# U.S. Department of Energy

Oakland Operations Office, Oakland, California

# DRAFT FINAL ENGINEERING EVALUATION/COST ANALYSIS (EE/CA) FOR THE SOUTHWEST TRENCHES, RADIUM-226/STRONTIUM-90 (Ra/Sr) TREATMENT SYSTEMS, AND DOMESTIC SEPTIC SYSTEM AREAS

for the

## DOE AREAS AT THE LABORATORY FOR ENERGY-RELATED HEALTH RESEARCH (LEHR) SITE UNIVERSITY OF CALIFORNIA AT DAVIS, CALIFORNIA

*Prepared for:*

**United States Department of Energy**
Oakland Operations Office
1301 Clay Street
Oakland, California 95612-5208

*Prepared by:*

**Weiss Associates**
5500 Shellmound Street
Emeryville, CA 94608-2411

January 20, 1998
Rev. E

Weiss Associates
*Environmental and Geologic Services*

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Approvals Page

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January 20, 1998
Rev. E

Approved by: Mary Stallard Date: 1-20-98
Mary Stallard, R.G.
Quality Assurance Project Manager
Weiss Associates

Approved by: Robert O. Devany Date: 1-20-98
Robert O. Devany, R.G., C.H.G.
Project Manager
Weiss Associates

Approved by: Michael D. Dresen Date: 1-20-98
Michael D. Dresen, R.G., C.H.G.
Program Manager
Weiss Associates

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# ACRONYMS AND ABBREVIATIONS

| | |
|---|---|
| µCi/ml | microcuries per milliliter |
| µg/L | micrograms per liter |
| µR | microRoentgens |
| °F | degrees Fahrenheit |
| Ac-228 | Actinium-228 |
| AEC | Atomic Energy Commission (now the Department of Energy) |
| AH-1 and AH-2 | Animal Hospital Numbers 1 and 2 |
| ALARA | as low as reasonably achievable |
| Am-241 | Americium-241 |
| ARAR | applicable or relevant and appropriate requirement |
| AWQC | ambient water quality criteria |
| bgs | below ground surface |
| Bi-214 | Bismuth-214 |
| C-14 | Carbon-14 |
| CalEPA | California Environmental Protection Agency |
| CCR | California Code of Regulations |
| CEQA | California Environmental Quality Act |
| CERCLA | Comprehensive Environmental Response, Compensation and Liability Act of 1980 |
| CFR | Code of Federal Regulations |
| cfs | cubic feet per second |
| cm/sec | centimeters per second |
| Co-60 | Cobalt-60 |
| COCs | constituents of concern |
| CPM | counts per minute |
| Cs-137 | Cesium-137 |
| CVRWQCB | Central Valley Regional Water Quality Control Board |

| | |
|---|---|
| cy | cubic yards |
| DCG | Derived Concentration Guide |
| D&D | decontamination and decommissioning |
| DDD | Dichlorodiphenyldichloroethane |
| DDE | 4, 4-dechlorodiphenyldichloroethylene |
| DDT | Dichlorodiphenyltricholoroethane |
| DHS | California Department of Health Services |
| DOE | U.S. Department of Energy |
| DPM | disintegrations per minute |
| DTSC | Department of Toxic Substances Control |
| EE/CA | Engineering Evaluation/Cost Analysis |
| EPA | U.S. Environmental Protection Agency |
| FFA | Federal Facilities Agreement |
| FS | Feasibility Study |
| g/cc | grams per cubic centimeter |
| GM | Geiger-Muller |
| GPR | ground-penetrating radar |
| HI | Hazard Index |
| HSUs | hydrostratigraphic units |
| IC | indicator constituents |
| IDW | investigation derived wastes |
| ITEH | Institute of Toxicology and Environmental Health |
| K-40 | Potassium-40 |
| LAS | LAS Analytical Laboratory |
| LEHR | Laboratory for Energy-Related Health Research |
| LFI | Limited field investigation |
| MCL | Maximum contaminant level |
| mg/kg | milligrams per kilogram |
| MOA | Memorandum of Agreement |
| msl | mean sea level |
| NaI | sodium iodide |

| | |
|---|---|
| NCP | National Oil and Hazardous Substances Pollution Contingency Plan |
| ND | non-detect |
| NEPA | National Environmental Policy Act |
| NPL | National Priorities List |
| NRC | Nuclear Regulatory Commission |
| NUFT | Non-isothermal, Unsaturated Flow and Transport Model Numerical Computer Code |
| OUs | operable units |
| PAHs | polynuclear aromatic hydrocarbons |
| Pb-212 | Lead-212 |
| PCBs | polychlorinated biphenyls |
| pCi/g | picocuries per gram |
| PID | photoionization detector |
| PL | Public Law |
| PNNL | Pacific Northwest National Laboratory |
| PRGs | preliminary remediation goals |
| Pu-241 | Plutonium-241 |
| PVC | Polyvinylchloride |
| RA | Removal Action |
| Ra-226 | Radium-226 |
| RAGS | Risk Assessment Guidance for Superfund |
| RAO | removal action objective |
| RBAS | risk-based action standard |
| RCRA | Resource Conservation and Recovery Act |
| RESRAD | Residual Radioactive Material Guideline Computer Program |
| RI/FS | Remedial Investigation/Feasibility Study |
| SARA | Superfund Amendments and Reauthorization Act of 1986 |
| SCDS | South Campus Disposal Sites |
| sq ft | square feet |
| Sr-90 | Strontium-90 |
| STLC | soluble threshold limit concentration |

| | |
|---|---|
| SVOCs | semivolatile organic compounds |
| SW | southwest |
| TBC | to be considered ARAR requirements |
| TC | toxicity characteristic |
| TCLP | toxicity characteristic leaching procedure |
| Th-233 | Thorium-232 |
| Ti-208 | Thallium-208 |
| TPHRL | Toxic Pollutant Health Research Laboratory |
| U-235 | Uranium-235 |
| UC | University of California |
| USC | United States Code |
| UTL | upper threshold limit of background |
| VOCs | volatile organic compounds |
| Yr | year |

# SELECTED DEFINITIONS

| | |
|---|---|
| As-low-as-reasonably-achievable, (ALARA): | The approach to radiation protection to manage, control, and minimize exposures (both individual and collective) to the work force and the general public from radiation and releases of radioactive material to the environment, taking into account social, technical, economic, practical, and public policy considerations. ALARA is not a dose limit, but rather a process that has as its objective the attainment of dose levels as low as practical. |
| Constituents of Concern (COC): | A Constituent of Concern is any chemical, metal, or radionuclide that has been, or may be, identified at the Site at a concentration that may pose an unacceptable risk of exposure. |
| Concentration/Risk quotient, (C/RQ): | A quotient obtained by dividing a sample analytical result by its respective RBAS at a specified risk level (i.e. - a C/RQ below 1 indicates that the measured concentration was below the specified RBAS while a C/RQ of 10 indicates that the measured concentration is ten times greater than its respective RBAS). The denominator was not set below background for this computation. |
| Department of Energy (DOE) Area: | An area of site contamination whose environmental restoration is the responsibility of the DOE in accordance with the Memorandum of Agreement (MOA) between UC Davis and DOE. |
| Domestic Septic Systems: | Seven individual and non-contiguous Domestic Septic Systems consisting of a septic tank, associated leach field and interconnected piping located at the LEHR facility. The tanks and associated systems have been abandoned in-place and site facilities have been connected directly to the UC Davis sanitary sewer system. |
| Domestic Septic Systems Areas: | Areas consisting of the Domestic Septic Systems described above, and including associated tanks, leach field, and soil if impacted by COCs. |

| | |
|---|---|
| Engineering Evaluation / Cost Analysis, (EECA): | An analysis of removal actions required by the National Contingency Plan (NCP) prior to implementing a removal action. |
| Imhoff Tanks: | A series of nine sedimentation tanks used as part of the former Strontium Treatment System. |
| Memorandum of Agreement (MOA): | The legal document between DOE and UC Davis, which apportions responsibility for environmental restoration of various contaminated areas on the Site. |
| Non-Time Critical Removal Action: | A designation used by the EPA for removal actions that can commence later than six months after discovery of a release of contaminants. |
| Operable Unit (OU): | A designation for Site areas whose contamination is logically related through site use, contaminant type, extent of contamination, or responsible party. Formal Site OU designations will be developed when the Federal Facilities Agreement (FFA) is approved for this Site. |
| Radium-226 and Strontium-90 (Ra/Sr) Treatment Systems: | The former Radium Treatment System used at LEHR consisting of two septic tanks, with each tank having two compartments separated by a weir, an effluent distribution box feeding three drywells, a leach trench, and associated distribution pipelines. The former Strontium Treatment System consisted of filters and cation exchange drums, a series of nine "Imhoff " tanks, and a leach field. |
| Ra/Sr Treatment Systems Area: | The structures described in the Ra/Sr Treatment Systems aforementioned description, as well as surface soil along the Old Davis road and radium leach field, and near associated piping. |
| Removal Action Objective (RAO): | The environmental restoration goals of the proposed removal actions. |
| Removal Action (RA): | A cleanup or removal of hazardous substances from the environment, including the disposal of removed material. These actions include actions to prevent, minimize, or mitigate damage to public health and welfare or to the environment. |

| | |
|---|---|
| Risk-Based Action Standard (RBAS): | The RBAS is a calculated allowable surface soil concentration or activity for a specific soil constituent, which would allow a lifetime exposure to an individual at the specified risk level. This standard does not address the cumulative effects of multiple site constituents. The allowable surface soil concentration or activity will not be set below background. |
| Risk Level A: | A nominal *cumulative* excess cancer risk equal to $10^{-4}$ and *cumulative* COC hazard index less than 1. Soil RBASs for *individual* COCs at a risk level of $10^{-4}$ are used as target levels to guide removal activities. |
| Risk Level B: | A nominal *cumulative* excess cancer risk in the range of $10^{-4}$ to $10^{-5}$ and *cumulative* COC hazard index less than 1. Soil RBASs for *individual* COCs at a risk level of $10^{-5}$ are used to guide removal activities. |
| Risk Level C: | The nominal *cumulative* excess cancer risk in the range of $10^{-4}$ to $10^{-5}$ and *cumulative* COC hazard index less than 1. Further reduction in nominal *cumulative* excess cancer risk over Risk Level B is not technically achievable due to analytical limitations regarding accurate measurement of very low radium-226 activities. However, Risk Level C is more protective of human health than Risk Level B because $10^{-6}$ RBASs for *individual* COC are used to guide removal activities. |
| Site: | Refers to the former location of the Laboratory for Energy-related Health Research (LEHR) along Old Davis Road at the University of California, Davis. |
| Southwest Trenches: | An area located in the south western portion of the Site where low-level radioactive waste and miscellaneous laboratory waste were placed in a network of subsurface disposal trenches and burial pits. |
| Southwest Trenches Area: | The disposal areas described above for the Southwest Trenches. |

# EXECUTIVE SUMMARY

This Engineering Evaluation/Cost Analysis (EE/CA) is prepared to fulfill the requirements of Section 300.415 (b)(4)(I) of the National Contingency Plan (NCP) for the proposed non-time-critical removal actions (RA) at the former Laboratory for Energy-Related Health Research (LEHR) located at the University of California (UC) Davis, (Site).

The primary objective of this EE/CA is to determine the most suitable RAs for three Department of Energy (DOE) areas located within the Site known as: the Southwest Trenches, the Radium-226 and Strontium-90 (Ra/Sr) Treatment Systems, and the Domestic Septic Systems. A removal action for the Former Dog Pens Area (Eastern and Western) is not developed in this EE/CA because additional site characterization data are needed to properly develop RA alternatives. The DOE Disposal Box was previously addressed as a time-critical RA in 1996.

This document establishes removal action objectives (RAOs) for these DOE areas as:

- Lower the cumulative excess incremental cancer risk to an individual from exposure to site contaminants to within a nominal range of $10^{-4}$ to $10^{-6}$ using $10^{-6}$ as the point of departure;
- Reduce non-cancer hazard indices to levels below 1;
- Mitigate potential future impact to ground water;
- Mitigate potential ecological risks during and after the RA; and,
- Minimize impact to on-site University research.

Based on these RAOs and a review of site characterization data, vadose zone modeling, and risk assessment, the RAs presented in this EE/CA will focus on:

- The location of buried solid waste material containing various radionuclides and chemical residues placed in trenches throughout the area, the concentration of Ra-226 in subsurface soil; and, the concentration of pesticides in surface soil in the southwest (SW) Trenches Area;
- Ra-226 soil concentrations associated with the radium treatment system; associated radium treatment system structures, including the radium distribution box, radium drywells, and associated piping; and structures associated with the Imhoff Tanks and associated leach field distribution system in the Ra/Sr Treatment Systems Area; and,
- Concentrations of mercury in soil associated with the leach field of Domestic Septic System No. 6, and Ra-226 soil concentrations associated with the leach field of Domestic Septic System No. 3 in the Domestic Septic System Areas.

Of particular importance in assessing the potential achievement of RAOs is the technical limitation involved in measuring extremely low Ra-226 activity (concentration) in soil. Specifically, analytical measurement error for Ra-226 soil activity is greater than the respective 0.042 and 0.0042 pCi/g risk-based action standards for the $10^{-5}$ and $10^{-6}$ target incremental cancer risks. For this reason it is not technically feasible to differentiate Ra-226 soil concentrations from background concentrations at either of these risk levels.

This EE/CA followed a standard protocol recommended by NCP and Environmental Protection Agency (EPA) guidance to select the most suitable RA for each DOE area. This protocol involved: 1) screening potentially applicable remedial technologies; 2) developing RA alternatives from the retained remedial technologies; 3) evaluating the developed alternatives; and, 4) recommending a preferred RA for each DOE area. Results of this process are summarized below.

The following alternatives were developed for the DOE areas:

- For the Southwest Trenches Area, three alternatives were developed:

  Alternative 1 – No Action
  Alternative 2 – Excavation and Off-Site Disposal
  Alternative 3 – Excavation, Off-Site Disposal, and Institutional Controls

- For the Ra/Sr Treatment Systems Area, three alternatives were developed:

  Alternative 1 – No Action
  Alternative 2 – Excavation and Off-Site Disposal
  Alternative 3 – Excavation, Off-Site Disposal, and Institutional Controls

- For the Domestic Septic Systems Areas, two alternatives were developed:

  Alternative 1 – No Action
  Alternative 2 – Excavation, Off-Site Disposal, and Institutional Controls

The limited available characterization data and technical limitation for Ra-226 measurement create significant uncertainty in the amount of subsurface soil excavation. Excavation alternatives without institutional controls require higher volumes of excavated soil and a greater uncertainty in the extent of excavation. Conversely, alternatives using institutional controls have smaller excavation soil volumes and less uncertainty in the extent of excavation. This is due to the higher residual Ra-226 soil activities (which are easier to measure) that would be allowed when using institutional controls.

Each of the above alternatives was evaluated and compared based on cost, effectiveness and implementability for varying excess cumulative risk levels within NCP guidelines. The most suitable RA and risk level for each of the DOE areas was then selected through a comparison of the developed alternatives.

- For the Southwest Trenches, this comparison found that:

  Alternative 1, No Action, is not effective or implementable;

Alternative 2, Excavation and Off-Site Disposal, is the most expensive alternative and also the most difficult to implement because it results in the greatest level of uncertainty in soil excavation volumes and costs; and,

Alternative 3, Excavation, Off-Site Disposal and Institutional Controls, is less expensive and is easier to implement because it results in considerably less uncertainty in soil volumes and costs in comparison to Alternative 2.

- For the Ra/Sr Treatment Systems, this comparison found that:

  Alternative 1, No Action, is not effective or implementable;

  Alternative 2, Excavation and Off-Site Disposal, is the most expensive alternative and also the most difficult to implement because it results in the greatest level of uncertainty in soil excavation volumes and costs; and,

  Alternative 3, Excavation, Off-Site Disposal, and Institutional Controls, is less expensive and is easier to implement because it results in considerably less uncertainty in soil volumes and costs in comparison to Alternative 2.

- For the Domestic Septic Systems, this comparison found that:

  Alternative 1, No Action, is not effective or implementable;

  Alternative 2, Excavation Off-Site Disposal, and Institutional Controls, is more effective than Alternative 1 and is easily implementable.

The following RAs and accompanying risk levels were selected for the DOE areas:

- For the Southwest Trenches Area the recommended RA alternative is Excavation, Off-Site Disposal, and Institutional Controls: This alternative intends to achieve RAOs through removal of waste, surface and subsurface soils impacted with carcinogenic constituents of concern (COCs) and achieve a cumulative excess cancer risk in the range of $10^{-4}$ to $10^{-5}$. Non-carcinogenic COCs would be removed to levels that would result in a cumulative hazard index (HI) less than 1.

  Buried solid waste material within these trenches would be removed. Removal action would be guided by Ra-226 and pesticide concentrations, allowing an increased Ra-226 activity based on depth and cover thickness. Institutional controls implemented as part of this alternative would involve restrictions on future land disturbance activities and administrative monitoring. This alternative would require off-site disposal of approximately 1,378 cubic yards (cy) of low level radioactive soil and waste material at an appropriate disposal facility. In addition, results of confirmation samples taken from the excavation limits would be appraised. This appraisal would evaluate the achievement of RAOs, as well as demonstrate the effectiveness of the institutional controls. This appraisal would also be included as part of a final construction certification report documenting the completed RAs and be available for public review. Total estimated cost for implementing this alternative is $4,300,000.

- For the Ra/Sr Treatment Systems Area, the recommended RA alternative is Excavation, Off-Site Disposal, and Institutional Controls: This alternative intends to achieve RAOs through removal of surface and subsurface soils impacted with carcinogenic COCs to achieve a cumulative excess cancer risk in the range of $10^{-4}$ to $10^{-5}$. Non-carcinogenic COCs would be removed to levels that would result in a cumulative HI less than 1.

  The removal action would be guided by Ra-226 concentrations, allowing an increasing Ra-226 activity based on depth and cover thickness. Institutional controls implemented as part of this alternative would involve restrictions on future land disturbance activities and administrative monitoring. This alternative would require off-site disposal of approximately 864 cy of soil at an appropriate disposal facility. In addition, results of confirmation samples taken from the excavation limits would be appraised. This appraisal would evaluate achievement of RAOs, as well as demonstrating effectiveness of the institutional controls. This appraisal would also be included as part of a final construction certification report documenting the completed RAs and be available for public review. Total estimated cost for implementing this alternative is $3,200,000.

- For the Domestic Septic System Areas, the recommended alternative is Excavation, Off-Site Disposal and Institutional Controls: This alternative intends to achieve RAOs through removal of surface and subsurface soils impacted with carcinogenic COCs to achieve a cumulative excess cancer risk in the range of $10^{-4}$ to $10^{-6}$. Non-carcinogenic COCs would be removed to levels that would result in a cumulative HI less than 1.

  This RA involves investigative sampling to confirm the need for the RA, followed as necessary by excavating approximately 26 cy of mercury contaminated soil associated with Domestic Septic System No. 6 for off-site disposal at a Class I landfill. Institutional controls would be implemented at Domestic Septic System No. 3 along with confirmation sampling to ensure that no removal action is required and institutional controls are necessary. In addition, results of confirmation samples taken from the excavation limits of Domestic Septic System No. 6 would be appraised. This appraisal will evaluate achievement of RAOs, will be included as part of a final construction certification report documenting the completed RAs, and be available for public review. Total estimated cost for implementing this alternative is $600,000.

Field implementation of these recommended RAs will be performed in accordance with a field optimization decision process described in this EE/CA which allows for additional removal of site contaminants under prescribed conditions. Assuming regulatory and public acceptance and available RA funding, these RAs could commence during May 1998, and would be completed by December 1999.

This EE/CA includes an assessment of the environmental effects of each of the proposed alternatives in accordance with the National Environmental Policy Act (NEPA) guidance. Probable environmental impacts of all alternatives were reviewed and it was found that there would be either

no impacts or minimal impacts to the environment should an RA alternative be selected. The areas where no impacts would likely occur are: water resources; aesthetics and scenic values; biological resources; socioeconomic conditions; historical and cultural resources; and land use. Short-term, minimal impacts would occur, primarily from removal alternatives, in the following areas: air quality; noise impact; occupational and public health considerations; and transportation of low-level radioactive waste. These are identified as short-term and minimal because these impacts would occur during the RA, would be mitigated through existing (in-place) regulations or subject to permit requirements, and/or would adhere (especially in the case of low-level radioactive transportation) to strictly enforced regulations. In the case of dust generation and noise, the impacts would be restricted to the Site and immediate surroundings. Mitigation measures will be implemented to minimize environmental impacts of each RA.

No long-term, significant, or adverse environmental impacts are likely to occur from any of the RA alternatives discussed in the EE/CA, except for the No Action alternative in the Southwest Trenches Area and the Ra/Sr Treatment Systems Area. In both of these areas, the No Action alternative would leave site contaminants in place exceeding the $10^{-4}$ target risk level, thereby potentially resulting in a total cumulative risk exceeding the nominal $1x10^{-4}$ maximum excess cancer risk stipulated by the NCP.

Although the RAs described in this document are not officially a final remedy for DOE areas, it is anticipated and intended that these DOE areas will not require further remedial actions in the future. In addition, the final Record of Decision (ROD) for this Site will determine compliance with future (not as yet established) Applicable or Relevant and Appropriate Requirements (ARARs) and RAOs based on hazards posed by all site areas; including the UC Davis areas and DOE Dog Pens Area not addressed in this EE/CA. The need for potential future remedial actions at the Southwest Trenches, the Ra/Sr Treatment Systems, and the Domestic Septic System Areas will be determined at that time.

# 1. INTRODUCTION, SCOPE AND OBJECTIVES

This Engineering Evaluation/Cost Analysis (EE/CA) was prepared to fulfill the requirements of Section 300.415(b)(4)(I) of the National Contingency Plan (NCP) for the proposed non-time-critical Remedial Actions (RAs) at the former Laboratory for Energy-Related Health Research (LEHR)/South Campus Disposal Site (SCDS) located at the University of California (UC) at Davis, California (Site).

The site location is shown on Figure 1-1. The area designated as "LEHR" includes facilities and disposal areas whose environmental restoration is the responsibility of DOE. The area designated as "SCDS" includes disposal areas whose environmental restoration is the responsibility of UC Davis. Historically, the Site has been divided into six Operable Units (OUs) as described on Table 1-1 and shown on Figure 1-2. The current OU designations are used solely for the purpose of environmental characterization and remediation activities. The Memorandum of Agreement (MOA) allocates site environmental restoration responsibilities between DOE and UC Davis (DOE, 1997). According to the MOA, DOE is responsible for the environmental restoration of the following areas:

- The Southwest Trenches Area;
- The DOE Disposal Box;
- The Ra/Sr Treatment Systems Area;
- The Former Dog Pens Area; and,
- The Domestic Septic Systems Area.

DOE Areas covered by this EE/CA are:

- The Southwest Trenches Area;
- The Ra/Sr Treatment Systems Area; and,
- The Domestic Septic System Areas.

The Former Dog Pens Area (Eastern and Western) is not part of this EE/CA because additional site characterization data are needed to better define the extent of contamination in that area and develop RA alternatives. The DOE Disposal Box was addressed as a time-critical RA in 1996.

## 1.1 Objectives and Scope

The primary objective of this EE/CA is to develop suitable RA alternatives for the environmental restoration of DOE areas in OUs 1, 2, and 4. The DOE areas in these OUs are the Southwest Trenches Area, the Radium-226 and Strontium-90 (Ra/Sr) Treatment Systems Area, and

the Domestic Septic System Areas. Environmental restoration of the other remaining site areas is the responsibility of UC Davis.

Prior site data used as a basis for this EE/CA include the Final Site Characterization Summary Report (WA, 1997a), the Draft Final Determination of Risk-Based Standards (WA, 1997c), and the Draft Final One-Dimensional Vadose Zone Modeling Report (WA, 1997b). Information from these reports was used to evaluate and select RAs presented in this EE/CA in accordance with guidance from the United States Environmental Protection Agency (EPA). The data were used in these evaluations to: 1) assess the nature and extent of impact associated with each source; 2) evaluate potential contaminant migration pathways; 3) assess the actual and potential risks posed by the contaminants to human health and the environment; 4) compare alternatives for each source area based on technical, economic, and environmental considerations; and, 5) select a preferred RA alternative for each DOE area.

## 1.2 Report Organization

The organization and content of this EE/CA is based on the EPA guidance document, "Guidance on Conducting Non-Time-Critical Removal Actions Under CERCLA (EPA, 1993). This EE/CA also addresses the requirements of the National Environmental Policy Act (NEPA) for preparing an Environmental Assessment (EA). The required components of the EA, as outlined in DOE guidance "Recommendations for the Preparation of Environmental Assessments and Environmental Impact Statements" (DOE, 1993) are presented in Section 7 of this report. The NEPA component is an additional component to this EE/CA in compliance with DOE Order 451.1A.

The goals of this EE/CA are to:

- Establish Removal Action Objectives (RAOs) defining the environmental restoration goals for the proposed RAs;
- Develop, evaluate and compare alternatives capable of meeting these RAOs;
- Evaluate the potential environmental effects of conducting the proposed RA; and,
- Select a preferred RA for each DOE area.

This report consists of nine sections, including this Introduction (Section 1.). Section 2 provides a brief site history and description of the environmental setting. Section 3 presents a synopsis of the source, nature and extent of contamination, including a description of previous site investigations. Section 4 identifies RA objectives including legal requirements and risk-based action standards. Section 5 develops RA alternatives and evaluates each alternative based on cost, effectiveness, and implementability. Section 6 compares RA alternatives developed in Section 5. Section 7 provides a description of environmental impact considerations for the preferred RAs. Section 8 selects preferred RAs for each of these DOE areas. Section 9 is a list of references cited.

Table 1-1. Summary of Site Operable Units[1]

| Operable Unit (OU) Removal Area[2] | Description | Restoration Responsibility UC Davis | Restoration Responsibility DOE | EE/CA Coverage | Comments |
|---|---|---|---|---|---|
| **OU-1** | | | | | |
| **Southwest Trenches** | **Disposal trenches and chemical dispensing area in the southwest corner of the Site.** | | ✔ | **Yes** | **Part of the former DOE Laboratory for Energy-Related Health Research (LEHR)** |
| DOE Disposal Box | Subsurface disposal area defined by metal matting located between the two sets of dog pens. | | ✔ | No | Time-critical RA has already been completed by DOE. Part of LEHR. |
| Southern Solid Waste Trenches | Trenches located along the south side of the Western Dog Pens. | ✔ | | No | Not addressed due to division of responsibility between DOE and UC Davis. Part of the former UC Davis South Campus Disposal Site (SCDS). |
| Eastern Solid Waste Trenches | Trenches located between Landfill Nos. 1 and 2. | ✔ | | No | Not addressed due to division of responsibility between DOE and UC Davis. Part of SCDS. |
| 49 Waste Holes | Pits located along the south side of the Eastern Dog Pens. | ✔ | | No | Not addressed due to division of responsibility between DOE and UC Davis. Part of SCDS. |
| **OU-2** | | | | | |
| **Radium Treatment System** | **Radium-226 treatment tank and the associated leach field and dry wells.** | | ✔ | **Yes** | **Part of LEHR.** |
| **Strontium Treatment System** | **Strontium-90 treatment tanks and associated leach system.** | | ✔ | **Yes** | **Part of LEHR.** |

Table 1-1. Summary of Site Operable Units[1] (continued).

| **Operable Unit (OU)** Removal Area[2] | Description | Restoration Responsibility UC Davis | Restoration Responsibility DOE | EE/CA Coverage | Comments |
|---|---|---|---|---|---|
| **OU-3** | | | | | |
| Dog Pens Area | Western set of dog pens including the southern portion of the area currently occupied by the Cellular Biology Lab. The Eastern Dog Pens and North Chemical Dispensing Area are also included. | | ✔ | No | Part of the former DOE Laboratory for Energy-Related Health Research. Additional site characterization is being completed. Will be addressed in a separate future EE/CA. |
| **OU-4** | | | | | |
| **Domestic Septic Systems** | **Abandoned domestic septic systems at LEHR.** | | ✔ | **Yes** | **Part of LEHR.** |
| **OU-5** | | | | | |
| Landfill Disposal Units | Three inactive UC Davis landfill units. | ✔ | | No | Not addressed due to division of responsibility between DOE and UC Davis. Part of SCDS. |
| **OU-6** | | | | | |
| Ground Water | Ground water beneath LEHR site. | ✔ | | No | Not addressed due to division of responsibility between DOE and UC Davis. |
| Surface Water | Surface water (includes Putah Creek and storm water runoff). | ✔ | | No | Not addressed due to division of responsibility between DOE and UC Davis. |

Notes:

1 = The Operable Unit (OU) designations shown are consistent with previous documents and reports. However, these classifications are not formal CERCLA OU designations and are likely to change when the Federal Facilities Agreement (FFA) for this site is signed.
2 = Removal Area designations are used throughout the following sections of this EE/CA; OU designations are not used for the reasons stated in note 1 above.

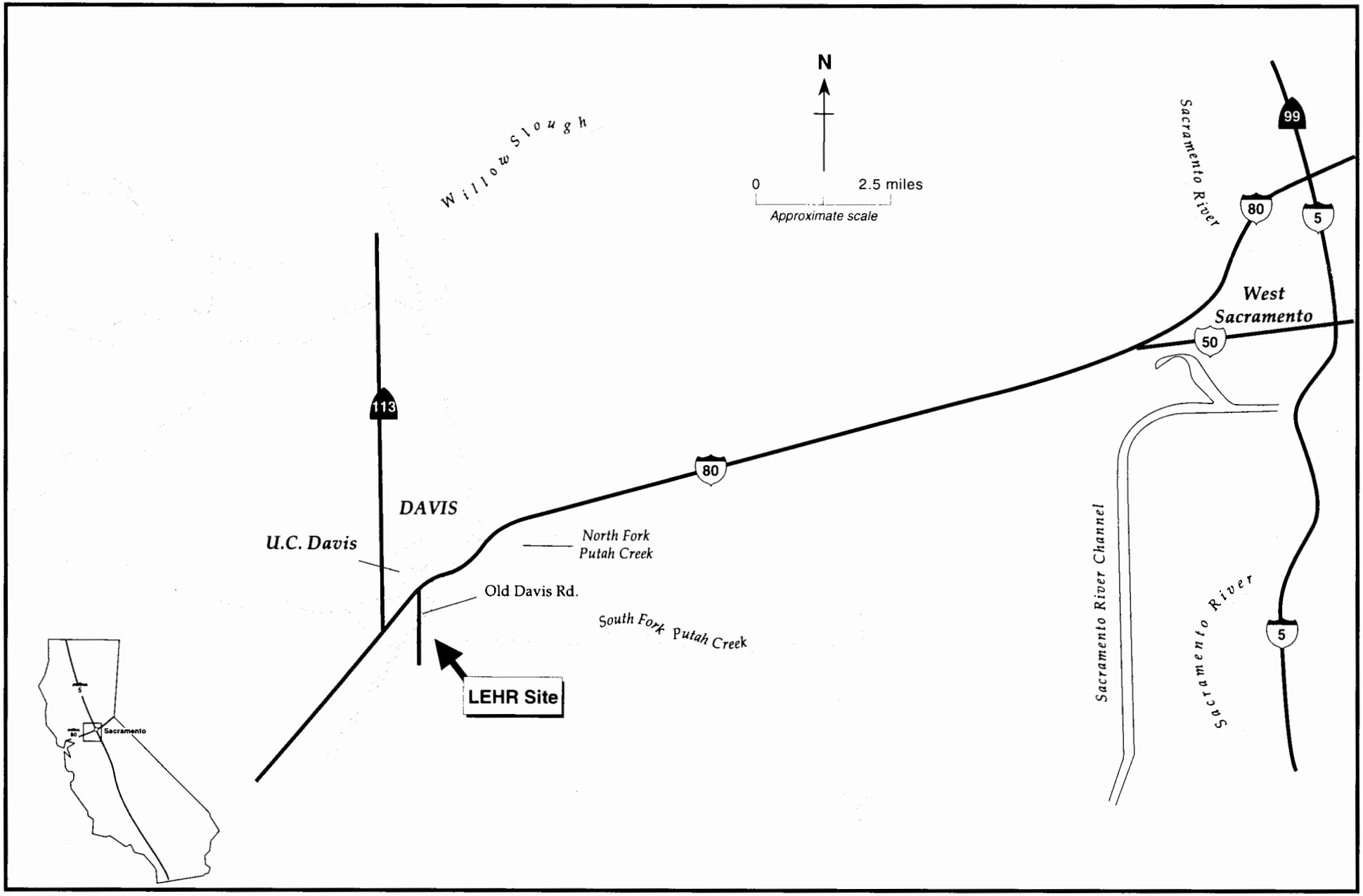


Figure 1-1. LEHR Site Location Map

Weiss Associates

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Figure 1. DOE Cleanup Areas at the LEHR site.

Weiss Associates work at the LEHR site directly benefits LLNL because of our familiarity with the regulatory agency representatives overseeing both sites.

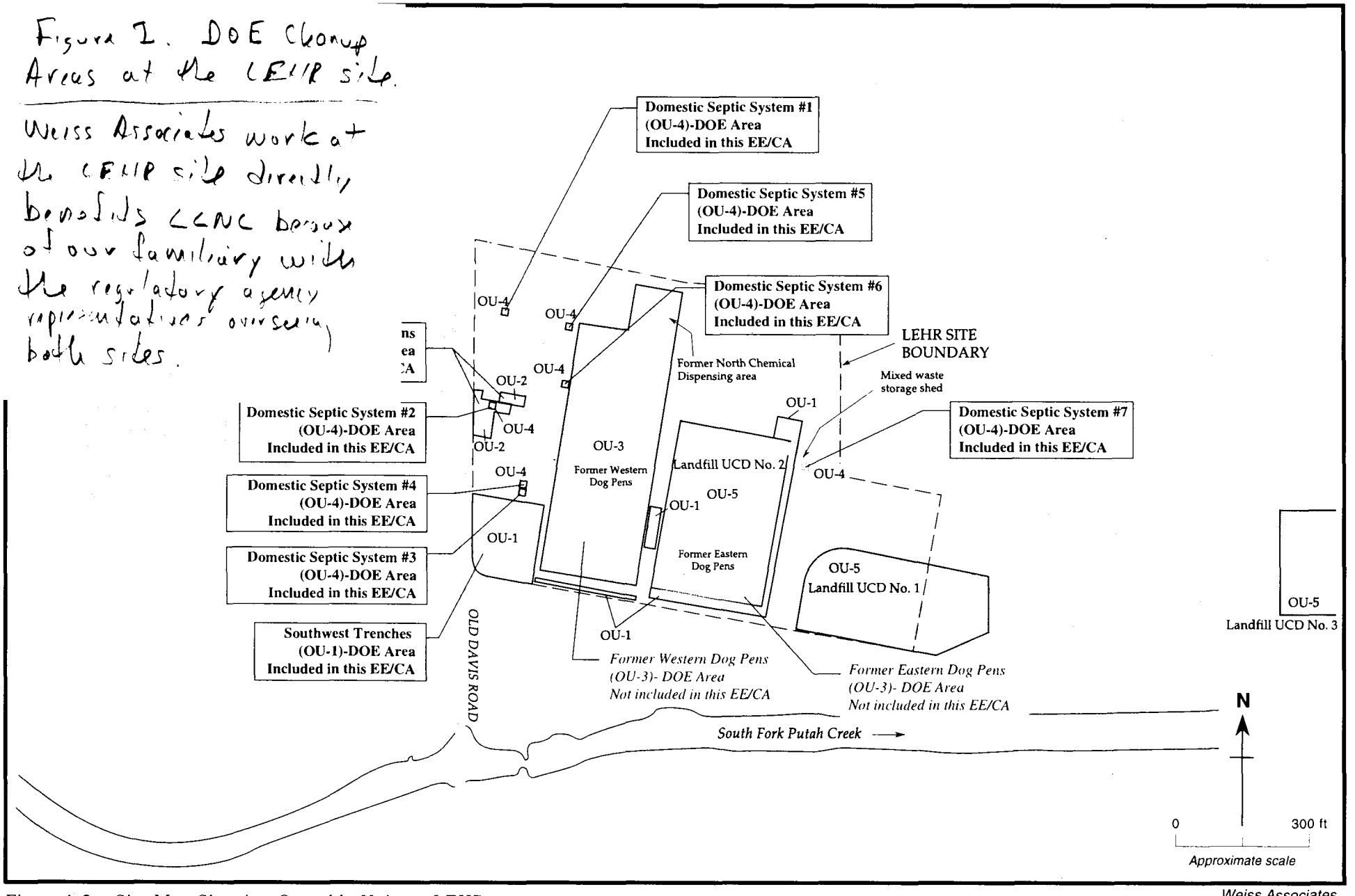



Figure 1-2. Site Map Showing Operable Units at LEHR

Weiss Associates

# 2. BACKGROUND AND ENVIRONMENTAL SETTING

## 2.1 Site Background

### *2.1.1 Location*

The Site is located immediately east of Old Davis Road, just south of Interstate 80 in Solano County California, in the southeast quarter of Section 21, Township 8 North, Range 2 East, Mount Diablo Base and Meridian. It is approximately 1.5 miles south of the town of Davis (Figure 2-1), and occupies the southeast portion of the UC Davis campus.

### *2.1.2 History of Operations*

The Atomic Energy Commission (AEC, now DOE) began conducting radiological studies on laboratory animals, particularly beagles, in the early 1950s. Initial studies were carried out on the main campus and involved the irradiation of beagles. The Site began operating in its present location in 1958 when full-scale experimental use of radioactive materials began. Research at LEHR through the mid-1980s focused on the health effects from chronic exposure to radionuclides, primarily strontium-90 (Sr-90) and radium-226 (Ra-226). In the early 1970s, a cobalt-60 (Co-60) irradiator facility was constructed at the Site to study the effects of chronic exposure to gamma rays on bone marrow cells of beagles. In 1975, DOE initiated a program at the Site to study the potential health effects of combustion products from fossil fuel power plants. In 1983, the Toxic Pollutant Health Research Laboratory (TPHRL) became operative at the Site. The UC Davis Institute of Toxicology and Environmental Health (ITEH) presently occupies the Site.

From the 1940s through the mid-1960s, portions of the Site were used as the UC Davis campus landfill. UC Davis landfills were operated on-site until 1967, including Landfill Disposal Unit 1, used from the 1940s through the late 1950s or early 1960s, and Landfill Disposal Unit 2, used from 1956 through 1967. A third UC Davis Landfill, Disposal Unit 3, is located approximately 600 feet (ft) east of the Site and was used from 1963 to the 1970s. Burial holes and trenches around the landfills were used for disposal of low-level radioactive and mixed waste from UC Davis and LEHR research activities. Figure 2-2 shows the locations of the three UC Davis landfills and other waste disposal areas. This Site was placed on the EPA's National Priority List (NPL) in September 1994.

### *2.1.3 Present Facility Use*

DOE has no present or planned future activities at the LEHR Site aside from environmental restoration and waste management activities. Site improvements originally completed by DOE will be transferred to UC Davis upon completion of any necessary environmental restoration associated with those structures, as described in the MOA between DOE and UC Davis.

UC Davis is currently using the LEHR Site for research activities, and is likely to continue these activities in the future. Currently, the UC Davis ITEH occupies several former LEHR facilities. ITEH activities involve approximately 200 University researchers and support staff. ITEH researchers and student assistants have varying schedules and are not present on the Site at the same time.

Various ongoing DOE environmental restoration activities on-site involve contractor staff and subcontractors. The total number of on-site workers employed in these activities is currently six, but this number is likely to change depending on the implementation of planned environmental remediation and waste management projects. These remedial actions are likely to continue through the year 2000.

### *2.1.4 Physical Setting*

The land within a one-mile radius of the Site is owned both privately and by UC Davis, and is used for animal research, agriculture, and recreation. Immediately adjacent to the Site to the east and west are UC Davis-owned research facilities. Privately owned lands within one mile to the south and east of the Site include permanent residences and support some crops. Approximately 75 percent of the surrounding land in the general vicinity of the Site is used for agriculture. Major crops include fruits, nuts and grains. Approximately 40 percent of the agricultural land in the LEHR vicinity is irrigated, and some of the nearby lands are used for cattle grazing (DOE, 1988). Recreational uses in this area primarily involve fishing and swimming along nearby Putah Creek.

### *2.1.5 Structures and Topography*

The Site occupies approximately 15 acres and is located in a rural area in the Sacramento Valley. The property contains laboratory buildings and former animal-handling facilities that were used by DOE. Figure 2-2 shows the spatial distribution of the buildings at the Site. Of the 15 acres, approximately 40 percent is paved or covered by structures. Approximately 30 percent is unpaved and relatively free of vegetation. Approximately 5 percent is covered by large, deep-rooted vegetation. The outdoor dog pens occupy approximately 20 percent, or 3 acres.

The Site is situated on gently sloping land, with an average elevation of approximately 50 ft above mean sea level (msl). The land surface slopes to the east/northeast at approximately 0.001 ft/linear ft (5 ft per mile). Relief across the Site is about 2 ft.

#### 2.1.5.1 Sanitary Sewer Systems

The LEHR Site currently discharges sanitary waste water to the UC Davis Wastewater Treatment Plant. UC Davis operates the plant under the conditions specified in its National Pollutant Discharge Elimination System (NPDES) permit, granted by the EPA in conjunction with the Central Valley Regional Water Quality Control Board (CVRWQCB). All seven Domestic Septic Systems and associated leach fields addressed in this report have been abandoned and replaced by direct connection between the site buildings and the sanitary sewer.

#### 2.1.5.2 Storm Water Collection System

As shown in Figure 2-3, storm water runoff at the LEHR Site is controlled through surface and sub-surface drainage systems. According to facility drawings, storm water from the paved area in the west part of the site is collected in catch-basins and discharged to Putah Creek. Drainage around the southern buildings in the western area is collected in a main storm water drainage system and routed to the LEHR Site storm water lift station and subsequently pumped to an outfall along the west side of the Old Davis Road, where it is discharged to unlined earthen ditches which flow south to Putah Creek. Storm water that falls along the eastern and non-paved southern portions (including the Southwest Trenches Area) of the Site percolates into the soil, except for a section of the former Co-60 field where dog pens were once located and drainage is connected to the sanitary sewer. Water ponds during heavy rains in some areas on the Site. Specifically, storm water within the three DOE areas is collected as follows:

- Storm water within the northern part of the Southwest Trenches Area drains through catch basins into a central storm drain. Storm water in the southern and central sections of the Southwest Trenches Area, however, ponds and infiltrates into the subsurface;
- Storm water within the Ra/Sr Treatment Systems Area generally drains on the western side into the Old Davis Road drainage ditch, on the eastern side into catch basins and the main storm drain. Storm water directly in or adjacent to the abandoned Imhoff tanks ponds and evaporates or infiltrates into the subsurface. The Old Davis Road Drainage ditch was investigated as part of the Ra/Sr Treatment Systems Area as described in Section 3; and,
- Storm water within the Domestic Septic System Areas generally results in surface runoff prior to contact with any Domestic Septic System Areas with the possible exception of some sub-surface infiltration at Domestic Septic Systems Nos. 3 and 4.

### *2.1.6 Geology/Hydrogeology*

#### 2.1.6.1 Local Geology

The Site and vicinity are in the Putah Plain of the Sacramento Valley (DWR, 1978), which consists of alluvial fan deposits associated with Putah Creek. These alluvial sediments consist

primarily of silt and clay with localized interfingered coarse-grained sediments and are approximately 180 ft thick (DWR, 1978). Beneath the Site, the sediments are flat lying and conformably overlie the Tehama Formation, the principal water-bearing geologic unit on the west side of the Sacramento Valley.

The depths and types of major sedimentary units encountered in boreholes beneath the Site are described below from youngest to oldest. Some of the units contain gradational sequences or more than one lithology.

- 0 to 80 ft: interbedded silt, clay and sand with some sand and gravel channel deposits. The surficial soils are underlain by a sequence of interbedded clay, silty clay, silt, and sand. This fine-grained interval is fairly continuous across the Site and contains some coarse sand and gravel. The ground water table is in this stratigraphic unit and varies in depth from approximately 30 to 65 ft below ground surface (bgs), depending on the season.
- 80 to 135 ft: cobbles and gravel. Well-rounded cobbles and gravel are encountered at approximately 80 ft bgs and appear to be laterally continuous beneath most of the Site. Where present, this unit is approximately 35 to 52 ft thick.
- 135 to 143 ft: clay and some silt. Clay and silt underlie the cobbles and gravel. The top of this clayey unit was encountered at depths ranging from 120 to 137 ft bgs (Dames & Moore, 1993).

### 2.1.6.2 Surface Soil

The surface soils at the Site have been mapped as Reiff fine sandy loam in the Soil Survey of Solano County, California (USDA, 1977). These soils are relatively young and weakly developed. The "A" horizons are relatively thick and organic-rich, and therefore ideal for agriculture (USDA, 1977).

### 2.1.6.3 Hydrogeology

Unconsolidated Pliocene and Pleistocene deposits are the major ground water sources for public and private water supplies in the Sacramento Valley (DWR, 1978). Both unconfined and confined fresh water aquifers are present in these sedimentary deposits in the uppermost 3,000-ft of the valley subsurface. Ground water generally flows from the valley sides towards the valley axis. In the vicinity of the Site, regional ground water generally flows east from the Coast Ranges towards the Sacramento River (Dames & Moore, 1993).

At various depths beneath the valley floor, fresh water gives way to saline water as a result of entrapment during the deposition of sediments in a marine environment. The depth to the base of fresh water in the Sacramento Valley varies from 400 ft to over 3,000 ft, and is 2,600 to 3,100 ft bgs at Davis (Division of Oil & Gas, 1982).

The uppermost distinct aquifer beneath the Site has been divided into two hydrostratigraphic units (HSUs), based on the stratigraphy of the sediments at the Site, and the associated ground water

flow and contaminant migration characteristics (Dames & Moore, 1994d). HSU-1 consists predominantly of fine-grained sediments and extends from the water table to approximately 80 ft bgs. HSU-2 consists of cobbles and gravel and extends from 80 to 135 ft bgs. Well drillers' logs indicate that a 90-foot-thick clay unit separates HSU-2 from a second aquifer (or third HSU) below (Dames & Moore, 1994a).

Irrigation water, rainfall, and Putah Creek recharge ground water in the vicinity of the Site (Dames and Moore, 1997a). The main component of ground water recharge, however, has been identified as irrigation water infiltration. Ground water pumping associated with agricultural demands is largely responsible for ground water discharge at the Site.

In 1996, ground water levels varied from approximately 21 ft above msl (about 28 ft bgs) in winter to 7 ft above msl (about 42 ft bgs) in summer. Generally, there is a 20- to 30-ft seasonal fluctuation in the depth-to-ground water beneath the Site caused predominantly by the lack of surface recharge and agricultural pumping in the summer. The vertical ground water gradient between HSU-1 and HSU-2 was downward during the summer months of 1996 and upward in most wells during the rainy season (WA, 1997e). Vertical gradients vary both temporally and spatially. The magnitude of the vertical gradient is greatest when ground water elevations are rising or falling sharply. Short-term activities such as local agricultural pumping can produce downward vertical gradients during periods of an otherwise rising water table.

Based on 1996 data, the HSU-1 lateral gradient across the Site varies from approximately 0.01 to 0.04 ft/ft, and the direction of ground water flow is predominantly northeast (WA, 1997e). Representative values of HSU-1 horizontal hydraulic conductivity from slug tests are about $5 \times 10^{-4}$ centimeters per second (cm/sec). The lateral gradient across the Site within HSU-2 typically ranges from 0.005 ft/ft to 0.015 ft/ft. The direction of flow appears to be predominantly northeast; although it can occasionally be east-southeast. Horizontal hydraulic conductivity from slug tests are about $1 \times 10^{-2}$ cm/sec in HSU-2 (WA, 1997a). Based on pumping tests, hydraulic conductivity in HSU-2 ranges from 0.26 to 0.43 cm/sec (Dames & Moore 1997a).

Ground water in HSU-1 and HSU-2 has been impacted by Site activities. Based on investigations to date presented in the Site Characterization Summary Report (WA, 1997a), significant ground water impact appears to be associated only with the UC Davis disposal areas.

### 2.1.6.4 Surface Water

The east-flowing South Fork of Putah Creek borders the southern portion of the site and is separated from the site by the north levee of the creek. In 1948, the U.S. Army Corps of Engineers modified the South Fork and dammed the North Fork so that all water in Putah Creek now flows in the South Fork. Putah Creek is a "losing" stream in the LEHR vicinity; therefore, Putah Creek water may impact shallow ground water beneath the site, but not vice-versa.

Flow in the South Fork of Putah Creek is regulated by releases from Monticello Dam at Lake Berryessa and from the Putah Diversion Dam, located about 18 and 14 miles west of the site, respectively. Based on data from 1980 through 1991, flows several miles upstream from the site typically range from 0.1 cubic feet per second (cfs) to about 3 cfs; although, flows as high as 15,500

cfs (in March 1983) have been reported (Dames & Moore, 1994a). In the reach bordering the Site, flow in the South Fork of Putah Creek is supplemented by discharge from the UC Davis Wastewater Treatment Plant (Figure 2-1). Based on data from the gauge near Old Davis Road, flow rates for the reach bordering the Site ranged from 0.17 to 148 cfs from 1989 to 1993. Flows have not changed substantially since 1993 (WA, 1997a).

As shown on federal flood maps, the 100-year flood plain is confined within the Putah Creek levees at the southern boundary of the Site. The Site lies in the Federal Emergency Management Administration (FEMA) Zone C, the area expected to experience minimal flooding.

## 2.2 Existing Environmental Setting

The environmental setting sections presented below are those necessary to assess impacts as required under NEPA and DOE statutes. The subsections below include conditions of the existing site and some surroundings:

- water resources;
- ambient air quality;
- ambient noise quality;
- aesthetics and scenic values;
- biological resources (plants and wildlife);
- socioeconomic conditions;
- historical and cultural resources;
- land use; and,
- human health issues.

### *2.2.1 Water Resources*

This subsection describes the water resources within the Site and, where appropriate, the adjacent area. Water resources include ground water and surface and recreational waters (i.e., rivers and wetlands).

#### 2.2.1.1 Ground Water

The occurrence and characteristics of ground water beneath the Site have been summarized in numerous reports (WA, 1997e; Dames & Moore 1994a, 1994b, 1997b; Pacific Northwest National Laboratory (PNNL), 1996). Hydrogeologic characteristics of the Site are described in Section 2.1.6.3. A summary of the ground water quality is provided here based on the detailed information most recently reported in "Final Tiered Initial Study, Laboratory for Energy-related Health Research

and South Campus Disposal Site (LEHR/SCDS) Interim Remedial Actions Project" (UC Davis, 1997).

There are a total of 17 wells within the Site and 15 wells (plus one extraction well) in the immediately surrounding area that monitor HSU-1 and/or HSU-2 ground water. Ground water samples from these wells and Hydropunch locations provide information on ground water characteristics and quality. Ground water wells are also present in the surrounding areas and are used to provide water for agricultural and domestic purposes. Ground water is not currently used on-site for drinking water or other direct human use nor is it expected to be used on-site in the future.

Regional water quality has been impacted by the presence of nitrates, due to agricultural sources, and hexavalent chromium, probably from natural sources (Dames & Moore, 1997a). On-site, ground water in both HSUs appears to have been impacted by historical activities on-site, and appears to be related specifically to the UC Davis disposal areas.

As indicated in Section 1, a MOA has been developed between DOE and UC Davis to divide responsibility for Site areas of contamination according to historical information regarding use and operation. UC Davis has assumed responsibility for ground water remediation activities because contamination of the ground water appears to be related to the UC disposal areas. The primary constituents of concern (COC) are chloroform and other VOCs, chromium (primarily as chromium VI in ground water), and nitrate. As part of the CERCLA action for UC Davis areas of the Site, UC Davis has submitted an EE/CA for plans to pump and treat ground water. Construction began in 1997. Environmental controls will be in place for the system, and UC Davis will continue to monitor ground water quality at the Site. Actions relating to the UC Davis ground water treatment system and operations will be subject to the oversight by the EPA, CVRWQCB, the California Department of Toxic Substances Control (DTSC), and the California Department of Health Services (DHS).

#### 2.2.1.2 Surface and Recreational Waters

No natural or manmade surface and recreational waters are found on the Site. The south fork of Putah Creek lies about 125 ft south of the Site within a manmade channel; the channel is separated from the boundaries of the Site by a two-lane paved roadway. Unrelated to on-site activities, the south fork of Putah Creek was redirected within a manmade channel to divert flood waters from the City of Davis and the UC Davis main campus. It is an intermittent stream, sometimes containing only scattered pools during the dry summer months. In the past, drought conditions have resulted in the lower portions going dry and have resulted in significant fish and invertebrate kills (Marchetti and Moyle, 1995). The creek is surrounded by vegetation and small trees within and adjacent to the channel.

The south fork of Putah Creek in the area of the Site is a location for recreational activities such as fishing, swimming, rafting, and other related water activities. In addition, the creek and channel with its dense vegetation and trees, represent an open space area that provides habitat for birds and small wildlife. A photograph of the south fork of Putah Creek in the vicinity of the Site is provided in Appendix A, Environmental Setting – Support Documentation and Information.

The south fork of Putah Creek is identified as wetlands by the U.S. Army Corps of Engineers. Wetlands perform vital ecological functions and are important to the public interest. Wetlands provide communities with a variety of resident and migratory animal species habitat, breeding and spawning, and forage areas. Wetlands also provide for the movement of water and sediments, ground water recharge, water purification, storage of storm runoff, recreation, and transportation.

Direct sampling of surface water in Putah Creek is conducted by UC Davis as part of its CERCLA responsibilities. Surface water samples are collected from two sampling points in Putah Creek; one located upstream from the Site (PCU) and one located downstream (PCD). Water samples are also collected at the UC Davis treatment plant outfall (STPO). These data, while valuable, do not allow evaluation of the impact from DOE Areas on Putah Creek surface water since it characterizes in-stream contaminant levels that may have many sources other than DOE Areas.

Storm water sampling data could potentially be considered as direct measurements of potential DOE related impacts to Putah Creek (Figure 2-3). Storm water sample data for DOE Areas of the Site are from two storm water sampling points. Storm water sampling point SWL-1 is a lift station on the west side of the Site that discharges to Putah Creek. Storm water from the primarily paved portion of the Site, including the eastern side of the Animal Hospital Buildings and the area near the former Western Dog Pens, is sampled at a second sampling location, SWL-2 (Figure 2-3). This water is then routed to the SWL-1 lift station and subsequently discharged to Putah Creek. A portion of the Ra/Sr Treatment System and Septic Tanks Areas also drains to Putah Creek via the lift station at SWL-1. Storm water runoff from the remainder of DOE Areas, including a small portion of the Ra/Sr Treatment System Area, Western Dog Pens, DOE Southwest Trenches Area and Disposal Box ponds and percolates into Site soil, or evaporates. Storm water has been observed to pond at the Southwest Trenches Area during the wet season.

Two additional storm water monitoring points, LF-1 and LF-3, are monitored by UC Davis in UC landfill units 1 and 3 respectively. In these areas, storm water either collects or percolates into the soil, is directed to the sanitary sewer or is discharged to Putah Creek via culverts and a drainage ditch. These monitoring points are not in DOE Areas of the Site.

### *2.2.2 Ambient Air Quality*

The Site is located within the Yolo/Solano Air Quality Management and is part of the Sacramento Valley Air Basin. A summary of current air quality information is presented in Appendix A. The Site is located in a State and Federal non-attainment area for particulate matter ($PM_{10}$) and ozone.

The prevailing wind direction is from the south, reflecting frequent incursions of marine air through the Carquinez Strait into the Sacramento Valley. Changes in wind direction are common, with winds from the northwest occurring diurnally. During the summer months (May – September) the predominant wind direction is from the south. The average windspeed recorded at the LEHR Site meteorological station in 1995 was approximately 2.2 meters per second (5 miles per hour).

Within the Site and surrounding areas, the most notable sources of air pollution are from moving automobiles (primarily from Old Davis Road, on the Site, adjacent roads and freeways). Fugitive dust (i.e., particulate matter) is associated with moving vehicles, construction equipment (when construction or earth-moving activities occur), and agricultural equipment (when soil work such as harvesting, planting, and clearing is involved. Fugitive dust is also generated when high winds blow over dry, barren or open fields.

Airborne radionuclides are sampled by a network of four continuously operating samplers: three on the site perimeter and one at a distant location. Perimeter samplers were located around the Site, with emphasis on the prevailing downwind directions to the north and south of the Site. The distant location was approximately 6 miles (10 km) northwest of the LEHR Site and provided background data from an area essentially unaffected by site operations.

The analytical results of the one-year baseline air sampling investigation were presented in PNNL's Baseline Air Monitoring Report (PNNL, 1996). The current air monitoring program includes:

- Continuous monitoring at the three on-site stations and the background station for alpha & beta activities, with the filters collected for semi-annual composite analysis for gamma-emitting radionuclides;
- Quarterly radon sampling of the three on-site stations and the background station; and,
- Continued collection of meteorological data at the on-site meteorological station.

Both the average and maximum activities of total alpha radiation collected during the one-year baseline air sampling investigation were similar for site perimeter locations and the distant location, indicating that the observed levels were predominantly the result of natural sources and worldwide fallout. The highest measured average air activity was $0.0017 \pm 0.0004$ pCi/m$^3$ (result $\pm$ 2 sigma counting error), which was not statistically different from the average activity at the distant location of $0.0017 \pm 0.0005$ pCi/m$^3$ (PNNL, 1996).

Total beta radiation activities in ambient air collected during the one-year baseline air sampling investigation peaked during the winter. The highest average total beta activity at a site perimeter location ($0.030 \pm 0.012$ pCi/m$^3$) was similar to the distant background location ($0.027 \pm 0.010$ pCi/m$^3$), indicating that the observed levels were predominantly a result of natural sources and worldwide fallout. No statistical differences were observed between the average total beta activities measured at the site perimeter locations compared to the distant location.

Air monitoring data confirm that detectable levels of gamma-emitting radionuclides at the LEHR site are in compliance with 40 CFR Part 61 Subpart H requirements, and that small detectable levels are likely associated with background sources (PNNL, 1996). All measured activities for isotopic thorium, uranium, radium, and strontium collected during the one-year baseline air sampling investigation were also well below the DOE Derived Concentration Guide. These data are shown in detail in PNNL, 1996.

Nonradiological parameters for the air sampling program include: 1) selected metals that were reported in soil as potentially above regional background levels as listed in the RI/FS workplan; 2) the pesticide chlordane, which was stored and used at the Site and has been found in soil samples; and, 3) the volatile organic compounds (VOCs) chloroform and methylene chloride that have been found in site soil and water. In addition, air samples are analyzed for total respirable particulates, defined as those particulates with an aerodynamic diameter less than 10 micrometers ($PM_{10}$). Baseline $PM_{10}$ information will be used to evaluate potential increases in fugitive dust emissions during RA. The analytical results for samples analyzed for nonradiological pollutants are presented in detail in PNNL's Baseline Air Monitoring Report (PNNL, 1996).

In general, detectable concentrations of metals were found in ambient air at both the Site and distant stations. Alpha-chlordane, gamma-chlordane, heptachlor, and trans-nonachlor were detected in most samples. Cis-nonachlor and heptachlor epoxide were only occasionally detected, with no location reporting more than one detectable concentration for the six sampling events. However, the differences were not statistically significant. Average air concentrations at on-site stations were similar to the distant station, with no statistical differences compared to the distant station.

The air concentrations for the majority of VOCs were below the detection limits. Toluene, dichlorodifluoromethane (Freon 12), trichloroethane, and chlorobenzene were detected with low frequencies and concentrations at the Site. Freon 12 and toluene were also detected at the distant station.

### *2.2.3 Ambient Noise Quality*

No significant or loud noises appear to affect the Site; although several sources of noise were observed at the Site which include vehicular traffic, sounds from air conditioning units and other operating equipment (such as monitoring equipment on the Site), moving railroad trains and cars (located about 0.25-mile from the Site), and small aircraft. Ambient noise level surveys were not conducted as a part of this analysis.

### *2.2.4 Aesthetics and Scenic Values*

The Site is primarily covered with buildings, pavement, and relatively small (less than 0.25-acre) open or grassy areas, with trees and scattered strips of landscaping alongside buildings. The boundaries of the Site are demarcated by chain link fences and/or dense bush vegetation. Mature pine trees and a chain link fence are located along the south boundary of the Site. Although aesthetics and scenic values are subjective, the present site appearance is not found to have high scenic values.

Surrounding farmlands represent open space with visual diversity from the Site's synthetic structures and modifications. Visually, these farmlands provide a sense of wide expanse and greenery, which lends scenic and visual value to the area.

Putah Creek, south of the Site, provides another area of scenic and visual value because of its flowing water. Bodies of water and flowing water generally have a pleasing visual value because of their gentle motion, reflectivity, and appeal. In addition, the diversity of vegetation alongside the creek, and its arcade of trees arching the channel, add to the scenic appeal of Putah Creek.

### *2.2.5 Biological Resources*

The biological resources discussed here are plant communities and wildlife. Detailed information on the plant communities and wildlife has been gathered to develop an Ecological Scoping Assessment that is contained in the "Draft Final Ecological Scoping Assessment for DOE Areas for the U.S. Department of Energy Areas at the Laboratory for Energy-Related Health Research, University of California at Davis, California" (WA, 1997d). The subsections below summarize the information regarding existing on-site plants and wildlife. Tables 2-1 and 2-2 provide a list of plant and animal species known or expected to occur on-site and off-site, respectively.

#### 2.2.5.1 Plant Communities

Areas of the Site not covered by buildings, structures, and pavement support ruderal vegetation (e.g., weeds), non-native grassland, landscaping (primarily horticultural trees) and bare ground. Habitats include ruderal/non-native grassland, buildings and structures, and ruderal/landscaped, ornamental trees. The locations within the Site that do not fall within one of these three habitats are few and sparse but may be foraged. No naturally occurring special-status communities occur at the Site or immediately adjacent to the Site (including the south fork of Putah Creek and the channel it lies within).

Special-status species are those species of plants and animals defined under the Endangered Species Act (50 CFR 17.12), California Endangered Species Act (14 CCR 670.5), and those considered sufficiently rare by the scientific community to quality for such a listing. No special-status species of plants were detected or have been recorded at the Site or the surrounding region (within approximately a one-mile radius from the Site).

#### 2.2.5.2 Wildlife

A variety of animal species were observed on the Site and the adjacent areas. Although many of these animal species are not likely to live within the Site, they may forage within the Site. Resident burrowing mammals observed on the Site include the California ground squirrel, California vole, Botta's pocket gopher, and house mouse. Common predatory mammals and reptiles likely to forage on-site include the coyote, gray fox, red fox, house cat, gopher snake, and western terrestrial garter snake. Common predatory birds likely to forage on the Site include the red-tailed hawk, red-shouldered hawk, American kestrel, great-horned owl, and barn owl. Common fish expected in the creek include largemouth bass, green sunfish, carp, and catfish. Fish-eating animals likely to occur in the south fork of Putah Creek include river otter, beaver and muskrat.

A total of 14 special-status wildlife species are considered to have a moderate to high potential to inhabit or forage on the Site. Off-site, a total of 32 special-status wildlife species have

been recorded in the vicinity or are considered to have a moderate to high potential for occurrence in the area.

### *2.2.6 Socioeconomic Conditions*

The Site is presently occupied by the UC Davis ITEH. Current Site use is described in Section 2.1.3.

The Site is located in a rural area in northeast Solano County just outside of the City of Davis (although the City of Davis is located in Yolo County). Although located inside Solano County, the Site is considered part of the Davis community. This is also true of the UC Davis main campus, which is actually in Solano County but has greater affiliation with the City of Davis. UC Davis has a 3,600-acre campus and research area, has a student population of approximately 22,000, and employs approximately 15,000 full-time faculty and staff. The current population of Davis is approximately 53,000 and the current total population of Yolo County is over 150,000. In 1997, the total employment in Yolo County was 81,800; government (25,800) provided 31.5 percent of those jobs. The City of Davis has approximately 21,000 housing units. The more densely populated and metropolitan Sacramento area is approximately 13 miles east of the Site. The population of Sacramento County is about 1,150,000, and approximately 396,000 people live in the City of Sacramento. Agricultural employment is a small fraction of total employment; it should not be considered a major employment source.

### *2.2.7 Historical and Cultural Resources*

The past DOE-sponsored operations of the Site are discussed in Section 2.1.2. Historically, the Site was used for agriculture. Cultural resources are not known to be present within the Site. Given the high disturbance to the surface and subsurface of the Site, it is highly unlikely that cultural resources are there or could be found.

### *2.2.8 Land Use*

As shown on Figure 2-4, land within the vicinity of the Site is either part of the UC Davis campus or in agricultural use. Immediately adjacent to the project Site are the UC Davis Raptor Research Center and animal research facilities. The raptor research center primarily houses raptors inside small buildings for research. Additionally, an unrestricted outdoor area containing a burrowing owl project is also located about 1,500 ft east of the Site. Other UC Davis animal research includes horses, cows, goats, and other domesticated farm animals located in corrals. Agricultural land lies south of Putah Creek and east and west of property owned by UC Davis land. Wheat, tomatoes, corn, barley, and oats are mainly grown on this agricultural land. The main UC Davis campus and the City of Davis (downtown area) are located 1.2 and 1.9 miles, respectively, north of the Site.

The Site is designated as "Urban and Built-up Land" by the State of California Department of Conservation for Yolo and Solano Counties Important Farmlands Maps (UC Davis, 1997). Specific land uses on the Site and the immediate adjacent areas are under the control of UC Davis and are consistent with the UC Davis long range development plans (UC Davis, 1997).

Future land use plans for the surrounding areas (outside of UC Davis) do not identify significant changes with the exception of development of a light industrial area about 1 mile north of the Site, near Interstate 80 and within the boundaries of the City of Davis. According to UC Davis, long-range planning predicts on-site use to remain research-oriented for the foreseeable future.

### *2.2.9 Human Health Considerations*

Concerns for human health in the DOE areas are primarily related to radiation exposure from previous activities at the Site. Radiation levels are monitored within and at the perimeter of the Site, and radiation dosage estimate calculations are performed and reported annually. As reported in the 1996 Annual Site Environmental Report (WA, 1997f), the maximum individual dose was estimated to be 0.0018 mrem/yr. This is well below National Emission Standards for Hazardous Air Pollutants (NESHAP) of 10 mrem/yr. The Site complies with 40 CFR Part 61 Subpart H NESHAPs for Emissions of Radionuclides from DOE Facilities. It should be noted that these calculations were based on on-site residual surface soil contamination (diffuse sources) and that no significant remediation activities resulting in elevated fugitive emissions (i.e., dust) were undertaken during the year.

Other issues relating to public health and safety from the standpoint of remediation goals are provided in Section 4.

## 2.3 Previous and Planned RAs

Over the past six years, numerous expedited cleanup and source RAs have been successfully completed at the Site. Most of these actions, including decontamination of four on-site buildings, were accomplished prior to EPA adding the Site to the NPL in 1994. Table 2-3 summarizes the more significant Site restoration actions accomplished or planned.

Table 2-1. Summary of On-Site Habitats and Potential Ecological Receptors[1]

| Habitat Type | Area (% of Site) | Exposure Group[a] | Expected Species | Observed Species | Relative Occurrence | Fed/CA Status |
|---|---|---|---|---|---|---|
| Ruderal/Non-native Grassland | 222,400 sf 5.1 acres (27%) | | | | | |
| | | Amphibian | | | | |
| | | | Western Toad | - | uncommon | none |
| | | | Pacific Tree Frog | - | common | none |
| | | Bats | | | | |
| | | | Big Brown Bat | - | uncommon | none |
| | | | California Myotis | - | uncommon | none |
| | | Burrowing Mammal | | | | |
| | | | CA Ground Squirrel | x | common | none |
| | | | CA Vole | - | common | none |
| | | | House Mouse | - | common | none |
| | | | W. Harvest Mouse | - | uncommon | none |
| | | | Bottas Pocket Gopher | x | common | none |
| | | | Black-tailed Jackrabbit | x | common | none |
| | | | Audubon's Cottontail | x | common | none |
| | | Granivorous Bird | | | | |
| | | | Mourning Dove | x | common | MB |
| | | | House Finch | x | common | MB |
| | | | Rock Dove | x | common | MB |
| | | | Golden-crowned Sparrow | x | common | MB |
| | | | White-crowned Sparrow | x | common | MB |
| | | Insectivorous Bird | | | | |
| | | | Black Phoebe | x | common | none |
| | | Omnivorous Bird | | | | |
| | | | Red-winged Blackbird | - | common | MB |
| | | | Hermit Thrush | x | uncommon | MB |
| | | | Killdeer | x | common | MB |
| | | | American Crow | x | common | MB |
| | | | CA Horned Lark | x | uncommon | SC MB/ SSC |
| | | | Brewer's Blackbird | x | common | MB |
| | | | Dark-eyed Junco | x | common | MB |
| | | | California Towhee | x | common | none |
| | | | Western | x | common | MB |

Table 2-1. Summary of On-Site Habitats and Potential Ecological Receptors (continued)

| Habitat Type | Area (% of Site) | Exposure Group[a] | Expected Species | Observed Species | Relative Occurrence | Fed/CA Status |
|---|---|---|---|---|---|---|
| Ruderal/Non-native Grassland (continued) | | | Meadowlark | | | |
| | | | European Starling | x | common | none |
| | | | American Robin | x | common | MB |
| | | Predatory Mammal | | | | |
| | | | Coyote | x | uncommon | none |
| | | | Opossum | - | uncommon | none |
| | | | Striped Skunk | x | common | none |
| | | | Raccoon | x | common | none |
| | | | Red Fox | - | uncommon | none |
| | | | Gray Fox | - | uncommon | MB |
| | | Raptor | **Short-eared Owl** | **-** | **uncommon** | **MB/SSC** |
| | | | Great Horned Owl | x | uncommon | MB |
| | | | Barn Owl | x | uncommon | MB |
| | | | Red-tailed Hawk | x | common | MB |
| | | | **Northern Harrier** | **x** | **common** | **MB/SSC** |
| | | | White-tailed Kite | x | common | MB* |
| | | | American Kestrel | x | common | MB |
| | | Reptile | | | | |
| | | | Gopher Snake | - | uncommon | none |
| | | | Western Fence Lizard | - | common | none |
| | 61,300 sf 1.4 acres (26%) | Granivorous Bird | | | | |
| | | | House Finch | x | common | MB |
| | | | Hermit Thrush | x | uncommon | MB |
| | | | Rock Dove | x | common | none |
| | | | Golden-crowned Sparrow | x | common | MB |
| | | | White-crowned Sparrow | x | common | MB |
| | | | Red Crossbill | x | uncommon | MB |
| | | | Mourning Dove | x | common | MB/- |
| | | Insectivorous Bird | | | | |
| | | | Northern Flicker | x | uncommon | MB |
| | | | Ruby-crowned Kinglet | x | common | MB |
| | | | Black Phoebe | x | common | MB |
| | | | Red-breasted Nuthatch | x | uncommon | MB |
| | | | House Wren | x | uncommon | MB |

Table 2-1. Summary of On-Site Habitats and Potential Ecological Receptors (continued)

| | | | | | | |
|---|---|---|---|---|---|---|
| Ruderal/Non-native Grassland (continued) | | Omnivorous Bird | | | | |
| | | | Anna's Hummingbird | x | Common | MB |
| | | | Scrub Jay | x | common | MB |
| | | | American Crow | x | common | MB |
| | | | California Towhee | x | common | none |
| | | | Western Meadowlark | x | common | MB |
| | | | European Starling | x | common | none |
| | | | American Robin | x | common | MB |
| | | | Yellow-rumped Warbler | x | common | MB |
| | | | Dark-eyed Junco | x | common | MB |
| | | | Yellow-billed Magpie | x | common | MB |
| | | | Rufous-sided Towhee | x | uncommon | MB |
| | | Raptor | | | | |
| | | | Coopers Hawk | x | uncommon | MB/SSC |
| | | | Great Horned Owl | x | uncommon | MB |
| | | | Barn Owl | x | uncommon | MB |
| | | | Red-tailed Hawk | x | common | MB |
| | | | American Kestrel | x | uncommon | MB |
| Buildings and Structures | 100,900 sf, 2.3 acres, (12%) | | | | | |
| | | Bats | | | | |
| | | | Townsend's Big-eared Bat | - | uncommon | SC/SSC |
| | | | Pallid Bat | - | uncommon | SSC |
| | | | California Mastiff Bat | - | uncommon | SC/SSC |
| | | | Big Brown Bat | - | common | none |
| | | | California Myotis | - | common | none |
| | | Granivorous Bird | | | | |
| | | | House Finch | x | common | MB |
| | | | House Sparrow | - | common | none |
| | | | Rock Dove | x | common | none |
| | | Raptor | Barn Owl | x | common | MB |

Table 2-1. Summary of On-Site Habitats and Potential Ecological Receptors (continued)

Notes:

- = Expected Species
x = Observed Species
a = Terrestrial invertebrate species not listed, not in scope of site reconnaissance
TEXT = Special status species, likely representative species selection
(1) Source: Draft Ecological Scoping Assessment for the DOE Areas at the Laboratory for Energy-Related Health Research, University of California at Davis, California, Weiss Associates, July 9, 1997. Pages 4-17 to 4-30.
FE = Listed as Endangered by the Federal Government
FT = Listed as Threatened by the Federal Government
SC = Species of Concern
MB = Migratory non-game birds of management concern to the USFWS; protected under the Migratory Bird Treaty Act
CE = Listed as Endangered by the State of California
CT = Listed as Threatened by the State of California
SSC = California Species of Special Concern
* = Taxa that are restricted in distribution, declining throughout their range, or associated with habitats that are declining in California

Table 2-2. Summary of Off-Site Habitats and Potential Ecological Receptors[1]

| Habitat Type | Exposure Group[a] | Expected Species | Observed Species | Relative Occurrence | Fed/CA Status |
|---|---|---|---|---|---|
| Ruderal/Non-native Grassland | | | | | |
| | Amphibian | | | | |
| | | Western Toad | - | uncommon | none |
| | | Pacific Tree Frog | - | common | none |
| | Bats | | | | |
| | | Big Brown Bat | - | uncommon | none |
| | | California Myotis | - | uncommon | none |
| | Burrowing Mammal | | | | |
| | | CA Ground Squirrel | x | common | none |
| | | CA Vole | - | common | none |
| | | House Mouse | - | common | none |
| | | W. Harvest Mouse | - | uncommon | none |
| | | Bottas Pocket Gopher | x | common | none |
| | | Black-tailed Jackrabbit | x | common | none |
| | | Audubon's Cottontail | x | common | none |
| | Burrowing Owl | | | | |
| | | **Burrowing Owl** | **x** | **uncommon** | **SC, MB/SSC** |
| | Granivorous Bird | | | | |
| | | Mourning Dove | x | common | MB |
| | | House Finch | x | common | MB |
| | | Rock Dove | x | common | MB |
| | | Golden-crowned Sparrow | x | common | MB |
| | | White-crowned Sparrow | x | common | MB |
| | Insectivorous Bird | | | | |
| | | Black Phoebe | x | common | none |
| | Omnivorous Bird | | | | |
| | | Red-winged Blackbird | - | common | MB |
| | | Hermit Thrush | x | uncommon | MB |
| | | Killdeer | x | common | MB |
| | | American Crow | x | common | MB |
| | | **CA Horned Lark** | **x** | **uncommon** | **SC,MB/SS** |

Table 2-2. Summary of Off-Site Habitats and Potential Ecological Receptors (continued)[1]

| Habitat Type | Exposure Group[a] | Expected Species | Observed Species | Relative Occurrence | Fed/CA Status |
|---|---|---|---|---|---|
| | | | | | C |
| | | Brewer's Blackbird | x | common | MB |
| | | Dark-eyed Junco | x | common | MB |
| | | California Towhee | x | common | none |
| | | Western Meadowlark | x | common | MB |
| | | European Starling | x | common | none |
| | | American Robin | x | common | MB |
| | Predatory Mammal | | | | |
| | | Coyote | x | uncommon | none |
| | | Opossum | - | uncommon | none |
| | | Striped Skunk | x | common | none |
| | | Raccoon | x | common | none |
| | | Red Fox | - | uncommon | none |
| | | Gray Fox | - | uncommon | MB |
| | Raptor | | | | |
| | | **Short-eared Owl** | **-** | **uncommon** | **MB/SSC** |
| | | Great Horned Owl | x | uncommon | MB |
| | | Barn Owl | x | uncommon | MB |
| | | Red-tailed Hawk | x | common | MB |
| | | **Northern Harrier** | **x** | **common** | **MB/SSC** |
| | | White-tailed Kite | x | common | MB* |
| | | American Kestrel | x | common | MB |
| | Reptile | | | | |
| | | Gopher Snake | - | uncommon | none |
| | | Western Fence Lizard | - | common | none |
| Ruderal/ Landscaped-Ornamental Trees | Granivorous Bird | | | | |
| | | House Finch | x | common | MB |
| | | Hermit Thrush | x | uncommon | MB |
| | | Rock Dove | x | common | none |
| | | Golden-crowned Sparrow | x | common | MB |
| | | White-crowned Sparrow | x | common | MB |
| | | Red Crossbill | x | uncommon | MB |
| | | Mourning Dove | x | common | MB/- |

Table 2-2. Summary of Off-Site Habitats and Potential Ecological Receptors (continued)[1]

| Habitat Type | Exposure Group[a] | Expected Species | Observed Species | Relative Occurrence | Fed/CA Status |
|---|---|---|---|---|---|
| | Insectivorous Bird | | | | |
| | | Northern Flicker | x | uncommon | MB |
| | | Ruby-crowned Kinglet | x | common | MB |
| | | Black Phoebe | x | common | MB |
| | | Red-breasted Nuthatch | x | uncommon | MB |
| | | House Wren | x | uncommon | MB |
| | Omnivorous Bird | | | | |
| | | Anna's Hummingbird | x | common | MB |
| | | Scrub Jay | x | common | MB |
| | | American Crow | x | common | MB |
| | | California Towhee | x | common | none |
| | | Western Meadowlark | x | common | MB |
| | | European Starling | x | common | none |
| | | American Robin | x | common | MB |
| | | Yellow-rumped Warbler | x | common | MB |
| | | Dark-eyed Junco | x | common | MB |
| | | Yellow-billed Magpie | x | common | MB |
| | | Rufous-sided Towhee | x | uncommon | MB |
| | Raptor | | | | |
| | | Coopers Hawk | x | uncommon | MB/SSC |
| | | Great Horned Owl | x | uncommon | MB |
| | | Barn Owl | x | uncommon | MB |
| | | Red-tailed Hawk | x | common | MB |
| | | American Kestrel | x | uncommon | MB |
| Buildings and Structures | | | | | |
| | Bats | | | | |
| | | Townsend's Big-eared Bat | - | uncommon | SC/SSC |
| | | Pallid Bat | - | uncommon | SSC |
| | | California Mastiff Bat | - | uncommon | SC/SSC |
| | | Big Brown Bat | - | common | none |

Table 2-2. Summary of Off-Site Habitats and Potential Ecological Receptors (continued)[1]

| Habitat Type | Exposure Group[a] | Expected Species | Observed Species | Relative Occurrence | Fed/CA Status |
|---|---|---|---|---|---|
| | | California Myotis | - | common | none |
| | Granivorous Bird | | | | |
| | | House Finch | x | common | MB |
| | | House Sparrow | - | common | none |
| | | Rock Dove | x | common | none |
| | Raptor | Barn Owl | x | common | MB |
| Cultivated Fields and Orchards | Burrowing Mammal | | | | |
| | | Bottas Pocket Gopher | x | common | none |
| | | Black-tailed Jackrabbit | x | common | none |
| | | Audubon's Cottontail | x | common | none |
| | Granivorous Bird | | | | |
| | | Golden-crowned Sparrow | x | common | MB |
| | | White-crowned Sparrow | x | common | MB |
| | Omnivorous Bird | | | | |
| | | Red-winged Blackbird | - | common | MB |
| | | **Tricolored Blackbird** | **-** | **uncommon** | **MB/SSC** |
| | | Killdeer | x | common | MB |
| | | American Crow | x | common | MB |
| | | **CA Horned Lark** | **x** | **uncommon** | **MB/SSC** |
| | | Brewer's Blackbird | x | common | MB |
| | | Yellow-billed Magpie | x | common | MB |
| | | Western Meadowlark | x | common | MB |
| | | American Robin | x | common | MB |
| | Predatory Mammal | | | | |
| | | Striped Skunk | x | common | none |
| | | Coyote | x | uncommon | none |
| | Raptor | | | | |
| | | Red-tailed Hawk | x | common | MB |
| | | **Northern Harrier** | **x** | **common** | **MB/SSC** |
| | | **White-tailed Kite** | **x** | **common** | **MB/SSC** |
| | | American Kestrel | x | common | MB |
| | Reptile | | | | |

Table 2-2. Summary of Off-Site Habitats and Potential Ecological Receptors (continued)[1]

| Habitat Type | Exposure Group[a] | Expected Species | Observed Species | Relative Occurrence | Fed/CA Status |
|---|---|---|---|---|---|
| | | Gopher Snake | - | uncommon | none |
| | | Western Fence Lizard | - | common | none |
| Great Valley Mixed Riparian Forest | Amphibian | | | | |
| | | Western Toad | - | uncommon | none |
| | | Pacific Treefrog | - | common | none |
| | Aquatic Mammal | | | | |
| | | Beaver | x | common | none |
| | | River Otter | - | uncommon | none |
| | Bats | Big Brown Bat | - | common | none |
| | | Western Red Bat | - | uncommon | none |
| | | California Myotis | - | uncommon | none |
| | | Yuma Myotis | - | uncommon | none |
| | Burrowing Mammal | | | | |
| | | California Vole | - | common | none |
| | | House Mouse | - | common | none |
| | | Deer Mouse | - | common | none |
| | | Western Harvest Mouse | - | common | none |
| | | Audubon's Cottontail | x | common | none |
| | Granivorous Bird | | | | |
| | | California Quail | x | common | none |
| | | American Goldfinch | - | common | MB |
| | | Lesser Goldfinch | x | common | MB |
| | | Lark Sparrow | - | common | MB |
| | | Lincoln's Sparrow | - | uncommon | MB |
| | | Song Sparrow | x | common | MB |
| | | Black-headed Grosbeak | - | uncommon | MB |
| | | Chipping Sparrow | - | uncommon | MB |
| | | Mourning Dove | - | common | MB |
| | | Golden-crowned Sparrow | - | common | MB |
| | | White-crowned Sparrow | - | common | MB |
| | Herbivorous Mammal | | | | |
| | | Mule Deer | - | uncommon | none |
| | Insectivorous Bird | | | | |
| | | Killdeer | x | common | MB |
| | | Marsh Wren | - | uncommon | MB |

Table 2-2. Summary of Off-Site Habitats and Potential Ecological Receptors (continued)[1]

| Habitat Type | Exposure Group[a] | Expected Species | Observed Species | Relative Occurrence | Fed/CA Status |
|---|---|---|---|---|---|
| Great Valley Mixed Riparian Forest (continued) | | Northern Flicker | x | common | MB |
| | | Cliff Swallow | - | common | MB |
| | | Acorn Woodpecker | - | uncommon | MB |
| | | Ash-throated Flycatcher | - | uncommon | MB |
| | | Nuttall's Woodpecker | x | common | MB |
| | | Downy Woodpecker | - | uncommon | MB |
| | | Barn Swallow | x | common | MB |
| | | Red-breasted Nuthatch | x | common | MB |
| | | No. Rough-winged Swallow | - | common | MB |
| | | Tree Swallow | - | uncommon | MB |
| | | Violet-green Swallow | - | common | MB |
| | | Bewick's Wren | - | common | MB |
| | | House Wren | x | common | MB |
| | Omnivorous Bird | | | | |
| | | **Loggerhead Shrike** | **-** | **uncommon** | **MB/SSC** |
| | | Plain Titmouse | - | common | MB |
| | | Anna's Hummingbird | - | Common | MB |
| | | Scrub Jay | x | common | MB |
| | | Hermit Thrush | x | uncommon | MB |
| | | American Crow | x | common | MB |
| | | Yellow-rumped Warbler | x | common | MB |
| | | Black-throated Gray Warbler | - | uncommon | MB |
| | | Brewer's Blackbird | x | common | MB |
| | | Northern Oriole | - | common | MB |
| | | Varied Thrush | - | uncommon | MB |
| | | Dark-eyed Junco | x | common | MB |
| | | California Gull | x | common | MB |
| | | Ring-billed Gull | - | uncommon | MB |
| | | Northern Mockingbird | - | common | MB |
| | | Brown-headed Cowbird | - | common | MB |
| | | Lazuli Bunting | - | common | MB |
| | | Ring-necked Pheasant | - | uncommon | none |
| | | Yellow-billed Magpie | x | common | MB |
| | | California Towhee | x | common | none |

Table 2-2. Summary of Off-Site Habitats and Potential Ecological Receptors (continued)[1]

| Habitat Type | Exposure Group[a] | Expected Species | Observed Species | Relative Occurrence | Fed/CA Status |
|---|---|---|---|---|---|
| Great Valley Mixed Riparian Forest (continued) | | Rufous-sided Towhee | x | uncommon | MB |
| | | Bushtit | - | common | MB |
| | | Ruby-crowned Kinglet | x | common | MB |
| | | Black Phoebe | x | common | MB |
| | | Pays Phoebe | x | common | MB |
| | | Mountain Bluebird | - | common | MB |
| | | Western Bluebird | - | uncommon | MB |
| | | European Starling | x | common | none |
| | | American Robin | x | common | MB |
| | | Western Kingbird | - | uncommon | MB |
| | | Orange-crowned Warbler | - | common | MB |
| | | Wilson's Warbler | - | common | MB |
| | Piscivorous Bird | | | | |
| | | Belted Kingfisher | x | uncommon | MB |
| | | Forster's Tern | - | common | MB |
| | Wading Shore Bird | | | | |
| | | Green-backed Heron | - | uncommon | MB |
| | | Common Snipe | - | uncommon | MB |
| | | Great Egret | x | uncommon | MB |
| | | Snowy Egret | x | common | MB |
| | | Black-crowned Night Heron | x | common | MB |
| | Predatory Mammal | | | | |
| | | American Badger | - | uncommon | * |
| | | Coyote | x | common | none |
| | | Opossum | - | common | none |
| | | Bobcat | - | uncommon | none |
| | | Striped Skunk | x | common | none |
| | | Long-tailed Weasel | - | uncommon | none |
| | | Raccoon | x | common | none |
| | | Ornate Shrew | - | uncommon | none |
| | | Spotted Skunk | - | uncommon | none |
| | | Gray Fox | - | uncommon | none |
| | | Red Fox | - | uncommon | none |
| | Raptor | | | | |
| | | **Coopers Hawk** | **x** | **uncommon** | **MB/SSC** |
| | | **Sharp-shinned** | **-** | **uncommon** | **MB/SSC** |

Table 2-2. Summary of Off-Site Habitats and Potential Ecological Receptors (continued)[1]

| Habitat Type | Exposure Group[a] | Expected Species | Observed Species | Relative Occurrence | Fed/CA Status |
|---|---|---|---|---|---|
| Great Valley Mixed Riparian Forest (continued) | | **Hawk** | | | |
| | | **Golden Eagle** | - | **uncommon** | **MB/SSC** |
| | | Great Horned Owl | x | uncommon | MB |
| | | Red-tailed Hawk | x | common | MB |
| | | Red-shouldered Hawk | - | uncommon | MB |
| | | **Northern Harrier** | **x** | **common** | **MB/SSC** |
| | | **White-tailed Kite** | **x** | **common** | **MB/SSC** |
| | | **Merlin** | **-** | **uncommon** | **MB/SSC** |
| | | American Kestrel | x | common | MB |
| | | Western Screech-owl | - | uncommon | MB |
| | | Barn Owl | x | common | MB |
| | Reptile | | | | |
| | | **Western Pond Turtle** | **-** | **uncommon** | **SC/SSC** |
| | | Racer | - | uncommon | none |
| | | Gilbert's Skink | - | uncommon | none |
| | | Southern Alligator Lizard | - | uncommon | none |
| | | Common Kingsnake | - | uncommon | none |
| | | Gopher Snake | - | uncommon | none |
| | | Western Fence Lizard | - | common | none |
| | | Western Terrestrial Garter Snake | - | common | none |
| | | **Giant Garter Snake** | **-** | **uncommon** | **FT/CT** |
| | | Side-blotched Lizard | - | common | none |
| | Water Fowl | | | | |
| | | Wood Duck | | uncommon | MB |
| | | Northern Pintail | - | uncommon | MB |
| | | American Widgeon | | uncommon | MB |
| | | Green-winged Teal | | uncommon | MB |
| | | Northern Shoveler | | uncommon | MB |
| | | Cinnamon Teal | - | uncommon | MB |
| | | Mallard | x | common | MB |
| | | Gadwall | | uncommon | MB |
| | | Greater White-fronted Goose | - | uncommon | MB |
| | | Lesser Scaup | - | uncommon | MB |
| | | Ring-necked Duck | - | uncommon | MB |
| | | Canada Goose | x | uncommon | MB |
| | | Common Goldeneye | - | uncommon | MB |

Table 2-2. Summary of Off-Site Habitats and Potential Ecological Receptors (continued)[1]

| Habitat Type | Exposure Group[a] | Expected Species | Observed Species | Relative Occurrence | Fed/CA Status |
|---|---|---|---|---|---|
| Great Valley Mixed Riparian Forest (continued) | | American Coot | x | common | MB |
| | | Common Moorhen | - | uncommon | MB |
| | | Black-necked Stilt | - | uncommon | MB |
| | | Common Yellowthroat | - | uncommon | MB |
| | Water Fowl (continued) | Black-bellied Plover | | uncommon | MB |
| | | Common Merganser | | uncommon | MB |
| | | Bufflehead | | uncommon | MB |
| | Wading Shore Bird | | | | |
| | | Western Sandpiper | | common | MB |
| | | Least Sandpiper | | common | MB |
| | | Virginia Rail | | uncommon | MB |
| | | American Avocet | | uncommon | MB |
| | | Greater Yellowlegs | | uncommon | MB |
| | | Spotted Sandpiper | - | uncommon | MB |
| | | **Long-billed Curlew** | **-** | **uncommon** | **MB/SSC** |
| | | Sora | - | uncommon | MB |
| | | **Great Blue Heron** | **x** | **uncommon** | **MB/?** |
| | | Pied-billed Grebe | x | uncommon | MB |
| | | Double-crested Cormorant | - | uncommon | MB |
| Creek | Benthic/Pelagic Invertebrates[b] | | | | |
| | | Diptera (family chronomide) | - | NA | none |
| | | Trichoptera (family lepidostomatidai) | - | NA | none |
| | | Oligocheata | - | NA | none |
| | | Tubellaria | - | NA | none |
| | | GasTrapoda | - | NA | none |
| | | Amphipoda | - | NA | none |
| | | Mollusca | - | NA | none |
| | | Crustacea - crayfish | - | NA | none |
| | Fish | | | | |
| | | **Pacific Lamprey** | **-** | **uncommon** | **SC** |
| | | Hitch | - | common | none |
| | | Sacramento Blackfish | - | common | none |
| | | American Shad | - | uncommon | none |
| | | White Catfish | - | common | none |
| | | Common Carp | - | common | none |

Table 2-2. Summary of Off-Site Habitats and Potential Ecological Receptors (continued)(1)

| Habitat Type | Exposure Group[a] | Expected Species | Observed Species | Relative Occurrence | Fed/CA Status |
|---|---|---|---|---|---|
| Creek (continued) | Fish (continued) | Black Bullhead | - | common | none |
| | | Channel Catfish | - | common | none |
| | | Green Sunfish | - | common | none |
| | | White Crappie | - | common | none |
| | | Sacramento Sucker | - | NA | none |
| | | Three-spined Stickleback | - | NA | none |
| | | Tule Perch | - | NA | none |
| | | Sacramento Squawfish | - | NA | none |
| | | Threadfin Shad | - | NA | none |
| | | Mosquitofish | - | NA | none |
| | | Brown Bullhead | - | NA | none |
| | | Bluegill | - | NA | none |
| | | Redear Sunfish | - | NA | none |
| | | Mississippi Silverside | - | NA | none |
| | | Golden Shiner | - | NA | none |
| | | Bigscale Logperch | - | NA | none |
| | | Fathead Minnow | - | NA | none |
| | | Black Crappie | - | NA | none |
| | Predatory Fish | Rainbow Trout | - | uncommon | None |
| | | Chinook Salmon | - | uncommon | FE/CE |
| | | Smallmouth Bass | - | common | none |
| | | Largemouth Bass | - | common | none |
| | | Striped Bass | - | NA | none |

Notes:

- = Expected Species
x = Observed Species
[a] = Terrestrial invertebrate species not listed, not in scope of site reconnaissance
[b] = Data not available due to exceedingly heavy rainfall and record-breaking floods, water levels in Putah creek were too high to effectively conduct fish and benthic/pelagic invertebrate studies. Expected species list generated from personal communication with UC Davis research staff and published literature
TEXT = Special status species, likely representative species selection.
(1) Source: Draft Ecological Scoping Assessment for DOE Areas for the DOE Areas at the Laboratory for Energy-Related Health Research, University of California at Davis, California, Weiss Associates, July 9, 1997. Pages 4-17 to 4-30.
FE = Listed as Endangered by the Federal Government
FT = Listed as Threatened by the Federal Government
SC = Species of Concern
MB = Migratory non-game birds of management concern to the USFWS; protected under the Migratory Bird Treaty Act
CE = Listed as Endangered by the State of California
CT = Listed as Threatened by the State of California
SSC = California Species of Special Concern
* = Taxa that are restricted in distribution, declining throughout their range, or associated with habitats that are declining in California

Table 2-3. Synopsis of Previous and Planned Remedial Actions (RAs)

| Year | RA | Result |
|---|---|---|
| 1990 | Removal of Biological Waste | 856 biological waste packages (primarily dog carcasses) were removed from two large on-site freezers, packaged and shipped to the DOE Hanford Site for disposal as low-level radioactive waste. |
| 1992 | Removal of Contaminated Liquid and Sludge | Approximately 40,000 gallons of low-level radioactive liquid and sludge waste were removed from a series of underground concrete tanks located beneath and adjacent to the Imhoff waste water treatment facility. This strontium- and radium-contaminated waste was solidified on-site, packed in 55 gallon drums, and shipped to the DOE Hanford Site for disposal. |
| 1992-1995 | Decontamination and Decommissioning (D&D) of Four On-Site Buildings: Animal Hospital Number 1 (AH-1), Animal Hospital Number 2 (AH-2), Cobalt-60 Building, and the Specimen Storage Room (SSR) | Post decontamination radiological surveys, as verified by the California Department of Health Services (DHS) and the DOE Independent Verification Contractor (IVC), have confirmed that the residual radioactive contamination in these four buildings has been reduced to levels below regulatory limits for unrestricted use. These buildings are being released by DOE to the University of California (landlord) for unrestricted use. |
| 1993-1995 | Removal of Radioactive Sources | Several radioactive sources were removed and shipped to off-site facilities for reuse in industrial processes or scientific research. These sources included a Cobalt-60 source, strontium and radium standards, and thorium and uranium salts. The 100 curie Co-60 source was removed from the top of the Cobalt-60 building and transferred to an off-site hotcell facility to remove the source from its shielding prior to being transferred to the private sector for reuse. |
| 1995 | Removal of Tanker Trailer | A ten-ton tanker trailer that was used to transport low-level radioactive waste to off-site locations was shipped to a commercial waste processing facility near the DOE Hanford Site. At this facility, the tanker was dismantled and its components were supercompacted, packaged, and transported to the DOE Hanford Site for disposal. |

Table 2-3. Synopsis of Previous and Planned Removal Actions (continued)

| Year | RA | Result |
|---|---|---|
| 1995 | Removal of the Imhoff Building and Associated Facilities | The Imhoff Tank Building and associated laboratory facilities were demolished and removed from the Site. |
| 1996 | Removal of Laboratory Research Waste | A total of 80 drums of various laboratory mixed waste were characterized, packaged, and shipped to several off-site locations for treatment and disposal. |
| 1996 | Removal of On-Site Buried Waste | Approximately 3,000 cubic feet of low-level radioactive waste, including gravel and laboratory hardware, was excavated from an on-site trench known as the "DOE Box" and shipped to the DOE Hanford Site for disposal. Post-removal sampling of residual trench soil showed that the RA objective was achieved. This action was performed through a CERCLA Time-Critical Action Memorandum. |
| 1996 | Removal of Outdoor Dog Pens | The 352 outdoor aboveground dog pens including barrels and concrete pedestals, were removed, packaged, and shipped to the DOE Hanford Site for disposal as low-level radioactive waste. |
| 1997 | Ground Water Interim Remedial Action for UC Davis | Planned start of interim air stripping system to address VOC contamination in ground water from Hydrostratigraphic Units (HSUs) 1 and 2. |
| May 1998/1999 (Planned) | Proposed non-time-critical RAs for three DOE Areas: the Southwest Trenches, Ra/Sr Treatment Systems, and the Domestic Septic Systems Areas. | Excavation of contaminated soil and structures at the Southwest Trenches, Ra/Sr Treatment Systems, and Domestic Septic Systems. |
| 1998/1999/2000 (Planned) | Proposed Dog Pen RA | Additional Site characterization is currently being completed. A future EE/CA is planned for this DOE area. |
| 1998/1999/2000 (Planned) | Environmental Restoration of the UC Davis Operable Units | To be conducted by UC Davis. |

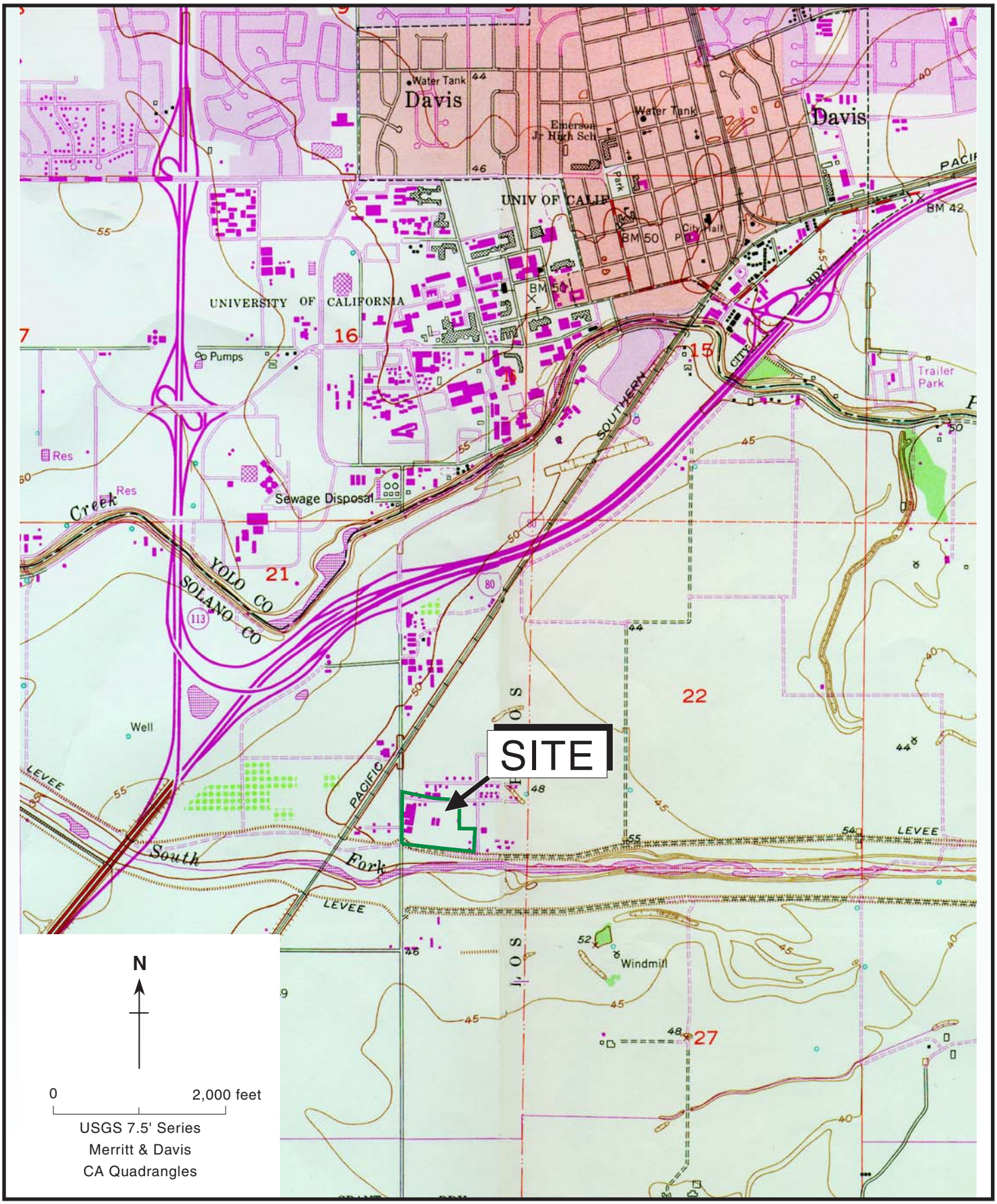



Figure 2-1. Site Vicinity Map.

