetical on-site residents can be managed by maintaining the existing land use. The UC Davis long-range plan is to continue using the site as an academic research facility.

UC Davis is in the process of evaluating remedies for the landfills and existing groundwater contamination. Soil contamination remaining at the EDPs will be considered in the evaluation of options for this area and in the selection of a final remedy for the UC Davis areas by EPA.

2.13.6.8 Statutory Determinations for the EDPs Area

Protection of Human Health and the Environment

The selected remedy protects the public from exposure to dieldrin by implementing land-use restrictions. The representative concentration of Sr-90 is near the cleanup goal; therefore, the residual Sr-90 in soil presents a minimal risk to the public.

Compliance with ARARs

The selected remedy complies with ARARs presented in Tables A−1 through A−3 in Appendix A.

Cost-Effectiveness

All the alternatives evaluated except Alternative 1 (No Action) satisfied the threshold criteria of protection of human health and the environment and compliance with ARARs. The long-term effectiveness and permanence; reduction in toxicity, mobility, and volume through treatment; and short-term effectiveness of each of the alternatives were then compared to estimated costs to evaluate cost-effectiveness. These criteria are summarized in Table 2−16. Alternative 3 is not considered to be cost-effective, as it provides only incremental risk reduction at costs that are approximately 30 times that of the estimated cost of Alternative 2, which is estimated at about $50,000.

Utilization of Permanent Solutions and Alternative Treatment Technologies to the Maximum Extent Practicable

Source material has been removed from the EDP areas, and no principal-threat waste is present in the area. Residual concentrations of dieldrin are assumed to remain at current concentration in soil indefinitely. The concentrations are too low to make treatment practicable.

Of the alternatives that are protective of human health and the environment and comply with ARARs, DOE has determined that the selected remedy provides the best balance of trade-offs in terms of the five balancing criteria. The selected remedy also considers the statutory preference for treatment as a principal element, bias against off-site treatment and disposal, and State and community acceptance.

The selected remedy satisfies the criteria for long-term effectiveness by leaving no principal-threat wastes or contaminant sources in soil. Since only residual contamination remains in the area, the selected remedy does not present short-term risks different from the removal and disposal alternative. There are no special implementability issues that set the selected remedy apart from the waste excavation and disposal option evaluated. The implementability of the selected remedy is preferable to that of Alternative 3, which requires excavation and creates worker safety issues in its implementation.

Preference for Treatment as a Principal Element

EPA expects the use of treatment to address principal threats posed by a site, wherever practicable, and engineering controls for wastes that pose a relatively low long-term threat (40 CFR 300.430[a][A][iii][A] and [B]). No principal-threat waste remains at the EDPs area; therefore, land-use control is an appropriate remedy.

5-Year Review Requirements

The remedy selected for the area results in hazardous substances remaining on-site at levels that may potentially impact groundwater quality. To ensure that the selected remedy continues to be protective of the environment, a review of the selected remedial action will be conducted within 5 years of the adoption of this ROD. The effectiveness of the land-use restrictions will be evaluated during these reviews. An assessment will be conducted to determine whether disturbance permits or equivalent processes established in the Soil Management Plan and/or land-use covenants are sufficiently protective, and whether contaminated soil has been brought to the surface without proper risk management controls. Revisions of the land-use restriction will be made as necessary to ensure the continued protectiveness of the selected remedy. Five-year reviews will continue as long as contamination requiring the implementation of land-use restrictions remains in place.

2.14 Documentation of Significant Changes

The Proposed Plan for DOE areas at LEHR was released for public comment in October 2008. No significant changes to the remedies originally identified in the Proposed Plan and selected in this ROD were necessary or appropriate.

3.0 Responsiveness Summary

This section responds to public comments directed to DOE, EPA, and the State of California regarding the Proposed Plan for LEHR issued by DOE in October 2008 (DOE 2008). Responses to community comments and questions are incorporated into this ROD. A 30-day public comment period began on October 15, 2008, and ended on November 17, 2008. On October 23, 2008, DOE and the regulatory agencies held a public meeting at the Veterans Memorial Center in Davis, California, to present the proposed remediation plans and receive public questions and comments on the preferred remedial alternatives. At the meeting, representatives from DOE summarized information from the Proposed Plan. Following the presentations, the public was given the opportunity to present their comments into the formal public record. Comments received at the meeting and DOE's responses are summarized in Section 3.1.

3.1 Stakeholder Comments and Lead Agency Responses

3.1.1 Written Comments

Comment: A written comment was received on the Proposed Plan from Sue Fields, representing UC Davis: "UC Davis requests that the word 'new' be deleted from the language in Section 7.2 in the first line at the top of page 8 in the bound hardcopy of the Proposed Plan provided at the October 23, 2008 public meeting."

Response: DOE agrees to the requested change to the Proposed Plan. Revised, including an editorial correction, the sentence referred to in the comment reads as follows: "If implementation is required, the selected contingent remedial alternative would address ~~only new~~ contamination in groundwater attributable to residual <u>contaminants</u> in the soil in the DOE areas" (deletion indicated by strike-out and addition indicated by underline).

Comment: Written comments on the Proposed Plan were submitted by Steven Ross, Hazardous Substances Engineer of Brownfields and Environmental Restoration Program of the DTSC on November 4, 2008.