*Weiss Associates*

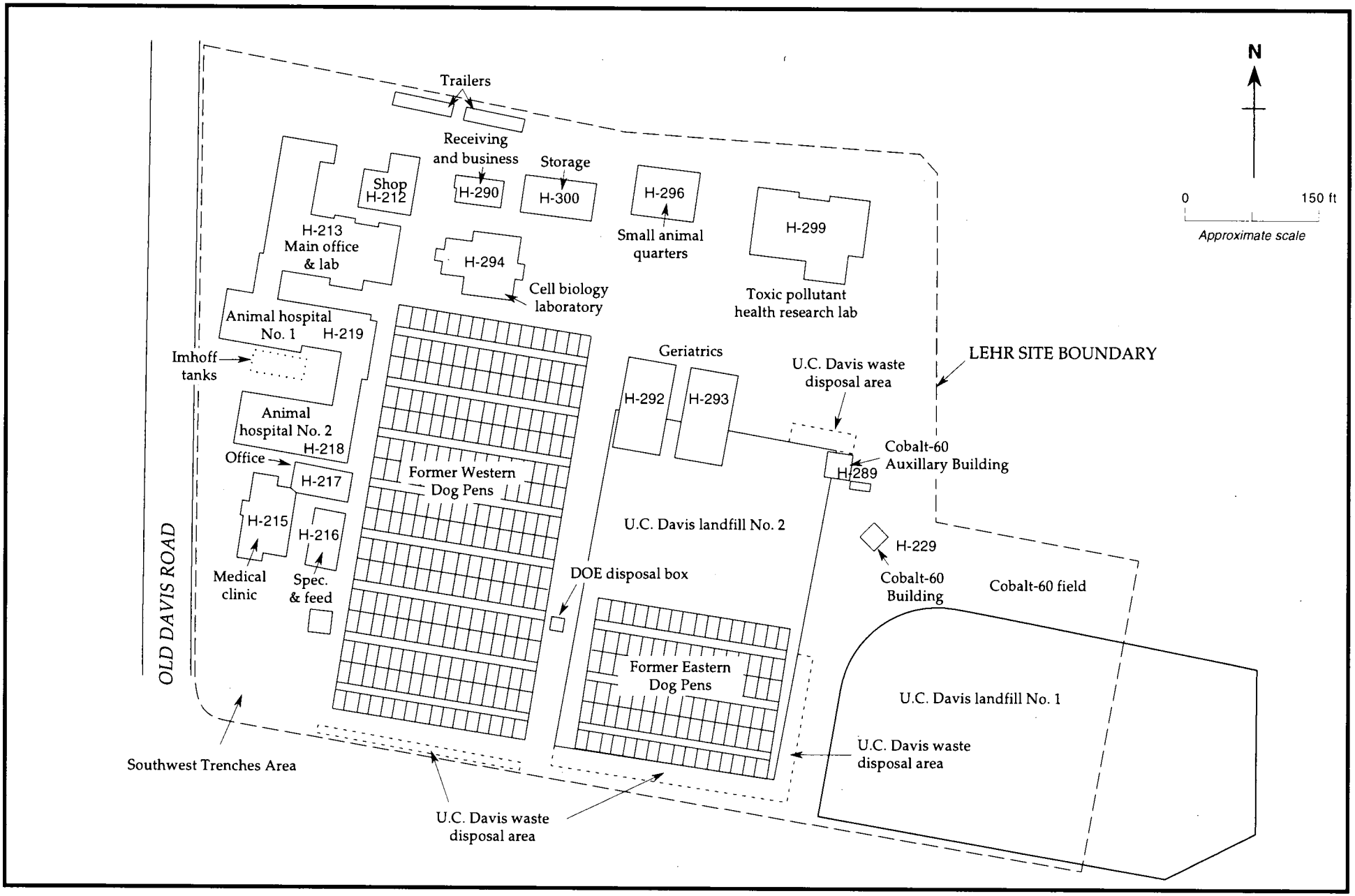
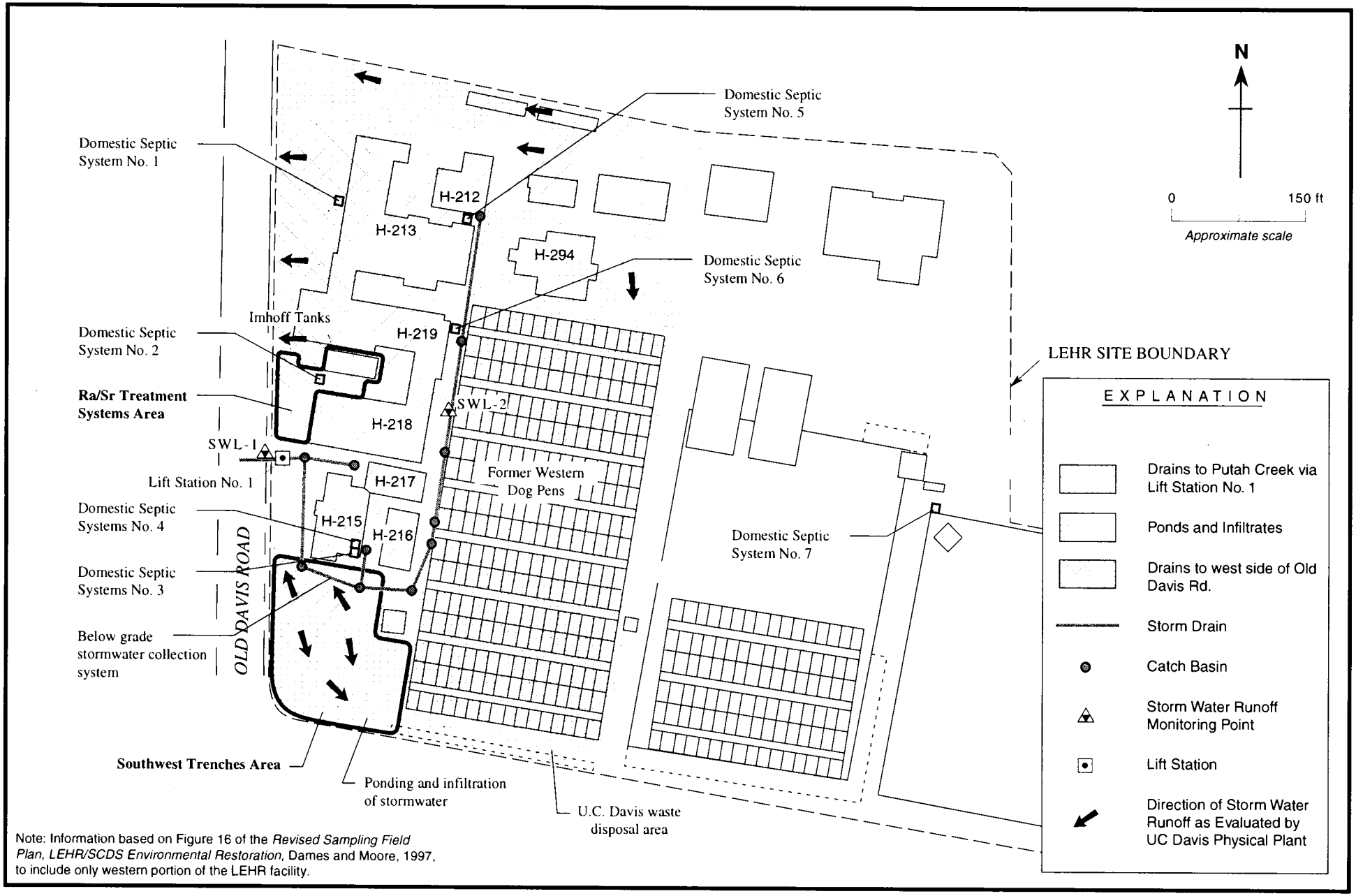



Figure 2-2. Site Structures and Features

Weiss Associates

la1e-026.ai

11/16/97




Note: Information based on Figure 16 of the *Revised Sampling Field Plan, LEHR/SCDS Environmental Restoration*, Dames and Moore, 1997, to include only western portion of the LEHR facility.

Figure 2-3. Storm Water Runoff Flow Patterns and Collection Systems

*Weiss Associates*

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*11/17/97*

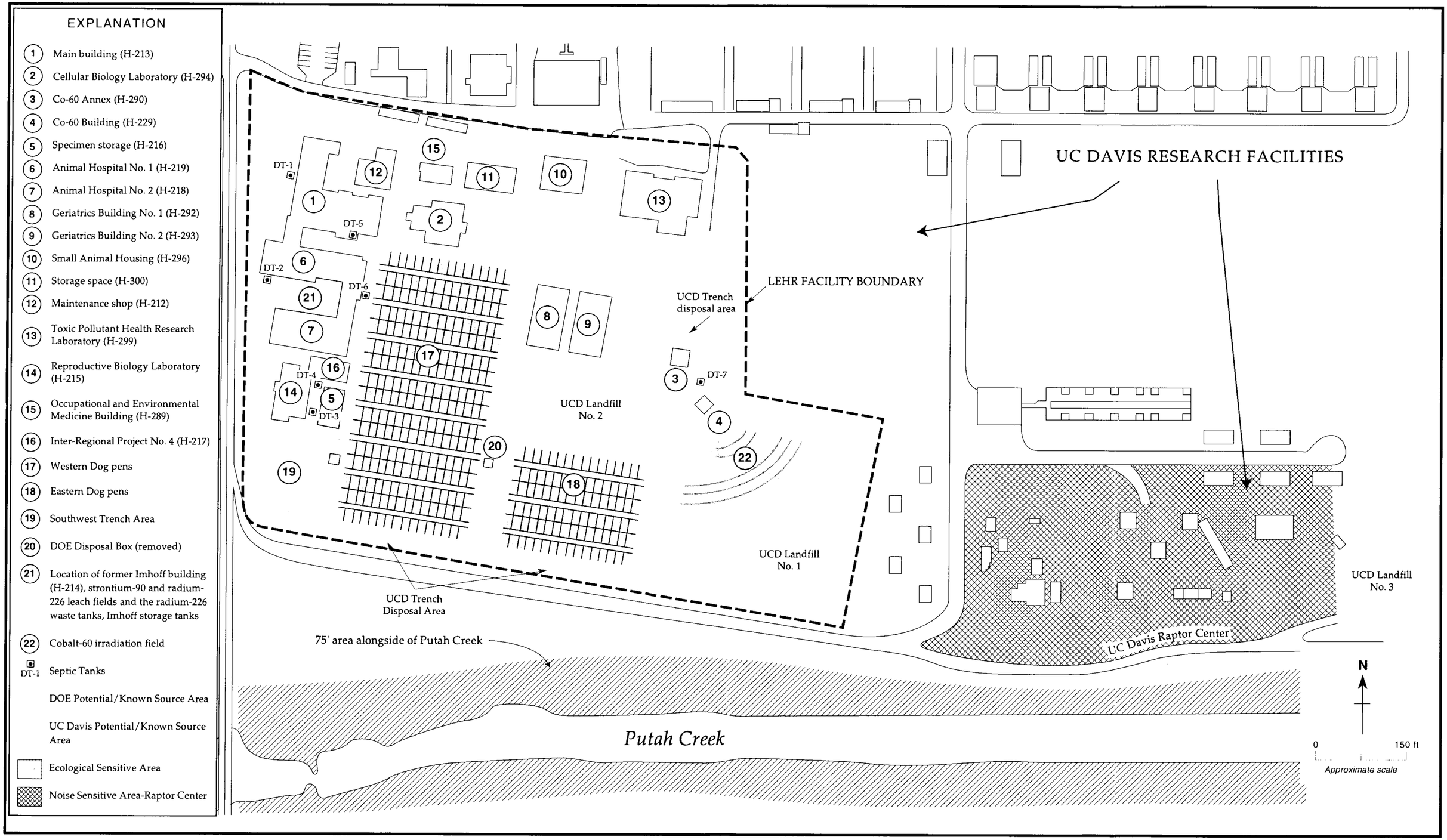



Figure 2-4. Surrounding Land Uses and Environmentally Sensitive Areas

Weiss Associates

# 3. SOURCE, NATURE AND EXTENT OF CONTAMINATION

This section summarizes the findings of previous environmental investigations conducted at the Site that are discussed in the Final Site Characterization Report, (WA, 1997a). Many of the data discussed in this section were collected prior to the issuance of the Remedial Investigation/Feasibility Study– Environmental Assessment (RI/FS-EA) Work Plan in September 1994, and may not have been collected in full compliance with CERCLA standards. Data collected before the Phase II Investigation were used to screen for contamination; therefore, these results are considered only qualitative. In general, the Limited Field Investigation (LFI) data, which were collected in compliance with the RI/FS-EA Work Plan, are emphasized over other data. However, the Sr-90 results reported for some of the LFI samples may be higher than actual concentrations due to a laboratory analytical problem (WA, 1997a). These results are noted as such on the appropriate figures.

A general summary of background ranges for soil constituents developed from site investigations to date is provided in Table 3-1. Background levels for the Site have been defined as the 80% lower confidence level on the 95$^{th}$ quantile of the background data collected in 1994 (WA, 1997c). The background level calculation method is described in detail in Appendix B – Calculation of Background Concentrations. The 1994 data are the only background data presently available in compliance with the RI/FS-EA Work Plan. However, additional background soil samples were collected during October 1997, but the laboratory analytical results are not yet available for inclusion in this EE/CA. This additional background data will be utilized during the RA. As described previously, this EE/CA only addresses DOE Areas in the Southwest Trenches Area, the Ra/Sr Treatment Systems Area, and the Domestic Septic System Areas.

## 3.1 Southwest Trenches Area

The Southwest Trenches Area is located in the southwest corner of the Site. Figure 3-1 is a detailed map of the area showing previous sampling locations. The trenches are reported to have received primarily LEHR-generated low-level radioactive waste, fecal material, and laboratory wastes (Dames & Moore, 1993). Additionally, it was reported that a resin column from the Imhoff system was buried in one of the trenches (IT Corporation, 1996).

The locations and dimensions of the trenches are not known with certainty; however, the trenches were reportedly approximately 120 ft long, 2 ft wide, 8 to 10 ft deep, and oriented in a north-south and west-east direction. Trenches 15, 16, and 17 were reportedly used between September 1963 and November 1965, and probably received dog fecal waste containing Ra-226 and Sr-90 (PNNL, 1995a). A ground-penetrating radar (GPR) survey (Norcal, 1994) conducted in 1994 suggests additional burial areas are present (Figure 3-1).

A chemical dispensing area where chemicals were reportedly stored in an open wooden structure was also present in the Southwest Trenches Area. Bulk chemicals, which were used at the Site, and may have been stored and dispensed in this area include: acetone, kerosene, toluene, xylene, benzene, formaldehyde, ethyl alcohol, formalin, diesel fuel, and chlordane (Dames & Moore, 1993). A wash down pad in the Southwest Trenches Area has been shown on historical maps of the facility; however, no information has been reported on the use of the pad (PNNL, 1995).

A chronology of previous site investigations for the Southwest Trenches Area is presented in Table 3-2. Perspective views of the subsurface trench showing LFI sample locations are presented in Figures 3-2 and 3-3.

### *3.1.1 Constituents of Concern Above Background Levels*

Chemical compounds and radionuclides detected above background in the soil and/or solid waste samples collected from the Southwest Trenches Area are detailed in Table 3-3, and are listed below:

**Radionuclides**:

Radium-226, cesium-137, carbon-14, gross alpha, gross beta, tritium, bismuth-214, strontium-90, potassium-40, lead-212, uranium-235, actinium-228, thallium-208, thorium-234, cobalt-60

**Metals**:

Arsenic, barium, beryllium, cobalt, chromium, hexavalent chromium, copper, iron, nickel, manganese, mercury, selenium, vanadium, lead, zinc

**Volatile Organic Compounds (VOCs):**

Methylene chloride, ethylbenzene, xylenes, toluene, benzene, styrene, 2-hexanene

**Semi Volatile Organic Compounds (SVOCs):**

Polynuclear aromatic hydrocarbons (PAHs) including naphthalene, 2-methylnaphthalene, acenaphthene, dibenzofuran, fluorene, phenanthrene, pyrene, and others

**Pesticides and Polychlorinated Biphenyls (PCBs):**

Chlordane, DDD, DDE, DDT, endosulfan, heptachlor, PCB-1260, dieldrin, pyrene, heptachlorepoxide, carbon tetrachloride and methoxychlor

**Other compounds**:

Formaldehyde, nitrate, hexanol, nonanol

While all of these compounds were detected in samples collected from the Southwest Trenches Area, the majority of high concentrations were detected in only one or two samples of

actual waste uncovered from solid waste samples. Figures 3-4 and 3-5 summarize the analytical results from the LFI for soil and solid waste samples collected from this area. Many of the organic compounds were detected in only trace concentrations and many of the metals and radionuclides were detected in concentrations only slightly exceeding the background concentrations for the Site. Compounds which were either present at significant concentrations or which were laterally persistent throughout the Southwest Trenches Area include:

- Cesium-137;
- Strontium-90;
- Radium-226;
- SVOCs (phenanthrene, fluorene and acenaphthene);
- Chlordane; and,
- Nitrate.

The following section describes the extent of each of these chemical compounds/radionuclides in the soil in the Southwest Trenches Area, and the extent of buried solid waste.

### *3.1.2 Extent of Contamination*

**Buried Solid Waste**

Miscellaneous wastes were buried with gravel in the Southwest Trenches. Based on prior field activities, these trenches were well defined during excavation because the backfill/waste material is visually distinct from the native soil. However, the exact locations and lengths of these trenches were not well defined. The "typical" disposal trench encountered during previous field activities in this area was approximately 2 ft to 6 ft wide by 12 ft deep with sporadic placement of bagged and loose laboratory wastes such as sharps (syringes, etc.), bones, wood, and discarded containers within the gravel backfill.

**Cesium-137**

Cesium-137 (Cs-137) was detected at concentrations exceeding background in seven of the 70 LFI samples collected from the Southwest Trenches Area. The background level for Cs-137 in soil at the Site is 0.053 pCi/g. The maximum reported activity for Cs-137 (23 pCi/g) was reported from sample S-350, which was collected from a depth of 0.5 ft bgs in Grid 7-9. This activity far exceeded those reported in the remainder of the samples, and the next highest reported activity was 0.119 pCi/g (S-359). Cs-137 activities as high as 0.12 pCi/g had been reported from previous investigations. The vertical extent of Cs-137 appears to be confined to near surface soil with only two detections above background in soil greater than 2.5 ft bgs. The deeper samples were both collected from Pit No. 1 at a depth of 12 ft bgs. Cs-137 was not detected in soil below this depth. Laterally, Cs-137 appears to be confined to the waste disposal zones. Cs-137 was detected above background only in soil collected within, or immediately below, a disposal trench or pit. Additionally, Cs-137 contamination in soil does not appear to have affected ground water in the Southwest Trenches Area, as Cs-137 was not detected above background in any of the ground water samples collected from this area in 1996 (WA, 1997e).

### Strontium-90

Strontium-90 (Sr-90) was the most prevalent compound of concern in the Southwest Trenches Area. Sr-90 was detected above background (0.36 pCi/g) in 40 of 68 soil and solid waste samples collected from the Southwest Trenches Area during the LFI. However, as noted on Figures 3-4 and 3-5, many Sr-90 results are considered suspect because of a laboratory analytical problem. The highest reported Sr-90 activities (16,700 pCi/g and 3,690 pCi/g) were measured in a bagged sludge sample and a wood sample, respectively collected from the disposal trench uncovered by exploratory trench T-6. Sr-90 activities above background were also measured in soil samples collected beneath both of these solid waste samples. However, the affected soil does not appear to extend beyond 10 ft bgs, as Sr-90 activities in soil below 10 ft bgs in SB-6 and SB-7 (located adjacent to the wastes) were below background.

The highest Sr-90 activity reported in soil from the Southwest Trenches Area was 22.3 pCi/g in Trench 6. The lateral extent of Sr-90 in the Southwest Trenches Area does not appear to be immediately confined to waste disposal areas. Sr-90 levels above background were reported in numerous shallow soil samples collected around the washdown pad, around the chemical storage area and in the southwest corner of the Site. These samples appear to have been collected from undisturbed soil and are located a minimum distance of 7.5 ft from the nearest known disposal trench or pit. Vertically, Sr-90 appears to be confined to the upper 15-20 ft bgs. The deepest sample with Sr-90 activities measured above background was collected from SB-8 at a depth of 16 ft bgs. Sr-90 activity in the next deepest sample from this boring (26 ft bgs) was below background. Sr-90 in soil in the Southwest Trenches Area does not appear to have affected ground water, as Sr-90 was not detected above background in ground water samples collected from the Southwest Trenches Area during 1996 (WA, 1997e).

### Radium-226

Radium-226 (Ra-226) was detected above background (0.77 pCi/g) in only 15 of 55 soil samples, and six of 15 solid waste samples collected from the Southwest Trenches Area. The maximum Ra-226 activities reported during the LFI in solid waste and soil were 7.06 pCi/g and 2.44 pCi/g, respectively. Ra-226 activities in soil as high as 3.94 pCi/g were reported in previous investigations. The extent of Ra-226 activity above background appears to be confined to solid waste and soil within, and immediately below, the disposal trenches and pits.

### SVOCs

PAHs typical of wood preservatives were detected at a total concentration of over 34,000 mg/kg in one wood sample, which was removed for disposal. PAHs were also detected at approximately 780 mg/kg in the bagged sludge sample, which was also removed. Soil samples collected immediately under these wastes contained no detectable SVOCs. In fact, only one soil sample from the Southwest Trenches Area contained detectable SVOCs.

**Chlordane**

Chlordane was measured in trace concentrations in the majority of samples collected from the Southwest Trenches Area, in both shallow and deeper soil samples. The maximum concentration of chlordane measured in samples collected during the LFI was 3.6 mg/kg. This soil sample (S-484) was collected from a depth of 3.5 ft bgs in the southwest corner of the Site. Chlordane was detected at a concentration of 2,000 mg/kg in this area in a previous investigation; however, shallow soil samples collected near the reported location of this sample (S-484, S-485, S-486) contained far lower chlordane concentrations. Trace chlordane concentrations were measured in soil samples collected from as deep as 30 ft bgs in the Southwest Trenches Area. No consistent pattern of vertical attenuation of chlordane in soil was observed; soil at depth appears to be as likely to contain chlordane as shallow soil. However, chlordane in soil in the Southwest Trenches Area does not appear to have affected ground water, as chlordane was not detected in any of the ground water samples collected from this area during 1996 (WA, 1997e).

Based on the LFI data, neither the southwest chemical storage area nor the washdown pad could be confirmed as source areas for chlordane. While chlordane was detected in shallow soil surrounding both of these locations, the observed concentrations are no higher than measured at other locations in the Southwest Trenches Area.

**Nitrate**

Nitrate concentrations significantly above background (10 mg/kg) were measured in 24 of 70 soil and solid waste samples collected from the Southwest Trenches Area during the LFI. Nitrate levels as high as 390 mg/kg were measured and nitrate levels in excess of twice the background concentration were observed in 19 of the 24 samples. However, the extent of elevated nitrate appears to be confined within and beneath disposal trenches and pits. No significant nitrate concentrations were measured in shallow soil samples collected outside the waste disposal areas. However, nitrates do not appear to be vertically confined to soil immediately beneath the waste trenches. Nitrate concentrations exceeding background were measured in soil samples collected from as deep as 15 ft bgs beneath the waste trenches. However, nitrate was not detected above background in any of the ground water samples collected from the Southwest Trenches Area during 1996 (WA, 1997e).

### *3.1.3 Waste Disposal Characteristics*

The potential exists that some wastes or wastes, which may be excavated during removal activity, may be classified as mixed waste. Total contaminant levels in the waste removed and soil samples collected during the LFI were compared with the Toxicity Characteristic (TC) levels for leachate derived from the TC Leaching Procedure (TCLP) defined under the Resources Conservation and Recovery Act (RCRA). As a general rule of thumb, soil that exhibits total contaminant concentrations, which are less than 20 times the TC levels (see Table 3-4), will produce TCLP leachate concentrations less than the TC levels and are unlikely to be classified as hazardous waste based on toxicity. All RA waste will be analyzed in accordance with an approved Sampling and Analysis Plan to be developed with the RA Work Plan prior to the RAs.

Chlordane was the only COC detected in any of the samples collected during the LFI that exceeded twenty times the TC limit. The maximum reported concentration of chlordane (3.6 mg/kg) is above twenty times the TC limit (0.6 mg/l). Additionally, chlordane levels far in excess of those reported in the LFI have been detected in previous sampling events. Thus, there is some potential for soil leachate to exceed the TC limit for chlordane, which would result in classification of that soil volume as a hazardous waste.

Excavated trench soil and waste from previous investigations was disposed as low level radioactive waste; therefore, the potential for characterization of excavated soil from the Southwest Trenches Area as mixed waste is relatively low. Radionuclide levels and other constituents, which might render the waste toxic, were low in soil samples collected during the LFI. Characterization of wastes will be required prior to disposal to ensure compliance with disposal facility requirements.

## 3.2 Radium-226/Strontium-90 (Ra/Sr) Treatment Systems Area

The Ra-226 Treatment System consisted of two septic tanks, each with two compartments separated by a weir, an effluent distribution box feeding three dry wells and a leach trench, and associated distribution pipelines (Figure 3-6) (Chemical Waste Management, 1992). Cross-sections of the leach trench and dry wells are included as Figure 3-8 and 3-9, respectively.

A cumulative total of 6.129 milliCuries (mCi) of Ra-226 was injected into beagles housed in AH-2 (DOE, 1988). Of that total, approximately 3.827 mCi were subsequently discharged to the Ra-226 Treatment System (Dames and Moore, 1993, 1994a). After settling of solids in the septic tanks, fluids were piped out of the tanks through the distribution box to the three dry wells and the leach field (Weiss Associates, 1997a).

The two septic tanks, with a combined capacity of 14,400 gallons, are located between AH-2 and the former Imhoff Building (Figure 3-6). Currently, the tanks are empty. The contents of the septic tanks were homogenized, pumped, solidified, and shipped to the Hanford facility in the state of Washington for disposal as a low-level waste in 1992 (Chemical Waste Management, 1992).

The three Ra-226 dry wells were installed to facilitate subsurface infiltration of waste water. These dry wells, each with a diameter of about 2.5 ft, consist of open boreholes filled with gravel to a depth between about 6 ft and 40 ft bgs (DOE, 1988). While, the dry wells reportedly received primarily waste water from the Ra-226 Treatment System, Sr-90 may also be present.

Because of frequent exceedences of the infiltration capacity of the original dry well system, a cobble-lined leach trench was added in 1965. This trench extends toward the south from the dry wells and is aprroximately 91 ft long, 3 ft wide, and 14 ft deep (Figure 3-7). A second leach trench, extending toward the north, is shown on several engineering drawings of the area; however, its location has not been confirmed in the field (Weiss Associates, 1997a).

The Sr-90 Treatment System consisted of filters and cation exchange columns, a series of nine "Imhoff" tanks (Tanks A through I), and a leach field. The tanks are lined with concrete coated

with plastic sealant and are located in the ground beneath the area once occupied by the Imhoff Building. The total capacity of these Imhoff tanks is 46,000 gallons. In 1962, Building H-322 was built over the "original" leach field; therefore, a second leach field, commonly referred to as the "existing" leach field, was constructed to replace the original field (Figure 3-6).

The Imhoff system was used to treat approximately 200 to 500 gallons of waste per day prior to discharging it to the leach field. During the 27 years the Imhoff system operated, approximately 710 batches of effluent from Sr-90 experiments totaling about 3.2 million gallons were treated (DOE, 1988). The total throughput of Sr-90 through the Imhoff system is estimated between 645 and 943 mCi. After treatment through the Imhoff system, an estimated 2.55 mCi of Sr-90 was released to the Imhoff leach field and subsurface soil. The half-life of Sr-90 is 29 years. In addition to Sr-90, a total of 39.59 μCi of plutonium-241 (Pu-241) and 0.136 μCi of americium-241 (Am-241) was processed through the Imhoff treatment system (DOE, 1988).

The average concentration of Sr-90 reportedly released to the leach field was in compliance with the $3x10^{-7}$ μCi/ml standard established by the Nuclear Regulatory Commission (NRC) (Dames & Moore, 1993). Records indicate that this concentration was exceeded occasionally in individual batch discharges due to a faulty valve that allowed raw waste to mix with treated batches. In 1987, a deionized water spill introduced additional water to the system and allowed cross-contamination of partially treated waste.

During operation, the tanks periodically filled up with sludge, which was removed by a subcontractor or pumped to a tanker trailer, and disposed off-site. The Imhoff system has been inactive since 1987. In 1989, UC Davis collected samples of the liquid and sludge remaining in the Imhoff tanks to characterize the materials for disposal. The materials were reported to have varying levels of radioactivity and SVOC concentrations (Dames & Moore, 1994a).

In 1991 and 1992, liquids and sludge remaining in the Imhoff tanks were removed, solidified, and disposed at the Hanford facility as low-level radioactive waste. During the sludge removal operations, the plastic sealant in all tanks was observed to be cracked and blistering, leaving concrete exposed (Chemical Waste Management, 1992). The integrity of the Imhoff tanks has never been tested. Currently, approximately 250 gallons of sludge remains in Imhoff Settling Tank (Tank A). This sludge will be characterized in fall 1997.

A chronology of previous site investigations at this area is presented in Table 3-5. Locations of pre-1996 and LFI soil sample locations are presented in Figure 3-6 and 3-7, respectively.

### *3.2.1 Constituents of Concern Above Background Levels*

Chemical compounds and radionuclides detected above background in soil samples from these investigations are detailed in Table 3-6 and are listed below.

**Radionuclides:**

Ra-226, Sr-90, gross alpha, gross beta, tritium, bismuth-214, potassium-40, cobalt-60, actinium-228, lead-212, lead-214, Cs-137, thorium-232, carbon-14, thallium-208, thorium-228, thorium-234, uranium-235

**Metals:**

Beryllium, cobalt, chromium, hexavalent chromium, copper, manganese, thallium, lead, zinc and vanadium

**VOCs:**

Methylene chloride

**SVOCs:**

PAHs including phenanthrene, fluoranthrene, pyrene, benzoanthracene, chrysene, benzofluoranthene, and others

**Pesticides**

DDD, DDT

**Other compounds:**

Nitrate, sulfate

While all of these compounds were detected in samples collected from the Ra/Sr treatment area, the majority were detected in only one or two samples. Soil sample analytical results are summarized on Figures 3-10 and 3-11 for the Ra-226 Leach System and Sr-90 Leach System, respectively. Figure 3-12 shows results for four near-surface samples collected along the Old Davis Road storm water ditch to assess potential impacts from the Ra-226 system overflows. Many of the organic compounds were detected in only trace concentrations and many of the metals and radionuclides were detected in concentrations, which only slightly exceeded the background concentrations for the Site. Compounds that were either present at significant concentrations or laterally persistent throughout the Ra/Sr area include:

- Ra-226;
- Sr-90;
- Gross Alpha;
- Gross Beta;
- Nitrate; and,
- Sulfate.

The following section describes the extent of each of these chemical compounds/radionuclides in the soil in the Ra/Sr area.

### *3.2.2 Extent of Contamination*

**Radium-226**

Radium-226 was detected at concentrations exceeding the 0.77 pCi/g background level in 34 of the 62 samples collected from the Ra/Sr area during the LFI. The maximum reported activity for Ra-226 was 106.2 pCi/g in the distribution box sediment sample, S-427. The highest Ra-226 activity in soil, however, was only 14.7 pCi/g in sample S-422 collected at 9.5 ft bgs in Trench 4. The other 32 samples above background had activities ranging from 0.79 to 8.2 pCi/g. Ra-226 was not detected above background in previous soil investigations in the Ra/Sr area.

Ra-226 activities were detected above background in each of the five soil borings, SB-1 through SB-5. Ra-226 activities in each boring decreased with depth. In addition, Ra-226 is not detected above background in nearby downgradient well, UCD1-22. Laterally, Ra-226 appears to be confined to the vicinity of the Ra-226 dry wells, associated piping, and the leach line, based on the absence of Ra-226 above background in all samples from the Sr-90 system trenches.

**Strontium-90**

Sr-90 was detected above background (0.36 pCi/g) in 26 of the 52 Ra/Sr area LFI samples analyzed. However, as noted on Figures 3-10 and 3-11, many of the Sr-90 results may be erroneously high due to laboratory analytical problems (WA, 1997a). The highest reported Sr-90 activity of 2.18 pCi/g was measured in S-427, collected from the Ra-226 system distribution box. The next highest Sr-90 activities were detected in samples S-426 (1.82 pCi/g) from Trench 5 at 11 ft and in S-384 (1.61 pCi/g) from 5 ft 4 in. bgs adjacent to a Sr-90 system leach line. Sr-90 was only detected above background in one sample from the previous investigations at 0.61 pCi/g from soil boring SB-28 at 10 ft. Laterally and vertically, Sr-90 does not appear to be confined to any particular area. Sr-90 levels above background were reported in samples in both the Ra-226 area and the Sr-90 area. However, the most significant reported activities are associated with the Ra-226 system rather than the Sr-90 system.

**Gross Alpha and Gross Beta**

Gross alpha and gross beta were detected above their background levels of 11.8 pCi/g and 17.4 pCi/g in 13 and 16 LFI samples, respectively, from the Ra/Sr area. The maximum reported gross alpha activity in LFI samples was 46 pCi/g in soil and 185 pCi/g in the distribution box sample. The maximum reported gross beta activity in LFI samples was 39.7 pCi/g in soil and 156 pCi/g in the distribution box sample. The highest activities of both gross alpha and gross beta in soil were detected in S-437 at a depth of 18-20 ft in soil boring SB-1. For the most part, gross alpha and beta activity above background appears to be confined to soils between 10 and 20 ft. Both are detected in all areas associated with the Ra-226 Treatment System. In general, gross beta activities are similar to the total activities of the individual beta emitters (including Sr-90, tritium and K-40) analyzed for each sample. However, gross alpha activities are significantly higher than those for Ra-226, the only individual alpha emitter analyzed, suggesting that other alpha emitters are present.

**Nitrate**

Nitrate concentrations above background (10 mg/kg) were measured in 28 of 62 soil samples collected from the Ra/Sr area during the LFI. Nitrate levels as high as 110 mg/kg were measured, and nitrate levels in excess of twice the background concentration were observed in 16 of the 28 samples. Nitrate was detected above background in previous investigations in 18 of 49 samples. Eleven of the samples were in excess of twice the background level. In previous investigations, nitrate was detected to a depth of 30 ft in the leach field in the Sr-90 area and to 15 ft bgs in the Ra-226 area. However, in LFI samples, nitrate was detected in only four samples from the Sr-90 area at depths of 10.8 ft or less in Trench 1. In the Ra-226 area, nitrate was detected above background at depths up to 31 ft bgs.

**Sulfate**

Sulfate concentrations above background (36 mg/kg) were measured in 22 of 62 soil samples collected during the LFI from the Ra/Sr area. The highest sulfate detected was 400 mg/kg in sample S-427 from the Ra-226 system distribution box. Sulfate levels as high as 270 mg/kg were measured in sample S-462, and sulfate levels exceeding twice the background concentration were observed in two other samples. Sulfate was not detected in previous investigations above background concentrations.

### *3.2.3 Waste Disposal Characteristics*

Some investigative derived wastes (IDW) uncovered during field activities or wastes, which may be excavated during a removal activity, may be classified as mixed waste. There is a potential to encounter lead joints from distribution pipes and possible tank master sealants, which would classify as mixed waste. WA compared total contaminant levels in soil samples collected during the LFI with 20 times the TC limits (Table 3-4). None of the contaminants detected in any of the samples collected from the Ra/Sr Area during the LFI exceeded twenty times the TC limits.

Based on all investigations to date, the potential for characterization of soil from the Ra/Sr area as mixed waste is quite low. However, characterization of wastes will likely be required prior to disposal.

## 3.3 Domestic Septic System Areas

There are seven domestic septic tanks located throughout the LEHR Site, which collectively constitute the Domestic Septic System Areas (Figure 3-13). A Domestic Septic System is defined as a septic tank, leach field, and interconnecting piping. Liquid wastes and sewage were discharged to six on-site septic tanks (Septic Tank Nos. 1, 2, 3, 4, 5 and 6) prior to 1971. In 1971, the LEHR facility was connected to the currently active UC Davis sewage treatment plant. A seventh septic tank, Septic Tank No. 7, was installed adjacent to the Cobalt-60 field to receive wastes from that building; this tank was reportedly not used, and was abandoned in 1988 (Dames & Moore, 1994a). Septic Tank Nos. 1, 2, 3, 4, 5 and 6, reportedly received all liquid wastes from the facility except for

Sr-90 and Ra-226 wastes. Domestic sewage is not classified as hazardous waste. However, the LEHR septic systems may have potentially received influent from laboratory sinks and floor drains. Therefore, the potential exists that hazardous and/or radioactive materials were disposed to these septic systems during the operation of the LEHR facility. For example, during a sewer backup of the Ra-226 system, Septic Tank No. 2 reportedly received effluent from Animal Hospital No. 2 (AH-2) (Figure 3-14).

In 1971, Septic Tank Nos. 1, 2, 3, 4, 5 and 6, were reportedly backfilled with sand and the influent/effluent lines for each tank were reportedly cut and capped (IT Corporation, 1996). No formal closure reports for Septic Tank Nos. 1, 2, 3, 4, 5 and 6, have been discovered.

Septic Tank No. 1 (Figure 3-14) was positively located as part of preliminary work conducted during the Phase II Site Characterization (Dames and Moore, 1993). Septic Tank No. 1 is a concrete, 5-ft diameter, 6-ft high, approximately 800-gallon capacity, vertically oriented cylindrical tank.

The location of Septic Tank No. 2 was positively identified during backhoe exploration and sampling in June 1995 (Figure 3-14). Septic Tank No. 2 is located within the leach field for the Ra-226 treatment system. It is reported that during backup of the Ra-226 system, Septic Tank No. 2 received effluent from AH-2.

In 1996, as part of the LFI, exploratory trenches were excavated using a backhoe around Septic Tank No. 7. Septic Tank No. 7 was located on the north side of the Cobalt-60 Building. Septic Tank No. 7 is a concrete tank whose exact size was not confirmed. The long axis of Tank No. 7 is oriented north south.

In June and September 1997, a Data Gap Investigation was conducted for the Septic Tank System0 Nos. 1, 3, 4 and 6. Results of this investigation are presented in a technical memorandum (WA, 1998).

Constituents detected above background in soil collected from Domestic Septic System Nos. 1, 3, 4, 6 and 7 are presented in Figures 3-14, 3-15, 3-16 and 3-17. Constituents detected above background in soil collected from the vicinity of Septic Tank No. 2 are discussed in Section 3.2.2 (Ra-226 Seepage Trench). Table 3-9 presents the maximum concentration above background of constituents detected in soil. Significant analytic results are discussed below.

### *3.3.1 Constituents of Concern Above Background Levels*

Chemical compounds detected above background in the soil samples from these previous investigations at the domestic septic tanks are detailed in Table 3-8 and Table 3-9, and are listed below:

**Radionuclides:**

Carbon-14, radium-226, bismuth-214, cesium-137, gross alpha, gross beta, strontium-90, thallium-208, tritium and uranium-235.

**Metals:**

Copper, zinc, mercury, arsenic, cadmium, chromium, hexavalent chromium, iron, lead, manganese, nickel and vanadium

**Other Compounds:**

Nitrate, chloride, sulfate, 1,2-dichloroethene, trichloroethene and Aroclor-1254

While all of these compounds were detected in the samples taken from the domestic tanks, the majority were detected in only one or two samples. Soil sample analytical results for the domestic tanks are presented in Figures 3-14 through 3-17. Compounds which were present at significant concentrations include the following:

**Radionuclides:**

Radium-226, tritium

**Metals:**

Mercury

**Other Compounds:**

Nitrate, chloride

### *3.3.2 Extent of Contamination*

Domestic Septic System No. 1

Radium-226, Sr-90, gross beta, copper, manganese, and zinc were detected in some soil samples taken adjacent to Septic Tank No. 1 at activities/concentrations that are less than 2 times the background levels (see Figure 3-14 and Table 3-9). Carbon-14 was detected at 2.1 pCi/g in the sample at 7.5-ft depth, less than 3 times the background level of 0.87 pCi/g.

Investigation of Trench T1A, located south of Septic Tank No. 1, detected radium-226, bismuth-214, thallium-208, uranium-235, gross alpha, manganese, vanadium, and zinc at activities/concentrations that are less than 2 times the background levels (see Figure 3-14 and Table 3-9). Nitrate was detected at 23.5 mg/kg in the sample at 7.5 ft depth, less than 3 times the background level of 10 mg/kg. Tritium was detected at 340 pCi/L in the sample at 5 ft depth; the background level is 105 pCi/L. 1,2-Dichloroethene (1,2-DCE), trichloroethene (TCE), and Aroclor-1254 were also detected in the sample collected from 12.5-ft depth, at low concentrations of 0.004, 0.010, and 0.091 mg/kg, respectively.

Domestic Septic System No. 2

Constituents detected above background in soil collected from the vicinity of Domestic Septic System No. 2 are discussed in Section 3.2.2 (Ra-226 Seepage Trench).

Domestic Septic System No. 3

Radium-226, bismuth-214, thallium-208, uranium-235, arsenic, chromium (VI), copper, iron, manganese, and vanadium were detected in some soil samples at activities/concentrations that are less than 2 times the background levels (see Figure 3-15 and Table 3-9). Zinc was detected at 258 mg/kg in the sample at 8-ft depth, slightly more than 3 times the background level of 82 mg/kg. Cesium-137 was detected at 0.126 pCi/g in the sample at 8-ft depth, less than 3 times the background level of 0.053 pCi/g.

Domestic Septic System No. 4

Total chromium, lead, nickel, vanadium, and zinc were detected in some soil samples at concentrations that are less than 2 times the background levels (see Figure 3-15 and Table 3-9). Mercury was detected at 1.52 mg/kg in the sample at 5.5-ft depth, slightly more than 3 times the background level of 0.49 mg/kg. However, mercury was detected at a low concentration of 0.99 mg/kg (less than 2 time background) for the co-located sample collected on 9/17/97 (LEHR-S-T404). Mercury was detected below background at sample depths of 8.0 and 13.0 ft. Tritium was detected at 1270 pCi/L in the sample at 8 ft depth; the background level is 105 pCi/L. Uranium-235 was detected at 0.16 pCi/g in the sample at 5.5 ft depth, less than 3 times the background level of 0.071 pCi/g.

Domestic Septic System No. 5

No samples were taken from the area of investigation for Tank 5. The location of the tank was undetermined. However, it is believed that a building has been constructed atop Tank 5 and that the effluent drained to the Septic System No. 1 leach field. Facility drawings indicate the effluent line from Tank 5 was installed at an angle in the approximate direction of Domestic Septic System No. 1 leach field and a pipe was field located draining into the leach field from the purported direction of Tank No. 5.

Domestic Septic System No. 6

Radium-226, bismuth-214, thallium-208, iron, vanadium, and zinc were detected in some soil samples at activities/concentrations that are less than 2 times the background levels (see Figure 3-16 and Table 3-9). Tritium was detected at 460 pCi/L in the sample at 8 ft depth; the background level is 105 pCi/L. Uranium-235 was detected at 0.16 pCi/g in the sample at 8 ft depth, less than 3 times the background level of 0.071 pCi/g. Trichloroethene (TCE) was also detected in the sample collected from 8.0 ft depth, at a low concentration of 0.004 mg/kg.

Mercury was detected at a concentration of 49.4 mg/kg in the sample collected from 5.5 ft depth on 6/12/97 (LEHR-S-T601). However, a significantly lower concentration (0.15 mg/kg of mercury was detected for a co-located sample collected on 9/17/97 (LEHR-S-T604). It was noted that the sample LEHR-S-T604 consisted of clayey silt soil only, whereas the sample LEHR-S-T601 consisted of both clayey silt soil and sand/gravel material. The clayey silt soil and sand/gravel materials were analyzed (outside the holding time and; therefore, not validated) separately, on 11/7/97 and 11/12/97, respectively. Mercury was not detected in the clayey silt soil, but was detected in the sand/gravel material at 16.8 mg/kg. The background level for mercury is 0.49 mg/kg.

Domestic Septic System No. 7

Radium-226, strontium-90, uranium-235, barium, copper, manganese, zinc, and sulfate were detected in some soil samples at activities/concentrations that are less than 2 times the background levels (see Figure 3-17 and Table 3-9). Chloride was detected at 100 mg/kg in the sample at 12 ft depth; the background level is 14 mg/kg. Nitrate was detected at 120 mg/kg in the sample at 9.5 ft depth; the background level is 10 mg/kg. Formaldehyde was also detected in the sample collected from 12 ft depth, at a concentration of 2.2 mg/kg.

### *3.3.3 Waste Disposal Characteristics*

Some IDW produced during field activities or wastes that may be excavated during a removal activity could be classified as mixed waste. WA compared total contaminant levels in soil samples collected during the LFI with 20 times the TC limits (see Table 3-4). None of the contaminants detected in any of the samples collected from the septic tank systems during the LFI exceeded these levels.

## 3.4 Vadose Zone Modeling

One-dimensional vadose zone modeling was performed to estimate the downward contaminant transport in unsaturated sediments beneath the LEHR Site. The modeling was limited to the DOE Areas addressed by this EE/CA (WA, 1997b).

### *3.4.1 Model Methodology*

Soil boring logs from the Site were used to develop three generalized stratigraphic columns representing the primary areas of concern at the Site. Contaminant transport simulations were conducted using these geologic zones to evaluate the effects of varying sediment types beneath the Site on contaminant migration. Five Indicator Constituents (ICs) were selected to represent site COCs. These ICs are nitrate, Ra-226, Sr-90, chlordane, and hexavalent chromium.

Site characterization data indicate that elevated levels of COCs are generally limited to the upper few feet of soil beneath the Site. To conservatively represent contaminant spatial distribution, initial IC concentrations were assigned to the upper 6 feet of the soil. Sensitivity analyses indicate that the travel time to the simulated water table of a non-sorbing IC, (e.g. nitrate), is not highly sensitive to the initial contaminant distribution depth. However, the maximum calculated ground water concentration is sensitive to the quantity of contaminant mass assigned to the model. As described above, the initial IC concentrations were assigned to the uppermost sediments in these models.

The calculated results are also sensitive to the surficial infiltration rate applied to the model. Based on soil moisture content data and analytical results of soil samples, it was estimated that the

average infiltration rate may be approximately 3 centimeters per year (cm/yr) at the Site, which is less than 10% of the average annual precipitation. Higher infiltration rates, up to 50% of the average annual precipitation, were also applied to the models to evaluate the effects of this parameter on contaminant transport rates.

Although contaminants may exist at greater depths, it is not likely that the total contaminant mass in soil beneath the Site is greater than the mass assigned to the models. Based on this and other conservative assumptions, the ground water concentrations calculated by these models should represent an upper limit of potential ground water impact.

### *3.4.2 Model Results*

Results of the LEHR vadose zone modeling indicate that observed levels of Ra-226, Sr-90, and chlordane in soil beneath the Site should not result in ground water activities/concentrations that exceed either the Maximum Contaminant Levels (MCLs) or the 95% Upper Threshold Limit (UTL) of background concentrations (WA, 1997b). The modeling results are summarize below.

Considering the magnitude of the Sr-90 initial activity and the relatively short 29 year half-life of this radionuclide, it appears that levels of Sr-90 observed at the Site in the upper portion of the vadose zone should not impact ground water at levels near either the 1.63 pCi/L 95% UTL or the 8 pCi/L MCL. Similarly for Ra-226, the model results suggest that even extremely high (mCi/L) shallow soil concentrations should not impact ground water above either the 95% UTL or the MCL, when the baseline 3 cm/yr infiltration rate is assumed. When higher infiltration rates are applied to the NUFT model, the concentrations of radionuclides allowed to remain in the ground decreases. For example the 1997 NUFT modeling results for Ra-226 at a depth of 0-6 feet bgs are presented below:

| Infiltration Rate | Allowable Soil Concentration | GW Concentration |
|---|---|---|
| 3 cm/yr (10%) | 10,000,000 pCi/g | 2.7 pCi/L |
| 10 cm/yr (25%) | 100 pCi/g | 1.9 pCi/L |
| 21.5 cm/yr (50%) | 23 pCi/g | 4 pCi/L |

Model results for chlordane indicate that, due to its assumed high $K_d$ value of 650 L/kg, the transport velocity is extremely slow. The time estimated for the peak concentration of chlordane to reach the water table beneath the Southwest Trenches is more than 20,000 years even when an unrealistically high infiltration rate equal to 50% of the average annual precipitation is applied. This calculated peak concentration of $1 \times 10^{-4}$ mg/L (0.1 µg/L) is equivalent to the chlordane MCL. Chlordane is not a naturally occurring chemical, hence there is not a corresponding background concentration. The initial chlordane concentration of 100 mg/kg assigned to this model is considerably higher than the maximum concentration of 15 mg/kg observed in soil beneath the Site (WA, 1997a). A very high infiltration rate was conservatively assumed in addition to the assumption that no degradation would occur during the 20,000 year travel time. Therefore, it is reasonable to assume that chlordane does not pose a significant risk to the quality of ground water beneath the Site.

Results of hexavalent chromium simulations indicate that concentrations in shallow soil of 1 mg/kg should not impact ground water above the 0.0229 mg/L (22.9 µg/L) 95% UTL for hexavalent chromium. Similarly, the calculated peak ground water concentrations should not exceed the 0.05 mg/L (50 µg/L) MCL for total chromium if shallow soil concentrations are less than 10 mg/kg. These results were based on a simulation of hexavalent chromium transport beneath the Southwest Trenches using a $K_d$ value of 10 L/kg and a constant infiltration rate of 3 cm/yr. The maximum total chromium concentration detected in soil from beneath the Ra/Sr Leach Systems Area is 7 mg/kg (WA, 1997a).

The initial IC soil concentrations were distributed along the generalized soil columns from the ground surface to a depth of 6 ft. Although the contaminants may exist at greater depths, the model results indicate that transport is highly retarded for the sorptive constituents (e.g. chlordane, Sr-90, and Ra-226) and; therefore, the travel times necessary to reach ground water should be extremely large (hundreds to thousands of years). Although it is unlikely based on existing data, if the total contaminant mass in soil beneath the Site is greater than that which was modeled, the peak concentration in ground water may increase. However, the peak concentrations predicted by these models are conservative estimates; and therefore, should represent an upper limit of concentrations that may impact ground water.

The modeling results of nitrate migration to the water table is discussed separately in the next section.

### *3.4.3 Evaluation of Nitrate Results*

Vadose zone modeling results indicate that nitrate will reach the water table (HSU-1) at a peak ground water concentration of 18 mg/l assuming an infiltration rate of 3 cm/yr and an initial soil nitrate concentration of 10 mg/kg evenly distributed from 0 to 6 feet bgs (WA, 1997b). The nitrate peak ground water concentration predicted by the model is below the background ground water nitrate concentration of 25.2 mg/l (UCD1-18), but above the MCL of 10 mg/l. It should be noted that existing regional and background ground water quality has been degraded over the years by irrigation water infiltration to levels above the MCL of 10 mg/l. Furthermore, it appears that the nitrate degradation of ground water in the region continues at a rate of 0.62 mg/l each year (Dames and Moore 1997a). Given the model's prediction that nitrate leaching through the soil will reach ground water in approximately 100 years, it appears that the future ground water impact of nitrate from site soil relative to future regional ground water quality will be insignificant. The predicted nitrate peak concentration in HSU-1 upon arrival in 100 years will be negligible when compared to the existing ground water condition and the degradation trend due to irrigation water infiltration.

Furthermore, the RA is expected to remove a significant volume (over 90%) of soil and waste from the site and replace it with clean fill free of any contamination. Review of the analytical results indicates that all of the nitrate detections above background of 10 mg/kg occur within the proposed areas of excavation. Therefore it is apparent that the total mass of nitrate in soil following the RA will be much less than the mass of nitrate used in the vadose zone modeling. Thus, the predicted future impacts to ground water from site soil following the RA are substantially reduced. Appendix C – Evaluation of Potential Post-Removal Action Ground Water Impact, presents a more detailed discussion of these nitrate issues.

Table 3-1. Background Ranges for Chemical and Radiological Constituents in Soil

| Parameter | Units | Regional Background | | Phase II Background | | 1994 Background | | 1994 Background |
|---|---|---|---|---|---|---|---|---|
| | | Min | Max | Min | Max | Min | Max | 80% LCL on 95th quantile |
| Radionuclides | | | | | | | | |
| Actinium-228 | pCi/g | N/A | N/A | N/A | N/A | 0.31 | 0.84 | 0.71 |
| Bismuth-214 | pCi/g | N/A | N/A | N/A | N/A | 0.426 | 0.67 | 0.57 |
| Carbon-14 | pCi/g | N/A | N/A | N/A | N/A | -4.2 | 2.2 | 0.87 |
| Cesium-137 | pCi/g | N/A | N/A | 0.15 | 0.20 | -0.12 | 0.106 | 0.053 |
| Cobalt-60 | pCi/g | N/A | N/A | 0.17 | 0.17 | -0.034 | 0.0265 | 0.016 |
| Gross Alpha | pCi/g | N/A | N/A | 0.15 | 1.90 | 2.7 | 24.5 | 11.8 |
| Gross Beta | pCi/g | N/A | N/A | 0.40 | 4.70 | 10.1 | 19.6 | 17.4 |
| Lead-212 | pCi/g | N/A | N/A | N/A | N/A | 0.298 | 0.83 | 0.74 |
| Lead-214 | pCi/g | N/A | N/A | N/A | N/A | 0.514 | 0.99 | 0.75 |
| Potassium-40 | pCi/g | N/A | N/A | 2.00 | 46.40 | 8.3 | 14.9 | 13.6 |
| Radium-226 | pCi/g | N/A | 0.77 | 0.05 | 1.40 | -1.37 | 1.74 | 0.77 |
| Strontium-90 | pCi/g | N/A | N/A | 0.03 | 0.24 | -0.86 | 0.57 | 0.36 |
| Thallium-208 | pCi/g | N/A | N/A | N/A | N/A | 0.095 | 0.270 | 0.21 |
| Thorium-228 | pCi/g | N/A | N/A | N/A | N/A | 0.484 | 0.82 | 0.71 |
| Thorium-230 | pCi/g | N/A | N/A | N/A | N/A | 0.57 | 1.32 | 0.80 |
| Thorium-232 | pCi/g | N/A | 0.54 | 0.25 | 1.10 | 0.394 | 0.92 | 0.64 |
| Thorium-234 | pCi/g | N/A | N/A | N/A | N/A | 0.41 | 2.80 | 1.09 |
| Tritium | pCi/L | N/A | N/A | N/A | N/A | -100 | 180 | 105 |
| | pCi/g | N/A | N/A | 0.10 | 0.50 | -0.02[1] | 0.0387 | 0.023 |
| Uranium-233/234 | pCi/g | N/A | N/A | N/A | N/A | 0.370 | 0.724 | 0.66 |
| Uranium-235 | pCi/g | N/A | N/A | N/A | N/A | -0.03 | 0.22 | 0.071 |
| Uranium-238 | pCi/g | N/A | N/A | N/A | N/A | 0.327 | 0.69 | 0.63 |
| Metals | | | | | | | | |
| Antimony | mg/kg | <1 | 2.20 | 0.50 | 26.50 | nd | 0.37 | NA |
| Arsenic | mg/kg | 6.50 | 10.00 | 0.50 | 3.00 | 4.00 | 11.90 | 9.46 |
| Barium | mg/kg | 500.00 | 700.00 | 71.50 | 181.00 | 107.00 | 308.00 | 237 |
| Beryllium | mg/kg | <1 | 1.00 | 0.05 | 3.64 | 0.27 | 0.57 | 0.66 |
| Cadmium | mg/kg | -1.00 | N/A | 0.50 | 18.10 | nd | 0.23 | NA |
| Chromium | mg/kg | 70.00 | 100.00 | 3.00 | 156.00 | 59.60 | 251.00 | 178 |
| Chromium VI | mg/kg | N/A | N/A | N/A | N/A | 0.023 | 0.25 | 0.099 |
| Cobalt | mg/kg | 10.00 | 70.00 | 0.50 | 20.80 | 12.60 | 32.90 | 29 |

Table 3-1. Background Ranges for Chemical and Radiological Constituents in Soil (continued)

| Parameter | Units | Regional Background | | Phase II Background | | 1994 Background | | 1994 Background |
|---|---|---|---|---|---|---|---|---|
| | | Min | Max | Min | Max | Min | Max | 80% LCL on 95th quantile |
| Copper | mg/kg | 30.00 | 50.00 | 14.10 | 55.00 | 20.10 | 59.50 | 50 |
| Iron | mg/kg | N/A | N/A | N/A | N/A | 20600.00 | 46300.00 | 42,000 |
| Lead | mg/kg | 15.00 | 300.00 | 2.00 | 27.00 | 3.40 | 11.90 | 10.1 |
| Manganese | mg/kg | N/A | N/A | N/A | N/A | 437.00 | 870.00 | 720 |
| Mercury | mg/kg | N/A | N/A | 0.02 | 0.19 | 0.10 | 1.60 | 0.49 |
| Molybdenum | mg/kg | <3 | 3.00 | 1.00 | 11.70 | nd | 0.00 | NA |
| Nickel | mg/kg | 15.00 | 300.00 | 5.00 | 198.00 | 78.60 | 404.00 | 326 |
| Selenium | mg/kg | <0.1 | 0.30 | 0.50 | 3.00 | 0.21 | 1.40 | 1.0[2] |
| Silver | mg/kg | N/A | N/A | 1.00 | 7.00 | nd | 0.26 | NA |
| Thallium | mg/kg | N/A | N/A | 1.50 | 32.00 | nd | 0.68 | NA |
| Vanadium | mg/kg | 100.00 | 500.00 | 6.30 | 58.50 | 37.10 | 78.70 | 73 |
| Zinc | mg/kg | 74.00 | 510.00 | 31.60 | 77.40 | 37.60 | 101.00 | 82 |
| Other Parameters | | | | | | | | |
| Alkalinity | mg/kg | N/A | N/A | N/A | N/A | 370 | 1000 | 708 |
| Ammonia | mg/kg | N/A | N/A | N/A | N/A | nd | 17 | 22[3] |
| Chloride | mg/kg | N/A | N/A | N/A | N/A | 0.58 | 46 | 14 |
| Nitrate (as N) | mg/kg | N/A | N/A | N/A | N/A | 0.41 | 45 | 10 |
| pH | pH units | N/A | N/A | N/A | N/A | 8.0 | 10 | 10.2 |
| Specific Conductivity | µS/cm | N/A | N/A | N/A | N/A | 30 | 620 | 338 |
| Sulfate | mg/kg | N/A | N/A | N/A | N/A | 2.6 | 53 | 36 |
| Sulfide | mg/kg | N/A | N/A | N/A | N/A | nd | 15 | 30[3] |

Notes:

[1]Tritium values in pCi/g calculated from laboratory results in pCi/L, assuming 18% moisture content.
[2]Three selenium and four mercury results were below the detection limit. These results were assumed to be at the detection limit for calculation purposes.
[3]95th quantile used instead of 80% LCL on 95th quantile. 80% LCL in 95th quantile was a negative number.
N/A = Not Available nd = not detected LCL = lower confidence level

Table 3-2. Investigation Chronology, Southwest Trenches Area

| Date | Characterization Activity | Result |
|---|---|---|
| 1984 | Rockwell soil sampling. | Sr-90, Ra-226, and Carbon-14 (C-14) detected above background in soil samples (Rockwell, 1984). |
| 10/87 | Shallow monitor well UCD1-4 installation. | |
| 1987-1988 | Exploratory trenches (EX-01 through EX-11). | Soil samples analyzed for radionuclides only, field readings up to 2,500 counts per minute (cpm) recorded in trench EX-11 (Wahler, 1989). |
| 3/90 | Three soil borings (SB-19 through SB-21), deep monitor well UCD2-15 installation. | Beryllium exceeded background concentrations. Ra-226 detected at maximum concentration of 0.9 pCi/g (Dames & Moore, 1993). |
| 10/90 | Shallow monitor well UCD1-23 installation. | Transmissivity value calculated (Dames & Moore, 1993). |
| | Slug test on UCD1-23. | |
| 5/92 | Resampling/analysis of trench samples from EX-01 through EX-10. | Chlordane detected up to 2,000 mg/kg in T-06 compoSite (Dames & Moore, 1993). |
| 11/94 | Ground-penetrating radar survey. | Trenches tentatively located, additional anomalies located in eastern half of area (Norcal, 1994). |
| 1/95 | Soil gas survey. | Chloroform, Freon-12, toluene, and xylene detected at low concentrations (PNNL, 1995). |
| 5/95 | Two soil borings to evaluate two geophysical/soil gas anomalies. | Total chromium detected above background (PNNL, 1995). |
| 6/95 | Three surface soil samples analyzed (SSL00001 – SSL00003). | Cesium-137 (Cs-137) exceeded background (PNNL, 1995). |
| 7-8/96 | Limited Field Investigation. | |
| | Surface radiation survey on a 10 ft by 10 ft grid spacing. Six exploratory trenches. Thirty-eight soil and solid waste sample. Three soil borings to depths of 30-38 ft bgs. Geophysical logging (gamma and inductive resistivity) of one borehole. Sixteen soil samples from the soil borings for laboratory analysis. Fourteen shallow soil samples at depths of less than 5 ft bgs for laboratory analysis. | Ra-226 up to 7.06 pCi/g, Sr-90 up to 16,700 pCi/g, Gross Beta up to 34,700 pCi/g, SVOCs up to 30,947 mg/kg, chlordane up to 3.6 mg/kg were detected. Several other radionuclides, metals and other organics were detected above background. |

Table 3-3. Analytes Detected in Soil/Waste Above Background Southwest Trenches

| Analyte | Max. Activity/ Concentration | Background | Sample No. | Matrix | Location | Depth (ft bgs) | Date |
|---|---|---|---|---|---|---|---|
| **Radionuclides (pCi/g)** | | | | | | | |
| Cs-137 | 23.0 | 0.053 | S-350 | Soil | Grid 7-9 | 5 | Jul-96 |
| Sr-90 | 16,700 | 0.36 | S-340 | Sludge | T-2, T-6 | 6.5 | Jul-96 |
| Ra-226 | 7.06 | 0.77 | S-338 | Gravel | T-2 | 6.5 | Jul-96 |
| Gross Alpha | 16.7 | 11.8 | S-357 | Soil | T-6, Pit No. 2 | 14.5 | Jul-96 |
| Gross Beta | 34,700 | 17.4 | S-340 | Sludge | T-2, T-6 | 6.5 | Jul-96 |
| Tritium | 91.1 | 0.023 | S-347 | Gravel | T-5 | 1.5 | Jul-96 |
| Pb-214 | 4.3 | 0.75 | S-342 | Plastic Bag | T-2 | 3.5 | Jul-96 |
| U-235 | 2.6 | 0.072 | S-362 | Wood | T-6, Pit No. 1 | 12 | Jul-96 |
| Ac-228 | 5.5 | 0.71 | S-342 | Plastic Bag | T-2 | 3.5 | Jul-96 |
| C-14 | 117.0 | 0.87 | S-339 | Bone | T-2 | 6 | Jul-96 |
| Tl-208 | 0.6 | 0.21 | S-340 | Sludge | T-2, T-6 | 6.5 | Jul-96 |
| K-40 | 16.7 | 13.6 | S-473 | Soil | SB-7 | 21 | Aug-96 |
| Bi-214 | 1.68 | 0.57 | S-356 | Soil | T-6 | 1 | Jul-96 |
| Co-60 | 0.04 | 0.016 | S-340 | Sludge | T-2, T-6 | 6.5 | Jul-96 |
| Th-234 | 39.5 | 1.09 | S-362 | Wood | T-6, Pit No. 1 | 12 | Jul-96 |
| **Metals (mg/kg)** | | | | | | | |
| Arsenic | 9.7 | 9.46 | S-481 | Soil | SB-8 | 30 | Aug-96 |
| Barium | 270 | 237 | S-336 | Soil | T-2 | 3.5 | Jul-96 |
| Beryllium | 4.80 | 0.66 | --- | Soil | SB-20 | 0.0 | Mar-90 |
| Chromium VI | 1.2 | 0.099 | --- | Soil | SB-19 | 0.0 | Mar-90 |
| Chromium | 250 | 178 | S-349 | Soil | T-5 | 4 | Jul-96 |
| Cobalt | 35.00 | 29 | --- | Soil | SB-21 | 10.0 | Mar- 96 |
| Copper | 890 | 50 | S-340 | Sludge | T-2 | 6.5 | Jul-96 |
| Iron | 46,000 | 42,000 | S-352 | Soil | Grid 7-9 | 3.5 | Jul-96 |
| Lead | 49 | 10.1 | S-340 | Sludge | T-2 | 6.5 | Jul-96 |
| Manganese | 1,000 | 720 | S-357 | Soil | T-6 | 14.4 | Jul-96 |
| Mercury | 5.2 | 0.49 | S-483 | Soil | SW Corner of Site | 3 | Aug-96 |
| Nickel | 420 | 326 | S-495 | Soil | Washdown Pad | 3-4.5 | Aug-96 |
| Selenium | 1.5 | 1.0 | S-340 | Sludge | T-2 | 6.5 | Jul-96 |
| Vanadium | 82 | 73 | S-481 | Soil | SB-8 | 30 | Aug-96 |
| Zinc | 730 | 82 | S-340 | Sludge | T-2 | 6.5 | Jul-96 |
| **VOCs (mg/kg)** | | | | | | | |
| Benzene | 0.001 | N/A | S-359 | Gravel | 7-6, Pit No. 1 | 12 | Jul-96 |
| Carbon tetrachloride | 0.044 | N/A | S-352 | Soil | Grid 7-9 | 3.5 | Jul-96 |
| Ethylene Benzene | 1.2 | N/A | S-362 | Wood | T-6, Pit No. 1 | 12 | Jul-96 |
| 2-Hexanane | 0.075 | N/A | S-362 | Wood | T-6, Pit No. 1 | 12 | Jul-96 |
| Methylene | 0.03760 | N/A | --- | Soil | UCD1-15 | N/A | Mar-96 |

Table 3-3. Analytes Detected in Soil/Waste Above Background in Southwest Trenches (continued)

| Analyte | Max. Activity/ Concentration | Background | Sample No. | Matrix | Location | Depth (ft bgs) | Date |
|---|---|---|---|---|---|---|---|
| Chloride | | | | | | | |
| Toluene | 0.49 | N/A | S-362 | Wood | T-6, Pit No. 1 | 12 | Jul-96 |
| Styrene | 0.80 | N/A | S-362 | Wood | T-6, Pit No. 1 | 12 | Jul-96 |
| Xylenes | 6.2 | N/A | S-362 | Wood | T-6, Pit No. 1 | 12 | Jul-96 |
| **SVOCs (mg/kg)** | 30,947 | N/A | S-362 | Wood | T-6, Pit No. 1 | 12 | Jul-96 |
| **Pesticides (mg/kg)** | | | | | | | |
| Chlordane | 2,000 | N/A | --- | Soil | T-06 | N/A | 1988 |
| DDD | 0.26 | N/A | S-484 | Soil | Shallow soil | 3.5 | Aug-96 |
| DDE | 0.014 | N/A | S-378 | Soil | T-3 | 2.5 | Aug-96 |
| DDT | 0.0037 | N/A | S-490 | Soil | Shallow soil | 4 | Aug-96 |
| Dieldrin | 0.07 | N/A | S-484 | Soil | Shallow soil | 3 | Aug-96 |
| Heptachlor | 0.10 | N/A | S-486 | Soil | Shallow soil | 3 | Aug-96 |
| Endosulfan I | 0.011 | N/A | S-485 | Soil | Shallow soil | 3 | Aug-96 |
| Endosulfan-SO[4] | 0.011 | N/A | S-485 | Soil | Shallow soil | 3 | Aug-96 |
| Heptachlorepoxide | 0.0013 | N/A | S-490 | Soil | Shallow soil | 4 | Aug-96 |
| Methoxychlor | 0.0011 | N/A | S-490 | Soil | Shallow soil | 4 | Aug-96 |
| PCB-1260 | 1.0 | N/A | S-340 | Sludge | T-2 | 6.5 | Jul-96 |
| Pyrene | 0.033 | N/A | S-333 | Soil | T-1 | 6 | Jul-96 |
| **Others (mg/kg)** | | | | | | | |
| Chloride | 470 | 14 | S-331 | Soil | T-1 | 2 | Jul-96 |
| Formaldehyde | 530.0 | N/A | --- | Soil | SSL00001 | 0.4 | Jun-95 |
| Hexanol | 660.00 | N/A | --- | Soil | SSL00003 | 0.5 | Jun-95 |
| Nitrate (as N) | 390.0 | 10 | S-357 | Soil | T-6, Pit No. 2 | 14.4 | Jul-96 |
| Nonanol | 340.0 | N/A | --- | Soil | SSL00002 | 0.4 | Jun-95 |
| Sulfate | 5,700 | 36 | S-340 | Sludge | T-2, T-6 | 6.5 | Jul-96 |

Notes:

Ref: Dames & Moore, 1994a, and PNNL, 1995
N/A = Not Available (Location) or Not Applicable (Background Level)

Table 3-4. Background Levels and Toxicity Characteristics (TC) Limits x 20 for Selected Analytes in Soil

| Analyte | Background 80% LCL | TC Limit x 20 |
|---|---|---|
| **Radionuclides** | | |
| Carbon-14 | 0.87 pCi/g | NE |
| Cesium-137 | 0.053 pCi/g | NE |
| Radium-226 | 0.77 pCi/g | NE |
| Strontium-90 | 0.36 pCi/g | NE |
| Tritium | 105 pCi/L | NE |
| Gross Alpha | 11.8 pCi/g | NE |
| Gross Beta | 17.4 pCi/g | NE |
| **Organic Compounds** | | |
| Total chlordane | NA | 0.6 mg/L |
| Endosulfan sulfate | NA | 0.4 mg/L |
| Heptachlor | NA | 0.16 mg/L |
| **Metals** | | |
| Arsenic | 9.46 mg/kg | 100 mg/L |
| Chromium | 178 mg/kg | 100 mg/L |
| Lead | 10.1 mg/kg | 100 mg/L |
| Mercury | 0.49 mg/kg | 4 mg/L |
| Selenium | 1.0 mg/kg | 20 mg/L |
| Chromium VI | 0.099 mg/kg | NE |
| Nitrate (as N) | 10 mg/kg | NE |
| Sulfate | 36 mg/kg | NE |

Notes:

Background 80% LCL = 80% lower confidence level for 24 background samples collected at 0, 4, 20, and 40 ft below ground surface at six locations within one-half mile of the LEHR facility.
NE = none established
NA = not applicable

Table 3-5. Investigation Chronology, Ra/Sr Treatment Systems Area

| Date | Activity | Sample Locations | Results |
|---|---|---|---|
| 1987 | Soil investigation for radionuclides | SB-01 through SB-10 & SB-12 through SB-14 | Cs-137, gross beta, and Sr-90 detected above background (Wahler, 1988). |
| 1989 | Imhoff Tank A sludge sampling | | Ra-226, Sr-90, Tritium, and SVOCs detected above background (Dames & Moore, 1994a). |
| 3/90 | Soil investigation for VOCs, SVOCs, pesticides/PCBs, metals, and radionuclides | SB-22 to SB-28 | Nitrate, Be, $Cr^{+6}$, Co, Zn, Bi-214, Cs-137, K-40, Sr-90, Pb-212, Pb-214, Th-232, and methylene chloride detected above background (Dames & Moore, 1993). |
| 10/90 | Soil investigation for VOCs, SVOCs, pesticides/ PCB, metals, and radionuclides | UCD-22 | Sb, $Cr^{+6}$, Cd, Mo, T1, and Th-232 above background (Dames & Moore, 1993). |
| 3/92 | Sludge sampling from Imhoff Tank A. Soil sampling beneath Ra and Sr system tanks for radionuclides | Imhoff Tanks A through I, Radium Tanks A through D | Total xylenes and SVOCs detected above background in the sludge sample. Ra-226, Th-228, Th-232, and Sr-90 were above background in soil (Chemical Waste Management, 1992). |
| 7-8/96 | Limited Field Investigation – Exploratory trenches and soil borings. Soil sampling from trenches and soil | Five exploratory trenches sixty-two soil samples five soil borings to depths of 30-36 ft bgs. Geophysical logging (gamma and inductive resistivity) one borehole. | Ra-226 up to 106 pCi/g, Sr-90 up to 2.18 pCi/g, and SVOCs up to 243 mg/kg were detected. Several other radionuclides, metals and other organics were detected above background. |
| 10/97 | Data Gaps Phase II – off-site surface soil sampling along Old Davis Road | Not available | Not available |

Table 3-6. Analytes Detected in Soil Above Background in Previous Investigations, Ra-226 Treatment System

| Analyte | Maximum Concentration/ Activity | Location of Maximum | Depth (ft) | Date | Background |
|---|---|---|---|---|---|
| **Radionuclides (pCi/g):** | | | | | |
| Actinium-228 | 0.93 | SB-4 | 25-27 | Aug-96 | 0.71 |
| Bismuth-214 | 6.52 | SB-1 | 18-20 | Aug-96 | 0.57 |
| Cesium-137 | 6.2 | SB-13 | N/A | Oct-87 | 0.053 |
| Carbon-14 | 16 | SB-5 | 6.5-8 | Aug-96 | 0.87 |
| Gross Alpha | 185 | Distribution Box | 9.5 | Aug-96 | 11.8 |
| Gross Beta | 156 | Distribution Box | 9.5 | Aug-96 | 17.4 |
| Lead-212 | 0.94 | SB-5 | 19-20 | Aug-96 | 0.74 |
| Lead-214 | 7.73 | SB-1 | 18-20 | Aug-96 | 0.75 |
| Potassium-40 | 17.24 | SB-28 | 10.0 | Mar-90 | 13.6 |
| Radium-226 | 106.2 | Distribution Box | 9.5 | Aug-96 | 0.77 |
| Strontium-90 | 37.6 | SB-2 | 15-17 | Aug-96 | 0.36 |
| Thallium-208 | 0.25 | SB-5 | 19-20 | Aug-96 | 0.21 |
| Thorium-228 | 2.1 | Beneath Ra Tank B | N/A | Mar-92 | 0.71 |
| Thorium-232 | 1.66 | Beneath Ra Tank B | N/A | Mar-92 | 0.64 |
| Thorium-234 | 1.41 | SB-5 | 19.20 | Aug-96 | 1.09 |
| Tritium (pCi/l) | 230 | Distribution Box | 9.5 | Aug-96 | 105 |
| Uranium-235 | 0.15 | SB-2 | 15-17 | Aug-96 | 0.071 |
| **Metals (mg/kg):** | | | | | |
| Beryllium | 2.40 | SB-26 | 10.0 | Mar-90 | 0.66 |
| Chromium VI | 5.00 | SB-26 | 25.0 | Mar-90 | 0.099 |
| Cobalt | 38.4 | SB-28 | 6.5 | Mar-90 | 29 |
| Copper | 160 | SB-5 | 23-25 | Aug-96 | 50 |
| Lead | 19.3 | UCD1-22 | 5.0 | Oct-90 | 10.1 |
| Manganese | 870 | SB-4 | 29-31 | Aug-96 | 720 |
| Vanadium | 75 | SB-5 | 13-15/28.5-30 | Aug-96 | 73 |
| Zinc | 165 | SB-25 | 5 | Mar-90 | 82 |
| **VOCs (mg/kg):** | | | | | |
| Methylene Chloride | 0.044 | SB-28 | 10 | Mar-90 | N/A |
| **SVOCs (mg/kg)** | 164 | SB-3 | 7-10 | Aug-96 | N/A |
| **Pesticides (mg/kg)** | | | | | |
| DDD | 0.0003 | SB-5 | 23-25 | Aug-96 | N/A |
| DDT | 0.0018 | SB-5 | 23-25 | Aug-96 | N/A |
| **Others (mg/kg):** | | | | | |
| Nitrate (as N) | 736.00 | SB-28 | 15.0 | Mar-90 | 10 |

Notes:

N/A = Not available (Location/depth) or not applicable (Background Level).

Table 3-7. Analytes Detected in Soil Above Background in Previous Investigations, Sr-90 Treatment Area

| Analyte | Maximum Concentration/ Activity | Location of Maximum | Depth (ft) | Date | Background |
|---|---|---|---|---|---|
| **Radionuclides (pCi/g):** | | | | | |
| Cesium-137 | 6.20 | SB-03-B-32 | N/A | Oct-87 | 0.053 |
| Gross Beta | 60 | SB-03-B-4 | N/A | Oct-87 | 17.4 |
| Strontium-90 | 2.11 | Beneath Tank B | N/A | Mar-92 | 0.36 |
| Thorium-232 | 1 | SB-24 | 10 | Mar-90 | 0.64 |
| Thorium-228 | 0.9 | Beneath Tank B | N/A | Mar-92 | 0.71 |
| Tritium | 1.16 | Beneath Tank B | N/A | Mar-92 | 0.023 |
| **Metals (mg/kg):** | | | | | |
| Chromium VI | 7.00 | SB-24 | 1.0 | Mar-90 | 0.099 |
| Cobalt | 38.4 | SB-23 | 0.5 | Mar-90 | 29 |
| Zinc | 120 | SB-22 | 5.0 | Mar-90 | 82 |
| **VOCs (mg/kg):** | | | | | |
| Methylene Chloride | 0.023 | SB-22 | 15 | Mar-90 | N/A |
| **Other (mg/kg):** | | | | | |
| Nitrate (as N) | 92.00 | SB-24 | 20.0 | Mar-90 | 10 |

N/A = Not available (Depth) or not applicable (Background Level).

Table 3-8. Investigation Chronology, Domestic Septic Systems

| Date | Activity | Sample Numbers | Results |
|---|---|---|---|
| 1990 | Verify tank locations. | | Located Tanks 1 and 2. Tanks 4, 5 and 6 may not be accessible due to utilities, building slabs, or other obstacles. |
| 6/95 | Backhoe exploration and sampling for Septic Tank #2. | | No contaminants discovered above PRGs in tank sediments or trench soil samples. |
| 7-8/96 | Soil sampling at Tanks 1 and 7. | | Tanks 1 and 7 located. |
| 6/97 | Determination of southern extent of Tank 1 effluent line. | Excavated trenches T1, T1A, and T2. Collected soil samples T1A01, T1A02, T1A03 and T1A04 from trench T1A. | Trench T1 - no indication of Tank 1 effluent line or leach field material.<br>Trench T2 - located Tank 1 effluent line and leach field material.<br>Trench T1A – located southern extension of Tank 1 effluent line and leach field material. At T1A, the Tank 1 effluent line appears truncated by newer sanitary sewer, trending at a high angle to the former Tank 1 effluent line.<br>Gross alpha, bismuth-214, manganese, nitrate, ra-226, tritium, uranium-235, thallium-208, vanadium, zinc detected above background levels in samples T1A01, T1A02, T1A03, and T1A04 from trench T1A. Located end of cast iron pipe angled in the purported location of Tank 5. |
| 6/97 | Determination of the northern extent of the Ra-226 Seepage Trench. | Hand-augered 8 borings to 5-ft depth in order to find leach field material (i.e. sand, drain rock, gravel). | No. 3 sand pack identified at depth in boring Nos. 1, 3, 6, and 8. No sand identified in boring Nos. 5 and 2. |

Table 3-8. Investigation Chronology, Domestic Septic Systems (continued)

| Date | Activity | Sample Numbers | Results |
|---|---|---|---|
| 6/97 | Locate domestic Septic Tank No. 3 and its associated leach field. | Hand-augered 13 borings to 5-ft depth. Collected soil samples T301, T302 and T303 from leach- field at 8.0, 11.0, and 15.5-ft depths. | Unable to locate exact location of Tank No. 3. Located Tank No. 3 leach field and sampled Tank No. 3 leach field. See Figure 3-15. |
| 6/97 | Locate domestic Septic Tank No. 4 and its associated leach field. | Hand-augered 10 borings to 5-ft depth. Collected soil samples T401, T402, and T403 from leach field at 5.5, 8.0, and 13.0-ft depths. | Unable to locate exact location of Tank No. 4. Located Tank No. 4 leach field and sampled Tank No. 4 leach field. See Figure 3-15. |
| 6/97 | Locate the leach field associated with domestic Septic Tank No. 5. | Hand-augered 5 borings to 5-ft depth. Collected no samples. | Unable to locate leach field associated with Septic Tank No. 5. Septic Tank No. 5 is believed to exist beneath southeast corner of main office and lab building. |
| 6/97 | Locate domestic Septic Tank No. 6 and its associated leach field. | Hand-augered 14 borings to 5-ft depth. Collected soil samples T601, T602 and T603 from leach- field at 5.5, 8.0, and 13.0-ft depths. | Unable to locate exact location of Tank No. 6. Located Tank No. 6 leach field and sampled Tank No. 6 leach field. See Figure 3-16 |
| 9/97 | Soil samples for VOCs and Pest/PCBs at domestic Septic Systems No. 1, 3, 4 and 6. (6/97 VOC data did not meet CLP quality measures; 6/97 Pest/PCBs data did not meet analytical holding time.) | Augered one boring each at Septic Systems No. 1, 3, 4 and 6. Collected soil samples T1A05, T1A06, T1A07; T304, T305, T306; T404, T405, T406; and T604, T605, T606 from leach fields. | All Soil Samples were analyzed for VOCs and Pest/PCBs. In addition, samples T404 and T601 were analyzed for mercury and lead. Constituents detected in soil above background are presented in Figures 3-14, 3-15 and 3-16 |

Table 3-9. Analytes Detected in Soil Above Background, Domestic Septic Systems

| Analyte | Background | Max. Conc./Activity | Location | Depth | Date |
|---|---|---|---|---|---|
| Cations and Anions (mg/kg) | | | | | |
| Chloride | 14 | 100 | Tank 7 | 12 | 8/16/96 |
| Nitrate (as N) | 10 | 120 | Tank 7 | 9.5 | 8/16/96 |
| | | 23.5 | Trench T1A | 7.5 | 6/11/97 |
| Sulfate | 36 | 69 | Tank 7 | 9.5 | 8/16/96 |
| Metals (mg/kg) | | | | | |
| Arsenic | 9.46 | 11 | Tank 3 | 11 | 6/12/97 |
| Barium | 237 | 270 | Tank 7 | 9.5 | 8/16/96 |
| Cadmium | 0.46 | 0.78 | Tank 4 | 5.5 | 6/12/97 |
| Chromium | 178 | 319 | Tank 4 | 8 | 6/12/97 |
| Chromium | 0.099 | 0.132 | Tank 3 | 15.5 | 6/12/97 |
| Copper | 50 | 56 | Tank 1 | 10 | 8/19/96 |
| | | 59.3 | Tank 3 | 8 | 6/12/97 |
| | | 60 | Tank 7 | 7 | 8/16/96 |
| Iron | 42,000 | 42,400 | Tank 3 | 11 | 6/12/97 |
| | | 43,200 | Tank 6 | 13 | 6/12/97 |
| Lead | 10.1 | 12 | Tank 4 | 5.5 | 6/12/97 |
| Manganese | 720 | 770 | Tank 1 | 13 | 8/19/96 |
| | | 808 | Tank 3 | 15.5 | 6/12/97 |
| | | 790 | Tank 7 | 7 | 8/16/96 |
| | | 776 | Trench T1A | 7.5 | 6/11/97 |
| Mercury | 0.49 | 1.52 | Tank 4 | 5.5 | 6/12/97 |
| | | 49.4 | Tank 6 | 5.5 | 6/12/97 |
| Nickel | 326 | 405 | Tank 4 | 8 | 6/12/97 |
| Vanadium | 73 | 76.7 | Tank 3 | 11 | 6/12/97 |
| | | 74.5 | Tank 4 | 13 | 6/12/97 |
| | | 84.8 | Tank 6 | 13 | 6/12/97 |
| | | 73.1 | Trench T1A | 12 | 6/11/97 |
| Zinc | 82 | 84 | Tank 1 | 7.5 | 8/19/96 |
| | | 258 | Tank 3 | 8 | 6/12/97 |
| | | 97 | Tank 4 | 5.5 | 6/12/97 |
| | | 94.6 | Tank 6 | 13 | 6/12/97 |
| | | 110 | Tank 7 | 12 | 8/16/96 |
| | | 136 | Trench T1A | 5 | 6/11/97 |

Table 3-9. COCs Detected in Soil Above Background, Domestic Septic Systems (continued)

| | | | | | |
|---|---|---|---|---|---|
| Radionuclides (pCi/g) | | | | | |
| Bismuth-214 | 0.57 | 0.593 | Tank 3 | 15.5 | 6/12/97 |
| | | 0.61 | Tank 6 | 8 | 6/12/97 |
| | | 0.68 | Trench T1A | 7.5 | 6/11/97 |
| Carbon-14 | 0.87 | 2.1 | Tank 1 | 7.5 | 8/19/96 |
| Cesium-137 | 0.053 | 0.126 | Tank 3 | 8 | 6/12/97 |
| Gross Alpha | 11.8 | 16.2 | Trench T1A | 5 | 6/11/97 |
| Gross Beta | 17.4 | 17.6 | Tank 1 | 10 | 8/16/96 |
| Radium-226 | 0.77 | 0.78 | Tank 1 | 13 | 8/19/96 |
| | | 1.45 | Tank 3 | 15.5 | 6/12/97 |
| | | 0.85 | Tank 7 | 12 | 8/16/96 |
| | | 0.9 | Trench T1A | 5 | 6/11/97 |
| Strontium-90 | 0.36 | 0.4 | Tank 1 | 10 | 8/19/96 |
| | | 0.45 | Tank 7 | 12 | 8/16/96 |
| Thallium-208 | 0.21 | 0.214 | Tank 3 | 15.5 | 6/12/97 |
| | | 0.242 | Tank 6 | 8 | 6/12/97 |
| | | 0.211 | Trench T1A | 7.5 | 6/11/97 |
| Tritium (pCi/L) | 105 | 1270 | Tank 4 | 8 | 6/12/97 |
| | | 460 | Tank 6 | 8 | 6/12/97 |
| | | 340 | Trench T1A | 5 | 6/11/97 |
| Uranium-235 | 0.071 | 0.1 | Tank 3 | 15.5 | 6/12/97 |
| | | 0.16 | Tank 4 | 5.5 | 6/12/97 |
| | | 0.16 | Tank 6 | 8 | 6/12/97 |
| | | 0.1 | Tank 7 | 7 | 8/16/96 |
| | | 0.091 | Trench T1A | 12 | 6/11/97 |
| Organics (µg/kg) | | | | | |
| 1,2-Dichloroethene | - | 4 | Trench T1A | 12.5 | 9/17/97 |
| Trichloroethene | - | 10 | Trench T1A | 12.5 | 9/17/97 |
| | | 4 | Tank 6 | 8 | 9/17/97 |
| Aroclor-1254 | - | 91 | Trench T1A | 12.5 | 9/17/97 |
| Formaldehyde (mg/kg) | - | 2.2 | Tank 7 | 12 | 8/16/96 |

Table 3-10. Summary of Vadose Zone Model Indicator Constituents, NUFT Model Input Parameter Values

**RADIOLOGICAL COMPOUNDS**

| Indicator Constituent | Background[a] in soil | 95% UTL in water[b] | MCL[c] | Maximum soil activity reported at Site[d] | Partitioning Co-efficient ($K_d$) | Molecular weight | Decay rate half-life |
|---|---|---|---|---|---|---|---|
| | (pCi/g) | (pCi/L) | (pCi/L) | (pCi/g) | (L/kg) | (g/mole) | (y) |
| Radium 226 | 1.50 | 0.272 | 5 | 15 | 100 | 226.0254 | 1,600 |
| Strontium 90 | 0.52 | 1.63 | 8 | 23 | 10 | 87.62 | 29 |

**NON-RADIOLOGICAL COMPOUNDS**

| Indicator Constituent | Background[a] in soil | 95% UTL in water[b] | MCL[c] | Maximum soil concentration reported at Site[d] | Partitioning Co-efficient ($K_d$) | Molecular weight | Henry's Law constant |
|---|---|---|---|---|---|---|---|
| | (mg/kg) | (mg/L) | (mg/L) | (mg/kg) | (L/kg) | (g/mole) | (atm-m$^3$/mole) |
| Chlordane | NA | NA | 0.0001 | 15 | 650/1230[e] | 409.8 | 1.9E-03[f] |
| Hexavalent Chromium | 0.16 | 0.0229 | 0.05 | 7 | 10 | 52 | 0 |
| Nitrate (as N) | 29.1 | 25.2 | 10 | 390 | 0 | 14.0067 | 0 |

Notes

[a]Background = 95% Upper Confidence Level (UCL) for 24 background samples collected at 0, 4, 20, and 40 ft below ground surface at six locations within one-half mile of the LEHR Site (Weiss Associates, 1997).
[b]Based on analytical results of ground water samples from HSU-1. UTL = Upper Tolerance Limit (Stewart *et al.*, 1996: *1995 Annual Water Monitoring Report*, LEHR Environmental Restoration, University of California at Davis).
[c]MCL = EPA Region 9, Maximum Contaminant Level, Drinking Water Standards and Health Advisory Table, 1996.
[d]Based on analytical results of soil samples from the LEHR Site taken as part of the 1996 Characterization Investigation (Weiss Associates, 1997).
[e]Values assuming 10% and 20% organic carbon content, respectively (Strenge *et al.*, 1989).
[f]Calculated from vapor pressure (VP) and solubility (S) [H=VP/S].
NA = Not Available.