As a period of time will elapse, DTSC requests the Record of Decision define the steps necessary to isolate those institutional controls on DOE areas which will eventually be subject to an enforceable land-use restriction with the property owner. This may require surveys and legal descriptions of the Domestic Septic Systems #4 area, areas subject to a Soils Management Plan, and areas protecting remedial and monitoring systems. Any land-use restrictions would be recorded after the remedy is implemented at the University of California, Davis (UCD) responsible areas. Currently, recorded land-use restriction documents are signed by DTSC and the landowner with U. S. EPA as third-party beneficiary at National Priorities List sites. Applicable soils management plan requirements and the trigger mechanisms are typical provisions in the recorded document. The restrictions in this recorded document would be enforceable by DTSC and U. S. EPA. They will run with the land in perpetuity and will bind the current property owner and all subsequent title holders. The proposed plan indicates DOE will require the development of a Soils Management Plan with updates during five-year reviews for the reuse and disposal of soil in DOE areas. As DOE will not become a party to the recorded land-use restriction, DTSC is unclear how DOE could enforce requirements of a soils management plan.

Response: DOE has identified surveys, the development of legal descriptions describing the areas of concern, a Soil Management Plan, and the trigger mechanisms for areas subject to land-use restrictions in this ROD. DOE will work with EPA and the state agencies to develop the specifics of these land-use restrictions at the remedial design phase and will obtain concurrence/approval of these restrictions from the regulatory agencies as appropriate. The restrictions (including the soils management plan) will be signed by UC Davis and DTSC and would list EPA as a third-party beneficiary and will be enforceable by UC Davis, DTSC and EPA.

3.1.2 Comments Provided at Public Meeting

Comments were received during the public meeting held on October 23, 2008. Julie Roth and G. Fred Lee, representing the Davis South Campus Superfund Oversight Committee (DSCSOC), a group funded by a Technical Assistance Grant (TAG) from the EPA, presented comments on the Proposed Plan which are provided below.

Comment: "My name is Julie Roth, and I'm with [DSCSOC]. We are the USEPA TAG […] group for the Davis community, and we represent the citizens of the community.

Overall, the DOE proposed plan for the remediation of the DOE areas of the LEHR site Superfund site addresses the near term control of conventional pollutants. The key issue to DSCSOC and its concerns is how well the proposed plan is implemented during the time that the residual waste is left in the soil at the LEHR site and will remain a threat to the public health and the environment. This concern over the adequacy of the implementation exists from the time the record of decision is signed, to over the very long period of time during which the residual, known pollutants—as well as the yet unrecognized pollutants—left in the soil will be a threat to the off-site waters. There could readily be residual pollutants at LEHR that thus far have not been identified. For planning purposes, the period of time should be considered forever.

A particular concern is the adequacy of monitoring the groundwater or off-site mitigation to groundwater under the adjacent properties. Another issue of concern is the adequacy of the implementation of restrictions of future land use at LEHR site to prevent buried pollutants being brought to the surface soils and, thereby becoming a presently unconsidered threat to the public health and the environment. Some of the pollutants that are proposed to be left at the site buried under surface soils will be a threat essentially forever. At some time in the future, the soils at LEHR may be brought to the surface by future construction activities that violate the restrictions or the land-use activities at the site. There will be a need for a strong implemented oversight of LEHR-site activities forever. It should not be left to DOE, UCD, USEPA, DTSC, or the Water Board to police the LEHR-site activities to conform to the land-use restrictions adopted.

There is no assurance that these agencies will continue to be funded or will implement land-use-activity restrictions essentially forever. As long as there are waste residuals in the LEHR-site subsoils that are a threat to the public health and/or the environment, consideration should be given to funding independent site oversight to ensure that the public is kept informed of the adequacy of the protection of the public health and the environment.

As discussed in DSCSOC's comments on this plan, there are several potential technical problems with this plan, and a detailed discussion of these issues is provided in the DSCSOC's web site. These comments are under are technical adviser, Dr. G. Fred Lee's reports.

DSCSOC has a new Web site due to the changes at AOL. The URL for DSCSOC is now www.gfredlee.com/dscsoc/dscsoc.htm."

Response: The management of the selected remedy at LEHR is under the purview of the DOE's Office of Legacy Management. The Office of Legacy Management was formally established as a new DOE element on December 15, 2003, with the primary mission of ensuring that DOE's long-term cleanup obligations are met. DOE identifies and documents post-closure actions that are required to maintain the protection of the remedy and involve and inform the public in a long-term surveillance and maintenance (LTS&M) Plan. For CERCLA sites, the LTS&M Plan must meet the requirements of the ROD, remedial implementation work plans, and 5-year review findings.

Stakeholders can participate in the development and implementation of the LTS&M Plan. The Office of Legacy Management works with DOE's Office of Environmental Management to ensure that appropriate cost estimates are developed for the post-closure management of the site to obtain adequate funding for these activities.

Comment: "I'm Fred Lee, advisor to DSCSOC. An issue I think that should be understood -- and it may be in the record […] is that this is just part of the pollution and remediation at the LEHR site; that there is a separate action underway by UCD that will address the rest of the issues, particularly the groundwater pollution issues. So I think it's important that that be understood, and may be a source of information for those interested that that exists."

Response: Comment noted.

COMMENT: Jeff Wong noted a typographical error in the Proposed Plan regarding the human health risks of Sr-90 in the EDPs area.

"Paragraph—Section 4.1, the human health risks section, mentions the strontium-90 risk at the Eastern Dog Pens, parentheses, two in one million. This seems to be an inconsistency because Table 1 lists strontium-90 as 1 in 1 million. So I think there's—I believe it should be one in a million. The table lists it as one in the numerical value."

Response: Comment noted. The value of 1 in 1 million presented in Table 1 is correct.

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4.0 References

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Appendix A

Applicable or Relevant and Appropriate Requirements

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Table A−1. Chemical-Specific Requirements for the Selected Remedy for the DOE Areas for the LEHR Federal Facility

Requirement/Authority	Description	Applicability	Area	ARAR Category
Federal				
Safe Drinking Water Act (42 USC 300 and 40 CFR 141.11-16, 141.23-24, 141.50-51, and 141.61-62)	Establishes maximum contaminant levels (MCLs) for drinking water in public water supply systems based on acceptable health-based criteria.	Groundwater beneath the LEHR site is identified by the State of California as a potential source of drinking water. Although there is no public water supply system at the LEHR site, contaminants released to the soil at the site may migrate and impact the beneficial use of underlying groundwater; therefore, this requirement is relevant and appropriate. Unless otherwise noted, federal MCLs and background concentration values were used by DOE as the reference standard for defining acceptable residual concentrations of contaminants in soil where migration of these contaminants from soil to groundwater has occurred or may occur. Those contaminants for which a state MCL or standard was used as the reference standard are specifically identified in the text of this Record of Decision and in this ARARs table.	Ra/Sr DSS 3 DSS 4 DW A-E SWT	Relevant and Appropriate
Uranium Mill Tailings Radiation Control Act (UMTRCA) 42 USC Chapter 88 (40 CFR 192.12(a) and 192.32(b))	Establishes cleanup criteria for uranium and thorium mill tailings, and properties contaminated with uranium and thorium mill tailings. Ra-226 cleanup standards are established as 5 pCi/g above natural background to a depth of 15 cm, and 15 pCi/g above natural background for deeper soil.	While LEHR is not subject to UMTRCA, long-term soil management may need to address Ra-226 in soil; therefore, the UMTRCA cleanup criteria are relevant and appropriate. All areas at LEHR were evaluated using a site-specific risk-based cleanup goal which was well below the UMTRCA cleanup criteria and thus the Site would comply with this regulation.	Ra/Sr DSS 3 DSS 4 DW A–E SWT EDP	Relevant and Appropriate
Use of Soil Cleanup Criteria for 40 CFR 192 as Remediation Goals for CERCLA Sites (OSWER Directive 9200.4–25, February 12, 1998)	OSWER Directive 9200.4-25 addresses the use of the soil cleanup criteria in 40 CFR 192 when setting remediation goals at CERCLA sites with radioactive contamination. In particular, it clarifies the intent of 40 CFR 192 in setting remediation levels for subsurface soil. Subpart B of 40 CFR 192 contains two different soil standards: concentration criterion for surface soil of 5 pCi/g of radium-226, and the concentration criterion for subsurface of 15 pCi/g of radium-226. The 15 pCi/g standard would be expected to achieve an actual subsurface cleanup level of below 5 pCi/g in practice.	Same as above.	Ra/Sr DSS 3 DSS 4 DW A–E SWT EDP	To Be Considered
State and Local				
Criteria for Identifying Hazardous Wastes (CCR, Title 22, 66261. 21–33)	Tests for identifying hazardous waste characteristics are set forth in these regulations. If a chemical is either listed or tested and found hazardous, then remedial actions must comply with the applicable CCR Title 22 requirements.	Applies to waste generated during well installation, groundwater monitoring, future development, or maintenance activities involving contaminated soil, groundwater, or other material.	Ra/Sr DSS 3 DSS 4 DW A–E SWT EDP	Applicable
Porter-Cologne Water Quality Control Act (California Water Code, Div. 7 13000, *et seq.* and 23 CCR Chap. 15, 2510–2559, 2580–2601)	Establishes authority for state and regional water boards to determine site-specific waste discharge requirements and to regulate disposal of waste to land. Authorizes regional boards to protect existing and probable future beneficial uses of waters of the state.	Applies to all residual soil contamination.	Ra/Sr DSS 3 DSS 4 DW A–E SWT	Applicable
Central Valley Regional Water Quality Control Board Basin Plan, Chapter ll	Describes water basins in the Central Valley Region, establishes beneficial uses of groundwater and surface waters, establishes water quality objectives and numerical standards, establishes implementation plans to meet water quality objectives and protect beneficial uses, and incorporates statewide water quality control plans and policies. The substantive provisions of this plan dealing with the beneficial uses of water bodies and water quality objectives identified in the Basin Plan are applicable to the cleanup. Under CERCLA, the implementation requirements of this plan are not applicable.	Identifies groundwater beneath LEHR as a potential source of drinking, agricultural, and industrial supply. Water quality objectives and numerical standards apply to residual soil contamination in specific areas that may impact the beneficial use of groundwater in the future.	Ra/Sr DSS 3 DSS 4 DW A–E SWT	Applicable
Central Valley Regional Water Quality Control Board Basin Plan, Chapter lll	Requires that groundwater not contain chemical constituents in concentrations that exceed beneficial uses. At a minimum, groundwater designated for use as MUN shall not contain chemical constituents in excess of the MCLs specified in Title 22. To protect all beneficial uses, the Regional Water Board may apply limits more stringent the MCLs. Groundwater shall be maintained free of toxic substances in concentrations that produce detrimental physiological response in human, plant, animal, or aquatic life associated with designated beneficial uses. Groundwater shall not contain taste- or odor-producing substances in concentrations that cause nuisance or adversely affect beneficial uses.[1]	Applies to areas where residual soil contamination may impact the beneficial use of groundwater in the future	Ra/Sr DSS 3 DSS 4 DW A–E SWT	Applicable