Table 3-11. Initial Model Soil Concentrations, MCLs, and Model Results for the LEHR Site

| NON-RADIOLOGICAL COMPOUNDS | MODEL INPUT | | | | MODEL RESULTS | |
|---|---|---|---|---|---|---|
| Constituent and Area | Initial Soil Concentration | Infiltration Rate | Ground Water MCL[a] | 95% UTL Background in Ground Water[b] | Peak Ground Water Concentration | Arrival Time |
| | (mg/kg) | (cm/y) | (mg/L) | (mg/L) | (mg/L) | (y) |
| Nitrate (SW Trenches) | 10 | 3.0 | 10 | 25.2 | 18 | 107 |
| Nitrate (SW Trenches) | 10 | 10.0 | 10 | 25.2 | 23 | 26 |
| Nitrate (SW Trenches) | 10 | 21.5 | 10 | 25.2 | 25 | 17 |
| Nitrate (SW Trenches)[c] | 10 | 10.0 | 10 | 25.2 | 55 | 26 |
| Nitrate (Ra/Sr Area) | 10 | 3.0 | 10 | 25.2 | 15 | 116 |
| Nitrate (Ra/Sr Area) | 10 | 10.0 | 10 | 25.2 | 26 | 28 |
| Nitrate (Ra/Sr Area) | 10 | 21.5 | 10 | 25.2 | 26 | 28 |
| Chlordane (SW Trenches) | 100 | 3.0 | 1.0E-4 | NA | 5.7E-5 | 125,000 |
| Chlordane (SW Trenches) | 100 | 10.0 | 1.0E-4 | NA | 2.3E-4 | 50,000 |
| Chlordane (SW Trenches) | 100 | 21.5 | 1.0E-4 | NA | 9.3E-4 | 28,000 |
| Chlordane (SW Trenches) | 40 | 10.0 | 1.0E-4 | NA | 9.3E-5 | 56,000 |
| Chlordane (SW Trenches) | 10 | 21.5 | 1.0E-4 | NA | 9.6E-5 | 28,000 |

Notes:

[a]MCL = Maximum Contaminant Level, EPA Region 9 Drinking Water Standards and Health Advisory Table, 1996.
[b]Based on analytical results of ground water samples from HSU-1. UTL = Upper Tolerance Limit (Stewart *et al.*, 1996, *1995 Annual Water Monitoring Report*, LEHR Environmental Restoration, University of California at Davis).
[c]Initial concentration applied from 0 to 15 ft below ground surface (bgs). Initial concentrations applied from 0 to 6 ft bgs for all other simulations.
NA = Not Available

Table 3-11. Initial Model Soil Concentrations, MCLs, and Model Results for the LEHR Site (continued)

| RADIOLOGICAL COMPOUNDS | MODEL INPUT | | | | MODEL RESULTS | |
|---|---|---|---|---|---|---|
| Indicator Constituent (and Area) | Initial Soil Concentration | Infiltration Rate | Ground Water MCL[a] | 95% UTL Background in Ground Water[b] | Peak Ground Water Concentration | Arrival Time |
| | (pCi/g) | (cm/y) | (pCi/L) | (pCi/L) | (pCi/L) | (y) |
| Strontium 90 (SW Trenches) | 1.0E+6 | 10.0 | 8 | 1.63 | 0.14 | 470 |
| Strontium 90 (SW Trenches) | 1.0E+7 | 10.0 | 8 | 1.63 | 1.3 | 470 |
| Strontium 90 (SW Trenches) | 1.0E+8 | 10.0 | 8 | 1.63 | 13 | 470 |
| Radium 226 (SW Trenches) | 1.0E+7 | 3.0 | 5 | 0.272 | 0.34 | 25,300 |
| Radium 226 (SW Trenches) | 1.0E+8 | 3.0 | 5 | 0.272 | 3.4 | 25,300 |
| Radium 226 (SW Trenches) | 1.0E+9 | 3.0 | 5 | 0.272 | 34 | 25,300 |
| Radium 226 (SW Trenches) | 1.0 E+1 | 10.0 | 5 | 0.272 | 0.094 | 11,600 |
| Radium 226 (SW Trenches) | 1.0 E+2 | 10.0 | 5 | 0.272 | 0.94 | 11,600 |
| Radium 226 (SW Trenches) | 1.0 E+3 | 10.0 | 5 | 0.272 | 9.4 | 11,600 |

Notes:

[a]MCL = Maximum Contaminant Level, EPA Region 9 Drinking Water Standards and Health Advisory Table, 1996.
[b]Based on analytical results of ground water samples from HSU-1. UTL = Upper Tolerance Limit (Stewart *et al.*, 1996, *1995 Annual Water Monitoring Report*, LEHR Environmental Restoration, University of California at Davis).
[c]Initial concentration applied from 0 to 15 ft below ground surface (bgs). Initial concentrations applied from 0 to 6 ft bgs for all other simulations.
NA = Not Available

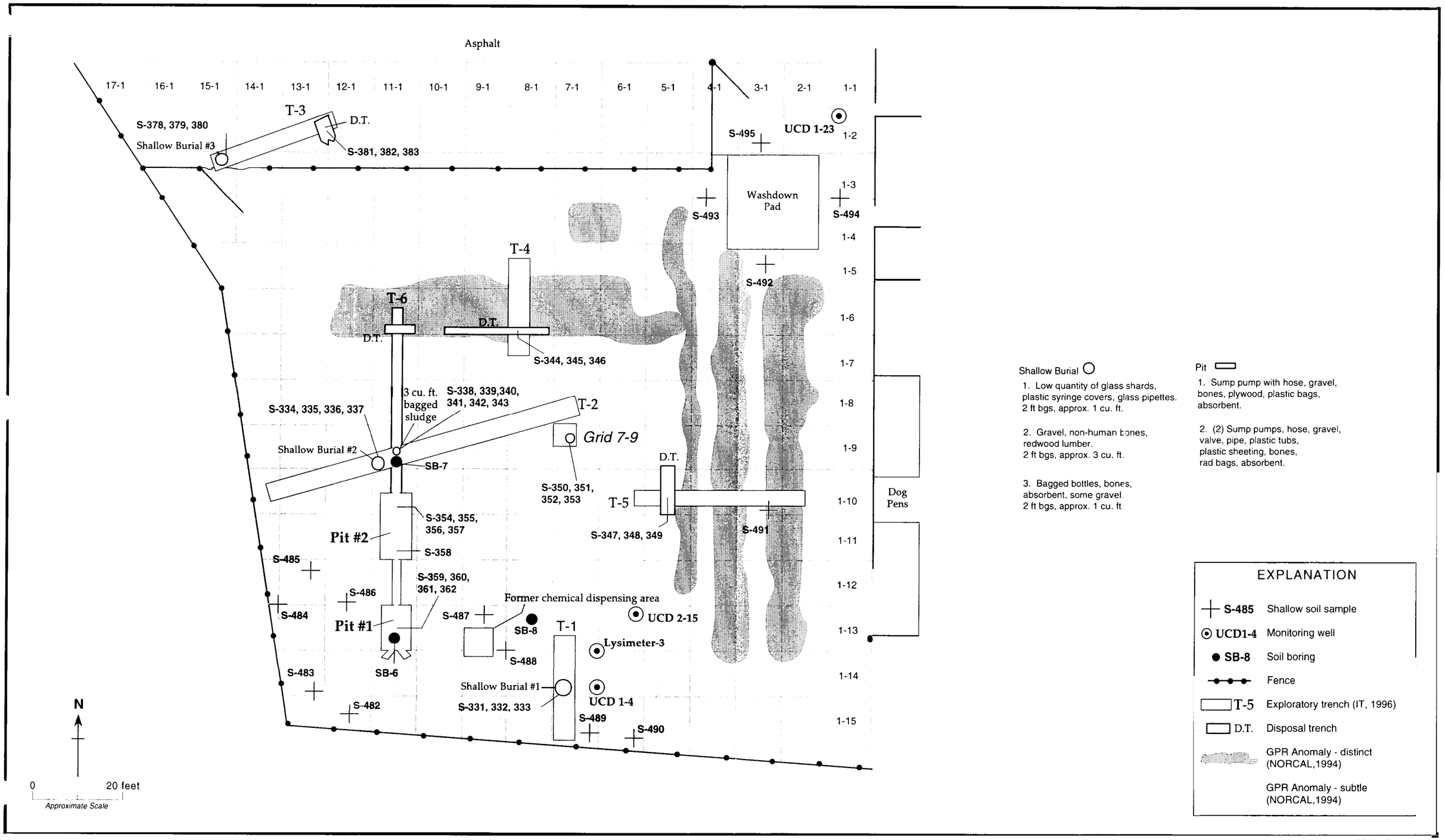



Figure 3-1. Soil and Solid Waste Sampling Locations, Southwest Trenches

*Weiss Associates*

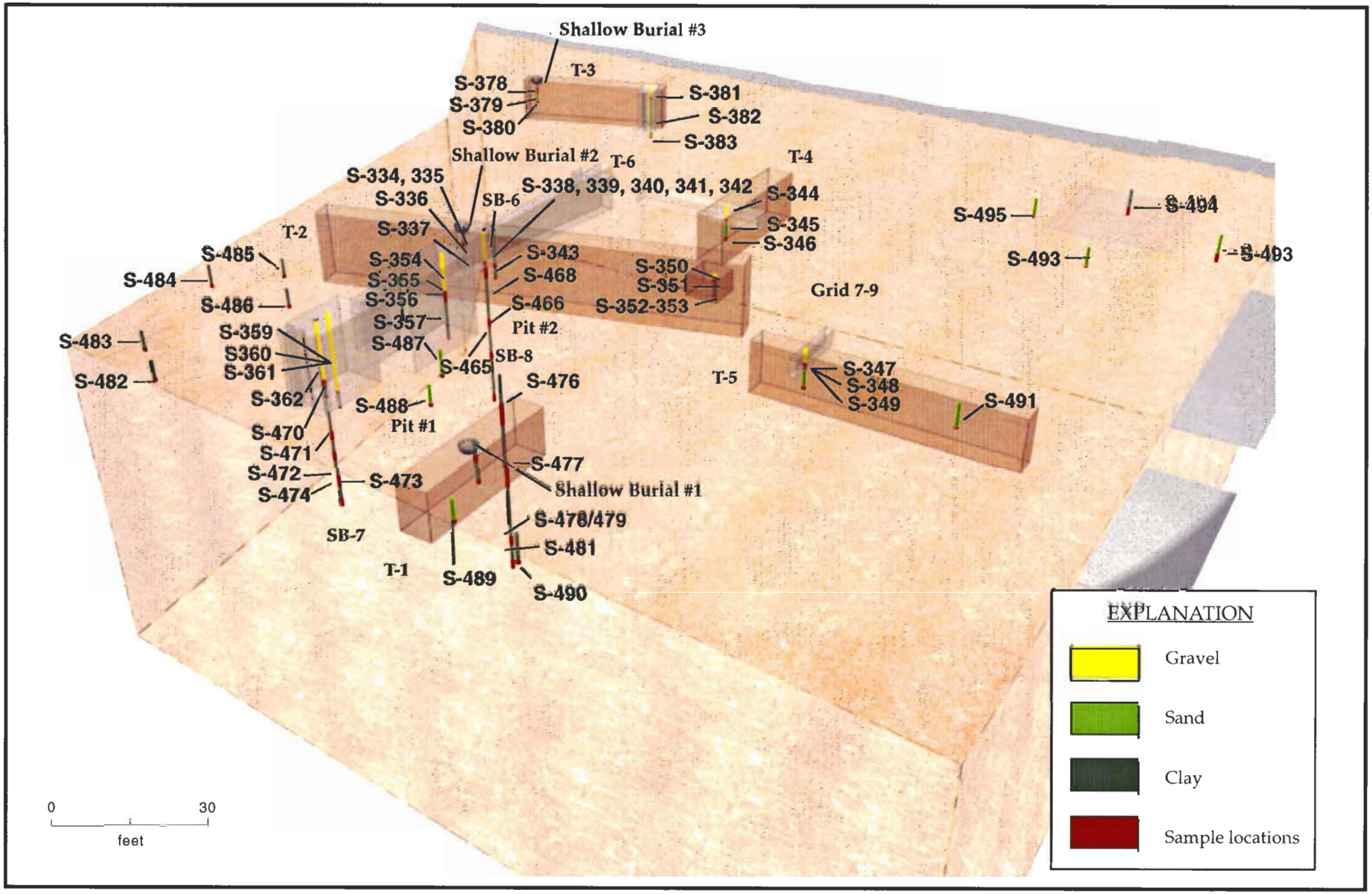



Figure 3-2. Perspective View of the Southwest Trenches (from Southeast corner)

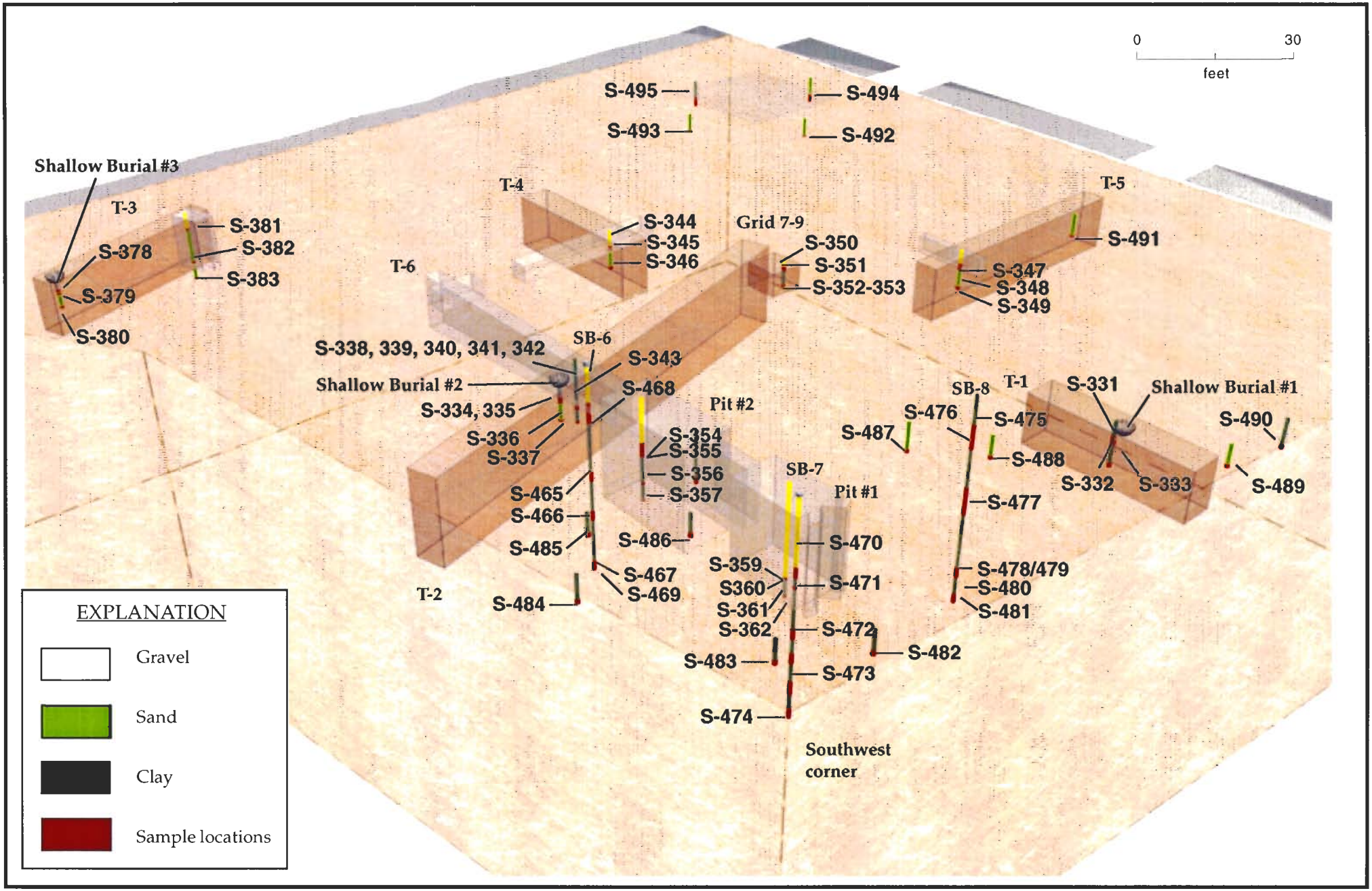



Figure 3-3. Perspective View of the Southwest Trenches (from Southwest corner) Showing Exploratory Trenches and Sampling Locations

| LEHR-S | 338 | 339 | 340 | 342 |
|---|---|---|---|---|
| Depth | *6.5' gravel* | *6.5' bones* | *6.5' bagged storage* | *3-6 Platic bag* |
| $^{226}Ra$ | 7.06 | - | - | 1.06 |
| $^{90}Sr$ | 34.1* | 10.7* | 16,700* | 18.7* |
| $^{3}H$(pCi/g) | - | 1.0 | - | - |
| $^{14}C$ | 2.70 | 117 | - | - |
| $^{60}Co$ | - | - | 0.04 | - |
| $^{214}Pb$ | 0.83 | - | 1.8 | 4.3 |
| $^{234}Th$ | - | - | 7 | - |
| $^{208}Tl$ | - | - | 0.6 | - |
| $^{228}Ac$ | - | - | - | 5.5 |
| $^{235}U$ | - | 0.22 | 0.1 | - |
| Gross Beta | 103 | 27.6 | 34,700 | 29.3 |
| Cu | - | NA | 890 | NA |
| Hg | - | NA | 0.61 | NA |
| Se | - | NA | 1.5 | NA |
| Zn | - | NA | 730 | NA |
| Pb | 16 | NA | 49 | NA |
| $NO_3$ | 210 | NA | - | NA |
| $SO_4$ | 270 | NA | 5,700 | NA |
| Cl | - | NA | 78 | NA |
| PCB 1260 | - | NA | 1.0 | - |
| Chlordane | 0.138 | NA | - | 0.43 |
| DDD | *0.028* | NA | - | *0.080* |
| VOCS | - | NA | 0.821 | NA |
| SVOCS | - | - | *777.7* | - |

*Trench 3*

| LEHR-S | 381 |
|---|---|
| Depth | *2.5' gravel* |
| $^{226}Ra$ | 1.16 |
| $^{90}Sr$ | 1.48 |
| $^{60}Co$ | 0.021 |
| $^{214}Bi$ | 0.59 |
| $^{137}Cs$ | 0.105 |
| Gross Beta | 22.8 |
| Cu | 62 |
| Mn | 880 |
| Pb | 21 |
| Zn | 130 |
| $NO_3$ | 55 |
| DDD | *0.0033* |
| Chlordane | 0.0103 |

*Trench 4*

| LEHR-S | 344 |
|---|---|
| Depth | *2.5' gravel* |
| $^{137}Cs$ | 0.085 |
| Chlordane | 0.05 |

*Grid 7-9*

| LEHR-S | 350 |
|---|---|
| Depth | *0.5' gravel* |
| $^{137}Cs$ | 23 |
| $^{3}H$(pCi/L) | 190 |
| $^{235}U$ | 0.1 |
| Gross Beta | 33.3 |
| Pb | 11 |
| Cr VI | 0.22 |
| $NO_3$ | 11 |
| DDD | 0.20 |
| Chlordane | 1.54 |

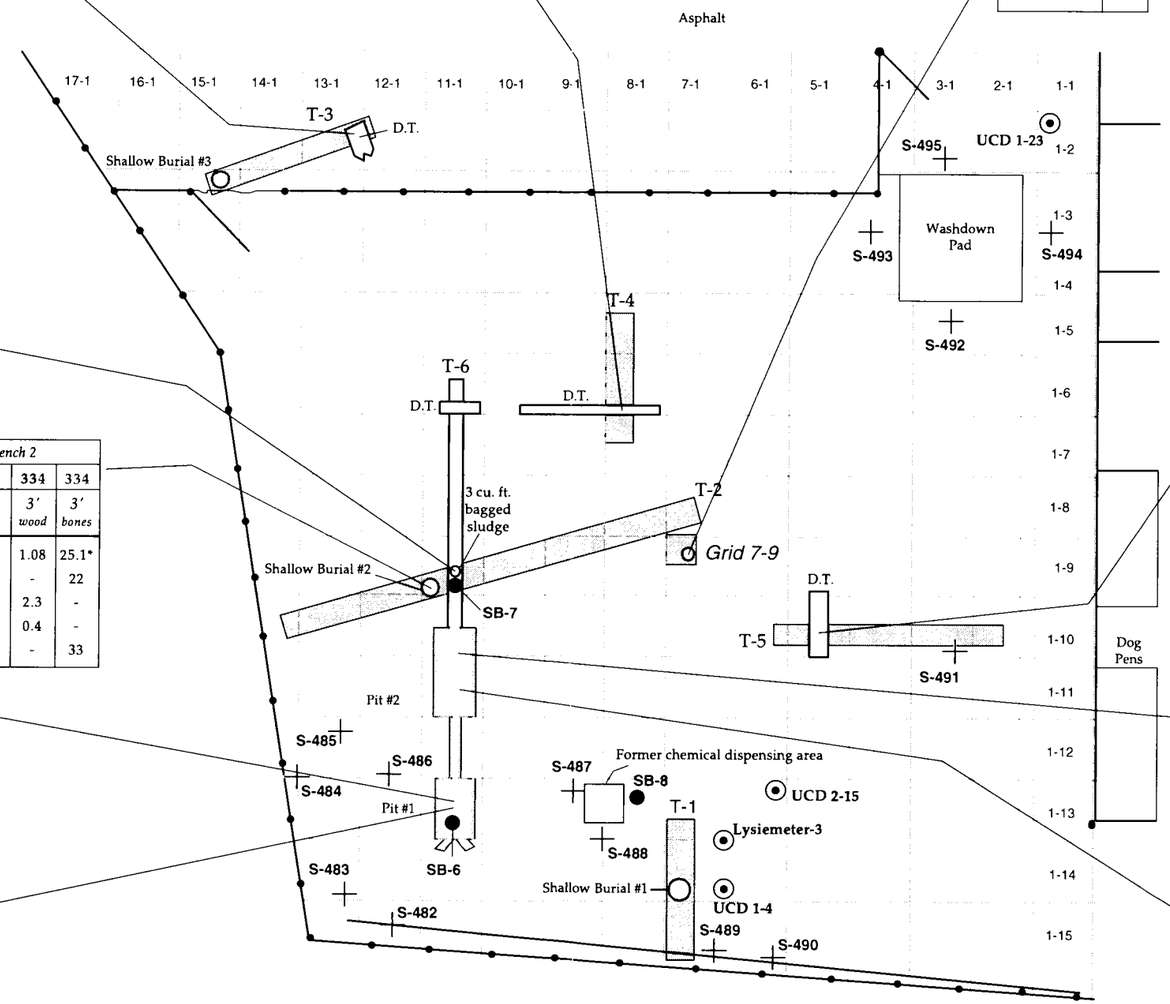
EXPLANATION

| | |
|---|---|
| UCD1-4 | Monitoring well |
| SB-8 | Soil boring |
| | Fence |
| S-492 | Shallow soil sample |
| T-6 | Exploratory trench (IT, 1996) |
| D.T. | Disposal trench |
| NA | Not analyzed |

Note: Shading indicates maximum concentrations recorded in SW Trench Area during LFI

Unless otherwise noted, all radionuclides reported in pCi/g, all other results reported in mg/kg, italics indicate approximate data based on validation results, dash indicates result below background

* May be higher than actual activity present due to systematic laboratory error




*Trench 5*

| LEHR-S | 347 |
|---|---|
| Depth | *2' gravel* |
| $^{90}Sr$ | 2.59* |
| $^{60}Co$ | 0.016 |
| $^{3}H$(pCi/g) | 91.1 |
| DDD | *0.24* |
| Chlordane | 0.61 |

*Trench 6*

| LEHR-S | 354 | 355 |
|---|---|---|
| Depth | *6-8' gravel* | *6-8' bones* |
| $^{226}Ra$ | 2.26 | 2.02 |
| $^{90}Sr$ | 3.15 | 13.8 |
| $^{214}Bi$ | - | 1.47 |
| $^{214}Pb$ | - | 1.68 |
| $^{3}H$(pCi/g) | - | 0.05 |
| Gross Alpha | 14.7 | 12.4 |
| Gross Beta | 36.7 | 52.8 |
| Hg | 0.55 | - |
| $NO_3$ | 350 | - |
| $SO_4$ | 170 | - |
| DDD | 0.0057 | - |
| Chlordane | 0.021 | - |

*Trench 2*

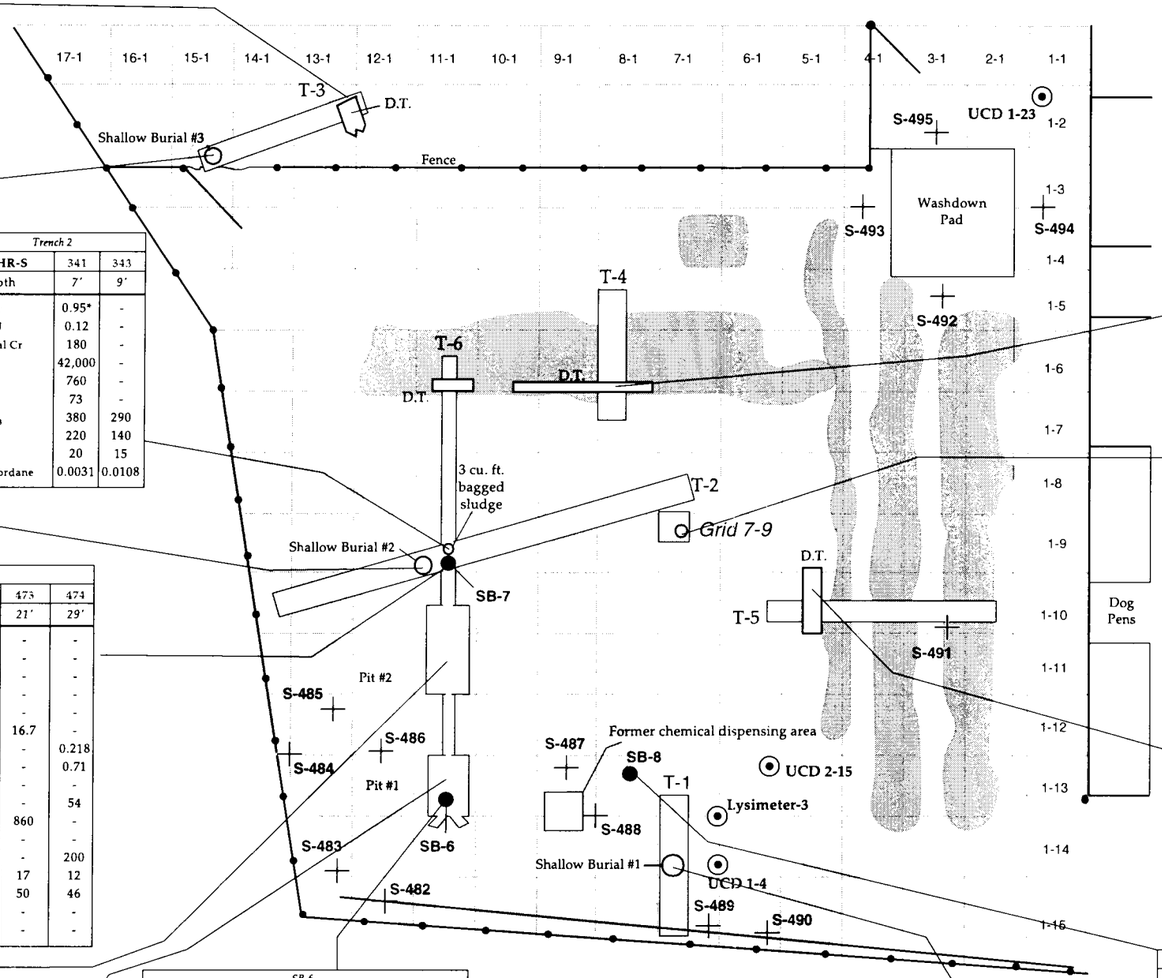
| LEHR-S | 334 | 334 |
|---|---|---|
| Depth | *3' wood* | *3' bones* |
| $^{90}Sr$ | 1.08 | 25.1* |
| $^{3}H$(pCi/g) | - | 22 |
| $^{234}Th$ | 2.3 | - |
| $^{235}U$ | 0.4 | - |
| Gross Beta | - | 33 |

| LEHR-S | 362 |
|---|---|
| Depth | *12' wood* |
| $^{90}Sr$ | 3,690 |
| $^{14}C$ | 2.1 |
| $^{228}Ac$ | 1.6 |
| $^{234}Th$ | 39.5 |
| $^{235}U$ | 2.6 |
| Gross Beta | 1,698 |
| Zn | 95 |
| Cu | 88 |
| $SO_4$ | 260 |
| Cl | 43 |
| Ethyl Benzene | *1.2* |
| Xylenes | *6.2* |
| Toluene | *0.490* |
| Styrene | *0.800* |
| 2-Hexanone | *0.075* |
| SVOCS | *30,947* |

| LEHR-S | 359 |
|---|---|
| Depth | *12' gravel* |
| $^{226}Ra$ | 1.28 |
| $^{90}Sr$ | 3.16 |
| $^{137}Cs$ | 0.119 |
| Hg | 0.66 |
| Zn | 310 |
| Pb | 14 |
| Benzene | *0.001* |
| DDD | *0.0078* |
| Chlordane | *0.033* |

| LEHR-S | 358 |
|---|---|
| Depth | *6-7' sorbent material* |
| $^{90}Sr$ | 0.37 |
| $^{3}H$(pCi/g) | 2.6 |

Figure 3-4. Analytic Results above Background for Solid Waste Samples, Southwest Trenches Area




| Trench 3 | | | |
|---|---|---|---|
| LEHR-S | 378 | 379 | 380 |
| Depth | 2.5′ | 3′ | 5′ |
| $^{226}Ra$ | 0.86 | - | - |
| $^{90}Sr$ | 2.47 | - | - |
| $^{137}Cs$ | 0.092 | - | - |
| $^{208}Tl$ | - | 0.224 | - |
| $^{235}U$ | - | 0.12 | 0.1 |
| Gross Beta | 26 | - | - |
| Hg | 0.57 | 0.94 | - |
| Mn | - | 740 | - |
| $NO_3$ | - | 21 | 18 |
| $SO_4$ | 53 | 47 | 81 |
| Cl | - | - | 17 |
| Chlordane | 0.0112 | - | - |
| DDD | 0.0076 | - | - |
| DDE | 0.014 | - | - |

| Trench 3 | | |
|---|---|---|
| LEHR-S | 382 | 383 |
| Depth | 8′ | 10.5′ |
| $^{226}Ra$ | - | 0.96 |
| $^{90}Sr$ | 6.53 | 5.25 |
| Gross Beta | 36.9 | 51.8 |
| Total Cr | 180 | - |
| Chlordane | 0.0098 | - |
| DDD | 0.0034 | - |

| Trench 2 | | | |
|---|---|---|---|
| LEHR-S | 335 | 336 | 337 |
| Depth | 3′ | 3.5′ | 6′ |
| $^{90}Sr$ | 0.77* | - | 1.88* |
| $^{14}C$ | - | - | 3.9 |
| $^{3}H$(pCi/L) | - | - | 340 |
| $^{137}Cs$ | 0.057 | - | - |
| $^{235}U$ | - | 0.1 | - |
| Total Cr | - | - | 180 |
| Hg | - | - | 0.58 |
| Ba | - | 270 | - |
| Mn | 750 | 720 | - |
| $NO_3$ | 54 | 88 | 21 |
| $SO_4$ | 37 | 120 | - |
| Cl | - | 15 | - |
| Chlordane | 0.087 | 0.0039 | 0.183 |
| DDD | 0.017 | - | 0.031 |

| Trench 2 | | |
|---|---|---|
| LEHR-S | 341 | 343 |
| Depth | 7′ | 9′ |
| $^{90}Sr$ | 0.95* | - |
| $^{235}U$ | 0.12 | - |
| Total Cr | 180 | - |
| Fe | 42,000 | - |
| Mn | 760 | - |
| Va | 73 | - |
| $NO_3$ | 380 | 290 |
| $SO_4$ | 220 | 140 |
| Cl | 20 | 15 |
| Chlordane | 0.0031 | 0.0108 |

| Trench 6 | | |
|---|---|---|
| LEHR-S | 356 | 357 |
| Depth | 12′ | 14.4′ |
| $^{226}Ra$ | 1.98 | 1.73 |
| $^{60}Co$ | - | 0.017 |
| $^{228}Ac$ | - | 0.75 |
| $^{214}Bi$ | 1.68 | 1.37 |
| $^{214}Pb$ | 1.90 | 1.32 |
| $^{235}U$ | - | 0.1 |
| Gross Alpha | 12.9 | 16.7 |
| Gross Beta | 18.3 | 23.2 |
| Ba | 240 | - |
| Fe | 43,000 | - |
| Hg | 0.79 | - |
| Mn | - | 1,000 |
| Cu | 53 | 58 |
| Va | 79 | 73 |
| Zn | 90 | 99 |
| $NO_3$ | 56 | 390 |
| $SO_4$ | - | 250 |
| Chlordane | 0.0029 | 0.0035 |

| SB-7 | | | | | |
|---|---|---|---|---|---|
| LEHR-S | 470 | 471 | 472 | 473 | 474 |
| Depth | 5-6′ | 6-8′ | 15′ | 21′ | 29′ |
| $^{226}Ra$ | 1.18 | 2.44 | - | - | - |
| $^{90}Sr$ | 2.4* | - | 0.36* | - | - |
| $^{3}H$ (pCi/L) | - | 200 | - | - | - |
| $^{214}Bi$ | 0.0571 | 1.56 | 0.6 | - | - |
| $^{214}Pb$ | 0.791 | 1.73 | - | - | - |
| $^{40}K$ | - | - | - | 16.7 | - |
| $^{208}Tl$ | - | 0.227 | - | - | 0.218 |
| $^{228}AC$ | - | - | - | - | 0.71 |
| Gross Beta | 20.8 | - | - | - | - |
| Cu | 64 | 51 | 67 | - | 54 |
| Mn | - | - | - | 860 | - |
| Pb | 11 | - | - | - | - |
| Zn | 88 | 92 | 110 | - | 200 |
| $NO_3$ | 56 | 91 | 48 | 17 | 12 |
| $SO_4$ | 99 | 110 | 66 | 50 | 46 |
| Chlordane | 0.1 | - | 0.00123 | - | - |
| DDD | 0.032 | - | - | - | - |

| | | | | | |
|---|---|---|---|---|---|
| LEHR-S | 482 | 483 | 484 | 485 | 486 |
| Depth | 3′ | 3′ | 3′6″ | 3′ | 3′ |
| $^{226}Ra$ | 0.79 | - | - | - | - |
| $^{90}Sr$ | 0.95* | - | 0.5* | 0.64* | 0.49* |
| $^{14}C$ | - | - | 2.0 | - | - |
| $^{214}Bi$ | - | 0.57 | - | - | - |
| $^{214}Pb$ | 0.78 | - | - | - | - |
| $^{208}Tl$ | 0.243 | - | - | - | - |
| $^{235}U$ | - | - | 0.136 | - | - |
| Hg | 0.64 | 5.2 | 0.72 | - | 0.98 |
| Mn | 720 | 720 | - | 720 | - |
| Pb | - | - | - | 11 | - |
| Se | - | - | 1.1 | 1 | - |
| Chlordane | 0.00173 | 0.0152 | 3.6 | 1.21 | 0.92 |
| Endosulfan I | - | 0.002 | - | 0.11 | - |
| DDD | - | 0.004 | 0.26 | - | 0.099 |
| DDE | 0.00069 | - | - | 0.013 | 0.014 |
| Heptachlor | - | - | 0.043 | 0.011 | 0.096 |
| Dieldrin | - | - | 0.07 | 0.029 | 0.019 |
| Formaldeyde | 1.4 | - | - | - | - |

| Trench 6 | | |
|---|---|---|
| LEHR-S | 360 | 361 |
| Depth | 12′ | 14.5′ |
| $^{226}Ra$ | 0.91 | - |
| $^{90}Sr$ | 4.38 | 22.3 |
| $^{235}U$ | - | 0.09 |
| Gross Beta | 19.2 | 20.9 |
| Hg | 0.54 | 0.5 |
| Mn | 850 | - |
| Va | - | 73 |
| $NO_3$ | 64 | 17 |
| $SO_4$ | 45 | - |
| Chlordane | 0.0034 | 0.0044 |
| SVOCS | - | 8.1 |

| SB-6 | | | | | |
|---|---|---|---|---|---|
| LEHR-S | 465 | 466 | 467 | 468 | 469 |
| Depth | 12′ | 19′ | 25′ | 10′ | 29′ |
| $^{226}Ra$ | - | - | - | 0.92 | - |
| $^{90}Sr$ | 0.46* | 0.47* | - | 9.46* | - |
| $^{137}Cs$ | - | - | - | 0.062 | - |
| $^{208}Tl$ | - | - | 0.213 | - | - |
| $^{235}U$ | - | - | - | - | 0.09 |
| Gross Beta | - | - | - | 42.6 | 17.7 |
| Cu | 52 | 59 | - | 59 | 78 |
| Fe | - | - | - | - | 44,000 |
| Mn | - | - | - | - | 750 |
| Pb | - | - | - | 12 | - |
| Va | - | - | - | - | 80 |
| Zn | - | 130 | - | 350 | 130 |
| $SO_4$ | - | - | - | 69 | 43 |
| Chlordane | 0.00224 | 1.08 | 0.004 | 0.198 | 0.002 |
| DDD | 0.00048 | 0.14 | 0.00073 | 0.03 | 0.0005 |
| Endosulfan I | - | - | 0.00044 | - | 0.0002 |
| Dieldrin | - | 0.026 | - | 0.0042 | - |
| Heptachlor | - | 0.047 | - | 0.017 | - |
| SVOCS | - | 0.250 | 0.041 | 0.247 | 0.091 |

| | | | | | |
|---|---|---|---|---|---|
| LEHR-S | 487 | 488 | 489 | 490 | 491 |
| Depth | 4′ | 3′ | 3′ | 4′ | 3.5′ |
| $^{226}Ra$ | - | 1.06 | - | - | - |
| $^{90}Sr$ | - | - | - | 0.53* | 1.01* |
| $^{40}K$ | - | - | 14.8 | - | - |
| Total Cr | 200 | - | - | 180 | - |
| Hg | - | 0.52 | - | - | - |
| Mn | - | - | 910 | - | - |
| Chlordane | 0.49 | 0.198 | 0.0172 | 0.017 | - |
| Heptachlor | 0.0088 | 0.0013 | - | - | - |
| Dieldrin | - | 0.0029 | - | 0.00041 | - |
| Heptachlorepoxide | - | - | - | 0.0013 | - |
| Methoxychlor | - | - | - | 0.0011 | - |
| DDD | 0.05 | 0.032 | 0.0038 | - | - |
| DDE | - | - | - | 0.0018 | - |
| DDT | - | - | - | 0.0037 | - |

| Trench 1 | | | |
|---|---|---|---|
| LEHR-S | 331 | 332 | 333 |
| Depth | 2′ | 3′ | 6′ |
| $^{226}Ra$ | 0.86 | - | 0.81 |
| $^{90}Sr$ | 1.47* | 2.01* | - |
| $^{232}Th$ | - | - | 0.71 |
| $^{228}Th$ | - | 0.71 | 0.76 |
| $^{14}C$ | 3.9 | - | - |
| Gross Beta | - | - | 17.6 |
| Ba | - | - | 240 |
| Cu | - | - | 51 |
| Mn | - | - | 770 |
| Va | - | - | 74 |
| $NO_3$ | 250 | - | - |
| $SO_4$ | 1,700 | - | - |
| Cl | 470 | 27 | - |
| Chlordane | 0.09 | 0.00181 | - |
| Pyrene | - | - | 0.033 |
| DDD | 0.019 | - | - |

| | | | | |
|---|---|---|---|---|
| LEHR-S | 492 | 493 | 494 | 495 |
| Depth | 3′ | 3′ | 3-4.5′ | 3-4.5′ |
| $^{226}Ra$ | - | - | - | 0.88 |
| $^{90}Sr$ | 0.91* | - | 0.81* | 0.59* |
| $^{235}U$ | - | - | - | 0.09 |
| Total Cr | 210 | 180 | 210 | 240 |
| Ni | 330 | - | 340 | 420 |
| Hg | - | 0.72 | 1.1 | - |
| Methylene Chloride | - | - | - | 0.004 |
| Toluene | - | - | 0.005 | - |
| DDD | - | - | - | 0.0011 |
| Chlordane | - | - | - | 0.0030 |

| Trench 4 | | |
|---|---|---|
| LEHR-S | 345 | 346 |
| Depth | 3′ | 6′ |
| $^{90}Sr$ | - | 0.49* |
| Chlordane | 0.00188 | - |

| Grid 7-9 | | | |
|---|---|---|---|
| LEHR-S | 351 | 352 | 353 |
| Depth | 1′ | 3.5′ | 3-5′ |
| $^{60}Co$ | 0.016 | - | - |
| Total Cr | - | 230 | 180 |
| Mn | - | 750 | - |
| Fe | - | 46,000 | - |
| Ni | - | 360 | - |
| $NO_3$ | 39 | 49 | 59 |
| $SO_4$ | - | - | 36 |
| Carbontetra- Chloride | - | 0.004 | - |
| DDE | - | 0.0018 | 0.0056 |
| DDT | - | - | 0.0022 |

| Trench 5 | | |
|---|---|---|
| LEHR-S | 348 | 349 |
| Depth | 3′ | 6′ |
| Total Cr | 230 | 250 |
| Formaldehyde | 1.6 | - |
| Pyrene | - | 0.023 |
| Chlordane | 0.048 | 0.0046 |

| SB-8 | | | | | | | |
|---|---|---|---|---|---|---|---|
| LEHR-S | 475 | 476 | 477 | 478 | 479 | 480 | 481 |
| Depth | 5′ | - | 14′ | 16′ | - | 26′ | 30′ |
| $^{226}Ra$ | - | 0.84 | - | - | - | - | 1.07 |
| $^{90}Sr$ | - | - | 2.44* | 0.84* | - | - | - |
| $^{14}C$ | 4.3 | - | - | - | - | - | - |
| Gross Alpha | - | - | - | 14.3 | - | - | - |
| Ar | - | - | - | - | - | - | 9.7 |
| Ba | - | 270 | - | - | 240 | - | 250 |
| Total Cr | - | - | 180 | - | - | - | - |
| Co | - | 29 | - | - | - | - | - |
| Hg | 0.59 | - | - | - | - | 0.84 | - |
| Cu | - | 55 | - | 66 | - | - | 59 |
| Mn | - | 910 | - | 800 | 750 | - | 940 |
| Pb | - | - | - | - | - | - | 11 |
| Va | - | - | - | - | - | - | 82 |
| Fe | - | - | - | - | - | - | 45,000 |
| Se | - | 1.2 | - | 1.1 | - | - | - |
| Zn | - | 82 | - | 88 | - | - | 89 |
| Chlordane | 0.0107 | - | 0.00159 | - | 0.0015 | - | 0.0035 |
| DDD | - | - | - | - | - | - | 0.00057 |
| DDE | 0.0037 | - | - | - | - | - | - |

## EXPLANATION

- S-482 — Shallow soil sample
- UCD1-4 — Monitoring well
- SB-8 — Soil boring
- Fence
- T-6 — Exploratory trench (IT, 1996)
- D.T. — Disposal trench
- GPR Anomaly - distinct (NORCAL, 1994)
- GPR Anomaly - subtle (NORCAL, 1994)

Note: Shading indicates maximum concentrations recorded in SW Trench Area during LFI

Unless otherwise noted, all radionuclides reported in pCi/g, all other results reported in mg/kg, italics indicate approximate data based on validation results, dash indicates result below background

* May be higher than actual activity present due to systematic laboratory error

N

0 — 25 feet
Approximate Scale

Figure 3-5. Analytic Results above Background for Soil Samples, Southwest Trenches Area

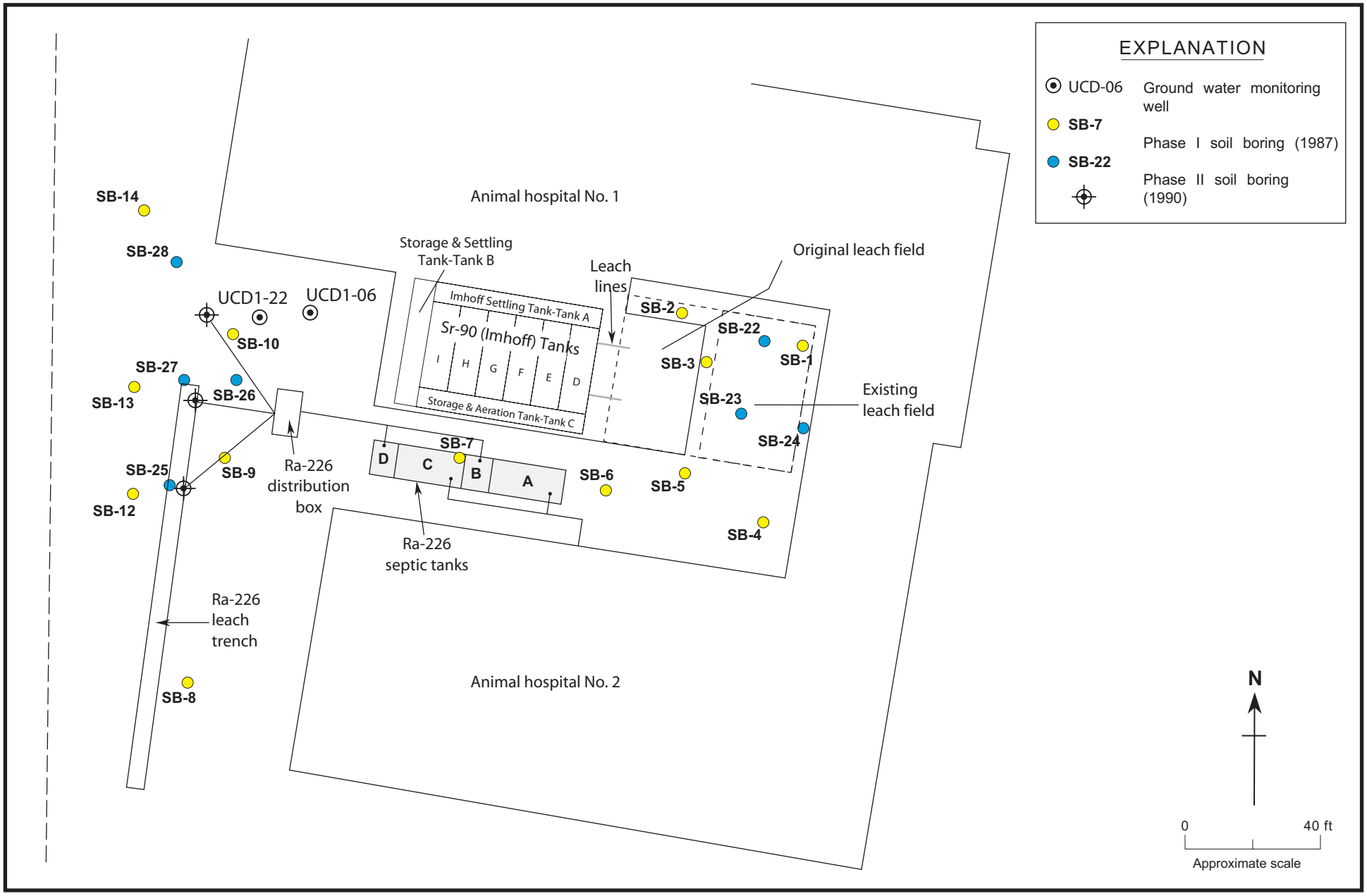



Figure 3-6. Soil Sampling Locations, Pre-1996 Investigations, Ra/Sr Treatment Systems Area

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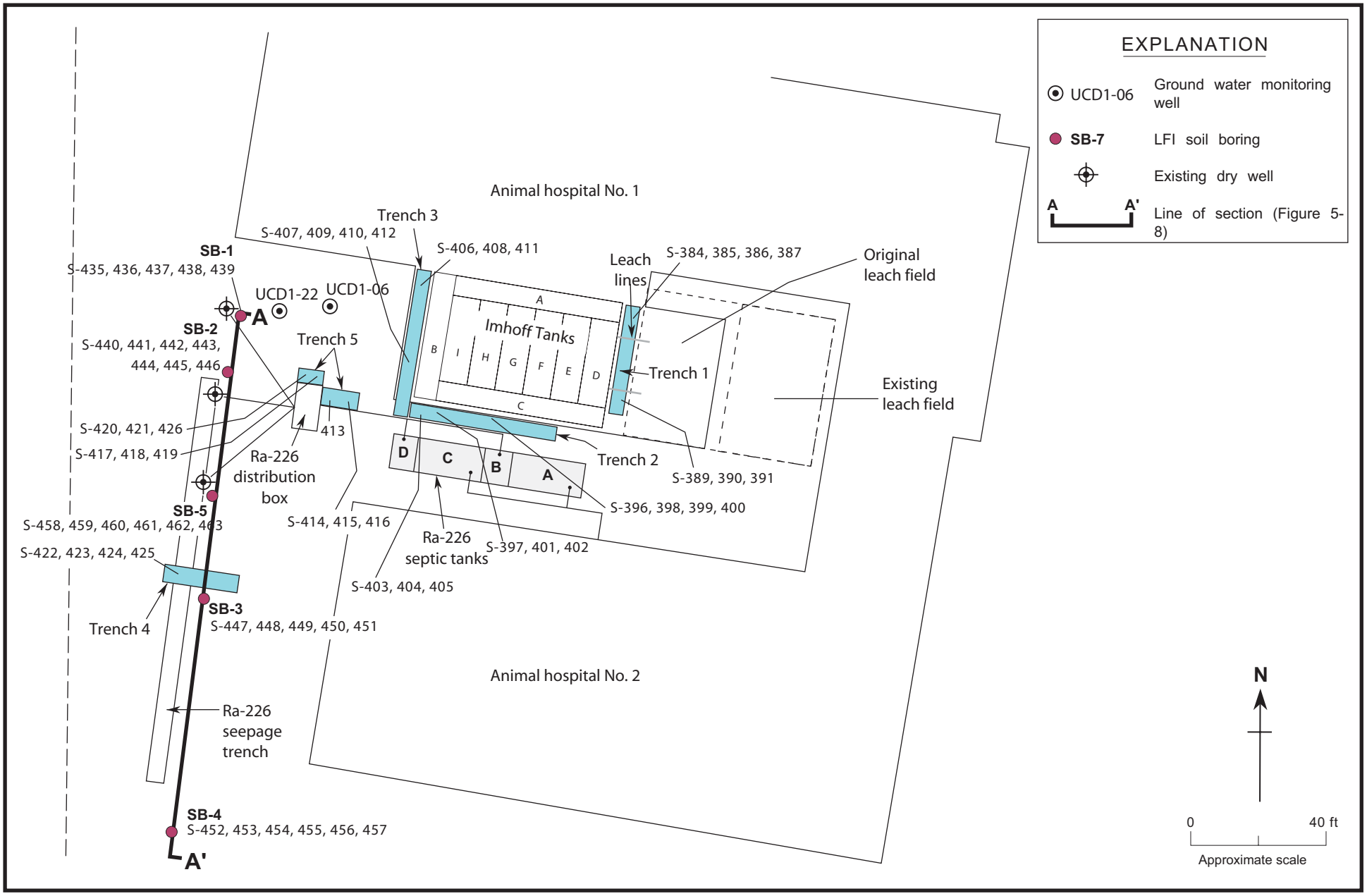


Figure 3-7. LFI Exploratory Trench, Soil Boring and Cross-Section Locations, Ra/Sr Treatment Systems Area

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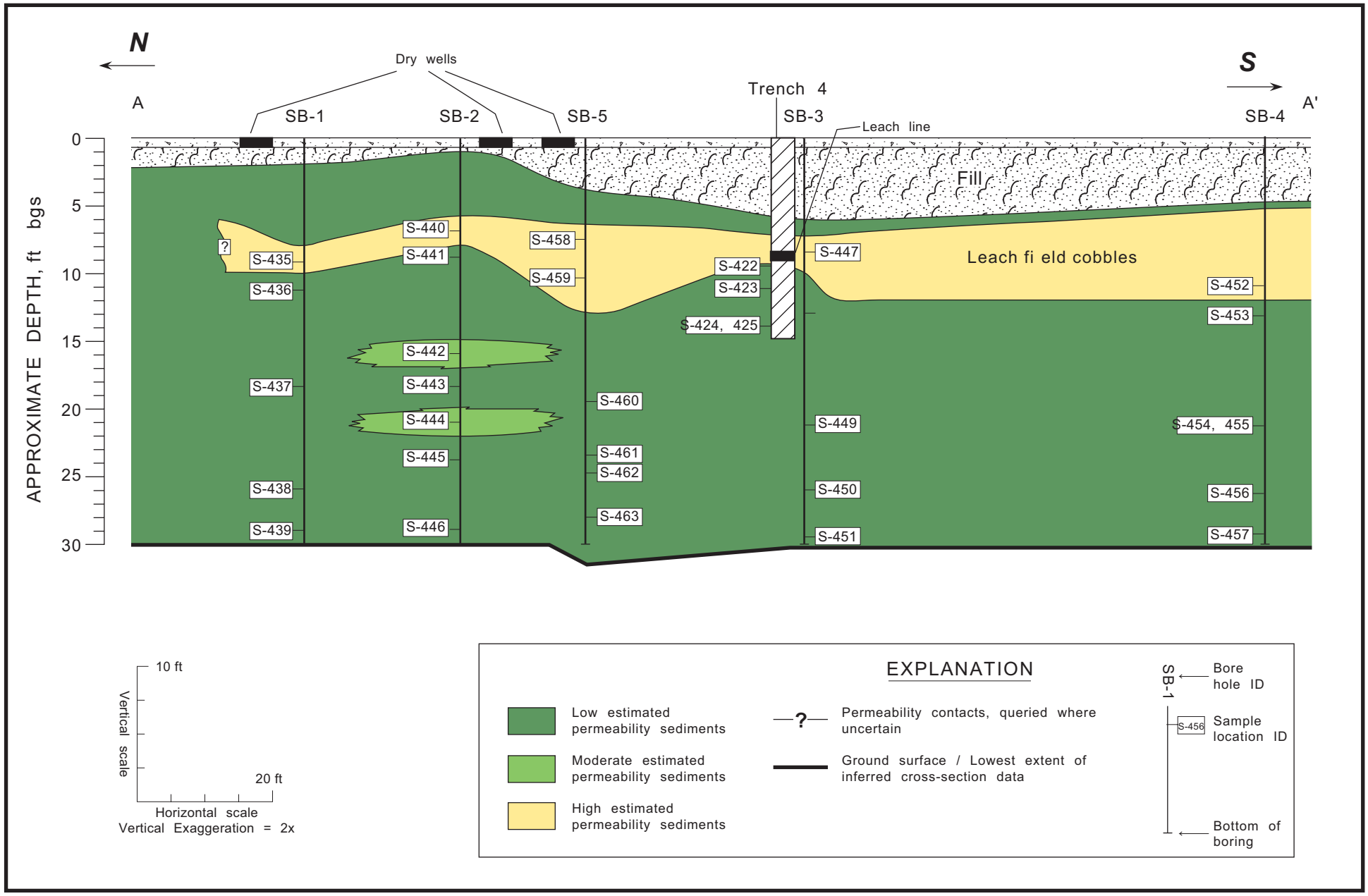


Figure 3-8. Cross-Section A-A' of Ra-226 Seepage Trench Area

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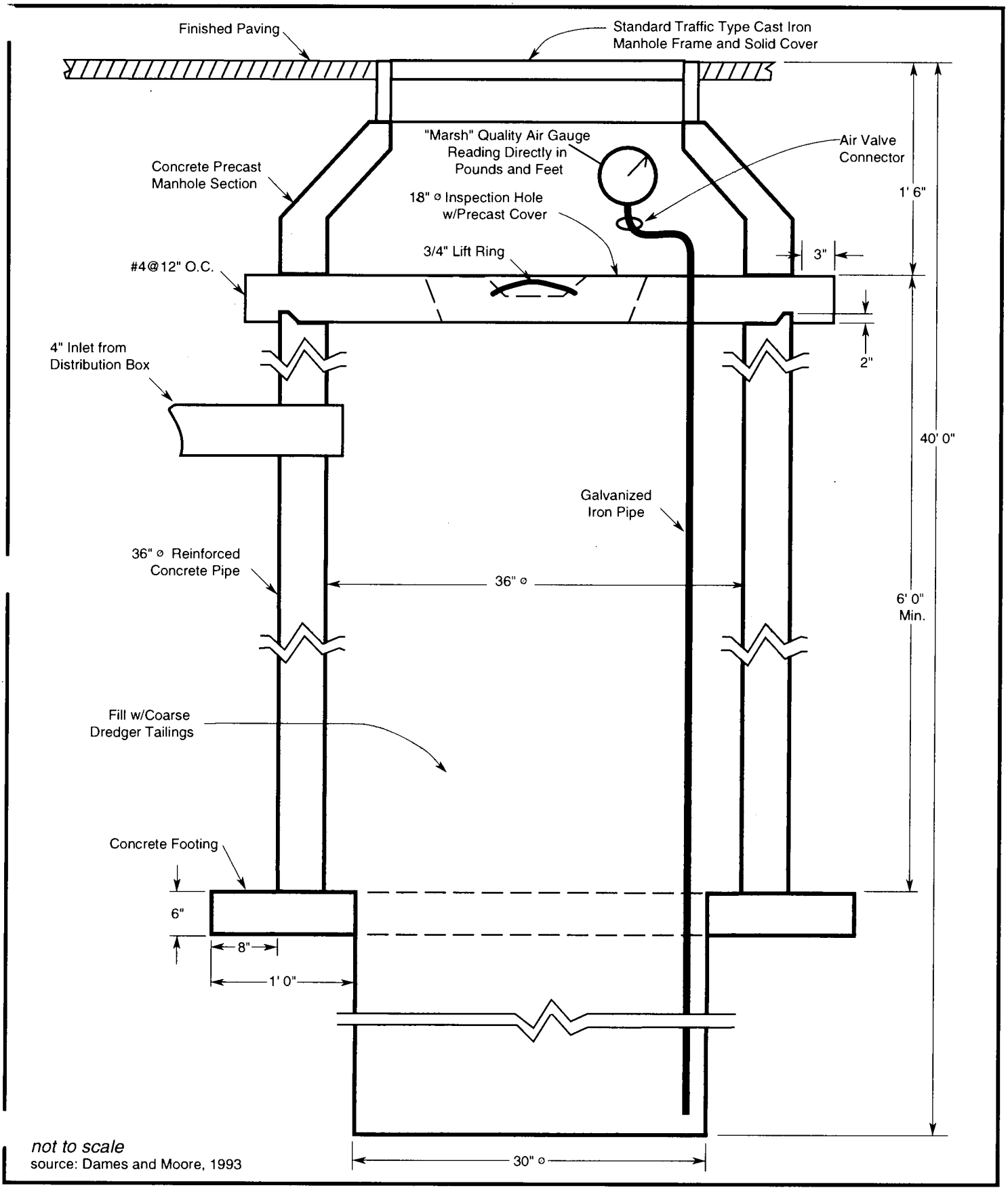
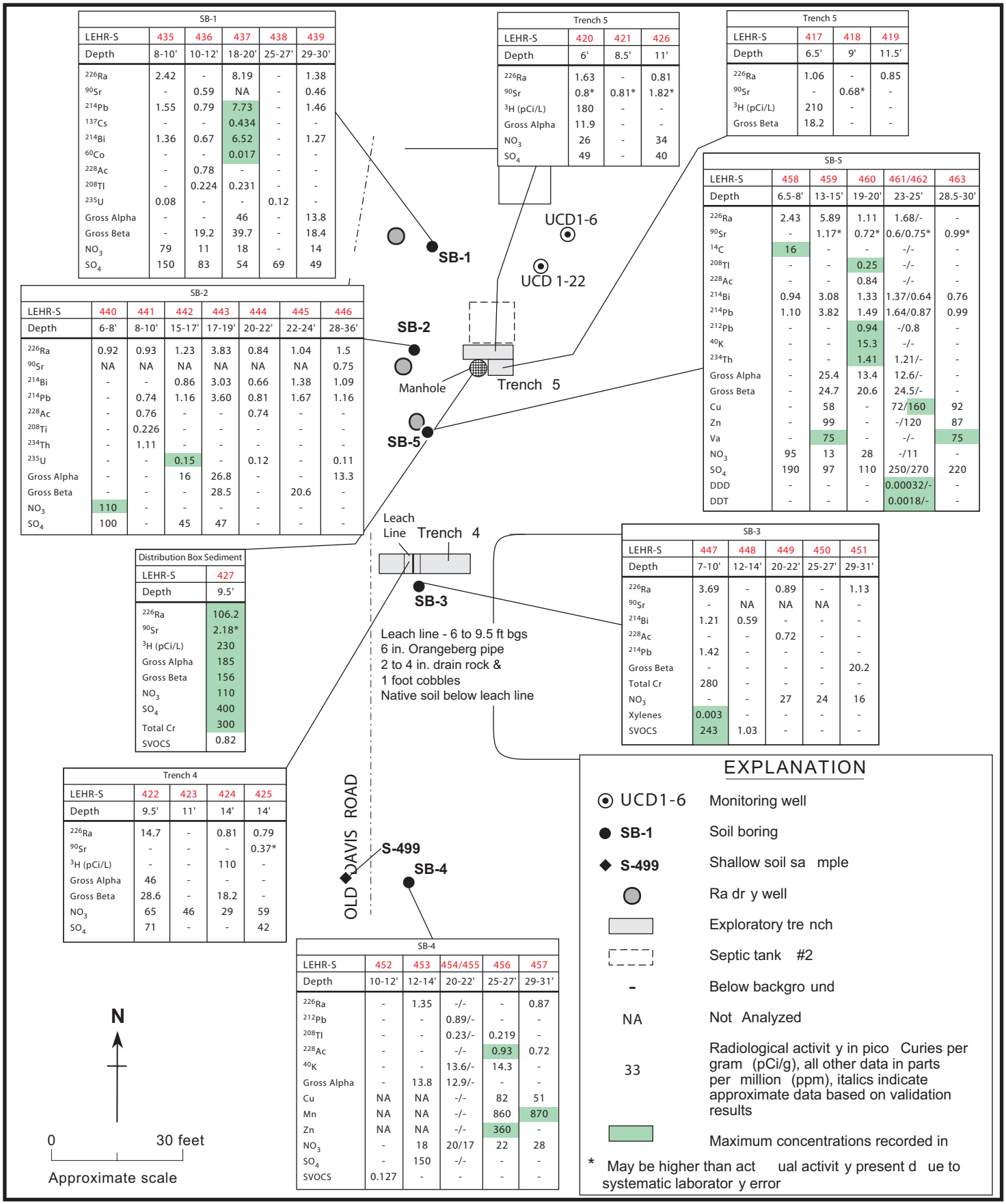



Figure 3-9. Typical Cross-Section of Radium Dry Well, (DOE, 1988)

*Weiss Associates*




| SB-1 | | | | | |
|---|---|---|---|---|---|
| LEHR-S | 435 | 436 | 437 | 438 | 439 |
| Depth | 8-10' | 10-12' | 18-20' | 25-27' | 29-30' |
| $^{226}Ra$ | 2.42 | - | 8.19 | - | 1.38 |
| $^{90}Sr$ | - | 0.59 | NA | - | 0.46 |
| $^{214}Pb$ | 1.55 | 0.79 | 7.73 | - | 1.46 |
| $^{137}Cs$ | - | - | 0.434 | - | - |
| $^{214}Bi$ | 1.36 | 0.67 | 6.52 | - | 1.27 |
| $^{60}Co$ | - | - | 0.017 | - | - |
| $^{228}Ac$ | - | 0.78 | - | - | - |
| $^{208}Tl$ | - | 0.224 | 0.231 | - | - |
| $^{235}U$ | 0.08 | - | - | 0.12 | - |
| Gross Alpha | - | - | 46 | - | 13.8 |
| Gross Beta | - | 19.2 | 39.7 | - | 18.4 |
| $NO_3$ | 79 | 11 | 18 | - | 14 |
| $SO_4$ | 150 | 83 | 54 | 69 | 49 |

| Trench 5 | | | |
|---|---|---|---|
| LEHR-S | 420 | 421 | 426 |
| Depth | 6' | 8.5' | 11' |
| $^{226}Ra$ | 1.63 | - | 0.81 |
| $^{90}Sr$ | 0.8* | 0.81* | 1.82* |
| $^{3}H$ (pCi/L) | 180 | - | - |
| Gross Alpha | 11.9 | - | - |
| $NO_3$ | 26 | - | 34 |
| $SO_4$ | 49 | - | 40 |

| Trench 5 | | | |
|---|---|---|---|
| LEHR-S | 417 | 418 | 419 |
| Depth | 6.5' | 9' | 11.5' |
| $^{226}Ra$ | 1.06 | - | 0.85 |
| $^{90}Sr$ | - | 0.68* | - |
| $^{3}H$ (pCi/L) | 210 | - | - |
| Gross Beta | 18.2 | - | - |

| SB-5 | | | | | |
|---|---|---|---|---|---|
| LEHR-S | 458 | 459 | 460 | 461/462 | 463 |
| Depth | 6.5-8' | 13-15' | 19-20' | 23-25' | 28.5-30' |
| $^{226}Ra$ | 2.43 | 5.89 | 1.11 | 1.68/- | - |
| $^{90}Sr$ | - | 1.17* | 0.72* | 0.6/0.75* | 0.99* |
| $^{14}C$ | 16 | - | - | -/- | - |
| $^{208}Tl$ | - | - | 0.25 | -/- | - |
| $^{228}Ac$ | - | - | 0.84 | -/- | - |
| $^{214}Bi$ | 0.94 | 3.08 | 1.33 | 1.37/0.64 | 0.76 |
| $^{214}Pb$ | 1.10 | 3.82 | 1.49 | 1.64/0.87 | 0.99 |
| $^{212}Pb$ | - | - | 0.94 | -/0.8 | - |
| $^{40}K$ | - | - | 15.3 | -/- | - |
| $^{234}Th$ | - | - | 1.41 | 1.21/- | - |
| Gross Alpha | - | 25.4 | 13.4 | 12.6/- | - |
| Gross Beta | - | 24.7 | 20.6 | 24.5/- | - |
| Cu | - | 58 | - | 72/160 | 92 |
| Zn | - | 99 | - | -/120 | 87 |
| Va | - | 75 | - | -/- | 75 |
| $NO_3$ | 95 | 13 | 28 | -/11 | - |
| $SO_4$ | 190 | 97 | 110 | 250/270 | 220 |
| DDD | - | - | - | 0.00032/- | - |
| DDT | - | - | - | 0.0018/- | - |

| SB-2 | | | | | | | |
|---|---|---|---|---|---|---|---|
| LEHR-S | 440 | 441 | 442 | 443 | 444 | 445 | 446 |
| Depth | 6-8' | 8-10' | 15-17' | 17-19' | 20-22' | 22-24' | 28-36' |
| $^{226}Ra$ | 0.92 | 0.93 | 1.23 | 3.83 | 0.84 | 1.04 | 1.5 |
| $^{90}Sr$ | NA | NA | NA | NA | NA | NA | 0.75 |
| $^{214}Bi$ | - | - | 0.86 | 3.03 | 0.66 | 1.38 | 1.09 |
| $^{214}Pb$ | - | 0.74 | 1.16 | 3.60 | 0.81 | 1.67 | 1.16 |
| $^{228}Ac$ | - | 0.76 | - | - | 0.74 | - | - |
| $^{208}Ti$ | - | 0.226 | - | - | - | - | - |
| $^{234}Th$ | - | 1.11 | - | - | - | - | - |
| $^{235}U$ | - | - | 0.15 | - | 0.12 | - | 0.11 |
| Gross Alpha | - | - | 16 | 26.8 | - | - | 13.3 |
| Gross Beta | - | - | - | 28.5 | - | 20.6 | - |
| $NO_3$ | 110 | - | - | - | - | - | - |
| $SO_4$ | 100 | - | 45 | 47 | - | - | - |

| Distribution Box Sediment | |
|---|---|
| LEHR-S | 427 |
| Depth | 9.5' |
| $^{226}Ra$ | 106.2 |
| $^{90}Sr$ | 2.18* |
| $^{3}H$ (pCi/L) | 230 |
| Gross Alpha | 185 |
| Gross Beta | 156 |
| $NO_3$ | 110 |
| $SO_4$ | 400 |
| Total Cr | 300 |
| SVOCS | 0.82 |

| SB-3 | | | | | |
|---|---|---|---|---|---|
| LEHR-S | 447 | 448 | 449 | 450 | 451 |
| Depth | 7-10' | 12-14' | 20-22' | 25-27' | 29-31' |
| $^{226}Ra$ | 3.69 | - | 0.89 | - | 1.13 |
| $^{90}Sr$ | - | NA | NA | NA | - |
| $^{214}Bi$ | 1.21 | 0.59 | - | - | - |
| $^{228}Ac$ | - | - | 0.72 | - | - |
| $^{214}Pb$ | 1.42 | - | - | - | - |
| Gross Beta | - | - | - | - | 20.2 |
| Total Cr | 280 | - | - | - | - |
| $NO_3$ | - | - | 27 | 24 | 16 |
| Xylenes | 0.003 | - | - | - | - |
| SVOCS | 243 | 1.03 | - | - | - |

| Trench 4 | | | | |
|---|---|---|---|---|
| LEHR-S | 422 | 423 | 424 | 425 |
| Depth | 9.5' | 11' | 14' | 14' |
| $^{226}Ra$ | 14.7 | - | 0.81 | 0.79 |
| $^{90}Sr$ | - | - | - | 0.37* |
| $^{3}H$ (pCi/L) | - | - | 110 | - |
| Gross Alpha | 46 | - | - | - |
| Gross Beta | 28.6 | - | 18.2 | - |
| $NO_3$ | 65 | 46 | 29 | 59 |
| $SO_4$ | 71 | - | - | 42 |

| SB-4 | | | | | |
|---|---|---|---|---|---|
| LEHR-S | 452 | 453 | 454/455 | 456 | 457 |
| Depth | 10-12' | 12-14' | 20-22' | 25-27' | 29-31' |
| $^{226}Ra$ | - | 1.35 | -/- | - | 0.87 |
| $^{212}Pb$ | - | - | 0.89/- | - | - |
| $^{208}Tl$ | - | - | 0.23/- | 0.219 | - |
| $^{228}Ac$ | - | - | -/- | 0.93 | 0.72 |
| $^{40}K$ | - | - | 13.6/- | 14.3 | - |
| Gross Alpha | - | 13.8 | 12.9/- | - | - |
| Cu | NA | NA | -/- | 82 | 51 |
| Mn | NA | NA | -/- | 860 | 870 |
| Zn | NA | NA | -/- | 360 | - |
| $NO_3$ | - | 18 | 20/17 | 22 | 28 |
| $SO_4$ | - | 150 | -/- | - | - |
| SVOCS | 0.127 | - | - | - | - |

Figure 3-10. Analytic Results above Background for Soil Samples, Radium-226 Leach System

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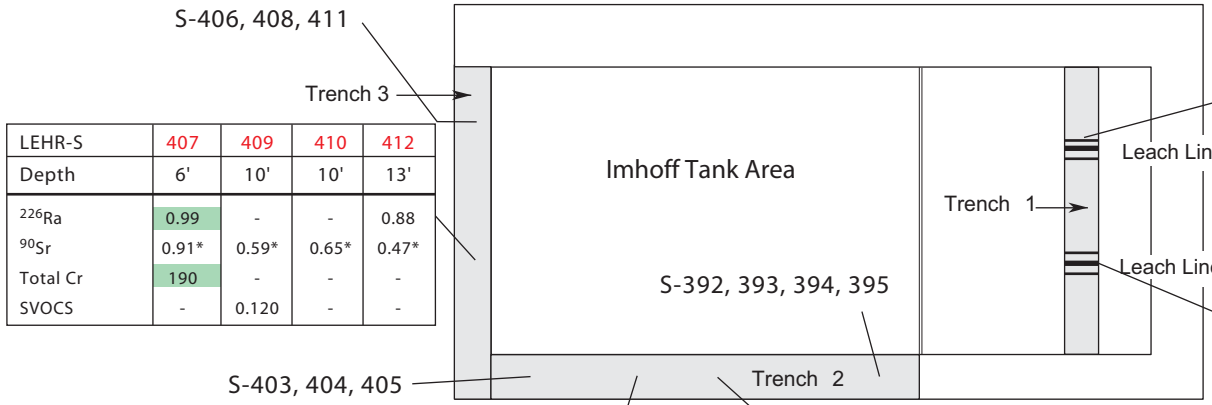


| LEHR-S | 384 | 385 | 386 | 387 |
|---|---|---|---|---|
| Depth | 5'4" | 5'4" | 8' | 10'8" |
| $^{90}Sr$ | 1.61 | 0.76 | 0.86* | - |
| Gross Alpha | - | - | 12 | - |
| Gross Beta | - | 20.6 | - | - |
| $NO_3$ | - | - | 14 | 10 |
| SVOCS | 0.07 | 0.276 | - | - |

| LEHR-S | 407 | 409 | 410 | 412 |
|---|---|---|---|---|
| Depth | 6' | 10' | 10' | 13' |
| $^{226}Ra$ | 0.99 | - | - | 0.88 |
| $^{90}Sr$ | 0.91* | 0.59* | 0.65* | 0.47* |
| Total Cr | 190 | - | - | - |
| SVOCS | - | 0.120 | - | - |

| LEHR-S | 389 | 390 | 391 |
|---|---|---|---|
| Depth | 4'6" | 7' | 9'6" |
| $^{226}Ra$ | 0.8 | - | 0.87 |
| $^{90}Sr$ | 0.59 | 0.45* | - |
| Gross Beta | - | 17.8 | - |
| $NO_3$ | 42 | 33 | - |
| $SO_4$ | 51 | 40 | - |
| Cl | 25 | 29 | - |
| SVOCS | 0.404 | - | - |

| LEHR-S | 397 | 401 | 402 |
|---|---|---|---|
| Depth | 5' | 10' | 13' |
| $^{226}Ra$ | - | 0.79 | - |
| $^{90}Sr$ | 0.78* | - | - |
| Benzene | 0.005 | 0.004 | 0.004 |
| Toulene | 0.004 | - | - |

| LEHR-S | 396 | 398 | 399 | 400 |
|---|---|---|---|---|
| Depth | 5' | 10' | 13' | 13' |
| $^{90}Sr$ | 0.6* | - | 0.63 | - |
| Benzene | - | 0.004 | 0.004 | 0.004 |

## EXPLANATION

Exploratory trenc h

\- Below backgro und

33 Radiological data in pico-Curies per gra m (pCi/g), a ll other data in parts per million (ppm) - Italics indicate appro ximate data based on validation res ults

Maximum concentrations recorded in the Strontium-90 leach s ystem area during the L FI

* May be higher than act ual acti vity present d ue to s ystematic laboratory

Figure 3-11. Analytic Results above Background for Soil Samples, Strontium-90 Leach System

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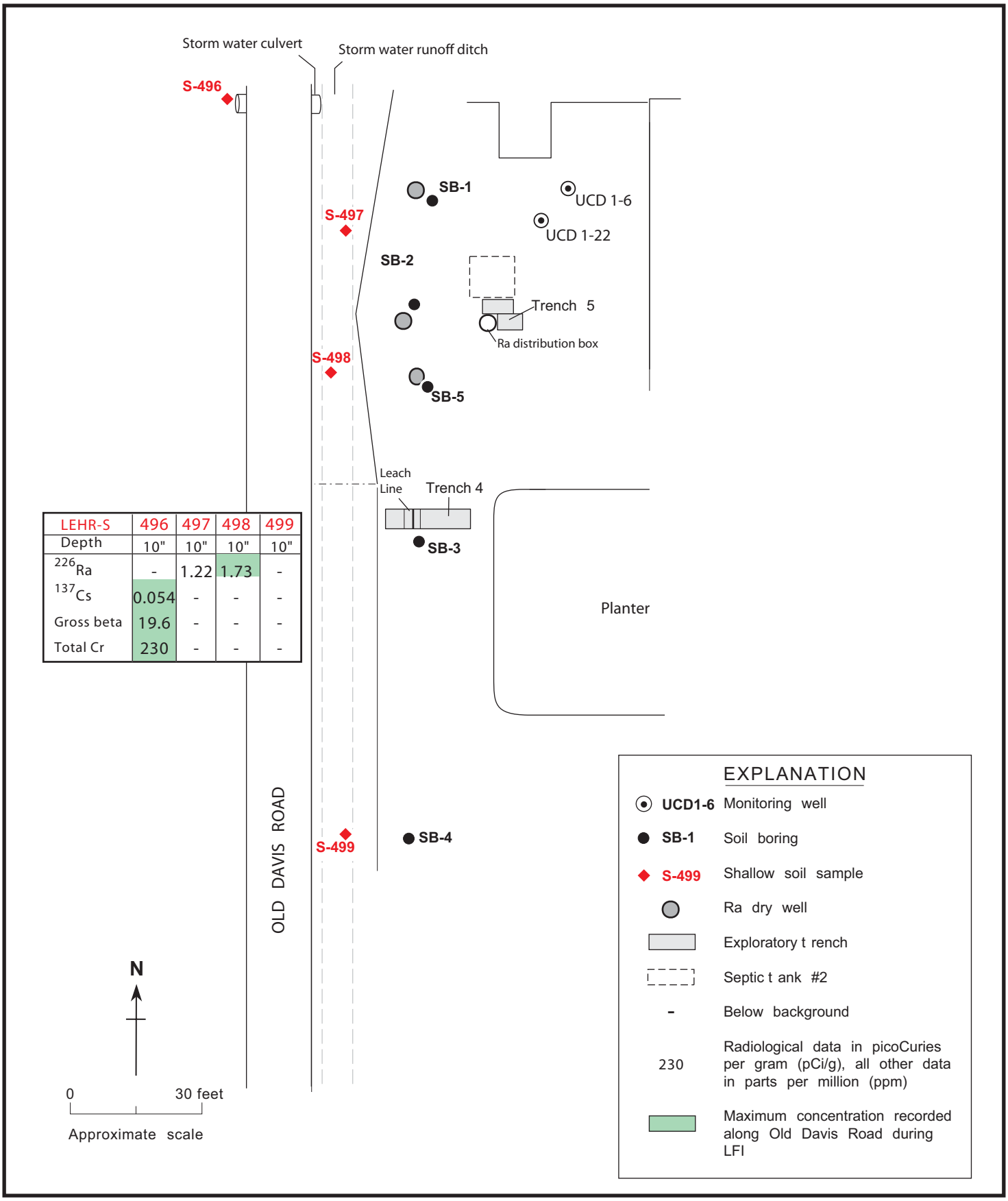


| LEHR-S | 496 | 497 | 498 | 499 |
|---|---|---|---|---|
| Depth | 10" | 10" | 10" | 10" |
| $^{226}$Ra | - | 1.22 | 1.73 | - |
| $^{137}$Cs | 0.054 | - | - | - |
| Gross beta | 19.6 | - | - | - |
| Total Cr | 230 | - | - | - |

Figure 3-12. Analytic Results above Background for LFI Soil Samples, Old Davis Road

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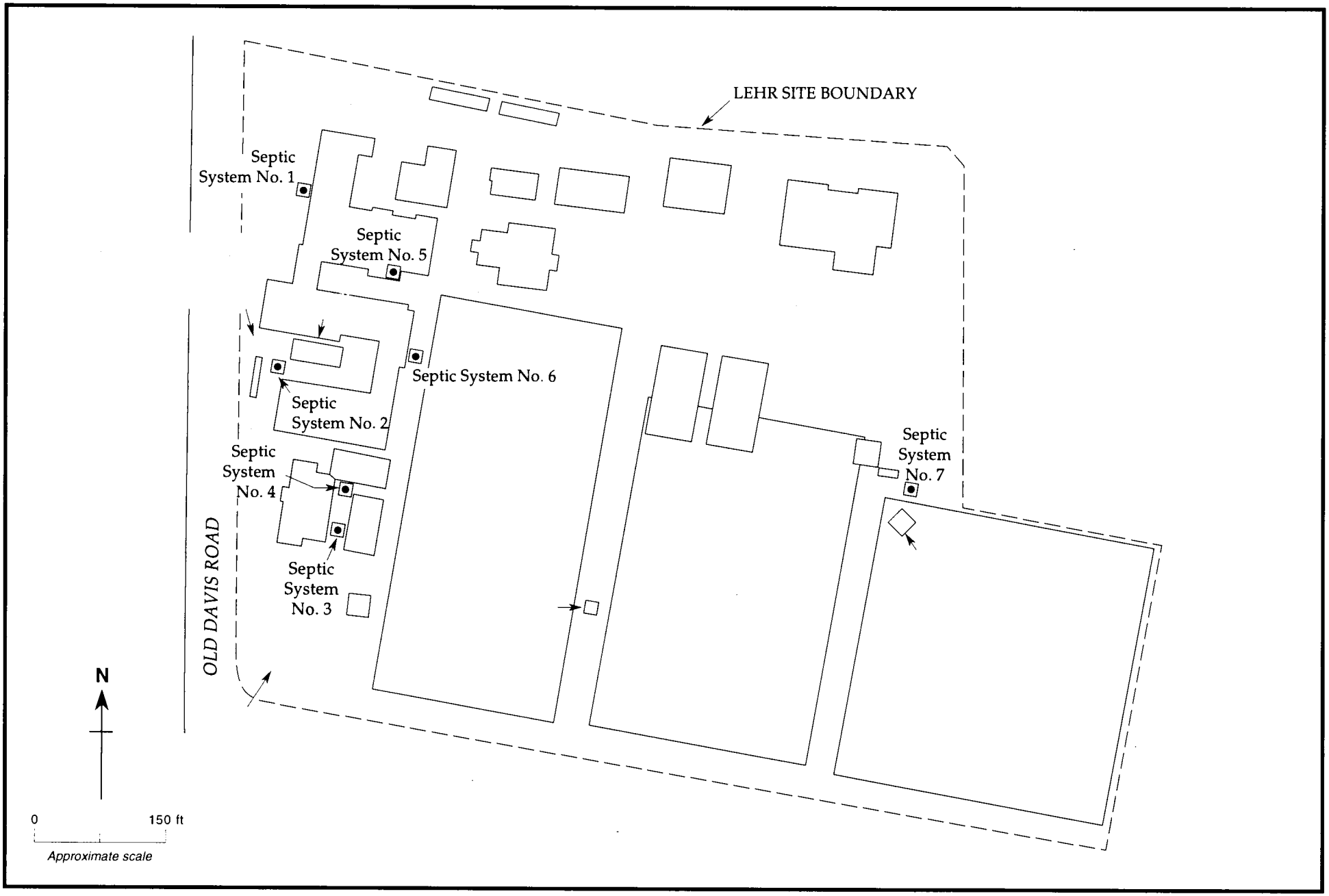


Figure 3-13. Locations of Domestic Septic Systems No. 1 through 7

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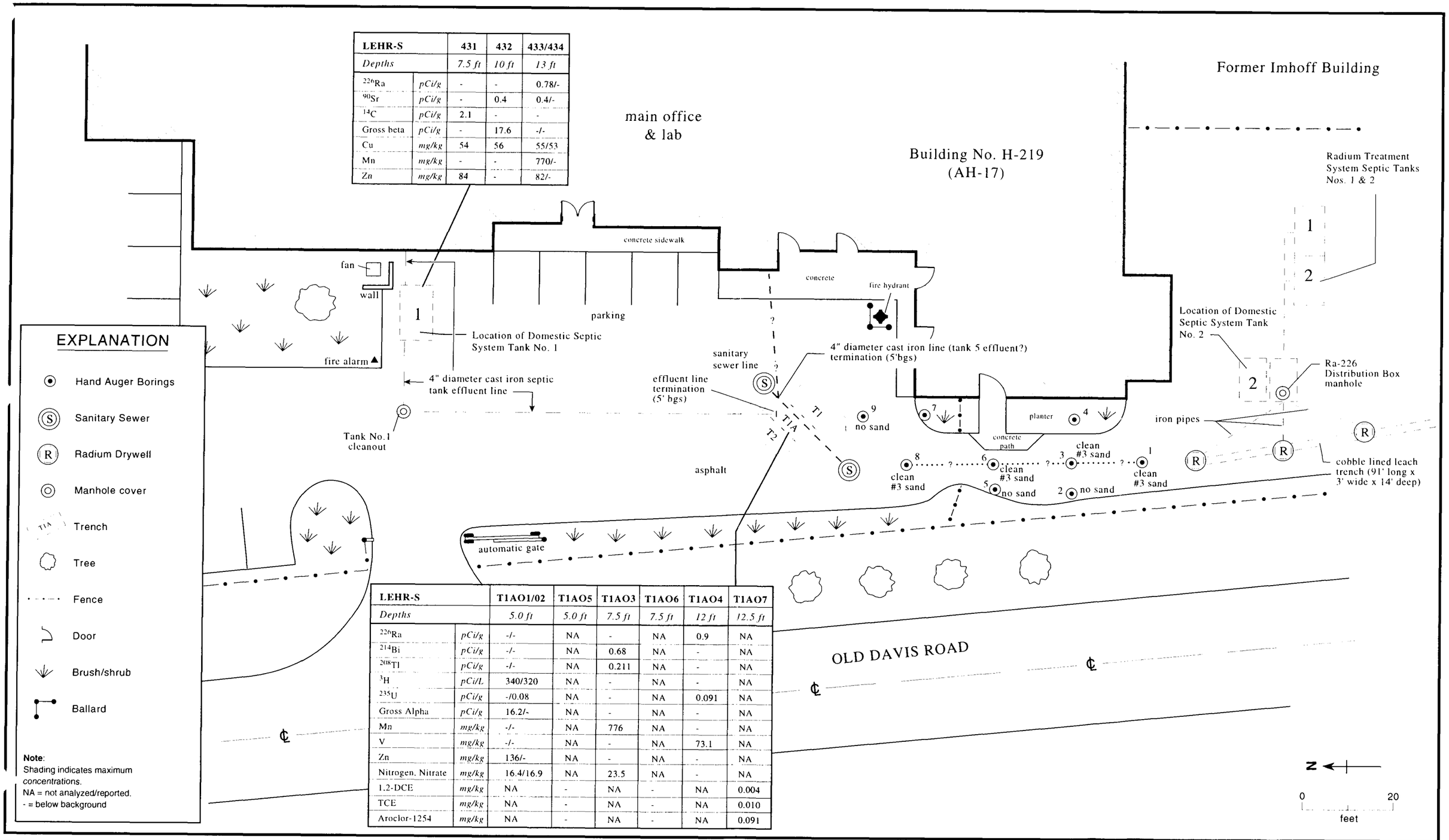


| LEHR-S | | 431 | 432 | 433/434 |
|---|---|---|---|---|
| *Depths* | | *7.5 ft* | *10 ft* | *13 ft* |
| $^{226}$Ra | *pCi/g* | - | - | 0.78/- |
| $^{90}$Sr | *pCi/g* | - | 0.4 | 0.4/- |
| $^{14}$C | *pCi/g* | 2.1 | - | - |
| Gross beta | *pCi/g* | - | 17.6 | -/- |
| Cu | *mg/kg* | 54 | 56 | 55/53 |
| Mn | *mg/kg* | - | - | 770/- |
| Zn | *mg/kg* | 84 | - | 82/- |

| LEHR-S | | T1AO1/02 | T1AO5 | T1AO3 | T1AO6 | T1AO4 | T1AO7 |
|---|---|---|---|---|---|---|---|
| *Depths* | | *5.0 ft* | *5.0 ft* | *7.5 ft* | *7.5 ft* | *12 ft* | *12.5 ft* |
| $^{226}$Ra | *pCi/g* | -/- | NA | - | NA | 0.9 | NA |
| $^{214}$Bi | *pCi/g* | -/- | NA | 0.68 | NA | - | NA |
| $^{208}$Tl | *pCi/g* | -/- | NA | 0.211 | NA | - | NA |
| $^{3}$H | *pCi/L* | 340/320 | NA | - | NA | - | NA |
| $^{235}$U | *pCi/g* | -/0.08 | NA | - | NA | 0.091 | NA |
| Gross Alpha | *pCi/g* | 16.2/- | NA | - | NA | - | NA |
| Mn | *mg/kg* | -/- | NA | 776 | NA | - | NA |
| V | *mg/kg* | -/- | NA | - | NA | 73.1 | NA |
| Zn | *mg/kg* | 136/- | NA | - | NA | - | NA |
| Nitrogen, Nitrate | *mg/kg* | 16.4/16.9 | NA | 23.5 | NA | - | NA |
| 1,2-DCE | *mg/kg* | NA | - | NA | - | NA | 0.004 |
| TCE | *mg/kg* | NA | - | NA | - | NA | 0.010 |
| Aroclor-1254 | *mg/kg* | NA | - | NA | - | NA | 0.091 |

Figure 3-14. Analytic Results above Background for Soil Samples, Domestic Septic Systems No. 1 and 2

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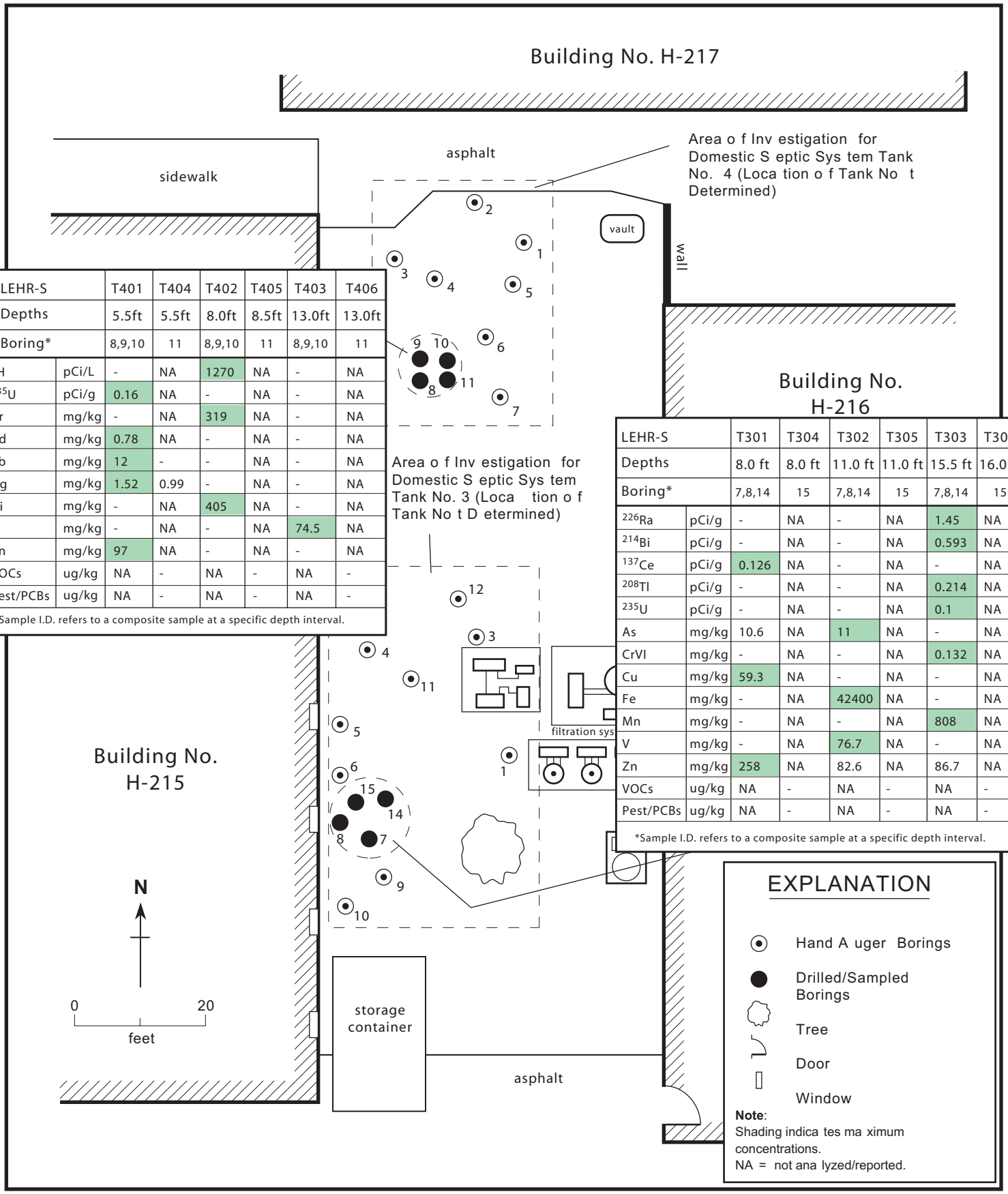


| LEHR-S | | T401 | T404 | T402 | T405 | T403 | T406 |
|---|---|---|---|---|---|---|---|
| Depths | | 5.5ft | 5.5ft | 8.0ft | 8.5ft | 13.0ft | 13.0ft |
| Boring* | | 8,9,10 | 11 | 8,9,10 | 11 | 8,9,10 | 11 |
| $^{3}H$ | pCi/L | - | NA | 1270 | NA | - | NA |
| $^{235}U$ | pCi/g | 0.16 | NA | - | NA | - | NA |
| Cr | mg/kg | - | NA | 319 | NA | - | NA |
| Cd | mg/kg | 0.78 | NA | - | NA | - | NA |
| Pb | mg/kg | 12 | - | - | NA | - | NA |
| Hg | mg/kg | 1.52 | 0.99 | - | NA | - | NA |
| Ni | mg/kg | - | NA | 405 | NA | - | NA |
| V | mg/kg | - | NA | - | NA | 74.5 | NA |
| Zn | mg/kg | 97 | NA | - | NA | - | NA |
| VOCs | ug/kg | NA | - | NA | - | NA | - |
| Pest/PCBs | ug/kg | NA | - | NA | - | NA | - |

*Sample I.D. refers to a composite sample at a specific depth interval.

| LEHR-S | | T301 | T304 | T302 | T305 | T303 | T306 |
|---|---|---|---|---|---|---|---|
| Depths | | 8.0 ft | 8.0 ft | 11.0 ft | 11.0 ft | 15.5 ft | 16.0 ft |
| Boring* | | 7,8,14 | 15 | 7,8,14 | 15 | 7,8,14 | 15 |
| $^{226}Ra$ | pCi/g | - | NA | - | NA | 1.45 | NA |
| $^{214}Bi$ | pCi/g | - | NA | - | NA | 0.593 | NA |
| $^{137}Ce$ | pCi/g | 0.126 | NA | - | NA | - | NA |
| $^{208}Tl$ | pCi/g | - | NA | - | NA | 0.214 | NA |
| $^{235}U$ | pCi/g | - | NA | - | NA | 0.1 | NA |
| As | mg/kg | 10.6 | NA | 11 | NA | - | NA |
| CrVI | mg/kg | - | NA | - | NA | 0.132 | NA |
| Cu | mg/kg | 59.3 | NA | - | NA | - | NA |
| Fe | mg/kg | - | NA | 42400 | NA | - | NA |
| Mn | mg/kg | - | NA | - | NA | 808 | NA |
| V | mg/kg | - | NA | 76.7 | NA | - | NA |
| Zn | mg/kg | 258 | NA | 82.6 | NA | 86.7 | NA |
| VOCs | ug/kg | NA | - | NA | - | NA | - |
| Pest/PCBs | ug/kg | NA | - | NA | - | NA | - |

*Sample I.D. refers to a composite sample at a specific depth interval.

Figure 3-15. Analytic Results above Background for Soil Samples, Domestic Septic System No. 3 and 4

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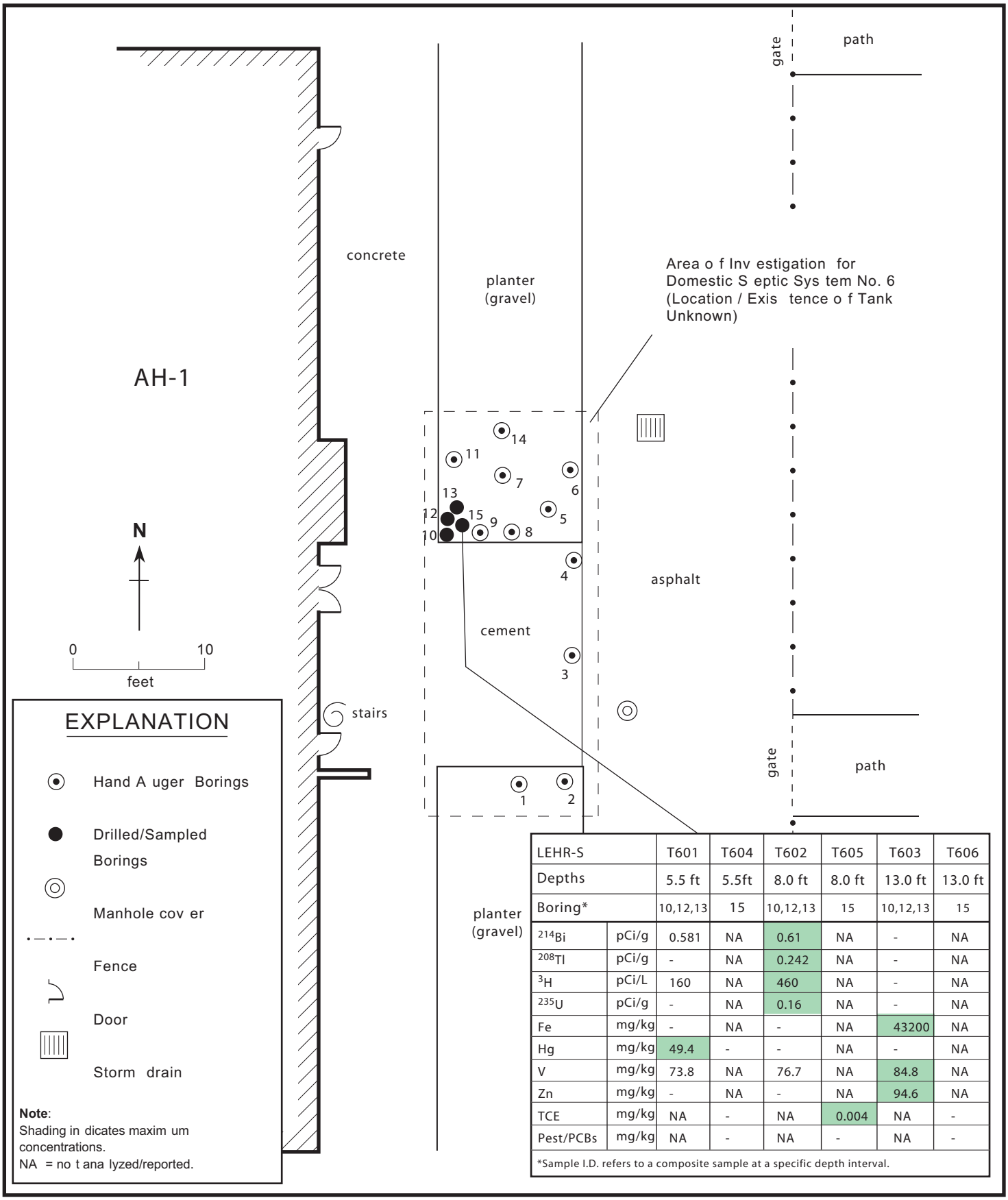
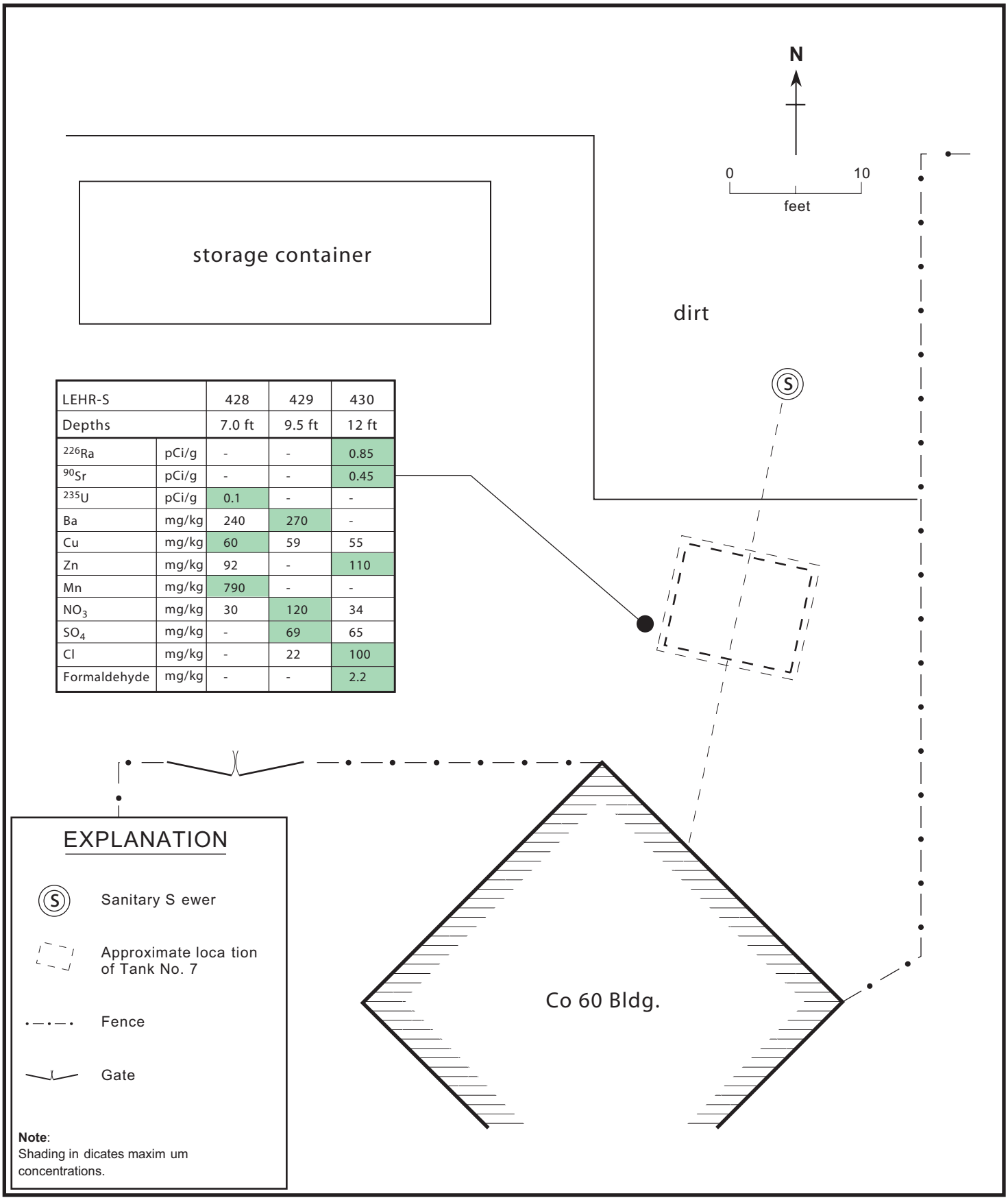



| LEHR-S | | T601 | T604 | T602 | T605 | T603 | T606 |
|---|---|---|---|---|---|---|---|
| Depths | | 5.5 ft | 5.5ft | 8.0 ft | 8.0 ft | 13.0 ft | 13.0 ft |
| Boring* | | 10,12,13 | 15 | 10,12,13 | 15 | 10,12,13 | 15 |
| $^{214}$Bi | pCi/g | 0.581 | NA | 0.61 | NA | - | NA |
| $^{208}$Tl | pCi/g | - | NA | 0.242 | NA | - | NA |
| $^{3}$H | pCi/L | 160 | NA | 460 | NA | - | NA |
| $^{235}$U | pCi/g | - | NA | 0.16 | NA | - | NA |
| Fe | mg/kg | - | NA | - | NA | 43200 | NA |
| Hg | mg/kg | 49.4 | - | - | NA | - | NA |
| V | mg/kg | 73.8 | NA | 76.7 | NA | 84.8 | NA |
| Zn | mg/kg | - | NA | - | NA | 94.6 | NA |
| TCE | mg/kg | NA | - | NA | 0.004 | NA | - |
| Pest/PCBs | mg/kg | NA | - | NA | - | NA | - |

*Sample I.D. refers to a composite sample at a specific depth interval.

Figure 3-16. Analytic Results above Background for Soil Samples, Domestic Septic System No. 6

Weiss Assoc iates




| LEHR-S | | 428 | 429 | 430 |
|---|---|---|---|---|
| Depths | | 7.0 ft | 9.5 ft | 12 ft |
| $^{226}Ra$ | pCi/g | - | - | 0.85 |
| $^{90}Sr$ | pCi/g | - | - | 0.45 |
| $^{235}U$ | pCi/g | 0.1 | - | - |
| Ba | mg/kg | 240 | 270 | - |
| Cu | mg/kg | 60 | 59 | 55 |
| Zn | mg/kg | 92 | - | 110 |
| Mn | mg/kg | 790 | - | - |
| $NO_3$ | mg/kg | 30 | 120 | 34 |
| $SO_4$ | mg/kg | - | 69 | 65 |
| Cl | mg/kg | - | 22 | 100 |
| Formaldehyde | mg/kg | - | - | 2.2 |

Figure 3-17. Analytic Results above Background for Soil Samples, Domestic Septic System No. 7

Weiss Assoc iates

# 4. REMOVAL ACTION OBJECTIVES

Removal Action Objectives (RAOs) ensure that removal alternatives achieve acceptable exposure levels that are protective of human health and the environment. The development of RAOs considers Applicable or Relevant and Appropriate Requirements (ARARs), CERCLA risk ranges (e.g., $10^{-4}$ to $10^{-6}$ excess cancer risk), and other pertinent factors. Specific RAOs for these proposed RAs are identified at the end of this section.

## 4.1 Statutory Authority

Executive Order 12580 "Superfund Implementation", Amended August 1996, delegates to DOE the authority for RAs at DOE sites, whether or not the sites are on the NPL (E.O., 1996). Authority for responding to releases or threats of releases from a hazardous waste site is addressed in Section 104 of CERCLA. Under CERCLA Section 104(b), DOE is authorized to undertake such investigations, surveys, testing, or other data gathering deemed necessary to identify the existence, extent, and nature of the contaminants, including the extent of threats to human health and the environment. In addition, DOE is authorized to undertake planning, engineering, and other studies or investigations appropriate to directing response actions to prevent, limit or mitigate the risk to human health and the environment.

## 4.2 Applicable or Relevant and Appropriate Requirements (ARARS)

CERCLA Section 121 requires that RAs be protective of human health and the environment and, where practical, meet any federal standards, requirements, criteria, or limitations that are determined to be legally applicable or relevant and appropriate. CERCLA Section 121 also requires that state ARARs must be met if they are promulgated, more stringent than the federal requirements, and identified by the state in a timely manner. An analysis of state standards must be performed to determine if they impose additional or exclusive requirements. Applicable requirements are those promulgated federal and state requirements that would be legally applicable to the RA if that action were not taken pursuant to Sections 104 and 106 of CERCLA. Relevant and appropriate requirements are those promulgated federal or state requirements that, while not legally applicable to the Site, apply to sites or circumstances sufficiently similar to the subject Site that their application is appropriate. In addition, the NCP published in 40 CFR 300, requires that local ordinances, unpromulgated criteria, advisories, or guidance that do not meet the definition of ARARs, but that may assist in the development of remedial objectives, be included as "to be considered" (TBC) requirements.

Potential ARARs to be reviewed for CERCLA Sites fall into three broad categories, based on: 1) the COC; 2) the site location and conditions; and, 3) the RA being considered. The three categories are:

1. **Chemical-specific ARARs** are chemical-specific requirements that define acceptable exposure concentrations or water quality standards. An example of a chemical-specific ARAR is an ambient air quality standard.

2. **Location-specific ARARs** govern activities in certain environmentally sensitive areas such as flood plains, wetlands, endangered species habitat, or historically significant areas.

3. **Action-specific ARARs** are technology or activity-based requirements or restrictions. Examples of RA-specific ARARs are monitoring requirements, effluent discharge limitations, hazardous waste manifesting requirements, and occupational health and safety requirements.

In accordance with Section 300.415(I) of the NCP, on-site RAs conducted under CERCLA are required to attain ARARs to the extent practicable, considering the exigencies of the situation. Situations in which it may not be practicable to comply with an ARAR because it would be outside the scope of the RA include:

- When compliance involves a degree of cleanup that would be inconsistent with the purpose of the RA; and,
- When compliance with ARARs would result in performing a RA with a duration longer than one year and no statutory exemption applies.

### *4.2.1 Chemical-Specific ARARs*

The following are chemical-specific ARARs and TBCs for the DOE Areas. These requirements are summarized in Table 4-1.

**Federal Requirements**

- Clean Water Act (33 USCA 1251-1376, 40 CFR 122, 125, and 136);
- Safe Drinking Water Act (42 USCA 300 and 40 CFR 141.11-16, 141.50-51); and,
- Establishment of Cleanup Levels for CERCLA Sites with Radioactive Contamination (EPA, 1997).