Table A−1 (continued). Chemical-Specific Requirements for the Selected Remedy for the DOE Areas for the LEHR Federal Facility

Requirement/Authority	Description	Applicability	Area	ARAR Category
Policies and Procedures for Investigation, Cleanup and Abatement of Discharges under Water Code Section 13304, State Water Resources Control Board Resolution No. 92-49 Paragraph lll G	The "Policy for Investigation and Cleanup of Contaminated Sites" establishes and describes policy for investigation and remediation of contaminated sites. Also includes implementation actions for setting groundwater and soil cleanup levels. Cleanup levels for soils should be equal to levels that would achieve background concentrations in groundwater unless such levels are technically and economically infeasible to achieve. In such cases, soil cleanup levels are such that groundwater will not exceed applicable groundwater quality objectives.	Applies to areas where residual soil contamination may impact the beneficial use of groundwater in the future.	Ra/Sr DSS 3 DSS 4 DW A–E SWT	Relevant and Appropriate[2]
Statement of Policy with Respect to Maintaining High Quality Waters in California, State Water Resources Control Board Resolution No. 68-16 (Anti-Degradation Policy)	Requires that high-quality surface and groundwater be maintained to the maximum extent possible. Degradation of waters will be allowed (or allowed to remain) only if it is consistent with the maximum benefit to the people of the state, does not unreasonably affect present and anticipated beneficial uses, and does not result in water quality less than that prescribed in RWQCB and SWRCB policies, as defined by the substantive requirements. If degradation is allowed, the discharge must meet best practicable treatment or control, which must prevent pollution or nuisance and result in the highest water quality consistent with maximum benefit to the people of the state.	Applies to areas where residual soil contamination may impact the beneficial use of groundwater in the future.	Ra/Sr DSS 3 DSS 4 DW A–E SWT	Applicable
Sources of Drinking Water Policy, State Water Resources Control Board Resolution No. 88-63	Applies in determining beneficial uses for water that may be affected by discharges of waste. SWRCB Resolution 88-63 applies to all sites that may be affected by discharges of waste to groundwater or surface water. The resolution specifies that, with certain exceptions, all groundwater and surface water have the beneficial use of municipal use or domestic supply. Consequently, California primary MCLs are relevant and appropriate; however, the most stringent federal or state standard will be the ARAR.	Applies to areas where residual soil contamination may impact the beneficial use of groundwater in the future.	Ra/Sr DSS 3 DSS 4 DW A–E SWT	Applicable
The Safe Drinking Water and Toxic Enforcement Act (California Health & Safety Code 25249.5–25249.13) Title 22 CCR, Sections 64431–64445	Title 22 CCR Sections 64431–64445 provides primary MCLs that must be met by all public drinking water systems to which they apply. MCLs are to be used as a reference for defining acceptable residual levels of site contaminants with potential to impact groundwater in areas of the site where migration of contaminants from soil to groundwater has occurred or may occur.	Groundwater beneath the LEHR site is identified by the State of California as a potential source of drinking water. Although there is no public water supply system at the LEHR site, contaminants released at the site may impact the beneficial use of underlying groundwater; therefore, this requirement is relevant and appropriate for total chromium for which the California MCL is more stringent than the federal MCL in areas where total chromium soil contamination may impact groundwater quality.	Ra/Sr DSS 3 DSS 4 DW A–E SWT	Relevant and Appropriate
Title 27 CCR, Division 2, Subdivision 1, Section 20080 *et seq.* and Title 23 CCR, Division 3, Chapter 15, Section 2510 *et seq.*	Establishes waste and siting classification systems and minimum waste management standards for discharges of waste to land for treatment, storage, or disposal. Engineered alternatives that are consistent with Title 27 and Title 23 CCR performance goals may be considered. Establishes corrective action requirements for responding to leaks and other unauthorized discharges. Applies to all discharges of waste to land for treatment, storage, or disposal that may affect water quality.	Applies to waste generated during well installation, groundwater monitoring, future development, or maintenance activities involving contaminated soil, groundwater, or other material.	Ra/Sr DSS 3 DSS 4 DW A–E SWT	Applicable
Title 23 CCR, Sections 2520 and 2521	Requires that hazardous waste be discharged to Class I waste management units that meet certain design and monitoring standards. Applies to discharges of hazardous waste to land for treatment, storage, and disposal.	Applies to waste generated during well installation, groundwater monitoring, future development, or maintenance activities involving contaminated soil, groundwater, or other material.	Ra/Sr DSS 3 DSS 4 DW A–E SWT EDP	Applicable
Title 27 CCR, Sections 20200 (c) and 20210	Requires that designated waste be discharged to Class I or Class II waste management units. Applies to discharges of designated waste (non-hazardous waste that could cause degradation of surface or groundwater) to land for treatment, storage, or disposal.	Applies to waste generated during well installation, groundwater monitoring, future development, or maintenance activities involving contaminated soil, groundwater, or other material.	Ra/Sr DSS 3 DSS 4 DW A–E SWT EDP	Applicable
Title 27 CCR, Section 20230	Requires that inert waste does not need to be discharged at classified units. Applies to discharges of inert waste to land for treatment, storage, or disposal.	Applies to waste generated during well installation, groundwater monitoring, future development, or maintenance activities involving contaminated soil, groundwater, or other material.	Ra/Sr DSS 3 DSS 4 DW A–E SWT	Applicable
Title 27 CCR, Sections 20200 (c) and 20220	Requires that non-hazardous solid waste be discharged to a classified waste management unit. Applies to discharges of non-hazardous solid waste to land for treatment, storage, or disposal.	Applies to waste generated during well installation, groundwater monitoring, future development, or maintenance activities involving contaminated soil, groundwater, or other material.	Ra/Sr DSS 3 DSS 4 DW A–E SWT EDP	Applicable
Title 27 CCR, Section 20080 (g) and Title 23 CCR, Section 2510 (g)	Requires monitoring of land where discharges had ceased as of November 27, 1984. If water quality is threatened, corrective action consistent with Title 27 and Title 23 is required.	Applies to all areas at the site where residual soil contamination may impact water quality.	Ra/Sr DSS 3 DSS 4 DW A–E SWT	Applicable

Table A−1 (continued). Chemical-Specific Requirements for the Selected Remedy for the DOE Areas for the LEHR Federal Facility

Requirement/Authority	Description	Applicability	Area	ARAR Category
Title 27 CCR, Section 20385 and Title 23 CCR, Section 2550.1	Requires detection monitoring for all areas where waste has been discharged to land in order to determine the threat to water quality. Once a significant release has occurred, evaluation or corrective action monitoring is required.	Applies to all areas at the site where residual soil contamination may impact water quality.	Ra/Sr DSS 3 DSS 4 DW A–E SWT	Applicable
Title 27 CCR, Section 20390 and Title 23 CCR Section 2550.2	Requires establishment of a water quality protection standard consisting of a list of constituents of concern, concentration limits, compliance monitoring, and all monitoring points. Applies to all areas where waste has been discharged to land where groundwater is threatened.	Applies to all areas at the site where residual soil contamination may impact water quality.	Ra/Sr DSS 3 DSS 4 DW A–E SWT	Applicable
Title 27 CCR, Section 20395 and Title 23 CCR, Section 2550.3	Requires development of a list of constituents of concern, which includes all waste constituents that are reasonably expected to be present in the soil from discharges to land, and could adversely affect water quality. Applies to all areas where waste has been discharged to land where groundwater is threatened.	Applies to all areas at the site where residual soil contamination may impact water quality.	Ra/Sr DSS 3 DSS 4 DW A–E SWT	Applicable
Title 27 CCR, Section 20400 and Title 23 CCR, Section 2550.4	Concentration limits must be established for groundwater, surface water, and the unsaturated zone and must be based on background, must be equal to background, or, for corrective actions, may be greater than background, not to exceed the lower of the applicable water quality objective or the concentration technologically or economically achievable. Specific factors must be considered in setting cleanup standards above background levels. If water quality is threatened, this section applies to setting soil cleanup levels for the total cleanup of discharges of waste to land.	Applies to all areas at the site where residual soil contamination may impact water quality.	Ra/Sr DSS 3 DSS 4 DW A–E SWT	Applicable
Title 27 CCR, Section 20405 and Title 23 CCR, Section 2550.5	Requires identification of the point of compliance, hydraulically downgradient from the area where waste was discharged to land. Applies to all areas where waste has been discharged to land where groundwater is threatened.	Applies to all areas at the site where residual soil contamination may impact water quality.	Ra/Sr DSS 3 DSS 4 DW A–E SWT	Applicable
Title 27 CCR, Section 20410 and Title 23 CCR, Section 2550.6	Requires monitoring of all soil-cleaning activities for compliance with remedial action objectives for three years from the date of achieving cleanup levels.	Applies to all areas at the site where residual soil contamination may impact water quality.	Ra/Sr DSS 3 DSS 4 DW A–E SWT	Applicable
Title 27 CCR, Section 20415 and Title 23 CCR, Section 2550.7	Requires general soil, surface water, and groundwater monitoring for all areas where waste has been discharged to land.	Applies to all areas at the site where residual soil contamination may impact water quality.	Ra/Sr DSS 3 DSS 4 DW A–E SWT	Applicable
Title 27 CCR, Section 20420 and Title 23 CCR, Section 2550.8	Requires detection monitoring to determine if a release has occurred in all areas where waste has been discharged to land where groundwater is threatened.	Applies to all areas at the site where residual soil contamination may impact water quality.	Ra/Sr DSS 3 DSS 4 DW A–E SWT	Applicable
Title 27 CCR, Section 20425 and Title 23 CCR, Section 2550.9	Requires an assessment of the nature and extent of the release, including a determination of the spatial distribution and concentration of each constituent. Applies to sites at which monitoring results show statistically significant evidence of a release.	Applies to all areas at the site where residual soil contamination may impact water quality.	Ra/Sr DSS 3 DSS 4 DW A–E SWT	Applicable
Title 27 CCR, Section 20430 and Title 23 CCR, Section 2550.10	Requires implementation of corrective action measures that ensure that cleanup levels are achieved throughout the zone affected by the release by removing the waste constituent or treating it in place. Source control may be required. Also requires monitoring to determine the effectiveness of the corrective actions. This section applies to all soil cleanup activities if water quality is threatened.	Applies to all areas at the site where residual soil contamination may impact water quality.	Ra/Sr DSS 3 DSS 4 DW A–E SWT	Relevant and Appropriate
Title 22 CCR Division 4.5, Section 66261.21–33	Provides criteria for identifying and handling hazardous waste. Regulations include soluble threshold limit concentration and total threshold limit concentration analytical procedures.	Applies to waste generated during well installation, groundwater monitoring, future development, or maintenance activities involving contaminated soil, groundwater, or other material.	Ra/Sr DSS 3 DSS 4 DW A–E SWT EDP	Applicable