- 

**State and Local Requirements**

- Criteria for Identifying Hazardous Wastes CCR, Title 22, 66261.21-33;
- Minimum Standards for Management of Hazardous and Extremely Hazardous Wastes Hazardous Waste Control Act (generally, Health and Safety Code, Sections 25100 et seq. and CCR, Title 22, Chap. 30);
- Persistent and Bioaccumulative Toxic Substances (CCR, Title 22, 66261.113);
- Porter-Cologne Water Quality Control Act (Generally, California Water Code, Div. 7, Section 13000, et. seq. and 23 CCR Chap. 15, 2510-2559, 2580-2601);
- Water Quality Control Plan (Basin Plan) for the Central Valley Regional Water Quality Control Board (RWQCB); and,
- State Water Resources Control Board Resolution 68-16.
- State Water Resources Control Board Resolution 92-49.
- State Water Resources Control Board Resolution 88-63.

### *4.2.2 Location-Specific ARARs*

The following are location-specific ARARs and TBCs for the DOE Areas. These requirements are summarized in Table 4-2.

**Federal Requirements**

- Endangered Species Act of 1973 (16 USC Section 1531 et seq., 50 CFR Parts 10, 11, 17, 200, 402, & 424, and 40 CFR 257.3);
- Executive Order 11988 (floodplain management) and 11990 (protection of wetlands) (40 CFR 6, 10 CFR 1022);
- National Historic Preservation Act of 1966 (16 USC 470 et seq., Public Law 89-665 and amendments of 1980, Public Law 96-515, 36 CFR 800); and,
- Fish and Wildlife Coordination Act (16 USC 661-666).

**State and Local Requirements**

- California Endangered Species Act California Fish and Game Code (Sections 2050–2068).

### *4.2.3 Action-Specific ARARs*

The following are action-specific ARARs and TBCs for the DOE Areas. These requirements are summarized in Table 4-3.

**Federal Requirements**

- Clean Water Act Section 404 (33USC 1344, 33CFR328 and 40 CFR 230);
- National Emissions Standards for Hazardous Air Pollutants (42USC 7401-7671, 40 CFR 61, Subparts H & M);
- Federal Facilities Compliance Act of 1992 (PL 102-386);
- Toxic Substances Control Act (15USC 2601 et seq., 40CFR761, 763);
- Radiation Protection of the Public (10 CFR 20);
- Licensing Requirements for Land Disposal of Radioactive Waste (10 CFR 61);
- Noise Control Act of 1972, as amended by the Quiet Communities Act of 1978(40 CFR 204, 205, 211);
- Radiation Protection of the Public and the Environment (DOE Order 5400.5). This requirement establishes requirements for DOE facilities and operations for control of radiation exposure to the public. Although not promulgated standards, the DOE Order requirements were developed for protection of the public and the environment and are mandatory requirements for DOE activities. These requirements are proposed for codification in a formal rule at 10 CFR 834 (proposed 3/23/93, 58 FR 16268), which would be applicable upon final promulgation. Chapter II establishes DOE public dose limit for all exposure modes and DOE sources of radiation of 100 mrem/yr effective dose equivalent (EDE). The public dose limit specifically applies to remedial actions. This radiation dose limit also forms the basis for the release of radionuclides to the environment and the release of properties for unrestricted use. Chapter I further specifies that the public dose limit be based on consideration of levels that are as-low-as-reasonably-achievable (ALARA). Chapter IV specifies that residual generic guidelines for residual radionuclides (Ra-226, Ra-228, Th-230, and Th-232) are 5 pCi/g average over the first 15-cm of soil and 15 pCi/g averaged over each successive 15-cm level of soil. The proposed action would comply with these requirements; and,
- Radioactive Waste Management (DOE Order 5820.2A).

**State and Local Requirements**

- Yolo-Solano Air Quality Management District Rules and Regulations, Rule 2.3, Ringlemann Chart;
- Prohibited Acts, Health and Safety Code (Section 41700);

- Environmental Health Standards for the Management of Hazardous Wastes, Chapter 12, Standards Applicable to Generators of Hazardous Wastes, (Title 22 CCR 66262.10-.45);
- Hazardous Waste Control Act Land Disposal Restrictions (22 CCR 66268.1–124);
- State Water Resources Control Board Order No. 97-03-DWQ;
- State Water Resources Control Board Order No. 92-08-DWQ;
- Title 27, CCR Section 21090;
- Control of Radioactive Contamination in the Environment (California Health and Safety Code, Sections 114705, et. seq.);
- Radiation Control Law (California Health and Safety Code, Sections 14960, et. seq.); and,
- Radiation (CCR, Title 17, Sections 30100, et. seq.).

## 4.3 Risk-Based Requirements

40 CFR Section 300.430 specifies that the acceptable human exposure to carcinogens at CERCLA sites is an excess upper bound lifetime cancer risk between $10^{-4}$ and $10^{-6}$. Furthermore, in situations involving radionuclides, EPA states that a specific risk estimate around $10^{-4}$ may be considered acceptable if justified based on site-specific conditions (EPA, 1997). For systemic non-carcinogen toxicants, this regulation specifies that acceptable exposure shall result in a no-adverse-effect during a lifetime, which is measured using a hazard index (HI) of less than 1.0. The Draft Final Determination of Risk-Based Action Standards (WA, 1997c) developed site-specific soil concentrations, called risk-based action standards (RBASs), that meet these acceptable exposure levels.

### *4.3.1 Risk Evaluation Scenarios and Methodology*

Three exposure scenarios were evaluated in the site risk evaluation for these DOE areas (WA, 1997c).

- Scenario 1, On-Site Researcher, represents potential on-site workers that may be exposed to source area soil through external radiation from ground surface radionuclides (for radionuclides only), ingestion, inhalation and dermal exposure.
- Scenario 2, the East Side Residential Farmer, involves potential off-site residential farmers that may be exposed to potentially impacted ground water, potentially impacted surface water (via recreational use of Putah Creek), and via external radiation from ground surface radionuclides (for radionuclides only),

inhalation of fugitive dust, soil ingestion, and agricultural foods potentially impacted by fugitive dust migration from the on-site source areas.

- Scenario 3, the South Side Residential Farmer, is identical to Scenario 2 except that exposure to impacted ground water is not included, since ground water flow is generally toward the east, away from this receptor location, and ground water contamination does not impact Putah Creek nor the ground water south of the creek.

At the request of the regulatory agencies, a fourth on-site residential scenario has also been included, in which the action standards are set equal to those established in the EPA Region 9 August 1996 Preliminary Remediation Goals (PRGs) for chemical constituents (EPA, 1996a) and the EPA Region 9 December 1996 PRGs for radionuclides (EPA, 1996b). This fourth scenario was included for comparison purposes only. Future land use planning by UC Davis does not indicate any possibility of future residential land use at this time. Rather, continued use as a research facility is anticipated for the foreseeable future.

The approach for establishing RBASs for chemicals in Site soil consisted of the following general process. First, chemical and radionuclide COCs were identified as those detected in Site soil above site-specific background levels. Next, action standards for these contaminants were calculated using the Argonne National Laboratory computer code RESRAD for radionuclides and a "Risk Assessment Guidance for Superfund" (RAGS)-based approach for chemical constituents. To complete these back calculations, it was necessary to relate DOE source area soil concentrations to concentrations in exposure media at the receptor location for each scenario. Fate and transport modeling was conducted to establish these relationships for each COC. For chemical constituents, chemical dose (or intake) was then calculated using the intake equations presented in the "Risk Assessment Guidance for Superfund, Volume 1, Human Health Evaluation Manual (Part A)" (EPA, 1989). Incremental human health risk was then calculated using toxicological parameters from the "EPA Region IX August 1996 Preliminary Remedial Goals" tabulation and the EPA's "Integrated Risk Information System" online database. The RBAS for source soil was revised by iterative back calculation to determine the source soil concentration that yields the target incremental cancer risk (or target HI) value. The target incremental cancer risk (or target HI) is a sum of risk (or HI) across all pathways for a particular chemical and a particular exposure scenario.

Radionuclide RBASs were similarly calculated using RESRAD Version 5.62, which uses the EPA dose conversion factors from the 1995 Health Effects Assessment Summary Tables. For each radionuclide, the target risk is equivalent to a specific radiologic dose to the receptor.

For chemical and radiological constituents, this approach closely parallels that devised in "RAGS Part B - Development of Risk-Based Preliminary Remediation Goals" (EPA, 1991), in which soil concentrations equivalent to RBASs are back-calculated based on a target risk level. In comparison, a forward calculation approach uses measure concentrations in environmental media to estimate risk.

These RBASs are presented in Tables 4-4 through 4-15 for all three risk scenarios and residential PRGs. Calculated RBASs represent single constituent concentrations which, if present

throughout the horizontal and vertical extent of each of the DOE areas, might theoretically result in the specified maximum individual excess risk level to an exposed individual. It should be emphasized that because the calculation methodologies used to drive RBASs are conservative, so are the calculated RBASs. The actual excess risk to an exposed individual resulting from site contaminants at the RBASs could be significantly less than the original specified risk.

## 4.4 Other Pertinent Factors for Determining RAOs

Other relevant factors, in addition to ARARs and the human and ecological risk evaluation data, were considered in the development of RA objectives. These factors included potential ground water impacts, Memorandum of Agreement, and technical limitations, as described below.

### *4.4.1 Potential Ground Water Impacts*

A qualitative evaluation of potential future ground water impacts resulting from post-RA residual soil contamination is presented in Appendix C. A more detailed analysis of potential impacts to ground water from site soil following the RA will be evaluated during the Work Plan preparation phase of the removal action. As requested by the Regional Water Quality Control Board (RWQCB), contaminant migration through the vadose zone will be modeled during this analysis in order to derive maximum compound concentrations at specific depths and for specific soil types that, when left in place, would be protective of ground water (RWQCB, 1997). These derived concentrations will be used during the RA to ensure that residual soil contaminants do not adversely impact ground water. Derived concentrations will be developed for potential impacts at MCLs and at ground water background concentrations. Since ground water protection is an RAO, the selected RA alternative shall be protective of ground water. A goal of the RA will be to clean up the soil to levels protective of ground water at background concentrations unless it is demonstrated that it is technically or economically infeasible to do so. If cleanup to concentrations protective of ground water and surface water at background concentrations is infeasible, then clean up to levels protective of water quality objectives (MCLs) will be conducted.

### *4.4.2 Memorandum of Agreement (MOA)*

A MOA has been signed between UC Davis and DOE in which DOE is tasked with cleanup of soil contamination in the Southwest Trenches Area, Ra/Sr Treatment Systems Area and the Domestic Septic Systems Area. In addition, the RAs are to be implemented in a manner to minimize impact to on-site university research. The proposed RAs are expected to comply with the requirements of the MOA.

### *4.4.3 Technical Limitations*

Per 40 CFR 300.430(e)(a)(3) of the NCP, a factor to be considered when determining RA objectives are technical limitations, such as the ability to detect or quantify contaminant soil

concentrations. This issue is important at this site for RBASs that are close to background concentrations, such as for Ra-226. Specifically, analytical measurement error for Ra-226 soil activity is greater than the respective 0.042 and 0.0042 pCi/g risk-based action standards for the $10^{-5}$ and $10^{-6}$ target incremental cancer risks. For this reason it is not technically feasible to differentiate Ra-226 soil concentrations from background concentrations at either of these risk levels.

## 4.5 Determination of Removal Action Objectives

The specific RAOs (developed from the above risk-based requirements, ARARs, and other pertinent factors) for the proposed RAs are:

- Lower the excess cumulative cancer risk to an individual from exposure to site contaminants to within a nominal range of $10^{-4}$ to $10^{-6}$, using $10^{-6}$ as the point of departure;
- Reduce non-cancer hazard indices to levels below 1;
- Mitigate potential future impact to ground water;
- Mitigate potential ecological risks during and after RA; and,
- Minimize impact to on-site university research.

Table 4-1. Potential Chemical-Specific ARARs for the LEHR Facility

| Requirement | Comments | ARAR Category |
|---|---|---|
| **Federal** | | |
| Clean Water Act (33 USCA 1251-1376, 40 CFR 122, 125, 136) | Both on-site and off-site discharges from CERCLA Sites to surface waters are required to meet substantive Clean Water Act limitations, monitoring requirements and best management practices. | Applicable |
| Safe Drinking Water Act (42 USCA 300 and 40 CFR 141.11-16, 141.50-51). | Establishes MCLs as health-based standards and MCLGs as health goals for public water supply systems. The LEHR site is not a public water supply system. However, this requirement is relevant and appropriate. | Relevant and Appropriate |
| Establishment of Cleanup Levels at CERCLA Sites with Radioactive Contamination (EPA, 1997, OSWER No. 9200.4-23) | Cleanup should generally achieve a carcinogenic risk within the $10^{-4}$ to $10^{-6}$ range based on the reasonable maximum exposure for an individual. A specific risk estimate around $10^{-4}$ may be considered acceptable if justified based on site-specific conditions. | To Be Considered |
| **State and Local** | | |
| Criteria for Identifying Hazardous Wastes (CCR, Title 22, 66261. 21–33) | Tests for identifying hazardous characteristics are set forth in these regulations. If a chemical is either listed or tested and found hazardous, then remedial actions must comply with those CCR, Title 22 requirements. | Applicable |
| Minimum Standards for Management of Hazardous and Extremely Hazardous Wastes Hazardous Waste Control Act (Generally, Health and Safety Code, Sections 25100 et seq. and CCR, Title 22, Chap. 30) | Generally regulates the management of hazardous wastes from their point of generation through accumulation, transportation, treatment, storage, and ultimate disposal. Requires, among other things, that all potentially hazardous materials are handled in accordance with standard chain-of-custody procedures. | Applicable |

Table 4-1. Potential Chemical-Specific ARARs for the LEHR Facility (continued)

| Requirement | Comments | ARAR Category |
|---|---|---|
| **Federal** | | |
| Persistent and Bioaccumulative Toxic Substances (CCR, Title 22, 66261.113) | Total Threshold Limit Concentrations (TTLC) and Soluble Threshold Limit Concentrations (STLC) have been established for selected substances to be used in establishing whether waste is hazardous. If a chemical is either listed or tested and found hazardous, then remedial actions generally must comply with the hazardous waste requirements under CCR, Title 22. | Applicable |
| Porter-Cologne Water Quality Control Act (Generally, California Water Code, Div. 7, Section 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. Contains corrective action requirements stating that a COC not exceed background values unless it is technically or economically infeasible, in which case the default clean up values would be the Basin Plan Water Quality Objectives. | Applicable |
| Water Quality Control Plan (Basin Plan) for the Central Valley Regional Water Quality Control Board | Describes water basins in the Central Valley Region, establishes beneficial uses of ground 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. | Applicable |
| State Water Resources Control Board Resolution No. 68-16 | Requires that high quality surface and ground waters be maintained to the maximum extent possible. *In-situ* cleanup levels for contaminated soils must be set so that ground waters will not be degraded, as defined by substantive requirements. | Applicable |
| State Water Resources Control Board Resolution No. 92-49 (as amended April 21, 1994) | Section IIIG directs the Water Boards to ensure dischargers clean up and abate the "effects" of discharges in a manner promoting attainment of either background water quality or the best reasonable water quality if background water quality is not feasible (feasibility determined by factors listed in Section IIIG and Chapter 14, Section 2550.4). Minimum water standards must be protective of beneficial use. Section IIIG directs the Water Board to apply 23CCR Chapter 14, Section 2550.4 in approving any alternative cleanup levels less stringent than background quality. | Relevant and Appropriate[1] |

Table 4-1. Potential Chemical-Specific ARARs for the LEHR Facility (continued)

| Requirement | Comments | ARAR Category |
|---|---|---|
| **Federal** | | |
| State Water Resources Control Board Resolution No. 88-63 | Specifies that, with certain exceptions, all ground and surface water have the beneficial use of municipal or domestic water supply. 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 ground water or surface water. The resolution specifies that, with certain exceptions, all ground water and surface water have the beneficial use of municipal use or domestic supply. Consequently, California State primary MCLs are relevant and appropriate; however, the most stringent federal or state standard will be the ARAR for the removal action. | Applicable |

1 The following standard is set forth in Title 22 CCR section 66264.94, Title 22 CCR section 66265.94, Title 23 CCR section 2550.4, and SWRCB Res. No. 92-49 section IIIG: "Concentration limits for a constituent of concern greater than background values for that constituent can be established only if it is demonstrated that it is technologically or economically possible to achieve the background value for that constituent; in no event shall a concentration limit greater than background for a constituent of concern exceed the lowest concentration that is technologically or economically achievable."
Department of Energy reserves their position that this standard is a Federal ARAR via its incorporation in Title 22 CCR section 66264.94 which was federally authorized via EPA's authorization of the State of California RCRA program.

Table 4-2. Potential Location-Specific ARARs for the LEHR Facility

| Requirement | Comments | ARAR Category |
|---|---|---|
| **Federal** | | |
| Endangered Species Act of 1973 (16 USC Section 1531 et seq., 50 CFR Parts 10, 11, 17, 200, 402, & 424, and 40 CFR 257.3) | Facilities or practices shall not cause or contribute to the taking of any endangered or threatened species of plants, fish, or wildlife. Specific mitigation measures for this species will be met prior to any construction. All of these requirements will be additionally met through NEPA and DOE implementing requirements. | Applicable |
| Executive Order 11988 (floodplain management) and 11990 (protection of wetlands) (40 CFR 6, 10 CFR 1022) | Requires actions to avoid adverse effects, minimize potential harm, restore and preserve natural and beneficial values required flood plan/wetlands determination, assessment, and applicant responsibilities. Any DOE action in a floodplain and new construction not located in a floodplain would receive careful evaluation of potential effects. 44 Federal Register 12594 states that DOE can meet requirements of these Executive Orders through applicable DOE and NEPA procedures. | Applicable |
| National Historic Preservation Act of 1966 (16 USC 470 et seq., Public Law 89-665 and amendments of 1980, Public Law 96-515, 36 CFR 800) | Requires federal agencies to take into account the effects of their projects on historic properties listed, or eligible for listing, on the National Register of Historic Properties and to afford the Advisory Council a reasonable opportunity to comment on them. | Applicable |
| Fish and Wildlife Coordination Act (16 USC 661-666) | Requires action to preserve endangered species or threatened species. Prior to conducting any ground disturbing activities, surveys will be conducted for species of concern. | Applicable |
| **State And Local** | | |
| California Endangered Species Act California Fish and Game Code, Sections 2050–2068 | Requires action to preserve endangered species or threatened species. Prior to conducting any ground-disturbing activities, surveys will be conducted for species of concern. | Applicable |

Table 4-3. Potential Action-Specific ARARs for the LEHR Facility

| Requirement | Comments | ARAR Category |
|---|---|---|
| **Federal** | | |
| Clean Water Act Section 404 (33USC 1344, 33CFR328 and 40 CFR 230) | Establishes a national program to control the discharge of dredged or fill materials into "waters of the United States". "Waters of the US" is defined to include all tributaries of navigable waters and nearly all wetlands. Although no permit would be required for actions affecting a wetland, the substantive provisions of Section 404, including agency coordination prior to construction, state water quality certification, and possibly even mitigation for loss may be applicable. These requirements may apply if RAs cause turbid water to enter drainages, or if RAs impact wetlands adjacent to Putah Creek. | Applicable |
| National Emissions Standards for Hazardous Air Pollutants (42USC 7401-7671, 40 CFR 61, Subparts H & M) | Emissions of radionuclides from any DOE facility to the ambient air shall not exceed levels that would result in an effective dose equivalent of 10 mrem/year. Dust generated from excavation activities would be subject to this requirement. In addition, Subpart M establishes work practices and disposal requirements for asbestos-containing materials. Asbestos requirements may be applicable to unidentified potential sub-surface asbestos-containing materials. | Applicable |
| Federal Facilities Compliance Act of 1992 (PL 102-386) | Requires federal facilities that generate or store mixed wastes subject to land disposal restrictions to obtain regulator approval of treatment plans. Mixed waste may possibly be generated during the RA. Applicable until an FFA covering Site cleanup activities, including management of mixed waste, is signed. | Applicable |
| Toxic Substances Control Act (15USC 2601 et seq., 40CFR761, 763) | Regulates management and disposal of asbestos-containing materials and other toxic wastes including PCBs as may be generated during RAs. | Applicable |
| Radiation Protection of the Public (10 CFR 20) | NRC requirements are not applicable to CERCLA activities conducted at LEHR. NRC Standards are not considered to be appropriate if DOE Orders adequately establish standards of control for the management of radioactive materials to ensure protection of human health and the environment. | To Be Considered |
| Licensing Requirements for Land Disposal of Radioactive Waste (10 CFR 61) | Establishes requirements for radiation protection, access restrictions, future impacts, siting, drainage, final cover, buffer zones, ground water monitoring and waste disposal requirements. | To Be Considered |

Table 4-3. Potential Action-Specific ARARs for the LEHR Facility (continued)

| Requirement | Comments | ARAR Category |
|---|---|---|
| **Federal** | | |
| 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, and 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. | Applicable |
| Radiation Protection of the Public and the Environment (DOE Order 5400.5) | Establishes requirements for DOE facilities and operations for control of radiation exposure to the public. Although not promulgated standards, the DOE Order requirements were developed for protection of the public and the environment and are mandatory requirements for DOE activities. See text for further discussion. | To Be Considered |
| Radioactive Waste Management (DOE Order 5820.2A) | Specifies requirements for managing DOE radioactive waste. Chapter III specifies that DOE's performance objective for handling certain low-level waste is to assure that the effective dose equivalent to the public does not exceed 25 mrem/yr. To the extent that 10 CFR 61 requirements are incorporated into this DOE order, these portions should be considered. Although not promulgated standards, these requirements constitute requirements for protection of the public with which the proposed action would comply. See text for further detail. | To Be Considered |
| **State and Local** | | |
| Yolo-Solano Air Quality Management District Rules and Regulations, Rule 2.3, Ringlemann Chart | Establishes a permissible limit on visible emissions (Ringlemann Chart) resulting from construction activities, such as soil disturbance during a RA. | Applicable |
| Prohibited Acts, Health and Safety Code ( Section 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. Regulation applicable to construction activities during RA. | Applicable |

Table 4-3. Potential Action-Specific ARARs for the LEHR Facility (continued)

| Requirement | Comments | ARAR Category |
|---|---|---|
| **Federal** | | |
| Environmental Health Standards for the Management of Hazardous Wastes, Chapter 12, Standards Applicable to Generators of Hazardous Wastes, (Title 22 CCR 66262.10-.45) | Owners or operators who generate hazardous waste shall comply with the generator standards in these regulations. These standards include keeping of manifests (66261.21), submission of manifests to the Department of Toxic Substances Control within 30 days of shipment (66262.23), preparation of a biennial report (66262.41), and a maximum 90-day accumulation time (66262.34). By reference, the requirements for general operations of interim status and permitted facilities, including preparedness and prevention (66265.30-37), contingency plans and emergency procedures (66265.50-55), and manifesting and monitoring requirements (66265.70-77) and personal training (66265.16) also apply. | Applicable |
| Hazardous Waste Control Act Land Disposal Restrictions (22 CCR 66268.1–124). | This law requires that certain hazardous wastes meet minimum treatment standards prior to disposal at a landfill. | Applicable. |
| State Water Resources Control Board Order No. 97-03-DWQ | Establishes criteria for industrial activities storm water general permit. | Applicable |
| State Water Resources Control Board Order No. 92-08-DWQ | Establishes criteria for construction activities storm water general permit. | Applicable |
| Title 27, CCR Section 21090 | Applies to wastes contained or left in place at the end of the removal action that could affect water quality. Requires a final cover constructed in accordance with specific prescriptions as long as wastes pose a threat to water quality. | Relevant and Appropriate |
| Control of Radioactive Contamination in the Environment (California Health and Safety Code, Sections 114705, et. seq.) | Details administration of programs of surveillance and control of those activities that could lead to the introduction of radioactive materials into the environment. Applicable unless activity is governed by DOE statute. | Applicable |
| Radiation Control Law (California Health and Safety Code, Sections 114960, et. seq.) | Institutes and maintains a regulatory program for sources of ionizing radiation so as to provide for compatibility with standards and regulatory programs of the Federal government and an integrated system within the state. Applicable unless activity is governed by DOE statute. | Applicable |

Table 4-3. Potential Action-Specific ARARs for the LEHR Facility (continued)

| Requirement | Comments | ARAR Category |
|---|---|---|
| **Federal** | | |
| Radiation (CCR, Title 17, Sections 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. Applicable unless activity is governed by DOE statute. | Applicable |

Table 4-4. Summary of Risk-Based Action Standards (RBASs) for Chemical Carcinogens in Surface Soil at the $10^{-4}$, $10^{-5}$, and $10^{-6}$ Risk Levels for Scenario 1 – On-Site Researcher Risk

| Analyte | Background Concentration (mg/kg) | Risk-Based Action Standards (RBAS) $10^{-4}$ Risk (mg/kg) | $10^{-5}$ Risk (mg/kg) | $10^{-6}$ Risk (mg/kg) |
|---|---|---|---|---|
| 4,4'-DDD | none | 790 | 79 | 7.9 |
| 4,4'-DDE | none | 560 | 56 | 5.6 |
| 4,4'-DDT | none | 560 | 56 | 5.6 |
| Alpha-BHC | none | 30 | 3.0 | 0.30 |
| Alpha-Chlordane | none | 150 | 15 | 1.5 |
| Arochlor-1260 | none | 25 | 2.5 | 0.25 |
| Benzene | none | 23 | 2.3 | 0.23 |
| Benzo(a)anthracene | none | 260 | 26 | 2.6 |
| Benzo(a)pyrene | none | 26 | 2.6 | 0.26 |
| Benzo(b)fluoranthene | none | 260 | 26 | 2.6 |
| Benzo(k)fluoranthene | none | 2600 | 260 | 26 |
| Bis(2-Ethylhexyl)phthalate | none | 14,000 | 1,400 | 136 |
| Cadmium (Cd) | 0.46 | 480,000 | 48,000 | 4,800 |
| Carbazole | none | 9,500 | 950 | 95 |
| Carbon Tetrachloride | none | 22 | 2.2 | 0.22 |
| Chlordane | none | 150 | 15 | 1.5 |
| Chromium (Cr) | 178 | 72,000 | 7,200 | 720 |
| Chromium, Hexavalent (Cr+6) | 0.099 | 10,000 | 1,000 | 100 |
| Chrysene | none | 26,000 | 2,600 | 260 |
| Delta-BHC | none | 30 | 3.0 | 0.30 |
| Dibenzo(a,h)anthracene | none | 26 | 2.6 | 0.26 |
| Dieldrin | none | 12 | 1.2 | 0.12 |
| Formaldehyde | none | 22,000 | 2,200 | 220 |
| Gamma-BHC | none | 150 | 15 | 1.5 |
| Gamma-Chlordane | none | 150 | 15 | 1.5 |
| Heptachlor | none | 42 | 4.2 | 0.42 |
| Heptachlor Epoxide | none | 21 | 2.1 | 0.21 |
| Indeno(1,2,3-cd)pyrene | none | 260 | 26 | 2.6 |
| Lead (Pb) | 10.1 | 300 | 30 | 3.0 |
| Mercury (Hg) | 0.49 | RES | 160,000 | 16,000 |
| Methylene Chloride | none | 720 | 72 | 7.2 |
| Pentachlorophenol | none | 1,600 | 160 | 16 |

Notes:

none = no background available for the analyte.

RES = $10^{-4}$, $10^{-5}$ or $10^{-6}$ risk not exceeded for pure compound present at any concentration.

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Table 4-5. Summary of Risk-Based Action Standards (RBASs) for Radionuclides in Surface Soil at the $10^{-4}$, $10^{-5}$, and $10^{-6}$ Risk Levels for Scenario 1 – On-Site Researcher Risk

| | | **Risk-Based Action Standards (RBAS)** | | |
|---|---|---|---|---|
| **Isotope** | **Background Concentration (pCi/g)** | **$10^{-4}$ Risk (pCi/g)** | **$10^{-5}$ Risk (pCi/g)** | **$10^{-6}$ Risk (pCi/g)** |
| Americium-241 | none | 1,700 | 170 | 17 |
| Bismuth-212 (Th-228 Daughter) | DP | DP | DP | DP |
| Bismuth-214 (Ra-226 Daughter) | DP | DP | DP | DP |
| Carbon-14 | 0.87 | 420,000 | 42,000 | 4,200 |
| Cesium-137+D | 0.053 | 10 | 1.0 | 0.10 |
| Cobalt-60 | 0.016 | 2.2 | 0.22 | 0.022 |
| Lead-210+D | none | 960 | 96 | 9.6 |
| Lead-214 (Ra-226 Daughter) | DP | DP | DP | DP |
| Plutonium-241 +D | none | 60,000 | 6,000 | 600 |
| Radium-223 (U-235 Daughter) | DP | DP | DP | DP |
| Radium-226+D | 0.77 | 0.42 | 0.042 | 0.0042 |
| Strontium-90+D | 0.36 | 1,000 | 100 | 10 |
| Thorium-228+D | 0.71 | 3.2 | 0.32 | 0.032 |
| Thorium-232 | 0.64 | 2.2 | 0.22 | 0.022 |
| Thorium-234 (U-238+D) | none | 320 | 32 | 3.2 |
| Tritium | 0.023 | 13,000,000 | 1,300,000 | 130,000 |
| Uranium-235+D | 0.071 | 79 | 7.9 | 0.79 |

Notes:

none = no background available for the analyte.

DP = Daughter Product; Standard driven by parent isotope.

j:\doe\4000\Tbl4risk.xls\Table 4-5r

Table 4-6. Summary of Risk-Based Action Standards (RBASs) Chemical Non-Carcinogens in Surface Soil at a Hazard Index of 1.0 for Scenario 1 – On-Site Researcher Risk

| Analyte | Background Concentration (mg/kg) | Risk-Based Action Standards (RBAS) (mg/kg) |
|---|---|---|
| 2-Butanone (MEK) | none | 710 |
| Acenaphthene | none | 41,000 |
| Acetone | none | 830 |
| Anthracene | none | 200,000 |
| Antimony (Sb) | 0.74 | 680 |
| Barium (Ba) | 237 | 110,000 |
| Benzo(g,h,i)perylene | none | 20,000 |
| Cadmium (Cd) | 0.46 | 850 |
| Chromium (Cr) | 178 | RES |
| Chromium, Hexavalent (Cr+6) | 0.099 | 8,500 |
| Copper (Cu) | 50 | 63,000 |
| Dibenzofuran | none | 2,700 |
| Diethyl Phthalate | none | 550,000 |
| Di-n-Butylphthalate | none | 68,000 |
| Di-n-Octylphthalate | none | 14,000 |
| Endosulfan I | none | 4,100 |
| Endosulfan Sulfate | none | 4,100 |
| Ethyl Benzene | none | 2,400 |
| Fluoranthene | none | 27,000 |
| Fluorene | none | 27,000 |
| Formaldehyde | none | 100,000 |
| Manganese (Mn) | 720 | 52,000 |
| Mercury (Hg) | 0.49 | 510 |
| Methoxychlor | none | 3,400 |
| Naphthalene | none | 27,000 |
| Phenanthrene | none | 20,000 |
| Pyrene | none | 20,000 |
| Selenium (Se) | 1 | 8,500 |
| Silver (Ag) | 0.52 | 8,500 |
| Styrene | none | 710 |
| Toluene | none | 920 |
| Xylenes (Total) | none | 1,700 |
| Zinc (Zn) | 82 | 510,000 |

Notes:
none = no background available for the analyte.
RES = $10^{-4}$, $10^{-5}$ or $10^{-6}$ risk not exceeded for pure compound present at any concentration.
RES = HI not exceeded for pure compound. j:\doe\4000\A1e\Tbl4risk.xls\Table 4-6r

Table 4-7. Summary of Risk-Based Action Standards (RBASs) for Chemical Carcinogens in Surface Soil at the $10^{-4}$, $10^{-5}$, and $10^{-6}$ Risk Levels for Scenario 2 – East Side Residential Farmer Risk

| | | Risk-Based Action Standards (RBAS) | | |
|---|---|---|---|---|
| **Analyte** | **Background Concentration (mg/kg)** | **$10^{-4}$ Risk (mg/kg)** | **$10^{-5}$ Risk (mg/kg)** | **$10^{-6}$ Risk (mg/kg)** |
| 4,4'-DDD | none | 940 | 94 | 9.4 |
| 4,4'-DDE | none | 900 | 90 | 9.0 |
| 4,4'-DDT | none | 3,000 | 300 | 30 |
| Alpha-BHC | none | 0.75 | 0.075 | 0.0075 |
| Alpha-Chlordane | none | 80 | 8.0 | 0.80 |
| Arochlor-1260 | none | 490 | 49 | 4.9 |
| Benzene | none | 1.5 | 0.15 | 0.015 |
| Benzo(a)anthracene | none | 120 | 12 | 1.2 |
| Benzo(a)pyrene | none | 24 | 2.4 | 0.24 |
| Benzo(b)fluoranthene | none | 330 | 33 | 3.3 |
| Benzo(k)fluoranthene | none | 2,700 | 270 | 27 |
| Bis(2-Ethylhexyl)phthalate | none | 770 | 77 | 7.7 |
| Cadmium (Cd) | 0.46 | RES | RES | RES |
| Carbazole | none | 220 | 22 | 2.2 |
| Carbon Tetrachloride | none | 5.5 | 0.55 | 0.055 |
| Chlordane | none | 78 | 7.8 | 0.78 |
| Chromium (Cr) | 178 | RES | RES | 840,000 |
| Chromium, Hexavalent (Cr+6) | 0.099 | RES | RES | 120,000 |
| Chrysene | none | 2,000 | 200 | 20 |
| Delta-BHC | none | 1.3 | 0.13 | 0.013 |
| Dibenzo(a,h)anthracene | none | 54 | 5.4 | 0.54 |
| Dieldrin | none | 1.5 | 0.15 | 0.015 |
| Formaldehyde | none | NC | NC | NC |
| Gamma-BHC | none | 3.0 | 0.30 | 0.030 |
| Gamma-Chlordane | none | 81 | 8.1 | 0.81 |
| Heptachlor | none | 17 | 1.7 | 0.17 |
| Heptachlor Epoxide | none | 0.057 | 0.0057 | 0.00057 |
| Indeno(1,2,3-cd)pyrene | none | 490 | 49 | 4.9 |
| Lead (Pb) | 10.1 | 4.4 | 0.44 | 0.044 |
| Mercury (Hg) | 0.49 | 1,500 | 150 | 15 |
| Methylene Chloride | none | 13 | 1.3 | 0.13 |
| Pentachlorophenol | none | 1,300 | 130 | 13 |

Notes:
none = no background available for the analyte.
RES = $10^{-4}$, $10^{-5}$ or $10^{-6}$ risk not exceeded for pure compound present at any concentration.
NC = Exposure pathway incomplete for compound. j:\doe\4000\A1e\Tbl4risk.xls\Table 4-7r

Table 4-8. Summary of Risk-Based Action Standards (RBASs) for Radionuclides in Surface Soil at the $10^{-4}$, $10^{-5}$, and $10^{-6}$ Risk Levels for Scenario 2 – East Side Residential Farmer Risk

| | | **Risk-Based Action Standards (RBAS)** | | |
|---|---|---|---|---|
| **Isotope** | **Background Concentration (pCi/g)** | **$10^{-4}$ Risk (pCi/g)** | **$10^{-5}$ Risk (pCi/g)** | **$10^{-6}$ Risk (pCi/g)** |
| Americium-241 | none | 9.2 | 0.92 | 0.092 |
| Bismuth-212 (Th-228 Daughter) | DP | DP | DP | DP |
| Bismuth-214 (Ra-226 Daughter) | DP | DP | DP | DP |
| Carbon-14 | 0.87 | 950,000 | 95,000 | 9,500 |
| Cesium-137+D | 0.053 | 20,000,000 | 2,000,000 | 200,000 |
| Cobalt-60 | 0.016 | 3,200,000 | 320,000 | 32,000 |
| Lead-210+D | none | 4,000 | 400 | 40 |
| Lead-214 (Ra-226 Daughter) | DP | DP | DP | DP |
| Plutonium-241 +D | none | 320 | 32 | 3.2 |
| Radium-223 (U-235 Daughter) | DP | DP | DP | DP |
| Radium-226+D | 0.77 | 110,000 | 11,000 | 1,100 |
| Strontium-90+D | 0.36 | 29,000,000 | 2,900,000 | 290,000 |
| Thorium-228+D | 0.71 | 200,000 | 20,000 | 2,000 |
| Thorium-232 | 0.64 | 380,000 | 38,000 | 3,800 |
| Thorium-234 (U-238+D) | none | 8,800,000 | 880,000 | 88,000 |
| Tritium | 0.023 | 540 | 54 | 5.4 |
| Uranium-235+D | 0.071 | 15 | 1.5 | 0.15 |

Notes:

none = no background available for the analyte.

DP = Daughter Product; Standard driven by parent isotope.

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Table 4-9. Summary of Risk-Based Action Standards (RBASs) for Chemical Non-Carcinogens in Surface Soil at a Hazard Index for Scenario 2 – East Side Residential Farmer Risk

| Analyte | Background Concentration (mg/kg) | Risk-Based Action Standards (RBAS) (mg/kg) |
|---|---|---|
| 2-Butanone (MEK) | none | 12 |
| Acenaphthene | none | 250 |
| Acetone | none | 1.7 |
| Anthracene | none | 1,400 |
| Antimony (Sb) | 0.74 | 0.30 |
| Barium (Ba) | 237 | 53 |
| Benzo(g,h,i)perylene | none | 9,100 |
| Cadmium (Cd) | 0.46 | 0.38 |
| Chromium (Cr) | 178 | 760 |
| Chromium, Hexavalent (Cr+6) | 0.099 | 3.8 |
| Copper (Cu) | 50 | 28 |
| Dibenzofuran | none | 14 |
| Diethyl Phthalate | none | 220 |
| Di-n-Butylphthalate | none | 890 |
| Di-n-Octylphthalate | none | 28,000 |
| Endosulfan I | none | 29 |
| Endosulfan Sulfate | none | 26 |
| Ethyl Benzene | none | 10 |
| Fluoranthene | none | 1,800 |
| Fluorene | none | 170 |
| Formaldehyde | none | 1.7 |
| Manganese (Mn) | 720 | 36 |
| Mercury (Hg) | 0.49 | 0.22 |
| Methoxychlor | none | 100 |
| Naphthalene | none | 39 |
| Phenanthrene | none | 1,200 |
| Pyrene | none | 490 |
| Selenium (Se) | 1 | 58 |
| Silver (Ag) | 0.52 | 3.8 |
| Styrene | none | 76 |
| Toluene | none | 19 |
| Xylenes (Total) | none | 700 |
| Zinc (Zn) | 82 | 3,400 |

Notes:
none = no background available for the analyte.

j:\doe\4000\A1e\Tbl4risk.xls\Table 4-9r

Table 4-10. Summary of Risk-Based Action Standards (RBASs) for Chemical Carcinogens in Surface Soil at the $10^{-4}$, $10^{-5}$, and $10^{-6}$ Risk Levels for Scenario 3 – South Side Residential Farmer Risk

| | | Risk-Based Action Standards (RBAS) | | |
|---|---|---|---|---|
| **Analyte** | **Background Concentration (mg/kg)** | **$10^{-4}$ Risk (mg/kg)** | **$10^{-5}$ Risk (mg/kg)** | **$10^{-6}$ Risk (mg/kg)** |
| 4,4'-DDD | none | RES | 700,000 | 70,000 |
| 4,4'-DDE | none | RES | 610,000 | 61,000 |
| 4,4'-DDT | none | RES | 230,000 | 23,000 |
| Alpha-BHC | none | 840,000 | 84,000 | 8,400 |
| Alpha-Chlordane | none | 590 | 59 | 5.9 |
| Arochlor-1260 | none | 12,000 | 1,200 | 120 |
| Benzene | none | NC | NC | NC |
| Benzo(a)anthracene | none | RES | 300,000 | 30,000 |
| Benzo(a)pyrene | none | 130,000 | 13,000 | 1,300 |
| Benzo(b)fluoranthene | none | RES | 120,000 | 12,000 |
| Benzo(k)fluoranthene | none | RES | RES | 130,000 |
| Bis(2-Ethylhexyl)phthalate | none | 860 | 86 | 8.6 |
| Cadmium (Cd) | 0.46 | RES | RES | RES |
| Carbazole | none | RES | RES | RES |
| Carbon Tetrachloride | none | NC | NC | NC |
| Chlordane | none | 590 | 59 | 5.9 |
| Chromium (Cr) | 178 | RES | RES | 160,000 |
| Chromium, Hexavalent (Cr+6) | 0.099 | RES | 230,000 | 23,000 |
| Chrysene | none | RES | RES | RES |
| Delta-BHC | none | 21 | 2.1 | 0.21 |
| Dibenzo(a,h)anthracene | none | 26,000 | 2,600 | 260 |
| Dieldrin | none | 410,000 | 41,000 | 4,100 |
| Formaldehyde | none | NC | NC | NC |
| Gamma-BHC | none | RES | 350,000 | 35,000 |
| Gamma-Chlordane | none | 640 | 64 | 6.4 |
| Heptachlor | none | RES | 140,000 | 14,000 |
| Heptachlor Epoxide | none | 180,000 | 18,000 | 1,800 |
| Indeno(1,2,3-cd)pyrene | none | 460,000 | 46,000 | 4,600 |
| Lead (Pb) | 10.1 | 1,900 | 190 | 19 |
| Mercury (Hg) | 0.49 | 54,000 | 5,400 | 540 |
| Methylene Chloride | none | NC | NC | NC |
| Pentachlorophenol | none | RES | RES | 130,000 |

Notes:
none = no background available for the analyte.
RES = $10^{-4}$, $10^{-5}$ or $10^{-6}$ risk not exceeded for pure compound present at any concentration.
NC = Exposure pathway incomplete for compound. j:\doe\4000\A1e\Tbl4risk.xls\Table 4-10r

Table 4-11. Summary of Risk-Based Action Standards (RBASs) for Radionuclides in Surface Soil at the $10^{-4}$, $10^{-5}$, and $10^{-6}$ Risk Levels for Scenario 3 – South Side Residential Farmer Risk

| | | Risk-Based Action Standards (RBAS) | | |
|---|---|---|---|---|
| **Isotope** | **Background Concentration (pCi/g)** | **$10^{-4}$ Risk (pCi/g)** | **$10^{-5}$ Risk (pCi/g)** | **$10^{-6}$ Risk (pCi/g)** |
| Americium-241 | none | 1,600,000 | 160,000 | 16,000 |
| Bismuth-212 (Th-228 Daughter) | DP | DP | DP | DP |
| Bismuth-214 (Ra-226 Daughter) | DP | DP | DP | DP |
| Carbon-14 | 0.87 | 700,000 | 70,000 | 7,000 |
| Cesium-137+D | 0.053 | 2,500,000 | 250,000 | 25,000 |
| Cobalt-60 | 0.016 | 580,000 | 58,000 | 5,800 |
| Lead-210+D | none | 4,000 | 400 | 40 |
| Lead-214 (Ra-226 Daughter) | DP | DP | DP | DP |
| Plutonium-241 +D | none | 220,000,000 | 22,000,000 | 2,200,000 |
| Radium-223 (U-235 Daughter) | DP | DP | DP | DP |
| Radium-226+D | 0.77 | 110,000 | 11,000 | 1,100 |
| Strontium-90+D | 0.36 | 3,400,000 | 340,000 | 34,000 |
| Thorium-228+D | 0.71 | 160,000 | 16,000 | 1,600 |
| Thorium-232 | 0.64 | 220,000 | 22,000 | 2,200 |
| Thorium-234 (U-238+D) | none | 6,300,000 | 630,000 | 63,000 |
| Tritium | 0.023 | 250,000,000 | 25,000,000 | 2,500,000 |
| Uranium-235+D | 0.071 | 3,200,000 | 320,000 | 32,000 |

Notes:

none = no background available for the analyte.

DP = Daughter Product; Standard driven by parent isotope.

j:\doe\4000\A1e\Tbl4risk.xls\Table 4-11r

Table 4-12. Summary of Risk-Based Action Standards (RBASs) for Chemical Non-Carcinogens in Surface Soil at a Hazard Index of 1.0 for Scenario 3 – South Side Residential Farmer Risk

| Analyte | Background Concentration (mg/kg) | Risk-Based Action Standards (RBAS) (mg/kg) |
|---|---|---|
| 2-Butanone (MEK) | none | NC |
| Acenaphthene | none | RES |
| Acetone | none | 1,900 |
| Anthracene | none | RES |
| Antimony (Sb) | 0.74 | RES |
| Barium (Ba) | 237 | RES |
| Benzo(g,h,i)perylene | none | RES |
| Cadmium (Cd) | 0.46 | RES |
| Chromium (Cr) | 178 | RES |
| Chromium, Hexavalent (Cr+6) | 0.099 | 740 |
| Copper (Cu) | 50 | 610,000 |
| Dibenzofuran | none | RES |
| Diethyl Phthalate | none | RES |
| Di-n-Butylphthalate | none | 3,300 |
| Di-n-Octylphthalate | none | 4,900 |
| Endosulfan I | none | RES |
| Endosulfan Sulfate | none | RES |
| Ethyl Benzene | none | NC |
| Fluoranthene | none | RES |
| Fluorene | none | RES |
| Formaldehyde | none | 10,000 |
| Manganese (Mn) | 720 | RES |
| Mercury (Hg) | 0.49 | 6.4 |
| Methoxychlor | none | RES |
| Naphthalene | none | RES |
| Phenanthrene | none | RES |
| Pyrene | none | RES |
| Selenium (Se) | 1 | RES |
| Silver (Ag) | 0.52 | RES |
| Styrene | none | NC |
| Toluene | none | NC |
| Xylenes (Total) | none | NC |
| Zinc (Zn) | 82 | 150,000 |

Notes:
none = no background available for the analyte.
RES = $10^{-4}$, $10^{-5}$ or $10^{-6}$ risk not exceeded for pure compound present at any concentration.
RES = HI not exceeded for pure compound.
NC = Exposure pathway incomplete for compound. j:\doe\4000\A1e\Tbl4risk.xls\Table 4-12r

Table 4-13. Summary of Risk-Based Action Standards (RBASs) for Chemical Carcinogens in Surface Soil at the $10^{-4}$, $10^{-5}$, and $10^{-6}$ Risk Levels for PRGs – Residential Soil

| | | **1996 PRGs- Residential Soil (PRGs)** | | |
|---|---|---|---|---|
| **Analyte** | **Background Concentration (mg/kg)** | **$10^{-4}$ Risk (mg/kg)** | **$10^{-5}$ Risk (mg/kg)** | **$10^{-6}$ Risk (mg/kg)** |
| 4,4'-DDD | none | 190 | 19 | 1.9 |
| 4,4'-DDE | none | 130 | 13 | 1.3 |
| 4,4'-DDT | none | 130 | 13 | 1.3 |
| Alpha-BHC | none | 7.1 | 0.71 | 0.071 |
| Alpha-Chlordane | none | 34 | 3.4 | 0.34 |
| Arochlor-1260 | none | 6.6 | 0.66 | 0.066 |
| Benzene | none | 63 | 6.3 | 0.63 |
| Benzo(a)anthracene | none | 61 | 6.1 | 0.61 |
| Benzo(a)pyrene | none | 6.1 | 0.61 | 0.061 |
| Benzo(b)fluoranthene | none | 61 | 6.1 | 0.61 |
| Benzo(k)fluoranthene | none | 610 | 61 | 6.1 |
| Bis(2-Ethylhexyl)phthalate | none | 3,200 | 320 | 32 |
| Cadmium (Cd) | 0.46 | 3,800 | 380 | 38 |
| Carbazole | none | 2,200 | 220 | 22 |
| Carbon Tetrachloride | none | 23 | 2.3 | 0.23 |
| Chlordane | none | 34 | 3.4 | 0.34 |
| Chromium (Cr) | 178 | 21,000 | 2,100 | 210 |
| Chromium, Hexavalent (Cr+6) | 0.099 | 20 | 2.0 | 0.20 |
| Chrysene | none | 610 | 61 | 6.1 |
| Delta-BHC | none | 25 | 2.5 | 0.25 |
| Dibenzo(a,h)anthracene | none | 6.1 | 0.61 | 0.061 |
| Dieldrin | none | 2.8 | 0.28 | 0.028 |
| Formaldehyde | none | 980,000 | 98,000 | 9,800 |
| Gamma-BHC | none | 34 | 3.4 | 0.34 |
| Gamma-Chlordane | none | 34 | 3.4 | 0.34 |
| Heptachlor | none | 10 | 1.0 | 0.099 |
| Heptachlor Epoxide | none | 4.9 | 0.49 | 0.049 |
| Indeno(1,2,3-cd)pyrene | none | 61 | 6.1 | 0.61 |
| Lead (Pb) | 10.1 | 130 | 130 | 130 |
| Mercury (Hg) | 0.49 | 2,300 | 230 | 23 |
| Methylene Chloride | none | 780 | 78 | 7.8 |
| Pentachlorophenol | none | 250 | 25 | 2.5 |

Notes:

none = no background available for the analyte.

j:\doe\4000\A1e\Tbl4risk.xls\Table 4-13r

Table 4-14. Summary of Risk-Based Action Standards (RBASs) for Radionuclides in Surface Soil at the $10^{-4}$, $10^{-5}$, and $10^{-6}$ Risk Levels for PRGs – Residential Soil

| | | 1996 PRGs- Residential Soil (PRGs) | | |
|---|---|---|---|---|
| **Isotope** | **Background Concentration (pCi/g)** | **$10^{-4}$ Risk (pCi/g)** | **$10^{-5}$ Risk (pCi/g)** | **$10^{-6}$ Risk (pCi/g)** |
| Americium-241 | none | 190 | 19 | 1.9 |
| Bismuth-212 (Th-228 Daughter) | DP | DP | DP | DP |
| Bismuth-214 (Ra-226 Daughter) | DP | DP | DP | DP |
| Carbon-14 | 0.87 | 77,000 | 7,700 | 770 |
| Cesium-137+D | 0.053 | 2.0 | 0.20 | 0.020 |
| Cobalt-60 | 0.016 | 0.43 | 0.043 | 0.0043 |
| Lead-210+D | none | 78 | 7.8 | 0.78 |
| Lead-214 (Ra-226 Daughter) | DP | DP | DP | DP |
| Plutonium-241 +D | none | 15,000 | 1,500 | 150 |
| Radium-223 (U-235 Daughter) | DP | DP | DP | DP |
| Radium-226+D | 0.77 | 0.62 | 0.062 | 0.0062 |
| Strontium-90+D | 0.36 | 1,400 | 140 | 14 |
| Thorium-228+D | 0.71 | 4.1 | 0.41 | 0.041 |
| Thorium-232 | 0.64 | 2,400 | 240 | 24 |
| Thorium-234 (U-238+D) | none | 69 | 6.9 | 0.69 |
| Tritium | 0.023 | 1,100,000 | 110,000 | 11,000 |
| Uranium-235+D | 0.071 | 16 | 1.6 | 0.16 |

Notes:

none = no background available for the analyte.

DP = Daughter Product; Standard driven by parent isotope.

j:\doe\4000\A1e\Tbl4risk.xls\Table 4-14r

Table 4-15. Summary of Risk-Based Action Standards (RBASs) for Chemical Non-Carcinogens in Surface Soil at a Hazard Index of 1.0 for 1996 PRGs – Residential Soil

| Analyte | Background Concentration (mg/kg) | Risk-Based Action Standards (RBAS) (mg/kg) |
|---|---|---|
| 2-Butanone (MEK) | none | 7,100 |
| Acenaphthene | none | 110 |
| Acetone | none | 2,100 |
| Anthracene | none | 5.7 |
| Antimony (Sb) | 0.74 | 31 |
| Barium (Ba) | 237 | 5,300 |
| Benzo(g,h,i)perylene | none | no ref |
| Cadmium (Cd) | 0.46 | 9.0 |
| Chromium (Cr) | 178 | 210 |
| Chromium, Hexavalent (Cr+6) | 0.099 | 0.20 |
| Copper (Cu) | 50 | 2,800 |
| Dibenzofuran | none | 140 |
| Diethyl Phthalate | none | 52,000 |
| Di-n-Butylphthalate | none | 6,500 |
| Di-n-Octylphthalate | none | 1,300 |
| Endosulfan I | none | 390 |
| Endosulfan Sulfate | none | no ref |
| Ethyl Benzene | none | 230 |
| Fluoranthene | none | 2,600 |
| Fluorene | none | 90 |
| Formaldehyde | none | 9,800 |
| Manganese (Mn) | 720 | 3,200 |
| Mercury (Hg) | 0.49 | 23 |
| Methoxychlor | none | 330 |
| Naphthalene | none | 240 |
| Phenanthrene | none | no ref |
| Pyrene | none | 100 |
| Selenium (Se) | 1 | 380 |
| Silver (Ag) | 0.52 | 380 |
| Styrene | none | 680 |
| Toluene | none | 790 |
| Xylenes (Total) | none | 320 |
| Zinc (Zn) | 82 | 23,000 |

Notes:
none = no background available for the analyte.
No Ref = Do data available for this analyte.

j:\doe\4000\A1e\Tbl4risk.xls\Table 4-15r

# 5. IDENTIFICATION AND EVALUATION OF REMOVAL ACTION ALTERNATIVES

Sections 1.0 through 4.0 of this document defined the COCs and their associated risks to human health and the environment, and established RAOs. Section 5.0 develops and evaluates RA alternatives for each DOE area. In accordance with the "Guidance on Conducting Non-Time Critical RAs" (EPA, 1993), the following process was followed to develop and evaluate RA alternatives for each DOE area:

- Potentially applicable remedial technologies were screened based on effectiveness, implementability, and cost;
- Remedial technologies which pass this initial screening were developed into RA alternatives for each area;
- Alternative evaluation criteria were defined; and,
- RA alternatives were evaluated based on effectiveness, implementability, and cost.

## 5.1 Remedial Technology Evaluation

Remedial technologies potentially capable of achieving RAOs were identified based on their suitability with site waste types and COCs. Remedial technologies were screened based on effectiveness, implementability, and cost as presented in Table 5-1. A preliminary analysis of remedial technologies completed for the Site ("Cost of Presumptive Source Term Remedial Actions," Batelle, 1995) was also used to provide guidance in selecting appropriate remedial technologies. Only proven technologies known to be applicable for the Site were retained for alternative development.

Because of the presence of highly sorptive and non-mobile contaminants, as well as buried solid waste, the screening process indicates that only a limited number of remedial technologies are suitable for the proposed RAs. These technologies include:

- Excavation;
- Waste segregation/consolidation;
- Off-site disposal; and,
- Institutional controls including physical controls, legal controls, and COC/administrative site monitoring.

## 5.2 Development and Description of RA Alternatives

As shown on Table 5-2, alternatives were developed for each DOE area using the retained remedial technologies from Section 5-1. In accordance with CERCLA and NEPA requirements, a "No Action" alternative was also retained for evaluation.

For the Southwest Trenches Area, three alternatives were developed:

- Alternative 1: No Action
- Alternative 2: Excavation and Off-Site Disposal
- Alternative 3: Excavation, Off-Site Disposal and Institutional Controls

For the Ra/Sr Treatment Systems, three alternatives were developed:

- Alternative 1: No Action
- Alternative 2: Excavation and Off-Site Disposal
- Alternative 3: Excavation, Off-Site Disposal and Institutional Controls

For the Domestic Septic Systems, two alternatives were developed:

- Alternative 1: No Action
- Alternative 2: Excavation, Off-Site Disposal and Institutional Controls

These alternatives are described in the following sections for the Southwest Trenches, Ra/Sr Treatment Systems, and Domestic Septic System Areas. The description and development of alternatives presented in this section are intended to provide enough detail to select a preferred RA alternative as well as evaluate its potential environmental impacts. A more detailed work plan will be prepared for the selected RA alternative describing the exact specifications to be followed and field activities to be implemented during the proposed RAs.

A general description of the common elements involved in implementing the no action, excavation, institutional control, and off-site disposal technologies is provided in the protocols presented below. Specific changes to the alternative description are presented later as applicable for each DOE area. Each of these protocols is conceptual in nature with the selected alternative to be designed during preparation of the RA work plan to ensure that all aspects of the selected alternative are optimized.

### *5.2.1 Protocol for No Action Alternatives*

As required by NCP guidance, the No Action alternative was developed for each of the DOE areas to determine the effects and costs associated with leaving Site contamination in place.

The No Action process includes operating the site as it is currently without any further environmental restoration. A removal action would not be initiated. Required regulatory site

monitoring would be conducted to assess impacts to public health and environment, if necessary. No other Site activities are included.

### *5.2.2 Protocol for Alternatives Using Excavation.*

RA alternatives use excavation as a main technique for waste removal. Excavation activities will have the following common elements:

- Soil would be excavated using standard construction equipment (i.e., excavation backhoe), or drilling for excavations deeper than 20 ft in depth;
- Shoring would be provided as necessary to prevent caving or damage to nearby structures;
- Field soil samples would be collected on an ongoing basis from the sidewalls and floor of the excavation and analyzed for indicator compounds (ICs) using field analytical methods (with selective laboratory analysis) where appropriate;
- Field instrumentation and laboratory analysis would be combined to assist in determining the limits of the excavation. If field tests indicate that residual COC soil concentration does not meet desired risk levels, then excavation would continue by removing additional soil until the target risk level is achieved. An initial determination of excavation surface COC concentrations would be conducted upon removal of visually observed wastes;
- Soil would be segregated from waste and debris materials based on visual observation and field instrumentation, with each waste stream placed into appropriate transport disposal bins. Furthermore, surface soils that may contain pesticides (and potentially require disposal as mixed waste) would be stockpiled and characterized separately from subsurface soils (that are generally characterized as low-level radioactive waste);
- Excavated impacted soil and waste material would be profiled, characterized, packaged in bins, transported by truck, and disposed;
- Clean soil excavated to expose waste or COC-impacted soil would be placed on a liner and covered as necessary to prevent potential storm water erosion or dust migration. Clean soils removed to access contaminated soils would be field instrument inspected, stockpiled, sampled for laboratory analysis, and returned to the excavation provided that this soil is not impacted with COCs above RBASs;
- Once the final extent of excavation has been defined, a land survey of the extent of excavation and confirmatory sample locations would be conducted;
- A layer of geotextile fabric would be added to the bottom and sides of the excavation to ensure that the clean fill could be easily separated from the native soils. The geotextile fabric will serve, not only as a warning during intrusive

unplanned subsurface activities, but also as an aid if future Site excavations should be required;

- Open excavations would be backfilled and compacted with clean fill material, either from clean over-burden soils or imported from an offsite source known to be uncontaminated;
- The Site would be paved or covered with topsoil and seeded;
- Existing Site features (fences, trees, fire line / hydrants, monitoring wells, structures, and other utilities) would be protected during the RA or restored to their original condition at the end of the RA; and,
- Proper health and safety procedures would be followed during all field RA activities.

### *5.2.3 Protocol for Alternatives Using Off-Site Disposal*

Several waste disposal options are available for the proposed RAs. For the purposes of cost comparison in this EE/CA, the waste disposal option selected was segregation and placement of waste in B-25 bins for transport and off site disposal as low level radioactive waste at a DOE-approved disposal site. Mixed waste, as identified during implementation of a RA, would be disposed at a DOE-approved disposal site. Other disposal options/scenarios are more fully developed in Appendix D – Waste Characterization and Disposal Options. All disposal options presented in Appendix D are effective and can be implemented. The actual disposal option selected will be dictated by DOE policy and cost.

### *5.2.4 Protocol for Alternatives Using Institutional Controls.*

An alternative developed for the Southwest Trenches, the Ra/Sr Treatment Systems Area, and the Domestic Septic System Areas uses institutional controls. The concentration levels of COCs that remain in soil correspond to the acceptable risk level established for cleanup. These concentrations, and in turn risk levels, may vary depending on proposed future land use. Institutional controls were considered as a component of RA alternatives for Ra-226 exposure since they ensure that the RA is protective over time for a given risk level by utilization of land use restrictions. Institutional controls for these DOE areas involve the following common elements and have been developed to assist in reducing risk levels resulting from low levels of radionuclides (i.e. Ra-226) that may remain in site soils following the RA:

- Permanent postings may be required to prevent unsupervised subsurface soil disturbance below the level of the clean fill;
- A deed restriction would be placed on the Site to control future Site excavation activities;

- An agreement between DOE and UC Davis would likely be required if residual site contamination remains after the RA; and,
- Annual administrative Site monitoring would be conducted and documented to ensure that no subsurface soil disturbance has occurred since the previous inspection.

The institutional control component of the RA alternatives for Ra-226 was developed with the help of RESRAD modeling to determine the minimum cover required as well as the maximum allowable concentrations for total Ra-226 activity in subsurface soil at varying risk levels. These scenarios were used to define the type of controls that may be required for different risk levels in the nominal range of $10^{-4}$ to $10^{-6}$. A more detailed discussion of the RESRAD model and the general approach followed in this evaluation is presented in Appendix E – Determination of Cover Thickness vs. Ra-226 Activity. This model indicates that clean fill can be used as an effective cover (control) over Ra-226 subsurface soil contamination. This model and the calculation of RBAS assumes that an indoor air exposure for Ra-226 will be present in the selected land use scenario. For example, soil with a total Ra-226 activity of 2.0 pCi/g would require a minimum cover thickness of clean fill that increases with decreasing risk levels as follows:

- No cover for a $3x10^{-4}$ risk level;
- 5.7 ft of cover for a $10^{-4}$ risk level;
- 9.4 ft of cover for a $5x10^{-5}$ risk level;
- 17.9 ft of cover for a $1x10^{-5}$ risk level; and,
- 30.1 ft of cover for a $1x10^{-6}$ risk level.

Similarly, for a total excess cancer risk of $10^{-5}$ this modeling indicates that total Radium-226 soil activities could increase with depth as follows:

- 0.81 pCi/g of Ra-226 could remain in surface soil;
- 1.0 pCi/g of Ra-226 could remain in subsurface soil at a depth of 8.9 ft; and
- 2.0 pCi/g of Ra-226 could remain in subsurface soil at a depth of 17.9 ft.

The above data were utilized in the evaluation of alternatives involving institutional controls.

## 5.3 Evaluation Criteria

In accordance with EPA guidance, the alternatives developed for each area were evaluated based on cost, effectiveness, and implementability. Subsections under these general headings also include more specific criteria recommended in CERCLA and EPA guidance, as described below.

Effectiveness was evaluated using the following criteria:

- Overall Protection of Human Health and the Environment – This criteria assesses the degree to which human health and the environment is protected;

- Compliance with ARARs – This criterion determines whether the alternative meets ARARs as described in Section 4.0, and if any waivers of these requirements are necessary;
- Long term effectiveness – This criterion evaluates the degree of permanence and degree of certainty that the proposed RA will prove successful;
- Reduction in Toxicity, Mobility, or Volume through Treatment – This criterion assesses the degree to which an alternative can reduce the toxicity, mobility, or volume of contamination; and,
- Short Term Effectiveness – This criterion assesses the immediate threats to surrounding community, and on-site workers created during implementation of the RA.

Implementability was evaluated using the following criteria:

- Technical Feasibility - This criterion assesses the reliability and difficulty of implementing the proposed remedial technologies, and the ability to monitor the effectiveness of the RA;
- Administrative Feasibility – This criterion assesses the difficulty in obtaining the necessary permits or regulatory approvals for the alternative;
- Availability of Services – This criterion assesses the difficulty of obtaining necessary products or services needed to complete the RA;
- Regulatory Acceptance – This criterion assesses the likelihood that an alternative will be accepted by the EPA and the CalEPA including the Department of Toxic Substances Control (DTSC) and the Regional Water Quality Control Board (RWQCB); and,
- Community Acceptance – This criterion assesses the likelihood that an alternative will be met with public approval when the Action Memorandum for the proposed RA is distributed for public comment.

Cost was calculated for the following categories at an estimated accuracy of plus 50 percent / minus 30 percent. Cost estimate summaries for each alternative are presented in Appendix F – Cost Estimate Summaries for Removal Action Alternatives.

- Direct costs – This criterion estimates the cost of the actual field work and payment of contractors in fiscal year 1998 dollars;
- Post-Removal costs – This criterion estimates the cost of continued Site monitoring and maintenance of institutional controls; and,
- Net present value – This criterion estimates the cost of post-removal costs over a 100-year time frame. A 100-year timeframe was selected (instead of the 30-year timeframe commonly used) due to the extended persistence of radionuclides on the Site.

In addition to these EPA recommended criteria, RA alternatives were evaluated with respect to two other factors. These factors included risk and uncertainty. These factors were incorporated in the evaluation process as a cost-benefit analysis measure. Each of these factors are described in more detail below.

### *5.3.1 Risk Levels*

Three human health risk levels (A, B and C) have been defined in evaluating and comparing the RA alternatives. These risk levels include.

- Risk Level A: A nominal *cumulative* excess cancer risk equal to $10^{-4}$ and a *cumulative* COC hazard index less than 1. Soil RBASs for *individual* COCs at a risk level of $10^{-4}$ are used as target levels to guide removal activities;
- Risk Level B: A nominal *cumulative* excess cancer risk in the range of $10^{-4}$ to $10^{-5}$ and a *cumulative* COC hazard index less than 1. Soil RBASs for *individual* COCs at a risk level of $10^{-5}$ are used to guide removal activities; and,
- Risk Level C: A nominal *cumulative* excess cancer risk in the range of $10^{-4}$ to $10^{-5}$ and a *cumulative* COC hazard index less than 1. Further reduction in nominal *cumulative* excess cancer risk over Risk Level B is not technically achievable due to analytical limitations regarding accurate measurement of very low radium-226 activities. However, Risk Level C is more protective of human health than Risk Level B because $10^{-6}$ RBASs for *individual* COCs are used to guide removal activities.

These risk levels represent cumulative excess cancer risk in the range of $10^{-4}$ to $10^{-5}$ and non-cancer hazard index less than 1, and are consistent with EPA's policy on risk characterization. RBASs for individual COCs will be used at varying risk levels ($10^{-4}$, $10^{-5}$, or $10^{-6}$), based on which risk level is selected, to guide the remedial activities and ensure attainment of cumulative excess cancer risk for the selected risk scenario (Section 4.3.1). RA alternatives will be evaluated for each risk level in order to compare the effectiveness, implementability, and cost of attaining these risk levels.

### *5.3.2 Uncertainty*

Uncertainty issues for this EE/CA are related to the extent of contamination at the site. The extent of buried solid waste disposal trenches and waste burial pits within the Southwest Trenches Area has not been fully defined. The extent of subsurface soil contamination is based on a limited number of samples collected from soil explorations. Lack of information on the type and depth of the solid waste at the site has created a large uncertainty in the volume of waste and associated soil that may require removal during the RA. Therefore, the effectiveness, implementability, and cost of each alternative at a given risk level carries some degree of uncertainty.

For the purposes of estimating costs and comparing alternatives certain assumptions regarding the conceptual excavation area and volume of waste were made. These volume estimates are presented in Appendix G – Excavation Area and Volume Estimates. Site data presented in Section 3.0 was reviewed with respect to the RAOs stated in Section 4.5 to define the extent and type of contamination requiring RA in each of the three DOE areas. The following general guidelines were used in this process:

- Areas containing laterally persistent COCs detected above their respective RBASs were identified for RA; and,
- Limited areas containing a high concentration of compounds observed in particular soil samples, but not in surrounding soil samples, were considered 'hot-spots'. Observed hot spots were identified for RA unless the COC did not exceed a level twice the background concentration.

Data was evaluated in comparison to the RBASs and concentration-risk quotients (C/RQ) were calculated for each sample analytical result by dividing the actual measured concentration by its respective surface soil RBAS. The lowest value used of each risk scenario (1, 2 or 3) for each risk level was used for this computation. Analytical Data Summaries are presented in Appendix H – Analytical Data Summary, and show the analytical results and C/RQs for data sample collections by area, as well as by analyte. Figures presented in the following sections depict the COCs for specified risk levels ($10^{-4}$ and $10^{-6}$) but in no case less than 1.5 times that COC's respective background concentration.

## 5.4 Evaluation of Alternatives for the Southwest Trenches Area

Table 5-3 presents the COCs, waste material and/or Site structures requiring RA in the Southwest Trenches Area for cancer risk levels of $10^{-4}$, $10^{-5}$, and $10^{-6}$ and non-cancer HI greater than 1. The estimated spatial distribution of COCs exceeding the $10^{-4}$ and $10^{-6}$ RBASs is presented in Figure 5-1. The extent of RA within the Southwest Trenches Area was determined by the extent of buried solid waste, Ra-226 soil activities, and surface soil pesticide and metal concentrations.

Three alternatives were developed for the Southwest Trenches: 1) No Action; 2) Excavation and Off-Site Disposal; and, 3) Excavation, Off-Site Disposal and Institutional Controls. Each of these alternatives was evaluated according to the criteria described above.

### *5.4.1 Alternative 1 - No Action*

This alternative would involve the standard No Action protocols described in Section 5.2.1. No specific additions or changes to these protocols are required at the Southwest Trenches Area. Table 5-4 presents a detailed evaluation of Alternative 1 by cost, effectiveness, and implementability. This evaluation is summarized below.

#### 5.4.1.1 Effectiveness

The No Action alternative will not meet RAOs, primarily because of Ra-226 and chlordane contamination present in surface and subsurface soil. Furthermore, the risks posed by buried solid waste would not be identified or addressed by this alternative. Finally, soil contamination and buried waste in this area could easily be exposed during future site construction activities therefore adversely impacting public health.

#### 5.4.1.2 Implementability

This alternative is unlikely to gain acceptance from the regulatory agencies or the surrounding community as a final remedial solution for this area.

#### 5.4.1.3 Cost

As shown on Figure 5-2, the estimated total cost of this alternative is $600,000 that consists solely of post-removal annual costs.

### *5.4.2 Alternative 2 – Excavation and Off-Site Disposal*

This alternative follows the standard excavation and off-site disposal protocols described in Sections 5.2.2 and 5.2.3, respectively. In addition to these protocols, this alternative includes the following elements:

- No limitations on future site use would be necessary;
- Achievement of RAOs would be based on the selected risk levels (A, B, or C). RBASs for the risk level selected would be applied throughout the excavation, regardless of depth, to allow unrestricted future site use;
- Immediately prior to commencement of the main excavation activities, the area would be cleared of vegetation and transected by exploratory trenches (6 ft deep by 1 ft wide). These trenches would be placed in a grid pattern (10-ft on center) in a north/south and east/west direction across the site to define the exact locations of unknown waste disposal trenches and waste burial pits. Waste disposal trenches/burial pits would be identified and located by a combination of visual observations and field instrument inspection. Waste disposal trenches/burial pits identified from this process would then be excavated to include overburdened soil and buried waste; and,
- After excavation activities have been completed, confirmation samples would be taken from the limits of the excavation. If the confirmation samples results indicate that RAOs have been met, no further excavation or action would be conducted at this time. Otherwise, a detailed DOE appraisal would be completed to determine that the RA either achieved RAOs or a future RA may be necessary.

A conceptual excavation plan view for Alternative 2 is presented in Figure 5-3. The depth of waste disposal trenches/burial pits and the volume of excavated soil increase with risk levels. In addition, the amount of surface soil requiring removal due to pesticide contamination progressively increases between Risk Levels A, B, and C because of the additional soil removal required to achieve lower risk levels. A hypothetical excavation cross section illustrating these excavation scenarios at each risk level is presented in Figure 5-4.

Table 5-5 presents a detailed evaluation of Alternative 2 by cost, effectiveness, and implementability. This evaluation is summarized below.

#### 5.4.2.1 Effectiveness

This alternative meets RAOs, is protective of human health and the environment, and also complies with ARARs, as shown on Table 5-6. Risk Level C would be more protective of human health in the long-term relative to Risk Level B, while Risk Level B is more protective than Risk Level A.

The excavated material is not easily concentrated or otherwise treated due to the presence of radionuclides, pesticides, and buried solid waste. The uncertainty in waste/soil volumes requiring excavation increases from Risk Level A to Risk Level C as the RBASs guiding the remediation become smaller for individual COCs.

#### 5.4.2.2 Implementability

The feasibility of these excavation activities was established during the LFI conducted on-site during the summer of 1996. This field investigation excavated several trenches and properly disposed of the resulting excavated soil and solid waste at the DOE Hanford disposal facility.

Successful implementation of this alternative requires experienced field personnel due to the unusual nature of Site contaminants, complicated measuring equipment used on-site, and the uncertainties in the location and type of buried solid waste materials. Based upon the limitations of field and laboratory instrumentation, the differentiation of Ra-226 RBASs at the $10^{-5}$ and $10^{-6}$ levels from background concentrations is not technically feasible.

Regulatory and community acceptance of this alternative is less likely for Risk Level A than for Risk Levels B or C.

#### 5.4.2.3 Cost

As shown on Figure 5-2, costs for this alternative are:

- For Risk Level A, the estimated total cost for this alternative is $4,100,000 which consists solely of direct costs;
- For Risk Level B, the estimated total cost for this alternative is $5,300,000, which consists solely of direct costs; and,

- For Risk Level C, the estimated total cost for this alternative is $5,600,000, which consists solely of direct costs.

The costs for each of these alternatives is directly related to the excavated soil volume which increases with decreasing risk level. Soil volumes increased with decreasing risk levels at $10^{-5}$ and $10^{-6}$ due to additional surface soil excavation for pesticide removal. The uncertainty in the waste volume for this alternative is large and cannot be reduced until the exploratory excavation trenching is conducted just prior to the RA.

### *5.4.3 Alternative 3 –Excavation, Off-Site Disposal and Institutional Controls*

This alternative includes the standard excavation and off-site disposal protocols described in Sections 5.2.2 and 5.2.3, respectively, as well as the standard institutional controls protocol described in Section 5.2.4. In addition to these protocols, this alternative includes the following elements:

- This alternative requires excavation of buried waste and sufficient contaminated soil to achieve the specified risk level using institutional controls that allow higher residual Ra-226 soil concentrations to remain in place at depth;
- Exploratory trenching and waste identification would occur as described for Alternative 2;
- After excavation activities have been completed, confirmation samples would be taken from the limits of the excavation. If the confirmation samples results indicate that RAOs have been met, taking into account institutional controls, no further excavation or action would be conducted at this time. Otherwise, a detailed DOE appraisal would be completed to determine that the RA either achieved RAOs or a future RA may be necessary; and,
- Following completion of the RA, institutional controls, including administrative monitoring and land disturbance restrictions would be implemented as necessary.

A conceptual excavation plan view for Alternatives 3 is presented in Figure 5-3. The volume and depth of excavated soil from the waste disposal trenches/pits is the same at all risk levels. However, the amount of surface soil requiring removal due to pesticide contamination progressively increased between Risk Levels A, B and C because of the additional soil removal required to achieve these lower risk levels. A hypothetical excavation cross section illustrating these excavation scenarios at each risk level is presented in Figure 5-4.

Table 5-7 presents a detailed evaluation of Alternative 3 by cost, effectiveness, and implementability. This evaluation is summarized below.

#### 5.4.3.1 Effectiveness

This alternative meets RAOs, is protective of human health and the environment, and complies with ARARs, as shown on Table 5-6. Risk Level C would be more protective of human health in the long-term than Risk Level B, while Risk Level B is more protective than Risk Level A.

The excavated material is not easily concentrated or otherwise treated due to the presence of radionuclides, pesticides, and buried solid waste. Although, not by treatment, this alternative reduces contaminant mobility through placement of contaminated soil in an appropriate landfill facility.

This alternative is effective in the long term but requires continued administrative monitoring of access control measures and enforcement of Site use restrictions. Furthermore, there is minimal risk to the surrounding community outside of the work areas during the implementation of this RA.

#### 5.4.3.2 Implementability

The feasibility of these excavation activities was established during the recent LFI conducted on-site during the summer of 1996. This field investigation excavated several trenches and properly disposed of the resulting excavated soil and solid waste at the DOE Hanford disposal facility.

Successful implementation of this alternative requires experienced field personnel due to the unusual nature of Site contaminants, complicated measuring equipment used on-site, and the uncertainties in the location and type of buried solid waste materials. Based upon the limitations of field and laboratory instrumentation, the differentiation of Ra-226 at $10^{-5}$ and $10^{-6}$ level from background concentration is not technically feasible.

Regulatory and community acceptance of this alternative is less likely at Risk Level A than at Risk Levels B and C.

#### 5.4.3.3 Cost

As shown on Figure 5-2, cost for this alternative are:

- For Risk Level A, the estimated total cost for this alternative is $3,900,000, which includes $3,100,000 in direct capital costs, and $10,000 in post-RA annual costs with a net present value (100 yr) of $200,000.
- For Risk Level B, the estimated total cost for this alternative is $4,000,000, which includes $3,200,000 in direct capital costs, and $10,000 in post-RA annual costs with a net present value (100 yr) of $200,000.
- For Risk Level C, the estimated total cost for this alternative is $4,300,000, which includes $3,400,000 in direct capital costs, and $10,000 in post-RA annual costs with a net present value of (100 yr) of $200,000.

The costs for each of these alternatives is directly related to the excavated soil volume which increases with decreasing risk level. Soil volumes increase with decreasing Risk Levels A, B and C

due to additional surface soil excavation for pesticide removal. The uncertainty in the waste volume for this alternative is large and cannot be cost-effectively determined prior to the RA.

## 5.5 Evaluation of Alternatives for the Ra/Sr Treatment Systems

Table 5-8 describes the COCs, waste materials, and/or Site structures requiring RA in the Ra/Sr Treatment Systems Area for cancer risk levels $10^{-4}$, $10^{-5}$, and $10^{-6}$ and non-cancer HI greater than 1. The estimated spatial distribution of COCs exceeding the $10^{-4}$ and $10^{-6}$ RBASs is presented in Figure 5-5. The extent of RA in the Ra/Sr Treatment Systems is based on removing Ra-226 contamination in Site structures such as the radium dry wells, and in surface and subsurface soils.

Three alternatives were developed for the Ra/Sr Treatment System: 1) No Action, 2) Excavation and Off-Site Disposal, and 3) Excavation, Off-Site Disposal, and Institutional Controls. Each of these alternatives was evaluated according to the criteria defined in Section 5.3.

### *5.5.1 Alternative 1- No Action*

This alternative involves the standard No Action protocols described in Section 5.2.1. No specific additions or changes to these protocols are required for the Ra/Sr Treatment Systems Areas. Table 5-9 presents a detailed evaluation of Alternative 1 by cost, effectiveness, and implementability. This evaluation is summarized below.

#### 5.5.1.1 Effectiveness

The No Action alternative will not meet the RAO because of Ra-226 contamination in surface and subsurface soil. This soil contamination could easily be exposed during future site construction activities. In addition, site structures that potentially pose environmental or safety hazards such as the Imhoff tanks and radium dry wells will not be removed.

#### 5.5.1.2 Implementability

This alternative is unlikely to gain acceptance from the regulatory agencies or the surrounding community as a final remedial solution for this area.

#### 5.5.1.3 Cost

As shown on Figure 5-6, the estimated total cost of this alternative is $600,000 that consists solely of post-removal annual costs.

### *5.5.2 Alternative 2 – Excavation and Off-Site Disposal*

This alternative follows the standard excavation and off-site disposal protocols described in Sections 5.2.2 and 5.2.3, respectively. In addition to these protocols, this alternative includes the following elements:

- No limitations on future site use is necessary.
- Achievement of RAOs is based on the selected risk level. RBASs for the selected risk level would be applied throughout the excavation regardless of depth to allow unrestricted future site use.
- The radium drywells, treatment system piping, Imhoff tanks, and associated leach fields would be removed and properly disposed under this alternative.
- Domestic Septic System No. 2 Tank would be removed and properly disposed as a result of these excavation activities.
- After excavation activities have been completed, confirmation samples would be taken from the limits of the excavation. If the confirmation sample results indicate that RAOs have been met, no further excavation or action would be conducted at this time. Otherwise, a DOE appraisal would be completed to determine that the RA either achieved RAOs or a future RA may be necessary.

This alternative was developed only for Risk Levels A and C. Risk Level B was not developed under this alternative because Ra-226 governs the extent of excavation at the Ra/Sr Treatment Systems Area. The Ra-226 soil removal will be guided by its RBAS which can not be technically differentiated from background at Risk Levels B and C. Furthermore, after removal of the Ra-226, it is not anticipated that the residual concentrations/activities of other site COCs will be present above their respective $10^{-6}$ RBAS concentrations. A conceptual excavation plan view for Alternative 2 at Risk Levels A and C is presented in Figure 5-7. A conceptual excavation cross section for Alternative 2 is presented in Figure 5-8.

Table 5-10 presents the detailed evaluation of Alternative 2 by cost, effectiveness, and implementability. This evaluation is summarized below.

#### 5.5.2.1 Effectiveness

This alternative meets RAOs, is protective of human health and the environment, and complies with ARARs as shown on Table 5-6.

The excavated material is not easily concentrated or otherwise treated due to the presence of radionuclides. Although not by treatment, this alternative reduces contaminant mobility through placement of contaminated soil in an appropriate landfill facility.

#### 5.5.2.2 Implementability

The feasibility of these excavation activities was established during the recent LFI conducted on-site during the summer of 1996. This field investigation excavated several trenches and properly disposed of the resulting excavated soil and solid waste at the DOE Hanford disposal facility.

Successful implementation of this alternative requires experienced field personnel due to the unusual nature of Site contaminants, complicated measuring equipment used on-site, and the uncertainties in the location and type of buried solid waste materials. Based upon the limitations of field and laboratory instrumentation, the measurement of radium-226 at $10^{-5}$ and $10^{-6}$ level is not technically feasible.

Regulatory and community acceptance of this alternative is less likely at Risk Level A than at Risk Level C.

#### 5.5.2.3 Cost

As shown on Figure 5-6, costs for this alternative are:

- For Risk Level A, the estimated total cost for this alternative is $3,600,000, which consists solely of direct costs; and,
- For Risk Level C, the estimated total cost for this alternative is $4,100,000, which consists solely of direct costs.

The costs for each of these alternatives is directly related to the excavated soil volume which increases with decreasing risk level due to additional soil excavation for removal.

### *5.5.3 Alternative 3 – Excavation, Off-Site Disposal, and Institutional Controls*

This alternative includes the standard excavation and off-site disposal protocols described in Sections 5.2.2 and 5.2.3, respectively, and the standard institutional controls protocol described in Section 5.2.4. In addition to these protocols, this alternative includes the following elements:

- This alternative does not require as much soil excavation as Alternative 2 because institutional controls allow higher residual Ra-226 soil concentrations to remain in place at depth.
- The radium drywells, treatment system piping, Imhoff tanks, and associated leach field would be removed and properly disposed.
- Domestic Septic System No. 2 Tank would be removed and properly disposed as a result of these excavation activities.
- After excavation activities have been completed, confirmation samples would be taken from the limits of the excavation. If the confirmation samples results indicate that RAOs have been met, no further excavation or action would be conducted at this time. Otherwise, a DOE appraisal would be completed to

determine that the RA either achieved RAOs or if a future RA may be necessary.

- Following completion of the RA, institutional controls, including administrative monitoring and land disturbance restrictions would be implemented as necessary.

This alternative was developed only for Risk Level C, because it is anticipated that by removing the Ra/Sr treatment System structures (such as the Radium dry wells) enough contaminated soil will be removed, and enough depth provided for placement of cover, that Risk Level C will be attained. Furthermore, aside from Ra-226, no other COCs have been observed in the Ra/Sr Treatment Systems area above their $10^{-6}$ RBASs. A conceptual excavation plan view for Alternative 3 at Risk Level C is presented in Figure 5-7. A conceptual excavation cross section for Alternative 3 is presented in Figure 5-8.

Table 5-11 presents the detailed evaluation of Alternative 3 by cost, effectiveness, and implementability. This evaluation is summarized below.

### 5.5.3.1 Effectiveness

This alternative meets RAOs, is protective of human health and the environment, and complies with ARARs, as shown on Table 5-6.

The excavated material is not easily concentrated or otherwise treated due to the presence of radionuclides, pesticides, and buried solid waste. Although not by treatment, this alternative reduces contaminant mobility through placement of contaminated soil in an appropriate landfill facility.

This alternative is effective in the long term but requires continued administrative monitoring plus access control measures and enforcement of Site use restrictions. Furthermore, there is minimal risk to the surrounding community outside of the work areas during the implementation of this RA.

### 5.5.3.2 Implementability

The feasibility of these excavation activities was established during the recent LFI conducted on-site during the summer of 1996. This field investigation excavated several trenches and properly disposed of the resulting excavated soil and solid waste at the DOE Hanford disposal facility.

Successful implementation of this alternative requires experienced field personnel due to the unusual nature of Site contaminants, complicated measuring equipment used on-site, and the uncertainties in the location and type of buried solid waste materials. Based upon the limitations of field and laboratory instrumentation, the measurement of Ra-226 RBASs at the $10^{-5}$ and $10^{-6}$ levels from background concentrations is not technically feasible.

Regulatory and community acceptance of this alternative is likely at Risk Level C.

#### 5.5.3.3 Cost

As shown on Figure 5-6, the estimated net present value of this alternative is $3,200,000, which includes $2,500,000 in direct capital costs, and $10,000 in post RA annual costs, with a net present value of $200,000.

## 5.6 Evaluation of Alternatives for the Domestic Septic System Areas

Table 5-12 describes the COCs, waste materials, and/or site structures requiring RA in the Domestic Septic System Areas for cancer risk levels $10^{-4}$, $10^{-5}$, and $10^{-6}$ and non-cancer HI greater than 1. Seven separate Domestic Septic Systems are located throughout the Site as shown on Figure 5-9. However, the extent of RA within the Domestic Septic System Areas was based on Ra-226 and mercury subsurface soil contamination identified at Domestic Septic System Nos. 3 and 6, respectively. The extent of contamination at all Domestic Septic Systems is summarized below.

- Domestic Septic System No. 1: The spatial distribution of COCs exceeding RBASs at $10^{-4}$ and $10^{-6}$ for this area is presented in Figure 5-10. No COCs were detected above RBASs at Domestic Septic System No. 1 and therefore no RA is warranted or required for this Domestic Septic System with the exception of ensuring that the tank is closed in accordance to Solano County Regulations.
- Domestic Septic System No. 2: The RA associated with Domestic Septic System No. 2 is included with the RA for the Ra/Sr Treatment System Area. Domestic Septic System No. 2 will be removed under the RA planned for the Ra/Sr Treatment Systems Area.
- Domestic Septic System No. 3: The spatial distribution of COCs exceeding RBASs at $10^{-4}$ and $10^{-6}$ for this area is presented in Figure 5-11. No septic tank was observed in this area although the leach field was sampled. Figure 5-12 presents the approximate location of Domestic Septic System No. 3. Ra-226 was detected above its RBAS at a depth of 15 ft at Domestic Septic System No. 3.
- Domestic Septic System No. 4: The spatial distribution of COCs exceeding RBASs at 10-4 and 10-6 is presented in Figure 5-11. No septic tank was observed in this area although the leach field was sampled. Mercury was detected at approximately 3 times the RBAS at a depth of 5.5 ft. Since mercury concentrations at depths of 8 and 13 ft are below background and a co-located sample at 5.5 feet was less than 2 times background, no RA is warranted or required for this location.
- Domestic Septic System No. 5: The Septic Tank is reported to be under a building. The leach field for the Septic Tank is believed to be the same as the leach field identified with Domestic Septic System No. 1. No COCs were detected above RBASs and two times background at Domestic Septic System

No. 5. Therefore, no RA is warranted or required for this Domestic Septic System.

- Domestic Septic System No. 6: The spatial distribution of COCs exceeding RBASs at $10^{-4}$ and $10^{-6}$ for this area is presented in Figure 5-13. No septic tank was discovered in this area, but mercury was detected above the RBASs in a soil sample from a depth of 5.5 ft. Figure 5-14 presents the approximate location of Domestic Septic System No. 6.
- Domestic Septic System No. 7: The spatial distribution of COCs exceeding the RBASs at $10^{-4}$ and $10^{-6}$ for this area is presented in Figure 5-15. A septic tank was found, but no COCs above RBASs and 1.5 times background were detected in surface soil. No Action is warranted or required for this Domestic Septic System with the exception of ensuring that the tank is closed in accordance to Solano County Regulations.

As described above, two alternatives were developed for the Domestic Septic System Areas: 1) No action; and, 2) Excavation, Off-Site Disposal, and Institutional Controls. Each of these alternatives was evaluated according to the criteria defined in Section 5.3.

### *5.6.1 Alternative 1 – No Action*

This alternative would involve the standard No Action protocols described in Section 5.2.1. No specific additions or changes to these protocols are required at the Domestic Septic Systems. Table 5-13 presents the detailed evaluation of Alternative 1 by cost, effectiveness, and implementability. This evaluation is summarized below.

#### 5.6.1.1 Effectiveness

The No Action alternative does not likely meet the RAO because mercury subsurface soil contamination in the leach field soil will not be removed. Mercury contamination poses a threat to public health in both short and long-term.

#### 5.6.1.2 Implementability

This alternative is likely not to gain acceptance from the regulatory agencies or the surrounding community as a final remedial solution for this area.

#### 5.6.1.3 Cost

As shown on Figure 5-16, the estimated total cost of this alternative is $600,000, which consists of post RA annual costs.

### *5.6.2 Alternative 2 – Excavation, Off-Site Disposal, and Institutional Controls*

This alternative is presented in Figure 5-9. This alternative includes the following elements:

- At Domestic Septic System No. 1, no RA is warranted or required. However, the tank would be confirmed as closed in accordance to County requirements.
- At Domestic Septic System No. 2, the tank would be removed under the RA at the Ra/Sr Treatment System Areas.
- At Domestic Septic System No. 3, Ra-226 has been detected at one location at a concentration about two times above background and no excavation is recommended at this location. Rather, Institutional Controls, as described in 5.2.4, along with confirmatory sampling would be performed at Domestic Septic System No. 3. The approximate area requiring Institution Controls is shown on Figure 5-12. Prior to the RA, a subsurface soil investigation would be conducted at Domestic Septic System No. 3 to confirm the vertical and spatial extent of Ra-226. Assuming the Ra-226 level is confirmed, the RA would proceed. Otherwise, no RA would be undertaken for Domestic System No. 3.
- At Domestic Septic System No. 4, no RA is warranted or required.
- At Domestic Septic System No. 5, no RA is warranted or required.
- At Domestic Septic System No. 6, a RA consisting of a 10 ft by 10 ft by 7 ft deep excavation would be completed, as described in 5.2.2 and 5.2.3, to remove mercury contamination within leach field soil. A conceptual excavation plan view for this Domestic Septic System is presented in Figure 5-14. At Domestic Septic System No. 6, RBASs for the selected risk level would be applied throughout the excavation regardless of depth to allow unrestricted future site use. Prior to the RA, an initial subsurface soil investigation would be conducted at Domestic Septic System No. 6 to confirm the spatial extent of the mercury. Assuming the mercury level is confirmed, the RA would proceed. Otherwise, no RA would be conducted for Domestic Septic System No. 6.
- At Domestic Septic System No. 7, no RA is warranted or required. However, the tank would be confirmed as closed in accordance to County requirements.
- Achievement of RAOs is based on the selected risk level.
- After excavation activities have been completed, confirmation samples would be taken from the limits of the excavation. If the confirmation sample results indicate that RAOs have been met, no further excavation or action would be conducted at the Site. Otherwise, a detailed DOE appraisal would be completed to determine that the RA either achieved RAOs or future RA is necessary.

This alternative was developed only for Risk Level C because the volume of contamination is limited in extent, making Risk Level C potentially achievable. The cost of this alternative is shown on Figure 5-16.

Table 5-14 presents the detailed evaluation of Alternative 2 by cost, effectiveness, and implementability. This evaluation is summarized below.

#### 5.6.2.1 Effectiveness

This alternative meets RAOs, is protective of human health and the environment, and complies with ARARs, as shown on Table 5-6.

The excavated material is not easily concentrated or otherwise treated due to the potential presence of radionuclides, metals, and buried solid waste. Although not by treatment, this alternative reduces contaminant mobility through placement of contaminated soil in an appropriate landfill facility.

#### 5.6.2.2 Implementability

This alternative is implementable. Regulatory and community acceptance of this alternative is likely. Only Risk Level C is proposed for this alternative.

#### 5.6.2.3 Cost

As shown on Figure 5-16, the estimated total cost of this alternative is $600,000, which includes $300,000 in direct capital costs, and $10,000 in post-RA annual cost, with a net present value of $200,000.