Table A−1 (continued). Chemical-Specific Requirements for the Selected Remedy for the DOE Areas for the LEHR Federal Facility

Requirement/Authority	Description	Applicability	Area	ARAR Category
California Health and Safety Code, Division 20, Chapter 6.5, Section 25100 *et seq.*	Governs hazardous waste control.	Applies to waste generated during well installation, groundwater monitoring, future development, or maintenance activities involving contaminated soil, groundwater, or other material.	Ra/Sr DSS 3 DSS 4 DW A–E SWT EDP	Applicable
Title 22 CCR, Section 66268 *et seq.*	Defines land disposal restrictions establishing specific treatment standards of hazardous wastes prior to disposal to land.	Applies to hazardous waste generated during well installation, groundwater monitoring, future development, or maintenance activities involving contaminated soil, groundwater, or other material.	Ra/Sr DSS 3 DSS 4 DW A–E SWT EDP	Applicable

Notes

[1]Two policies in Chapter IV of the Basin Plan explain how appropriate cleanup levels are determined: “Policy for Application of Water Quality Objectives” explains how the Regional Water Board applies numerical and narrative water quality objectives to ensure the reasonable protection of beneficial uses of water and how the Regional Water Board applies Resolution No. 68-16 to promote the maintenance of existing high-quality waters; “Policy for Investigation and Cleanup of Contaminated Sites” explains how cleanup levels are established for soils and groundwater.

[2]RWQCB disagrees with EPA regarding the characterization of this requirement as relevant and appropriate, but it accepts the ROD notwithstanding. RWQCB considers the requirements to be applicable.

Abbreviations

ARAR	applicable or relevant and appropriate requirement
CCR	*Code of California Regulations*
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980
CFR	*Code of Federal Regulations*
DSS	Domestic Septic System
DW A–E	Dry Wells A–E
EDP	Eastern Dog Pens
LEHR	Laboratory for Energy-Related Health Research
MCL	maximum contaminant level
OSWER	Office of Solid Waste and Emergency Response
pCi/g	picocuries per gram
Ra/Sr	Radium/Strontium Treatment System
RWQCB	Regional Water Quality Control Board
SWRCB	State Water Resources Control Board
SWT	Southwest Trenches
UMTRCA	Uranium Mill Tailings Radiation Control Act
USC	*United States Code*

Table A−2. Location-Specific Requirements for the Selected Remedy for the DOE Areas for the LEHR Federal Facility

Requirement/Authority	Comments	Applicability	Area	ARAR Category
Federal				
Endangered Species Act of 1973 (16 USC § 1536; §1538, 50 CFR 402)	Facilities or practices shall not cause or contribute to the taking of any endangered or threatened species of plants, fish, or wildlife [16 USC §1538 (a) (1)]. Activities must be evaluated to determine their impact on listed species and species proposed for listing and their habitat [16 USC §1536(a)]. If jeopardy or adverse modification will result from any site activities, a determination will be made based on a consultation with the USFWS regarding the need for mitigation measures or an incidental take statement (50 CFR § 402.14). Specific mitigation measures will be identified and implemented per USFWS guidelines.	Applies to all field remediation activities, such as well installation and monitoring or maintenance activities that may impact listed species. No impacts of any endangered or threatened species of plants, fish, or wildlife are associated with residual contamination.	Ra/Sr DSS 3 DSS 4 DW A–E SWT	Applicable
Fish and Wildlife Coordination Act (16 USC 661–666)	Requires action to preserve endangered species or threatened species. Before any ground-disturbing activities are conducted in areas with potential for presence of such species, surveys will be conducted for species of concern.	Applies to all field remediation activities, such as well installation and monitoring or maintenance activities that may impact listed species.	Ra/Sr DSS 3 DSS 4 DW A–E SWT	Applicable
State and Local				
California Endangered Species Act (California Fish and Game Code § 2050–2068 and 2080)	Requires action to preserve endangered species or threatened species. Before any ground-disturbing activities are conducted in areas with potential for presence of such species, surveys will be conducted for species of concern.	Applies to all field remediation activities, such as well installation and monitoring or maintenance activities that may impact listed species. No impacts of any endangered or threatened species of plants, fish, or wildlife are associated with residual contamination.	Ra/Sr DSS 3 DSS 4 DW A–E SWT	Applicable

Abbreviations

ARAR	Applicable or Relevant and Appropriate Requirements
CFR	*Code of Federal Regulations*
DOE	Department of Energy
DSS	Domestic Septic System
DW A–E	Dry Wells A–E
Ra/Sr	Radium/Strontium Treatment System
SWT	Southwest Trenches
USC	United States Code
USFWS	U.S. Fish and Wildlife Service

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Table A−3. Action-Specific Requirements for the Selected Remedy for the DOE Areas for the LEHR Federal Facility