Table 5-1. Remedial Technology Screening for Soil and Waste Containing Radionuclides, SVOCs, Pesticides, and Metals

| **General Response Action** Remedial Technology Type | **Process Option -** Description | **Screening Criteria** Effectiveness | Implementability | Cost | Retained for Alternative Development |
|---|---|---|---|---|---|
| **NO ACTION** | | | | | |
| No Action | **No Action –** Leave Site as it is currently without further remedial action. | Site dependent | Implementable | Inexpensive | Yes – Retained per NCP guidance |
| Natural Attenuation | **Natural Attenuation –** Use natural Site geology and subsurface environment to degrade/restrict movement of contaminants | Decay time for radioactive isotopes is too long to be reasonably effective. Not effective for buried waste. | Implementable | Inexpensive | No – Not effective for Site contaminants. |
| **INSTITUTIONAL CONTROLS** | | | | | |
| Legal Controls | **Deed Restrictions –** Restricts future development and Site uses | Requires long-term enforcement of restriction | Implementable | Moderate | Yes – Easily implementable and potentially effective. |
| Monitoring | **COC Monitoring –** Monitor Constituents of Concern, radiation levels, and dust/contaminant migration | Useful for documenting changing conditions, ensuring containment | Implementable | Moderate | Yes – Easily implementable and potentially effective. |
| | **Administrative Monitoring** – Ensure institutional controls are maintained and Site uses are allowed. | Effective in ensuring continued enforcement / use of institutional controls | Implementable | Low | Yes – Easily implementable and potentially effective. |

Table 5-1. Remedial Technology Screening for Soil and Waste Containing Radionuclides, SVOCs, Pesticides, and Metals (continued)

| **General Response Action** Remedial Technology Type | **Process Option -** Description | **Screening Criteria** Effectiveness | Implementability | Cost | Retained for Alternative Development |
|---|---|---|---|---|---|
| Physical Control | **Perimeter Fencing** – Perimeter fence to restrict access and prevent exposure | Potentially effective in conjunction with other controls | Implementable | Inexpensive | Yes |
| Physical Control (continued) | **Permeable Surfacing** – Placement of soil, gravel or pavement to function as a horizontal barrier to prevent human exposure to underlying soils | Potentially effective | Implementable | Moderate | Yes – Easily implementable and potentially effective |
| **REMOVAL** | | | | | |
| Extraction | **Excavation** – Remove all or part of contaminated soil, buried solid waste, and/or existing structures | Effective | Implementable. Feasibility established during LFI | Moderate | Yes – Effective and proven technology |
| **TREATMENT / SEGREGATION** | . | | . | | |
| Accumulation | **Phytoremediation** – Use selected vegetation to bioaccumulate and concentrate contaminants (*in-situ*) | Not effective for buried waste/deep contamination | Implementable | Moderate | No – Not effective for deep contamination / buried waste |

Table 5-1. Remedial Technology Screening for Soil and Waste Containing Radionuclides, SVOCs, Pesticides, and Metals (continued)

| **General Response Action** Remedial Technology Type | **Process Option -** Description | **Screening Criteria** Effectiveness | Implementability | Cost | Retained for Alternative Development |
|---|---|---|---|---|---|
| Physical Segregation | **Waste segregation / consolidation –** Physical separation of excavated (i.e. lab waste, concrete, gravels, and soils) into separate waste streams prior to disposal. | Effective. Permits waste stream designation prior to off-site disposal. | Implementable. Initial separation by physical characteristics followed later by chemical waste profiles. Feasibility established during LFI. | Low | Yes – Effective and easily implementable |
| | **Stabilization/Solidification by Electrical Vitrification –** Chemically bonds radionuclides and metals into the soil matrix, thermally destroys VOCs, SVOCs, and pesticides (*in-situ* or *ex-situ*) | Radionuclides are still radioactive but have a reduced leaching and potential | Not retained for further investigation due to high unit cost for treatment and need for barrier between radioactive material and surface | Expensive | No |
| **TREATMENT / SEGREGATION** Physical Segregation (continued) | **Desorption by Electrokinetic Separation –** Mobilizes pesticides, metals, and radionuclides so they can be extracted for off-site disposal (*in-situ* or *ex-situ*) | May not be able to meet target soil concentrations for highly sorptive contaminants like chlordane, as well as for clay soils. | Unproven technology, difficult to implement *in-situ*. | Expensive | No – Not readily effective or easily implementable |

Table 5-1. Remedial Technology Screening for Soil and Waste Containing Radionuclides, SVOCs, Pesticides, and Metals (continued)

| **General Response Action** Remedial Technology Type | **Process Option -** Description | **Screening Criteria** Effectiveness | Implementability | Cost | Retained for Alternative Development |
|---|---|---|---|---|---|
| | **Soil Flushing –** Mobilizes pesticides, SVOCs, metals and radionuclides and concentrates them for removal from the subsurface with subsequent treatment or disposal | May cause unwanted migration of contaminants | Unproven technology. Difficult to implement. | Expensive | No – Unproven technology |
| Chemical | **Photocatalytic Reduction –** Degrade organic compounds by mixing catalyst into soil. | Effective only for organics such as pesticides, not for metals or radionuclides. May allow reclassification from mixed waste to low level radioactive waste | Implementable for suitable waste classifications. | Expensive | No – expected volume of mixed waste on-site is minimal. |
| | **Soil Washing –** Removes pesticides, SVOCs, metals, and radionuclides and concentrates them for disposal using solvent or other proprietary admixtures. (*ex-situ*) | Potentially ineffective for highly sorptive contaminants like Chlordane in clay soils. | Unproven technology. Difficult to implement for large soil volumes and radionuclides. | Expensive | No – Unproven technology |
| | **Soil Grouting –** Inject grout mixture to stabilize contaminants within soil matrix (*in-situ*) | Radionuclides are still radioactive but have reduced leaching and migration potential. | Implementable | Expensive | No – not effective for radionuclides |

Table 5-1. Remedial Technology Screening for Soil and Waste Containing Radionuclides, SVOCs, Pesticides, and Metals (continued)

| **General Response Action** Remedial Technology Type | **Process Option -** Description | **Screening Criteria** Effectiveness | Implementability | Cost | Retained for Alternative Development |
|---|---|---|---|---|---|
| | **Tank Grouting –** Inject grout mixture to fill abandoned existing Imhoff tank or other structures | Radionuclides are still radioactive but have reduced leaching and migration potential. | Implementable | Expensive | No – expensive and uncertainty related to waste volume and characterization of tank coating |
| | **Surfactant Flushing –** Inject surfactant into subsurface to increase contaminant mobility (*in-situ*) | Need to identify environmentally acceptable surfactant, geology may hamper distribution of surfactant | Unproven technology | Expensive | No – Unproven technology |
| **DISPOSAL** Off-Site Discharge | **Disposal at a Low Level Radioactive Waste or Mixed Waste Disposal Facility –** Transport/placement of waste at the DOE Hanford Facility or Envirocare for low level radioactive waste or Envirocare for mixed waste | Effective – removes contaminants from Site | Implementable for suitable waste characterization. Feasibility established during LFI | Expensive/ Very expensive | Yes – Effective and proven technology |

Table 5-1. Remedial Technology Screening for Soil and Waste Containing Radionuclides, SVOCs, Pesticides, and Metals (continued)

| **General Response Action** Remedial Technology Type | **Process Option -** Description | **Screening Criteria** Effectiveness | Implementability | Cost | Retained for Alternative Development |
|---|---|---|---|---|---|
| | **Off-Site disposal at Class I, II and III Hazardous Waste Disposal Facility–** Transport/placement of waste at a licensed landfill | Effective – removes contaminants from Site | Implementable suitable waste characterization. Feasibility established during LFI | Moderate | Yes – Effective and proven technology |
| **DISPOSAL (continued)** On-Site Discharge | **Cap In Place (RCRA cap) -** Placement of a low hydraulic conductivity geomembrane/soil layer (<10-7 cm/sec) to isolate radionuclides, metals, VOCs, SVOCs, and pesticides from potential receptors (*in-situ*) | Potentially effective for Site soils. Potentially ineffective due to uncertainties in underlying Site waste materials. | Lengthy anticipated negotiations and agreements between DOE and UC Davis would preclude implementing this technology during 1998. | Expensive | No – Not easily implementable |
| | **On-Site UC Davis Landfill -** Consolidates waste from DOE Areas during closure of inactive UC Davis landfills. Closure may involve RCRA cap and ground water monitoring. | Potentially effective, but landfills may currently be leaking. | Lengthy anticipated negotiations and agreements between DOE and UC Davis would preclude implementing this technology during 1998. | Moderate/ Expensive | No – Not easily implementable |

Table 5-1. Remedial Technology Screening for Soil and Waste Containing Radionuclides, SVOCs, Pesticides, and Metals (continued)

| **General Response Action** Remedial Technology Type | **Process Option -** Description | **Screening Criteria** Effectiveness | Implementability | Cost | Retained for Alternative Development |
|---|---|---|---|---|---|
| | **On-site RCRA landfill** – construction of new landfill in vicinity of Site for disposal of waste and soil. | Potentially effective. | Lengthy anticipated design and negotiation prior to implementation. Not likely to clear regulatory hurdles in time to accept RA waste. | Expensive | No – Not easily implementable. |

Table 5-2. Development of RA Alternatives

| Developed Alternative | Retained Remedial Technologies Included |
|---|---|
| Southwest Trenches | |
| Alternative 1 – No Action | • No Action<br>• COC and Administrative Monitoring |
| Alternative 2 – Excavation & Off-Site Disposal | • Soil Excavation<br>• Waste Segregation/Consolidation<br>• Off-Site Disposal |
| Alternative 3 – Excavation Off-Site Disposal, and Institutional Controls | • Soil Excavation<br>• Waste Segregation/Consolidation<br>• Off-Site Disposal<br>• Institutional controls (including cover, administrative monitoring) |
| Ra/Sr Treatment Systems | |
| Alternative 1 – No Action | • No Action<br>• COC and Administrative Monitoring |
| Alternative 2 – Excavation and Off-Site Disposal | • Soil Excavation<br>• Waste Segregation/Consolidation<br>• Off-Site Disposal |
| Alternative 3 – Excavation, Off-Site Disposal and Institutional Controls | • Soil Excavation<br>• Waste Segregation/Consolidation<br>• Off-Site Disposal<br>• Institutional controls (including cover, administrative monitoring) |
| Domestic Septic System Areas | |
| Alternative 1 – No Action | • No Action<br>• Site COC and Administrative Monitoring |
| Alternative 2 – Excavation, Off-Site Disposal, and Institutional Controls | • Soil Excavation<br>• Waste Segregation/Consolidation<br>• Off-Site Disposal<br>• Institutional controls (including cover, administrative monitoring) |

Table 5-3. COCs by Risk Level, Southwest Trenches

| | Risk Level $10^{-4}$ | $10^{-5}$ | $10^{-6}$ |
|---|---|---|---|
| Constituents of concern (COCs) above specified RBAS[1] | Carcinogens<br>Benzo(a)anthracene,<br>Benzo(a) pyrene<br>Carbazole<br>Lead<br><br>Radionuclides<br>✓ **Radium 226+D**<br><br>HI>1<br>Anthracene<br>Antimony<br>Copper<br>Dibenzofurane<br>Fluoranthene<br>Flourene<br>Manganese<br>Naphthalene<br>Phenanthrene<br>Pyrene<br><br>Other (not risk-based)<br>✓ **Buried waste** | Carcinogens<br>Benzo(a)anthracene,<br>Benzo(a) pyrene<br>Benzo(b) fluoranthene<br>Carbazole<br>Chrysene<br>Dibenzo(a,h)anthracene Indeno (1,2,3-cd)pyrene<br>Lead<br><br>Radionuclides<br>Cesium 137 +D<br>✓ **Radium 226**<br>Strontium 90+D<br>Thorium 228+D<br>Thorium 232<br>Tritium<br><br>HI>1<br>Anthracene<br>Antimony<br>Copper<br>Dibenzofurane<br>Fluoranthene<br>Flourene<br>Manganese<br>Naphthalene<br>Phenanthrene<br>Pyrene<br><br>Other (not risk-based)<br>✓ **Buried waste** | Carcinogens<br>✓ **Alpha-chlordane**<br>Arochlor-1260<br>Benzo(a)anthracene,<br>Benzo(a) pyrene<br>Benzo(b) fluoranthene<br>Benzo(k) fluoranthene<br>Carbazole<br>Chrysene<br>Dibenzo(a,h)anthracene<br>Dieldrin<br>Heptachlor Epoxide<br>Indeno (1,2,3-cd)pyrene<br>Lead<br><br>Radionuclides<br>Cesium 137 +D<br>✓ **Radium 226**<br>Strontium 90+D<br>Thorium 228+D<br>Thorium 232<br>Tritium<br><br>HI>1<br>Anthracene<br>Antimony<br>Copper<br>Dibenzofurane<br>Fluoranthene<br>Flourene<br>Manganese<br>Naphthalene<br>Phenanthrene<br>Pyrene<br><br>Other (not risk-based)<br>✓ **Buried waste** |

Notes:
✓ = **Bold** COCs are drivers that determine the size of the removal unit.
(1) = The COCs were compared to the lowest RBAS for all three risk scenarios, but not less than background.
(2) = The volume of soil increases at Risk Level $10^{-5}$ due (only) to Ra-226 contamination.
(3) = The total volume of soil increases between Risk Levels $10^{-5}$ and $10^{-6}$ due to additional chlordane contamination. The volume of Ra-226 impacted soil to be excavated is the same at both Risk Levels $10^{-5}$ and $10^{-6}$ because the same ALARA level is used for Ra-226.
HI = Hazard Index for non-carcinogenic health effects
RBAS = Risk-Based Action Standard
cy = cubic yards
sq feet = Square feet

Table 5-4. Evaluation of Alternative 1 – No Action, Southwest Trenches

| Evaluation Criteria | Comments |
|---|---|
| **Effectiveness** | |
| Protection of human health and the environment | Does not meet RAOs |
| Compliance with ARARs | Does not meet ARARs |
| Long Term Effectiveness | Not effective in the long term |
| Reduction of Toxicity, Mobility or volume through Treatment | Does not reduce toxicity, mobility, or volume |
| Short Term Effectiveness | Not effective in the short term |
| **Implementability** | |
| Technical and Administrative Feasibility | Feasible |
| Availability of Services and Materials | Readily Available |
| Regulatory Acceptance | Not likely to gain regulatory acceptance |
| Community Acceptance | Not likely to gain community acceptance |
| **Cost** | |
| Direct Cost | $ 0 |
| Annual Post-Removal Costs | $ 25,000 |
| Net Present Value of Annual Costs (100 yr) | $ 600,000 |
| Total Alternative Cost | $ 600,000 |

Table 5-5. Evaluation of Alternative 2 – Excavation and Off-Site Disposal, Southwest Trenches

| Evaluation Criteria | Comments | | |
|---|---|---|---|
| | Risk Level A | Risk Level B | Risk Level C |
| **Effectiveness**: | | | |
| Protection of Human Health and the Environment. | Meets RAOs | Meets RAOs | Meets RAOs |
| Compliance with ARARs | Complies with ARARs, see Table 5-6. | Complies with ARARs, see Table 5-6. | Complies with ARARs, see Table 5-6. |
| Long Term Effectiveness | Effective in long term | Effective in long term | Effective in long term |
| Reduction of Toxicity, Mobility or Volume through Treatment | Excavated soil and waste not readily treatable. However, though not by treatment, contaminant mobility and toxicity are reduced through placement in an appropriate landfill. | Excavated soil and waste not readily treatable. However, though not by treatment, contaminant mobility and toxicity are reduced through placement in an appropriate landfill. | Excavated soil not readily treatable. However, though not by treatment, contaminant mobility and toxicity are reduced through placement in an appropriate landfill. |
| Short Term Effectiveness | Effective | Effective | Effective |
| **Implementability** | | | |
| Technical and Administrative Feasibility | Feasibility of excavation/disposal established during Limited Field Investigation | Feasibility of excavation/disposal established during Limited Field Investigation. Infeasible to differentiate $10^{-5}$ and $10^{-6}$ RBASs from background concentrations for Ra-226. | Feasibility of excavation/disposal established during Limited Field Investigation. Infeasible to differentiate $10^{-5}$ and $10^{-6}$ RBASs from background concentrations for Ra-226. |
| Availability of Services and Materials | Limited number of available landfills for low level radioactive waste . Long sample analysis times for radionuclides can impede excavation activities. | Limited number of available landfills for low level radioactive waste. Long sample analysis times for radionuclides can impede excavation activities. | Limited number of available landfills for low level radioactive waste. Long sample analysis times for radionuclides can impede excavation activities. |
| Regulatory Acceptance | Not likely to gain regulatory acceptance | May obtain regulatory acceptance | Likely to gain regulatory acceptance |

Table 5-5. Evaluation of Alternative 2 – Excavation and Off-Site Disposal, Southwest Trenches (continued)

| Evaluation Criteria | Comments | | |
|---|---|---|---|
| | Risk Level A | Risk Level B | Risk Level C |
| Community Acceptance | Not likely to gain community acceptance | May obtain community acceptance | Likely to gain community acceptance |
| **Cost** | | | |
| Direct Cost | $ 3,400,000 | $ 4,400,000 | $ 4,700,000 |
| Annual Post-RA Costs | $ 0 | $ 0 | $ 0 |
| Net Present Value of Annual Costs (100 yr) | $ 0 | $ 0 | $ 0 |
| Total Alternative Cost | $ 4,100,000* | $ 5,300,000* | $5,600,000* |
| **Other** | | | |
| Estimated Excavation Volume | 1,841 cy | 3,064 cy(1) | 3,324 cy(2) |

Notes

(1) = Excavation volume increases at Risk Level B due to the additional removal of Ra-226 contamination.
(2) = Excavation volume increases due to additional removal of chlordane contamination at Risk Level C. Ra-226 is removed to the same as low as reasonably achievable (ALARA) levels under both Risk Levels B and C.

Table 5-´ . Includes a 20% contingency factor.
Cy = cubic yards

Table 5-6. RA Alternative Compliance with ARARs

| Regulation | Southwest Trenches[1] | | Ra/Sr Treatment Systems[1] | | Domestic Septic Systems[1] |
|---|---|---|---|---|---|
| | Alternative 2 | Alternative 3 | Alternative 2 | Alternative 3 | Alternative 2 |
| Chemical-Specific Requirements | | | | | |
| **Federal** | | | | | |
| Clean Water Act (33 USCA 1251-1376, 40 CFR 122, 125, 136) | ✔ | ✔ | ✔ | ✔ | ✔ |
| Safe Drinking Water Act (42 USCA 300 and 40 CFR 141.11-16, 141.50-51). | ✔ | ✔ | ✔ | ✔ | ✔ |
| Establishment Of Clean-Up Levels For CERCLA Sites With Radioactive Contamination (EPA, 1997, OSWER No. 9200.4-23) | ✔ | ✔ | ✔ | ✔ | ✔ |
| **State and Local** | | | | | |
| Criteria for Identifying Hazardous Wastes (CCR, Title 22, 66261. 21–33) | ✔ | ✔ | ✔ | ✔ | ✔ |
| Minimum Standards for Management of Hazardous and Extremely Hazardous Wastes Hazardous Waste Control Act (Generally, Health and Safety Code, Sections 25100 et seq. and CCR, Title 22, Chap. 30) | ✔ | ✔ | ✔ | ✔ | ✔ |
| Persistent and Bioaccumulative Toxic Substances (CCR, Title 22, 66261.113) | ✔ | ✔ | ✔ | ✔ | ✔ |
| Porter-Cologne Water Quality Control Act (Generally, California Water Code, Div. 7, Section 13000, et. seq. and 23 CCR Chap. 15, 2510-2559, 2580-2601) | ✔ | ✔ | ✔ | ✔ | ✔ |

Table 5-6. Removal Action Alternative Compliance with ARARs (continued)

| Regulation | Southwest Trenches[1] | | Ra/Sr Treatment Systems[1] | | Domestic Septic Systems[1] |
|---|---|---|---|---|---|
| | Alternative 2 | Alternative 3 | Alternative 2 | Alternative 3 | Alternative 2 |
| Water Quality Control Plan (Basin Plan) for the Central Valley Regional Water Quality Control Board. | ✔ | ✔ | ✔ | ✔ | ✔ |
| State Water Resources Control Board Resolution No 68-16. | ✔ | ✔ | ✔ | ✔ | ✔ |
| State Water Resources Control Board Resolution No. 92-49 (as amended April 21, 1994) | ✔ | ✔ | ✔ | ✔ | ✔ |
| State Water Resources Control Board Resolution No. 88-63 | ✔ | ✔ | ✔ | ✔ | ✔ |
| Location-Specific Requirements | | | | | |
| **Federal** | | | | | |
| Endangered Species Act of 1973 (16 USC Section 1531 et seq., 50 CFR Parts 10, 11, 17, 200, 402, & 424, and 40 CFR 257.3) | ✔ | ✔ | ✔ | ✔ | ✔ |
| Executive Order 11988 (floodplain management) and 11990 (protection of wetlands) (40 CFR 6, 10 CFR 1022) | ✔ | ✔ | ✔ | ✔ | ✔ |
| National Historic Preservation Act of 1966 (16 USC 470 et seq., Public Law 89-665 and amendments of 1980, Public Law 96-515, 36 CFR 800) | ✔ | ✔ | ✔ | ✔ | ✔ |
| Fish and Wildlife Coordination Act (16 USC 661-666) | ✔ | ✔ | ✔ | ✔ | ✔ |

Table 5-6. Removal Action Alternative Compliance with ARARs (continued)

| Regulation | Southwest Trenches[1] | | Ra/Sr Treatment Systems[1] | | Domestic Septic Systems[1] |
|---|---|---|---|---|---|
| | Alternative 2 | Alternative 3 | Alternative 2 | Alternative 3 | Alternative 2 |
| **State And Local** | | | | | |
| California Endangered Species Act (California Fish and Game Code, Sections 2050–2068) | ✔ | ✔ | ✔ | ✔ | ✔ |
| Action-Specific Requirements | | | | | |
| **Federal** | | | | | |
| Clean Water Act Section 404 (33USC 1344, 33CFR328 and 40 CFR 230) | ✔ | ✔ | ✔ | ✔ | ✔ |
| National Emissions Standards for Hazardous Air Pollutants (42USC 7401-7671, 40 CFR 61, Subparts H & M) | ✔ | ✔ | ✔ | ✔ | ✔ |
| Federal Facilities Compliance Act of 1992 (PL 102-386) | ✔ | ✔ | ✔ | ✔ | ✔ |
| Toxic Substances Control Act (15USC 2601 et seq., 40CFR761, 763) | ✔ | ✔ | ✔ | ✔ | ✔ |
| Radiation Protection of the Public (10 CFR 20) | ✔ | ✔ | ✔ | ✔ | ✔ |
| Licensing Requirements for Land Disposal of Radioactive Waste (10 CFR 61) | ✔ | ✔ | ✔ | ✔ | N/A |
| Noise Control Act of 1972, as amended by the Quiet Communities Act of 1978(40 CFR 204, 205, 211) | ✔ | ✔ | ✔ | ✔ | ✔ |

Table 5-6. Removal Action Alternative Compliance with ARARs (continued)

| Regulation | Southwest Trenches[1] | | Ra/Sr Treatment Systems[1] | | Domestic Septic Systems[1] |
|---|---|---|---|---|---|
| | Alternative 2 | Alternative 3 | Alternative 2 | Alternative 3 | Alternative 2 |
| Radiation Protection of the Public and the Environment (DOE Order 5400.5) | ✔ | ✔ | ✔ | ✔ | ✔ |
| Radioactive Waste Management (DOE Order 5820.2A) | ✔ | ✔ | ✔ | ✔ | ✔ |
| **State and Local** | | | | | |
| Yolo-Solano Air Quality Management District Rules and Regulations, Rule 2.3, Ringlemann Chart | ✔ | ✔ | ✔ | ✔ | ✔ |
| Prohibited Acts, Health and Safety Code ( Section 41700) | ✔ | ✔ | ✔ | ✔ | ✔ |
| Environmental Health Standards for the Management of Hazardous Wastes, Chapter 12, Standards Applicable to Generators of Hazardous Wastes, (Title 22 CCR 66262.10-.45) | ✔ | ✔ | ✔ | ✔ | ✔ |
| Hazardous Waste Control Act Land Disposal Restrictions (22 CCR 66268.1–124). | ✔ | ✔ | ✔ | ✔ | ✔ |
| State Water Resources Control Board Order No. 97-03-DWQ | ✔ | ✔ | ✔ | ✔ | ✔ |
| State Water Resources Control Board Order No. 92-08-DWQ | ✔ | ✔ | ✔ | ✔ | ✔ |
| Title 27, CCR Section 21090 | N/A | ✔ | N/A | ✔ | ✔ |

Table 5-6. Removal Action Alternative Compliance with ARARs (continued)

| Regulation | Southwest Trenches[1] | | Ra/Sr Treatment Systems[1] | | Domestic Septic Systems[1] |
|---|---|---|---|---|---|
| | Alternative 2 | Alternative 3 | Alternative 2 | Alternative 3 | Alternative 2 |
| Control of Radioactive Contamination in the Environment (California Health and Safety Code, Sections 114705, et. seq.) | N/A | ✔ | N/A | ✔ | ✔ |
| Radiation Control Law (California Health and Safety Code, Sections 114960, et. seq.) | N/A | ✔ | N/A | ✔ | ✔ |
| Radiation (CCR, Title 17, Sections 30100, et. seq.) | ✔ | ✔ | ✔ | ✔ | ✔ |

Notes

(1) = The No Action alternative was not included in this table because it does not meet removal action objectives.
N/A = Not applicable

Table 5-7. Evaluation of Alternative 3 – Excavation, Off-Site Disposal, and Institutional Controls, Southwest Trenches

| Evaluation Criteria | Comments<br>Risk Level A | Risk Level B | Risk Level C |
|---|---|---|---|
| **Effectiveness**: | | | |
| Protection of Human Health and the Environment. | Meets RAOs | Meets RAOs | Meets RAOs |
| Compliance with ARARs | Complies with ARARs, see Table 5-6 | Complies with ARARs see Table 5-6 | Complies with ARARs see Table 5-6 |
| Long Term Effectiveness | Potentially effective without institutional control | Requires continued implementation of institutional controls to be effective | Requires continued implementation of institutional controls to be effective |
| Reduction of Toxicity, Mobility or Volume through Treatment | Excavated soil and waste not readily treatable. However, though not by treatment, contaminant mobility and toxicity are reduced through placement in an appropriate landfill. | Excavated soil and waste not readily treatable. However, though not by treatment, contaminant mobility and toxicity are reduced through placement in an appropriate landfill. | Excavated soil and waste not readily treatable. However, though not by treatment, contaminant mobility and toxicity are reduced through placement in an appropriate landfill. |
| Short Term Effectiveness | Effective | Effective | Effective |
| **Implementability** | | | |
| Technical and Administrative Feasibility | Feasibility of excavation/disposal established during Limited Field Investigation | Feasibility of excavation/disposal established during Limited Field Investigation | Feasibility of excavation/disposal established during Limited Field Investigation |
| Availability of Services and Materials | Limited number of available landfills for low level radioactive waste. Long sample analysis times for radionuclides can impede excavation activities. | Limited number of available landfills for low level radioactive waste. Long sample analysis times for radionuclides can impede excavation activities. | Limited number of available landfills for low level radioactive waste. Long sample analysis times for radionuclides can impede excavation activities. |
| State Acceptance | Not likely to gain regulatory acceptance | May gain regulatory acceptance | May gain regulatory acceptance |

Table 5-7. Evaluation of Alternative 3 – Excavation, Off-Site Disposal, and Institutional Controls, Southwest Trenches (continued)

| Evaluation Criteria | Comments | | |
|---|---|---|---|
| | Risk Level A | Risk Level B | Risk Level C |
| Community Acceptance | Not likely to gain community acceptance | May gain community acceptance | May gain community acceptance |
| **Cost** | | | |
| Direct Cost | $ 3,100,000 | $ 3,200,000 | $ 3,400,000 |
| Annual Post RA Costs | $ 10,000 | $ 10,000 | $ 10,000 |
| Net Present Value of Annual Costs (100 yr) | $ 200,000 | $ 200,000 | $ 200,000 |
| Total Alternative Cost | $ 3,900,000* | $ 4,000,000* | $ 4,300,000* |
| **Other** | | | |
| Estimated Excavation Volume | 1,401 cy | 1,531 cy(1) | 1,791 cy(2) |

Notes

(1) = Excavation volume increases at Risk Level B due to the additional removal of Ra-226 contamination.
(2) = Excavation volume increases due to additional removal of pesticide contamination at Risk Level C. Ra-226 is removed to the same as low as reasonably achievable (ALARA) levels under both Risk Levels B and C.
* Includes a 20% contingency factor.
cy = cubic yards

Table 5-8. COCs by Risk Level, Ra/Sr Treatment Systems

| | Risk Level $10^{-4}$ | $10^{-5}$ | $10^{-6}$ |
|---|---|---|---|
| Constituents of concern (COCs) above specified RBASs [1] | Chemical<br>None<br><br>Radionuclides<br>✓ **Radium 226+D**<br><br>HI>1<br>Copper<br><br>Other (not risk-based)<br>✓ **Radium Distribution Box, Dry Wells, and Strontium Imhoff Tank** | Chemical<br>Benzo(a) anthracene,<br>Benzo(a) pyrene<br><br>Radionuclides<br>✓ **Radium 226+D**<br><br>HI>1<br>Copper<br><br>Other (not risk-based)<br>✓ **Radium Distribution Box, Dry Wells, and Strontium Imhoff Tank** | Chemical<br>Benzo(a) anthracene,<br>Benzo(a) pyrene<br>Benzo(b) fluoranthene<br>Carbazole<br>Chrysene<br>Dibenzo(a,h)anthracene<br>Indeno (1,2,3-cd)pyrene<br><br>Radionuclides<br>✓ **Radium 226+D**<br><br>HI>1<br>Copper<br><br>Other (not risk-based)<br>✓ **Radium System Distribution Box and, Dry Wells, and Strontium Imhoff Tank** |

Notes:

✓ = **Bold** COCs are drivers that determine the size of the removal unit.
(1) = The increase in volume between Risk Levels $10^{-4}$ and $10^{-5}$ is due (only) to increased Ra-226 contamination. The COCs were compared to the lowest RBAS for all three risk scenarios, but not less than background.
(2) = There is no volume change between Risk Levels $10^{-5}$ and $10^{-6}$ Ra-226 is removed to the same ALARA levels under both risk levels.
HI = Hazard Index for non-carcinogenic health effects.
RBAG = Risk-Based Action Guideline
cy = cubic yards
sq ft = square feet

Table 5-9. Evaluation of Alternative 1 – No Action, Ra/Sr Treatment Systems

| Evaluation Criteria | Comments |
|---|---|
| **Effectiveness** | |
| Protection of human health and the environment | Does not meet RAOs |
| Compliance with ARARs | Does not meet ARARs |
| Long Term Effectiveness | Not effective in the long term |
| Reduction of Toxicity, Mobility or Volume through Treatment | Does not reduce toxicity, mobility, or volume. |
| Short Term Effectiveness | Not effective in the short term. |
| **Implementability** | |
| Technical and Administrative Feasibility | Feasible |
| Availability of Services and Materials | Readily Available |
| Regulatory Acceptance | Not likely to gain regulatory acceptance |
| Community Acceptance | Not likely to gain community acceptance |
| **Cost** | |
| Direct Cost | $ 0 |
| Annual Post-Removal Site Control Costs | $ 25,000 |
| Net Present Value of Annual Costs (100 yr) | $ 600,000 |
| Total Alternative Cost | $ 600,000 |

## Table 5-10. Evaluation of Alternative 2 – Excavation and Off-Site Disposal Ra/Sr Treatment Systems

| Evaluation Criteria | Comments | |
|---|---|---|
| | Risk Level A | Risk Level C |
| **Effectiveness**: | | |
| Protection of Human Health and the Environment. | Meets RAOs | Meets RAOs |
| Compliance with ARARs | Complies with ARARs, see Table 5-6 | Complies with ARARs, see Table 5-6 |
| Long Term Effectiveness | Effective | Effective |
| Reduction of Toxicity, Mobility or Volume through Treatment | Excavated soil and debris not readily treatable. However, though not by treatment, contaminant mobility and toxicity are reduced through placement in an appropriate landfill. | Excavated soil and debris not readily treatable. However, though not by treatment, contaminant mobility and toxicity are reduced through placement in an appropriate landfill. |
| Short Term Effectiveness | Effective | Effective |
| **Implementability** | | |
| Technical and Administrative Feasibility | Feasibility of excavation/disposal established during LFI. | Feasibility of excavation/disposal established during LFI. Infeasible to differentiate $10^{-5}$ and $10^{-6}$ RBASs from background concentrations for Ra-226. |
| Availability of Services and Materials | Limited number of available landfills for low level radioactive waste. Long sample analysis times for radionuclides can impede excavation activities. | Limited number of available landfills for low level radioactive waste. Long sample analysis times for radionuclides can impede excavation activities. |
| Regulatory Acceptance | Not likely to gain regulatory acceptance | Likely to gain regulatory acceptance |
| Community Acceptance | Not likely to gain community acceptance | Likely to gain community acceptance |
| **Cost** | | |
| Direct Cost | $3,000,000 | $3,400,000 |
| Annual Post-Removal Costs | $0 | $0 |
| Net Present Value of Annual Costs (100 yr) | $0 | $0 |
| Total Alternative Costs | $3,600,000* | $4,100,000* |
| **Other** | | |
| Estimated Excavation Volume | 1,568 cy | 2,181 cy[1] |

Notes
[1] The excavation volume between Risk Levels B and C does not change. Ra-226 is removed to a level as low as reasonably achievable (ALARA) under both Risk Levels B and C.
* Includes a 20% contingency factor.
cy = cubic yards.

Table 5-11. Evaluation of Alternative 3 – Excavation, Off-Site Disposal, and Institutional Controls. Ra/Sr Treatment Systems

| Evaluation Criteria | Risk Level C Comments |
|---|---|
| **Effectiveness** | |
| Protection of Human Health and the Environment. | Meets RAOs |
| Compliance with ARARs | Complies with ARARs, see Table 5-6 |
| Long Term Effectiveness | Potentially effective without institutional control |
| Reduction of Toxicity, Mobility or Volume through Treatment | Excavated soil and debris not readily treatable. However, though not by treatment, contaminant mobility and toxicity are reduced through placement in an appropriate landfill. |
| Short Term Effectiveness | Effective |
| **Implementability** | |
| Technical and Administrative Feasibility | Feasibility of excavation/disposal established during Limited Field Investigation |
| Availability of Services and Materials | Limited number of available landfills for low level radioactive waste. Long sample analysis times for radionuclides can impede excavation activities. |
| Regulatory Acceptance | Likely to gain regulatory acceptance |
| Community Acceptance | Likely to gain community acceptance |
| **Cost** | |
| Direct Cost | $2,500,000 [1] |
| Annual Post-Removal Costs | $10,000 |
| Net Present Value of Annual Costs (100 yr) | $200,000 |
| Total Alternative Cost | $3,200,000 |
| **Other** | |
| Estimated Excavation Volume | 1,018 cy[1] |

Notes:

[1] Excavation volume (and associated costs) was the same at all risk levels for this alternative because it is assumed that once the Ra/Sr Treatment System structures (dry wells, Imhoff tank, etc.) are removed as required under all risk levels, much of the surrounding surface and subsurface contamination would also be removed. Thus, with the depth of cover required to backfill the excavation of these deeper treatment system structures Risk Level C could easily be achieved.

cy = cubic yards

Table 5-12. COCs by Risk Level, Domestic Septic System Areas

| | Risk Level $10^{-4}$ | $10^{-5}$ | $10^{-6}$ |
|---|---|---|---|
| Constituents of concern (COCs) above specified RBAS[(1) (2)] | Chemical<br>✓ **Mercury** (System 6) | Chemical<br>✓ **Mercury** (System 6) | Chemical<br>✓ **Mercury** (System 6) |
| | Radionuclides<br>None | Radionuclides<br>None | Radionuclides<br>Ra-226 (System 3) |
| | HI>1<br>Barium | HI>1<br>Barium | HI>1<br>Barium |
| | Other (not risk-based)<br>None | Other (not risk-based)<br>None | Other (not risk-based)<br>None |

Notes:

✓ = **Bold** COCs are drivers that determine the size of the removal unit.
(1) = The COCs were compared to the lowest RBAS for all three risk scenarios, but not less than background.
(2) = Excavation soil volume does not vary between Risk Levels because the volume of soil to be removed is so small and limited in extent that it is assumed all risk levels would be attained after excavation.
HI = Hazard Index for non-carcinogenic health effects.
RBAS = Risk-Based Action Standard
cy = cubic yards

Table 5-13. Evaluation of Alternative 1– No Action, Domestic Septic Systems

| Evaluation Criteria | Comments |
|---|---|
| **Effectiveness**: | |
| Protection of human health and the environment | Does not meet RAOs |
| Compliance with ARARs | Does not meet ARARS |
| Long Term Effectiveness | Not effective in the long term |
| Reduction of Toxicity, Mobility or Volume through Treatment | Does not reduce toxicity, mobility or volume |
| Short Term Effectiveness | Not effective in the short term. |
| **Implementability** | |
| Technical and Administrative Feasibility | Feasible |
| Availability of Services and Materials | Readily Available |
| Regulatory Acceptance | May gain regulatory acceptance |
| Community Acceptance | May gain community acceptance |
| **Cost** | |
| Direct Cost | $0 |
| Annual Post-Removal Site Control Costs | $25,000 |
| Net Present Value of Annual Costs (100 yr) | $600,000 |
| Total Alternative Cost | $600,000 |

Table 5-14. Evaluation of Alternative 2 – Excavation, Off-Site Disposal and Institutional Control Domestic Septic Systems

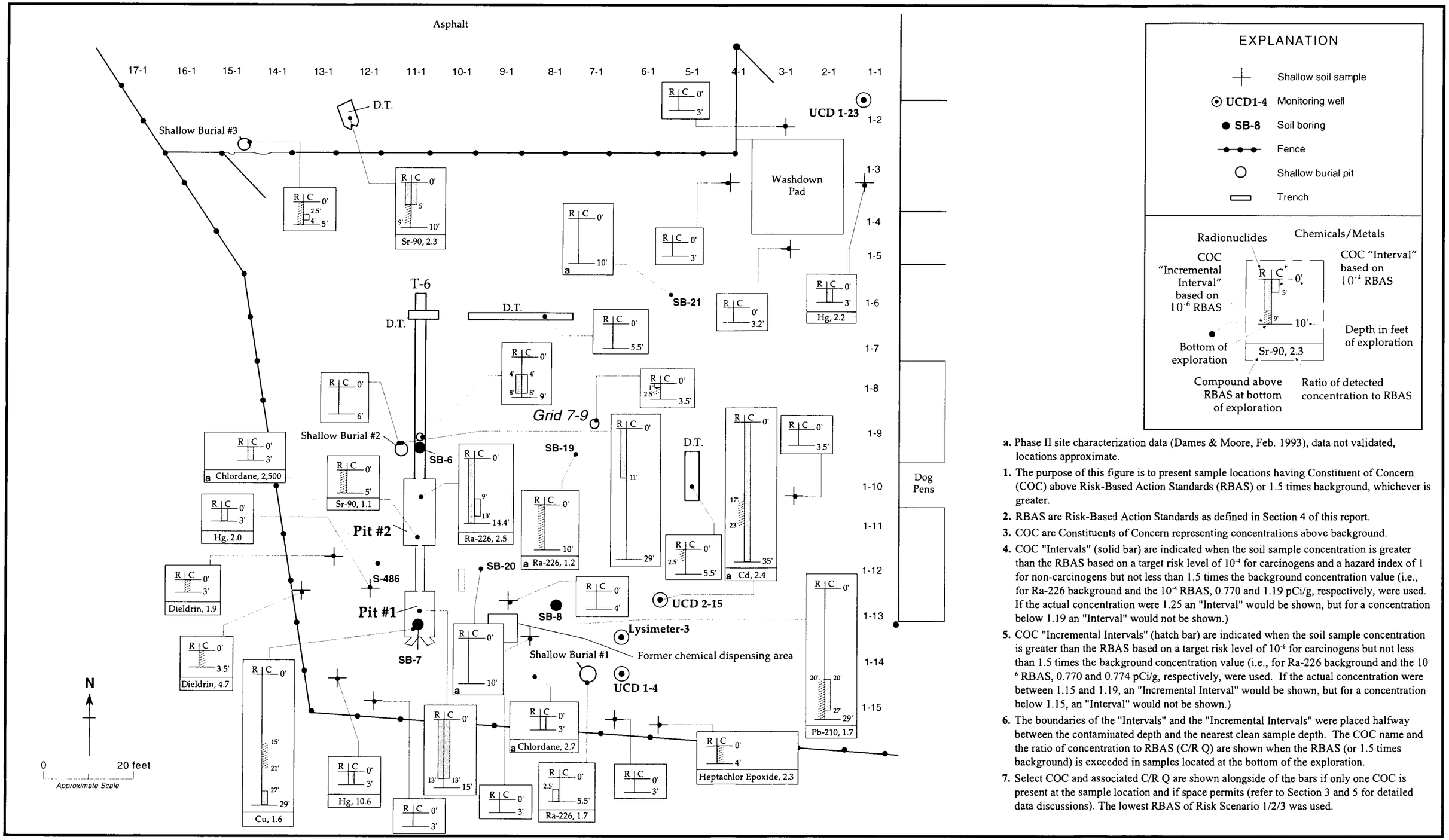
| Evaluation Criteria | Comments Risk Level C |
|---|---|
| **Effectiveness**: | |
| Protection of Human Health and the Environment. | Meets RAOs |
| Compliance with ARARs, see Table 5-6 | Complies with ARARs, see Table 5-6 |
| Long Term Effectiveness | Effective |
| Reduction of Toxicity, Mobility or Volume through Treatment | Excavated soil and debris not readily treatable. However, though not by treatment, contaminant mobility and toxicity are reduced through placement in an appropriate landfill. |
| Short Term Effectiveness | Effective |
| **Implementability** | |
| Technical and Administrative Feasibility | Feasibility of excavation/disposal established during Limited Field Investigation. |
| Availability of Services and Materials | Requires class I landfill disposal |
| Regulatory Acceptance | Likely to gain regulatory acceptance |
| Community Acceptance | Likely to gain community acceptance |
| **Cost** | |
| Direct Cost | $300,000 |
| Annual Post-RA Costs | $10,000 |
| Net Present Value of Annual Cost (100 yr) | $200,000 |
| Total Alternative Cost* | $600,000 |
| **Other** | |
| Estimated Excavation Volume | 34 cy[1] |

Notes:

[1] Excavation volume (and associated costs) was the same at all risk levels for this alternative because it is assumed that once the Domestic Septic System Areas are removed as required under all risk levels, much of the surrounding surface and subsurface contamination would also be removed. Thus, with the depth of cover required to backfill the excavation of these domestic Septic System Areas Risk Level C could easily be achieved.

* Includes a 20% contingency factor.

cy = cubic yards




a. Phase II site characterization data (Dames & Moore, Feb. 1993), data not validated, locations approximate.

1. The purpose of this figure is to present sample locations having Constituent of Concern (COC) above Risk-Based Action Standards (RBAS) or 1.5 times background, whichever is greater.
2. RBAS are Risk-Based Action Standards as defined in Section 4 of this report.
3. COC are Constituents of Concern representing concentrations above background.
4. COC "Intervals" (solid bar) are indicated when the soil sample concentration is greater than the RBAS based on a target risk level of $10^{-4}$ for carcinogens and a hazard index of 1 for non-carcinogens but not less than 1.5 times the background concentration value (i.e., for Ra-226 background and the $10^{-4}$ RBAS, 0.770 and 1.19 pCi/g, respectively, were used. If the actual concentration were 1.25 an "Interval" would be shown, but for a concentration below 1.19 an "Interval" would not be shown.)
5. COC "Incremental Intervals" (hatch bar) are indicated when the soil sample concentration is greater than the RBAS based on a target risk level of $10^{-6}$ for carcinogens but not less than 1.5 times the background concentration value (i.e., for Ra-226 background and the $10^{-6}$ RBAS, 0.770 and 0.774 pCi/g, respectively, were used. If the actual concentration were between 1.15 and 1.19, an "Incremental Interval" would be shown, but for a concentration below 1.15, an "Interval" would not be shown.)
6. The boundaries of the "Intervals" and the "Incremental Intervals" were placed halfway between the contaminated depth and the nearest clean sample depth. The COC name and the ratio of concentration to RBAS (C/R Q) are shown when the RBAS (or 1.5 times background) is exceeded in samples located at the bottom of the exploration.
7. Select COC and associated C/R Q are shown alongside of the bars if only one COC is present at the sample location and if space permits (refer to Section 3 and 5 for detailed data discussions). The lowest RBAS of Risk Scenario 1/2/3 was used.

Figure 5-1. Constituents of Concern at $10^{-4}$ and $10^{-6}$ Risk Based-Action Standards, Southwest Trenches Area

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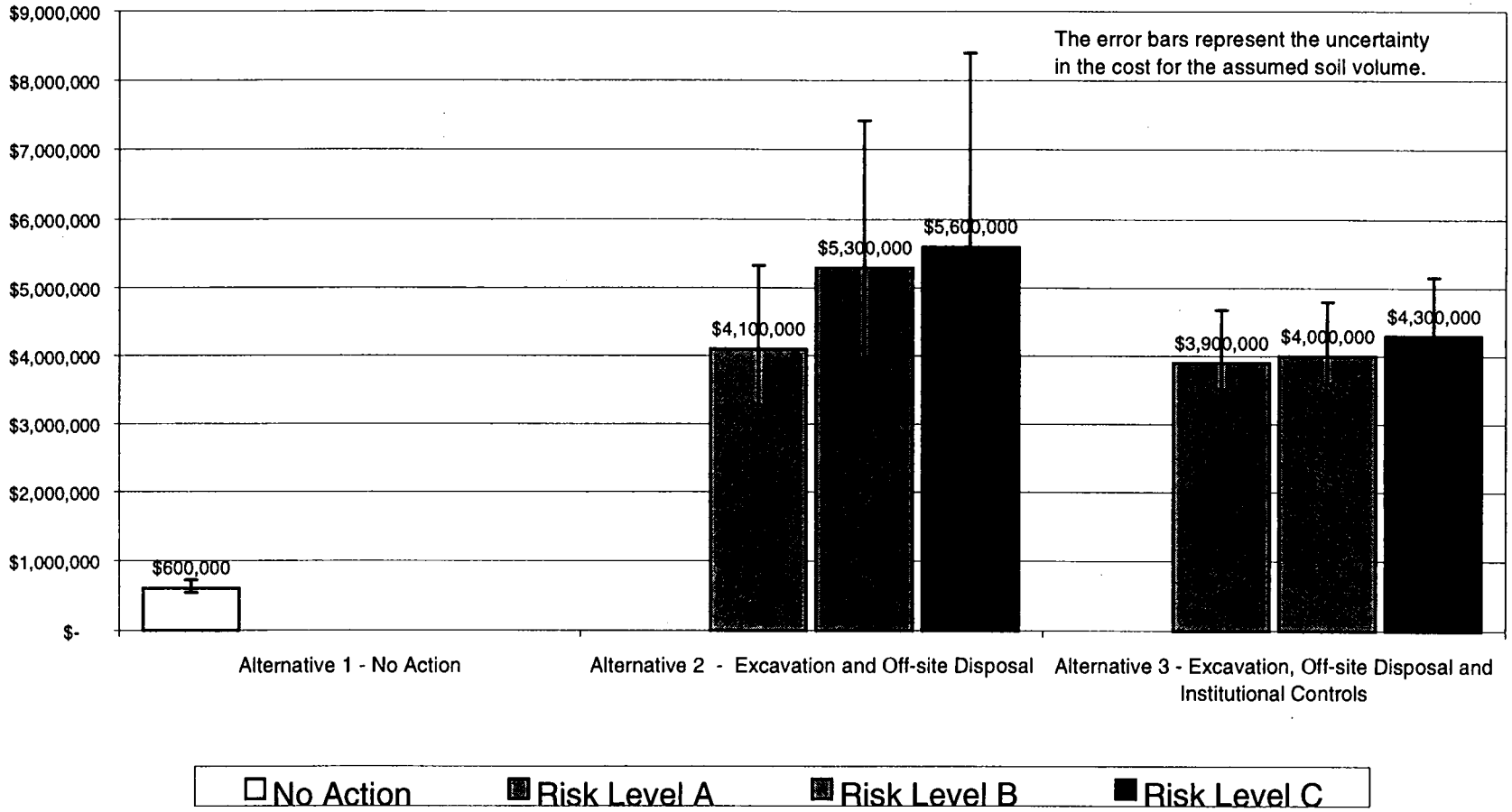
**Figure 5-2: Cost Comparison**
**Southwest Trenches Area, Alternatives 1, 2, and 3**



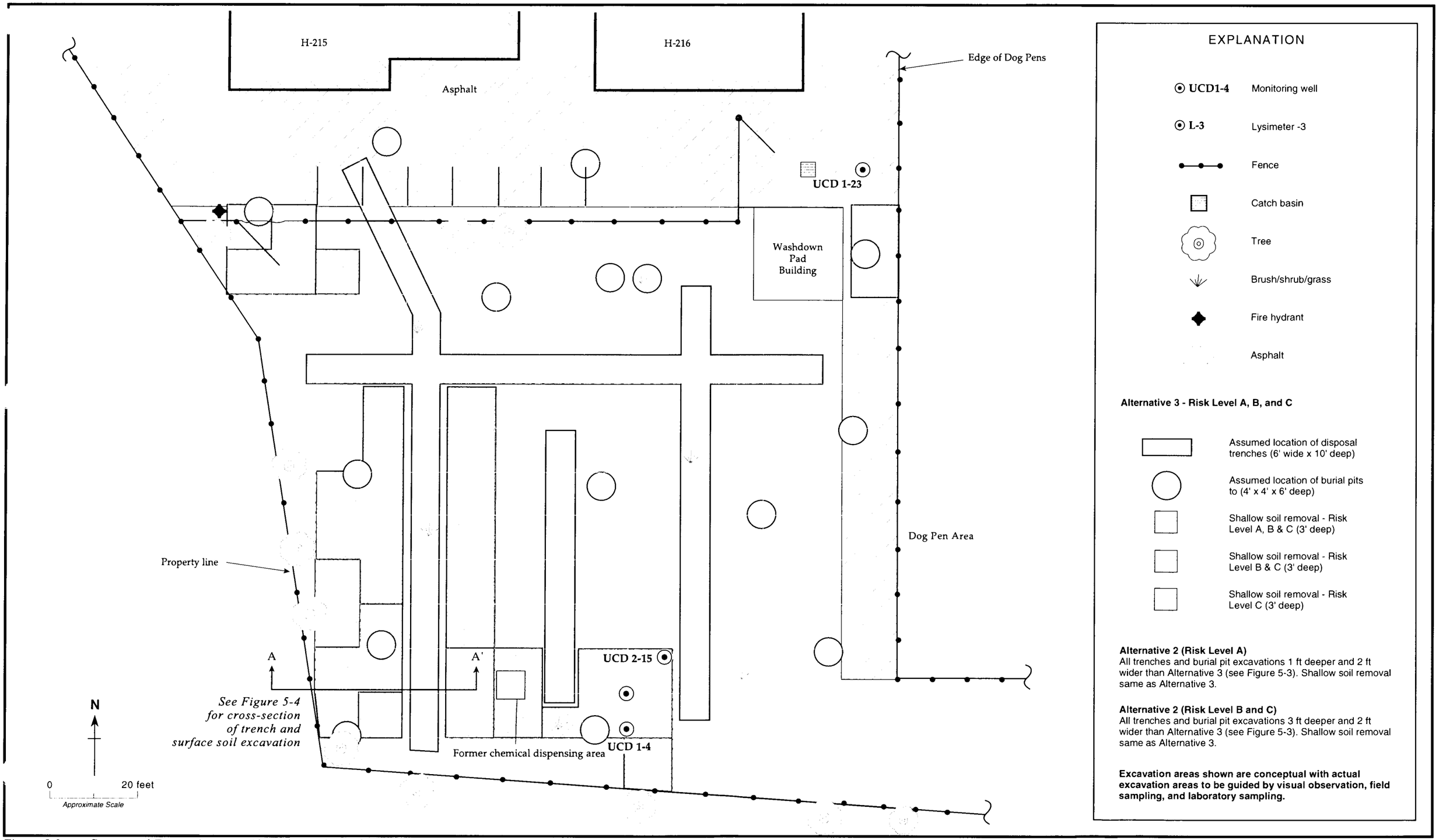



Figure 5-3. Conceptual Excavation Area Plan View, Alternatives 2 and 3, Southwest Trenches Area

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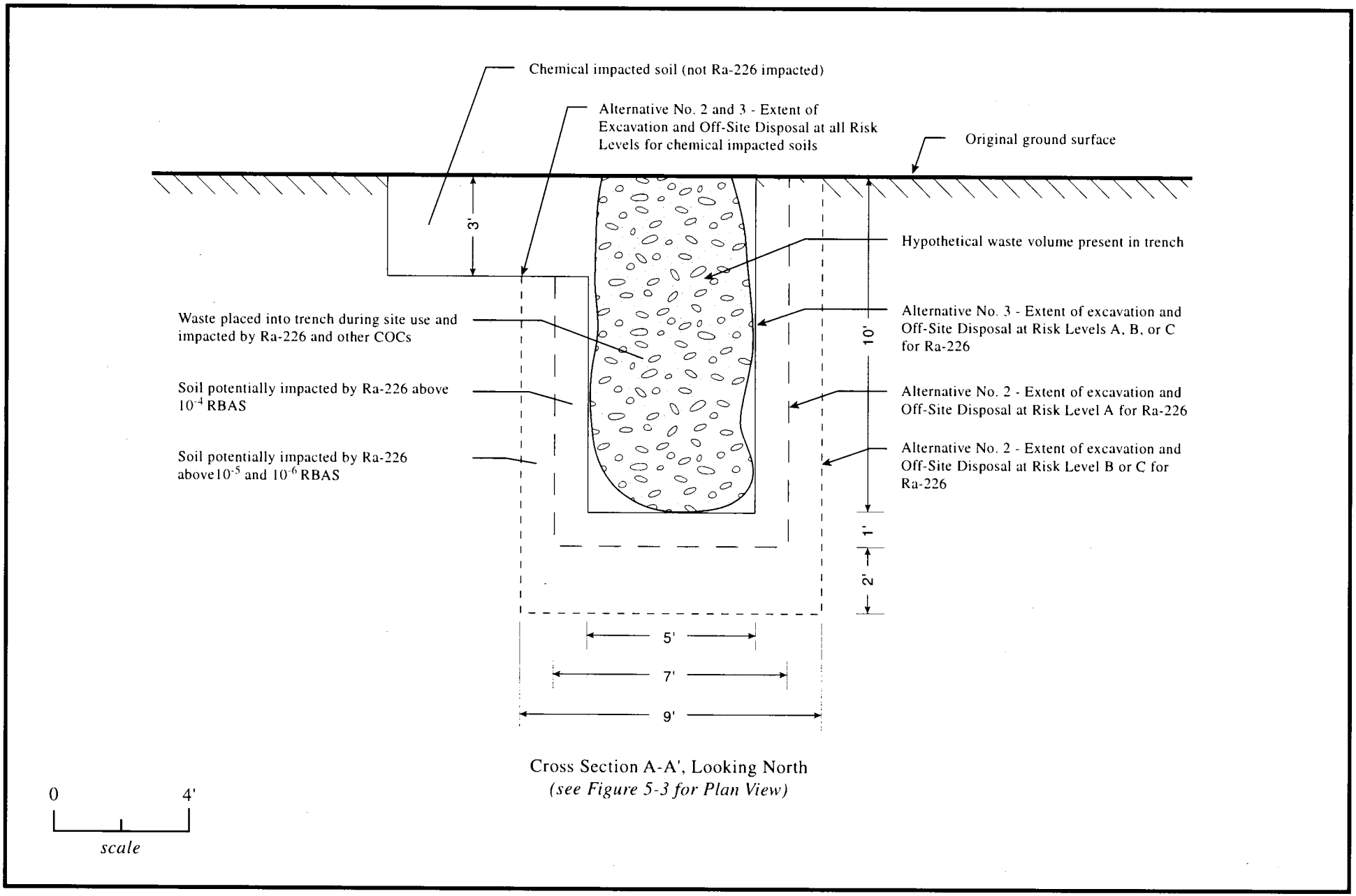
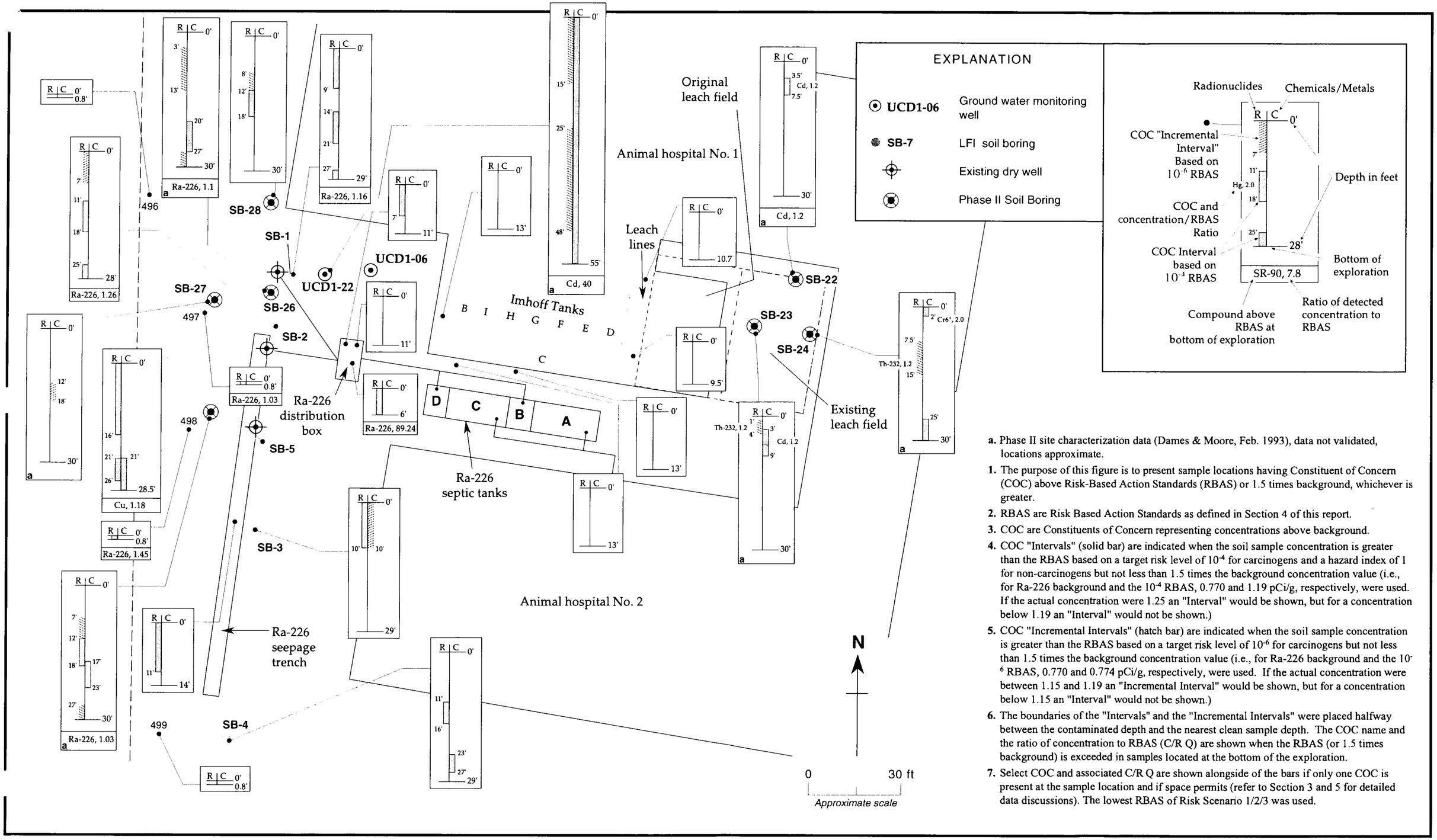



Figure 5-4. Conceptual Excavation Area Cross Section A-A', Alternatives 2 and 3, Southwest Trenches Area




a. Phase II site characterization data (Dames & Moore, Feb. 1993), data not validated, locations approximate.

1. The purpose of this figure is to present sample locations having Constituent of Concern (COC) above Risk-Based Action Standards (RBAS) or 1.5 times background, whichever is greater.
2. RBAS are Risk Based Action Standards as defined in Section 4 of this report.
3. COC are Constituents of Concern representing concentrations above background.
4. COC "Intervals" (solid bar) are indicated when the soil sample concentration is greater than the RBAS based on a target risk level of $10^{-4}$ for carcinogens and a hazard index of 1 for non-carcinogens but not less than 1.5 times the background concentration value (i.e., for Ra-226 background and the $10^{-4}$ RBAS, 0.770 and 1.19 pCi/g, respectively, were used. If the actual concentration were 1.25 an "Interval" would be shown, but for a concentration below 1.19 an "Interval" would not be shown.)
5. COC "Incremental Intervals" (hatch bar) are indicated when the soil sample concentration is greater than the RBAS based on a target risk level of $10^{-6}$ for carcinogens but not less than 1.5 times the background concentration value (i.e., for Ra-226 background and the $10^{-6}$ RBAS, 0.770 and 0.774 pCi/g, respectively, were used. If the actual concentration were between 1.15 and 1.19 an "Incremental Interval" would be shown, but for a concentration below 1.15 an "Interval" would not be shown.)
6. The boundaries of the "Intervals" and the "Incremental Intervals" were placed halfway between the contaminated depth and the nearest clean sample depth. The COC name and the ratio of concentration to RBAS (C/R Q) are shown when the RBAS (or 1.5 times background) is exceeded in samples located at the bottom of the exploration.
7. Select COC and associated C/R Q are shown alongside of the bars if only one COC is present at the sample location and if space permits (refer to Section 3 and 5 for detailed data discussions). The lowest RBAS of Risk Scenario 1/2/3 was used.

Figure 5-5. Constituents of Concern at $10^{-4}$ and $10^{-6}$ Risk-Based Action Standards, Ra/Sr Treatment Systems Area

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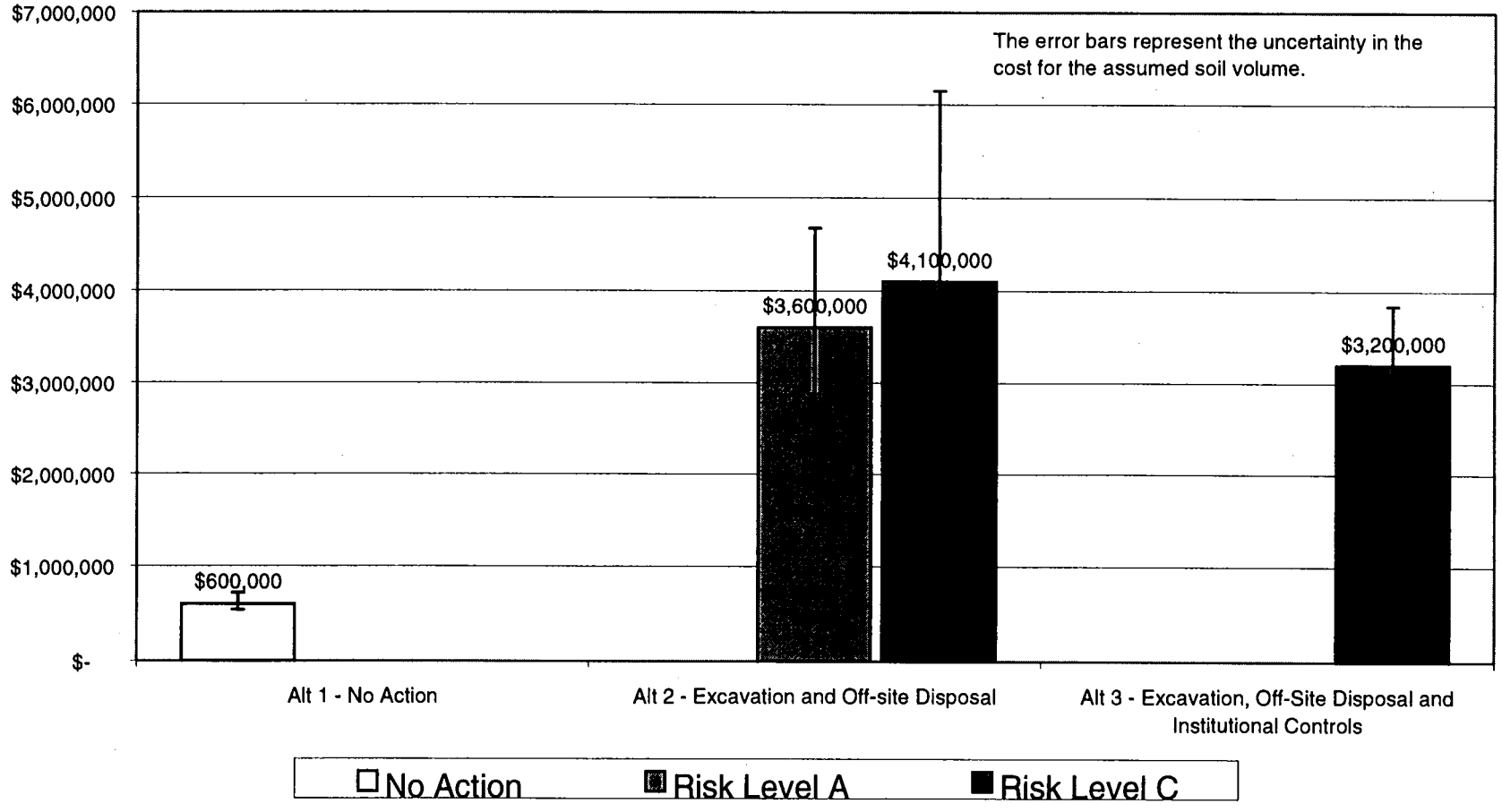
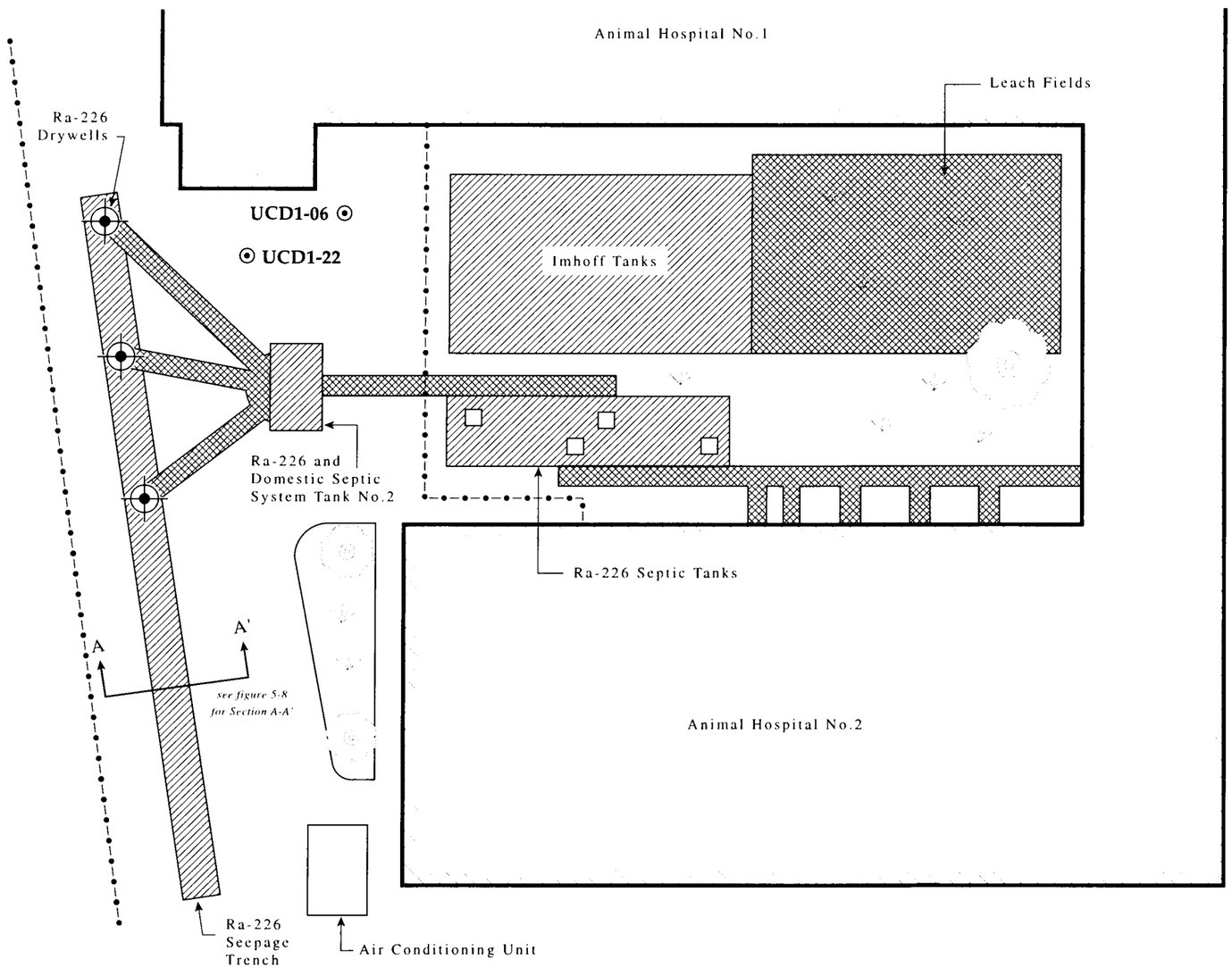
**Figure 5-6: Cost Comparison**
**Ra/Sr Treatment Systems Area, Alternatives 1, 2 and 3**






EXPLANATION

- Ra-226 Drywell
- UCD1-06 — Monitoring well
- Fence
- Tree
- Brush/shrub/grass
- Drilling Out of Ra-226 Dry Wells (nominal 5' x 5' x 40')
- Excavation to 10'
- Excavation to 5'

**Alternative 2 - Risk Level A**
All areas excavated or drilled 1' deeper and 2' wider than Alternative 3 (see Figure 5-7)

**Alternative 2 - Risk Level B & C**
All areas excavated or drilled 3' deeper and 4' wider than Alternative 3 (see Figure 5-7)

**Excavation areas shown are conceptual with actual excavation areas to be guided by visual observation, field sampling, and laboratory analysis.**

N

0 20
feet

Figure 5-7. Conceptual Excavation Area Plan View, Alternatives 2 and 3, Ra/Sr Treatment Systems Area

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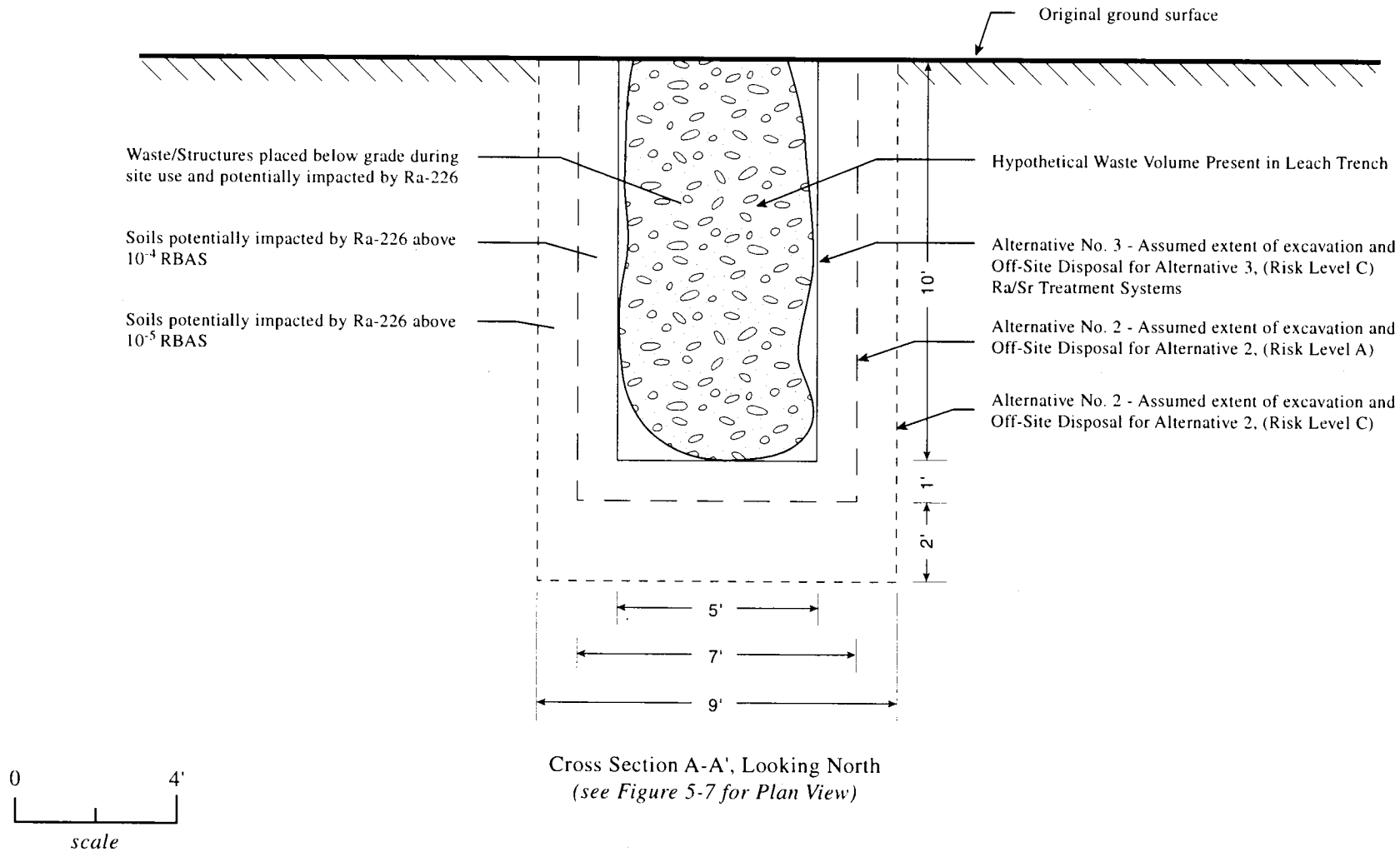


Figure 5-8. Conceptual Excavation Area Cross-Section A-A', Alternatives 2 and 3, Ra/Sr Treatment Systems Area

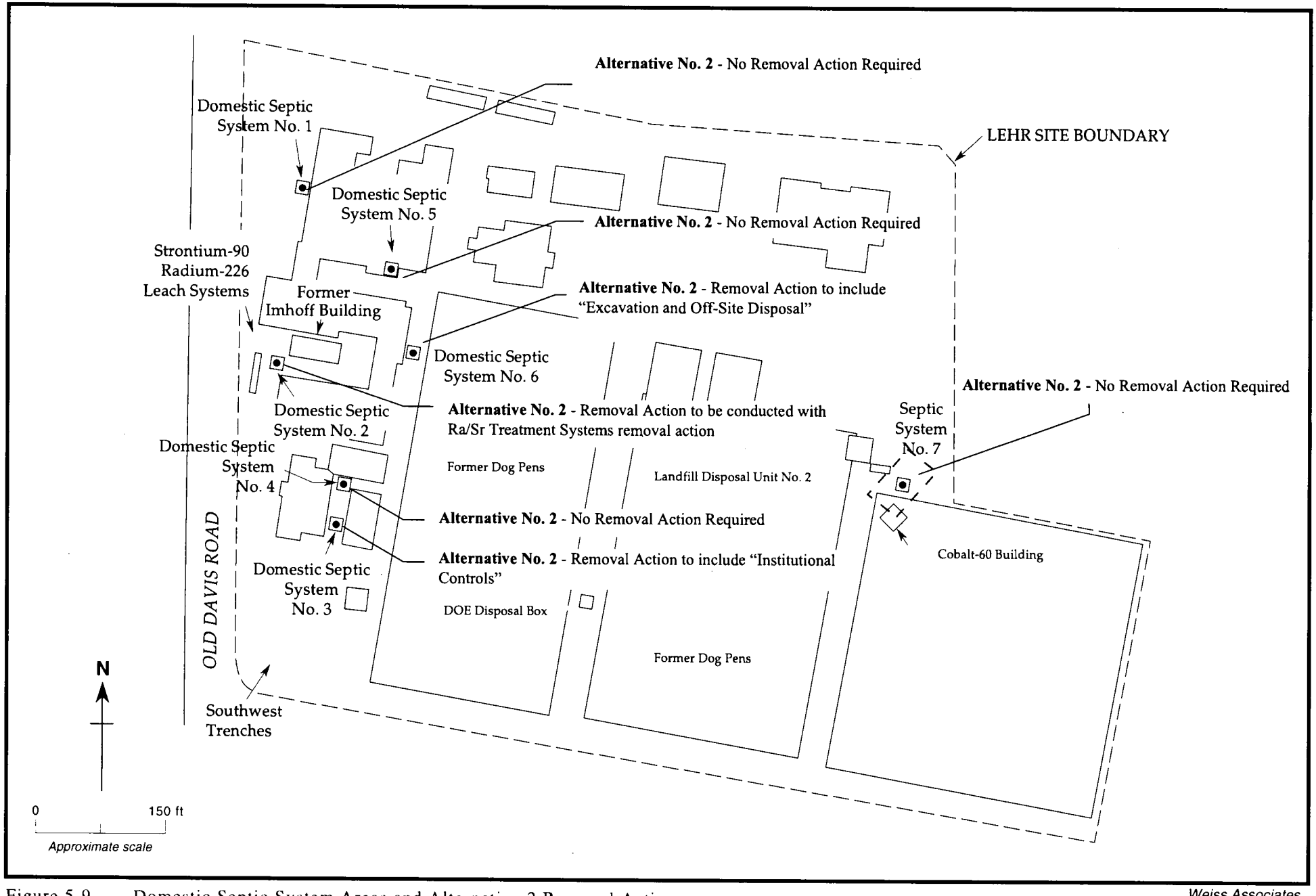


Figure 5-9. Domestic Septic System Areas and Alternative 2 Removal Actions

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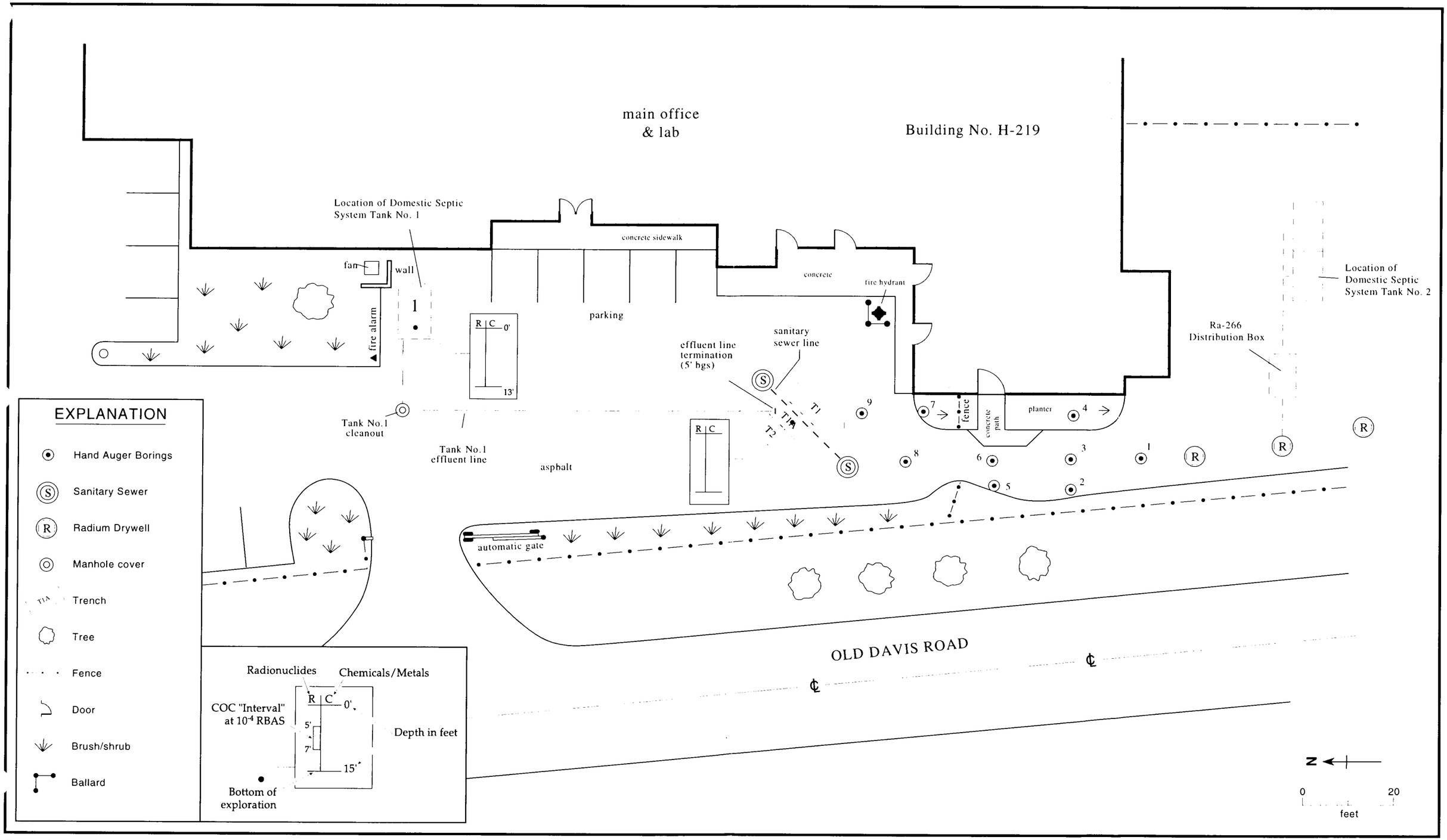


Figure 5-10. Constituents of Concern at $10^{-4}$ and $10^{-6}$ Risk-Based Action Standard, Domestic Septic System No. 1

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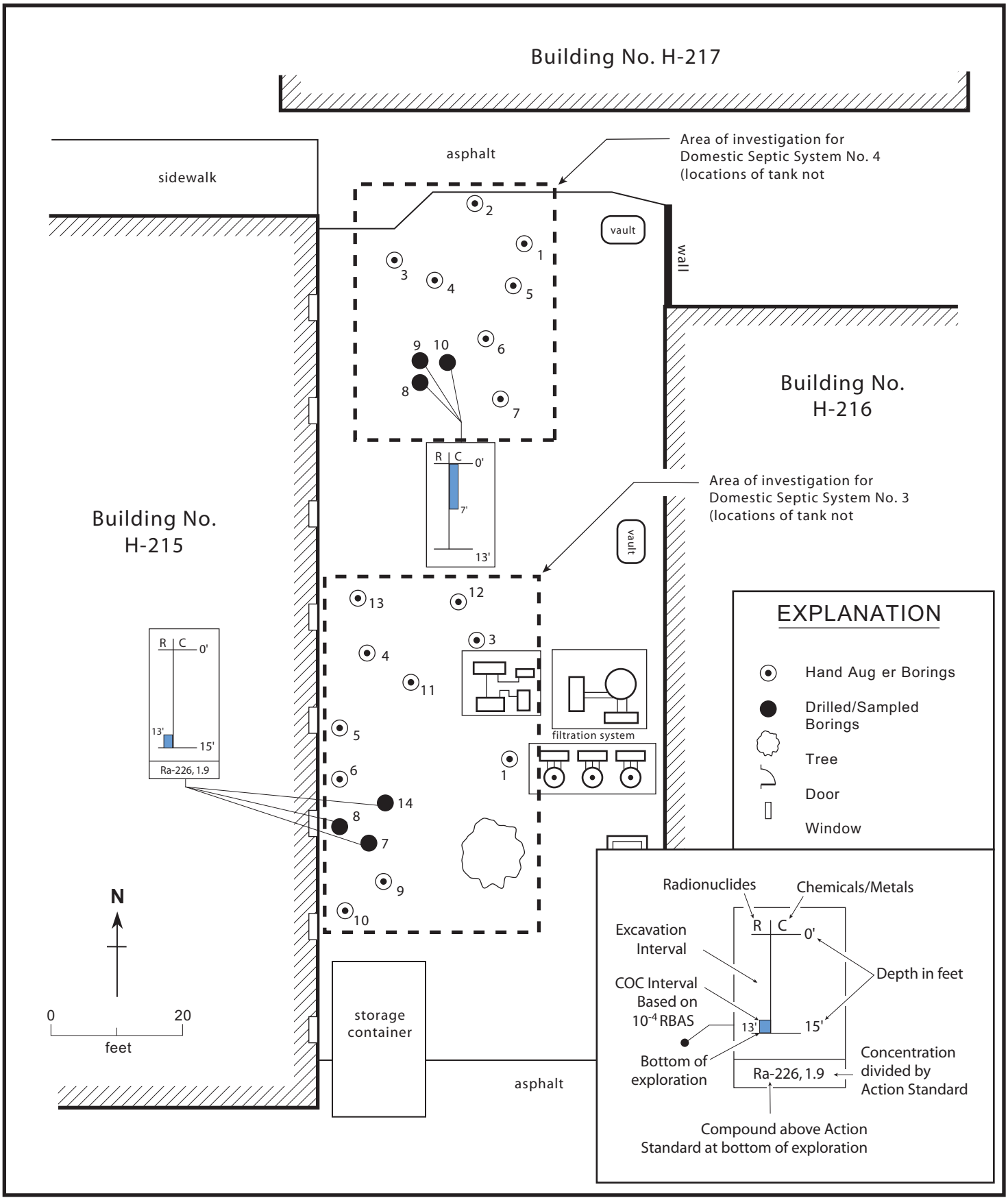


Figure 5-11. Constituents of Concern at $10^{-4}$ and $10^{-6}$ Risk-Based Action Standard, Domestic Septic Systems No. 3 and 4

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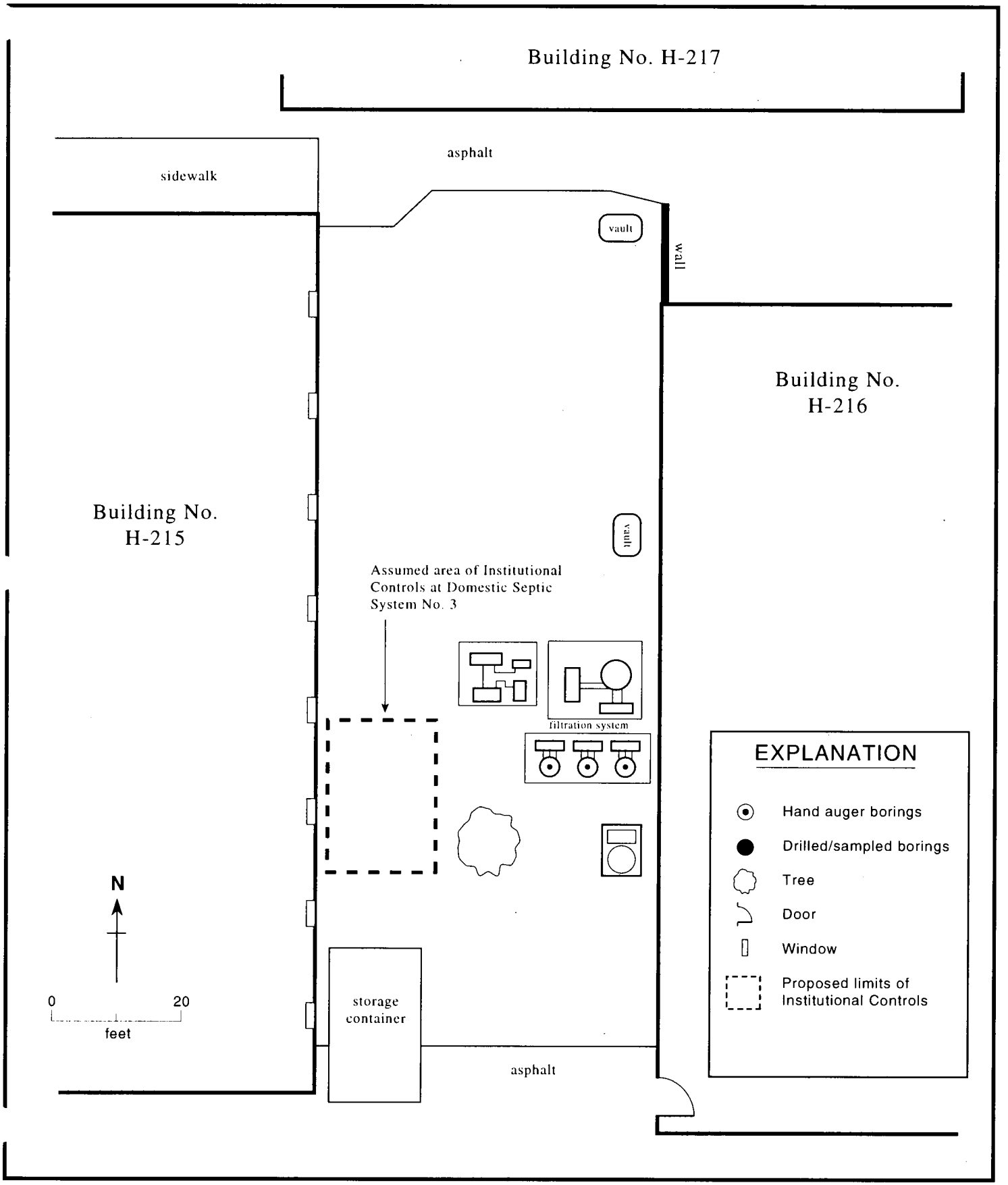


Figure 5-12. Conceptual Institutional Control Area Plan View for Alternative 2, Domestic Septic System No. 3

*Weiss Associates*

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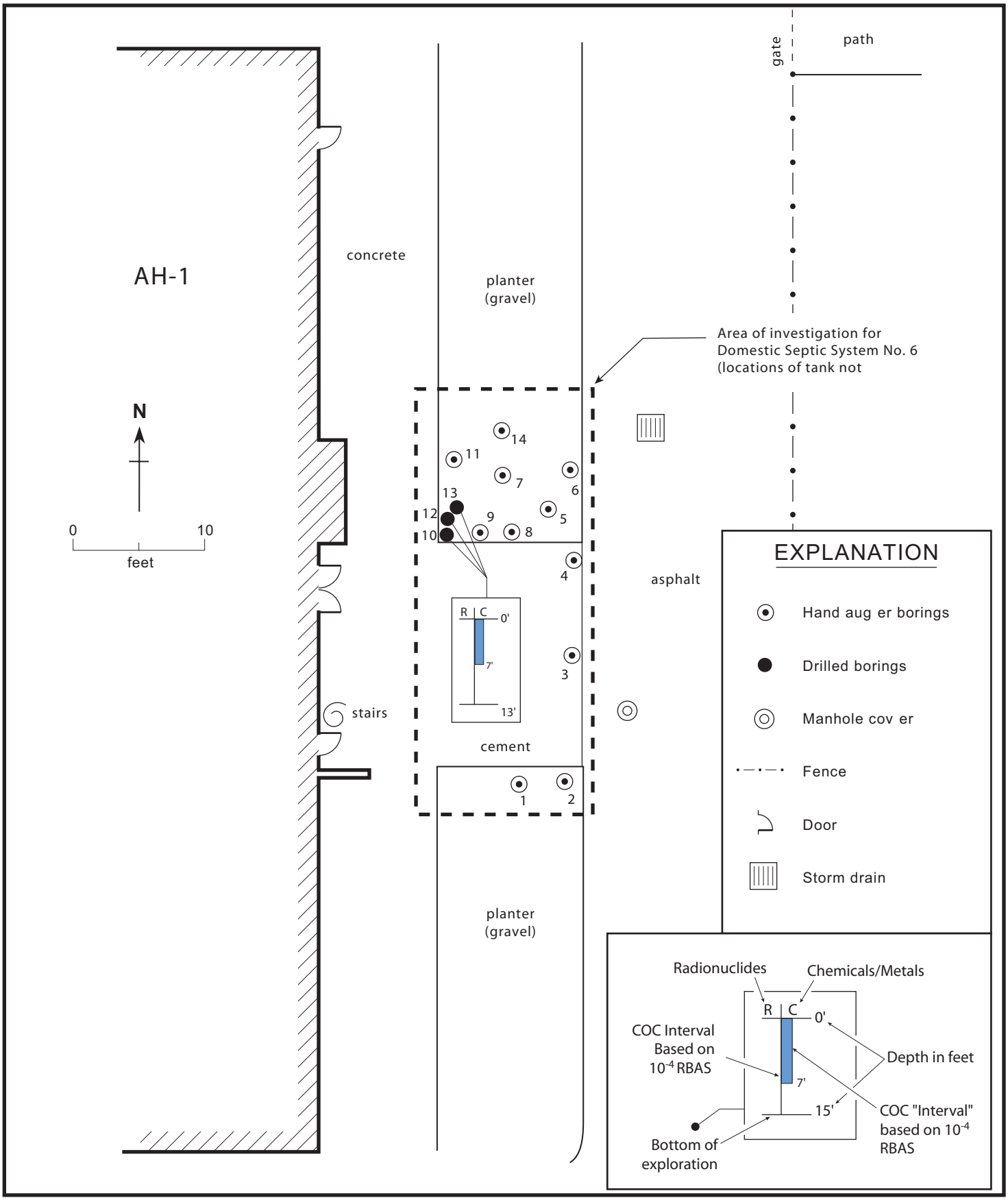


Figure 5-13. Constituants of Concern at $10^{-4}$ and $10^{-6}$ Risk-Based Action Standard, Domestic Septic Tank System No. 6

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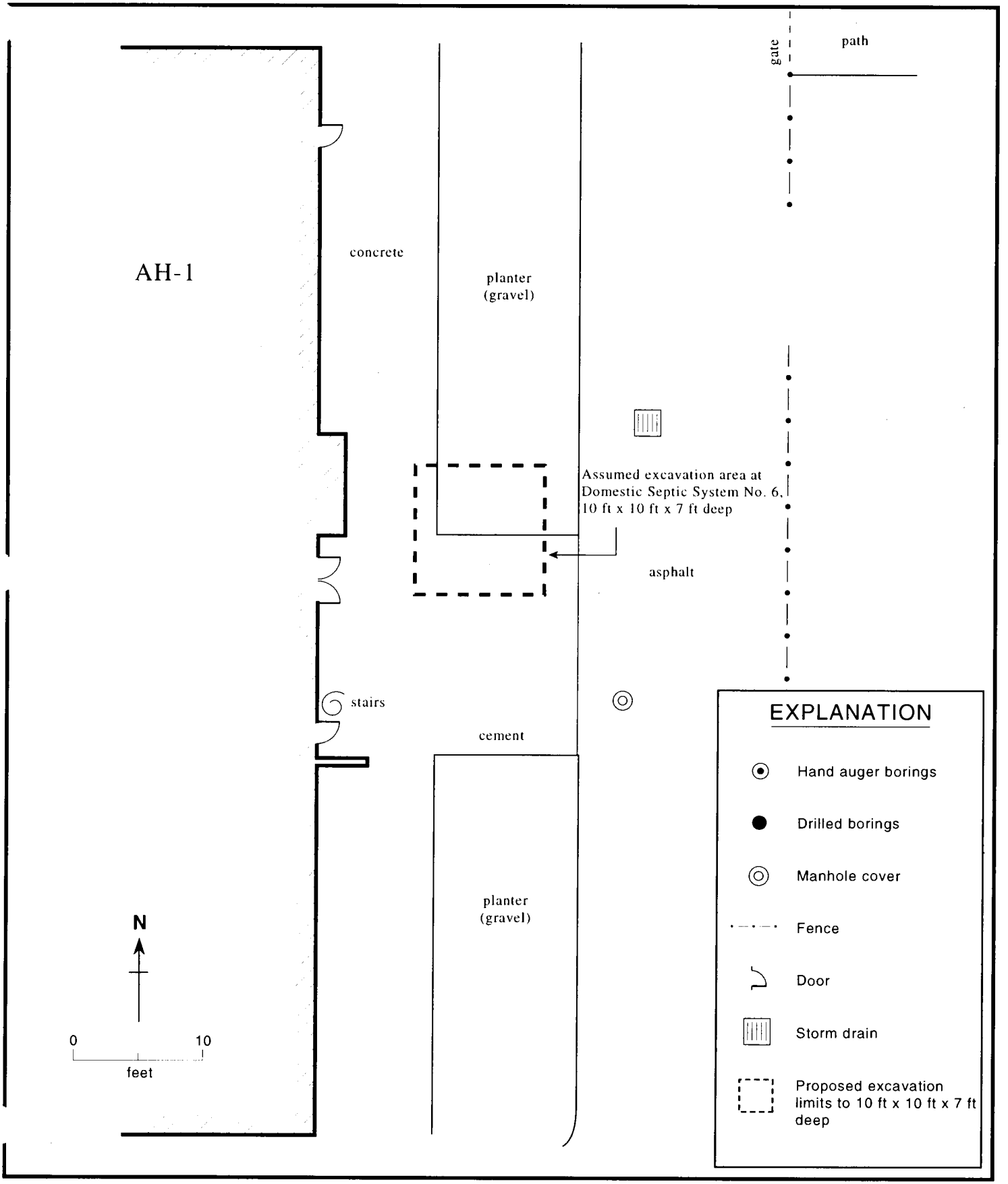


Figure 5-14. Conceptual Excavation Area Plan View for Alternative No. 2, Domestic Septic System No. 6

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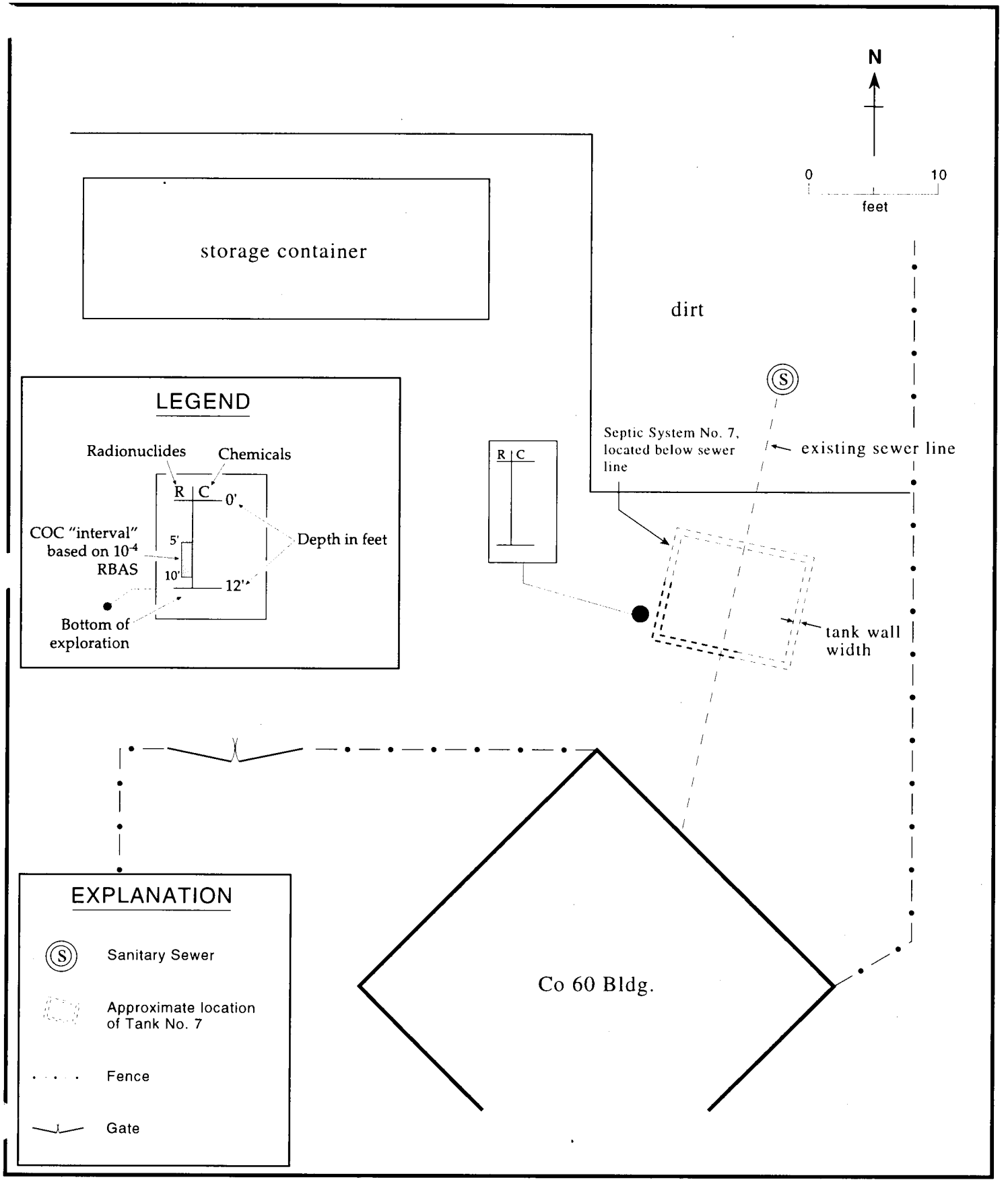
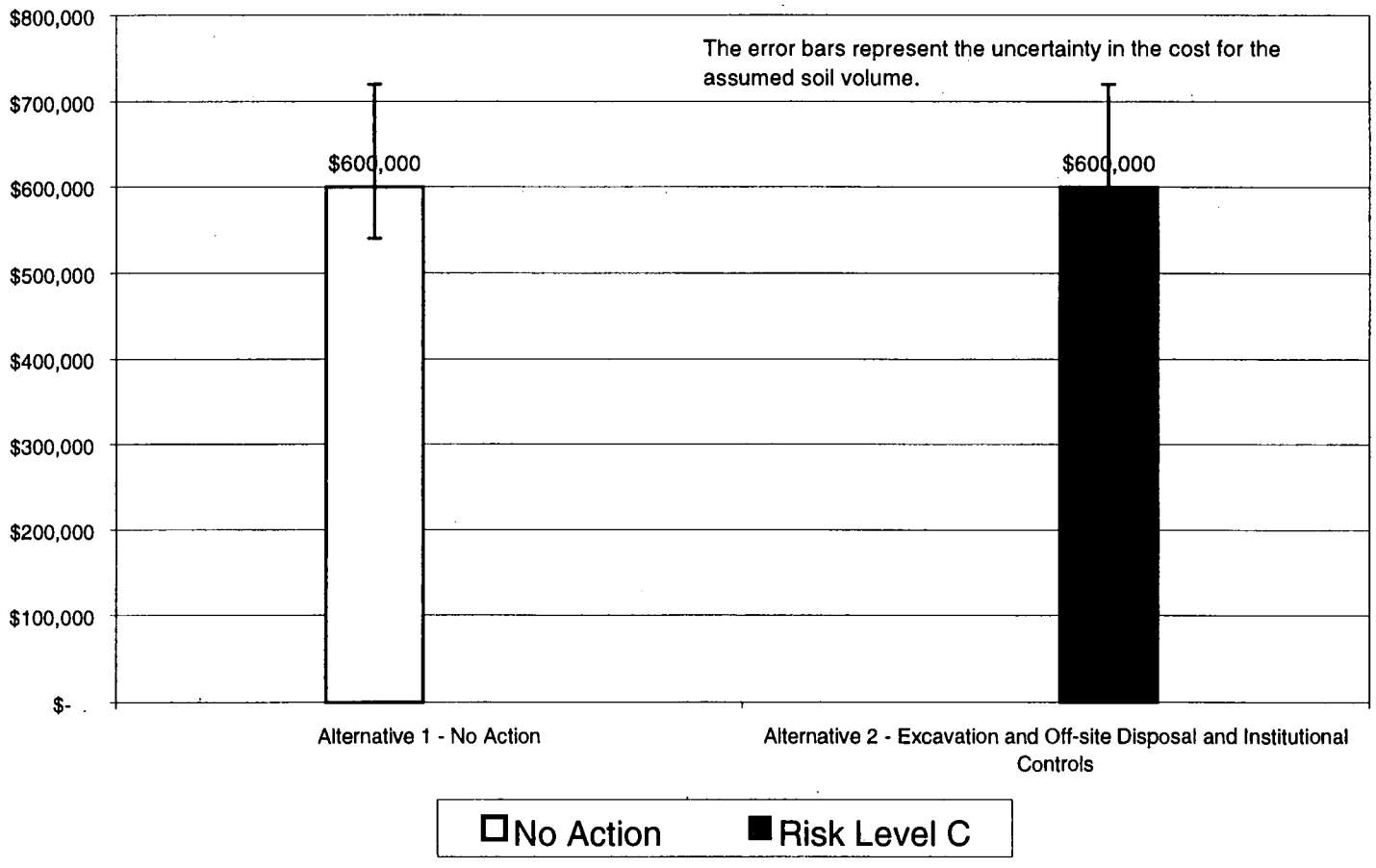



Figure 5-15. Constituants of Concern at $10^{-4}$ and $10^{-6}$ Risk-Based Action Standard, Domestic Septic Tank System No. 7

*Weiss Associates*

**Figure 5-16: Cost Comparison**
**Domestic Septic System Areas, Alternatives 1 and 2**



# 6. COMPARATIVE EVALUATION OF ALTERNATIVES

This section compares the RA alternatives developed in Section 5 for the Southwest Trenches, the Ra/Sr Treatment Systems and the Domestic Septic System Areas. Advantages and disadvantages were assessed for each alternative based on: 1) the effectiveness in achieving RA objectives; 2) implementability of the RA; and, 3) the estimated cost of the RA.

## 6.1 Comparison of the Alternatives for the Southwest Trenches Area

Three RA alternatives for the Southwest Trenches were evaluated in Section 5-4. Results of this evaluation were used to compare these alternatives relative to each other, as described below and summarized on Table 6-1. Table 6-2 also provides a quantitative cost comparison of these alternatives.

### *6.1.1 Effectiveness*

Alternative 1, the No Action alternative, is not an effective option for this Site because it does not meet RAOs, and is not sufficiently protective of human health.

Both Alternatives 2 and 3 are equally effective in protecting human health and the environment. Alternative 3 has the disadvantage of requiring administrative monitoring and restrictions on future subsurface soil disturbance activities. However, the two inactive UC Davis landfills on-site (not addressed in this EE/CA) will likely be capped under a future remedial action to be conducted by UC Davis that would require similar institutional controls and land use restrictions. Furthermore, Alternative 3 is readily achievable and has less uncertainty in the required volume of excavated soil than Alternative 2.

### *6.1.2 Implementability*

Alternative 1 is not implementable in the long term because it is unlikely to gain regulatory or public acceptance. Both Alternatives 2 and 3 are implementable. Alternative 3 would likely be easier to implement than Alternative 2 because its excavation volume does not vary appreciably by risk level. The excavation volume associated with Alternative 2 is uncertain because Ra-226 activities cannot be differentiated from background concentrations at Risk Levels B and C.

### *6.1.3 Cost*

As shown on Table 6-2, Alternative 1 is the least expensive alternative and Alternative 2 is the most expensive. Alternative 2 is the most expensive alternative at all risk levels because of the additional soil excavation and disposal costs. Also for this reason, the estimated cost of Alternative 2 has the largest degree of uncertainty. Alternative 3 is not only less expensive than Alternative 2, but also has far less uncertainty in total cost. It is possible that the cost for Alternative 2 may be two to three times the cost for Alternative 3 due to uncertainties in the excavated waste/soil volumes.

## 6.2 Comparison of the Alternatives for the Ra/Sr Treatment Systems Area

Three RA alternatives for the Ra/Sr Treatment Systems Area were evaluated in Section 5.5. Results of this evaluation were used to compare these alternatives relative to each other as described below and summarized on Table 6-3. Table 6-4 also provides a quantitative cost comparison of these alternatives.

### *6.2.1 Effectiveness*

Alternative 1, the No Action alternative, is not an effective option for this Site because it does not meet RAOs, and is not sufficiently protective of human health.

Both Alternatives 2 and 3 are equally effective in protecting human health and the environment. Alternative 3 has the disadvantage of requiring administrative monitoring and requiring restrictions on future Site subsurface soil disturbance activities. However, the two inactive UC Davis landfills on-site (not addressed in this EE/CA) will likely be capped under a future remedial action to be conducted by UC Davis that would require similar institutional controls and land use restrictions. Furthermore, Alternative 3 is readily achievable and has less uncertainty in the required volume of excavated soil than Alternative 2.

### *6.2.2 Implementability*

Alternative 1 is not implementable in the long-term because it is unlikely to gain regulatory or public acceptance. Both Alternatives 2 and 3 are implementable. Alternative 3 would likely be easier to implement than Alternative 2 because its excavation volume does not vary by risk level. The excavation volume associated with Alternative 2 is uncertain because Ra-226 activities cannot be differentiated from background at Risk Level C.

### *6.2.3 Cost*

As shown in Table 6-4, Alternative 1 is the least expensive alternative and Alternative 2 is the most expensive. Alternative 2 is the most expensive alternative at all risk levels because of the additional soil excavation and disposal costs. Also for this reason, the estimated cost of Alternative 2 has the largest degree of uncertainty. Alternative 3 is not only less expensive than Alternative 2, but also has far less uncertainty in total cost.

## 6.3 Comparison of the Alternatives for the Domestic Septic System Areas

Two RA alternatives for the Domestic Septic Systems Areas were evaluated in Section 5.6. Results of this evaluation were used to compare these alternatives relative to each other as described below, and summarized on Table 6-5. Table 6-6 also provides a quantitative cost comparison of these alternatives.

### *6.3.1 Effectiveness*

Alternative 1, the No Action alternative, is not an effective option for this Site because it does not meet RAOs, and is not sufficiently protective of human health. Alternative 2 is effective and meets RAOs.

### *6.3.2 Implementability*

Alternative 1 is not implementable in the long term because it is unlikely to gain regulatory and public acceptance. Alternative 2 is easy to implement in conjunction with other Site RAs. Furthermore, the limited quantity of surface soil requiring removal make this alternative readily implementable.

### *6.3.3 Cost*

As shown in Table 6-6, Alternative 2 costs the same as Alternative 1.

Table 6-1. Comparison of Alternatives, Southwest Trenches Areas

| Criteria | Alternative 1 – No Action | Alternative 2 – Excavation and Off-Site Disposal | Alternative 3 – Excavation, Offsite Disposal and Institutional Control |
|---|---|---|---|
| Effectiveness | • Not effective, does not meet RAOs | • Effective | • Effective with institutional controls |
| Implementability | • Implementable in short term, but may not gain regulatory or public acceptance | • More uncertainty in the volume of excavated soil than Alternative 3 because Ra-226 activity cannot be easily differentiated from background. | • Less uncertainty in the volume of excavated soil than Alternative 2 because soil cover would allow higher residual soil concentrations.<br>• Requires the establishment of long term agreement between UC Davis and DOE. |
| Cost | • Inexpensive in the short term but expensive in the long term due to administrative and COC site monitoring costs | • Most expensive alternative due to high disposal and analytical costs.<br>• Achieving Risk Levels B and C may be prohibitively expensive. | • Considerably less expensive than Alternative 2.<br>• Has long term administrative monitoring costs.<br>• Far less uncertainty than Alternative 2 resulting in potentially significant differential cost savings. |

Table 6-2. Cost Summary of Alternatives, Southwest Trenches Area

| Cost | Alternative 1 | Alternative 2 Risk A | Alternative 2 Risk B | Alternative 2 Risk C | Alternative 3 Risk A | Alternative 3 Risk B | Alternative 3 Risk C |
|---|---|---|---|---|---|---|---|
| Direct Costs | | | | | | | |
| Transportation and Disposal | $0 | $1,154,000 | $1,921,000 | $2,084,000 | $878,000 | $960,000 | $1,123,000 |
| Sampling and Analysis | $0 | $530,000 | $530,000 | $530,000 | $530,000 | $530,000 | $530,000 |
| Others | $0 | $1,716,000 | $1,949,000 | $2,086,000 | $1,692,000 | $1,710,000 | $1,747,000 |
| Total Direct Cost | $20,000 | $3,400,000 | $4,400,000 | $4,700,000 | $3,100,000 | $3,200,000 | $3,400,000 |
| Post RA Annual Costs | $25,000 | $0 | $0 | $0 | $10,000 | $10,000 | $10,000 |
| Net Present Value of Annual Costs (100 yr) | $600,000 | $0 | $0 | $0 | $200,000 | $200,000 | $200,000 |
| Total Alternative Cost* | $600,000 | $4,100,000 | $5,300,000 | $5,600,000 | $3,900,000 | $4,000,000 | $4,300,000 |

*Includes a 20% contingency factor.

Table 6-3. Comparison of Alternatives, Ra/Sr Treatment Systems Areas

| Criteria | Alternative 1 – No Action | Alternative 2 – Excavation and Off-Site Disposal | Alternative 3 – Excavation, Offsite Disposal and Institutional Control |
|---|---|---|---|
| Effectiveness | • Not effective, does not meet RAOs | • Effective | • Effective with institutional controls |
| Implementability | • Implementable in short-term, but may not gain regulatory or public acceptance | • More uncertainty in the volume of excavated soil than Alternative 3 because Ra-226 activity cannot be easily differentiated from background. | • Less uncertainty in the volume of excavated soil than Alternative 2 because soil cover would allow higher residual soil concentrations.<br>• Requires the establishment of long term agreement between UC Davis and DOE. |
| Cost | • Inexpensive in the short term but has long term site monitoring costs | • Most expensive alternative due to high disposal and analytical costs. Achieving Risk Level C may be prohibitively expensive. | • Less expensive than Alternative 2.<br>• Has long term monitoring costs. |

Table 6-4. Cost Summary of Alternatives, Ra/Sr Treatment Systems Area

| Cost | Alternative 1 – No Action | Alternative 2 Excavation and Off-Site Disposal Risk A | Alternative 2 Excavation and Off-Site Disposal Risk C | Alternative 3 Excavation, Off-Site Disposal and Institutional Controls Risk C |
|---|---|---|---|---|
| Direct Costs | | | | |
| Transportation and Disposal | $0 | $894,000 | $1,244,000 | $704,000 |
| Sampling and Analysis | $0 | $390,000 | $390,000 | $390,000 |
| Other | $0 | $1,716,000 | $1,766,000 | $1,406,000 |
| Total Direct | $20,000 | $3,000,000 | $3,400,000 | $2,500,000 |
| Post RA Annual Costs | $25,000 | $0 | $0 | $10,000 |
| Net Present Value of Annual Costs (100 yr) | $600,000 | $0 | $0 | $200,000 |
| Total Alternative Cost* | $600,000 | $3,600,000 | $4,100,000 | $3,200,000 |

*Includes a 20% contingency factor.

Table 6-5. Comparison of Alternatives, Domestic Septic Systems Area

| Criteria | Alternative 1 – No Action | Alternative 2 – Excavation, Off-Site Disposal, and Institutional Controls |
|---|---|---|
| Effectiveness | • Not effective, does not meet RAOs | • Effective |
| Implementability | • Easily implementable, but may not gain community or regulatory acceptance. | • Easily implementable due to relatively small volume of soil to excavate. |
| Cost | • Inexpensive in short term but has long term administrative site monitoring cost. | • Costs the same as Alternative 1. |

Table 6-6. Cost Summary of Alternatives, Domestic Septic Systems Areas

| Cost | Alternative 1 – No Action | Alternative 2- Excavation, Off-Site Disposal, and Institutional Controls Risk C |
|---|---|---|
| Direct Costs | | |
| Transportation and Disposal* | | |
| Sampling and Analysis | $0 | $40,000 |
| Other | $0 | $260,000 |
| Total Direct Cost | $0 | $300,000 |
| Post RA Annual Cost | $25,000 | $10,000 |
| Net Present Value of Annual Costs (100 yr) | $600,000 | $200,000 |
| Total Alternative Cost** | $600,000 | $600,000 |

Notes:

* Excavation costs were not a significant cost for this alternative, and were therefore not itemized below. See Appendix F for more detail.
**Includes a 20% contingency factor

# 7. ENVIRONMENTAL IMPACT CONSIDERATIONS

## 7.1 Purpose and Need

This section discusses existing environmental conditions and potential impacts that may result from implementing the proposed RAs. This section also reviews environmental impacts in a manner that is consistent with NEPA (Public Law 91-190), the Council on Environmental Quality 40 CFR 1500-1508 (Regulations for Implementing the Procedural Provisions of the NEPA), and DOE environmental compliance regulations 10 CFR 1021 (National Environmental Policy Act: Implementing Procedures and Guidelines Revocation; Final Rule and Notice).

Discussing environmental considerations in this EE/CA allows the environmental considerations of the proposed RA alternative to be included into the CERCLA process and eliminates the need to conduct a separate NEPA process which could delay implementation of the RA.

## 7.2 Environmental Setting

The environmental setting for the Site was discussed previously in Section 2.2, which provided information regarding the following topics:

- water resources;
- ambient air quality;
- ambient noise quality;
- aesthetics and scenic values;
- biological resources (plants and wildlife);
- socioeconomic conditions;
- historical and cultural resources;
- land use; and,
- human health issues.

## 7.3 Potential Environmental Impacts of the Alternatives

This section presents the potential environmental impacts of each alternative. Table 7-1 summarizes the specific work actions identified with each alternative. The potential environmental impacts of each alternative summarized in Table 7-2 are based on the description of each alternative in Section 5.0 and specific work actions identified in Table 7-1. Section 7.3.1 identifies and discusses the environmental areas that will not be affected by any of the alternatives. Section 7.3.2 identifies and discusses the environmental areas that will be affected on a short-term basis (i.e.,

construction type work actions) and/or have potentially negligible impact on the environment. Cumulative environmental impacts are discussed in Section 7.3.3.

### *7.3.1 Environmental Considerations Not Affected by the Alternatives*

There are several existing environmental conditions that will not be affected by the alternatives. These include:

- water resources;
- aesthetics and scenic values;
- biological resources;
- socioeconomic conditions;
- historical and cultural resources; and,
- land use.

#### 7.3.1.1 Water Resources

None of the alternatives would affect the existing water resources. The RAs identified for the Southwest Trenches Area and the Ra/Sr Treatment Systems Area may potentially benefit long-term ground water quality because they eliminate the potential for ground water contamination from these sources.

Construction will be conducted during the dry season; however, if rainfall occurs during any earth moving/construction activities, storm water flow from the disturbed areas will be handled in accordance with mitigation measures to be developed in the RA Work Plan.

No existing surface recreational waters will be affected by the alternatives.

#### 7.3.1.2 Aesthetics and Scenic Values

The aesthetics and scenic values of the area will not be affected. Under some alternatives, the appearance of the Site may change during construction activities; these visual changes are within small localized areas that are normally out of view from the public and public thoroughfares, and is expected to be unnoticed except for individuals working or visiting the project Site. Under the removal alternatives, the localized affected areas will be graded and vegetated as appropriate. The aesthetics and scenic values of the area will be unaffected.

#### 7.3.1.3 Biological Resources

The alternatives will not impact endangered plants or animals within the Site or adjacent areas. There are no sensitive or endangered plants that inhabit the project Site. There are 14 sensitive wildlife species that may inhabit or hunt within the project Site.

For the alternatives involving construction activities, disturbance would be temporary. There may be wild raptors that periodically use the Site to capture prey; however, the project Site would represent a small area within the raptor's hunting range and should not affect their welfare. Common species of wildlife on the Site may be displaced due to any construction activities. The surrounding areas will provide suitable habitat for wildlife that are displaced. Once completed, the disturbed

areas could again be used by wildlife. Plants that will be removed are introduced species and/or weed-type growth.

A focused biological resources survey would be conducted prior to and during RA to ensure that no biological resources are impacted by the RA.

#### 7.3.1.4 Socioeconomic Conditions

None of the alternatives will affect the socioeconomic conditions of the area. The cost of the project, number of jobs created, money spent in the area, sensitive populations (i.e., minorities, low-income), and land values will not be affected. The removal alternatives would result in the creation of approximately 12 full-time jobs over 12 months, which may be less than a fraction of 1 percent of the economy of the City of Davis.

#### 7.3.1.5 Historical and Cultural Resources

The State Historic Preservation Officer has indicated that there are no known historical and/or cultural resources identified within or adjacent to the Site (UC Davis, 1996). No historical and cultural resources are found on the project Site, and because of previous disturbances to the Site, no historical and cultural resources are expected to be uncovered. No impact on historical and cultural resources are expected under any alternative.

#### 7.3.1.6 Land Use

Land use and values of the Site and adjacent areas will not be affected by any alternative. The project Site will remain under the control of UC Davis and, after the DOE RAs, will continue to be used for UC Davis educational/research operations. This is consistent with the UC Davis Long Range Plan.

### *7.3.2 Foreseeable Short-term or Minimal Environmental Impacts*

There are several foreseeable short-term construction-related impacts. These impacts are shown on Table 7-2, and include:

- localized air quality impact;
- noise impact;
- occupational and public health considerations; and,
- transportation of low-level radioactive wastes.

#### 7.3.2.1 Air Quality Impact

All alternatives involving land moving/altering activities will have the potential to create dust. As noted in Section 2.0, the Site is within a non-attainment area for particulate matter ($PM_{10}$) and ozone. Standard dust suppression measures will be taken during construction activities, primarily wetting down the disturbed areas. Any stockpiled loose dirt or materials subject to blowing wind will be covered or placed in containers. Ground cover will be provided at the completion of the removal activities as permanent measures to reduce dust. Air monitoring will be performed during

removal actions to ensure that no significant adverse impact to air quality is occurring. No significant or adverse long term impact to the ambient air quality is foreseen.

#### 7.3.2.2 Noise Impact

Alternatives involving earthwork and construction will create short-term construction noise impact. A sensitive receptor may be the raptors in the UC Davis Raptor Center whose raptors are housed in small buildings adjacent to the Site. Depending on the research project, the raptors may be sensitive to noise created by the earthwork and construction activities. Construction noise will be minimized by working with construction and moving equipment. The researchers will be notified about any construction activities that may affect the raptor research and mitigation measures are expected to be utilized, as appropriate. No significant or adverse long-term noise impact is anticipated.

#### 7.3.2.3 Occupational and Public Health Considerations

Radiological health concerns are addressed in Section 5 as part of the objectives achieved by the alternatives. However, the removal alternatives will require worker contact with low-level radioactive and/or hazardous materials only. Worker protection is provided through health and safety plans prepared for the specific work and by following OSHA and DOE regulations on the handling of low-level radioactive and/or hazardous materials. Radiological monitoring badges will also be utilized by workers trained to work on hazardous waste sites. RA work will be performed only by 40-hour OSHA health and safety-trained certified personnel. Protective clothing will also be used when working with radioactive/hazardous materials. Given these precautions, the worker occupational health will be protected.

Public health considerations relating to transportation issues are discussed in Section 7.3.2.4, below. No adverse impact to public health is foreseen under any of the considered RA alternatives, except possibly for the No Action alternatives in the Southwest Trenches Area and Ra/Sr Treatment Systems Area. The No Action alternative in these areas would leave extensive amounts of surface soil contamination uncontrolled. The contamination in these areas may exceed the minimum $10^{-4}$ excess cancer risk required by the NCP, depending on future site use.

#### 7.3.2.4 Transportation of Low-Level Radioactive Waste

Appendix I – Transportation Impact Analysis, shows the number of shipments, their destination, and distance traveled to the disposal site from 1993 to present. A total of 53 shipments were made, 51 of which were sent to Hanford. This represents the existing level at which low-level radioactive waste is packaged and transported away from the Site. No accidents resulting in exposure to these low-level radioactive wastes have occurred during these shipments. This is primarily due to project standards and stringent compliance with federal and state transportation, packaging, and disposal rules and regulations applicable to low-level radioactive waste transport.

A total of approximately 400 shipments of low-level radioactive waste in strong, tight containers would be generated if the maximum excavation is performed under the removal alternatives for the Southwest Trenches Area and Ra/Sr Treatment Systems Area. The shipments would be transported by truck to a DOE-approved disposal facility. The packaging and transportation of this waste would comply with the applicable Federal and state regulations

including, but not limited to 49 CFR 173 (U.S. Department of Transportation [DOT]) and 10 CFR 71 (Nuclear Regulatory Commission). The waste carrier must comply with all DOT and state (California and out-of-state) permits to transport this waste. In addition to federal and state regulations, the Hanford disposal Site has waste acceptance criteria for packaging, labeling, and acceptance. All permit requirements, driver training/certifications, and manifests (including notification of shipments), will be met prior to waste shipments. Handling, packaging, transporting, and disposal requirements will be identified and discussed in the work plans that must be prepared for any Site work. Work plans, health and safety plans, and storm water pollution prevention plans will be implemented by Site personnel as applicable.

The shipments will take a pre-determined DOE-approved route from the Site to the DOE-approved disposal facility. The potential impact on the maximum total shipment was calculated and is discussed in Appendix I. The results of these calculations are provided below.

Radiological impacts. The maximum individual dose to a truck crew member was calculated to be 1.6 millirem per trip, or 1.2 person REM over the life of the project, assuming that one, 2-person crew would be utilized to transport all the generated waste to the disposal site. This calculated dose is well within the 5 rem/yr allowable radiation dose to workers as specified in DOE Order 5480.11.

Non-Radiological Impact. Non-radiological accident risk consists of injuries and fatalities that may result from traffic accidents involving the shipments of LEHR wastes to the disposal site. The probability of traffic accidents associated with all waste shipment is less than one (see Appendix I). There is an increase in the statistical risk of traffic-accident related fatalities (0.012 increased probability) and in the risk of fatalities from exposure to diesel exhaust and road dust in urban areas along the route (0.007 increased probability, assuming 10% travel through urban areas).

### *7.3.3 Cumulative Impacts*

Cumulative impacts for this project are categorized into potential short term cumulative impact related to construction activities involving the RA or potential long term cumulative impact associated with the release of COCs into the environment.

Short Term Cumulative Impact – There is one known project within the site that could have cumulative impacts with the removal alternatives, depending on the timing. UC Davis has issued a "Final Tiered Initial Study for the Laboratory for Energy-Related Health Research and South Campus Disposal Site (LEHR/SCDS) Interim Remedial Actions" (dated June 6, 1997). This document indicates that a ground water treatment plant and soil removal will occur at the Site before the end of 1997. Since the proposed schedule is being maintained, no cumulative impact is anticipated. However, if any UC Davis projects and removal alternatives for this project occur simultaneously, construction-related impacts would likely increase. The alternatives for this project will not likely affect any known project located within the near vicinity or region. Nor are there any known projects that will affect this project or project Site with the possible exception of RAs to be conducted by UC Davis in the vicinity of the Site.

Long Term Cumulative Impact - Under the No-Action alternative and under the excavation alternatives, it is possible that some soils containing above-background levels of nitrate will remain in place at the Site. UC Davis will also be conducting remedial action(s) associated with their landfill areas on contiguous portions of the LEHR facility. Should these action(s) result in nitrate above background levels remaining in place in soils within UC Davis landfills, it is possible that a cumulative impact could occur resulting in nitrates present in ground water above background levels. As discussed in Section 3, Appendix A and Appendix C, the existing UC Davis landfills appear to contribute significantly to nitrates detected in monitoring wells downgradient of the landfills. Presently, UC Davis is installing a downgradient extraction system (downgradient of the LEHR facility as a whole) as an interim removal action for containing the downgradient plume, and for treating chloroform. It was determined in the EE/CA prepared by UC Davis for the treatment system that ground water treatment to address nitrate would not be necessary. Further, DOE will be conducting modeling during the preparation of the EE/CA workplan to help determine what levels of nitrate can remain in site soils while still precluding significant ground water impacts. Therefore, it is unlikely that the contribution of nitrate to ground water from any of the remedial actions evaluated will result in an adverse cumulative impact to ground water.

## 7.4 Mitigation Measures

Mitigation measures will be implemented prior to and during RAs to ensure no environmental impacts occur. Mitigation measures to be implemented are summarized in Table 7-3.

## 7.5 List of Agencies and Persons Consulted

The local agencies and persons consulted are identified on Table 7-4.

## 7.6 Summary of Environmental Impacts

Probable environmental impacts of all the alternatives were reviewed and it was found that there would be either no impacts or minimal impacts to the environment should a RA alternative be selected. There are seven areas where no impacts would likely occur, these are: water resources; aesthetics and scenic values; biological resources; socioeconomic conditions; historical and cultural resources; and land use. For the most part, the project is in a relatively small area and in a land-disturbed area that subsequently would have little affect on the above mentioned environmental considerations. Short-term, minimal impacts would occur, primarily from removal alternatives, in the following areas: air quality; noise impact; occupational and public health considerations; and transportation of low-level radioactive waste. These are identified as short-term and minimal because these impacts would occur during the RA and would be mitigated through compliance with existing (in-place) regulations or subject to permit requirements and/or would adhere (especially in the case of low-level radioactive transportation) to strictly enforced regulations. In the case of dust generation and noise, the impacts would be restricted to the Site and immediate surroundings.

No long-term, significant, and adverse environmental impacts are likely to occur from any of the alternative actions discussed in the EE/CA, except for the long term effects of the No Action alternatives in the Southwest Trenches Area and the Ra/Sr Treatment Systems Area. The No Action alternatives in these two areas would leave extensive amounts of surface soil contamination uncontrolled. The contamination in these areas may exceed the minimum $10^{-4}$ excess cancer risk required by the NCP depending upon future site use.

Table 7-1. Description of Specific Types of Work Actions by Alternative

| Types of Work Actions | Southwest Trenches | | | Radium/Strontium Treatment Systems | | | Domestic Septic Systems | |
|---|---|---|---|---|---|---|---|---|
| | Alt 1 No Action | Alt 2 Soil Excavation and Off-Site Disposal | Alt 3 Soil Excavation, Off-Site Disposal and Institutional Controls | Alt 1 No Action | Alt 2 Soil Excavation and Off-Site Disposal | Alt 3 Soil Excavation, Off-Site Disposal and Institutional Controls | Alt 1 No Action | Alt 2 Soil Excavation, Off-Site Disposal, and Institutional Controls |
| 1. Mobilization | | ✓ | ✓ | | ✓ | ✓ | | ✓ |
| 2. Site Preparation | | ✓ | ✓ | | ✓ | ✓ | | ✓ |
| 3. Excavation | | ✓ | ✓ | | ✓ | ✓ | | ✓ |
| 4. Sampling Activities | | ✓ | ✓ | | ✓ | ✓ | | ✓ |
| 5. Segregating Waste | | ✓ | ✓ | | ✓ | ✓ | | ✓ |
| 6. Packaging/Transporting Low-Level Radioactive or Other Site Waste | | ✓ | ✓ | | ✓ | ✓ | | ✓ |
| 7. Importing and Placing Clean Fill Soil | | ✓ | ✓ | | ✓ | ✓ | | ✓ |
| 8. Final grading/Landscaping | | ✓ | ✓ | | ✓ | ✓ | | ✓ |
| 9. Demobilization | | ✓ | ✓ | | ✓ | ✓ | | ✓ |
| 10. Monitoring | ✓ | | ✓ | ✓ | | ✓ | ✓ | ✓ |
| 11. Site Surveillance | | | ✓ | | | ✓ | | ✓ |

Notes:

Alt = RA Alternative.

Table 7-2. Potential Environmental Impacts By Alternatives

| Environmental Consideration | Southwest Trenches Alternatives | | | Ra/Sr Treatment Systems Alternatives | | | Domestic Septic Systems Alternatives | |
|---|---|---|---|---|---|---|---|---|
| | Alt. 1 No Action | Alt. 2 Soil Excavation and Off-Site Disposal | Alt. 3 Soil Excavation, Off-Site Disposal and Institutional Controls | Alt. 1 No Action | Alt. 2 Soil Excavation & Off-Site Disposal | Alt. 3 Soil Excavation, Off-Site Disposal and Institutional Controls | Alt. 1 No Action | Alt. 2 Soil Excavation, Off-Site Disposal and Institutional Controls |
| 1. Water Resources | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| 2. Air Quality Impact | ○ | ◎ | ◎ | ○ | ◎ | ◎ | ○ | ◎ |
| 3. Noise Impact | ○ | ◎ | ◎ | ○ | ◎ | ◎ | ○ | ◎ |
| 4. Aesthetics and Scenic Values | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| 5. Sensitive/Endangered Plants and Wildlife | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| 6. Socioeconomic Conditions | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| 7. Historical and Cultural Resources | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| 8. Land Use | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| 9. Human Health | ● | ◎ | ◎ | ● | ◎ | ◎ | ● | ◎ |
| 10. Transportation of Low-level Radioactive waste | ○ | ◎ | ◎ | ○ | ◎ | ◎ | ○ | ○ |
| 11. Cumulative Impacts | ○ | ◎ | ◎ | ○ | ◎ | ◎ | ○ | ◎ |

Notes:

○ = No foreseeable impact
◎ = Short-term negligible (construction-type) impacts, mitigation measures will be implemented to minimize adverse impacts
● = Significant and/or adverse impacts – does not meet RAOs or NCP criteria.
Alt. = Removal Action Alternative.

Table 7-3. Mitigation Measures for Potential Environmental Impacts

| Impact Areas | Mitigation Measures |
|---|---|
| Water Resources | • Storm water runoff will be impounded to prevent surface runoff; and,<br>• Erosion control measures will be implemented to reduce soils transport. |
| Aesthetics and Scenic Values | • No mitigation measures required. |
| Biological Resources | • A focused biological resource survey will be conducted prior to and during RA;<br>• RA will be halted and appropriate measures will be implemented if a biological resource will be impacted. |
| Historical and Cultural Resources | • RA activities will be halted if any cultural resources are uncovered so that appropriate actions can be implemented. |
| Land Use | • No mitigation measures required. |
| Air Quality | • Dust suppression during construction activity using water or other approved liquids;<br>• Covering or containment of loose soil piles/areas when there is no work activity; and,<br>• Conduct Site air monitoring to ensure public protection. |
| Noise Impact | • Advise Raptor Center of construction noise activities; and,<br>• Use equipment that would produce less noise. |
| Human Health | • Conduct field, transportation, packaging and disposal activities related to wastes according to the site-specific health and safety plan procedures. This includes using the appropriate personal protective equipment required for the activity;<br>• Use decontamination facilities and procedures as appropriate; and,<br>• Provide procedures for emergencies and accidents. |
| Transportation of Low-level Radioactive Waste | • Adhere to applicable DOT regulations (49 CFR 173) relating to the packaging, handling, labeling, disposal, routing, and transporting of low-level radioactive waste; including driver training and regulations. |
| Local Traffic | • Check with local agencies (City of Davis) and CALTRANS to determine if any major projects in the area coincide with the proposed removal if traffic from the removal actions would result in several trucks per hour needing ingress/egress from the Site, then provide a construction traffic work person to control traffic stops on Old Davis Road. |
| Cumulative Impacts | • Monitoring of other Site activities will be conducted during RA and work will be halted as required to implement mitigation measures.<br>• Ground water modeling will be conducted during RA Work Plan to assess and confirm no significant cumulative impact. |

Table 7-4. Local Agencies Contacted

| Agency/Person | Date | Subject |
|---|---|---|
| Planning and Building Department, City of Davis<br>Mitch Sears, Assistant Planner | July 17, 1997 | Land use information |
| Planning and Budget Office, University of California Davis<br>A. Sidney England, Environmental Planner | July 21, 1997 | UC Davis projects at the project Site and vicinity |
| Davis Chamber of Commerce and Visitors' Center<br>Staff | July 23, 1997 | Population/commerce information |
| Public Works, City of Davis<br>Staff | July 24, 1997 | Storm water and flood information |
| Yolo/Solano Air Quality Management District<br>Staff | August 5, 1997 | Ambient air quality information |

# 8. RECOMMENDED REMOVAL ACTIONS

This section summarizes the evaluation process and results of the RA comparative analysis, and recommends RA alternatives. A decision process to be utilized during implementation of recommended RA alternatives is also described.

## 8.1 Evaluation Process

In accordance with NCP and EPA guidance, Sections 5.0 through 7.0 developed and compared RA alternatives for the Southwest Trenches, the Ra/Sr Treatment Systems, and the Domestic Septic System Areas as follows:

1. Potentially applicable remedial technologies were screened based on cost, effectiveness, and implementability (Section 5);
2. Site-specific RA alternatives for each area were developed from remedial technologies which passed this initial screening (Section 5);
3. These RA alternatives were then evaluated in further detail (Section 5);
4. Alternatives for each area were then compared to each other (Section 6); and,
5. Environmental impact considerations for the RA alternatives were discussed (Section 7).

This section recommends a preferred RA alternative for each of the DOE areas based on the information provided in Section 6.

## 8.2 Summary of Alternative Comparisons

Results of the alternative comparisons are summarized below and presented in Table 8-1 for each area.

For the Southwest Trenches:

- Alternative 1 - No Action. This alternative does not meet RAOs.
- Alternative 2 – Excavation and Off-Site Disposal. This alternative is more expensive than Alternative 3 and also more difficult to implement because it has a greater uncertainty in the extent of excavation necessary to meet RAOs. Attainment of the $10^{-5}$ or $10^{-6}$ cumulative cancer risk level for this alternative is

not possible because field and laboratory analysis for Ra-226 cannot differentiate the $10^{-5}$ (and $10^{-6}$) RBAS from the RA-226 background activity. This alternative, however, would likely require no further remedial action or institutional controls.

- Alternative 3 – Excavation, Off-Site Disposal and Institutional Controls. This alternative is less expensive, more easily implemented, and involves considerably less uncertainty than Alternative 2. Furthermore, this alternative could achieve RAOs within the selected risk levels given the institutional control measures. Although administrative monitoring and Site restrictions may be part of this alternative, such activities are likely at this Site due to the need for future remedial actions (conducted by UC Davis) to address soil and ground water contamination in the SCDS.

For the Ra/Sr Treatment Systems:

- Alternative 1 - No Action. This alternative does not meet RAOs.
- Alternative 2 – Excavation and Off-Site Disposal. This alternative is more expensive than Alternative 3 and also more difficult to implement because it has a much greater uncertainty in the extent of excavation necessary to meet RAOs. Attainment of the $10^{-5}$ or $10^{-6}$ cumulative excess cancer risk level for this alternative is not possible because field and laboratory sampling for Ra-226 cannot differentiate the $10^{-5}$ (and $10^{-6}$) RBAS from the background Ra-226 activity. This alternative, however, would most likely require no further remedial action or institutional controls.
- Alternative 3 – Excavation, Off-Site Disposal and Institutional Controls. This alternative is less expensive, more easily implemented, and involves less uncertainty than Alternative 2. This alternative could also easily achieve RAOs. Although administrative monitoring and Site restrictions are part of this alternative, such activities are likely at this Site due to the need for future remedial actions (conducted by UC Davis) to address soil and ground water contamination in the SCDS.

For the Domestic Septic System Areas:

- Alternative 1 - No Action. This alternative does not meet RAOs.
- Alternative 2 – Excavation, Off-Site Disposal, and Institutional Controls. This alternative at Domestic Septic System No. 6 meets RAOs. Furthermore, the limited excavations could easily be incorporated within the more extensive RAs proposed for the Southwest Trenches Areas and/or the Ra/Sr Treatment Systems Areas.

## 8.3 Recommended RA and Target Risk Level for the Southwest Trenches Area

The recommended alternative for the Southwest Trenches is Alternative 3 – Excavation, Off-Site Disposal and Institutional Controls. This alternative was chosen because it achieves RAOs at Risk Level C, and also limits the degree of uncertainty related to the volume of soil that needs to be excavated. Furthermore, it is possible that once the excavation is backfilled and confirmation samples are analyzed, RAOs may be attained in this area without the necessity of institutional controls.

Buried solid waste material within these trenches would be removed. Ra-226 removal would be based on an ALARA level, but allowing an increasing Ra-226 activity based on depth and cover thickness. Institutional controls implemented as part of this alternative would involve restrictions on future land disturbance activities and administrative monitoring. This alternative would require off-site disposal of approximately 1,378 cy of low level radioactive soil and waste material at an appropriate disposal facility. In addition, results of confirmation samples taken from the excavation limits would be appraised. This appraisal would evaluate the RA achievement of RAOs, as well as demonstrating the effectiveness of the institutional controls. This appraisal would also be included as part of a final construction certification report documenting the completed RAs and available for public review. Total estimated cost for implementing this alternative is $4,300,000.

## 8.4 Recommended RA and Target Risk Level for the Ra/Sr Treatment Systems Areas

The recommended alternative for the Ra/Sr Treatment Systems Areas is Alternative 3 – Excavation, Off-Site Disposal, and Institutional Controls. This alternative was chosen because it achieves RAOs at Risk Level C, and also limits the degree of uncertainty related to the volume of soil that needs to be excavated. Furthermore, it is possible that, once the excavation is backfilled and confirmation samples are analyzed, that RAOs may be attained at this area without the necessity of institutional controls.

Ra-226 removal would be based on an ALARA level, but allowing an increasing Ra-226 activity based on depth and cover thickness. Institutional controls implemented as part of this alternative would involve restrictions on future land disturbance activities and administrative monitoring. This alternative would require off-site disposal of approximately 864 cy of soil at an appropriate disposal facility. In addition, results of confirmation samples taken from the excavation limits would be appraised. This appraisal would evaluate the RAs achievement of RAOs, as well as demonstrating effectiveness of the institutional controls. This appraisal would also be included as part of a final construction certification report documenting the completed RAs and be available for public review. Total estimated cost for implementing this alternative is $3,200,000.

## 8.5 Recommended RA for the Domestic Septic System Areas

The recommended alternative for the Domestic Septic System Areas is Alternative 2 – Excavation, Off-Site Disposal, and Institutional Controls. This alternative was selected because it is

effective and because the excavations could easily be performed in conjunction with the RAs proposed for the Southwest Trenches and Ra/Sr Treatment Systems Areas.

This RA involves excavating approximately 26 cy of mercury surface soil containing mercury associated with Domestic Septic System No. 6 for off-site disposal at a Class I landfill. Institutional Controls would be imposed at Domestic Septic System No. 3 along with additional confirmational sampling to ensure that no removal action is warranted. In addition, results of confirmation samples taken from the excavation limits at Domestic Septic System No. 6 would be appraised. This appraisal would evaluate achievement of RAOs. This appraisal will also be included as part of a final construction certification report documenting the completed RAs and be available for public review. Total estimated cost for implementing this alternative is $600,000.

## 8.6 Recommended RAs

Figure 8-1 is a Site plan showing the recommended RAs at the Southwest Trenches, the Ra/Sr Treatment Systems, and the Domestic Septic System Areas. These RAs are tentatively scheduled to start in May 1998 and potentially be completed by December 1999. A preliminary schedule for completion of these RAs is presented in Figure 8-2.

This EE/CA includes an assessment of the environmental effects of each of the proposed alternatives in accordance with NEPA guidance. No long-term, significant, and adverse environmental impacts are likely to occur from the proposed RA alternatives. Mitigation measures will be implemented to minimize environmental impacts of each RA.

The necessity for ground water monitoring will be evaluated after completion of the RA. At that time additional specific soil concentration data will be available to evaluate the type and extent of ground water monitoring that may need to be conducted should the RA leave residual soil COCs that are not protective of ground water.

Offsite shipment of RA CERCLA waste, whether hazardous or not, will comply with offsite Rule (40 CFR 300.440) to include notification of EPA's offsite rule coordinator of the selected waste destination.

Institutional controls, as defined in Section 5.2.4, are included in the selected alternative based upon currently available data and the analysis provided in this EE/CA. It is not known at this time whether institutional controls will be necessary or whether institutional controls will be adequate should COC levels prove to be higher than expected. Data collected during the RA will be used to assess conformance with RAOs and the need or adequacy of institutional controls.

## 8.7 RA Field Optimization Decision Process

The primary objective of the recommended RAs is to reduce the risk posed by site contaminants to a nominal range of $10^{-4}$ to $10^{-6}$. It is anticipated that the proposed RAs will achieve

the RAOs in a cost-effective manner using institutional controls as described above. However, given the level of uncertainty in the extent of contamination present at the site, the scope of the RA may change during the implementation phase. In order to maximize benefits obtained from the RA (in the form of level of protection of human health and the environment), a conceptual RA optimization flowchart has been developed. This flowchart, presented in Figure 8-3, will be used to guide the remedial decisions that must be made following attainment of the proposed RAOs. This analysis will be required under DOE's ALARA program. This program provides an approach to radiation protection which minimizes workers and the general public's exposure by taking into account social, economical, technical, practical and public policy considerations. Hence, the process described in Figure 8-3 implements the ALARA program by determining whether additional cleanup is reasonable.

Once confirmation sampling and analysis have been performed and it is apparent that the proposed RAs have achieved their objective under the institutional controls scenario, three issues must be evaluated to determine whether any further removal action is deemed necessary. These are:

1. Has anti-degradation ground water protection been attained?

2. Have Alternative 2 RAOs been attained? (thus eliminating the need for institutional controls as defined in Section 5.2.4 – Protocol For Using Institutional Controls).

3. Have residential PRGs been attained? (If not, then residential use would be prohibited or institutional controls will be required to limit residential exposure within the target risk range).

The ground water protection guidelines (i.e. allowable soil concentrations which are protective of ground water) will be developed during the work plan preparation phase of the removal action per request of the RWQCB. As shown in Figure 8-3, if all guidelines and goals have been meet by the RA, no additional removal action would be considered for the site. This recommendation would be forwarded to the regulatory agencies for review and concurrence.

If any of the above guidelines have not been attained upon completion of the RAs, a cost analysis would be performed to evaluate the expected costs and level of remedial effort associated with attaining the particular guideline. The results of the analysis would be presented to the regulatory agencies and DOE for review and comment. Based on regulatory input, if additional removal action is warranted, the scope and objectives of the additional work would be defined and implemented, as necessary.

Table 8-1. Alternative Comparative Analysis Summary for DOE Areas.

| Alternatives/Criteria | Southwest Trenches Area | Ra/Sr Treatment Systems Area | Domestic Septic System Areas |
|---|---|---|---|
| Alternative 1 – No Action | | | |
| Total Cost | $600,000 | $600,000 | $600,000 |
| Advantages | • None | • None | • None |
| Disadvantages | • Not effective in protecting human health or the environment, does not meet RAOs. | • Not effective in protecting human health or the environment, does not meet RAOs. | • Not effective in protecting human health or the environment, does not meet RAOs. |
| **Alternative 2 – Excavation and Off-Site Disposal** | | | |
| Total Cost | | | |
| Risk Level A | $4,100,000 | $3,600,000 | $ - |
| Risk Level B | $5,300,000 | $ - | $ - |
| Risk Level C | $5,600,000 | $ 4,100,000 | $ 600,000 |
| Advantages | • Effective in protecting human health and the environment, meets RAOs. | • Effective in protecting human health and the environment, meets RAOs. | • Effective in protecting human health and the environment, meets RAOs. |
| Disadvantages | • Large uncertainty in volume of waste to be removed, therefore increasing cost and impacting RA schedule and implementation | • Large uncertainty in volume of waste to be removed, therefore increasing cost and impacting RA schedule and implementation | |
| **Alternative 3 – Excavation, Off-Site Disposal, and Institutional Controls** | | | |
| Total Cost | | | |
| Risk Level A | $3,900,000 | $- | |
| Risk Level B | $4,000,000 | $- | |
| Risk Level C | $4,300,000 | $3,200,000 | |
| Advantages | • Effective in protecting human health and the environment, meets RAOs. | • Effective in protecting human health and environment, meets RAOs. | |
| Disadvantages | • Limits future use of the Site and requires establishing a long-term agreement between UCD and DOE for Site use. | • Limits future use of the Site and requires establishing a long-term agreement between UCD and DOE for Site use. | |

$- No costs were estimated at this risk level.
Recommended RA and risk level for each area.

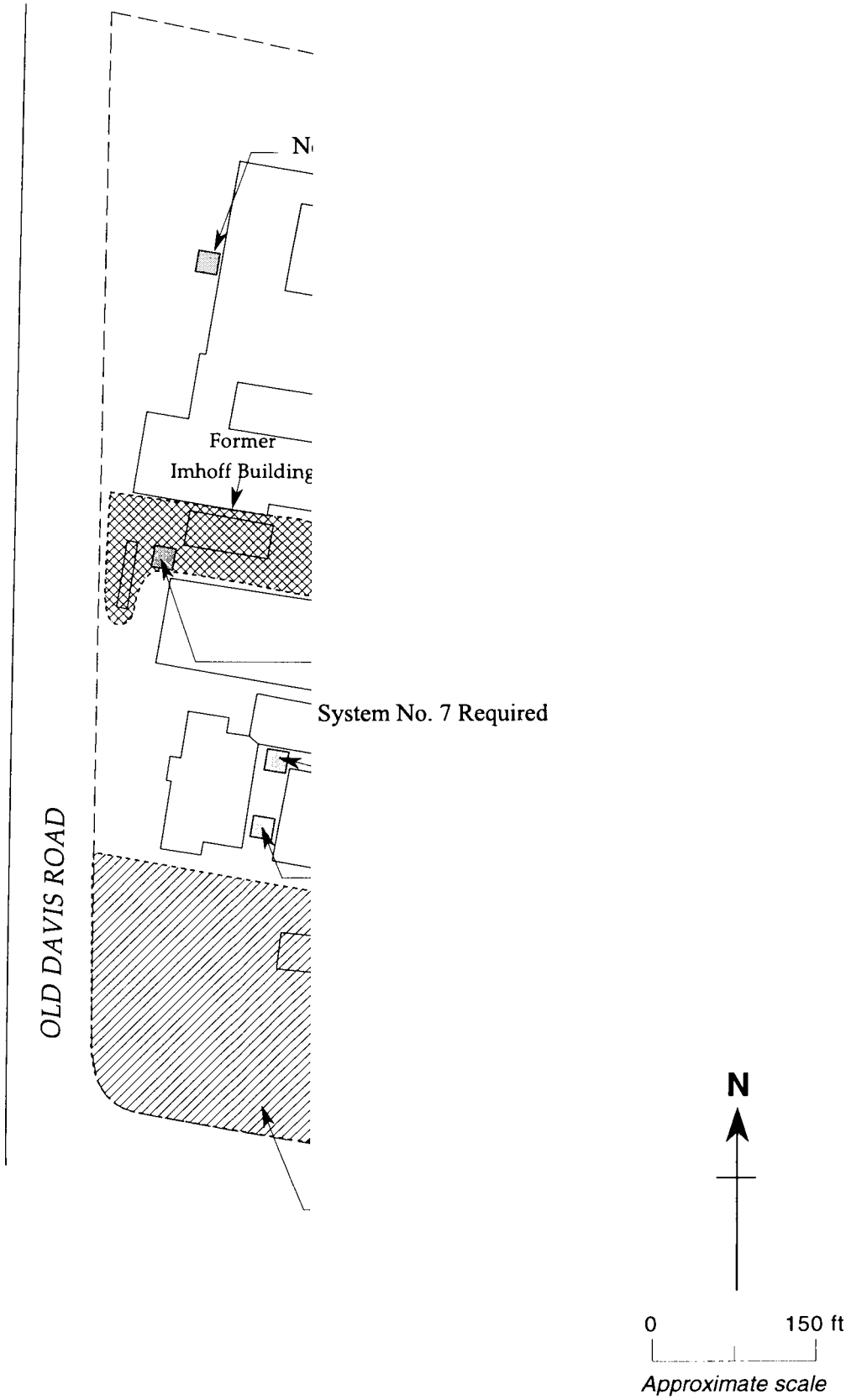



Figure 8-1. Recommended Removal Action for the South

## Figure 8-2 Preliminary Schedule of Proposed Removal Actions

| ID | Task Name |
|---|---|
| 1 | **EE/CA Preparation and Issuance** |
| 2 | Preparation and Review |
| 3 | Public Comment Period |
| 4 | **Pre Removal Action Reports** |
| 5 | Action Memorandum |
| 6 | Removal Action Workplan |
| 7 | **Removal Actions Field Work** |
| 8 | Southwest Trenches |
| 9 | Ra/Sr Treatment Systems Area |
| 10 | Domestic Septic Systems |
| 11 | Off-Site Disposal Activities |
| 12 | Site Wide Confirmation Sampling |
| 13 | **Post Removal Action Reports** |
| 14 | Final Removal Action Report |

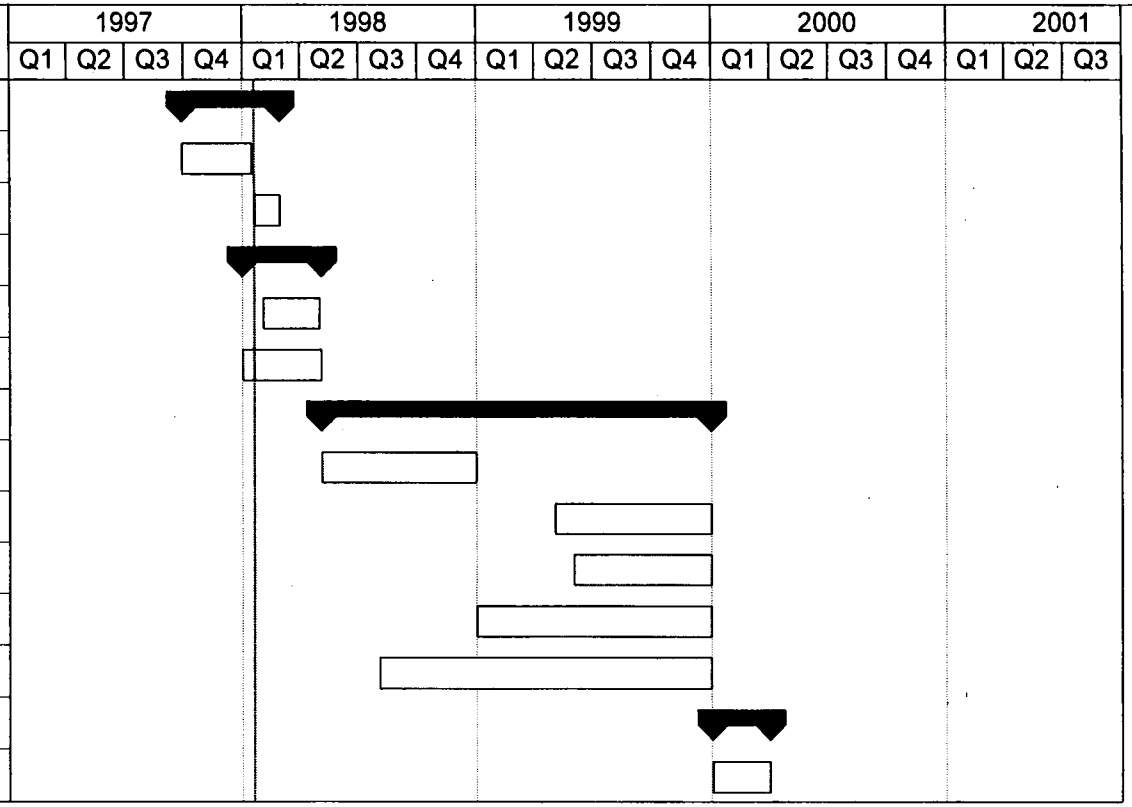
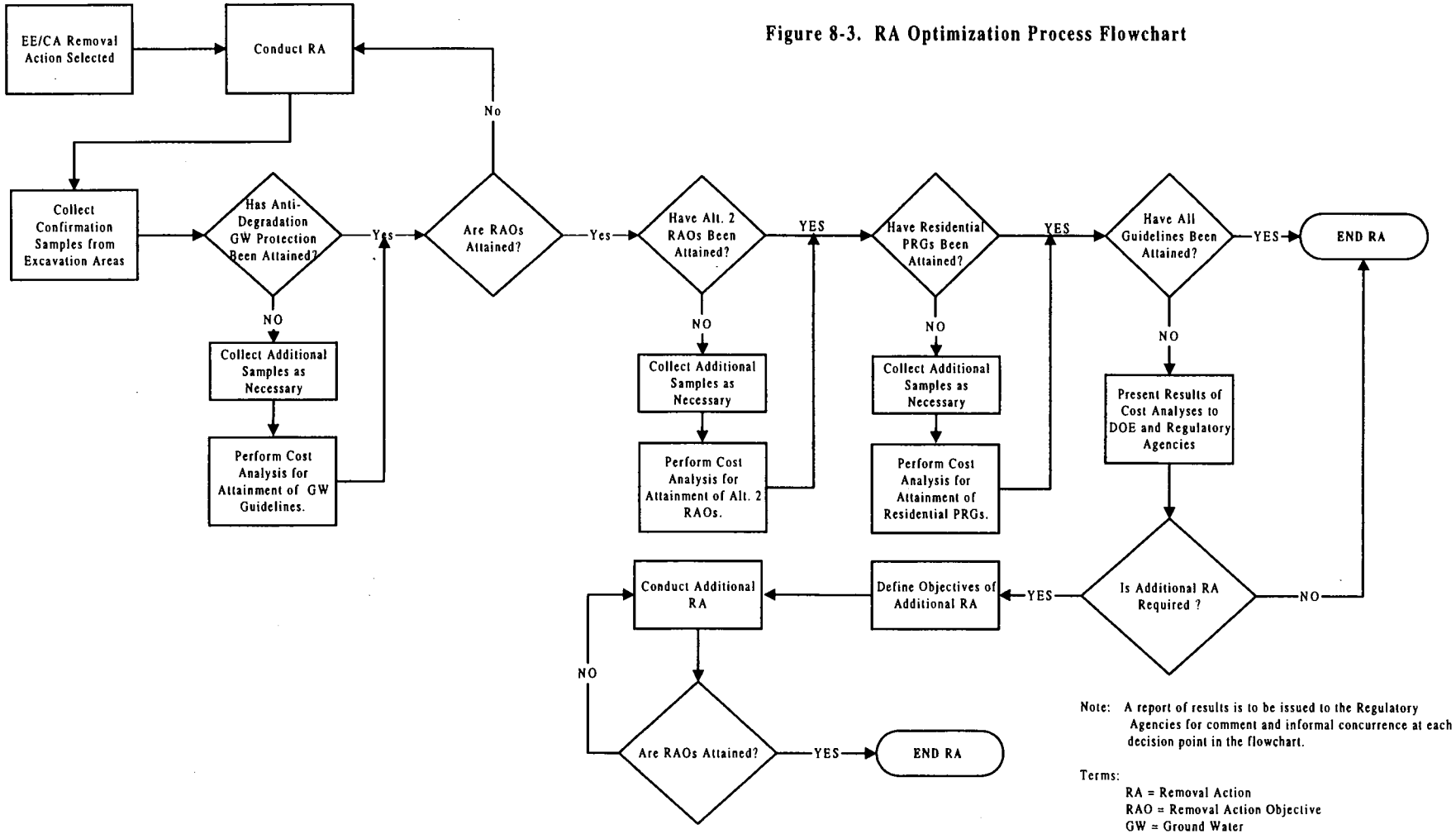


**Figure 8-3. RA Optimization Process Flowchart**




Note: A report of results is to be issued to the Regulatory Agencies for comment and informal concurrence at each decision point in the flowchart.

Terms:
RA = Removal Action
RAO = Removal Action Objective
GW = Ground Water
PRG = Preliminary Remedial Goal

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# APPENDIX A

## ENVIRONMENTAL SETTING – SUPPORT DOCUMENTATION AND INFORMATION

Appendix A-1 Ground Water Constituents of Primary Concern

Appendix A-2 Photographs of the Project Site and the South Fork of Putah Creek

Appendix A-3 Ambient Air Quality Information Relating to Air Pollutants of Concern

# APPENDIX A-1

## GROUND WATER: CONSITUENTS OF PRIMARY CONCERN

Source: UC Davis, Final Tiered Initial Study Laboratory for Energy-Related Health Research and South Campus Disposal Site (LEHR/SCDS) Interim Remedial Actions (State Clearinghouse No. 97042095), University of California, Davis, June 6, 1997. Pages 11 through 13.

Hydrographs[2] have been maintained for HSU-1 and HSU-2 wells for over six years. Water levels across the site in HSU-1 and HSU-2 are typically highest in March and April, decline rapidly from April to August, and recover from September through March. Seasonal/annual fluctuations since 1990 range from a maximum drop in water elevation of approximately 40 feet between August 1994 and March 1995 to a minimum drop of 15 feet between August 1993 and March 1994 (PNNL, 1996). The seasonal changes in water levels are primarily due to pumping from HSU-2 and deeper intervals to supply local agriculture during the summer months. Water levels in both HSU-1 and HSU-2 also respond to changes in river stage in Putah Creek. HSU-1 wells located near Putah Creek respond directly to changes in stage level: when water levels in the creek rise, a rise in groundwater elevations in HSU-1 also occurs. However, HSU-2 wells located near Putah Creek show a dampened response to stage level changes.

*Distribution of Constituents of Primary Concern*

Distribution of each constituent of primary concern discussed below is presented on Figures 4 through 7.

Three types of constituents of primary concern at the LEHR/SCDS site include 1) chloroform and other volatile organic compounds (VOCs); 2) chromium (primarily as chromium VI in groundwater); and 3) nitrate. These three constituents are considered representative of the main types of constituents found at the LEHR/SCDS site for the following reasons, and they are more widely found and/or are found in higher concentrations than other similar constituents:

- Chloroform is the only VOC of concern detected downgradient of the source and off-site. The actions required to capture chloroform would result in the capture of the other detected VOCs.
- Hexavalent chromium is more mobile and represents a higher risk to human health than other chromium species, and is present in groundwater at the LEHR/SCDS site. Based on mobility and the distribution of chromium at the LEHR/SCDS site, 80 percent or more of the chromium detected in LEHR/SCDS groundwater is considered to be the hexavalent form.
- Nitrate is the most widespread constituent of concern, and is the most common dissolved solid or salt in the area and on the project site.

Because treatment options and results would be the same for similar constituents, effective containment or removal of these three primary constituents would also result in effective containment/removal of similar constituents. Therefore, although other constituents may occur the project site, these three constituents of concern are treated as representative.

In addition to these three representative constituents, tritium is another constituent of concern found at the site. Tritium is more prevalent and more mobile than other project area radionuclides; other radionuclides detected on site are not found consistently either in soil or groundwater and are not known to be present in concentrations that require treatment of groundwater. Therefore, while tritium is a constituent of concern, it is not representative of a class or type of constituent found at the project site.

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[2] A hydrograph is a plot of groundwater elevations versus time.

*Chloroform*

Chloroform is the only VOC of concern detected downgradient of the source and off-site. The actions required to capture chloroform would result in the capture of the other VOCs detected. Therefore, this discussion focuses on chloroform as representative.

Chloroform and other VOC concentrations in soil gas are highest in the northern part of inactive Landfill Unit No. 2 and near the eastern disposal trenches (Figure 4). Based on soil gas sampling results, chloroform appears to have been released near the ground surface. Chloroform concentrations in groundwater at the LEHR/SCDS site decrease with depth near the suspected source areas (north portions of inactive Landfill Unit No. 2 and eastern trenches), and increase with depth downgradient of the source areas. Chloroform in HSU-1 occurs at higher concentrations (above 1,000 $\mu$g/L) in samples from well UCD1-12 and in hydropunch locations in the area immediately east and downgradient of UCD1-12. Further downgradient, however, HSU-1 concentrations decrease rapidly to values near the detection limit at the property boundary.

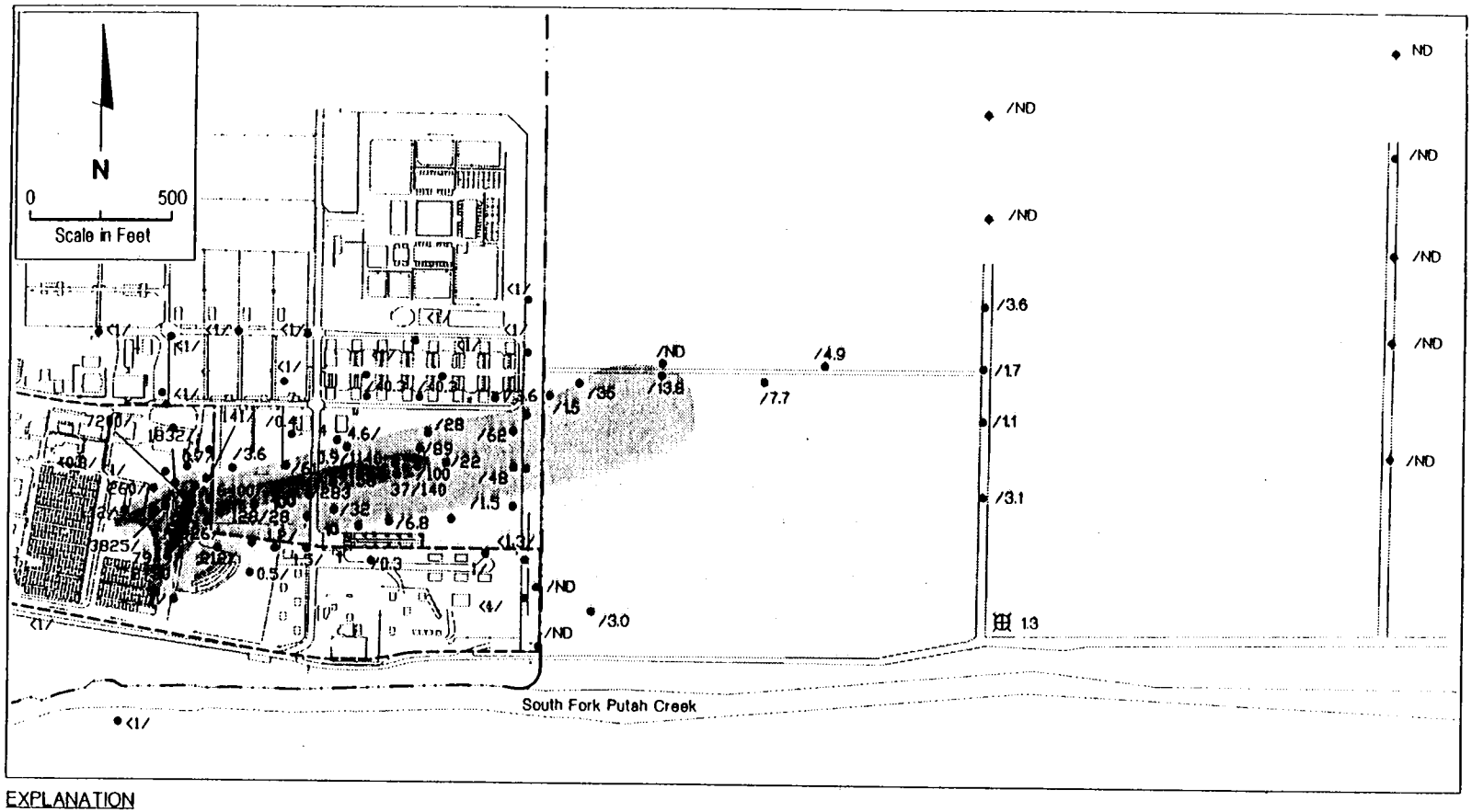
In HSU-2, data on chloroform are primarily from hydropunch samples and wells recently installed in response to recommendations of the 1994 Remedial Investigation/Feasibility Study (RI/FS) and IRA work plan. These data show that chloroform impacts are more widely distributed in HSU-2 and extend over 2,000 feet past the UC Davis property boundary (Figure 4). Chloroform has also been reported in at least two off-property agricultural wells downgradient of the site. Chloroform concentrations are highest in the middle and upper portions of HSU-2. Chloroform in the vicinity of anticipated IRA extraction is approximately 100 $\mu$g/L, as reported from extraction EW2-1 and monitoring wells UCD2-29, UCD2-30, and UCD2-31 (Dames & Moore, 1994).

*Hexavalent Chromium and Chromium*

Hexavalent chromium is more mobile and represents the higher risk to human health than other chromium species, and is present in groundwater at the LEHR/SCDS site. Based on mobility and the distribution of chromium at the LEHR/SCDS site, 80 percent or more of the chromium detected in LEHR/SCDS groundwater is considered to be the hexavalent form. As a result, discussion of chromium and hexavalent chromium in groundwater at the project site focuses on hexavalent chromium.

The total chromium maximum contaminant level (MCL)[3] is 50 mg/L. Hexavalent chromium concentrations in groundwater at the LEHR/SCDS site decrease with depth. Within HSU-1, two areas of hexavalent chromium-contaminated groundwater are present; one is centered north of inactive Landfill Unit No. 2, and the other is located northeast of inactive Landfill Unit No. 1. Both areas contain hexavalent chromium above the MCL, with the highest concentration reported for new HSU-1 well UCD1-28 at 550 mg/L located near the anticipated extraction well. In HSU-2, only a few detections of hexavalent chromium have been reported, and impacts are both lower in concentration and less widely distributed then in HSU-1. Downgradient data from wells recently

[3] Maximum Contaminant Level (MCL): Enforceable primary drinking water standards for California, adopted into regulation under the Safe Drinking Water Act. These standards are provided by the Department of Health Services as interim guidance for "safe" levels of contaminants in drinking water.




EXPLANATION

37/140 HSU-1 Concentration/HSU-2 Concentration

HSU-2 Concentration Contour (Middle Zone)

ND Non-detected

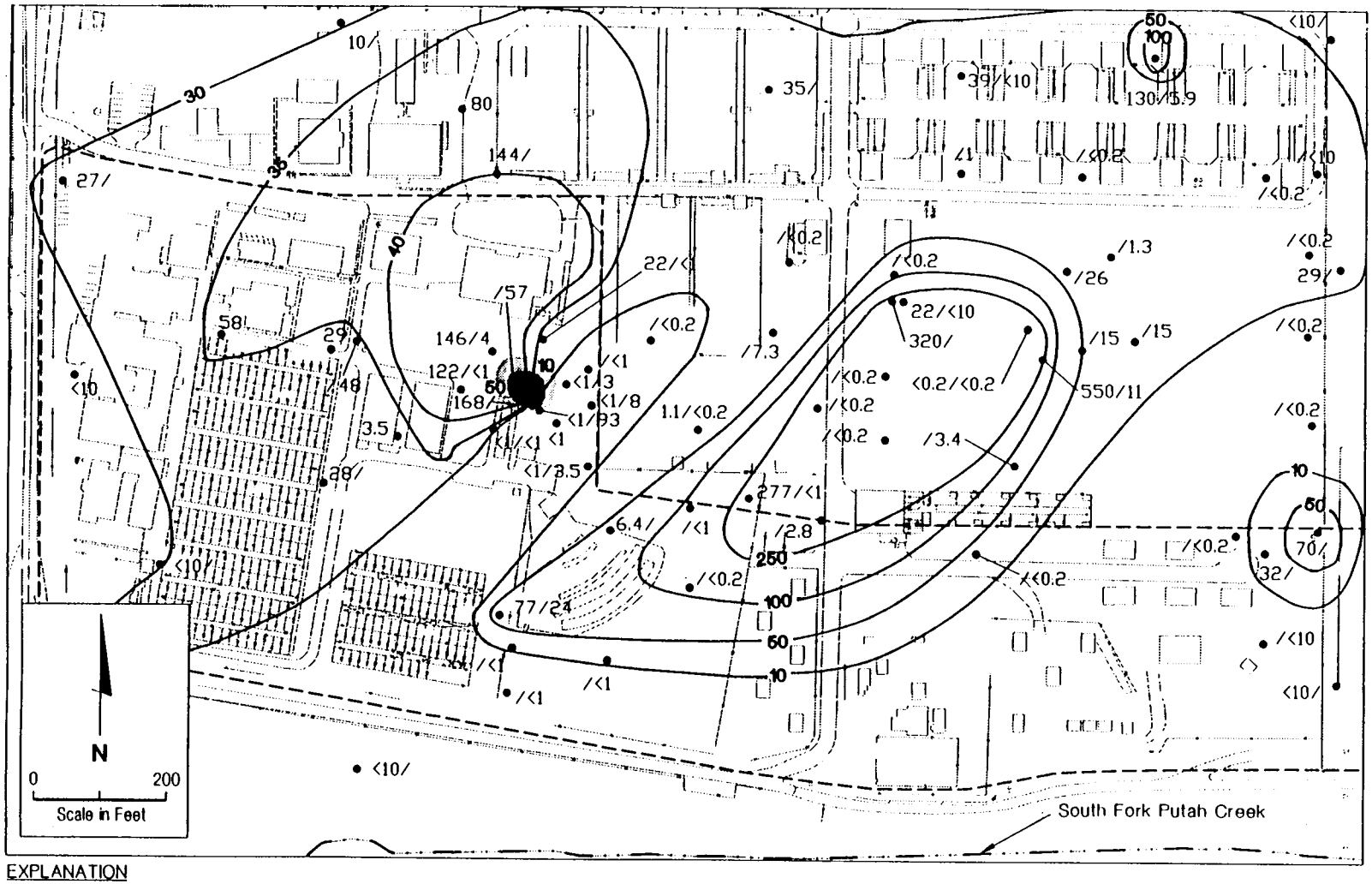
All Results Reported in ug/L

Campus Boundary

LEHR/SCDS Boundary

**CONCENTRATION CONTOUR PLOT**
**CHLOROFORM IN HSU-2**
LEHR/SCDS Groundwater IRA
LEHR Environmental Restoration
Davis, California
FIGURE 4

DAMES & MOORE
A DAMES & MOORE GROUP COMPANY




EXPLANATION

15/4.1 HSU-1 Concentration/HSU-2 Concentration

HSU-1 Concentration Contour

HSU-2 Concentration Contour

Campus Boundary

LEHR/SCDS Facility Boundary

All Results Reported in ug/L

DAMES & MOORE
A DAMES & MOORE GROUP COMPANY

# CONCENTRATION CONTOUR PLOT HEXAVALENT CHROMIUM IN HSU-1 AND HSU-2

LEHR/SCDS Groundwater IRA
LEHR/SCDS Environmental Restoration
Davis, California

FIGURE 5

installed in response to recommendations of the 1994 RI/FS and IRA work plan support these previous findings with relatively high detections reported from HSU-1 wells, but results below or near detection limits reported for wells screened in HSU-2.

*Nitrate as Nitrogen and Total Dissolved Solids (TDS)*[4]

Nitrate concentrations in project site soils are within the background range (16 to 222 $\mu$g/L) across most of the site, with some slightly elevated concentrations reported in waste zones in the eastern disposal trenches and the inactive landfill units (Figure 6).

The nitrate MCL is 10 mg/L, and the TDS MCL is 500 mg/L. Nitrate and TDS, essentially "salts", are the most widespread of the constituents of concern in both HSU-1 and HSU-2. Regionally, nitrate in groundwater is elevated above the MCL of 10 mg/L. Much of the groundwater within HSU-1 beneath the site and surrounding property contains nitrate at concentrations above the MCL, with the highest concentrations reported downgradient of the dog pens and beneath all three landfill units. The upper portion of HSU-2 also contains nitrate in excess of the MCL. Concentrations of TDS in HSU-2 are consistently reported above the MCL of 500 mg/L in downgradient wells UCD2-7 and UCD2-14. The highest concentrations of nitrate and TDS in HSU-2 are reported in a similar area (but at lower concentrations) to the areas of highest concentrations reported in HSU-1.

*Tritium*

The most significant and consistently reported radionuclide in groundwater at the LEHR/SCDS site is tritium (Figure 7); tritium is more prevalent and more mobile than other project area radionuclides. Other radionuclides detected on site are not found consistently either in soil or groundwater and are not known to be present in concentrations that require treatment of groundwater. Tritium and other radionuclides in soil have been reported as elevated in soil samples collected from the waste zone in the waste burial pits and the southern part of the eastern trenches, both at relatively shallow depths (less than 10 feet bgs).

The tritium MCL is 20,000 pCi/L. Historic tritium concentrations have been detected up to 30,000 pCi/L, with the most recent round of groundwater sampling showing tritium concentrations in groundwater highest in HSU-1 (17,893 pCi/L) and decreasing with depth into HSU-2.The highest concentrations of tritium are located in the vicinity of the eastern trenches and just downgradient of the waste burial holes, the likely source area. As seen with many other compounds, the lateral distribution of tritium in HSU-1 appears to be limited to a relatively small area downgradient of the probable source areas. Tritium concentrations decrease with depth in HSU-2. Other radionuclides have not been detected in groundwater at concentrations requiring treatment.

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[4] Total Dissolved Solids (TDS): The total mass of solid residue obtained by evaporating a measured volume of filtered sample to dryness. The solid residue consists mainly of organic material with small amount of inorganic material.

# APPENDIX A-2

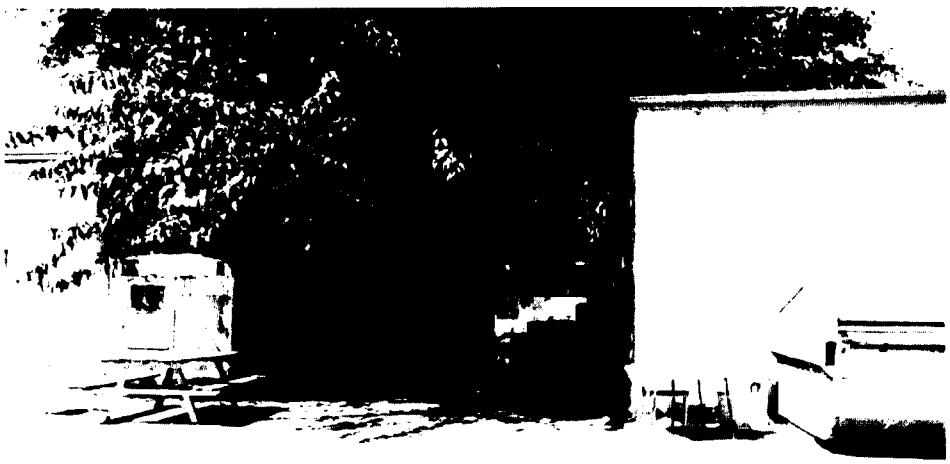
## PHOTOGRAPHS OF THE PROJECT SITE AND THE SOUTH FORK OF PUTAH CREEK

Note: Photographs were taken on July 7, 1997.

Southwest Trenches Area (looking westward).

Radium/Strontium Treatment Area (under pavement in foreground), fenced area is where the Imhoff system was located.

South Fork of Putah Creek along Old Davis Road (looking eastward) in the vicinity of LEHR site.



One of the locations of the domestic septic tanks (identified as numbers 3 and 4) located in shaded area between the buildings.

# APPENDIX A-3

## AMBIENT AIR QUALITY INFORMATION RELATING TO AIR POLLUTANTS OF CONCERN, IN VICINITY OF THE LEHR SITE

Source: Draft Environmental Impact Report Wastewater Treatment Plant Replacement Project, University of California, Davis, Planning and Budget Office, University of California, Davis, October 1996. Pages 4.2-2 and 4.2-10.

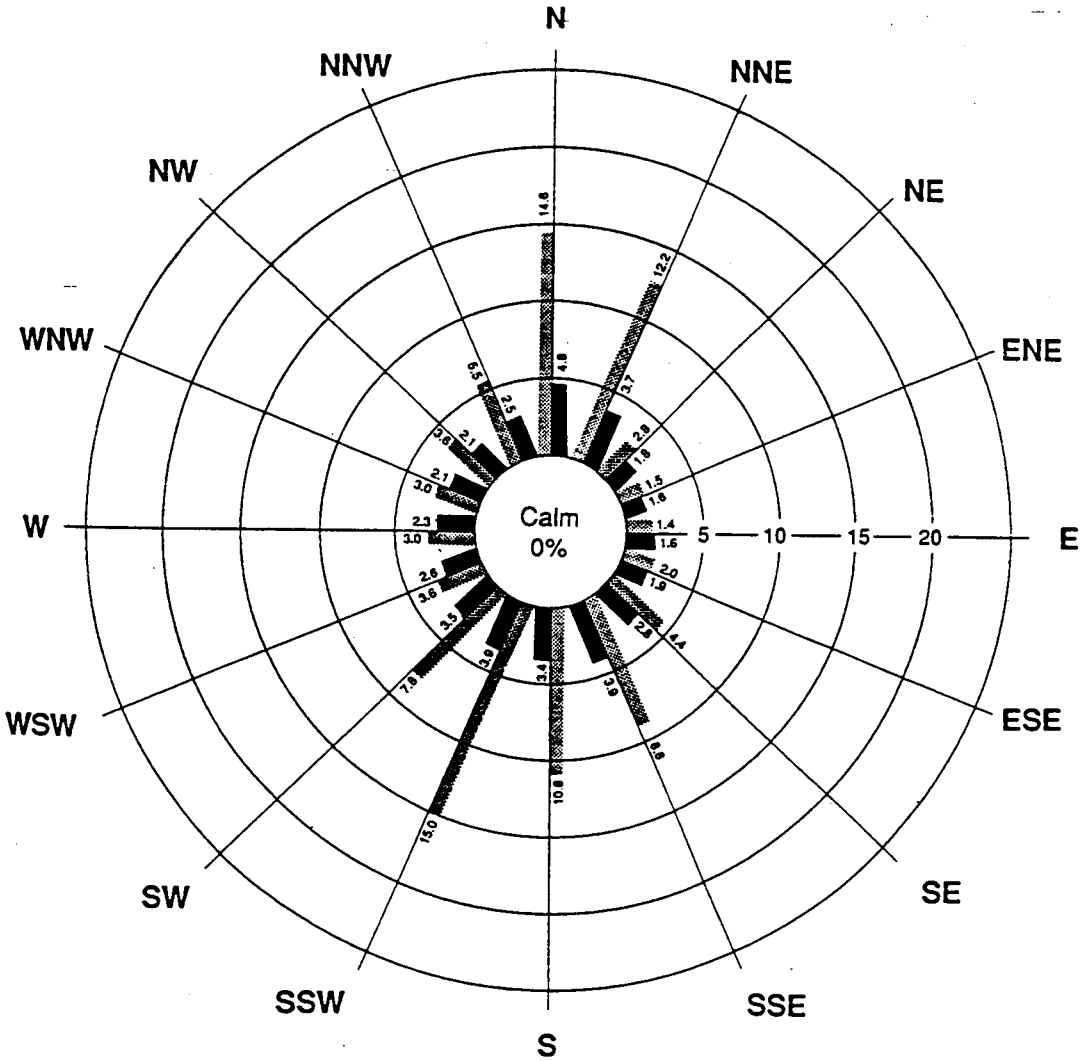
Geography plays a significant role in weather patterns throughout the California Central Valley, including the Campus area. The Central Valley, which extends from south of Bakersfield to north of Redding, is bordered by the Sierra Nevada on the east, the Coast Ranges on the west, the Tehachapi Range on the south, and the Cascade Range on the north. These mountain ranges tend to buffer the valley from the marine weather systems that originate over the Pacific and are drawn inland by the jet stream. The only breach in this barrier is the Carquinez Straits, which expose the midsection of the Central Valley to Pacific Coast marine weather patterns. The Sacramento area is noticeably affected by this marine influence, which helps moderate climatic extremes. The cooling effect of the sea breezes is especially evident on summer evenings.

The UC Davis campus is in Yolo and Solano counties, both of which are within the Sacramento Valley Air Basin (SVAB). Climate in the Davis area is characterized by long, hot, dry summers and short, cool winters. Summer temperatures range from an average low of 55°F to an average high of 98°F, with temperatures in excess of 100°F common. This high average summer temperature, combined with very low relative humidity, produces hot, dry summers. Temperature inversions, which limit the vertical dispersion of air pollutants, concentrate pollutants and exacerbate air pollution problems. These inversions are prevalent at night during autumn and winter and occasionally persist throughout the day. Winter temperatures range from an average low of 37°F to an average high of 61°F, with occasional overnight freezing temperatures. Annual precipitation averages 17 inches, with 88% of the precipitation falling in November through April. Predominant winds are from the south 35% of the time, at a speed of about 4 miles per hour. A wind rose indicating wind and speed direction for the project area is shown in Figure 4.2-1.

### Criteria Pollutants

Historically, air quality laws and regulations have divided airborne pollutants into two broad categories: "criteria pollutants" and "TACs". Federal and state air quality standards have been established for six ambient air pollutants, commonly referred to as "criteria" air pollutants. In general, "criteria" pollutants are pervasive constituents, such as those emitted in vast quantities by use of fossil fuels. These standards were developed primarily to protect human health and welfare and were so named because the U.S. Environmental Protection Agency (EPA) published criteria documents to justify the choice of each standard. The criteria air pollutants for which federal and state ambient standards have been established include ozone ($O_3$), carbon monoxide (CO), nitrogen oxides ($NO_x$), sulfur dioxide ($SO_2$), inhalable particulates (PM10), and lead. Criteria pollutants are regulated separately from TACs at both the federal and state levels.

The SVAB includes nine counties—Shasta, Tehama, Glenn, Butte, Colusa, Sutter, Yuba, Yolo, and Sacramento—and the valley portion of two other counties, Solano and Placer. The criteria pollutants of greatest concern in the SVAB include $O_3$, PM10, and CO. Although high $NO_x$ concentrations are not found in the SVAB, $NO_x$ plays a critical role in $O_3$ formation. Lead and $SO_2$ are not considered critical criteria pollutants because they are not pervasive in the SVAB and because they will not be emitted in substantial quantities by the proposed project. Information on critical criteria pollutants that are of concern to the Yolo-Solano Air Quality Management District




Based on 25,340 hourly observations from 1979 to 1982.

LEGEND
Percent by direction
Mean wind speed (mph)

Source: California Air Resources Board 1984.

Jones & Stokes Associates, Inc.

**Figure 4.2-1**
**Windrose Depicting Average Wind Speed and Directional Frequency at Davis, California**

(YSAQMD) and EPA (such as chemical form, generation mechanisms, and environmental fate) is presented below. Health effects of criteria pollutants of regulatory concern in the SVAB are described in Table 4.2-1.

**Carbon Monoxide**

CO is an odorless, invisible gas usually formed as the result of incomplete combustion of organic substances. As presented in Table 4.2-1, high levels of CO can impair oxygen transport in the bloodstream, thereby aggravating cardiovascular disease and also causing fatigue, headaches, and dizziness. Motor vehicles are a primary source of CO. CO tends to dissipate rapidly into the atmosphere, and consequently, violations of the CO standard are generally limited to major intersections during peak-hour traffic conditions.

**Ozone/Nitrogen Oxides**

Reactive organic gases (ROG) and $NO_x$ are primary pollutants that are emitted directly into the environment as exhaust from motor vehicles and other combustion sources. Secondary or indirect pollutants are formed in the atmosphere, usually as the result of a reaction involving primary pollutants. $O_3$ is a secondary pollutant that forms as a result of the interaction of ultraviolet light, ROG, and $NO_x$. During summer, $O_3$ is also of primary concern; a PSI of 100 is the maximum $O_3$ level at which the federal government considers air quality to be healthy. The major effects of $O_3$ and other components of photochemical smog include reductions in plant growth and crop yield, chemical deterioration of various materials, and irritation of the respiratory system and eyes.

A highly reactive molecule, $O_3$ readily combines with many different components of the atmosphere. Consequently, high levels of $O_3$ tend to exist only while high ROGs and $NO_x$ levels are present to sustain the $O_3$ formation process. Once the precursors have been depleted, O levels rapidly decline. Motor vehicles are a primary source of ROGs and $NO_x$.

**Particulate Matter**

Particulate matter consists of small liquid droplets or solid particles suspended in the atmosphere that are generated by industrial and agricultural operations, motor vehicle exhaust, stationary combustion sources, atmospheric photochemical reactions, construction activities, and agricultural waste burning.

Current EPA standards define acceptable concentrations of particulates that are smaller than 10 microns in diameter, referred to as PM10. Particulate matter can cause a wide range of health and safety effects, including respiratory irritation, visibility reduction, and soiling of structures and materials.

Table 4.2-1. Health Effects Summary of Criteria Air Pollutants of Regulatory Concern in the SVAB

| Air Pollutant | Adverse Effects |
|---|---|
| Ozone ($O_3$) | Eye irritation |
| | Respiratory function impairment |
| Carbon monoxide (CO) | Impairment of oxygen transport in the bloodstream, increase of carboxyhemoglobin |
| | Aggravation of cardiovascular disease |
| | Impairment of central nervous system function |
| | Fatigue, headache, confusion, dizziness |
| | Can be fatal in the case of very high concentrations in enclosed places |
| Particulate matter (PM10) | Increased risk of chronic respiratory disease with long exposure |
| | Altered lung function in children |
| | In combination with $SO_2$, may produce acute illness |
| | Particulate matter 10 microns or less in size (PM10) may lodge in and/or irritate the lungs |

Source: Bay Area Air Quality Management District 1985.

**Ambient Standards for Criteria Pollutants**

Air quality is evaluated based on ambient air quality standards developed by federal and state agencies. The Clean Air Act (CAA) of 1970 established national ambient air quality standards (NAAQS), with states retaining the option to adopt more stringent standards or to include other specific pollutants. Because California had standards in place before federal standards were established, and because of unique meteorological problems in the state, there is considerable diversity between state and federal standards in effect in California, as shown in Table 4.2-2.

The NAAQS are the levels of air quality considered by regulators to be necessary to protect the public health and welfare. The "primary" standards are levels of air quality necessary, with an adequate margin of safety, to protect the public health. The primary standards are designed to protect segments of the public considered to be most susceptible to respiratory distress, including asthmatics, children, the elderly, people weak from other illness or disease, and persons involved in heavy work or exercise. Healthy adults can tolerate periodic exposure to air pollution levels somewhat above these standards before adverse health effects are observed. "Secondary" standards are designed to protect the public welfare from any known or anticipated adverse effects of a pollutant.

In addition to the six criteria pollutants that are regulated by both the state and federal governments, four pollutants are regulated by the state only: sulfates, hydrogen sulfide, vinyl chloride, and visibility-reducing particles. The standards for these pollutants also are presented in Table 4.2-2. The status of sulfates, hydrogen sulfide, and visibility-reducing particles is unclassified in the SVAB because monitoring data on these pollutants are limited. State law does not require a designation for vinyl chloride.

The hydrogen sulfide standard was created to reduce odors. Hydrogen sulfide typically creates smells similar to rotten eggs. Hydrogen sulfide is produced in petroleum processing, in geothermal power plants, and by the decomposition of organic matter under anaerobic conditions (such as those that can occur in wastewater treatment systems).

**Air Quality Monitoring Results**

The California Air Resources Board (CARB) and YSAQMD maintain ambient air quality monitoring stations at numerous locations throughout the SVAB. The stations measure criteria pollutant levels and assist in the determination of agricultural "burn" days. The monitoring station for the Davis area, operated by the CARB, is on the Campus, west of Highway 113 and south of Hutchison Drive. This air quality monitoring station collects $O_3$ data. The closest monitoring station that collects CO and PM10 data is in Woodland. Table 4.2-3 is a summary of the highest annual concentrations of $O_3$, CO, and PM10 for 1988-1994, the most recent 7-year period for which data are available. In Table 4.2-3, ambient air pollutant concentrations are compared with the state ambient air quality standards, which are more stringent than the corresponding federal standards. Measured CO levels nearest to the project site did not violate the state 1-hour or 8-hour standards during 1988-1994. Table 4.2-3 shows that the PM10 standard was violated regularly at the

Table 4.2-2. Ambient Air Quality Standards Applicable in California

| Pollutant | Symbol | Average Time | Standard, as parts per million | | Standard, as micrograms per cubic meter | | Violation Criteria | |
|---|---|---|---|---|---|---|---|---|
| | | | California | National | California | National | California | National |
| Ozone | $O_3$ | 1 hour | 0.09 | 0.12 | 180 | 235 | If exceeded | If exceeded on more than 3 days in 3 years |
| Carbon monoxide | CO | 8 hours | 9.0 | 9 | 10,000 | 10,000 | If exceeded | If exceeded on more than 1 day per year |
| | | 1 hour | 20 | 35 | 23,000 | 40,000 | If exceeded | If exceeded on more than 1 day per year |
| (Lake Tahoe only) | | 8 hours | 6 | N/A | 7,000 | N/A | If exceeded | N/A |
| Nitrogen dioxide | $NO_2$ | Annual average 1 hour | N/A | 0.053 | N/A | 100 | N/A | If exceeded |
| | | | 0.25 | N/A | 470 | N/A | If exceeded | N/A |
| Sulfur dioxide | $SO_2$ | Annual average | N/A | 0.03 | N/A | 80 | N/A | If exceeded |
| | | 24 hours | 0.04 | 0.14 | 105 | 365 | If exceeded | If exceeded on more than 1 day per year |
| | | 1 hour | 0.25 | N/A | 655 | N/A | N/A | N/A |
| Hydrogen sulfide | $H_2S$ | 1 hour | 0.03 | N/A | 42 | N/A | If equaled or exceeded | N/A |
| Vinyl chloride | $C_2H_3Cl$ | 24 hours | 0.010 | N/A | 26 | N/A | If equaled or exceeded | N/A |
| Inhalable particulate matter | PM10 | Annual geometric mean | N/A | N/A | 30 | N/A | If exceeded | N/A |
| | | Annual arithmetic mean | N/A | N/A | N/A | 50 | N/A | If exceeded |
| | | 24 hours | N/A | N/A | 50 | 150 | N/A | If exceeded on more than 1 day per year |
| Sulfate particles | $SO_4$ | 24 hours | N/A | N/A | 25 | N/A | If equaled or exceeded | N/A |
| Lead particles | Pb | Calendar quarter | N/A | N/A | N/A | 1.5 | N/A | If exceeded no more than 1 day per year |
| | | 30 days | N/A | N/A | 1.5 | N/A | If equaled or exceeded | N/A |

Notes: All standards are based on measurements at 25°C and 1 atmosphere pressure.
National standards shown are the primary (health effects) standards.
N/A = not applicable.

Table 4.2-3. Criteria Air Pollutant Monitoring Summary, 1988-1994

| Pollutant | Monitoring Data by Year[a] | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 |
| **Ozone ($O_3$)** | | | | | | | |
| State 1-hour standard (ppm)[b] | 0.09 | 0.09 | 0.09 | 0.09 | 0.09 | 0.09 | 0.09 |
| Highest 1-hour average (ppm)[b] | *0.11 | *0.10 | *0.11 | *0.10 | *0.12 | *0.13 | *0.10 |
| Violations of standard | 15 | 1 | 4 | 4 | 20 | 4 | 4 |
| **Carbon Monoxide (CO)** | | | | | | | |
| State 1-hour standard (ppm)[b] | 20.0 | 20.0 | 20.0 | 20.0 | 20.0 | 20.0 | 20.0 |
| Highest 1-hour average (ppm)[b] | 9.0 | 13.0 | 12.0 | 7.0 | 7.0 | 6.0 | 6.6 |
| Violations of standard | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| State 8-hour standard (ppm)[b] | 9.0 | 9.0 | 9.0 | 9.0 | 9.0 | 9.0 | 9.0 |
| Highest 8-hour average (ppm)[b] | 4.9 | 5.4 | 5.0 | 3.5 | 3.9 | 3.4 | 5.1 |
| Violations of standard | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Particulate Matter (PM10)** | | | | | | | |
| State 24-hour standard ($\mu g/m^3$)[c] | 50 | 50 | 50 | 50 | 50 | 50 | 50 |
| Highest 24-hour average ($\mu g/m^3$)[c] | *96 | *113 | *80 | *102 | *103 | *96 | *84 |
| Violations of standard | 19 | 8 | 7 | 10 | 16 | 9 | 5 |
| State annual geometric mean standard ($\mu g/m^3$)[c] | 30 | 30 | 30 | 30 | 30 | 30 | 30 |
| Annual geometric mean ($\mu g/m^3$)[c] | *33.6 | *30.4 | 25.8 | *39.1 | *37.6 | 25.5 | 26.0 |

Notes: * = value is in excess of California standards.

[a] Ozone data are from the UC Davis campus. PM10 (1988-1994) and CO (1988-1993) data are from the West Main Street station in Woodland. CO data (1994) are from the Davis Russell Boulevard monitoring station.
[b] ppm = parts per million.
[c] $\mu g/m^3$ = micrograms per cubic meter.

Source: California Air Resources Board 1989-1995.

Woodland monitoring station during this 7-year period. Also, the $O_3$ standard was violated during each of these years.

The standards for $NO_x$, $SO_2$, and lead are being met within the region, and trends in historical data on ambient concentrations of these pollutants do not indicate that state or federal standards will be exceeded in the future.

California has adopted ambient standards that are more stringent than the federal standards for criteria air pollutants. Under the California Clean Air Act (patterned after the federal CAA), areas are designated as "attainment areas", "nonattainment areas", or "unclassified" with respect to meeting state ambient air quality standards. The SVAB is a nonattainment area for $O_3$ and PM10 under state standards. The SVAB also exceeds the CO standard in some urban areas but not within Solano or Yolo County. Solano and Yolo counties are designated as an attainment area under state and federal CO standards.

### Toxic Air Contaminants

TACs are a category of air pollutants that are highly poisonous in small doses. Examples include certain chlorinated hydrocarbons, certain metals, and asbestos. Adverse health effects of TACs may be carcinogenic (cancer causing), short-term (acute) non-carcinogenic, and long-term (chronic) non-carcinogenic. Several hundred such pollutants are currently regulated under various federal, state, and local programs.

Toxic air contaminants are generated by various sources, including stationary sources, such as dry cleaners, gas stations, and laboratories; mobile sources, such as automobiles, aircraft, railroads; natural sources, such as wind-blown dust and wildfires; and area sources, such as farms, construction sites, and residential areas.

The Davis area has many typical community sources of TACs, including dry cleaners, automobiles, and research laboratories. Frequent crop burning in the Davis area is also a substantial source of TACs. Other sources of TAC emissions in the Davis area are UC Davis research laboratories, the Campus WWTP, the Campus pathological waste incinerator, and other miscellaneous sources.

Monitoring stations for TACs are located throughout the state. These stations, maintained either by the CARB or the local air quality district, monitor and record levels of various organic gases and metals in air. The YSAQMD does not conduct TAC monitoring within its jurisdiction.

The TAC monitoring station closest to Davis is in Citrus Heights, northeast of the City of Sacramento, and is operated by the CARB. The land uses in the vicinity of the monitoring station are highly urban and are different from those near UC Davis. Data from this monitoring station are not considered representative of background concentrations in Davis because concentrations of many TACs are highly dependent on the proximity and types of contaminant sources.

One EPA study provides a general idea of the importance of community sources of air toxics in terms of health risk. This study, which considered cancer-related health risks resulting from air toxics in five cities, evaluated the relative contribution to cancer incidence of a number of common city sources of air toxics, as shown in Table 4.2-4. As the table indicates, road vehicles were found to cause more than 50% of the air-toxics-related health risk in the cities studied. Industrial sources, such as chrome platers, solvent users, and other manufacturing, were responsible for more than 20% of the identified risk. Other common community sources, such as fireplaces, gasoline stations, and hospital sterilizers, made up about 10% of the risk.

Although this study is not specific to Davis, the results can be viewed as indicative of the probable scale and relative importance of sources of air-toxics-related health risk likely to exist in the Davis area. Specifically, it is likely that automobiles are the major source of air toxics emissions and related health risk in Davis. Davis has little industry so it probably has less industry-related air toxics health risk than the cities studied. However, area agricultural operations (including field burning) probably contribute to the air toxics health risk. Overall, the EPA study found that the average cancer incidence attributable to airborne toxic substances was 5.8 cases of cancer per year per million city residents. If this is considered over an average lifetime of approximately 70 years (the standard lifetime considered in HRAs), the lifetime cancer risk from air toxics would be 400 cases of cancer per million city residents.

**Odors**

An individual's sensory perception of odors has four major dimensions: detectability, intensity, character, and hedonic tone. Detectability consists of two components: the detection threshold and recognition threshold. The detection threshold is the lowest concentration of an odor that will elicit a sensory response; at this concentration there is an awareness of the presence of an added substance, but not necessarily an odor sensation. The recognition threshold, however, is the minimum concentration that is recognized as having a characteristic odor quality by a population. Odor intensity refers to an individual's perceived strength of the odor sensation. Odor character is what the substance smells like (e.g., fish, hay, sewer, turpentine, ammonia). Hedonic tone is a categorical judgment of the relative pleasantness or unpleasantness of the odor and is influenced by factors such as subjective experience and frequency of occurrence. Each of these elements plays a role in an individual's identification of odor impacts.

Currently, there are several odor emission sources on the Campus. The major odor emission source is animal waste associated with confined animal facilities. Other sources include the WWTP, motor vehicles, and the Campus landfill.

# APPENDIX B

## CALCULATION OF BACKGROUND CONCENTRATIONS

# B. CALCULATION OF BACKGROUND CONCENTRATIONS

## B.1 Methodology

Statistical methods were used to characterize background concentrations, calculate background values, and estimate the uncertainties in these background values for metals and radionuclides. Soil analytic results from the LEHR site were compared to the background concentrations determined here. The 80% lower confidence limit on the 95$^{th}$ quantile (or percentile) was selected to determine the background values when sufficient data were available. The methodology for metals is presented below followed by the methodology for radionuclides.

### *B.1.1 Metals*

Background metals concentration data were tested to decide whether the underlying population could be modeled by the lognormal distribution[1]. The data were log transformed and tested by the Shapiro-Wilk *W* test (Gilbert, 1987) to establish normality of the transformed data. The transformed data sets that passed the *W* test with a reasonable significance level ($\alpha$ = 0.05) were assumed to be drawn from a lognormal population.

Two statistics of the transformed data, the sample mean, X, and the sample standard deviation, $S_x$, were calculated. These statistics were used to estimate quantiles (or percentiles) of the untransformed lognormal population distribution by the following formula (Gilbert, 1987):

$$\hat{X}_p = \bar{X} + Z_p S_x$$

where: $Z_p$ cuts off 100(1-p)% of the upper tail of the normal distribution

A percentile approach was selected to establish the cutoff value for background metals concentrations because it presents a reasonably low probability of making decision errors. For example, concentrations of metals in soil samples that are greater than the 95$^{th}$ percentile cutoff value will be falsely concluded to be above background about 5% of the time (called a "type I error" in statistical hypothesis testing). The $Z_p$ value cutting off 95% of the upper tail of the normal distribution is 1.645.

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[1] The histograms of naturally-occurring metals concentrations in soil can likely be modeled by lognormal density functions (EPA, 1992), which are used to model many types of environmental data (Ellgas, 1996).

Sample data were used to estimate the true 95th percentile of the background metals distributions. Transformed data fitting the normal model were used to calculate the upper confidence limit (UCL) on the estimated 95th percentile by use of the following formula (Gilbert, 1987):

$$UCL_{1-\frac{\alpha}{2}}\left(\hat{X}_p\right) = \bar{X} + S_x K_{1-\frac{\alpha}{2},p}$$

where:
$\alpha = 20\%$
$p = 95\%$
K = estimating factor for specified x, p (Gilbert, 1987)

The 80% lower confidence limit (LCL) on the 95th percentile was selected as the background value to conservatively estimate the true 95th percentile of the metals distributions. The 80% LCL on the estimated 95th percentile was approximated by assuming that, at the tail of the normal distribution, interpolation and extrapolation are approximately linear; therefore,

$$LC\,L_1 - \frac{\alpha}{2}(\hat{X}\,p) = \hat{X}\,p - [\exp(\bar{X} + S_x K_1 - \frac{\alpha}{2}, p) - \hat{X}\,p] = 2\,\hat{X}\,p - \exp(\bar{X} + S_x K_1 - \frac{\alpha}{2}, p)$$

Converting these transformed confidence limits back into the original untransformed space introduces a bias into the statistics. The approximate bias factor is (Gilbert, 1987):

$$\exp(\frac{S_x^2}{2n})$$

where: n = sample size

The background data for 20 metals were inspected for outlying data points and non-detect results. Non-detect sample results were assigned a numerical value equal to one-half the detection limit if the data contained less than 50% non-detect results (mercury, selenium). One data point was removed from the beryllium data set because the concentration was found to be below the 1% lower percentile of the log transformed data set when modeled by the normal distribution. Two data points were removed from the manganese data set because the data were flagged for concentrations measured above the calibration limits of the laboratory analytical instrument (the accuracy of these two data points is in question).

The 80% LCL on the 95th percentile was not calculated for antimony, cadmium, molybdenum, silver, and thallium, due to the lack of detected concentrations. Instead, the upper guidance limit was calculated (twice the maximum detected concentration).

All of the remaining data sets were found to have reasonable significance levels when tested by the Shapiro-Wilk *W* test on the log transformed data. Log normal distributions were assumed and

the 80% LCL on the 95th percentile was calculated as the background value for each. The Results of these calculations are summarized in Table B-1.

### *B.1.2 Radionuclides*

Background radionuclide concentration data were tested to decide whether the underlying population can be modeled by the normal distribution. The data were tested by the Shapiro-Wilk *W* test (Gilbert, 1987) to establish normality. Data sets that passed the *W* test with a reasonable significance level ($\alpha = 0.05$) were assumed to be drawn from a normal population.

The sample mean and standard deviation statistics were used to estimate percentiles of the normal population distribution using the following formula (Gilbert, 1987):

$$\hat{X}_p = \bar{X} + Z_p S_x$$

where: $Z_p$ cuts off 100(1-p)% of the upper tail of the normal distribution. The $Z_p$ value cutting off 95% of the upper tail of the normal distribution is 1.645.

Data fitting the normal model were used to calculate the upper confidence limit (UCL) on the estimated 95th percentile by use of the following formula (Gilbert, 1987):

$$UCL_{1-\frac{\alpha}{2}}\left(\hat{X}_p\right) = \bar{X} + S_x K_{1-\frac{\alpha}{2},p}$$

where:
$\alpha = 20\%$
$p = 95\%$
K = estimating factor for specified $\alpha$, p from Table A3 of Gilbert (Gilbert, 1987)

The 80% LCL on the estimated 95th percentile was approximated by assuming that, at the tail of the normal distribution, interpolation and extrapolation are approximately linear; therefore,

$$LCL_{1-\frac{\alpha}{2}}\left(\hat{X}_p\right) = 2\hat{X}_p - \left(\bar{X} + S_x \times K_{1-\frac{\alpha}{2},p}\right)$$

Two data points were removed from Ac-228, Bi-214, C-14, Pb-212, Pb-214, K-40, Ti-208, Th-232 and U-235 data sets because they were found to be above the 99% upper percentile of the data set when modeled by the normal distribution. Four data points were removed from the Th-230 data set because they were above the 99% upper percentile of the data set when modeled by a normal distribution.

All of the data sets were found to have reasonable significance levels when tested by the Shapiro-Wilk *W* test. Normal distributions were assumed and the 80% LCL on the 95th percentile was calculated as the background value for each. The results of these calculations are summarized in Table B-2.

Table B-1. Background Soil Statistics for Metals

| Compound | Lognormal? (Y/N) | 95th Quantile (mg/kg) | 80% Lower Confidence Limit on 95th Quantile (mg/kg) | 80% Upper Confidence Limit on 95th Quantile (mg/kg) |
|---|---|---|---|---|
| Antimony | N/A | N/A | N/A | N/A |
| Arsenic | Borderline | 10.47 | 9.46 | 11.5 |
| Barium | Y | 284 | 237 | 331 |
| Beryllium | Y | 0.78 | 0.66 | 0.90 |
| Cadmium | N/A | N/A | N/A | N/A |
| Chromium | Y | 223 | 178 | 268 |
| Hexavalent Chromium | Y | 0.147 | 0.099 | 0.19 |
| Cobalt | Y | 33 | 29 | 37 |
| Copper | Y | 60 | 50 | 69 |
| Iron | Borderline | 45,000 | 42,000 | 49,000 |
| Lead | Borderline | 11.5 | 10.1 | 13 |
| Manganese | Y | 785 | 720 | 850 |
| Mercury | Y | 1.09 | 0.49 | 1.7 |
| Molybdenum | N/A | N/A | N/A | N/A |
| Nickel | Y | 423 | 326 | 519 |
| Selenium | Y | 1.48 | 1.0 | 1.9 |
| Silver | N/A | N/A | N/A | N/A |
| Thallium | N/A | N/A | N/A | N/A |
| Vanadium | Y | 81 | 73 | 89 |
| Zinc | Y | 94 | 82 | 106 |

Notes:

N/A = Not Applicable. Not enough data to calculate statistics. For these compounds, background has been set at twice the maximum detected value from the background data set, if positively detected, or at the detection limit for compounds with no positive detections.