Requirement/Authority	Description	Applicability	Area	ARAR Category
Federal				
Clean Water Act § 404 (33 USC 1344, 33 CFR 328 and 40 CFR 230)	Establishes a national program to control the discharge of dredge or fill materials into "waters of the United States." "Waters of the United States" is defined to include all tributaries of navigable waters and nearly all wetlands.	These requirements apply if site remediation activities (well installation and monitoring) cause turbid water to enter drainages or if site activities impact wetlands adjacent to Putah Creek.	Ra/Sr DSS 3 DSS 4 DW A–E SWT	Applicable
Pretreatment Standards under the Clean Water Act (40 CFR Part 403)	Discharges of treated waste to sanitary sewers may be proposed and would be regulated under the pretreatment program of the UC Davis POTW. RWQCB is involved in oversight of the pretreatment program.	Applies to all areas where discharges to sanitary sewer may occur as part of the monitoring activities.	Ra/Sr DSS 3 DSS 4 DW A–E SWT	Applicable
Transportation of Hazardous Material, 49 USC 5101-5127; and 49 CFR 172.3 and 172.200–700 *et seq.*	49 USC 5101-5127, and 49 CFR 172.3 and 172.200-700 et seq. regulate transportation, including security, of hazardous material in intrastate, interstate, and foreign commerce to ensure the safe transportation of such material.	Applies to any hazardous materials and wastes generated during well installation, well monitoring, or the future development and maintenance activities transported off site.	Ra/Sr DSS 3 DSS 4 DW A–E SWT	Applicable
10 CFR 835 Occupational Radiation Protection	Provides for the protection of radiation workers at DOE facilities. Includes dose limits and requirements to reduce the dose to levels that are ALARA.	Applies to areas where residual radioactive contamination may be excavated.	Ra/Sr DW A–E SWT	Applicable
Noise Control Act of 1972, as amended by the Quiet Communities Act of 1978 (40 CFR 204, 205, 211)	Construction and transportation equipment noise levels (e.g. portable air compressors, medium and heavy trucks), process equipment noise levels, and noise levels at the property boundaries of the project are regulated under this act. State or local agencies typically enforce these levels.	Applies to all areas where noise may occur during the installation of monitoring wells and groundwater sampling.	Ra/Sr DSS 3 DSS 4 DW A–E SWT	Applicable
Licensing Requirements for Land Disposal of Radioactive Waste (10 CFR 61)	Establishes substantive requirements for radiation protection, access restrictions, future impacts, siting, drainage, final cover, buffer zones, groundwater monitoring, and waste disposal requirements.	Substantive requirements apply to all areas where radionuclides may remain at levels above natural background.	Ra/Sr DW A–E SWT EDP	Relevant and Appropriate
State and Local				
State Water Resources Control Board Resolution No. 92-49 (as amended April 21, 1994)	Establishes requirements for investigation, cleanup, and abatement of discharges. Among other requirements, dischargers must clean up and abate the effects of discharges in a manner that promotes the attainment of either background water quality or the best water quality that is reasonable if background water quality cannot be restored. Requires the application of Title 23, CCR, Section 2550.4 requirements for cleanups.	Applies to all areas at the site where residual soil contamination may impact water quality.	Ra/Sr DSS 3 DSS 4 DW A–E SWT	Relevant and Appropriate[1]
Yolo-Solano Air Quality Management District Rules and Regulations, Rule 2.3, Ringlemann Chart	Establishes a permissible limit on visible dust emissions (Ringlemann Chart).	Applies to all areas where dust emissions may be generated during well installation, monitoring, future development, or maintenance activities.	Ra/Sr DSS 3 DSS 4 DW A–E SWT	Applicable
Prohibited Acts (Health and Safety Code § 41700)	Prevents discharge of pollutants into the air that will cause injury, detriment, nuisance, or annoyance to any considerable number of persons or the public.	Applies to all areas where dust emissions may be generated during well installation, monitoring, future development, or maintenance activities.	Ra/Sr DSS 3 DSS 4 DW A–E SWT	Applicable
Control of Radioactive Contamination in the Environment (California Health and Safety Code, § 114705, *et seq.*)	Establishes state surveillance and control programs for activities that could lead to the introduction of radioactive materials into the environment. This statute specifically exempts DOE facilities from state surveillance of the storage, packaging, transportation, and loading of radioactive materials, however, LEHR is not a DOE facility. Only the code's substantive requirements apply to LEHR.	Substantive requirements apply to well installation, monitoring, future development, or maintenance activities if radioactive materials are present at levels that could result in a significant release to the environment. If these conditions are encountered, state substantive controls may be required to ensure that there are no significant releases of radioactive materials to the environment.	Ra/Sr DSS 3 DSS 4 DW A–E SWT	Applicable
Radiation Control Law (California Health and Safety Code, § 114960, *et seq.*)	Institutes and maintains a regulatory program for sources of ionizing radiation to provide for compatibility with standards and regulatory programs of the federal government and an integrated system within the state. The substantive requirements would be apply to remedial activities at LEHR unless the activity is governed by DOE statutory authority.	The substantive requirements are relevant to all actions that would leave radionuclides in place at levels above natural background and to actions such as well installation, monitoring, future development, or maintenance activities, where low-level radioactive waste may be removed and disposed off-site. Under Section 114985 of the California Health and Safety Code, the Radiation Control Law applies to persons, defined to exclude DOE or any successor thereto, and federal government agencies licensed by the U.S. Nuclear Regulatory Commission, under prime contract to DOE, or any successor thereto. Hence, the portions of the Radiation Control Law (California Health and Safety Code, § 114960, *et seq.*) addressing the management of low-level radioactive waste within California would be considered as relevant and appropriate for management and/or off-site disposal of low-level radioactive waste.	Ra/Sr DSS 3 DSS 4 DW A–E SWT EDP	Relevant and Appropriate