Table B-2. Radiological Background Soil Statistics

| Isotope | Normal?* (Y/N) | 95th Quantile (pCi/g) | Maximum MDA (pCi/g) | Minimum MDA (pCi/g) | 80% Lower Confidence Limit on 95th Quantile (pCi/g) | 80% Upper Confidence Limit on 95th Quantile (pCi/g) |
|---|---|---|---|---|---|---|
| Actinium-228 | Y | 0.76 | 0.71 | 0.14 | 0.71 | 0.81 |
| Bismuth-214 | Y | 0.62 | 0.44 | 0.083 | 0.57 | 0.67 |
| Carbon-14 | Y | 1.81a | 12 | 6 | 0.87 | 2.76 |
| Cesium-137 | Y | 0.075 | 0.27 | 0.033 | 0.053 | 0.1 |
| Cobalt-60 | Y | 0.023[a] | 0.21 | 0.028 | 0.016 | 0.03 |
| Gross Alpha | Y | 13.4 | 6.7 | 4.1 | 11.8 | 14.9 |
| Gross Beta | Y | 18.6 | 5.6 | 4.9 | 17.4 | 19.8 |
| Lead-212 | Y | 0.81 | 0.43 | 0.06 | 0.74 | 0.87 |
| Lead-214 | Y | 0.83 | 0.47 | 0.072 | 0.75 | 0.9 |
| Potassium-40 | Y | 14.4 | 1.7 | 0.42 | 13.6 | 15.2 |
| Radium-226 | Y | 0.88 | 0.68 | 0.11 | 0.77 | 0.98 |
| Strontium-90 | Y | 0.52[a] | 1.7 | 0.61 | 0.36 | 0.67 |
| Thallium-208 | Y | 0.23 | 0.24 | 0.04 | 0.21 | 0.25 |
| Thorium-228 | Y | 0.77 | 0.28 | 0.058 | 0.71 | 0.82 |
| Thorium-230 | Y | 0.84 | 0.097 | 0.021 | 0.8 | 0.87 |
| Thorium-232 | Y | 0.68 | 0.09 | 0.014 | 0.64 | 0.72 |
| Uranium-233/234 | Y | 0.71 | 0.046 | 0.016 | 0.66 | 0.75 |
| Uranium-235 | Y | 0.079 | 0.041 | 0.0066 | 0.071 | 0.087 |
| Uranium-238 | Y | 0.67 | 0.053 | 0.0086 | 0.63 | 0.71 |

Notes:

* = Does the Shapiro Wilk test indicate the distribution is normal?
MDA = Minimum Detectable Activity
a = Isotopes with 95th quantile below the MDA

# APPENDIX C

## EVALUATION OF POTENTIAL POST-REMOVAL ACTION GROUND WATER IMPACTS

# C. EVALUATION OF POTENTIAL POST-REMOVAL ACTION GROUND WATER IMPACTS

This appendix evaluates the potential for impacts to ground water at the site following completion of the recommended removal action (RA). Potential impacts to ground water associated with DOE areas are described in terms related to the contaminants of concern (COCs) detected in soil at three areas addressed by this Engineering Evaluation/Cost Analysis (EE/CA) report, namely the Southwest Trenches Area, Radium/Strontium Treatment Systems, and Domestic Septic Systems. This appendix presents a description of existing regional and site ground water quality conditions, a summary of COC concentrations in soil before and following the RA, and a qualitative evaluation of potential impacts to ground water due to residual COC concentrations remaining in soil following the RA.

The COCs evaluated in this appendix include nitrate ($NO^{-3}$), hexavalent chromium ($Cr^{+6}$), chlordane, radium-226 (Ra-226), and strontium-90 (Sr-90). These COCs have been selected as the contaminants which have been detected in site soils at highest concentrations and which might be of concern with regard to potential impact to ground water above background levels and/or the Maximum Contaminant Levels (MCLs).

This appendix focuses on three hydrogeologic units. These include the vadose zone and two water-bearing hydrostratigraphic units (HSUs), HSU-1 and HSU-2. The geologic and hydrogeologic characteristics of these zones are described in Section 2 of the EE/CA. Figure C-1 presents the lithological characteristics and depths of each unit.

The objectives of the proposed RA are to address contaminants present in the vadose zone. This appendix examines the potential adverse impacts to ground water in HSU-1 and HSU-2 from residual contamination remaining in the vadose zone after the completion of the recommended RA.

A detailed analysis of potential impacts to ground water from site soil contamination following the RA will be performed during the Work Plan preparation phase of the RA. At the request of the California Regional Water Quality Control Board (RWQCB), this analysis will consist of modeling of contaminant migration through the vadose zone in order to drive maximum soil concentrations, at specific depths and for specific soil types, that are protective of ground water.

## C.1 Regional Ground Water Quality

This section summarizes the available regional ground water quality data based on three sources: 1) data from municipal, domestic, and irrigation wells in the Davis area; 2) data from the neighbor's well sampling program; and, 3) data from two upgradient wells (UCD1-18 and UCD2-17)

which have been used to establish background conditions for the site. A summary of data from each source is presented below.

### *C.1.1 Regional Well Data*

As described in Section 2 of the EE/CA, 75 percent of the surrounding land in the vicinity of the site is used for agriculture with the majority of the irrigation water being supplied from HSU-2 and HSU-3. Dames and Moore performed a detailed review of background data and the results have been documented in the *Draft Technical memorandum for Background Data Review – Ground water* (Dames and Moore, 1995). Information on ground water quality and use in the region was compiled from California Water Resources Control Board, California Department of Water Resources (DWR), UCD Department of Agricultural Services, United States Geological Survey (USGS), and local well owners. Figure C-2 presents the location of ground water wells within about three miles of the site. City of Davis Municipal wells typically draw water at depths ranging from 150 to 500 ft. UCD domestic wells draw water from below 1,000 ft, while UCD irrigation and private supply wells draw water from between 150 and 300 ft.

Rainfall infiltration, irrigation water infiltration, and the Putah Creek recharge ground water in the vicinity of the site (Dames and Moore, 1995). The main component of ground water recharge, however, has been identified as irrigation water infiltration, which has also contributed to degradation of ground water quality in the region. Ground water pumping associated with irrigation is largely responsible for the ground water discharge, causing seasonal water level fluctuations of up to 30 ft in HSU-1.

According to DWR classification, ground water in the vicinity of the site is a magnesium bicarbonate type of hydrochemical facies, meaning that magnesium amounts to about 50 percent of the cations and bicarbonate amounts to least 50 percent of the anions (Dames and Moore 1995). High dissolved solid concentrations and elevated boron, fluoride, and chloride concentrations (Dames and Moore 1997) have characterized regional ground water. In addition, extensive agricultural use of fertilizers in the region since the mid-1950s has contributed to elevated concentrations of nitrate in ground water. Based on a review of ground water quality in the region, it appears that nitrate as nitrogen (N) in the Davis area ranges from less than 10 mg/l to greater than 40 mg/l (Dames and Moore, 1997). A summary of the regional data for nitrate and chromium is presented in Table C-1.

Historical data indicate that ground water quality has been steadily degrading due to mixing of ground water with irrigation water. Dissolved solids and nitrate concentrations in ground water have increased at a rate of 4.75 mg/l and 0.036 mg/l per year according to Hull (Hull, 1984). However, review of certain municipal wells in Davis indicate an annual increase in nitrate concentrations of about 0.62 mg/l (Dames and Moore, 1995). This difference in nitrate concentration further suggests that high municipal water supply demands have caused a localized increase in agricultural irrigation water mixing with ground water. Studies using naturally occurring oxygen isotopes as tracers have also indicated that irrigation water migrates downward and laterally during periods of seasonal high water use by municipal wells. This trend further impacts ground water quality in deeper HSUs.

### *C.1.2 Neighbor's Well Data*

Ground water results from 1995 and 1996 sampling of domestic and irrigation wells located near the site indicate a great level of variability in nitrate and chromium concentrations. The location of wells that were sampled during the neighbor's wells sampling program is shown in Figure C-3. In addition, Table C-1 presents the range of detections of nitrate and chromium in these wells. Results of nitrate as nitrogen range from 3.7 mg/l to 50 mg/l, while concentrations of hexavalent chromium range from less than 10 µg/l to 140 µg/l. It is important to note that although the domestic and irrigation wells are screened in different hydrostratigraphic units, the majority (90 %) of the flow in the neighbor's wells is anticipated to come from HSU-2 (Dames ad Moore, 1997).

### *C.1.3 Site Background Ground water Data*

Two ground water monitoring wells have been installed approximately 500 ft west of the site to evaluate background ground water conditions. Well USD1-18 has been installed within HSU-1 and well UCD2-17 has been installed within HSU-2. These wells have been included in the ground water monitoring program for the site since 1990.

In order to define a representative "background" value for each COC, a 95% upper tolerance limit (UTL) on the mean of the data series was calculated for each background well (PNNL, 1995). Specifically, eight quarters of monitoring data from UCD1-18 and UCD2-17 (collected between third quarter 1993 and second quarter 1995) were used to calculate background UTL values representative of each HSU (PNNL 1995). Background UTL values were then used for comparison with analytical results from Site ground water monitoring wells.

A summary of analytical results from UCD1-18 and UCD2-17 is presented in Table C-1. Nitrate results in each well have been plotted over time and depicted in Figure C-4. As shown in Figure C-4, nitrate concentrations in HSU-1 fluctuate significantly due to seasonal variations in water table. In addition, nitrate concentrations in HSU-1 appear to be rising steadily since the start of monitoring in 1990. This trend seems to correlate with historical data on ground water quality degradation due to irrigation water recharge into the ground water. The background 95% UTL for nitrate as nitrogen in HSU-1 has been calculated as 25.2 mg/l, which is above the MCL of 10 mg/l.

Nitrate background concentrations in HSU-2 appear to be more stable and less impacted by seasonal ground water fluctuations. The background 95% UTL for nitrate as nitrogen in HSU-2 has been calculated as 3.8 mg/l, which is below the MCL of 10 mg/l.

## C.2 Existing Site Ground water Quality

Ground water quality at the site has been investigated and monitored since 1989. Four ground water monitoring wells have been installed within the areas being remediated as shown in Figure C-5. Specifically, wells UCD1-4, UCD1-23, and UCD2-15 are located within the Southwest Trenches area, and well UCD1-22 is located in the Ra/Sr Treatment System area. Table C-1 presents

the maximum detected concentration of COCs in these wells from the 1995 Annual Water Monitoring Report.

Except for nitrate, none of the COCs exceeded their corresponding background concentrations in any of the wells. Ground water monitoring results for nitrate as detected in UCD1-4, UCD1-23, and UCD2-15 are shown in Figure C-6. Nitrate concentrations in HSU-1 in the Southwest Trenches area, as defined by UCD1-4 and UCD1-23 results, are generally below the MCL of 10 mg/l. Nitrate was detected in UCD1-23 at a maximum concentration of 11 mg/l, which is below the background UTL value of 25.2 mg/l but exceeds the MCL of 10 mg/l. Nitrate concentrations in HSU-2, as defined by UCD2-15 results, have been consistently below the MCL of 10 mg/l.

In general, it appears that ground water at the site has not been impacted by any of the contaminants detected in soil within the DOE areas.

## C.3 Vadose Zone Modeling Results Summary

A one-dimensional vadose zone modeling was performed to estimate the contaminant transport in the unsaturated soil and assess the potential impacts to ground water beneath the site. The modeling assumptions, methodology, results and conclusions have been detailed in the Draft Final One-Dimensional Vadose Zone Modeling Report (Weiss, 1997). This section summarizes the results and conclusions of the modeling effort. A discussion of modeling methodology and results are also presented in Section 3 of the EE/CA.

### *C.3.1 Modeling Assumptions*

A numerical one-dimensional model named NUFT (Non-isothermal Unsaturated Flow and Transport) was utilized to simulate downward contaminant migration from the unsaturated soil toward ground water in an attempt to assess potential impacts to ground water. Specifically, five indicator compounds (ICs) were selected from among the contaminants detected in site soils and used in developing the model. These ICs included nitrate, hexavalent chromium, chlordane, radium-226, and strontium-90. Several fundamental assumptions were made during the modeling in order to develop a conservative transport model. These assumptions include:

- Initial soil concentrations represent maximum detected concentrations and assume that no removal action has taken place.
- Evaluation of spatial distribution of contaminants in soil indicted that ICs are generally restricted to the upper few feet of the soil. Therefore, initial contaminant soil concentrations were assigned to the upper 6 ft of the model.
- The vadose zone thickness was conservatively assumed to be 30 ft.

- Liquid/Solid partitioning coefficients ($K_d$) were selected conservatively as the smallest numbers presented in the literature. The smaller the $K_d$ value, the less sorptive and therefore more mobile the constituent would be.
- Geotechnical characteristics of the vadose zone were obtained from analytical data available from previous investigations. In cases where data was missing for a given lithological strata, more conservative values for hydraulic conductivity and porosity were inputted into the model.
- Infiltration rates were taken as a percentage of total annual precipitation rate for the site. An infiltration rate of 3 centimeters per year (cm/yr) was selected as most realistic infiltration rate for the model. Other infiltration rates including 10 and 21.5 cm/yr were also modeled.
- Sensitivity analyses were performed to examine the effect of each parameter on model results. Three input parameters were examined namely, infiltration rate, lithology, and contamination mass inventory and distribution.
- Peak ground water concentrations calculated by the model represent the IC concentration in the upper 1 ft of the water table.

## *C.3.2 Modeling Conclusion and Results*

Based on the assumptions listed above, vadose zone modeling was performed to calculate the transport time and peak ground water concentration associated with each of the five ICs. Model results for hexavalent chromium, chlordane, Ra-226 and Sr-90 indicate that travel time to the water table ranges between hundreds to thousands of years. In addition, peak ground water concentrations for these compounds are below their respective MCL and background values. In summary, it appears that current concentrations of hexavalent chromium, chlordane, Ra-226 and Sr-90 in soil will not adversely impact ground water beneath the site. Modeling results for these ICs has been summarized in Section 3 of the EE/CA and detailed in the Draft-Final One-Dimensional Vadose Zone Modeling Report (Weiss 1997).

Modeling results from nitrate transport simulation require further discussion. The results and conclusions of the vadose zone modeling for nitrate have been summarized below.

### C.3.2.1 Nitrate

Modeling results indicate that nitrate will reach HSU-1 at a peak ground water concentration of 18 mg/l assuming an infiltration rate of 3 cm/yr and an initial soil nitrate concentration of 10 mg/kg evenly distributed from 0 to 6 ft below ground surface (bgs). Nitrate at 10 mg/kg represents the site-specific background soil concentration as calculated by taking the 80% lower confidence limit (LCL) of the 95 percentile of the background data series. The background data series consisted of 26 soil samples collected from five boring locations off-site.

Nitrate peak ground water concentration predicted by the model is below the background ground water nitrate concentration of 25.2 mg/l (UCD1-18) but above the MCL of 10 mg/l. The

modeling assumptions for total mass of nitrate in soil were very conservative. Review of the analytical data indicates that the proposed RA will likely remove nitrate present in soil above the existing background concentration of 10 mg/kg. Reduction in nitrate mass in soil will significantly reduce the peak ground water concentration and therefore minimize the predicted impact to ground water.

As indicated in Section C-1, existing regional and background ground water quality has been degraded by irrigation water resulting in current nitrate levels above the MCL of 10 mg/l. Furthermore, it appears that nitrate degradation of ground water in the region continues at a rate of 0.62 mg/l each year. The predicted nitrate concentration in ground water from the soil leachate after 100 years is therefore expected to be much less than the background nitrate concentration in ground water.

## C.4 Anticipate Soil Conditions at the Site Following RA

This section describes the anticipated soil conditions following implementation of the proposed RA. It is assumed that COC concentrations in soil will be reduced to the risk-based action standards (RBASs) defined in the EE/CA. In other words, COCs concentrations will be reduced to a level that is protective of human health and the environment at a Risk Level C. This risk level was defined as a cancer risk of $10^{-6}$ for chemical constituents and a risk level of $10^{-5}$ for radionuclides.

It is expected that the total mass of contaminants in soil will be reduced by over 90% since the source of contamination; namely waste trenches and pits in the Southwest Trench area; drywells, tanks and associated leach fields in the Ra/Sr treatment System area would be removed along with any contaminated soil. The scope of the RA has been defined by the extent of Ra-226, Sr-90 and chlordane contamination and therefore these contaminants will be removed during the RA to limits defined by their respective RAOs .

An evaluation of nitrate data and their spatial distribution at the site indicates that all of the nitrate detections above the background of 10 mg/kg have been within the waste pits and trenches. Therefore, it is expected that following the removal of these waste areas, mean nitrate concentrations in soil will be at or near the 10 mg/kg background level and that the extent of nitrate concentrations in soil will be limited to the surface of the site.

## C.5 Potential Ground water Impacts Following Completion of RA

The vadose zone modeling predicted that existing soil contaminants do not appear to pose an immediate threat to the ground water beneath the site. Nitrate was the only contaminant that appeared to reach the ground water table (HSU-1) at a peak ground water concentration above its MCL but below the background UTL value. It should be noted that existing regional and background ground water quality has already been degraded over the years by irrigation water infiltration to levels above the MCL of 10 mg/l.

Furthermore, the RA is expected to remove a significant volume (over 90%) of soil and waste from the site and replace it with clean fill free of any contamination. Review of the analytical results indicates that all of the nitrate detections above background of 10 mg/kg occur within the proposed areas of excavation. It is therefore assumed that the total mass of nitrate in soil following the removal action will be much less than mass of nitrate used in the vadose zone modeling. Thus, any future predicted impacts to ground water from site soil nitrate concentrations would be further reduced.

The total mass of nitrate in site soil after the removal action will be insignificant relative to the background mass of nitrate in soil. Therefore nitrate concentrations remaining in site soils following implementation of RA do not appear to pose a threat to the regional ground water quality.

A detailed analysis of potential impacts to ground water from site soil contamination following the RA will be performed during the Work Plan preparation phase of the RA. At the request of the California Regional Water Quality Control Board (RWQCB), this analysis will consist of modeling of contaminant migration through the vadose zone in order to drive maximum soil concentrations, at specific depths and for specific soil types, that are protective of ground water. These maximum soil concentrations will be used during the RA as guidelines to ensure that residual compounds remaining in soil above background do not adversely impact ground water.

Table C-1. Concentrations of Indicator Constituents in Ground Water

| Indicator Constituents (ICs) | Units | 40 CFR MCLs | UTL Value for Background Wells [1] HSU-1 (UCD1-18) | UTL Value for Background Wells [1] HSU-2 (UCD2-17) | Regional Wells [2] HSU-2/3 | Neighbor's Wells [2] HSU-2/3 | Maximum Concentration Site Data HSU-1 [1] OU-1 UCD1-4/23 | Maximum Concentration Site Data HSU-1 [1] OU-2 UCD1-22 | Maximum Concentration Site Data HSU-2 [1] OU-1 UCD2-15 |
|---|---|---|---|---|---|---|---|---|---|
| Hexavalent Chromium | mg/l | 0.05[3] | 0.0229 | 0.013 | <0.01 - 0.1 | <0.01 - 1.4 | 0.023 | ND | 0.006 |
| Nitrate (as N) | mg/l | 10 | 25.2 | 3.8 | <10 - 45 | 3.6 - 50 | 11 | 5 | 2.7 |
| Alpha-Chlordane | mg/l | 0.002 | NA | NA | NA | NA | ND | ND | ND |
| Gamma-Chlordane | mg/l | 0.002 | NA | NA | NA | NA | ND | ND | ND |
| Radium-226 | pCi/l | 5 | 272 | 2050 | NA | NA | 0.21 | 0.3 | 150+/-650 |
| Strontium-90 | pCi/l | 8 | 1.6 | 1.3 | NA | NA | 0.67 | 0.31 | 0.27 |

Notes:

[1] 95% Upper Tolerance Level (UTL) on the mean of data from 1995 Annual Water Monitoring Report (PNNL 1995).
[2] Data from Dames and Moore EE/CA (1997).
[3] State of California MCL
NA = means data was not available. ND = means not detected

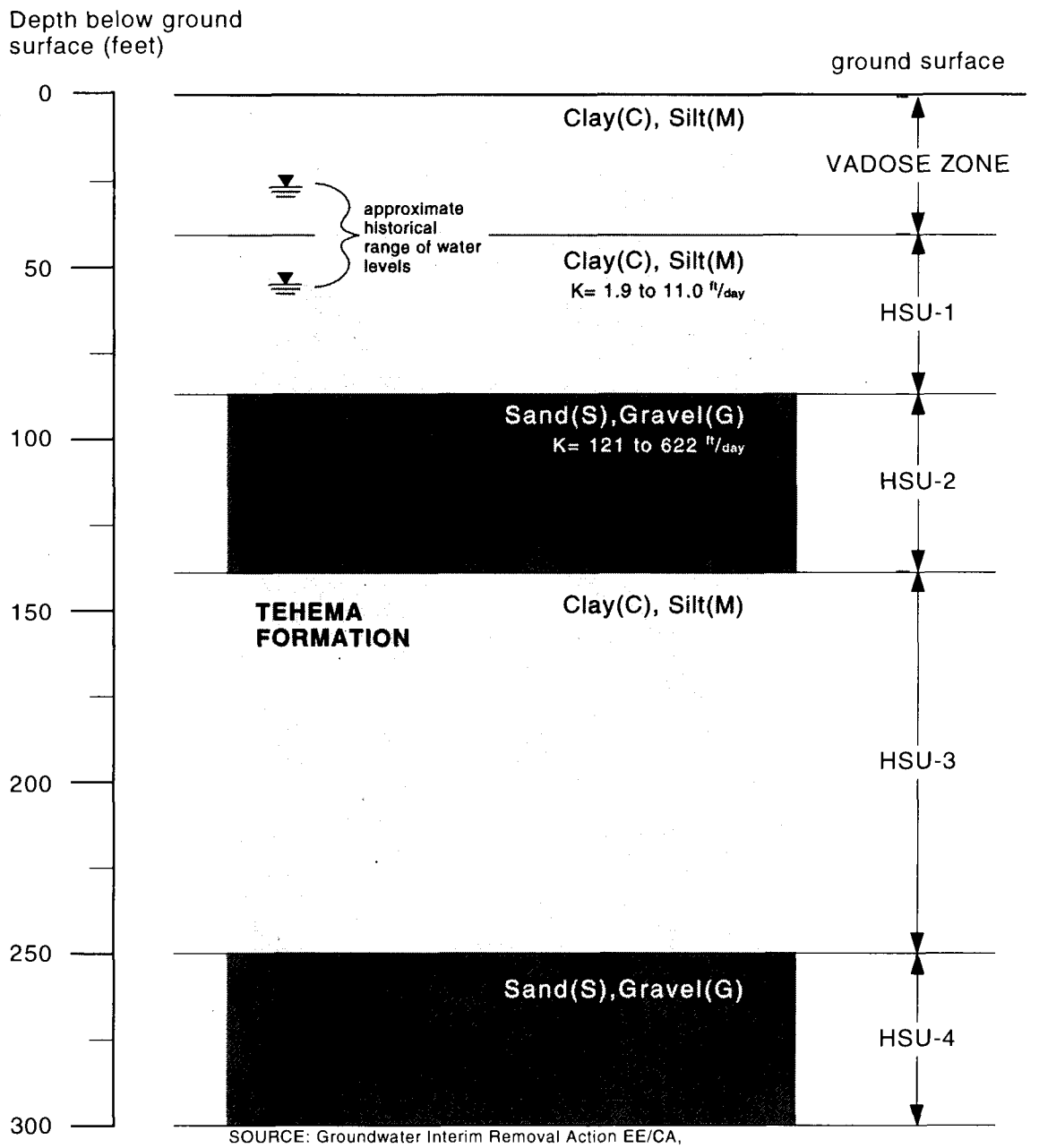
Table C-2. RME and Background Concentrations of Indicator Constituents in Soil

| Indicator Constituents (ICs) | Units | Background concentration (1) | SW Trenches RME Concentration (2) | | Ra/Sr Treatment System RME Concentration (2) | | Domestic Septic Systems RME Concentration (2) | |
|---|---|---|---|---|---|---|---|---|
| | | | Surface <3 ft bgs | Subsurface >3 ft bgs | Surface <3 ft bgs | Subsurface >3 ft bgs | Surface <3 ft bgs | Subsurface >3 ft bgs |
| Hexavalent Chromium | mg/kg | 0.099 | 0.22 | <BKG | -- | -- | -- | <BKG |
| Nitrate (as N) | mg/kg | 10 | 82 | 110 | <BKG | 26 | 33 | 27 |
| Alpha-Chlordane | mg/kg | NA | 0.8 | 0.19 | -- | -- | -- | -- |
| Gamma-Chlordane | mg/kg | NA | 0.74 | 0.21 | -- | -- | -- | -- |
| Radium-226 | pCi/g | 0.77 | <BKG | 17 | 1.7 | 4.6 | <BKG | <BKG |
| Strontium-90 | pCi/g | 0.36 | 6.9 | 850 | 0.35 | 8.9 | 0.02 | 0.45 |

Notes:

[1] Background concentration was calculated as the 80% lower confidence limit (LCL) of the 95th percentile of the data.
[2] Reasonable Maximum Exposure (RME) concentration represents either the maximum detected value in site soils or the 95% UCL on the mean if adequate data was available for statistical analysis. Data from the Draft Determination for Risk-Based Action Standards for DOE Areas (Weiss, 1997).

< BKG = less than background; "---" = below background or not detected; NA = data not available.




SOURCE: Groundwater Interim Removal Action EE/CA, Dames & Moore, 1997

**Note:**
K = **Coefficient of permeability**
HSU = **hydrostratigraphic unit**

Figure C-1. Schematic Cross Section of Hydrostratigraphic Units

*Weiss Associates*

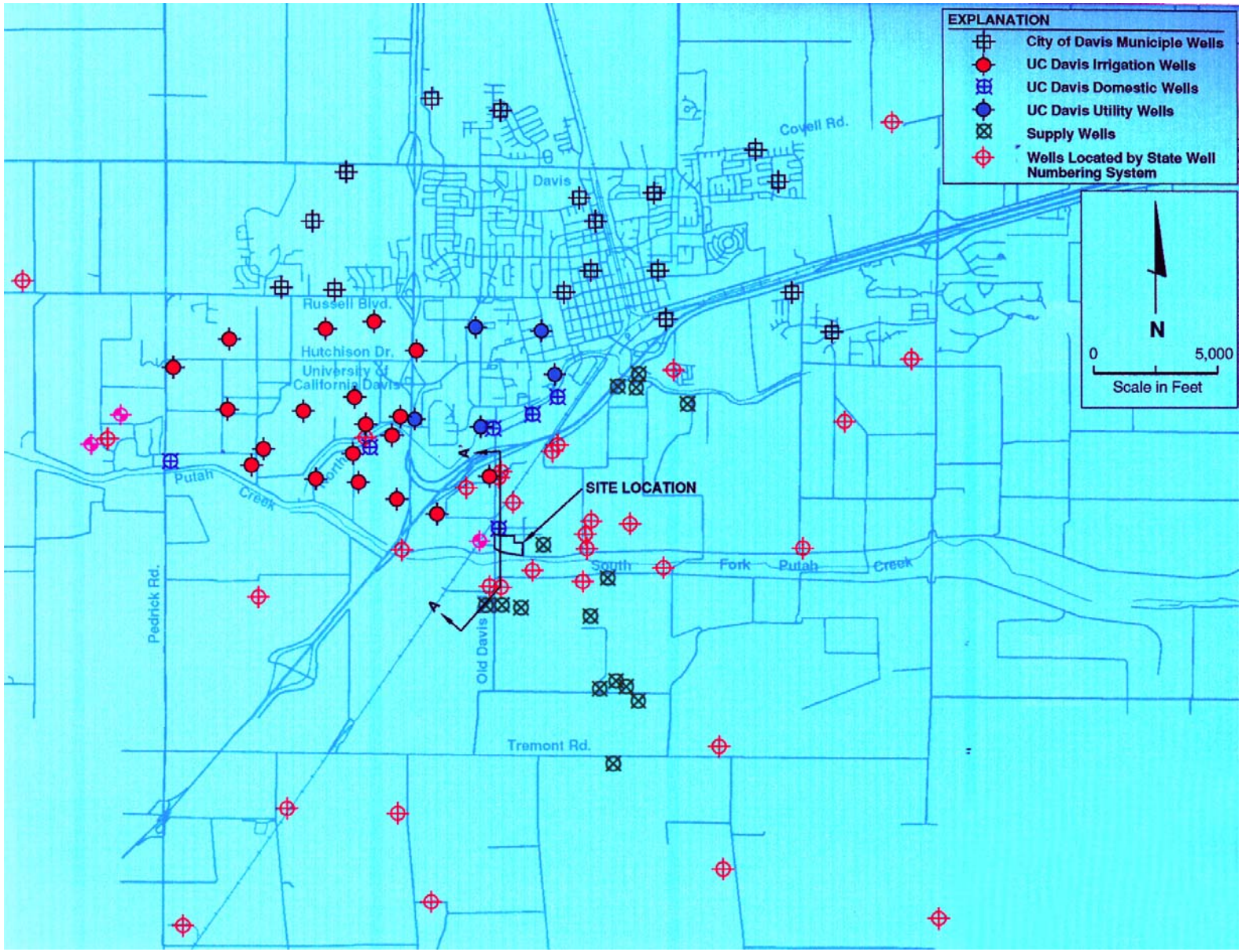



Figure C-2. Ground Water Wells Near LEHR Facility

Weiss Associates

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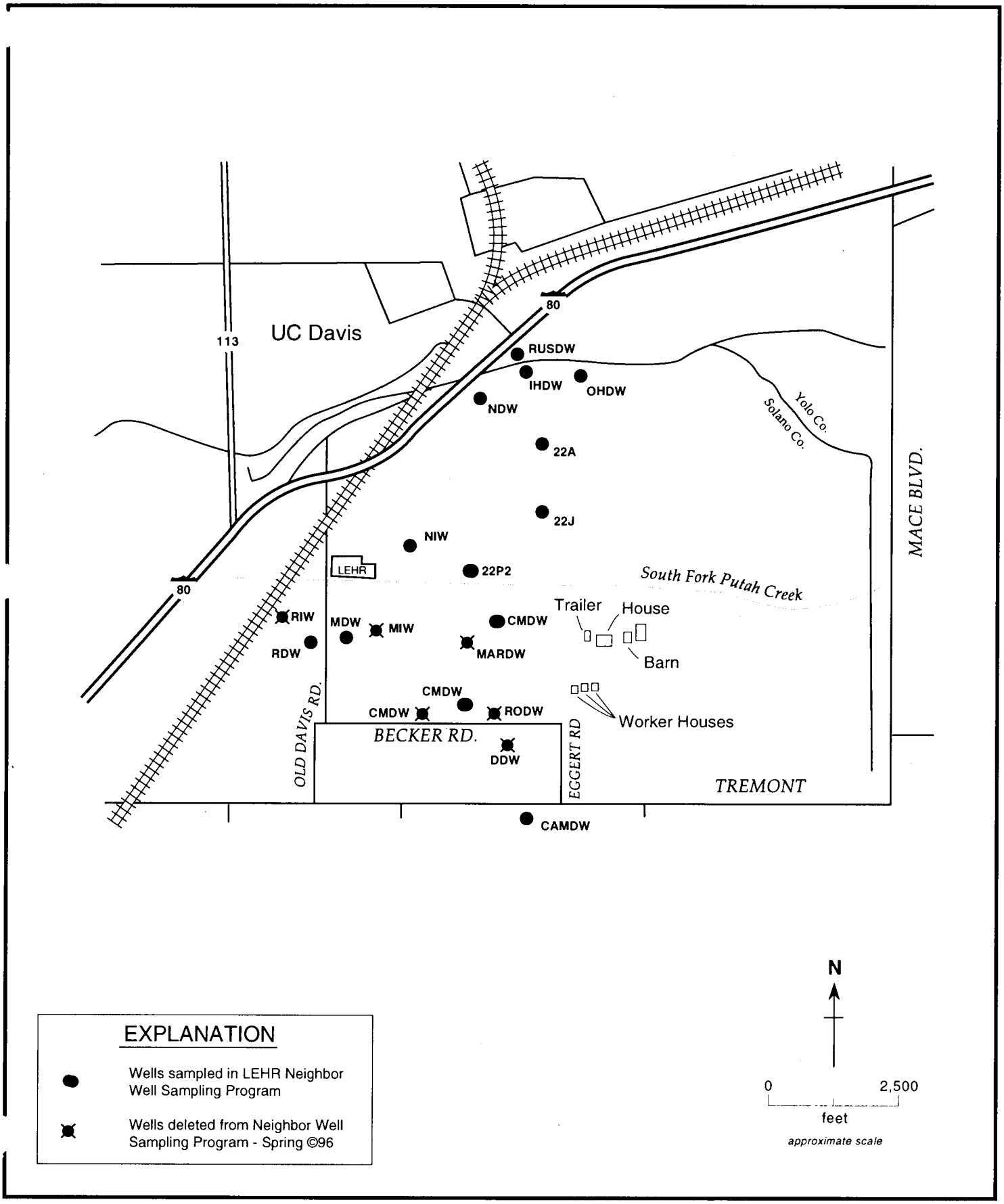
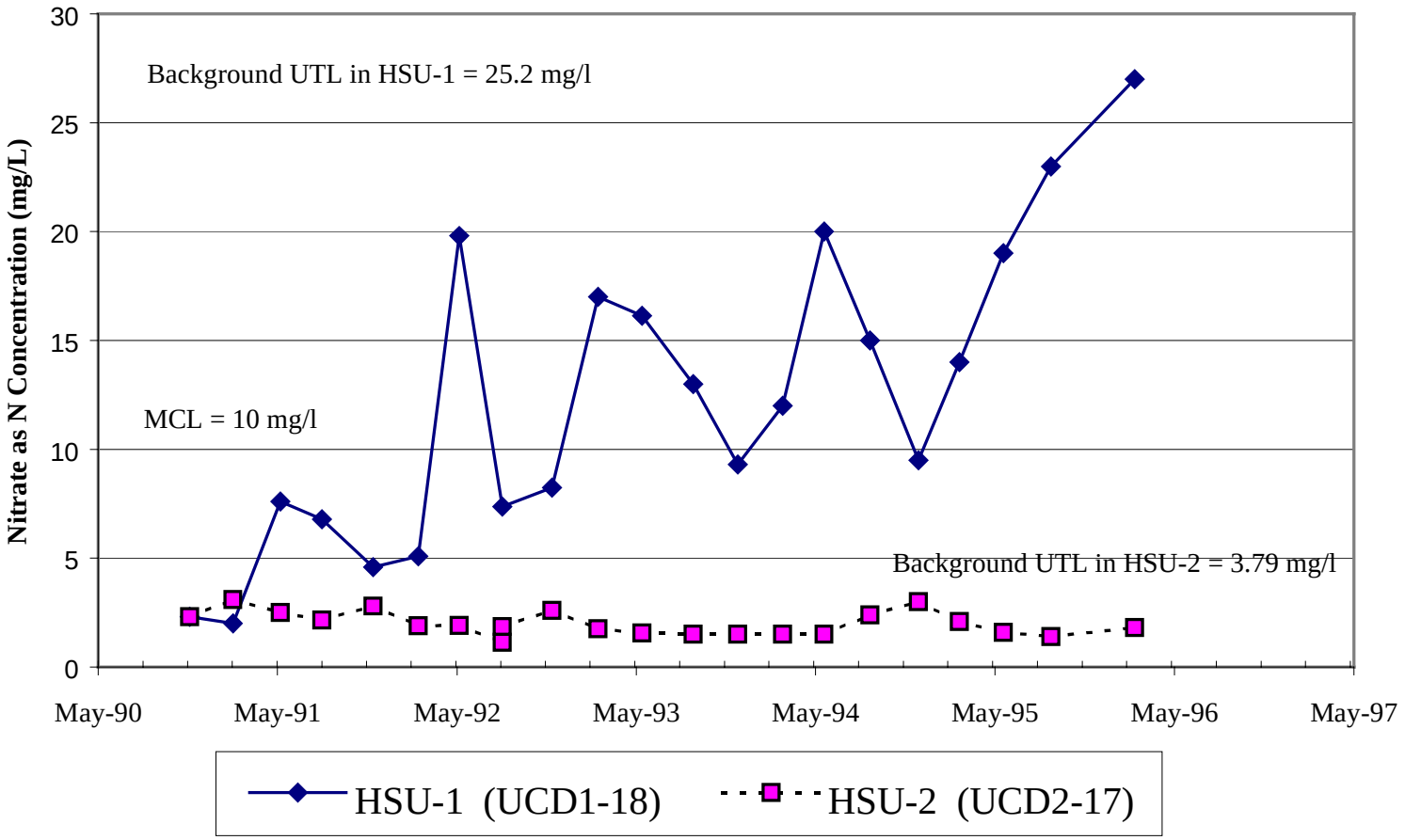



Figure C-3. Neighbor Well Sampling Program Locations near the LEHR Site

Weiss Associates

# Figure C-4
## Nitrate Concentration in Upgradient Wells (Background)



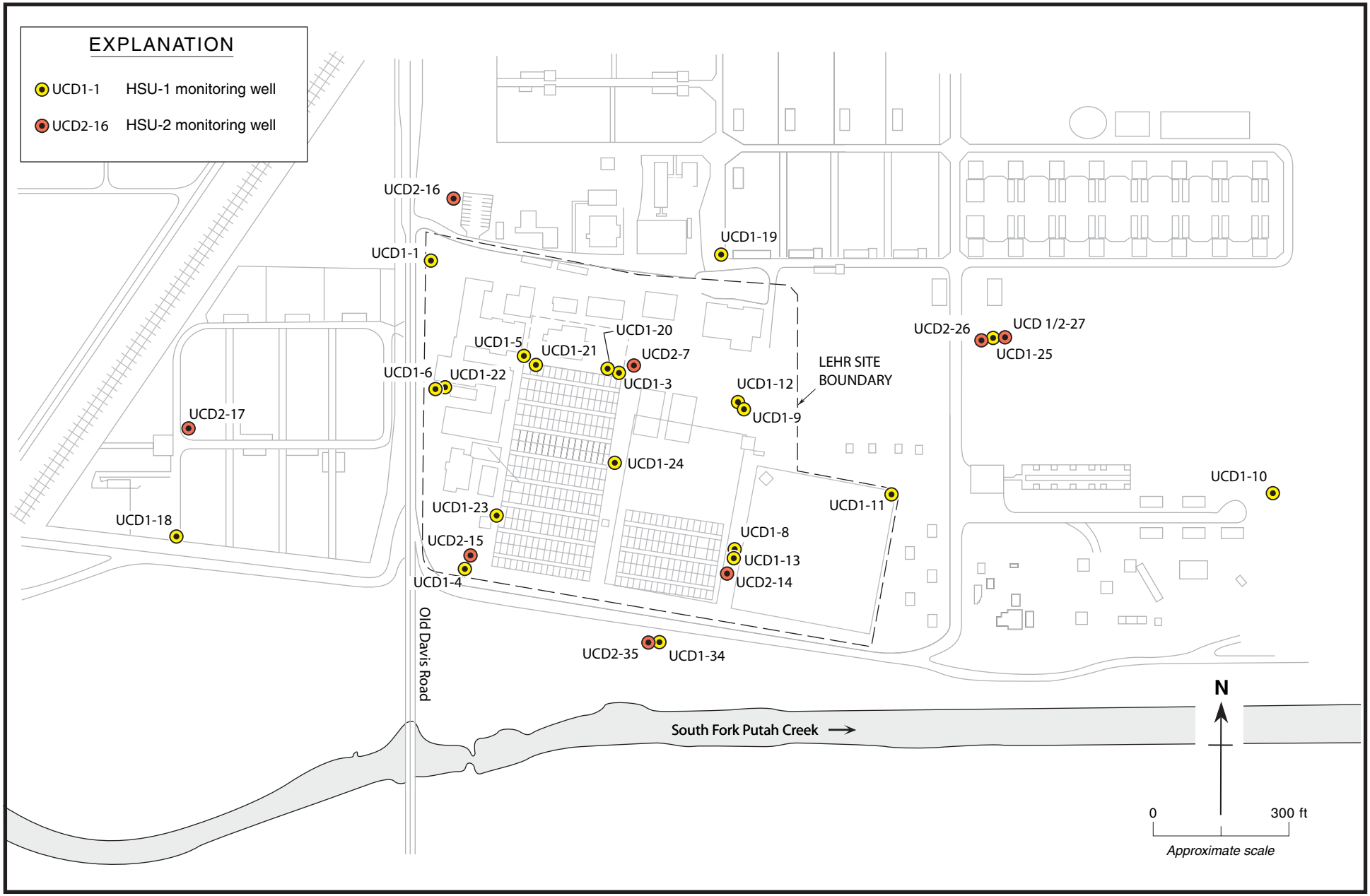



Figure C-5. Monitoring Well Locations

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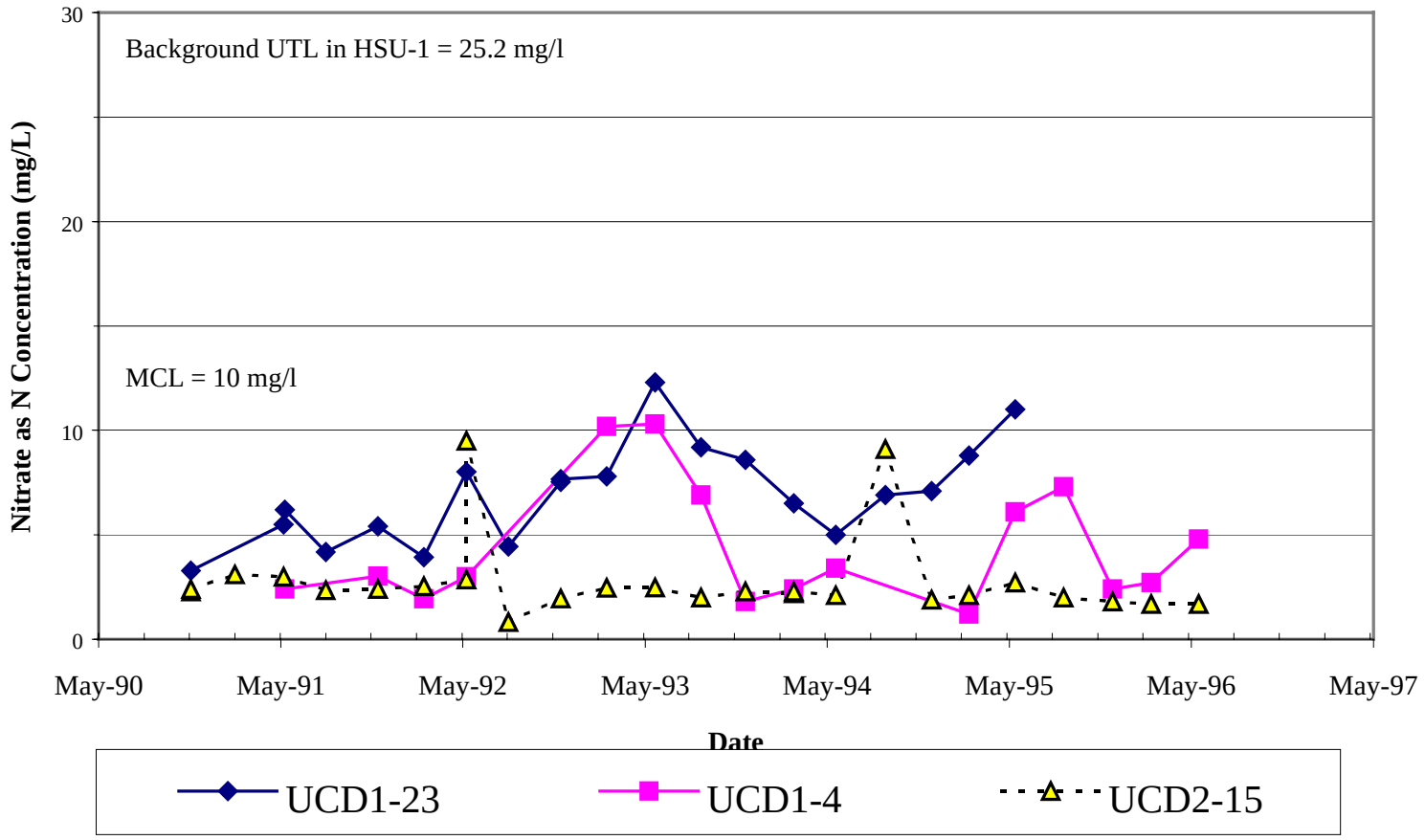
**Figure C-6**
**Nitrate Concentration in Ground Water**
**(Southwest Trenches Area)**



# APPENDIX D

## WASTE CHARACTERIZATION AND DISPOSAL OPTIONS

# D. WASTE CHARACTERIZATION AND DISPOSAL OPTIONS

Waste generated from the excavation removal action will likely be characterized in one of four general categories: municipal solid waste, hazardous waste, low-level radioactive waste (LLW), or radioactive mixed waste. This EE/CA assumes that most waste generated will be low level radioactive waste and a small volume will be hazardous waste.

In the body of the EE/CA, a conservative disposal scenario was developed in which LLW soil and debris are loaded into B-25 boxes and shipped to Hanford for disposal. This appendix evaluates the implementability, effectiveness, and costs of two alternate disposal scenarios associated with two disposal facilities. A waste disposal flow chart, Figure D-1, has been provided to further illustrate the different scenarios. Table D-1 provides a summary of associated unit costs.

## D.1 Hazardous Waste

The hazardous waste that may be generated during the removal action is assumed to be transported under hazardous waste manifest documentation to an approved Class I hazardous waste disposal facility after proper characterization and acceptance. The nearest Class I facility to the LEHR site is Chemical Waste Management Inc., in Kettleman City, California, located approximately 220 miles south of the site. Waste transportation cost from Davis to Kettleman City is $40 per cy of waste. The waste disposal fee at Kettleman City facility is $310 per cy of waste.

## D.2 Low Level Radioactive Waste (LLW)

LLW will be transported to an approved disposal facility after proper characterization and acceptance.

### *D.2.1 Disposal Facilities*

Envirocare is a private waste disposal facility permitted to accept LLW and radioactive mixed waste. Envirocare is located in Utah approximately 625 miles from the LEHR site. Envirocare has a contract in place with DOE for radioactive mixed waste and DOE-Oakland has an Interagency Agreement (IAA) with the Corps of Engineers for disposal of LLW at Envirocare.

The Hanford Solid Waste Disposal Facility is operated by the DOE. It is permitted to accept LLW. Hanford is located in Washington State approximately 900 miles from the LEHR site. DOE-Oakland is approved to dispose of low-level radioactive waste, designated as Category 1 low-level radioactive waste, at the Hanford facility.

### *D.2.2 Waste Acceptance*

The waste acceptance application requirements for both facilities are similar. The associated costs for preparation and analysis are also similar, and it is therefore assumed that both facilities will accept the waste generated during removal actions and that the cost for approval at each facility is equivalent.

Once the waste acceptance applications are approved, waste can be packaged for shipment to either facility. For the purposes of this appendix shipping in roll-off bins and B-25 boxes and shipping to either facility is evaluated. Other packaging options such as bulk bags may be evaluated as part of the RA work plan.

### *D.2.3 Shipping Containers*

B-25 boxes will accommodate approximately 3 cy of waste each. Four B-25 boxes can be shipped on a single truck. The B-25 boxes cost approximately $700 each based on a vender-quoted price. Part of the packaging process when using B-25 boxes is to compact the waste in the box. The B-25 boxes are buried full and the waste needs to be compacted to limit the potential subsidence of the disposal unit. B-25 boxes are evaluated for shipping to Hanford.

Roll-off bins will accommodate approximately 12 cy of waste each. One bulk role-off bin can be shipped on each truck. The bins cost approximately $8,750 each if purchased new with a fiberglass lid or $7,500 if purchased used in the same configuration. These costs do not reflect delivery of the bins to the site. If rented, the bins cost about $7 per day or $2,555 per year. The bins will require the use of a liner at a cost of $25 per bin and delivery of a rented bin to the site was quoted at $204 each. The cost of post use sampling of the bins is approximately $600 per bin and will be completed by the disposal facility. This cost assumes four hours of labor and materials at $150 per hour. Roll-off bins are evaluated for shipping to both Hanford and Envirocare.

### *D.2.4 Disposal Options Evaluation*

For the purposes of the EE/CA, waste-shipping analysis was based on shipping by truck. The shipping cost is assumed to be the same whether B-25 boxes or roll-off bins are used. Shipping by rail may be evaluated under the RA work plan phase of this project.

- Shipping to the Envirocare facility is estimated to be $180 per cy based on a vender bid.
- Shipping to the Hanford facility is estimated to be $217 per cy based on a vender bid.

Once the waste reaches the disposal facility, the loads are checked for consistency with the completed and accepted waste profile documentation. For both facilities, it was assumed that 10% of the loads would be confirmation sampled by DOE prior to shipment to insure compliance with the acceptance criteria. Therefore, these costs are not included in the evaluation.

Waste sent to Envirocare would be disposed of in one of two classifications: LLW as soil; or, as debris. The cost for disposing LLW as soil is approximately $8 per cubic ft. The cost for disposing LLW as debris is approximately $16 per cubic ft. Envirocare classifies gravel as debris.

Waste sent to Hanford, either soils or debris, is disposed of at a rate of $13.50 per cubic ft.

Once dumped, the roll-off bins will need to be back-hauled to the LEHR site. The cost for back-hauling the bins is about $800 per bin assuming two empty bins can be hauled on a flat bed truck. Since B-25 boxes are buried with the waste, this cost is not incurred.

Figure D-1 graphically shows the alternative waste disposal paths. Table D-1 summarizes the cost associated with the key stages from Figure D-1.

## D.3 Conclusions

Based upon the available site information and cost estimates developed from vender quotes, this evaluation indicates that the cost differences in the disposal options are small. At this time, it is difficult to identify the most cost-effective option due to the uncertainties of the final waste volumes.

Key factors in this evaluation are the following:

- The Envirocare facility will characterize most of the waste as debris, greatly increasing disposal costs with this option; and,
- The cost savings of using roll-off bins may not significantly off-set the costs of post disposal bin decontamination, sampling, and back-haul.

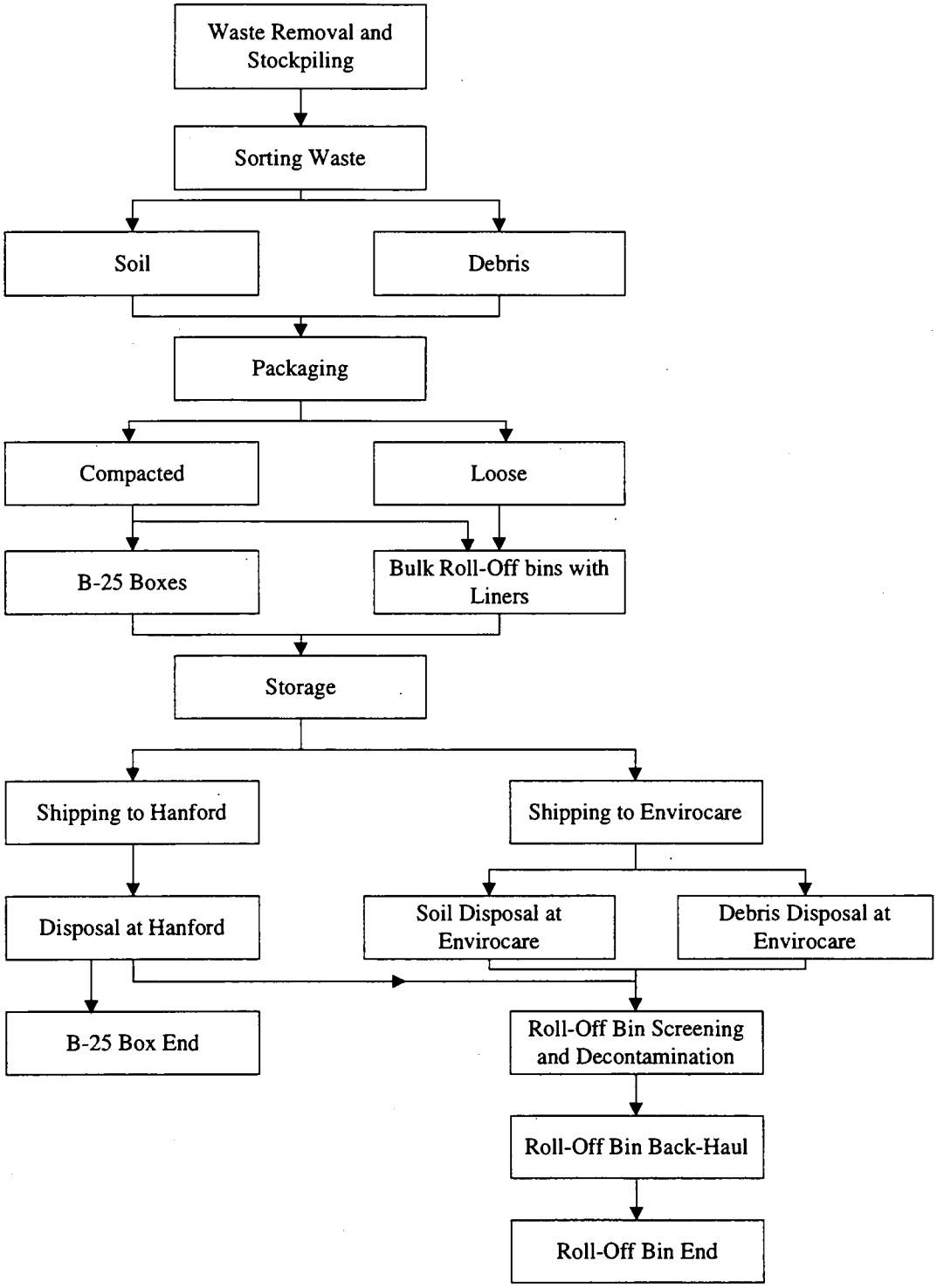



Figure D-1. Waste Disposal Flow Chart J:\DOE\4000\A1E\EE_CA\REV_D\FIGURES\APPGFIG1.VSD

Table D-1. Disposal Cost Summary

| Description | Unit Cost |
|---|---|
| Waste Container Packaging | |
| Compacted Waste | $56 per cy for labor and equipment. |
| Uncompacted (Loose)Waste | $0 for packaging. However, because the volume of the waste is greater uncompacted, the cost for containers, storage, shipping, and disposal is greater by approximately 30%. |
| Packaging Materials | |
| B-25 Bins (3 cy cap.) | $700 per bin |
| Roll-Off Bins (purchase new) (12 cy) | $8,750 per bin |
| Roll-Off Bins (purchase used) (12 cy) | $7,500 per bin |
| Roll-Off Bins rental, (12 cy) | $7 per bin per day |
| Roll-Off Liners (one use) | $25 per bin |
| Roll-Off deliver to Davis site | $204 per bin |
| Waste Shipping | |
| Ship from Davis to Hanford | $217 per cy |
| Ship from Davis to Envirocare | $180 per cy |
| Waste Disposal Tipping | |
| Disposal at Envirocare | |
| Low-level radioactive waste as soil | $8 per cubic ft |
| Low level radioactive waste as debris | $16 per cubic ft |
| Envirocare considers gravel as debris | |
| Disposal at Hanford | |
| Low-level radioactive waste as soil/debris | $13.50 per cubic ft |
| Post Disposal Tasks | |
| Using the B-25 bins at Hanford | $0 additional. The B-25 bins are buried at Hanford with the waste. |
| Using the Roll-Off bins at either Hanford or Envirocare | |
| Decontamination/sampling of bins | $600 per bin |
| Back–Haul of bins to Davis | $800 per bin |

# APPENDIX E

## DETERMINATION OF COVER THICKNESS VS. RA-226 ACTIVITY

# E. DETERMINATION OF COVER THICKNESS VS. RA-226 ACTIVITY

The computer program RESRAD (v5.62) was used to determine the minimum thickness of clean soil cover and maximum allowable radium-226 activity that will result in $1x10^{-5}$ and $5x10^{-5}$ risk levels for the exposed research workers scenario at the LEHR Site. This exercise was performed in support of removal action alternatives that contained institutional controls as a component.

We assumed the research workers are exposed to Ra-226 and its daughter products including radon gas through external radiation, ingestion, inhalation and dermal exposure. This exposure scenario corresponds to Scenario 1 described in the Exposure Assessment section of the Draft Final Determination of Risk-Based Action Standards for DOE Areas, dated August 4, 1997.

The site-specific data file for Ra-226 in Scenario 1 of the Risk-Based Action Standards calculations was used as the initial template for the RESRAD calculations. The cover thickness was varied to determine the Ra-226 activity that will result in target risk levels of $1x10^{-5}$ and $5x10^{-5}$. With the exception of cover thickness and Ra-226 activity, the Scenario 1 site-specific parameters and research worker exposure parameters were left unmodified for these calculations. However, the time scale was modified to determine peak dose rate.

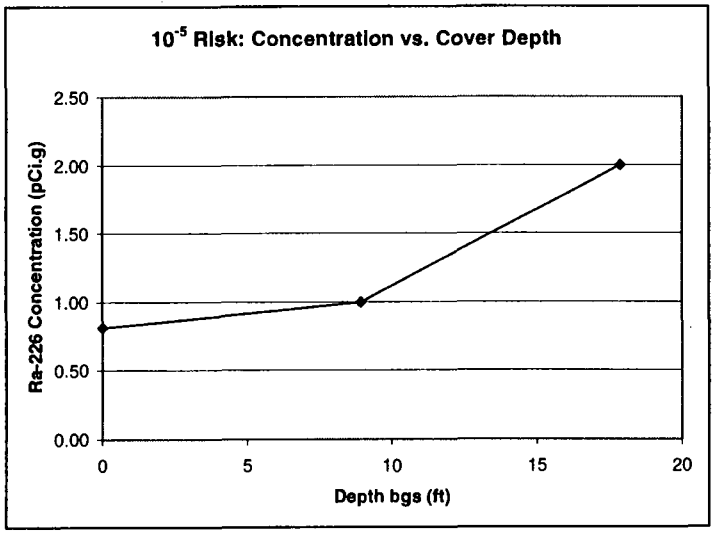
The peak dose rate occurred at t=0 years when the cover thickness was assumed to be zero. When the cover thickness was set between 4.7 and 17.9 ft, the dose rate peaked between approximately 1,400 years and 5,500 years.

The results of these calculations are presented in tabular and graphical form in Figure E-1. The graphs indicate that the relationship between concentration and depth is concave for a fixed risk level. As the cover thickness increases, higher Ra-226 activities may remain in soil to achieve a fixed risk level. This would also require placing restrictions on the future use of the site, specifically limits on intrusive activities involving excavation or disturbance of subsurface soils.

| $10^{-5}$ Risk | |
|---|---|
| depth (ft) | Ra-226 Concentration (pCi/g) |
| 0 | 0.81 |
| 8.9 | 1.0 |
| 17.9 | 2.0 |

| $5 \times 10^{-5}$ Risk | |
|---|---|
| depth (ft) | Ra-226 Concentration (pCi/g) |
| 0 | 0.98 |
| 4.7 | 1.3 |
| 9.4 | 2.0 |

Note: Ra-226 concentrations include background og 0.77 pCi/g.



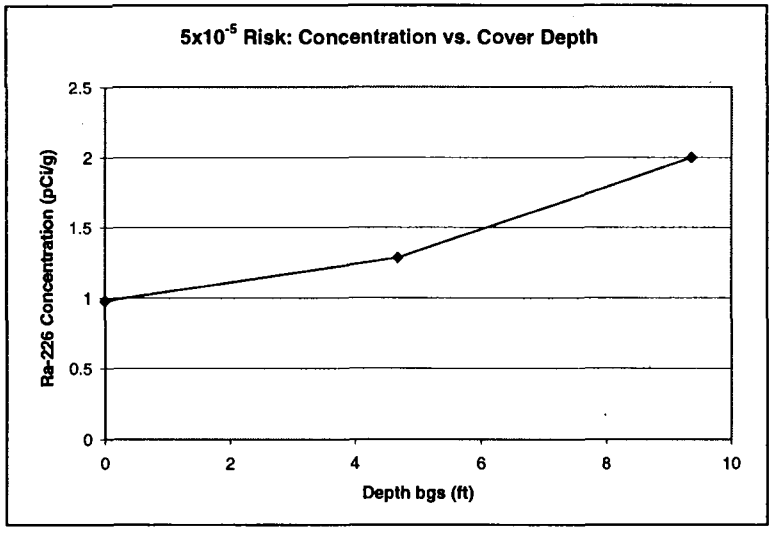




**Figure: E-1**

# APPENDIX F

## COST ESTIMATE SUMMARIES FOR REMOVAL ACTION ALTERNATIVES

# F. COST ESTIMATE SUMMARIES FOR REMOVAL ACTION ALTERNATIVES

This section provides the preliminary cost estimates for the removal actions being evaluated in the DOE LEHR EE/CA. The cost estimates are for the Southwest Trenches Area, the Ra/Sr Treatment System Area, and the Domestic Septic System Areas. The costs include the No Action alternative, the Excavation and Off-Site Disposal alternative, and the Excavation, Off-Site Disposal, and Institutional Controls alternative. The alternatives were evaluated at different risk levels, A, B, and C, as appropriate. The three risk levels are defined in the body of the EE/CA report. These cost estimates are used in the body of the EE/CA to compare the financial implications between the alternatives evaluated.

These cost estimates are intended to provide an accuracy of +50% to –30%. The accuracy range is for uncertainties involved in developing the costs for the assumed volume of soil and waste. There are also uncertainties in calculating the assumed soil and waste removal volumes. The calculation of soil and waste volumes is discussed in Appendix G. The uncertainties in soil and waste volumes are not reflected in these cost estimates. It is likely that increased soil volumes will increase the costs linearly. Thirteen cost estimates were developed and are broken down as follows:

1. Southwest Trenches
   - No Action
   - Excavation and Off-Site Disposal, Risk Level A
   - Excavation and Off-Site Disposal, Risk Level B
   - Excavation and Off-Site Disposal, Risk Level C
   - Excavation Off-Site Disposal and Institutional Controls, Risk Level A
   - Excavation Off-Site Disposal and Institutional Controls, Risk Level B
   - Excavation Off-Site Disposal and Institutional Controls, Risk Level C
2. Ra/Sr Treatment System
   - No Action
   - Excavation and Off-Site Disposal, Risk Level A
   - Excavation and Off-Site Disposal, Risk Level C
   - Excavation, Off-Site Disposal and Institutional Controls, Risk Level C
3. Domestic System
   - No Action
   - Excavation, Off-Site Disposal and Institutional Controls, Risk Level C

These estimates are to be used for cost comparison of the removal actions. These cost estimates are not intended to be inclusive or represent the final removal action costs. The final cost of the removal action will vary based on several key factors including, soil and waste volumes, soil and waste characteristics, contractor costs at the time the work is undertaken, actual schedule of implementation, special rates negotiated with transportation and disposal contractors, etc.

These costs target the primary cost components; these are the cost components that have the greatest impact on the removal actions. The key cost components are given unit cost values based on: current LEHR costs, WA- and vender-supplied cost estimates, and construction cost guides for environmental activities and excavation and earthwork activities. The key cost components are summarized below with their associated unit costs.

Table F-1. Primary Cost Components

| Primary Component | Cost | Source | Comments |
|---|---|---|---|
| | | *Capital Costs* | |
| Low Level Radiological Waste Disposal | $365/cy | Current LEHR Cost | Disposal at the Hanford Facility |
| Transportation | $450/cy | Current LEHR Cost | Includes shipping from Davis to Hanford in B25 boxes (box costs included) |
| Labor Rates | $65 to $85 per hour | WA estimated costs | Average cost range for field and office labor |
| Sampling and Analysis | $960,000 | Vendor quote and WA estimated cost | Total program cost (see detail in this appendix) |
| | | *Annual Costs* | |
| Ongoing Air Monitoring | $15,000/year | WA estimated annual cost | Biannual air sampling and analyses for target chemicals |
| Site Inspections | $10,000/year | WA estimated annual cost | Biannual site inspections and summary report of site condition |

The cost estimate models are most sensitive to the changes in estimated soil and waste volumes. Therefore, the most significant primary costs are soil and waste transportation and disposal costs. These components have high unit costs as compared to the other unit costs and are dependent on soil and waste volumes generated during the removal action. Changes in the soil and waste volumes reflect a significant change in the cost estimate.

In the detailed cost breakdowns that follow, the primary cost components are combined with secondary cost components. Secondary cost components are costs that are expected to impact the cost estimates at this level of accuracy but to a lesser extent than the primary cost components. A cost resource summary sheet is included prior to the detailed cost sheets. The cost resource summary sheet includes the basis and scope for the items included in the cost analyses.

## REFERENCES

1993 National Construction Estimator 41st Edition, edited by Martin D. Kiley and William M. Moselle, Craftsman Book Company, 1993.

Current LEHR site operating costs.

Environmental Restoration: Assemblies Cost Book and Unit Cost Book, ECHOS, 1995.

Estimating Construction Costs, by Robert L. Peurifoy and Garold D. Oberlender, 1989.

Weiss Associates estimated rates/costs or rates/costs supplied to WA by subcontractors or venders.

Table F-2. Cost Resource Data

**COST RESOURCE DATA SHEET**

| Item | Cost | Units | Basis of Unit Cost | Scope of Work |
|---|---|---|---|---|
| Air Surveillance and Maintenance | 400,000 | lump sum | WA estimated cost including fringe, overhead, and full fee | Five site air monitoring stations collecting particulate filter air samples for gross alpha and beta and Ra-226 analysis, and high volume particulate air sampling for PM-10 and metals analysis. Three perimeter stations and one off-site background station. |
| Back-fill and Compaction | 42 | $/cy | National Construction Estimator | Import fill and compact in excavation |
| Biannual Site Inspection | 10,000 | $/year | WA estimated cost including fringe, overhead, and full fee | The post removal action site inspection program shall include bi-annual day long site visits by a qualified field technician. The field technician shall physically walk the entire site, log all significant observations, and record the site visit with photographs. |
| B-25 Box Storage | 50,000 | $/item | WA estimated cost including fringe, overhead, and full fee | Waste may be stored on-site prior to disposal. A storage area will be prepared and full boxes will be placed there. While in storage, the containers will be inspected, inventoried, and maintained on a monthly basis. Weather protection of the storage containers will be provided. |
| Deed Restriction | 20,000 | lump sum | WA estimated cost including fringe, overhead, and full fee | Labor to negotiate and prepare the deed restriction. Includes fringe, overhead, and full fee. |
| Demobilization | 0.03 | % | National Construction Estimator | Removing construction related equipment supplies and personnel from the site at the completion of the site-work. Includes fringe, overhead, and full fee. |
| Disposal at Hanford | 365 | $/cy | Vender quote (Hanford Disposal Facility) | Disposal at Hanford as Class 1 LLW. |
| South West Trenches: Sample and Analysis | 520,000 | lump sum | Vender quote and WA estimates including fringe, overhead, and full fee | Field and lab sampling and analyses for all phases of this area. See backup tables included in this appendix. |
| Ra/Sr Area: Sample and Analysis | 380,000 | lump sum | Vender quote and WA estimates including fringe, overhead, and full fee | Field and lab sampling and analyses for all phases of this area. See backup tables included in this appendix. |

Table F-2. Cost Resource Data (continued)

| Item | Cost | Units | Basis of Unit Cost | Scope of Work |
|---|---|---|---|---|
| Domestic Septic System: Sample and Analysis | 30,000 | lump sum | Vender quote and WA estimates including fringe, overhead, and full fee | Field and lab sampling and analyses for all phases of this area. See backup tables included in this appendix. |
| Excavation, Backfill, Compact | 35 | $/cy | National Construction Estimator | Excavate, stockpile and backfill with excavated spoils during the excavation plan trenching task. |
| Field Labor | 65 | $/hour | WA estimated cost including fringe, overhead, and full fee | Includes fringe, overhead and full fee. |
| Additional Characterization | 17,000 | ls | WA estimated cost including fringe, overhead, and full fee | Additional characterization of domestic septic tanks 3 and 6. Up to three direct push borings to 20 ft at each location. Up to 10 samples from each location. Sampling for Ra at tank 3 and mercury at tank 6. |
| Geotextile Liner | 1 | $/sq ft installed | Vender quote (In-Line Plastics, Inc.) | Woven Geotextile liner for use prior to back-filling the excavations. |
| Grading and Paving | 10,000 | lump sum | ECHOS cost guide | Returning site to pre field work conditions. |
| Health and Safety | 300,000 | lump sum | WA estimated cost including fringe, overhead, and full fee | A SHSO shall be dedicated to HS issues at half time for all removal action field work. Project HS manager for oversight. Daily tail gate meetings, monthly meetings, periodic surveillance and audits. HS supplies and equipment are included. |
| Management Labor | 85 | $/hour | WA estimated cost including fringe, overhead, and full fee | Includes fringe, overhead and full fee. |
| Mobil Lab Costs | 120,000 | lump sum | Vender quote | |
| Mobilization | 0.03 | % | National Construction Estimator | |
| Office Labor | 75 | $/hour | WA estimated cost including fringe, overhead, and full fee | Includes fringe, overhead and full fee. |
| Ongoing Air Monitoring | 15,000 | $/year | WA estimated cost including fringe, overhead, and full fee | Two on-site perimeter air monitoring stations collecting particulate filter air samples for gross alpha and beta and Ra-226 analysis, and high volume particulate air sampling for PM-10 and metals analysis. Includes maintenance of on-site meteorological stations. |

Table F-2. Cost Resource Data (continued)

| Item | Cost | Units | Basis of Unit Cost | Scope of Work |
|---|---|---|---|---|
| QA/QC Inspections | 30,000 | lump sum | WA estimated cost including fringe, overhead, and full fee | A project QA assurance specialist shall be on-site for all removal action field work. Inspections shall be performed on a daily basis for removal action labor and materials. Inspection shall included testing of backfill compaction and concrete placement. |
| QA/QC Surveillance/Audits | 40,000 | lump sum | WA estimated cost including fringe, overhead, and full fee | A project QA assurance specialist shall be on site for all removal action field work. Task oversight shall be provided by a project QA assurance manager. The task program shall included daily quality control logs, weekly surveillances and weekly meetings. |
| Permit Fees and Labor | 40,000 | lump sum | WA estimated cost including fringe, overhead, and full fee | Fees for site work overseen by local agencies and other interested parties and labor for permits and/or notifications. Includes fringe, overhead and full fee. |
| Pre-field Work Preparation | 315,000 | lump sum | WA estimated cost including fringe, overhead, and full fee | Coordination and scheduling mobilization and field work activities. Prepare all pre-field work documents and SOPs. No permitting is included. |
| Site Management | 20,000 | $/month | ECHOS cost guide | Full-time site management including clerical. Includes fringe, overhead and full fee. |
| Site Preparation | 1 | $/sq foot | National Construction Estimator | Clearing and grubbing construction areas. |
| Site Survey | 20,000 | lump sum | WA estimated cost including fringe, overhead, and full fee | Site-wide property survey with emphasis on construction areas. |
| Soil/Debris Loading/Box Preparation and Handling | 56 | $/cy | National Construction Estimator | Loading soil and debris from stockpiles into B-25 boxes and machine compacting. |
| Soil/Debris removal | 29 | $/cy | National Construction Estimator | Excavating and stockpiling soil with a backhoe. |
| Soil/Debris Screening/Sorting | 56 | $/cy | National Construction Estimator | Sorting stockpiled material prior to loading into B-25 boxes. |
| Transportation | 450 | $/cy | Vender quote (Laidlaw) | Trucking 4 B-25 boxes (3 cy each) from Davis to Hanford for disposal. Includes $700 per B-25 box and $2,600 for the round trip trucking. |
| Utility Location/Rerouting | 100,000 | lump sum | Vender quote and WA estimates including fringe, overhead, and full fee | Locating underground and above ground utilities. Arranging temporary shut off or rerouting with the University and interested agencies. Implementing rerouting. |

Table F-2. Cost Resource Data (continued)

| Item | Cost | Units | Basis of Unit Cost | Scope of Work |
|---|---|---|---|---|
| Utility Restoration | 20,000 | lump sum | Vender quote and WA estimates including fringe, overhead, and full fee | Restoring Utilities after construction activities are completed. |
| Waste Characterization Forms | 60,000 | lump sum | WA estimated cost including fringe, overhead, and full fee | Prepare waste characterization paperwork and submitting to disposal facility. Negotiating for approval. |
| Dry Well Removal | 30,000 | $/well | Vender quote | Ra/Sr dry well removal costs |
| Hazardous Waste Disposal and Shipping | 350 | $/cy | Vender quote (Waste Management Inc.) | Disposal of RCRA Hazardous Waste at Chemical Waste management in CA. Includes shipping. |

Table F-3. Southwest Trenches, Alt 1 – No Action

| **Capital Costs** | *Quantity* | *Unit* | *Unit Cost ($)* | *Cost ($)* | *Comments* |
|---|---|---|---|---|---|
| None | | | | - | |
| | | | **Capital Cost Subtotal** | - | |
| **Annual Costs** | *Quantity* | *Unit* | *Unit Cost* | *Cost* | *Comments* |
| Monitoring | | | | | |
| Biannual Site Inspection | 1 | item | 10,000 | 10,000 | |
| Ongoing Air Monitoring | 1 | item | 15,000 | 15,000 | |
| | | | Annual Cost Subtotal | 25,000 | |
| | | | **Present Worth of Annual Cost Subtotal** | **600,000** | At 4% for 100 Years |
| **Total Cost** | | | | | |
| | | | No Action Subtotal | 600,000 | |
| | | | 20% Contingency | - | Capital Costs Only |
| | | | **TOTAL** | **$600,000** | |

# Table F-4. Southwest Trenches, Alt 2 - Excavation and Off-Site Disposal (Risk Level A)

**COST ANALYSIS**

**Capital Cost**

| | *Quantity* | *Unit* | *Unit Cost* | *Cost* | *Comments* |
|---|---|---|---|---|---|
| Site Survey | 0.50 | ls | 20000.00 | 10,000 | cost split between all three removal action areas |
| Permitting | | | | | |
| Permit fees/labor | 1.00 | ls | 40000.00 | 40,000 | |
| Pre-field Work Preparation | 0.50 | % | 315000.00 | 157,500 | |
| Excavation Plan Trenching | | | | | |
| Excavation, backfill, compact | 740.74 | cu yd | 35.00 | 25,926 | |
| Field Work | | | | | |
| Mobilization | 0.03 | % | 1389644.24 | 41,689 | Cost based on construction costs |
| Site Preparation | 22500.00 | sq ft | 0.54 | 12,161 | |
| Site Management | 2.00 | month | 20000.00 | 40,000 | |
| Utility Location/Rerouting | 0.40 | ls | 100000.00 | 40,000 | cost split between all three removal action areas |
| Soil/Debris Removal | 1841.23 | cu yd | 29.00 | 53,396 | based on excavated volume |
| Soil/Debris Screening/Sorting | 1841.23 | cu yd | 56.00 | 103,109 | based on excavated volume |
| Mobile Lab Equipment | 0.50 | ls | 120000.00 | 60,000 | cost split between all three removal action areas |
| Air Monitoring Program | 0.50 | ls | 400000.00 | 200,000 | cost split between all three removal action areas |
| Waste Disposal Permit | 0.50 | ls | 60000.00 | 30,000 | cost split between all three removal action areas |
| Soil/Debris Loading/Box Preparation and Handling | 1841.23 | cu yd | 56.00 | 103,109 | based on excavated volume |
| Soil/Debris Shipping and Disposal | 1416.33 | cu yd | 815.00 | 1,154,312 | based on compacted volume |
| QA/QC Inspections | 1.00 | ls | 30000.00 | 30,000 | |
| QA/QC Surveillance/Audits | 1.00 | ls | 40000.00 | 40,000 | |
| Health and Safety | 1.00 | ls | 300000.00 | 300,000 | |
| Box Storage | 1.00 | ls | 50000.00 | 50,000 | |
| Sampling and Analysis | 1.00 | ls | 530000.00 | 530,000 | |
| Geotextile Liner | 17104.00 | sq ft | 1.00 | 17,104 | |
| Utility Restoration | 1.00 | ls | 20000.00 | 20,000 | |
| Back-fill and Compaction | 1841.23 | cu yd | 35.00 | 64,443 | based on excavated volume |
| Grading and Paving | 1.00 | ls | 10000.00 | 10,000 | |
| Demobilization | 0.03 | % | 1389644.24 | 41,689 | Cost based on construction costs |
| Task Management | | | | | |
| Field Work Oversight | 1,040.00 | hrs | 85.00 | 88,400 | |
| Ongoing Progress Reports | 208.00 | hrs | 85.00 | 17,680 | |
| Data Management | 520.00 | hrs | 75.00 | 39,000 | |
| Meetings | 1,152.00 | hrs | 85.00 | 97,920 | |
| Final Report | 320.00 | hrs | 85.00 | 27,200 | |
| | | | **Capital Cost Subtotal** | **3,400,000** | |

**Annual Costs**

| | *Quantity* | *Unit* | *Unit Cost* | *Cost* | *Comments* |
|---|---|---|---|---|---|
| | | | Annual Cost Subtotal | - | |
| | **Present Worth of Annual Cost Subtotal** | | | - | At 4% for 100 Years |

**Total Cost**

| | |
|---|---|
| Alternative 2 - Risk Level A Subtotal | 3,400,000 |
| 20% Contingency | 680,000 |
| **TOTAL** | **4,100,000** |

# Table F-5. Southwest Trenches, Alt 2 – Excavation and Off-Site Disposal (Risk Level B)

**COST ANALYSIS**

**Capital Cost**

| | *Quantity* | *Unit* | *Unit Cost* | *Cost* | *Comments* |
|---|---|---|---|---|---|
| Site Survey | 0.50 | ls | 20000.00 | 10,000 | cost split between all three removal action areas |
| Permitting | | | | | |
| Permit fees/labor | 1.00 | ls | 40000.00 | 40,000 | |
| Pre-field Work Preparation | 0.50 | % | 315000.00 | 157,500 | |
| Excavation Plan Trenching | | | | | |
| Excavation, backfill, compact | 740.74 | cu yd | 35.00 | 25,926 | |
| Field Work | | | | | |
| Mobilization | 0.03 | % | 1628420.09 | 48,853 | Cost based on construction costs |
| Site Preparation | 22500.00 | sq ft | 0.54 | 12,161 | |
| Site Management | 2.00 | month | 20000.00 | 40,000 | |
| Utility Location/Rerouting | 0.40 | ls | 100000.00 | 40,000 | cost split between all three removal action areas |
| Soil/Debris Removal | 3063.52 | cu yd | 29.00 | 88,842 | based on excavated volume |
| Soil/Debris Screening/Sorting | 3063.52 | cu yd | 56.00 | 171,557 | based on excavated volume |
| Mobile Lab Equipment | 0.50 | ls | 120000.00 | 60,000 | cost split between all three removal action areas |
| Air Monitoring Program | 0.50 | ls | 400000.00 | 200,000 | cost split between all three removal action areas |
| Waste Disposal Permit | 0.50 | ls | 60000.00 | 30,000 | cost split between all three removal action areas |
| Soil/Debris Loading/Box Preparation and Handling | 3063.52 | cu yd | 56.00 | 171,557 | based on excavated volume |
| Soil/Debris Shipping and Disposal | 2356.56 | cu yd | 815.00 | 1,920,593 | based on compacted volume |
| QA/QC Inspections | 1.00 | ls | 30000.00 | 30,000 | |
| QA/QC Surveillance/Audits | 1.00 | ls | 40000.00 | 40,000 | |
| Health and Safety | 1.00 | ls | 300000.00 | 300,000 | |
| Box Storage | 1.00 | ls | 50000.00 | 50,000 | |
| Sampling and Analysis | 1.00 | ls | 530000.00 | 530,000 | |
| Geotextile Liner | 23653.00 | sq ft | 1.00 | 23,653 | |
| Utility Restoration | 1.00 | ls | 20000.00 | 20,000 | |
| Back-fill and Compaction | 3063.52 | cu yd | 35.00 | 107,223 | based on excavated volume |
| Grading and Landscaping | 1.00 | ls | 10000.00 | 10,000 | |
| Demobilization | 0.03 | % | 1628420.09 | 48,853 | Cost based on construction costs |
| Task Management | | | | | |
| Field Work Oversight | 1040.00 | hrs | 85.00 | 88,400 | |
| Ongoing Progress Reports | 208.00 | hrs | 85.00 | 17,680 | |
| Data Management | 520.00 | hrs | 75.00 | 39,000 | |
| Meetings | 1152.00 | hrs | 85.00 | 97,920 | |
| Final Report | 320.00 | hrs | 85.00 | 27,200 | |
| | | | **Capital Cost Subtotal** | **4,400,000** | |

**Annual Costs**

| | *Quantity* | *Unit* | *Unit Cost* | *Cost* | *Comments* |
|---|---|---|---|---|---|
| NONE | | | | | |
| | | | Annual Cost Subtotal | - | |
| | | | **Present Worth of Annual Cost Subtotal** | - | At 4% for 100 Years |

**Total Costs**

| | | |
|---|---|---|
| Alternative 2 - Risk Level B Subtotal | 4,400,000 | |
| 20% Contingency | 880,000 | On Capital costs only |
| **TOTAL** | **5,300,000** | |

# Table F-6. Southwest Trenches, Alt 2 – Excavation and Off-Site Disposal (Risk Level C)

**COST ANALYSIS**

**Capital Cost**

| | *Quantity* | *Unit* | *Unit Cost* | *Cost* | *Comments* |
|---|---|---|---|---|---|
| Site Survey | 0.50 | ls | 20,000.00 | 10,000 | cost split between all three removal action areas |
| Permitting | | | | | |
| Permit fees/labor | 1.00 | ls | 40,000.00 | 40,000 | |
| Pre-field Work Preparation | 0.50 | % | 315,000.00 | 157,500 | |
| Excavation Plan Trenching | | | | | |
| Excavation, backfill, compact | 740.74 | cu yd | 35.00 | 25,926 | |
| Field Work | | | | | |
| Mobilization | 0.03 | % | 1,676,142.09 | 50,284 | Cost based on construction costs |
| Site Preparation | 22,500.00 | sq ft | 0.54 | 12,161 | |
| Site Management | 2.00 | month | 20,000.00 | 40,000 | |
| Utility Location/Rerouting | 0.40 | ls | 100,000.00 | 40,000 | cost split between all three removal action areas |
| Soil/Debris Removal | 3,323.52 | cu yd | 29.00 | 96,382 | based on excavated volume |
| Soil/Debris Screening/Sorting | 3,323.52 | cu yd | 56.00 | 186,117 | based on excavated volume |
| Mobile Lab Equipment | 0.50 | ls | 120,000.00 | 60,000 | cost split between all three removal action areas |
| Air Monitoring Program | 0.50 | ls | 400,000.00 | 200,000 | cost split between all three removal action areas |
| Waste Disposal Permit | 0.50 | ls | 60,000.00 | 30,000 | cost split between all three removal action areas |
| Soil/Debris Loading/Box Preparation and Handling | 3,323.52 | cu yd | 56.00 | 186,117 | based on excavated volume |
| Soil/Debris Shipping and Disposal | 2,556.56 | cu yd | 815.00 | 2,083,593 | based on compacted volume |
| QA/QC Inspections | 1.00 | ls | 30,000.00 | 30,000 | |
| QA/QC Surveillance/Audits | 1.00 | ls | 40,000.00 | 40,000 | |
| Health and Safety | 1.00 | ls | 300,000.00 | 300,000 | |
| Box Storage | 1.00 | ls | 50,000.00 | 50,000 | |
| Sampling and Analysis | 1.00 | ls | 530,000.00 | 530,000 | |
| Geotextile Liner | 25,615.00 | sq ft | 1.00 | 25,615 | |
| Utility Restoration | 1.00 | ls | 20,000.00 | 20,000 | |
| Back-fill and Compaction | 3,323.52 | cu yd | 35.00 | 116,323 | based on excavated volume |
| Grading and Paving | 1.00 | ls | 10,000.00 | 10,000 | |
| Demobilization | 0.03 | % | 1,676,142.09 | 50,284 | Cost based on construction costs |
| Task Management | | | | | |
| Field Work Oversight | 1,040.00 | hrs | 85.00 | 88,400 | |
| Ongoing Progress Reports | 208.00 | hrs | 85.00 | 17,680 | |
| Data Management | 520.00 | hrs | 75.00 | 39,000 | |
| Meetings | 1,152.00 | hrs | 85.00 | 97,920 | |
| Final Report | 320.00 | hrs | 85.00 | 27,200 | |
| | | | **Capital Cost Subtotal** | **4,700,000** | |

**Annual Costs**

| | *Quantity* | *Unit* | *Unit Cost* | *Cost* | *Comments* |
|---|---|---|---|---|---|
| NONE | | | | | |
| | | | Annual Cost Subtotal | - | |
| | | | **Present Worth of Annual Cost Subtotal** | - | At 4% for 100 Years |

**Total Costs**

| | | |
|---|---|---|
| Alternative 2 - Risk level C Subtotal | 4,700,000 | |
| 20% Contingency | 940,000 | On Capital Costs Only |
| **TOTAL** | **5,600,000** | |

Table F-7. Southwest Trenches, Alt 3 – Excavation and Off-Site Disposal with Institutional Controls (Risk Level A)

**COST ANALYSIS**

**Capital Cost**

| | *Quantity* | *Unit* | *Unit Cost* | *Cost* | *Comments* |
|---|---|---|---|---|---|
| Site Survey | 0.50 | ls | 20,000 | 10,000 | cost split between all three removal action areas |
| Permitting | | | | | |
| Permit fees/labor | 1.00 | ls | 40,000 | 40,000 | |
| Excavation Plan Trenching | | | | | |
| Excavation, backfill, compact | 740.74 | cu yd | 35 | 25,926 | |
| Pre-field Work Preparation | 0.50 | % | 315,000 | 157,500 | cost split between all three removal action areas |
| Field Work | | | | | |
| Mobilization | 0.03 | % | 1,346,684 | 40,401 | Cost based on construction costs |
| Site Preparation | 22,500.00 | sq ft | 1 | 12,161 | |
| Site Management | 2.00 | month | 20,000 | 40,000 | |
| Utility Location/Rerouting | 0.40 | ls | 100,000 | 40,000 | cost split between all three removal action areas |
| Soil/Debris Removal | 1,401.11 | cu yd | 29 | 40,632 | based on excavated volume |
| Soil/Debris Screening/Sorting | 1,401.11 | cu yd | 56 | 78,462 | based on excavated volume |
| Mobile Lab Equipment | 0.50 | ls | 120,000 | 60,000 | cost split between all three removal action areas |
| Air monitoring program | 0.50 | ls | 400,000 | 200,000 | cost split between all three removal action areas |
| Waste Disposal Permit | 0.50 | ls | 60,000 | 30,000 | cost split between all three removal action areas |
| Soil/Debris Loading/Box Preparation and Handling | 1,401.11 | cu yd | 56 | 78,462 | based on excavated volume |
| Soil/Debris Shipping and Disposal | 1,077.78 | cu yd | 815 | 878,389 | based on compacted volume |
| QA/QC Inspections | 1.00 | ls | 30,000 | 30,000 | |
| QA/QC Surveillance/Audits | 1.00 | ls | 40,000 | 40,000 | |
| Health and Safety | 1.00 | ls | 300,000 | 300,000 | |
| Box Storage | 1.00 | ls | 50,000 | 50,000 | |
| Sampling and Analysis | 1.00 | ls | 530,000 | 530,000 | |
| Utility Restoration | 1.00 | ls | 20,000 | 20,000 | |
| Geotextile Liner | 14,501.00 | sq ft | 1 | 14,501 | |
| Back-fill and Compaction | 1,401.11 | cu yd | 35 | 49,039 | based on excavated volume |
| Grading and Paving | 1.00 | ls | 10,000 | 10,000 | |
| Demobilization | 0.03 | % | 1,346,684 | 40,401 | Cost based on construction costs |
| Deed restriction | 1.00 | ls | 20,000 | 20,000 | |
| Task Management | | | | | |
| Field Work Oversight | 1,040.00 | hrs | 85.00 | 88,400 | |
| Ongoing Progress Reports | 208.00 | hrs | 85.00 | 17,680 | |
| Data Management | 520.00 | hrs | 75.00 | 39,000 | |
| Meetings | 1,152.00 | hrs | 85.00 | 97,920 | |
| Final Report | 320.00 | hrs | 85.00 | 27,200 | |
| | | | **Capital Costs Subtotal** | **3,100,000** | |

**Annual Costs**

| | Quantity | *Unit* | *Unit Cost* | *Cost* | *Comments* |
|---|---|---|---|---|---|
| Field Work | | | | | |
| Biannual Site Inspection | 1.00 | item | 10,000 | 10,000 | |
| | | | Annual Cost Subtotal | 10,000 | |
| | | | **Present Worth of Annual Cost Subtotal** | **200,000** | At 4% for 100 Years |

**Total Costs**

| | | |
|---|---|---|
| Alternative 3 - Risk Level A Subtotal | 3,300,000 | |
| 20% Contingency | 620,000 | On Capital Costs Only |
| **TOTAL** | **3,900,000** | |

Table F-8. Southwest Trenches, Alt 3 – Excavation and Off-Site Disposal with Institutional Controls (Risk Level B)

**COST ANALYSIS**

**Capital Cost**

| | Quantity | Unit | Unit Cost | Cost | Comments |
|---|---|---|---|---|---|
| Site Survey | 0.50 | ls | 20,000 | 10,000 | cost split between all three removal action areas |
| Permitting | | | | | |
| Permit fees/labor | 1.00 | ls | 40,000 | 40,000 | |
| Excavation Plan Trenching | | | | | |
| Excavation, backfill, compact | 740.74 | cu yd | 35 | 25,926 | |
| Pre-field Work Preparation | 0.50 | % | 315,000 | 157,500 | cost split between all three removal action areas |
| Field Work | | | | | |
| Mobilization | 0.03 | % | 1,370,545 | 41,116 | Cost based on construction costs |
| Site Preparation | 22,500.00 | sq ft | 1 | 12,161 | |
| Site Management | 2.00 | month | 20,000 | 40,000 | |
| Utility Location/Rerouting | 0.40 | ls | 100,000 | 40,000 | cost split between all three removal action areas |
| Soil/Debris Removal | 1,531.11 | cu yd | 29 | 44,402 | based on excavated volume |
| Soil/Debris Screening/Sorting | 1,531.11 | cu yd | 56 | 85,742 | based on excavated volume |
| Mobile Lab Equipment | 0.50 | ls | 120,000 | 60,000 | cost split between all three removal action areas |
| Air Monitoirng Program | 0.50 | ls | 400,000 | 200,000 | cost split between all three removal action areas |
| Waste Disposal Permit | 0.50 | ls | 60,000 | 30,000 | cost split between all three removal action areas |
| Soil/Debris Loading/Box Preparation and Handling | 1,531.11 | cu yd | 56 | 85,742 | based on excavated volume |
| Soil/Debris Shipping and Disposal | 1,177.78 | cu yd | 815 | 959,889 | based on compacted volume |
| QA/QC Inspections | 1.00 | ls | 30,000 | 30,000 | |
| QA/QC Surveillance/Audits | 1.00 | ls | 40,000 | 40,000 | |
| Health and Safety | 1.00 | ls | 300,000 | 300,000 | |
| Box Storage | 1.00 | ls | 50,000 | 50,000 | |
| Sampling and Analysis | 1.00 | ls | 530,000 | 530,000 | |
| Utility Restoration | 1.00 | ls | 20,000 | 20,000 | |
| Geotextile Liner | 15,482.00 | sq ft | 1 | 15,482 | |
| Back-fill and Compaction | 1,531.11 | cu yd | 35 | 53,589 | based on excavated volume |
| Grading and Paving | 1.00 | ls | 10,000 | 10,000 | |
| Demobilization | 0.03 | % | 1,370,545 | 41,116 | Cost based on construction costs |
| Deed restriction | 1.00 | ls | 20,000 | 20,000 | |
| Task Management | | | | | |
| Field Work Oversight | 1,040.00 | hrs | 85.00 | 88,400 | |
| Ongoing Progress Reports | 208.00 | hrs | 85.00 | 17,680 | |
| Data Management | 520.00 | hrs | 75.00 | 39,000 | |
| Meetings | 1,152.00 | hrs | 85.00 | 97,920 | |
| Final Report | 320.00 | hrs | 85.00 | 27,200 | |
| | | | **Capitol Costs Subtotal** | **3,200,000** | |

**Annual Costs**

| | Quantity | Unit | Unit Cost | Cost | Comments |
|---|---|---|---|---|---|
| Field Work | | | | | |
| Biannual Site Inspection | 1.00 | item | 10,000 | 10,000 | |
| | | | Annual Cost Subtotal | 10,000 | |
| | | | **Present Worth of Annual Cost Subtotal** | **200,000** | At 4% for 100 Years |

**Total Cost**

| | | |
|---|---|---|
| Alternative 3 - Risk Level B Subtotal | 3,400,000 | |
| 20% Contingency | 640,000 | On Capital Costs |
| **Total** | **4,000,000** | |

Table F-9. Southwest Trenches, Alt 3 – Excavation and Off-Site Disposal with Institutional Controls (Risk Level C)

**COST ANALYSIS**

**Capital Cost**

| | Quantity | Unit | Unit Cost | Cost | Comments |
|---|---|---|---|---|---|
| Site Survey | 0.50 | item | 20,000 | 10,000 | cost split between all three removal action areas |
| Permitting | | | | | |
| Permit fees/labor | 1.00 | ls | 40,000 | 40,000 | |
| Pre-field Work Preparation | 0.50 | % | 315,000 | 157,500 | |
| Excavation Plan Trenching | | | | | |
| Excavation, backfill, compact | 740.74 | cu yd | 35 | 25,926 | |
| Field Work | | | | | |
| Mobilization | 0.03 | % | 1,418,267 | 42,548 | Cost based on construction costs |
| Site Preparation | 22,500.00 | sq ft | 1 | 12,161 | |
| Site Management | 2.00 | month | 20,000 | 40,000 | |
| Utility Location/Rerouting | 0.40 | item | 100,000 | 40,000 | cost split between all three removal action areas |
| Soil/Debris Removal | 1,791.11 | cu yd | 29 | 51,942 | based on excavated volume |
| Soil/Debris Screening/Sorting | 1,791.11 | cu yd | 56 | 100,302 | based on excavated volume |
| Mobile Lab Equipment | 0.50 | item | 120,000 | 60,000 | cost split between all three removal action areas |
| Air Monitoring Program | 0.50 | ls | 400,000 | 200,000 | cost split between all three removal action areas |
| Waste Disposal Permit | 0.50 | item | 60,000 | 30,000 | cost split between all three removal action areas |
| Soil/Debris Loading/Box Preparation and Handling | 1,791.11 | cu yd | 56 | 100,302 | based on excavated volume |
| Soil/Debris Shipping and Disposal | 1,377.78 | cu yd | 815 | 1,122,889 | based on compacted volume |
| QA/QC Inspections | 1.00 | item | 30,000 | 30,000 | |
| QA/QC Surveillance/Audits | 1.00 | item | 40,000 | 40,000 | |
| Health and Safety | 1.00 | item | 300,000 | 300,000 | |
| Box Storage | 1.00 | item | 50,000 | 50,000 | |
| Sampling and Analysis | 1.00 | ls | 530,000 | 530,000 | |
| Utility Restoration | 1.00 | item | 20,000 | 20,000 | |
| Geotextile Liner | 17,444.00 | sq ft | 1 | 17,444 | |
| Back-fill and Compaction | 1,791.11 | cu yd | 35 | 62,689 | based on excavated volume |
| Grading and Landscaping | 1.00 | item | 10,000 | 10,000 | |
| Demobilization | 0.03 | % | 1,418,267 | 42,548 | Cost based on construction costs |
| Deed restriction | 1.00 | item | 20,000 | 20,000 | |
| Task Management | | | | | |
| Field Work Oversight | 1,040.00 | hrs | 85.00 | 88,400 | |
| Ongoing Progress Reports | 208.00 | hrs | 85.00 | 17,680 | |
| Data Management | 520.00 | hrs | 75.00 | 39,000 | |
| Meetings | 1,152.00 | hrs | 85.00 | 97,920 | |
| Final Report | 320.00 | hrs | 85.00 | 27,200 | |
| | | | **Capital Cost Subtotal** | **3,400,000** | |

**Annual Costs**

| | Quantity | Unit | Unit Cost | Cost | Comments |
|---|---|---|---|---|---|
| Field Work | | | | | |
| Biannual Site Inspection | 1 | item | 10,000 | 10,000 | |
| | | | Annual Cost Subtotal | 10,000 | |
| | | | **Present Worth of Annual Cost Subtotal** | **200,000** | At 4% for 100 Years |

**Total Costs**

| | | |
|---|---|---|
| Alternative 3 - Risk Level C Subtotal | 3,600,000 | |
| 20% Contingency | 680,000 | On Capitol Costs Only |
| **TOTAL** | **4,300,000** | |

## Table F-10. Ra/Sr Treatment Systems, Alt 1 – No Action

| **Capital Cost** | *Quantity* | *Unit* | *Unit Cost* | *Cost* | *Comments* |
|---|---|---|---|---|---|
| None | | | | - | |
| | | | **Capital Costs Subtotal** | - | |
| **Annual Costs** | *Quantity* | *Unit* ($) | *Unit Cost* ($) | *Cost* ($) | *Comments* |
| Monitoring | | | | | |
| Ongoing Air Monitoring | 1.00 | item | 15,000 | 15,000 | |
| Biannual Site Inspection | 1.00 | item | 10,000 | 10,000 | |
| | | | Annual Cost Subtotal | 25,000 | |
| | **Present Worth of Annual Cost Subtotal** | | | **600,000** | At 4% for 100 Years |
| **Total Costs** | | | | | |
| | | | No Action Subtotal | 600,000 | |
| | | | 20% Contingency | - | Capital Costs Only |
| | | | **TOTAL** | **$600,000** | |