Table A−3 (continued). Action-Specific Requirements for the Selected Remedy for the DOE Areas for the LEHR Federal Facility

Requirement/Authority	Description	Applicability	Area	ARAR Category
State Department of Health Service Radiation Regulations (17 CCR, Chapter 5, Subchapter 4 § 30100, *et seq.*)	Presents regulations of the Department of Health Services pertaining to radiation, such as standards for protection against radiation, low-level radioactive waste disposal, and transportation regulations. The substantive requirements would be applicable unless activity is governed by DOE statutory authority or regulation.	The substantive requirements are relevant to all areas where radionuclides may remain at levels above natural background. They are also relevant to all areas where waste containing radionuclides above natural background may be generated during well installation, monitoring, future development, or maintenance activities.	Ra/Sr DSS 3 DSS 4 DW A–E SWT EDP	Relevant and Appropriate
Executive Order D-62-02 by the Governor of the State of California	Restricts the disposal of decommissioned waste in Class III landfills and unclassified waste management units, as described in 27 CCR, Sections 20260 and 20230.	Applies to all areas where waste containing radionuclides above background may be generated during well installation, monitoring, future development, or maintenance activities.	Ra/Sr DSS 3 DSS 4 DW A–E SWT EDP	To Be Considered
The Toxic Injection Well Control Act of 1985, California Health and Safety Code 25159.10	The Toxic Injection Well Control Act of 1985 prohibits underground injection of hazardous waste. Hazardous waste is defined as any waste specified as hazardous waste or extremely hazardous waste, as defined in Chapter 6.5, "Hazardous Waste Control," of the California Health and Safety Code, and any waste mixture formed by mixing any waste or substance with a hazardous waste.	Applies where hazardous waste may be generated during well installation, monitoring, future development, or maintenance activities.	Ra/Sr DSS 3 DSS 4 DW A–E SWT EDP	Applicable
Title 22 CCR, 66262 *et seq.*	Presents standards applicable to generators of hazardous waste, including waste characterization, manifest, and transportation requirements.	Applies where hazardous waste may be generated during well installation, monitoring, future development, or maintenance activities.	Ra/Sr DSS 3 DSS 4 DW A–E SWT EDP	Applicable
California Civil Code section 1471, and Health and Safety Code section 25222.1	Require that land-use covenants, restrictions, and conditions subject to which a property and relevant portions shall be improved, held, used, occupied, leased, sold, hypothecated, encumbered, and/or conveyed. Runs with the land and Civil Code section 1471.	Applies to any areas where residual contamination requires the restriction of land use.	Ra/Sr DSS 3 DSS 4 DW A–E SWT EDP	Relevant and Appropriate
Title 22 CCR, Division 4.5, Chapter 39, Section 67391.1(a)(1) and (2), (d)	Provides requirements for land-use covenants.	Applies to all areas where residual contamination requires additional controls based on land use.	Ra/Sr DSS 3 DSS 4 DW A–E SWT EDP	Relevant and Appropriate
Title 27, CCR, Section 20090(d) and Title 23 CCR, Section 2511(d)	Requires that remedial actions intended to contain wastes at the place of release shall implement applicable provisions of Title 27 Division 2 and Title 23 Chapter 15, to the extent feasible.	Applies to all areas where residual contamination requires remediation or monitoring.	Ra/Sr DSS 3 DSS 4 DW A–E SWT	Applicable
Title 27, CCR, Sections 20950(a)(1) and (a)(2)(A)2	Groundwater monitoring shall continue until such time as the wastes in the soil no longer constitute a potential threat to water quality.	Groundwater beneath and downgradient of each closed unit shall be monitored until DOE demonstrates and the regulatory agencies concur that the waste in that unit no longer poses a threat to groundwater quality. DOE can evaluate if the wastes no longer threaten water quality in its first five-year review.	Ra/Sr DSS 3 DSS 4 DW A–E SWT	Applicable

Notes

[1]RWQCB disagrees with EPA regarding the characterization of this requirement as relevant and appropriate, but it accepts the ROD notwithstanding. RWQCB considers the requirements to be applicable.

The California Environmental Quality Act was listed as an ARAR in the Feasibility Study, but it has been determined as functionally addressed by the CERCLA process, and therefore, it is not required to be listed as a separate ARAR.

Abbreviations

ALARA	as-low-as-reasonably-achievable
ARAR	Applicable or Relevant and Appropriate Requirement
CCR	California Code of Regulations
CFR	*Code of Federal Regulations*
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980
CEQA	California Environmental Quality Act
DOE	U.S. Department of Energy
DSS	Domestic Septic System
DW A–E	Dry Wells A–E
EDPs	Eastern Dog Pens
LEHR	Laboratory for Energy-Related Health Research
mrem/yr	millirem per year
No.	number
NRC	Nuclear Regulatory Commission
PL	Public Law
POTW	publicly owned treatment works
Ra/Sr	Radium/Strontium
SWT	Southwest Trenches
UC Davis	University of California, Davis
USC	*United States Code*