## Table F-11. Ra/Sr Treatment Systems, Alt 2 – Excavation and Off-Site Disposal (Risk Level A)

| **Capital Cost** | *Quantity* | *Unit* | *Unit Cost* | *Cost* | *Comments* |
|---|---|---|---|---|---|
| Site Survey | 0.4 | % | 20,000.00 | 8,000 | Cost split between all three removal action areas |
| Permitting | | | | | |
| Permit fees/labor | 1 | ls | 40,000.00 | 40,000 | |
| Pre-field Work Preparation | 0.4 | % | 315,000.00 | 126,000 | Cost split between all three removal action areas |
| Field Work | | | | | |
| Mobilization | 0.03 | % | 1,374,243 | 41,227 | Cost based on construction costs |
| Site Prepartion | 10000 | sq ft | 0.54 | 5,405 | |
| Site Management | 1 | month | 20,000.00 | 20,000 | |
| Utility Location/Rerouting | 3 | item | 100,000.00 | 300,000 | |
| Dry Well Removal | 3 | well | 30,000.00 | 90,000 | |
| Soil/Debris Removal | 1568 | cy | 29.00 | 45,469 | based on excavated volume |
| Soil/Debris Screening/Sorting | 1568 | cy | 56.00 | 87,802 | based on excavated volume |
| Moble Lab Equipment | 0.5 | item | 120,000.00 | 60,000 | |
| Air monitoring program | 0.4 | % | 400,000.00 | 160,000 | Cost split between all three removal action areas |
| Waste Disposal Permit | 0.4 | item | 60,000.00 | 24,000 | Cost split between all three removal action areas |
| Soil/Debris Loading/Box Preparation and Handling | 1568 | cy | 56.00 | 87,802 | based on excavated volume |
| Soil/Debris Shipping and Disposal (LLRW) | 1098 | cy | 815.00 | 894,478 | based on compacted volume |
| QA/QC Inspections | 0.8 | item | 30,000.00 | 24,000 | Cost split between Ra/Sr and Domestic Septic tank areas |
| QA/QC Surveillance/Audits | 0.8 | item | 40,000.00 | 32,000 | Cost split between Ra/Sr and Domestic Septic tank areas |
| Health and Safety | 0.8 | item | 300,000.00 | 240,000 | Cost split between Ra/Sr and Domestic Septic tank areas |
| Box Storage | 0.8 | item | 50,000.00 | 40,000 | Cost split between Ra/Sr and Domestic Septic tank areas |
| Sampling and analysis | 1 | ls | 390,000.00 | 390,000 | |
| Utility Restoration | 1 | item | 20,000.00 | 20,000 | |
| Geotextile Liner | 13914.75 | sq ft | 1.00 | 13,915 | |
| Back-fill and Compaction | 1568 | cy | 42.00 | 65,851 | |
| Grading and paving | 1 | item | 10,000.00 | 10,000 | |
| Demobilization | 0.03 | % | 1,374,242.57 | 41,227 | Cost based on construction costs |
| Task Management | | | | | |
| Field Work Oversight | 520 | hrs | 85.00 | 44,200 | |
| Ongoing Progress Reports | 104 | hrs | 85.00 | 8,840 | |
| Data Management | 260 | hrs | 75.00 | 19,500 | |
| Meetings | 576 | hrs | 85.00 | 48,960 | |
| Final Report | 160 | hrs | 85.00 | 13,600 | |
| | | | **Capital Cost Subtotal** | **3,000,000** | |
| **Annual Costs** | | | | | |
| NONE | | | | | |
| | | | Annual Cost Subtotal | - | |
| | | | **Present Worth of Annual Cost Subtotal** | - | At 4% for 100 Years |
| **Total Cost** | | | | | |
| | | | Alternative 2 - Risk Level A Subtotal | 3,000,000 | |
| | | | 20% Contingency | 600,000 | |
| | | | **TOTAL** | **3,600,000** | |

# Table F-12. Ra/Sr Treatment Systems, Alt 2 – Excavation and Off-Site Disposal (Risk Level C)

**COST ANALYSIS**

**Capital Cost**

| | *Quantity* | *Unit* | *Unit Cost* | *Cost* | *Comments* |
|---|---|---|---|---|---|
| Site Survey | 0.4 | % | 20,000.00 | 8,000 | Cost split between all three removal action areas |
| Permitting | | | | | |
| Permit fees/labor | 1 | ls | 40,000.00 | 40,000 | |
| Pre-field Work Preparation | 0.4 | % | 315,000.00 | 126,000 | Cost split between all three removal action areas |
| Field Work | | | | | |
| Mobilization | 0.03 | % | 1,393,680 | 41,810 | Cost based on construction costs |
| Site Prepartion | 10000 | sq ft | 0.54 | 5,405 | |
| Site Management | 2 | month | 20,000.00 | 40,000 | |
| Utility Location/Rerouting | 0.6 | item | 100,000.00 | 60,000 | |
| Dry Well Removal | 3 | well | 30,000.00 | 90,000 | |
| Soil/Debris Removal | 1677 | cy | 29.00 | 48,645 | based on excavated volume |
| Soil/Debris Screening/Sorting | 2181 | cy | 56.00 | 122,116 | based on excavated volume |
| Moble Lab Equipment | 0.5 | item | 120,000.00 | 60,000 | |
| Air monitoring program | 0.4 | % | 400,000.00 | 160,000 | Cost split between all three removal action areas |
| Waste Disposal Permit | 0.4 | item | 60,000.00 | 24,000 | Cost split between all three removal action areas |
| Air monitoring program | 0.4 | % | 400,000.00 | 160,000 | |
| Soil/Debris Loading/Box Preparation and Handling | 2181 | cy | 56.00 | 122,116 | based on excavated volume |
| Soil/Debris Shipping and Disposal (LLRW) | 1526 | cy | 815.00 | 1,244,056 | based on compacted volume |
| QA/QC Inspections | 0.8 | item | 30,000.00 | 24,000 | Cost split between Ra/Sr and Domestic Septic tank areas |
| QA/QC Surveillance/Audits | 0.8 | item | 40,000.00 | 32,000 | Cost split between Ra/Sr and Domestic Septic tank areas |
| Health and Safety | 0.8 | item | 300,000.00 | 240,000 | Cost split between Ra/Sr and Domestic Septic tank areas |
| Box Storage | 0.8 | item | 50,000.00 | 40,000 | Cost split between Ra/Sr and Domestic Septic tank areas |
| Sampling and analysis | 1 | ls | 390,000.00 | 390,000 | |
| Utility Restoration | 1 | item | 20,000.00 | 20,000 | |
| Geotextile Liner | 16947 | sq ft | 1.00 | 16,947 | |
| Back-fill and Compaction | 1677 | cy | 42.00 | 70,452 | |
| Grading and Landscaping | 1 | item | 10,000.00 | 10,000 | |
| Demobilization | 0.03 | % | 1,393,680.20 | 41,810 | Cost based on construction costs |
| Task Management | | | | | |
| Field Work Oversight | 520 | hrs | 85.00 | 44,200 | |
| Ongoing Progress Reports | 104 | hrs | 85.00 | 8,840 | |
| Data Management | 260 | hrs | 65.00 | 16,900 | |
| Meetings | 576 | hrs | 85.00 | 48,960 | |
| Final Report | 160 | hrs | 85.00 | 13,600 | |
| | | | **Capitol Cost Subtotal** | **3,400,000** | |

**Annual Costs**

| | *Quantity* | *Unit* | *Unit Cost* | *Cost* | *Comments* |
|---|---|---|---|---|---|
| NONE | | | | | |
| | | | Annual Cost Subtotal | - | |
| | | | **Present Worth of Annual Cost Subtotal** | - | At 4% for 100 Years |

**Total Cost**

| | |
|---|---|
| Alternative 2 - Risk Level C Subtotal | 3,400,000 |
| 20% Contingency | 680,000 |
| **TOTAL** | **4,100,000** |

Table F-13. Ra/Sr Treatment Systems, Alt 3 – Excavation and Off-Site Disposal with Institutional Controls (Risk Level C)

| **Capital Cost** | *Quantity* | *Unit* | *Unit Cost* | *Cost* | *Comments* |
|---|---|---|---|---|---|
| Site Survey | 0.4 | % | 20,000.00 | 8,000 | Cost split between all three removal action areas |
| Permitting | | | | | |
| Permit fees/labor | 0.8 | ls | 40,000.00 | 32,000 | Cost split between Ra/Sr and Domestic Septic tank areas |
| Pre-field Work Preparation | 0.4 | % | 315,000.00 | 126,000 | Cost split between all three removal action areas |
| Field Work | | | | | |
| Mobilization | 0.03 | % | 1,036,963.89 | 31,109 | Cost based on construction costs |
| Site Preparation | 10000 | sq ft | 0.54 | 5,405 | |
| Site Management | 1 | month | 20,000.00 | 20,000 | |
| Utility Location/Rerouting | 0.6 | item | 100,000.00 | 60,000 | Cost split between all three removal action areas |
| Dry Well Removal | 3 | well | 30,000.00 | 90,000 | |
| Soil/Debris Removal | 1018 | cy | 29.00 | 29,525 | based on excavated volume |
| Soil/Debris Screening/Sorting | 1018 | cy | 56.00 | 57,014 | based on excavated volume |
| Mobile Lab Equipment | 0.5 | item | 120,000.00 | 60,000 | Cost split between all three removal action areas |
| Air monitoring program | 0.4 | % | 400,000.00 | 160,000 | Cost split between all three removal action areas |
| Waste Disposal Permit | 0.4 | item | 60,000.00 | 24,000 | Cost split between all three removal action areas |
| Soil/Debris Loading/Box Preparation and Handling | 1018 | cy | 56.00 | 57,014 | based on excavated volume |
| Soil/Debris Shipping and Disposal (LLRW) | 864 | cy | 815.00 | 704,447 | based on compacted volume |
| QA/QC Inspections | 0.8 | ls | 30,000.00 | 24,000 | Cost split between Ra/Sr and Domestic Septic tank areas |
| QA/QC Surveillance/Audits | 0.8 | item | 40,000.00 | 32,000 | Cost split between Ra/Sr and Domestic Septic tank areas |
| Health and Safety | 0.8 | item | 300,000.00 | 240,000 | Cost split between Ra/Sr and Domestic Septic tank areas |
| Box Storage | 0.8 | item | 50,000.00 | 40,000 | Cost split between Ra/Sr and Domestic Septic tank areas |
| Sampling and analysis | 1 | ls | 390,000.00 | 390,000 | |
| Utility Restoration | 1 | item | 20,000.00 | 20,000 | |
| Geotextile Liner | 11704 | sq ft | 1.00 | 11,704 | |
| Back-fill and Compaction | 864 | cy | 42.00 | 36,303 | |
| Grading and Paving | 3 | item | 10,000.00 | 30,000 | |
| Demobilization | 0.03 | % | 1,036,963.89 | 31,109 | Cost based on construction costs |
| Task Management | | | | | |
| Field Work Oversight | 520 | hrs | 85.00 | 44,200 | |
| Ongoing Progress Reports | 104 | hrs | 85.00 | 8,840 | |
| Data Management | 260 | hrs | 75.00 | 19,500 | |
| Meetings | 576 | hrs | 85.00 | 48,960 | |
| Final Report | 160 | hrs | 85.00 | 13,600 | |
| | | | **Capital Costs** | **2,500,000** | |

| **Annual Costs** | *Quantity* | *Unit* | *Unit Cost* | *Cost* | *Comments* |
|---|---|---|---|---|---|
| Field Work | | | | | |
| Biannual Site Inspection | 1 | item | 10,000 | 10,000 | |
| | | | Annual Cost Subtotal | 10,000 | |
| | | | **Present Worth of Annual Cost Subtotal** | **200,000** | At 4% for 100 Years |

| **Total Costs** | | |
|---|---|---|
| Alt 3 - Risk Level B Subtotal | 2,700,000 | |
| 20% Contingency | 500,000 | Capital Costs Only |
| **TOTAL** | **3,200,000** | |

## Table F-14. Domestic Septic Systems, Alt 1 – No Action

**COST ESTIMATE**

**Capital Costs**

| | *Quantity* | *Unit* | *Unit Cost* | *Cost* | *Comments* |
|---|---|---|---|---|---|
| None | | | | - | |
| | | | **Capital Cost Subtotal** | - | |

**Annual Costs**

| | *Quantity* | *Unit* | *Unit Cost* | *Cost* | *Comments* |
|---|---|---|---|---|---|
| Field Work | | | | | |
| Ongoing Air Monitoring | 1 | item | 15,000 | 15,000 | |
| Biannual Site Inspection | 1 | item | 10,000 | 10,000 | |
| | | | Annual Costs Subtotal | 25,000 | |
| | | | **Present Worth of Annual Cost Subtotal** | **600,000** | At 4% for 100 Years |

**Total Cost**

| | | |
|---|---|---|
| No Action Subtotal | 600,000 | |
| 20% Contingency | - | Capital Costs Only |
| **TOTAL** | **$600,000** | |

Table F-15. Domestic Septic Systems, Alt 2 – Excavation and Off-Site Disposal with Institutional Controls (Risk Level C)

**COST ESTIMATE**

**Capital Costs**

| | *Quantity* | *Unit* | *Unit Cost* | *Cost* | *Comments* |
|---|---|---|---|---|---|
| Permitting | | | | | |
| Permit Fees and Labor | 0.2 | ls | 40,000.00 | 8,000 | Cost split between Ra/Sr and Domestic Septic tank areas |
| Pre-field Work Preparation | 0.1 | ls | 315,000.00 | 31,500 | Cost split between all three removal action areas |
| Additional Charactorization | 1 | ls | 17,000.00 | 17,000 | |
| Field Work | | | | | |
| Mobilization | 0.03 | % | 129,841.11 | 3,895 | |
| Site Preparation | 2000 | sq ft | 0.54 | 1,081 | |
| Site Management | 1 | month | 20,000.00 | 20,000 | |
| Utility Location/Rerouting | 0.1 | item | 100,000.00 | 10,000 | |
| Soil/Debris Removal | 34 | cy | 29.00 | 977 | based on excavated volume |
| Air monitoring program | 0.1 | % | 400,000.00 | 40,000 | Cost split between Ra/Sr and Domestic Septic tank areas |
| Soil/Debris Screening/Sorting | 34 | cy | 56.00 | 1,887 | based on excavated volume |
| Geotextile fabric | 6000 | sq ft | 1.00 | 6,000 | |
| Waste Characterization | 0 | item | 60,000.00 | - | not used for this area |
| Soil/Debris Loading/Box Preparation and Handling | 34 | cy | 56.00 | 1,887 | based on excavated volume |
| Soil/Debris Shipping and Disposal (Haz Waste) | 34 | cy | 350.00 | 11,796 | based on excavated volume |
| QA/QC Inspections | 0.2 | item | 30,000.00 | 6,000 | Cost split between Ra/Sr and Domestic Septic tank areas |
| QA/QC Surveillance/Audits | 0.2 | item | 40,000.00 | 8,000 | Cost split between Ra/Sr and Domestic Septic tank areas |
| Health and Safety | 0.2 | item | 300,000.00 | 60,000 | Cost split between Ra/Sr and Domestic Septic tank areas |
| Box Storage | 0.2 | item | 50,000.00 | 10,000 | Cost split between Ra/Sr and Domestic Septic tank areas |
| Sampling and Analysis | 1 | ls | 30,000.00 | 30,000 | |
| Utility Restoration | 1 | item | 20,000.00 | 20,000 | |
| Geotextile Liner | 380 | sq ft | 1.00 | 380 | |
| Back-fill and Compaction | 26 | cy | 42.00 | 1,089 | |
| Grading and Paving | 1 | item | 10,000.00 | 10,000 | |
| Deed Restriction | 1 | ls | 20,000.00 | 20,000 | For tank #3 |
| Demobilization | 0.03 | % | 129,841.11 | 3,895 | |
| Task Management | | | | | |
| Field Work Oversight | 80 | hrs | 85.00 | 6,800 | |
| Ongoing Progress Reports | 20 | hrs | 85.00 | 1,700 | |
| Data Management | 40 | hrs | 75.00 | 3,000 | |
| Meetings | 40 | hrs | 85.00 | 3,400 | |
| Final Report | 100 | hrs | 85.00 | 8,500 | |
| | | | **Capital Costs Subtotal** | **300,000** | |

**Annual Costs**

| | *Quantity* | *Unit* | *Unit Cost* | *Cost* | *Comments* |
|---|---|---|---|---|---|
| Biannual Site Inspection | 1 | item | 10,000 | 10,000 | |
| | | | Annual Costs Subtotal | 10,000 | |
| | | | **Present Worth of Annual Cost Subtotal** | **200,000** | At 4% for 100 Years |

**Total Cost**

| | | |
|---|---|---|
| Alt 2 - Risk Level C Subtotal | 500,000 | |
| 20% Contingency | 60,000 | Capital Costs Only |
| **TOTAL** | **600,000** | |

Table F-16. Southwest Trenches Area – Volume of Excavated Soil Calculation

| Excavation Areas | Number of Areas | Dimension of each area Length (ft) | Width (ft) | Depth (ft) | In-Place Volume (CF) | Excavated (3) Volume (CF) | Excavated(3) Volume (CY) | 1st Round of Excavation Soil Volume (CY) (1) | 2nd Round of Excavation Soil Volume (CY) (2) |
|---|---|---|---|---|---|---|---|---|---|
| Pits | 15 | 4 | 4 | 10 | 2,400 | 3,120 | 116 | 92 | 23 |
| Trenches | | | | | | | | | |
| T-1 | 1 | 120 | 6 | 10 | 7,200 | 9,360 | 347 | 277 | 69 |
| T-2 | 1 | 60 | 6 | 10 | 3,600 | 4,680 | 173 | 139 | 35 |
| T-3 | 1 | 130 | 6 | 10 | 7,800 | 10,140 | 376 | 300 | 75 |
| T-4 | 1 | 95 | 6 | 10 | 5,700 | 7,410 | 274 | 220 | 55 |
| Subtotal | | | | | 24,300 | 31,590 | 1,170 | 936 | 234 |
| Shallow Squares | 36 | 10 | 10 | 3 | 10,800 | 14,040 | 520 | 416 | 104 |
| **TOTAL** | | | | | 37,500 | 48,750 | **1,806** | **1,444** | **361** |

Notes:
(1) First round of excavation assumes 80% of total waste has been removed.
(2) Second round of excavation assumes 20% of total waste has been removed.
(3) Excavated soil is calculated assuming a 1.3 soil expansion factor.

Table F-17. Southwest Trenches Area – Excavation Screening and Confirmation Sampling Frequency

| Excavation Areas | Excavation Lengths | Excavation perimeter | # of samples from bottom (1) | # of samples from sidewalls (2) | 1st Round Total # of Samples | 2nd Round Total # of Samples (3) | QC Duplicate Samples (4) | Excavation Screening Samples (5) | Excavation Confirmation Samples (6) |
|---|---|---|---|---|---|---|---|---|---|
| Pits | 150 | 240 | 15 | 8 | 23 | 8 | 6 | 37 | 23 |
| Trenches | | | | | | | | | |
| T-1 | 120 | 252 | 12 | 8 | 20 | 8 | 4 | 33 | 20 |
| T-2 | 60 | 132 | 6 | 4 | 10 | 4 | 2 | 17 | 10 |
| T-3 | 130 | 272 | 13 | 9 | 22 | 9 | 4 | 36 | 22 |
| T-4 | 95 | 202 | 10 | 7 | 16 | 7 | 3 | 26 | 16 |
| Subtotal | 405 | 858 | 41 | 29 | 69 | 29 | 14 | 112 | 69 |
| Shallow Squares | 380 | 640 | 38 | 21 | 59 | 21 | 12 | 93 | 59 |
| **TOTAL** | **935** | **1,738** | **94** | **58** | **151** | **58** | **30** | **240** | **151** |

Notes:
(1) Excavation bottom sample frequency = one sample every 10 LF of excavation
(2) Excavation sidewall sample frequency = one sample every 30 LF of perimeter of excavation
(3) It is assumed that second round of samples will be taken from the sidewalls only since the excavation only gets wider and not deeper.
(4) QC sampling consists of duplicate samples at a rate of 20%
(5) Excavation screening samples = 1st and 2nd rounds of samples plus 20% QC samples.
(6) Excavation confirmation samples = 1st round of samples plus 20% QC samples of the 1st round of samples.

Table F-18. Southwest Trenches Area – Waste Characterization Sampling Frequency

| Waste Matrix | Total Volume | % of total Volume | Volume (CY) | # of field Samples | Assumptions | # of lab Samples | Assumptions |
|---|---|---|---|---|---|---|---|
| Soil | | | | | | | |
| 1st Round of Exc. | 1444 | 20% | 289 | 14 | 1 sample/20 cy of soil | 6 | 1 sample/50 CY of soil |
| 2nd Round of Exc. | 361 | 100% | 361 | 18 | 1 sample/20 cy of soil | 7 | 1 sample/50 CY of soil |
| TOTAL | | | 650 | **33** | | **13** | |
| Solid Waste | | | | | | | |
| 1st Round of Exc. | 1444 | 80% | 1156 | 12 | 1 sample/100 cy of Waste | 6 | 1 sample/200 CY of Waste |
| 2nd Round of Exc. | 361 | 0% | 0 | 0 | 1 sample/100 cy of Waste | 0 | 1 sample/200 CY of Waste |
| TOTAL | | | 1156 | **12** | | **6** | |

# Table F-19. Southwest Trenches Area – Analytical Plan

| Analytical Method | Chemical Parameter Tested | Cost/Sample | Analytical Result Turn-around-time | Removal Assessment # of Samples | Removal Assessment Analytical Cost | Waste Characterization Samples Excavated Soil | Excavated Waste | TOTAL | Analytical Cost | Excavation Screening # of Samples | Excavation Screening Analytical Cost | Excavation Limit Confirmation # of Samples | Excavation Limit Confirmation Analytical Cost | Final Site Confirmation # of Samples | Final Site Confirmation Analytical Cost | TOTAL ANALYTICAL COSTS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Field Methods | | | | | | | | | | | | | | | | |
| HPGe (Gamma Rad) | Radium-226 | $0.00 | 1 hr | 100 | $0.00 | 33 | 12 | 45 | $0.00 | 240 | $0.00 | 0 | $0.00 | 0 | $0.00 | $0.00 |
| BSD (Beta Rad) | Strontium-90 | $0.00 | 1 hr | 100 | $0.00 | 33 | 12 | 45 | $0.00 | 240 | $0.00 | 0 | $0.00 | 0 | $0.00 | $0.00 |
| Enzyme Immuno-assay | Chlordane | $27.00 | 1 hr | 100 | $2,700.00 | 33 | 12 | 45 | $1,203.00 | 240 | $6,470.64 | 0 | $0.00 | 0 | $0.00 | $10,373.64 |
| Total | | | | | $2,700.00 | | | | $1,203.00 | | $6,470.64 | | $0.00 | | $0.00 | $10,000 |
| Laboratory Methods | | | | | | | | | | | | | | | | |
| Lab SOP | Americium-241 | $130.50 | 30 days | 0 | $0.00 | 13 | 6 | 19 | $2,450.50 | 0 | $0.00 | 151 | $19,762.05 | 100 | $13,050.00 | $35,262.55 |
| Lab SOP | Carbon-14 | $117.00 | 30 days | 0 | $0.00 | 13 | 6 | 19 | $2,197.00 | 0 | $0.00 | 151 | $17,717.70 | 100 | $11,700.00 | $31,614.70 |
| Lab SOP | Plutonium-241 | $130.50 | 30 days | 0 | $0.00 | 13 | 6 | 19 | $2,450.50 | 0 | $0.00 | 151 | $19,762.05 | 100 | $13,050.00 | $35,262.55 |
| Lab SOP | Uranium-235 | $148.50 | 30 days | 0 | $0.00 | 13 | 6 | 19 | $2,788.50 | 0 | $0.00 | 151 | $22,487.85 | 100 | $14,850.00 | $40,126.35 |
| EPA 901.1 | Ra-226 (Gamma Emmiters) | $108.00 | 45 days | 10 | $1,080.00 | 13 | 6 | 19 | $2,028.00 | 24 | $2,588.26 | 151 | $16,354.80 | 100 | $10,800.00 | $32,851.06 |
| EPA 905 | Strontium-90 | $130.50 | 30 days | 10 | $1,305.00 | 13 | 6 | 19 | $2,450.50 | 24 | $3,127.48 | 151 | $19,762.05 | 100 | $13,050.00 | $39,695.03 |
| EPA 906 | Tritium | $49.50 | 30 days | 0 | $0.00 | 13 | 6 | 19 | $929.50 | 0 | $0.00 | 151 | $7,495.95 | 100 | $4,950.00 | $13,375.45 |
| CLP ILM 02.1 | 10 Metals | $126.00 | 30 days | 0 | $0.00 | 13 | 6 | 19 | $2,366.00 | 0 | $0.00 | 151 | $19,080.60 | 100 | $12,600.00 | $34,046.60 |
| EPA 6000/7000 series | Metals | $350.00 | 24 hrs | 0 | $0.00 | 0 | 0 | 0 | $0.00 | 240 | $84,000.00 | 0 | $0.00 | 0 | $0.00 | $84,000.00 |
| EPA 7196 | Hex. Chromium | $36.00 | 30 days | 0 | $0.00 | 13 | 6 | 19 | $676.00 | 0 | $0.00 | 151 | $5,451.60 | 100 | $3,600.00 | $9,727.60 |
| CLP ILM 01.8 | Pesticides | $126.00 | 30 days | 10 | $1,260.00 | 13 | 6 | 19 | $2,366.00 | 24 | $3,019.63 | 151 | $19,080.60 | 100 | $12,600.00 | $38,326.23 |
| CLP OLM 03.1 | VOCs | $160.00 | 30 days | 0 | $0.00 | 13 | 6 | 19 | $3,004.44 | 0 | $0.00 | 151 | $24,229.33 | 100 | $16,000.00 | $43,233.78 |
| CLP OLM 03.1 | SVOCs | $300.00 | 30 days | 0 | $0.00 | 13 | 6 | 19 | $5,633.33 | 0 | $0.00 | 151 | $45,430.00 | 100 | $30,000.00 | $81,063.33 |
| EPA 300 | Nitrate | $22.50 | 30 days | 0 | $0.00 | 13 | 6 | 19 | $422.50 | 0 | $0.00 | 151 | $3,407.25 | 100 | $2,250.00 | $6,079.75 |
| Total | | $1,935.00 | | | $3,645.00 | | | | $29,762.78 | | $92,735.36 | | $240,021.83 | | $158,500.00 | $520,000 |

| Capital Costs (Instrument Purchase/Rent) | |
|---|---|
| HPGe (Gamma Rad) | $60,000.00 |
| BSD (Beta Rad) | $60,000.00 |
| Enzyme Immuno-assay | $1,500.00 |

ASSUMPTIONS:

1- Removal assessment (pre-excavation trenching) will be performed and samples collected at 20-foot intervals along the grid.

2- Waste characterization sampling is as follows:

| Test | # of Samples Soil | Waste | Assumptions |
|---|---|---|---|
| Field | 33 | 12 | 1 sample/ 20 CY soil and 100 CY of waste |
| Laboratory | 13 | 6 | 1 sample/ 50 CY soil and 200 CY of waste |

3- Excavation Screening Samples will be collected from the bottom and sidewalls of the excavation and analyzed by field methods.
Sidewall Samples = 1 sample every 30 feet of excavation sidewall.
Bottom Samples = 1 sample every 10 linear feet of excavation.

4- Excavation Confirmation Samples will be collected from the sidewalls and bottom of the excavation and analyzed by lab methods.

5- Final site confirmation samples will be collected based on a random sampling approach and statistically-based number of samples.

6- Field test results will be verified using laboratory analytical methods at a rate of 10%.

Table F-20. Ra/Sr Treatment System Area – Volume of Excavated Soil Calculation

| Excavation Areas | Number of Areas | Dimension of each area Length (ft) | Width (ft) | Depth (ft) | In-Place Volume (CF) | Excavated[3] Volume (CF) | Excavated[3] Volume (CY) | 1st Round of Excavation Soil Volume (CY) [1] | 2nd Round of Excavation Soil Volume (CY) [2] |
|---|---|---|---|---|---|---|---|---|---|
| Dry Wells | 3 | 5 | 5 | 40 | 3,000 | 3,000 | 111 | 89 | 22 |
| Leach Trench | 1 | 110 | 5 | 10 | 5,500 | 5,500 | 204 | 163 | 41 |
| Distribution Box | 1 | 10 | 10 | 10 | 1,000 | 1,000 | 37 | 30 | 7 |
| Piping | 1 | 210 | 3 | 5 | 3,150 | 4,095 | 152 | 121 | 30 |
| Imhoff Tanks | 0.25 | 45 | 25 | 10 | 2,813 | 3,656 | 135 | 108 | 27 |
| Leach Fields | 1 | 45 | 30 | 5 | 6,750 | 8,775 | 325 | 260 | 65 |
| Radium Tanks | 0.25 | 45 | 10 | 10 | 1,125 | 1,463 | 54 | 43 | 11 |
| **TOTAL** | | | | | 23,338 | 27,489 | **1,018** | **814** | **204** |

Notes:
(1) First round of excavation assumes 80% of total waste has been removed.
(2) Second round of excavation assumes 20% of total waste has been removed.
(3) Excavated soil is calculated assuming a 1.3 soil expansion factor.

Table F-21. Ra/Sr Treatment System Area – Excavation Screening and Confirmation Sampling Frequency

| Excavation Areas | Excavation Lengths | Excavation perimeter | # of samples from bottom (1) | # of samples from sidewalls (2) | 1st Round Total # of Samples | 2nd Round Total # of Samples (3) | QC Duplicate Samples (4) | Excavation Screening Samples (5) | Excavation Confirmatory Samples (6) |
|---|---|---|---|---|---|---|---|---|---|
| Dry Wells (7) | 15 | 60 | 3 | 24 | 27 | 24 | 10 | 61 | 32 |
| Leach Trench | 110 | 230 | 11 | 8 | 19 | 8 | 4 | 30 | 22 |
| Distribution Box | 10 | 40 | 1 | 1 | 2 | 1 | 0 | 4 | 3 |
| Piping | 210 | 426 | 21 | 14 | 35 | 14 | 7 | 56 | 42 |
| Imhoff Tanks | 45 | 140 | 5 | 5 | 9 | 5 | 2 | 16 | 11 |
| Leach Fields | 45 | 150 | 5 | 5 | 10 | 5 | 2 | 16 | 11 |
| Radium Tanks | 45 | 110 | 5 | 4 | 8 | 4 | 2 | 13 | 10 |
| **TOTAL** | **480** | **1,156** | **50** | **61** | **110** | **61** | **22** | **193** | **132** |

Notes:
(1) Excavation bottom sample frequency = one sample every 10 LF of excavation
(2) Excavation sidewall sample frequency = one sample every 30 LF of perimeter of excavation
(3) Second round of samples will be taken from the sidewalls only.
(4) QC sampling consists of duplicate samples at a rate of 20%
(5) Excavation screening samples = 1st and 2nd rounds of samples plus 20% QC samples.
(6) Excavation confirmation samples = 1st round of samples plus 20% QC samples of the 1st round of samples.
(7) Samples collected from each drywell include one bottom sample and eight sidewall samples (two samples per wall 20 ft vertically part)

Table F-22. Ra/Sr Treatment System Area – Waste Characterization Sampling Frequency

| Waste Matrix | Total Volume | % of total Volume | Volume (CY) | # of field Samples | Assumptions | # of lab Samples | Assumptions |
|---|---|---|---|---|---|---|---|
| Soil | | | | | | | |
| 1st Round of Exc. | 814 | 10% | 81 | 4 | 1 sample/20 CY of soil | 2 | 1 sample/50 CY of soil |
| 2nd Round of Exc. | 204 | 100% | 204 | 10 | 1 sample/20 CY of soil | 4 | 1 sample/50 CY of soil |
| TOTAL | | | 285 | **14** | | **6** | |
| Solid Waste | | | | | | | |
| 1st Round of Exc. | 814 | 90% | 733 | 7 | 1 sample/100 CY of Waste | 4 | 1 sample/200 CY of Waste |
| 2nd Round of Exc. | 204 | 0% | 0 | 0 | 1 sample/100 CY of Waste | 0 | 1 sample/200 CY of Waste |
| TOTAL | | | 733 | 7 | | **4** | |

# Table F-23. Ra/Sr Treatment System Area – Analytical Plan

| Analytical Method | Chemical Parameter Tested | Cost/Sample | Analytical Result Turn-around-time | Waste Characterization Samples: Excavated Soil | Excavated Waste | TOTAL | Analytical Cost | Excavation Screening: # of Samples | Analytical Cost | Excavation Limit Confirmation: # of Samples | Analytical Cost | Final Site Confirmation: # of Samples | Analytical Cost | TOTAL ANALYTICAL COSTS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Field Methods | | | | | | | | | | | | | | |
| HPGe (Gamma Rad) | Radium-226 | $0.00 | 1 hr | 14 | 7 | 22 | $0.00 | 193 | $0.00 | 0 | $0.00 | 0 | $0.00 | $0.00 |
| BSD (Betta Rad) | Strontium-90 | $0.00 | 1 hr | 14 | 7 | 22 | $0.00 | 193 | $0.00 | 0 | $0.00 | 0 | $0.00 | $0.00 |
| Enzyme Immuno-assay | Chlordane | $27.00 | 1 hr | 14 | 7 | 22 | $582.76 | 193 | $5,199.48 | 0 | $0.00 | 0 | $0.00 | $5,782.24 |
| Total | | | | | | | $582.76 | | $5,199.48 | | $0.00 | | $0.00 | $10,000 |
| Laboratory Methods | | | | | | | | | | | | | | |
| Lab SOP | Americium-241 | $130.50 | 30 days | 6 | 4 | 9 | $1,222.33 | 0 | $0.00 | 132 | $17,231.22 | 50 | $6,525.00 | $24,978.55 |
| Lab SOP | Carbon-14 | $117.00 | 30 days | 6 | 4 | 9 | $1,095.88 | 0 | $0.00 | 132 | $15,448.68 | 50 | $5,850.00 | $22,394.56 |
| Lab SOP | Plutonium-241 | $130.50 | 30 days | 6 | 4 | 9 | $1,222.33 | 0 | $0.00 | 132 | $17,231.22 | 50 | $6,525.00 | $24,978.55 |
| Lab SOP | Uranium-235 | $148.50 | 30 days | 6 | 4 | 9 | $1,390.93 | 19 | $2,859.71 | 132 | $19,607.94 | 50 | $7,425.00 | $31,283.58 |
| EPA 901.1 | Ra-226 (Gamma Emmiters) | $108.00 | 45 days | 6 | 4 | 9 | $1,011.59 | 19 | $2,079.79 | 132 | $14,260.32 | 50 | $5,400.00 | $22,751.70 |
| EPA 905 | Strontium-90 | $130.50 | 30 days | 6 | 4 | 9 | $1,222.33 | 0 | $0.00 | 132 | $17,231.22 | 50 | $6,525.00 | $24,978.55 |
| EPA 906 | Tritium | $49.50 | 30 days | 6 | 4 | 9 | $463.64 | 0 | $0.00 | 132 | $6,535.98 | 50 | $2,475.00 | $9,474.62 |
| EPA 6000/7000 series | Metals | $350.00 | 24 hrs | 0 | 0 | 0 | $0.00 | 193 | $67,400.67 | 0 | $0.00 | 0 | $0.00 | $67,400.67 |
| CLP ILM 02.1 | 10 Metals | $126.00 | 30 days | 6 | 4 | 9 | $1,180.18 | 0 | $0.00 | 132 | $16,637.04 | 50 | $6,300.00 | $24,117.22 |
| EPA 7196 | Hex. Chromium | $36.00 | 30 days | 6 | 4 | 9 | $337.20 | 0 | $0.00 | 132 | $4,753.44 | 50 | $1,800.00 | $6,890.64 |
| CLP ILM 01.8 | Pesticides | $126.00 | 30 days | 6 | 4 | 9 | $1,180.18 | 19 | $2,426.42 | 132 | $16,637.04 | 50 | $6,300.00 | $26,543.65 |
| CLP OLM 03.1 | VOCs | $160.00 | 30 days | 6 | 4 | 9 | $1,498.65 | 0 | $0.00 | 132 | $21,126.40 | 50 | $8,000.00 | $30,625.05 |
| CLP OLM 03.1 | SVOCs | $300.00 | 30 days | 6 | 4 | 9 | $2,809.96 | 0 | $0.00 | 132 | $39,612.00 | 50 | $15,000.00 | $57,421.96 |
| EPA 300 | Nitrate | $22.50 | 30 days | 6 | 4 | 9 | $210.75 | 0 | $0.00 | 132 | $2,970.90 | 50 | $1,125.00 | $4,306.65 |
| Total | | $1,935.00 | | | | | $14,845.96 | 250 | $74,766.60 | | $209,283.40 | | $79,250.00 | $380,000 |

Capital Costs (Instrument Purchase/Rent)

| | |
|---|---|
| HPGe (Gamma Rad) | $30,000.00 |
| BSD (Betta Rad) | $15,000.00 |
| Enzyme Immuno-assay | $1,500.00 |

ASSUMPTIONS:

1- Waste characterization sampling is as follows:

| Test | # of Samples: Soil | Waste | Assumptions |
|---|---|---|---|
| Field | 14 | 7 | 1 sample/ 20 CY soil and 100 CY of waste |
| Laboratory | 6 | 4 | 1 sample/ 50 CY soil and 200 CY of waste |

2- Excavation Screening Samples will be collected from the bottom and sidewalls of the excavation and analyzed by field methods.
Sidewall Samples = 1 sample every 30 feet of excavation sidewall.
Bottom Samples = 1 sample every 10 linear feet of excavation.

3- Excavation Confirmation Samples will be collected from the sidewalls and bottom of the excavation and analyzed by lab methods.

4- Final site confirmation samples will be collected based on a random sampling approach and statistically-based number of samples.

5- Field test results will be verified using laboratory analytical methods at a rate of 10%.

Table F-24. Domestic Septic Systems Area – Volume of Excavated Soil Calculation

| Excavation Areas | Number of Areas | Dimension of each area Length (ft) | Width (ft) | Depth (ft) | In-Place Volume (CF) | Excavated[3] Volume (CF) | Excavated[3] Volume (CY) | 1st Round of Excavation Soil Volume (CY) [1] | 2nd Round of Excavation Soil Volume (CY) [2] |
|---|---|---|---|---|---|---|---|---|---|
| Former Tank 1 | 0 | 0 | 0 | 0 | - | - | - | 0 | 0 |
| Former Tank 2 | 0 | 0 | 0 | 0 | - | - | - | 0 | 0 |
| Former Tank 3 | 0 | 0 | 0 | 0 | - | - | - | 0 | 0 |
| Former Tank 4 | 0 | 0 | 0 | 0 | - | - | - | 0 | 0 |
| Former Tank 5 | 0 | 0 | 0 | 0 | - | - | - | 0 | 0 |
| Former Tank 6 | 1 | 10 | 10 | 7 | 700 | 910 | 34 | 27 | 7 |
| Former Tank 7 | 0 | 0 | 0 | 0 | - | - | - | 0 | 0 |
| **TOTAL** | | | | | 700 | 910 | **34** | **27** | **7** |

Notes:
(1) First round of excavation assumes 80% of total waste has been removed.
(2) Second round of excavation assumes 20% of total waste has been removed.
(3) Excavated soil is calculated assuming a 1.3 soil expansion factor.

Table F-25. Domestic Septic Systems Area – Excavation Screening and Confirmation Sampling Frequency

| Excavation Areas | Excavation Lengths | Excavation perimeter | # of samples from bottom (1) | # of samples from sidewalls (2) | 1st Round Total # of Samples | 2nd Round Total # of Samples (3) | QC Duplicate Samples (4) | Excavation Screening Samples (5) | Excavation Confirmatory Samples (6) |
|---|---|---|---|---|---|---|---|---|---|
| Former Tank 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Former Tank 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Former Tank 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Former Tank 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Former Tank 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Former Tank 6 | 10 | 40 | 1 | 4 | 5 | 4 | 1 | 10 | 6 |
| Former Tank 7 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **TOTAL** | **10** | **40** | **1** | **4** | **5** | **4** | **1** | **10** | **6** |

Notes:
(1) Excavation bottom sample frequency = one sample every 10 LF of excavation
(2) Excavation sidewall sample frequency = one sample every 10 LF of perimeter of excavation
(3) Second round of samples will be taken from the sidewalls only.
(4) QC sampling consists of duplicate samples at a rate of 20%
(5) Excavation screening samples = 1st and 2nd rounds of samples plus 20% QC samples
(6) Excavation confirmation samples = First round of samples plus 20% QC samples of the first round of samples

Table F-26. Domestic Septic Systems Area – Waste Characterization Sampling Frequency

| Waste Matrix | Total Volume | # of field Samples | Assumptions | # of lab Samples | Assumptions |
|---|---|---|---|---|---|
| Soil | | | | | |
| 1st Round of Exc. | 27 | 1 | 1 sample/20 CY of soil | 1 | 1 sample/50 CY of soil |
| 2nd Round of Exc. | 7 | 1 | 1 sample/20 CY of soil | 1 | 1 sample/50 CY of soil |
| TOTAL | | 2 | | 2 | |

# Table F-27. Domestic Septic Systems Area –Analytical Plan

| Analytical Method | Chemical Parameter Tested | Cost/Sample | Analytical Result Turn-around-time | Waste Characterization samples | Analytical Cost | Excavation Screening # of Samples | Excavation Screening Analytical Cost | Excavation Limit Confirmation # of Samples | Excavation Limit Confirmation Analytical Cost | Final Site Confirmation # of Samples | Final Site Confirmation Analytical Cost | TOTAL ANALYTICAL COSTS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Field Methods | | | | | | | | | | | | |
| HPGe (Gamma Rad) | Radium-226 | $0.00 | 1 hr | 2 | $0.00 | 10 | $0.00 | 0 | $0.00 | 0 | $0.00 | $0.00 |
| BSD (Betta Rad) | Strontium-90 | $0.00 | 1 hr | 2 | $0.00 | 10 | $0.00 | 0 | $0.00 | 0 | $0.00 | $0.00 |
| Enzyme Immuno-assay | Chlordane | $27.00 | 1 hr | 2 | $63.40 | 0 | $0.00 | 0 | $0.00 | 0 | $0.00 | $63.40 |
| Total | | | | | $63.40 | | $0.00 | | $0.00 | | $0.00 | $100 |
| Laboratory Methods | | | | | | | | | | | | |
| Lab SOP | Americium-241 | $130.50 | 30 days | 2 | $200.87 | 0 | $0.00 | 6 | $783.00 | 10 | $1,305.00 | $2,288.87 |
| Lab SOP | Carbon-14 | $117.00 | 30 days | 2 | $180.09 | 0 | $0.00 | 6 | $702.00 | 10 | $1,170.00 | $2,052.09 |
| Lab SOP | Plutonium-241 | $130.50 | 30 days | 2 | $200.87 | 0 | $0.00 | 6 | $783.00 | 10 | $1,305.00 | $2,288.87 |
| Lab SOP | Uranium-235 | $148.50 | 30 days | 2 | $228.58 | 0 | $0.00 | 6 | $891.00 | 10 | $1,485.00 | $2,604.58 |
| EPA 901.1 | Ra-226 (Gamma Emmiters) | $108.00 | 45 days | 2 | $166.24 | 1 | $108.00 | 6 | $648.00 | 10 | $1,080.00 | $2,002.24 |
| EPA 905 | Strontium-90 | $130.50 | 30 days | 2 | $200.87 | 1 | $130.50 | 6 | $783.00 | 10 | $1,305.00 | $2,419.37 |
| EPA 906 | Tritium | $49.50 | 30 days | 2 | $76.19 | 0 | $0.00 | 6 | $297.00 | 10 | $495.00 | $868.19 |
| EPA 6000/7000 series | Metals | $350.00 | 24 hrs | 0 | $0.00 | 10 | $3,500.00 | 0 | $0.00 | 0 | $0.00 | $3,500.00 |
| CLP ILM 02.1 | 10 Metals | $126.00 | 30 days | 2 | $193.95 | 0 | $0.00 | 6 | $756.00 | 10 | $1,260.00 | $2,209.95 |
| EPA 7196 | Hex. Chromium | $36.00 | 30 days | 2 | $55.41 | 0 | $0.00 | 6 | $216.00 | 10 | $360.00 | $631.41 |
| CLP ILM 01.8 | Pesticides | $126.00 | 30 days | 2 | $193.95 | 0 | $0.00 | 6 | $756.00 | 10 | $1,260.00 | $2,209.95 |
| CLP OLM 03.1 | VOCs | $160.00 | 30 days | 2 | $246.28 | 0 | $0.00 | 6 | $960.00 | 10 | $1,600.00 | $2,806.28 |
| CLP OLM 03.1 | SVOCs | $300.00 | 30 days | 2 | $461.78 | 0 | $0.00 | 6 | $1,800.00 | 10 | $3,000.00 | $5,261.78 |
| EPA 300 | Nitrate | $22.50 | 30 days | 2 | $34.63 | 0 | $0.00 | 6 | $135.00 | 10 | $225.00 | $394.63 |
| Total | | $1,935.00 | | | $2,439.73 | 12 | $3,738.50 | | $9,510.00 | | $15,850.00 | $30,000 |

ASSUMPTIONS:

1- Waste characterization sampling is as follows:

| Test | # of Soil Samples | Assumptions |
|---|---|---|
| Field | 2 | 1 sample/ 20 CY soil |
| Laboratory | 2 | 1 sample/ 50 CY soil |

2- Excavation Screening Samples will be collected from the bottom and sidewalls of the excavation and analyzed by field methods.
Sidewall Samples = 1 sample every 10 feet of excavation sidewall.
Bottom Samples = 1 sample every 10 linear feet of excavation.

3- Excavation Confirmation Samples will be collected from the sidewalls and bottom of the excavation and analyzed by lab methods.

4- Final site confirmation samples will be collected based on a random sampling approach and statistically-based number of samples.

# APPENDIX G

## EXCAVATION AREA AND VOLUME ESTIMATES

# G. EXCAVATION AREA AND VOLUME ESTIMATES

This Appendix contains the waste (soil and debris) volume calculation tables. There is a table for each of the three areas included in this EE/CA. In each table, the area is broken down into units based on location and description. Each unit has an assumed volume of waste associated with it and is described dimensionally by length, width, and depth. A unit multiplier is used to estimate the actual volume of waste associated with the dimensional description. The volumes are calculated as in place cubic feet and converted to in-place cubic yards. The in-place cubic yards are converted to excavated cubic yards using a 1.3 multiplier to account for material expansion after excavation. The 1.3 multiplier was chosen as an average expansion factor for the multiple waste characteristics (clays, soils, concrete/dense waste).

The waste volumes calculated in these tables are based on the current understanding of site conditions and sample results included in the body of this report. Actual waste volumes will likely be different based on actual site conditions discovered during the removal action. The volumes developed in this section were developed to aid in the development of the cost analysis for the alternatives evaluated in the body of the EE/CA.

## Table G-1. Southwest Trenches – Waste Volume Calculations

| | | Excavation of Impacted Waste | | | | In-Place | | Excavated |
|---|---|---|---|---|---|---|---|---|
| Alt/Risk Level | Area | Length (ft) | Width (ft) | Depth (ft) | Unit (ea) | Volume (cubic feet) | Volume (cubic yard) | Volume (cubic yard) |
| Alt 3 - Risk A | | | | | | | | |
| | Trench | 100 | 6 | 10 | 4 | 24,000 | 889 | 1,156 |
| | Waste Holes | 4 | 4 | 10 | 15 | 2,400 | 89 | 116 |
| | Surface Soils | 150 | 120 | 3 | 0.05 | 2,700 | 100 | 130 |
| | | | | | **TOTAL** | **29,100** | **1,078** | **1,401** |
| Alt 3 - Risk B | | | | | | | | |
| | Trench | 100 | 6 | 10 | 4 | 24,000 | 889 | 1,156 |
| | Waste Holes | 4 | 4 | 10 | 15 | 2,400 | 89 | 116 |
| | Surface Soils | 150 | 120 | 3 | 0.1 | 5,400 | 200 | 260 |
| | | | | | **TOTAL** | **31,800** | **1,178** | **1,531** |
| Alt 3 - Risk C | | | | | | | | |
| | Trench | 100 | 6 | 10 | 4 | 24,000 | 889 | 1,156 |
| | Waste Holes | 4 | 4 | 10 | 15 | 2,400 | 89 | 116 |
| | Surface Soils | 150 | 120 | 3 | 0.2 | 10,800 | 400 | 520 |
| | | | | | **TOTAL** | **37,200** | **1,378** | **1,791** |
| Alt 2 - Risk A | | | | | | | | |
| | Trench | 102 | 7 | 11 | 4 | 31,416 | 1,164 | 1,513 |
| | Waste Holes | 5 | 5 | 11 | 15 | 4,125 | 153 | 199 |
| | Surface Soils | 150 | 120 | 3 | 0.05 | 2,700 | 100 | 130 |
| | | | | | **TOTAL** | **38,241** | **1,416** | **1,841** |
| Alt 2 - Risk B | | | | | | | | |
| | Trench | 104 | 9 | 13 | 4 | 48,672 | 1,803 | 2,343 |
| | Waste Holes | 7 | 7 | 13 | 15 | 9,555 | 354 | 460 |
| | Surface Soils | 150 | 120 | 3 | 0.1 | 5,400 | 200 | 260 |
| | | | | | **TOTAL** | **63,627** | **2,357** | **3,064** |
| Alt 2 - Risk C | | | | | | | | |
| | Trench | 104 | 9 | 13 | 4 | 48,672 | 1,803 | 2,343 |
| | Waste Holes | 7 | 7 | 13 | 15 | 9,555 | 354 | 460 |
| | Surface Soils | 150 | 120 | 3 | 0.2 | 10,800 | 400 | 520 |
| | | | | | **TOTAL** | **69,027** | **2,557** | **3,324** |

Notes:
Excavated volume assumes a waste expansion factor of 1.3, unless the material being excavated is gravel or concrete.

## Table G-2. Ra/Sr Treatment Systems – Waste Volume Calculations

| | | Assumed Dimensions | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Excavation of Impacted Waste | | | | In-Place | | Excavated |
| Alt/Risk Level | Area | Length (ft) | Width (ft) | Depth (ft) | Units (ea) | Volume (cubic feet) | Volume (cubic yard) | Volume (cubic yard) |
| Alt 3 - Risk C | Dry Wells | 5 | 5 | 40 | 3 | 3,000 | 111 | 111 |
| | Leach Trench | 110 | 5 | 10 | 1 | 5,500 | 204 | 204 |
| | Distribution Box | 10 | 10 | 10 | 1 | 1,000 | 37 | 37 |
| | Piping | 210 | 3 | 5 | 1 | 3,150 | 117 | 152 |
| | Imhoff Tanks | 45 | 25 | 10 | 0.25 | 2,813 | 104 | 135 |
| | Leach Fields | 45 | 30 | 5 | 1 | 6,750 | 250 | 325 |
| | South Tanks | 45 | 10 | 10 | 0.25 | 1,125 | 42 | 54 |
| | | | | | **TOTAL** | **23,338** | **864** | **1,018** |
| Alt 2 - Risk A | Dry Wells | 6 | 6 | 41 | 3 | 4,428 | 164 | 164 |
| | Leach Trench | 112 | 7 | 11 | 1 | 8,624 | 319 | 319 |
| | Distribution Box | 11 | 11 | 11 | 1 | 1,331 | 49 | 64 |
| | Piping | 210 | 4 | 6 | 1 | 5,040 | 187 | 243 |
| | Imhoff Tanks | 47 | 27 | 11 | 0.25 | 3,490 | 129 | 168 |
| | Leach Fields | 45 | 30 | 6 | 1 | 8,100 | 300 | 390 |
| | South Tanks | 47 | 12 | 11 | 0.25 | 1,551 | 57 | 75 |
| | | | | | **TOTAL** | **32,564** | **1,206** | **1,568** |
| Alt 2 - Risk C | Dry Wells | 7 | 7 | 43 | 3 | 6,321 | 234 | 234 |
| | Leach Trench | 114 | 9 | 13 | 1 | 13,338 | 494 | 494 |
| | Distribution Box | 12 | 12 | 13 | 1 | 1,872 | 69 | 90 |
| | Piping | 210 | 4 | 8 | 1 | 6,720 | 249 | 324 |
| | Imhoff Tanks | 47 | 27 | 13 | 0.25 | 4,124 | 153 | 199 |
| | Leach Fields | 45 | 30 | 8 | 1 | 10,800 | 400 | 520 |
| | South Tanks | 47 | 12 | 15 | 0.25 | 2,115 | 78 | 102 |
| | | | | | **TOTAL** | **45,290** | **1,677** | **2,181** |

Notes:
Excavated volume assumes a waste expansion factor of 1.3, unless the material being excavated is gravel.

## Table G-3. Domestic Septic Systems - Waste Volume Calculations

| | Assumed Dimensions Excavation of Impacted Waste | | | | In-Place | | Excavated |
|---|---|---|---|---|---|---|---|
| Tank Number | Length (ft) | Width (ft) | Depth (ft) | Units (ea) | Volume (cubic ft) | Volume (cubic yard) | Volume (cubic yard) |
| Tank 1 | 0 | 0 | 0 | 0 | - | - | - |
| Tank 2 | 0 | 0 | 0 | 0 | - | - | - |
| Tank 3 | 0 | 0 | 0 | 0 | - | - | - |
| Tank 4 | 0 | 0 | 0 | 0 | - | - | - |
| Tank 5 | 0 | 0 | 0 | 0 | - | - | - |
| Tank 6 | 10 | 10 | 7 | 1 | 700 | 26 | 34 |
| Tank 7 | 0 | 0 | 0 | 0 | - | - | - |
| | | | | **TOTAL** | **700** | **26** | **34** |

Notes:
Excavated volume assumes a waste expansion factor of 1.3, unless the material being excavated is gravel.

# APPENDIX H

## ANALYTICAL DATA SUMMARIES

Table H-1. Analytical Data Summary for Selected Key Constituents - Southwest Trenches Area, Ra/Sr Treatment Systems, Domestic Septic Tanks

| Sample ID | Radium-226 pCi/g | Strontium-90 pCi/g | Lead mg/kg | Alpha-Chlordane ug/kg | Gamma-Chlordane ug/kg | Nitrogen, Nitrate (as N) mg/kg |
|---|---|---|---|---|---|---|
| | | | Southwest Trenches Area | | | |
| LEHR-S-331 | 0.86 | 1.47 | 8.7 | - | - | 250 |
| LEHR-S-331DL2 | - | - | - | 48 | 51 | - |
| LEHR-S-332 | 0.15 | 2.01 | 10 | 0.88 | 0.93 | 0.65 |
| LEHR-S-333 | 0.81 | 0.31 | 8.7 | <2 | <2 | 0.33 |
| LEHR-S-334 | - | 1.08 | - | - | - | - |
| LEHR-S-335 | 0.65 | 0.77 | 8.5 | - | - | 54 |
| LEHR-S-335DL2 | - | - | - | 37 | 43 | - |
| LEHR-S-336 | 0.59 | 0.15 | 8 | 1.8 | 2.1 | 88 |
| LEHR-S-337 | 0.59 | 1.88 | 9.6 | - | - | 21 |
| LEHR-S-337DL8 | - | - | - | 83 | 100 | - |
| LEHR-S-338 | 7.06 | 34.1 | 16 | 60 | 78 | 210 |
| LEHR-S-338-QC | 11.5 | 14 | 74 | 100 | 140 | 1,200 |
| LEHR-S-339 | 0.59 | 10.7 | - | - | - | - |
| LEHR-S-340 | 0.35 | 16,700 | 49 | <1.7 | <1.7 | 0.37 |
| LEHR-S-340-QC | 0.34 | 2,890 | 34 | <1.7 | <1.7 | - |
| LEHR-S-341 | 0.6 | 0.95 | 8.5 | 1.3 | 1.8 | 380 |
| LEHR-S-342 | 1.06 | 18.7 | - | 200 | 230 | - |
| LEHR-S-343 | 0.3 | 0.22 | 8.6 | 4.8 | 6 | 290 |
| LEHR-S-344 | 0.39 | 0.33 | 6.3 | 25 | 25 | 2.4 |
| LEHR-S-345 | 0.3 | 0.06 | 7 | 0.98 | 0.9 | 0.44 |
| LEHR-S-346 | 0.51 | 0.49 | 7.3 | <1.8 | <1.8 | - |
| LEHR-S-347 | 0.45 | 2.59 | 4.1 | 310 | 300 | - |
| LEHR-S-348 | 0.43 | 0.2 | 6.6 | 21 | 27 | 0.32 |
| LEHR-S-349 | 0.45 | 0.08 | 6.3 | 2.3 | 2.3 | 0.35 |
| LEHR-S-350 | 0.41 | -0.02 | 11 | 800 | 740 | 11 |
| LEHR-S-351 | 0.34 | 0.31 | 7.7 | <1.9 | <1.9 | 39 |
| LEHR-S-352 | 0.47 | 0.12 | 8 | <2 | <2 | 49 |
| LEHR-S-353 | 0.62 | 0.08 | 7.2 | <1.8 | <1.8 | 59 |
| LEHR-S-354 | 2.26 | 3.15 | 4.7 | 10 | 11 | 350 |
| LEHR-S-355 | 2.02 | 13.8 | - | - | - | - |
| LEHR-S-356 | 1.98 | 0.26 | 9.7 | 1.4 | 1.5 | 56 |
| LEHR-S-357 | 1.73 | 0.07 | 10 | 1.6 | 1.9 | 390 |
| LEHR-S-358 | 0.45 | 0.37 | - | - | - | - |
| LEHR-S-359 | 1.28 | 3.16 | 14 | 16 | 17 | 8.4 |
| LEHR-S-360 | 0.91 | 4.38 | 8.3 | 1.8 | 1.6 | 64 |
| LEHR-S-361 | 0.47 | 22.3 | 8.2 | 2.2 | 2.2 | 17 |
| LEHR-S-362 | 0.62 | 3,690 | 2.7 | <94 | <94 | - |
| LEHR-S-378 | 0.86 | 2.47 | 1.8 | 10 | 1.2 | 9.4 |
| LEHR-S-379 | 0.6 | 0.13 | 8 | <1.9 | <1.9 | 21 |
| LEHR-S-380 | 0.71 | -0.17 | 6.6 | <1.8 | <1.8 | 18 |
| LEHR-S-381 | 1.16 | 1.48 | 21 | 4.3 | 6 | 55 |

Table H-1. Analytical Data Summary for Selected Key Constituents - Southwest Trenches Area, Ra/Sr Treatment Systems, Domestic Septic Tanks (continued)

| Sample ID | Radium-226 pCi/g | Strontium-90 pCi/g | Lead mg/kg | Alpha-Chlordane ug/kg | Gamma-Chlordane ug/kg | Nitrogen, Nitrate (as N) mg/kg |
|---|---|---|---|---|---|---|
| Southwest Trenches Area | | | | | | |
| LEHR-S-382 | 0.62 | 6.53 | 8.3 | 3.8 | 6 | 7.2 |
| LEHR-S-383 | 0.96 | 5.25 | 8.9 | <1.8 | <1.8 | 4.7 |
| LEHR-S-465 | 0.57 | 0.46 | 8.2 | 0.94 | 1.3 | 0.9 |
| LEHR-S-466 | 0.62 | 0.47 | 9.6 | 490 | 590 | 0.69 |
| LEHR-S-467 | 0.3 | 0.04 | 9.1 | 1.7 | 2.3 | 1.7 |
| LEHR-S-468 | 0.92 | 9.46 | 12 | 88 | 110 | 3 |
| LEHR-S-469 | 0.64 | 0.07 | 9.5 | 0.92 | 1.1 | 3.1 |
| LEHR-S-470 | 1.18 | 2.4 | 11 | 50 | 50 | 56 |
| LEHR-S-471 | 2.44 | 0.33 | 8.9 | <2 | <2 | 91 |
| LEHR-S-472 | 0.68 | 0.36 | 8.4 | 0.56 | 0.67 | 48 |
| LEHR-S-473 | 0.64 | 0.13 | 8.9 | <1.8 | <1.8 | 17 |
| LEHR-S-474 | 0.53 | 0.08 | 7.7 | <2.1 | <2.1 | 12 |
| LEHR-S-475 | 0.48 | 0.01 | 8.7 | 5.1 | 5.6 | 5 |
| LEHR-S-476 | 0.84 | -0.08 | 9.3 | <2 | <2 | 9.6 |
| LEHR-S-477 | 0.55 | 2.44 | 6.3 | 0.73 | 0.86 | 3.9 |
| LEHR-S-478 | 0.61 | 0.84 | 9.1 | <2 | <2 | 3 |
| LEHR-S-479 | 0.63 | 0.09 | 9.1 | 0.68 | 0.82 | 2.3 |
| LEHR-S-480 | 0.32 | 0.27 | 8.8 | <2 | <2 | 1.4 |
| LEHR-S-481 | 1.07 | -0.02 | 11 | 1.6 | 1.9 | 3 |
| LEHR-S-482 | 0.79 | 0.95 | 9.1 | 0.73 | 1 | 0.57 |
| LEHR-S-483 | 0.58 | 0.22 | 8.4 | 6.8 | 8.4 | 3.6 |
| LEHR-S-484 | 0.46 | 0.5 | 9.7 | 1,700 | 1,900 | 0.77 |
| LEHR-S-485 | 0.49 | 0.64 | 11 | 580 | 630 | 6.1 |
| LEHR-S-486 | 0.42 | 0.49 | 8 | 420 | 500 | 8.1 |
| LEHR-S-487 | 0.66 | 0.21 | 7.8 | 220 | 270 | 0.62 |
| LEHR-S-488 | 1.06 | 0.13 | 8.2 | 88 | 110 | 1.6 |
| LEHR-S-489 | 0.5 | 0.1 | 8.9 | 8 | 9.2 | 0.27 |
| LEHR-S-490 | 0.69 | 0.53 | 8 | 8.1 | 8.9 | - |
| LEHR-S-491 | 0.38 | 1.01 | 6.8 | <1.9 | <1.9 | 0.37 |
| LEHR-S-492 | 0.51 | 0.91 | 6.8 | <1.8 | <1.8 | 0.26 |
| LEHR-S-493 | 0.52 | 0.34 | 6.5 | <1.8 | <1.8 | 0.38 |
| LEHR-S-494 | 0.39 | 0.81 | 6 | <1.8 | <1.8 | 1.1 |
| LEHR-S-495 | 0.88 | 0.59 | 6.6 | 1.2 | 1.8 | 0.22 |
| SSDT0001 | 0.33 | 0.06 | 10 | 81 | 100 | 3.1 |
| SSDT0002 | 0.35 | -0.03 | - | - | - | 0.39 |
| SSDT0003 | 0.36 | -0.14 | - | 33 | 41 | 8.7 |
| Ra/Sr Treatment Systems | | | | | | |
| LEHR-S-384 | 0.58 | 1.61 | - | - | - | 7.9 |
| LEHR-S-385 | 0.61 | 0.76 | - | - | - | 5.4 |
| LEHR-S-386 | 0.69 | 0.86 | - | - | - | 14 |
| LEHR-S-387 | 0.64 | 0.12 | - | - | - | 10 |

Table H-1. Analytical Data Summary for Selected Key Constituents - Southwest Trenches Area, Ra/Sr Treatment Systems, Domestic Septic Tanks (continued)

| Sample ID | Radium-226 pCi/g | Strontium-90 pCi/g | Lead mg/kg | Alpha-Chlordane ug/kg | Gamma-Chlordane ug/kg | Nitrogen, Nitrate (as N) mg/kg |
|---|---|---|---|---|---|---|
| | | | Ra/Sr Treatment Systems | | | |
| LEHR-S-389 | 0.8 | 0.59 | - | - | - | 42 |
| LEHR-S-390 | 0.69 | 0.45 | - | - | - | 33 |
| LEHR-S-391 | 0.87 | 0.27 | - | - | - | 8.3 |
| LEHR-S-396 | 0.17 | 0.6 | - | - | - | 0.3 |
| LEHR-S-397 | 0.65 | 0.78 | - | - | - | 0.99 |
| LEHR-S-398 | 0.73 | 0.01 | - | - | - | 0.36 |
| LEHR-S-399 | 0.55 | 0.63 | - | - | - | 0.24 |
| LEHR-S-400 | 0.67 | 0.17 | - | - | - | 0.4 |
| LEHR-S-401 | 0.79 | 0.02 | - | - | - | 0.67 |
| LEHR-S-402 | 0.45 | 0.27 | - | - | - | 0.91 |
| LEHR-S-407 | 0.99 | 0.91 | - | - | - | 4.9 |
| LEHR-S-409 | 0.49 | 0.59 | - | - | - | 0.42 |
| LEHR-S-410 | 0.62 | 0.65 | - | - | - | 0.54 |
| LEHR-S-412 | 0.88 | 0.47 | - | - | - | 0.22 |
| LEHR-S-417 | 1.06 | 0.22 | - | - | - | 1.1 |
| LEHR-S-418 | 0.64 | 0.68 | - | - | - | 0.58 |
| LEHR-S-419 | 0.85 | 0.19 | - | - | - | 0.42 |
| LEHR-S-420 | 1.63 | 0.8 | - | - | - | 26 |
| LEHR-S-421 | 0.67 | 0.81 | - | - | - | 6.4 |
| LEHR-S-422 | 14.7 | 0.24 | - | - | - | 65 |
| LEHR-S-423 | 0.59 | 0.06 | - | - | - | 46 |
| LEHR-S-424 | 0.81 | 0.12 | - | - | - | 29 |
| LEHR-S-425 | 0.79 | 0.37 | - | - | - | 59 |
| LEHR-S-426 | 0.81 | 1.82 | - | - | - | 34 |
| LEHR-S-427 | 106.2 | 2.18 | - | - | - | 110 |
| LEHR-S-435 | 2.42 | 0.03 | - | - | - | 79 |
| LEHR-S-436 | 0.59 | 0.59 | - | - | - | 11 |
| LEHR-S-437 | 8.19 | - | - | - | - | 18 |
| LEHR-S-438 | 0.67 | - | - | - | - | 2.4 |
| LEHR-S-439 | 1.38 | 0.46 | - | - | - | 14 |
| LEHR-S-440 | 0.92 | - | - | - | - | 110 |
| LEHR-S-441 | 0.93 | - | - | - | - | 6.4 |
| LEHR-S-442 | 1.23 | - | - | - | - | 7 |
| LEHR-S-443 | 3.83 | - | - | - | - | 2.3 |
| LEHR-S-444 | 0.84 | - | - | - | - | 0.85 |
| LEHR-S-445 | 1.04 | - | - | - | - | - |
| LEHR-S-446 | 1.5 | 0.75 | - | - | - | - |
| LEHR-S-447 | 3.69 | 0.22 | - | - | - | 1.2 |
| LEHR-S-448 | 0.68 | - | - | - | - | - |
| LEHR-S-449 | 0.89 | - | - | - | - | 27 |
| LEHR-S-450 | 0.41 | - | - | - | - | 24 |

Table H-1. Analytical Data Summary for Selected Key Constituents - Southwest Trenches Area, Ra/Sr Treatment Systems, Domestic Septic Tanks (continued)

| Sample ID | Radium-226 pCi/g | Strontium-90 pCi/g | Lead mg/kg | Alpha-Chlordane ug/kg | Gamma-Chlordane ug/kg | Nitrogen, Nitrate (as N) mg/kg |
|---|---|---|---|---|---|---|
| Ra/Sr Treatment Systems | | | | | | |
| LEHR-S-451 | 1.13 | -0.13 | - | - | - | 16 |
| LEHR-S-452 | 0.31 | -0.01 | - | - | - | - |
| LEHR-S-453 | 1.35 | 0.09 | - | - | - | 18 |
| LEHR-S-454 | 0.68 | 0.1 | 8.5 | <1.9 | <1.9 | 20 |
| LEHR-S-455 | 0.54 | 0.09 | 10 | <2 | <2 | 17 |
| LEHR-S-456 | 0.045 | 0.11 | 9.4 | <1.9 | <1.9 | 22 |
| LEHR-S-457 | 0.87 | 0.12 | 10 | <2 | <2 | 28 |
| LEHR-S-458 | 2.43 | 0.17 | 3 | <1.8 | <1.8 | 95 |
| LEHR-S-459 | 5.89 | 1.17 | 9.6 | <2.1 | <2.1 | 13 |
| LEHR-S-460 | 1.11 | 0.72 | 9.6 | <1.9 | <1.9 | 28 |
| LEHR-S-461 | 1.68 | 0.6 | 8.9 | <1.9 | <1.9 | 4.5 |
| LEHR-S-462 | 0.72 | 0.75 | 8.5 | <1.9 | <1.9 | 11 |
| LEHR-S-463 | 0.48 | 0.99 | 8 | <2 | <2 | 0.28 |
| LEHR-S-496 | 0.51 | 0.35 | - | - | - | 4.9 |
| LEHR-S-497 | 1.22 | 0.33 | - | - | - | 3.2 |
| LEHR-S-498 | 1.73 | 0.21 | - | - | - | 2.9 |
| LEHR-S-499 | 0.52 | 0.13 | - | - | - | 7.6 |
| Domestic Septic Tanks | | | | | | |
| LEHR-S-428 | 0.72 | 0.26 | 9.3 | <1.9 | <1.9 | 30 |
| LEHR-S-429 | 0.48 | 0.27 | 8.9 | <1.9 | <1.9 | 120 |
| LEHR-S-430 | 0.85 | 0.45 | 8.6 | <2 | <2 | 34 |
| LEHR-S-431 | 0.55 | 0.16 | 9 | <1.9 | <1.9 | - |
| LEHR-S-432 | 0.62 | 0.4 | 7.8 | <1.9 | <1.9 | - |
| LEHR-S-433 | 0.49 | 0.4 | 8.9 | <1.9 | <1.9 | 0.25 |
| LEHR-S-434 | 0.78 | 0.07 | 8.9 | <2 | <2 | 0.37 |
| LEHR-S-T1A01(5.0) | 0.6 | 0.06 | 5.5 | - | - | 16.4 |
| LEHR-S-T1A02(5.0) | 0.43 | 0.02 | 6.11 | - | - | 16.9 |
| LEHR-S-T1A03(7.5) | 0.54 | -0.03 | 6.33 | - | - | 23.5 |
| LEHR-S-T1A04(12.0) | 0.9 | 0.16 | 7.01 | - | - | 4.45 |
| LEHR-S-T1A05 | - | - | - | <2.2 | <2.2 | - |
| LEHR-S-T1A06 | - | - | - | <2.1 | <2.1 | - |
| LEHR-S-T1A07 | - | - | - | <2 | <2 | - |
| LEHR-S-T301 | 0.29 | 0.07 | 7.19 | - | - | 0.163 |
| LEHR-S-T302 | 0.46 | -0.02 | 7.21 | - | - | 0.454 |
| LEHR-S-T303 | 1.45 | -0.15 | 8.32 | - | - | <0.234 |
| LEHR-S-T304 | - | - | - | <2 | <2 | - |
| LEHR-S-T305 | - | - | - | <1.9 | <1.9 | - |
| LEHR-S-T306 | - | - | - | <2 | <2 | - |
| LEHR-S-T401 | 0.62 | -0.08 | 12 | - | - | 0.284 |
| LEHR-S-T402 | 0.5 | 0.08 | 5.32 | - | - | 0.3 |
| LEHR-S-T403 | 0.43 | 0.22 | 6.8 | - | - | 0.411 |

Table H-1. Analytical Data Summary for Selected Key Constituents - Southwest Trenches Area, Ra/Sr Treatment Systems, Domestic Septic Tanks (continued)

| Sample ID | Radium-226 pCi/g | Strontium-90 pCi/g | Lead mg/kg | Alpha-Chlordane ug/kg | Gamma-Chlordane ug/kg | Nitrogen, Nitrate (as N) mg/kg |
|---|---|---|---|---|---|---|
| | | | Domestic Septic Tanks | | | |
| LEHR-S-T404 | - | - | 8.1 | <2 | <2 | - |
| LEHR-S-T404DUP | - | - | 8.2 | - | - | - |
| LEHR-S-T405 | - | - | - | <2.1 | <2.1 | - |
| LEHR-S-T406 | - | - | - | <2 | <2 | - |
| LEHR-S-T601 | 0.64 | 0.0 | 6.7 | - | - | 0.597 |
| LEHR-S-T602 | 0.35 | 0.0 | 7.2 | - | - | 0.237 |
| LEHR-S-T603 | 0.22 | 0.0 | 8.1 | - | - | 0.919 |
| LEHR-S-T604 | - | - | 8 | <2.2 | <2.2 | - |
| LEHR-S-T605 | - | - | - | <2.1 | <2.1 | - |
| LEHR-S-T606 | - | - | - | <2.2 | <2.2 | - |
| WSST0002 | 0.049 | 0.02 | 3.1 | <1.8 | <1.8 | 33 |

Notes:

- = No data available
<n = Not detected at detection limit of n mg/kg or ug/kg

Table H-2a. Soil Samples in the Southwest Trenches Area with concentrations greater than the 10^-4 RBAG

| Sample ID: | Chemical: | Sample Depth: | Concentration: | UNITS: | C/RQ: |
|---|---|---|---|---|---|
| LEHR-S-333 | Manganese | 5.5 | 770 | mg/kg | 1.02 |
| LEHR-S-338 | Radium-226 | 6 | 7.06 | pCi/g | 5.93 |
| | Lead | 6 | 16 | mg/kg | 1.10 |
| LEHR-S-338-QC | Radium-226 | 6 | 11.5 | pCi/g | 9.66 |
| | Lead | 6 | 74 | mg/kg | 5.10 |
| | Cadmium | 6 | 2.2 | mg/kg | 2.62 |
| | Antimony | 6 | 2.2 | mg/kg | 2.12 |
| LEHR-S-340 | Strontium-90 | 6.75 | 16700 | pCi/g | 16.69 |
| | Copper | 6.75 | 890 | mg/kg | 11.41 |
| | Cadmium | 6.75 | 7.1 | mg/kg | 8.45 |
| | Lead | 6.75 | 49 | mg/kg | 3.38 |
| | Dibenzofuran | 6.75 | 26000 | ug/kg | 1.86 |
| | Antimony | 6.75 | 1.3 | mg/kg | 1.25 |
| LEHR-S-340-QC | Copper | 6.75 | 830 | mg/kg | 10.64 |
| | Cadmium | 6.75 | 6.3 | mg/kg | 7.50 |
| | Strontium-90 | 6.75 | 2890 | pCi/g | 2.89 |
| | Lead | 6.75 | 34 | mg/kg | 2.34 |
| | Dibenzofuran | 6.75 | 26000 | ug/kg | 1.86 |
| | Antimony | 6.75 | 1.3 | mg/kg | 1.25 |
| LEHR-S-340-QCDL | Dibenzofuran | 6.75 | 40000 | ug/kg | 2.86 |
| LEHR-S-340DL | Dibenzofuran | 6.75 | 39000 | ug/kg | 2.79 |
| LEHR-S-341 | Manganese | 6.75 | 760 | mg/kg | 1.01 |
| LEHR-S-350 | Cesium-137 | 0.5 | 23 | pCi/g | 2.29 |
| LEHR-S-354 | Radium-226 | 6 | 2.26 | pCi/g | 1.90 |
| LEHR-S-355 | Radium-226 | 6 | 2.02 | pCi/g | 1.70 |
| LEHR-S-356 | Radium-226 | 12 | 1.98 | pCi/g | 1.66 |
| | Mercury | 12 | 0.79 | mg/kg | 1.11 |
| LEHR-S-357 | Radium-226 | 14.4 | 1.73 | pCi/g | 1.45 |
| | Manganese | 14.4 | 1000 | mg/kg | 1.32 |
| LEHR-S-359 | Radium-226 | 12 | 1.28 | pCi/g | 1.08 |
| LEHR-S-360 | Manganese | 12 | 850 | mg/kg | 1.12 |
| LEHR-S-362 | Dibenzofuran | 12 | 1600000 | ug/kg | 114.29 |
| | Naphthalene | 12 | 1200000 | ug/kg | 30.77 |
| | Fluorene | 12 | 2400000 | ug/kg | 14.12 |
| | Acenaphthene | 12 | 3300000 | ug/kg | 13.20 |
| | Benzo(a)anthracene | 12 | 710000 | ug/kg | 5.92 |
| | Benzo(a)pyrene | 12 | 140000 | ug/kg | 5.83 |
| | Strontium-90 | 12 | 3690 | pCi/g | 3.69 |
| | Pyrene | 12 | 1800000 | ug/kg | 3.67 |
| | Fluoranthene | 12 | 5800000 | ug/kg | 3.22 |
| | Phenanthrene | 12 | 3300000 | ug/kg | 2.75 |
| | Carbazole | 12 | 410000 | ug/kg | 1.86 |

Table H-2a. Soil Samples in the Southwest Trenches Area with concentrations greater than the 10^-4 RBAG

| Sample ID: | Chemical: | Sample Depth: | Concentration: | UNITS: | C/RQ: |
|---|---|---|---|---|---|
| LEHR-S-362 | Anthracene | 12 | 2100000 | ug/kg | 1.50 |
| | Copper | 12 | 88 | mg/kg | 1.13 |
| | Benzo(b)fluoranthene | 12 | 270000 | ug/kg | 1.04 |
| LEHR-S-362DL | Dibenzofuran | 12 | 2100000 | ug/kg | 150.00 |
| | Naphthalene | 12 | 2600000 | ug/kg | 66.67 |
| | Fluorene | 12 | 3100000 | ug/kg | 18.24 |
| | Acenaphthene | 12 | 3300000 | ug/kg | 13.20 |
| | Pyrene | 12 | 3900000 | ug/kg | 7.96 |
| | Phenanthrene | 12 | 9500000 | ug/kg | 7.92 |
| | Benzo(a)pyrene | 12 | 180000 | ug/kg | 7.50 |
| | Benzo(a)anthracene | 12 | 660000 | ug/kg | 5.50 |
| | Fluoranthene | 12 | 4000000 | ug/kg | 2.22 |
| | Carbazole | 12 | 350000 | ug/kg | 1.59 |
| | Anthracene | 12 | 1500000 | ug/kg | 1.07 |
| LEHR-S-379 | Mercury | 3 | 0.94 | mg/kg | 1.32 |
| LEHR-S-381 | Lead | 2.5 | 21 | mg/kg | 1.45 |
| | Manganese | 2.5 | 880 | mg/kg | 1.16 |
| LEHR-S-471 | Radium-226 | 6.5 | 2.44 | pCi/g | 2.05 |
| LEHR-S-473 | Manganese | 21 | 860 | mg/kg | 1.14 |
| LEHR-S-476 | Manganese | 6 | 910 | mg/kg | 1.20 |
| LEHR-S-478 | Manganese | 15 | 800 | mg/kg | 1.06 |
| LEHR-S-480 | Mercury | 25 | 0.84 | mg/kg | 1.18 |
| LEHR-S-481 | Manganese | 29 | 940 | mg/kg | 1.24 |
| LEHR-S-483 | Mercury | 3 | 5.2 | mg/kg | 7.32 |
| LEHR-S-484 | Mercury | 3.5 | 0.72 | mg/kg | 1.01 |
| LEHR-S-486 | Mercury | 3 | 0.98 | mg/kg | 1.38 |
| LEHR-S-489 | Manganese | 3 | 910 | mg/kg | 1.20 |
| LEHR-S-493 | Mercury | 3.17 | 0.72 | mg/kg | 1.01 |
| LEHR-S-494 | Mercury | 3 | 1.1 | mg/kg | 1.55 |

RBAG = Risk Based Action Goal
C/RQ = Concentration/Risk Quotient

Table H-2b. Soil Samples in the Ra/Sr Treatment Systems with concentrations greater than the 10^-4 RBAG

| Sample ID: | Chemical: | Sample Depth: | Concentration: | UNITS: | C/RQ: |
|---|---|---|---|---|---|
| LEHR-S-420 | Radium-226 | 6 | 1.63 | pCi/g | 1.37 |
| LEHR-S-422 | Radium-226 | 9.5 | 14.7 | pCi/g | 12.35 |
| LEHR-S-427 | Radium-226 | 6 | 106.2 | pCi/g | 89.24 |
| LEHR-S-435 | Radium-226 | 8 | 2.42 | pCi/g | 2.03 |
| LEHR-S-437 | Radium-226 | 18 | 8.19 | pCi/g | 6.88 |
| LEHR-S-439 | Radium-226 | 29 | 1.38 | pCi/g | 1.16 |
| LEHR-S-442 | Radium-226 | 15 | 1.23 | pCi/g | 1.03 |
| LEHR-S-443 | Radium-226 | 17 | 3.83 | pCi/g | 3.22 |
| LEHR-S-446 | Radium-226 | 28 | 1.5 | pCi/g | 1.26 |
| LEHR-S-447 | Radium-226 | 7 | 3.69 | pCi/g | 3.10 |
| | Benzo(a)pyrene | 7 | 30000 | ug/kg | 1.25 |
| LEHR-S-453 | Radium-226 | 12 | 1.35 | pCi/g | 1.13 |
| LEHR-S-456 | Manganese | 25 | 860 | mg/kg | 1.14 |
| | Copper | 25 | 82 | mg/kg | 1.05 |
| LEHR-S-457 | Manganese | 29 | 870 | mg/kg | 1.15 |
| LEHR-S-458 | Radium-226 | 6.5 | 2.43 | pCi/g | 2.04 |
| LEHR-S-459 | Radium-226 | 13 | 5.89 | pCi/g | 4.95 |
| LEHR-S-461 | Radium-226 | 23 | 1.68 | pCi/g | 1.41 |
| LEHR-S-462 | Copper | 23 | 160 | mg/kg | 2.05 |
| LEHR-S-463 | Copper | 28.5 | 92 | mg/kg | 1.18 |
| LEHR-S-497 | Radium-226 | 0.83 | 1.22 | pCi/g | 1.03 |
| LEHR-S-498 | Radium-226 | 0.83 | 1.73 | pCi/g | 1.45 |

RBAG = Risk Based Action Goal
C/RQ = Concentration/Risk Quotient

Table H-2c. Soil Samples in the Domestic Septic Tanks with concentrations greater than the 10^-4 RBAG

| Sample ID: | Chemical: | Sample Depth: | Concentration: | UNITS: | C/RQ: |
|---|---|---|---|---|---|
| LEHR-S-428 | Manganese | 7 | 790 | mg/kg | 1.04 |
| LEHR-S-433 | Manganese | 13 | 770 | mg/kg | 1.02 |
| LEHR-S-T1A03(7.5) | Manganese | 7.5 | 776 | mg/kg | 1.03 |
| LEHR-S-T303 | Radium-226 | 15.5 | 1.45 | pCi/g | 1.22 |
| | Manganese | 15.5 | 808 | mg/kg | 1.07 |
| LEHR-S-T401 | Mercury | 5.5 | 1.52 | mg/kg | 2.14 |
| LEHR-S-T404 | Mercury | | 0.99 | MG/KG | 1.39 |
| LEHR-S-T404DUP | Mercury | | 0.95 | MG/KG | 1.34 |
| | Mercury | | 0.95 | MG/KG | 1.34 |
| LEHR-S-T601 | Mercury | 5.5 | 49.4 | mg/kg | 69.58 |

RBAG = Risk Based Action Goal
C/RQ = Concentration/Risk Quotient

Table H-3a. Soil Samples in the Southwest Trenches Area with concentrations greater than the 10^-5 RBAG

| Sample ID: | Chemical: | Sample Depth: | Concentration: | UNITS: | C/RQ: |
|---|---|---|---|---|---|
| LEHR-S-331 | Radium-226 | 2 | 0.86 | pCi/g | 1.06 |
| LEHR-S-333 | Manganese | 5.5 | 770 | mg/kg | 1.02 |
| LEHR-S-338 | Radium-226 | 6 | 7.06 | pCi/g | 8.69 |
| | Lead | 6 | 16 | mg/kg | 1.52 |
| LEHR-S-338-QC | Radium-226 | 6 | 11.5 | pCi/g | 14.16 |
| | Lead | 6 | 74 | mg/kg | 7.02 |
| | Cadmium | 6 | 2.2 | mg/kg | 2.62 |
| | Antimony | 6 | 2.2 | mg/kg | 2.12 |
| LEHR-S-340 | Strontium-90 | 6.75 | 16700 | pCi/g | 166.40 |
| | Copper | 6.75 | 890 | mg/kg | 11.41 |
| | Cadmium | 6.75 | 7.1 | mg/kg | 8.45 |
| | Lead | 6.75 | 49 | mg/kg | 4.65 |
| | Dibenzofuran | 6.75 | 26000 | ug/kg | 1.86 |
| | Benzo(a)pyrene | 6.75 | 4300 | ug/kg | 1.79 |
| | Benzo(a)anthracene | 6.75 | 16000 | ug/kg | 1.33 |
| | Antimony | 6.75 | 1.3 | mg/kg | 1.25 |
| LEHR-S-340-QC | Strontium-90 | 6.75 | 2890 | pCi/g | 28.80 |
| | Copper | 6.75 | 830 | mg/kg | 10.64 |
| | Cadmium | 6.75 | 6.3 | mg/kg | 7.50 |
| | Lead | 6.75 | 34 | mg/kg | 3.23 |
| | Dibenzofuran | 6.75 | 26000 | ug/kg | 1.86 |
| | Benzo(a)pyrene | 6.75 | 3200 | ug/kg | 1.33 |
| | Antimony | 6.75 | 1.3 | mg/kg | 1.25 |
| | Benzo(a)anthracene | 6.75 | 13000 | ug/kg | 1.08 |
| LEHR-S-340-QCDL | Dibenzofuran | 6.75 | 40000 | ug/kg | 2.86 |
| | Benzo(a)pyrene | 6.75 | 3600 | ug/kg | 1.50 |
| | Benzo(a)anthracene | 6.75 | 16000 | ug/kg | 1.33 |
| LEHR-S-340DL | Dibenzofuran | 6.75 | 39000 | ug/kg | 2.79 |
| | Benzo(a)pyrene | 6.75 | 5300 | ug/kg | 2.21 |
| | Benzo(a)anthracene | 6.75 | 19000 | ug/kg | 1.58 |
| LEHR-S-341 | Manganese | 6.75 | 760 | mg/kg | 1.01 |
| LEHR-S-342 | Radium-226 | 3 | 1.06 | pCi/g | 1.31 |
| LEHR-S-347 | Tritium | 2 | 91.1 | pCi/g | 1.69 |
| LEHR-S-350 | Cesium-137 | 0.5 | 23 | pCi/g | 21.84 |
| | Lead | 0.5 | 11 | mg/kg | 1.04 |
| LEHR-S-354 | Radium-226 | 6 | 2.26 | pCi/g | 2.78 |
| LEHR-S-355 | Radium-226 | 6 | 2.02 | pCi/g | 2.49 |
| LEHR-S-356 | Radium-226 | 12 | 1.98 | pCi/g | 2.44 |
| | Mercury | 12 | 0.79 | mg/kg | 1.11 |
| LEHR-S-357 | Radium-226 | 14.4 | 1.73 | pCi/g | 2.13 |
| | Manganese | 14.4 | 1000 | mg/kg | 1.32 |
| LEHR-S-359 | Radium-226 | 12 | 1.28 | pCi/g | 1.58 |

Table H-3a. Soil Samples in the Southwest Trenches Area with concentrations greater than the 10^-5 RBAG

| Sample ID: | Chemical: | Sample Depth: | Concentration: | UNITS: | C/RQ: |
|---|---|---|---|---|---|
| LEHR-S-359 | Lead | 12 | 14 | mg/kg | 1.33 |
| LEHR-S-360 | Manganese | 12 | 850 | mg/kg | 1.12 |
| | Radium-226 | 12 | 0.91 | pCi/g | 1.12 |
| LEHR-S-362 | Dibenzofuran | 12 | 1600000 | ug/kg | 114.29 |
| | Benzo(a)anthracene | 12 | 710000 | ug/kg | 59.17 |
| | Benzo(a)pyrene | 12 | 140000 | ug/kg | 58.33 |
| | Strontium-90 | 12 | 3690 | pCi/g | 36.77 |
| | Naphthalene | 12 | 1200000 | ug/kg | 30.77 |
| | Carbazole | 12 | 410000 | ug/kg | 18.64 |
| | Fluorene | 12 | 2400000 | ug/kg | 14.12 |
| | Acenaphthene | 12 | 3300000 | ug/kg | 13.20 |
| | Benzo(b)fluoranthene | 12 | 270000 | ug/kg | 10.38 |
| | Dibenzo(a,h)anthracene | 12 | 18000 | ug/kg | 6.92 |
| | Pyrene | 12 | 1800000 | ug/kg | 3.67 |
| | Fluoranthene | 12 | 5800000 | ug/kg | 3.22 |
| | Chrysene | 12 | 640000 | ug/kg | 3.20 |
| | Phenanthrene | 12 | 3300000 | ug/kg | 2.75 |
| | Anthracene | 12 | 2100000 | ug/kg | 1.50 |
| | Copper | 12 | 88 | mg/kg | 1.13 |
| | Indeno(1,2,3-cd)pyrene | 12 | 27000 | ug/kg | 1.04 |
| LEHR-S-362DL | Dibenzofuran | 12 | 2100000 | ug/kg | 150.00 |
| | Benzo(a)pyrene | 12 | 180000 | ug/kg | 75.00 |
| | Naphthalene | 12 | 2600000 | ug/kg | 66.67 |
| | Benzo(a)anthracene | 12 | 660000 | ug/kg | 55.00 |
| | Fluorene | 12 | 3100000 | ug/kg | 18.24 |
| | Carbazole | 12 | 350000 | ug/kg | 15.91 |
| | Acenaphthene | 12 | 3300000 | ug/kg | 13.20 |
| | Pyrene | 12 | 3900000 | ug/kg | 7.96 |
| | Phenanthrene | 12 | 9500000 | ug/kg | 7.92 |
| | Benzo(b)fluoranthene | 12 | 96000 | ug/kg | 3.69 |
| | Chrysene | 12 | 630000 | ug/kg | 3.15 |
| | Fluoranthene | 12 | 4000000 | ug/kg | 2.22 |
| | Anthracene | 12 | 1500000 | ug/kg | 1.07 |
| LEHR-S-378 | Radium-226 | 2.5 | 0.86 | pCi/g | 1.06 |
| LEHR-S-379 | Mercury | 3 | 0.94 | mg/kg | 1.32 |
| LEHR-S-381 | Lead | 2.5 | 21 | mg/kg | 1.99 |
| | Radium-226 | 2.5 | 1.16 | pCi/g | 1.43 |
| | Manganese | 2.5 | 880 | mg/kg | 1.16 |
| LEHR-S-383 | Radium-226 | 10.5 | 0.96 | pCi/g | 1.18 |
| LEHR-S-468 | Lead | 9 | 12 | mg/kg | 1.14 |
| | Radium-226 | 9 | 0.92 | pCi/g | 1.13 |
| LEHR-S-470 | Radium-226 | 5 | 1.18 | pCi/g | 1.45 |
| | Lead | 5 | 11 | mg/kg | 1.04 |
| LEHR-S-471 | Radium-226 | 6.5 | 2.44 | pCi/g | 3.00 |

Table H-3a. Soil Samples in the Southwest Trenches Area with concentrations greater than the 10^-5 RBAG

| Sample ID: | Chemical: | Sample Depth: | Concentration: | UNITS: | C/RQ: |
|---|---|---|---|---|---|
| LEHR-S-473 | Manganese | 21 | 860 | mg/kg | 1.14 |
| LEHR-S-476 | Manganese | 6 | 910 | mg/kg | 1.20 |
| | Radium-226 | 6 | 0.84 | pCi/g | 1.03 |
| LEHR-S-478 | Manganese | 15 | 800 | mg/kg | 1.06 |
| LEHR-S-480 | Mercury | 25 | 0.84 | mg/kg | 1.18 |
| LEHR-S-481 | Radium-226 | 29 | 1.07 | pCi/g | 1.32 |
| | Manganese | 29 | 940 | mg/kg | 1.24 |
| | Lead | 29 | 11 | mg/kg | 1.04 |
| LEHR-S-483 | Mercury | 3 | 5.2 | mg/kg | 7.32 |
| LEHR-S-484 | Mercury | 3.5 | 0.72 | mg/kg | 1.01 |
| LEHR-S-485 | Lead | 3 | 11 | mg/kg | 1.04 |
| LEHR-S-486 | Mercury | 3 | 0.98 | mg/kg | 1.38 |
| LEHR-S-488 | Radium-226 | 3 | 1.06 | pCi/g | 1.31 |
| LEHR-S-489 | Manganese | 3 | 910 | mg/kg | 1.20 |
| LEHR-S-493 | Mercury | 3.17 | 0.72 | mg/kg | 1.01 |
| LEHR-S-494 | Mercury | 3 | 1.1 | mg/kg | 1.55 |
| LEHR-S-495 | Radium-226 | 3 | 0.88 | pCi/g | 1.08 |

RBAG = Risk Based Action Goal
C/RQ = Concentration/Risk Quotient

Table H-3b. Soil Samples in the Ra/Sr Treatment Systems with concentrations greater than the 10^-5 RBAG

| Sample ID: | Chemical: | Sample Depth: | Concentration: | UNITS: | C/RQ: |
|---|---|---|---|---|---|
| LEHR-S-391 | Radium-226 | 9.5 | 0.87 | pCi/g | 1.07 |
| LEHR-S-407 | Radium-226 | 6 | 0.99 | pCi/g | 1.22 |
| LEHR-S-412 | Radium-226 | 13 | 0.88 | pCi/g | 1.08 |
| LEHR-S-417 | Radium-226 | 6.5 | 1.06 | pCi/g | 1.31 |
| LEHR-S-419 | Radium-226 | 11.5 | 0.85 | pCi/g | 1.05 |
| LEHR-S-420 | Radium-226 | 6 | 1.63 | pCi/g | 2.01 |
| LEHR-S-422 | Radium-226 | 9.5 | 14.7 | pCi/g | 18.10 |
| LEHR-S-427 | Radium-226 | 6 | 106.2 | pCi/g | 130.79 |
| LEHR-S-435 | Radium-226 | 8 | 2.42 | pCi/g | 2.98 |
| LEHR-S-437 | Radium-226 | 18 | 8.19 | pCi/g | 10.09 |
| LEHR-S-439 | Radium-226 | 29 | 1.38 | pCi/g | 1.70 |
| LEHR-S-440 | Radium-226 | 6 | 0.92 | pCi/g | 1.13 |
| LEHR-S-441 | Radium-226 | 8 | 0.93 | pCi/g | 1.15 |
| LEHR-S-442 | Radium-226 | 15 | 1.23 | pCi/g | 1.51 |
| LEHR-S-443 | Radium-226 | 17 | 3.83 | pCi/g | 4.72 |
| LEHR-S-444 | Radium-226 | 20 | 0.84 | pCi/g | 1.03 |
| LEHR-S-445 | Radium-226 | 22 | 1.04 | pCi/g | 1.28 |
| LEHR-S-446 | Radium-226 | 28 | 1.5 | pCi/g | 1.85 |
| LEHR-S-447 | Benzo(a)pyrene | 7 | 30000 | ug/kg | 12.50 |
| | Radium-226 | 7 | 3.69 | pCi/g | 4.54 |
| | Benzo(b)fluoranthene | 7 | 34000 | ug/kg | 1.31 |
| | Benzo(a)anthracene | 7 | 13000 | ug/kg | 1.08 |
| LEHR-S-447DL | Benzo(a)pyrene | 7 | 22000 | ug/kg | 9.17 |
| | Benzo(a)anthracene | 7 | 25000 | ug/kg | 2.08 |
| | Dibenzo(a,h)anthracene | 7 | 3600 | ug/kg | 1.38 |
| LEHR-S-449 | Radium-226 | 20 | 0.89 | pCi/g | 1.10 |
| LEHR-S-451 | Radium-226 | 29 | 1.13 | pCi/g | 1.39 |
| LEHR-S-453 | Radium-226 | 12 | 1.35 | pCi/g | 1.66 |
| LEHR-S-456 | Manganese | 25 | 860 | mg/kg | 1.14 |
| | Copper | 25 | 82 | mg/kg | 1.05 |
| LEHR-S-457 | Manganese | 29 | 870 | mg/kg | 1.15 |
| | Radium-226 | 29 | 0.87 | pCi/g | 1.07 |
| LEHR-S-458 | Radium-226 | 6.5 | 2.43 | pCi/g | 2.99 |
| LEHR-S-459 | Radium-226 | 13 | 5.89 | pCi/g | 7.25 |
| LEHR-S-460 | Radium-226 | 19 | 1.11 | pCi/g | 1.37 |
| LEHR-S-461 | Radium-226 | 23 | 1.68 | pCi/g | 2.07 |
| LEHR-S-462 | Copper | 23 | 160 | mg/kg | 2.05 |
| LEHR-S-463 | Copper | 28.5 | 92 | mg/kg | 1.18 |

Table H-3b. Soil Samples in the Ra/Sr Treatment Systems with concentrations greater than the 10^-5 RBAG

| Sample ID: | Chemical: | Sample Depth: | Concentration: | UNITS: | C/RQ: |
|---|---|---|---|---|---|
| LEHR-S-497 | Radium-226 | 0.83 | 1.22 | pCi/g | 1.50 |
| LEHR-S-498 | Radium-226 | 0.83 | 1.73 | pCi/g | 2.13 |

RBAG = Risk Based Action Goal
C/RQ = Concentration/Risk Quotient

Table H-3c. Soil Samples in the Domestic Septic Tanks with concentrations greater than the 10^-5 RBAG

| Sample ID: | Chemical: | Sample Depth: | Concentration: | UNITS: | C/RQ: |
|---|---|---|---|---|---|
| LEHR-S-428 | Manganese | 7 | 790 | mg/kg | 1.04 |
| LEHR-S-430 | Radium-226 | 12 | 0.85 | pCi/g | 1.05 |
| LEHR-S-433 | Manganese | 13 | 770 | mg/kg | 1.02 |
| LEHR-S-T1A03(7.5) | Manganese | 7.5 | 776 | mg/kg | 1.03 |
| LEHR-S-T1A04(12.0 | Radium-226 | 12 | 0.9 | pCi/g | 1.11 |
| LEHR-S-T303 | Radium-226 | 15.5 | 1.45 | pCi/g | 1.79 |
| | Manganese | 15.5 | 808 | mg/kg | 1.07 |
| LEHR-S-T401 | Mercury | 5.5 | 1.52 | mg/kg | 2.14 |
| | Lead | 5.5 | 12 | mg/kg | 1.14 |
| LEHR-S-T404 | Mercury | | 0.99 | MG/KG | 1.39 |
| LEHR-S-T404DUP | Mercury | | 0.95 | MG/KG | 1.34 |
| | Mercury | | 0.95 | MG/KG | 1.34 |
| LEHR-S-T601 | Mercury | 5.5 | 49.4 | mg/kg | 69.58 |

RBAG = Risk Based Action Goal
C/RQ = Concentration/Risk Quotient

Table H-4a. Soil Samples in the Southwest Trenches Area with concentrations greater than the 10^-6 RBAG

| Sample ID: | Chemical: | Sample Depth: | Concentration: | UNITS: | C/RQ: |
|---|---|---|---|---|---|
| LEHR-S-331 | Radium-226 | 2 | 0.86 | pCi/g | 1.11 |
| LEHR-S-333 | Thorium-232 | 5.5 | 0.71 | pCi/g | 1.07 |
| | Radium-226 | 5.5 | 0.81 | pCi/g | 1.05 |
| | Thorium-228 | 5.5 | 0.76 | pCi/g | 1.02 |
| | Manganese | 5.5 | 770 | mg/kg | 1.02 |
| LEHR-S-338 | Radium-226 | 6 | 7.06 | pCi/g | 9.12 |
| | Strontium-90 | 6 | 34.1 | pCi/g | 3.29 |
| | Lead | 6 | 16 | mg/kg | 1.58 |
| LEHR-S-338-QC | Radium-226 | 6 | 11.5 | pCi/g | 14.85 |
| | Lead | 6 | 74 | mg/kg | 7.29 |
| | Cadmium | 6 | 2.2 | mg/kg | 2.62 |
| | Antimony | 6 | 2.2 | mg/kg | 2.12 |
| | Strontium-90 | 6 | 14 | pCi/g | 1.35 |
| LEHR-S-339 | Strontium-90 | 6 | 10.7 | pCi/g | 1.03 |
| LEHR-S-340 | Strontium-90 | 6.75 | 16700 | pCi/g | 1611.97 |
| | Benzo(a)pyrene | 6.75 | 4300 | ug/kg | 17.92 |
| | Benzo(a)anthracene | 6.75 | 16000 | ug/kg | 13.33 |
| | Copper | 6.75 | 890 | mg/kg | 11.41 |
| | Cadmium | 6.75 | 7.1 | mg/kg | 8.45 |
| | Carbazole | 6.75 | 11000 | ug/kg | 5.00 |
| | Lead | 6.75 | 49 | mg/kg | 4.83 |
| | Arochlor-1260 | 6.75 | 1000 | ug/kg | 4.00 |
| | Dibenzofuran | 6.75 | 26000 | ug/kg | 1.86 |
| | Benzo(b)fluoranthene | 6.75 | 4600 | ug/kg | 1.77 |
| | Dibenzo(a,h)anthracene | 6.75 | 360 | ug/kg | 1.38 |
| | Antimony | 6.75 | 1.3 | mg/kg | 1.25 |
| LEHR-S-340-QC | Strontium-90 | 6.75 | 2890 | pCi/g | 278.96 |
| | Benzo(a)pyrene | 6.75 | 3200 | ug/kg | 13.33 |
| | Benzo(a)anthracene | 6.75 | 13000 | ug/kg | 10.83 |
| | Copper | 6.75 | 830 | mg/kg | 10.64 |
| | Cadmium | 6.75 | 6.3 | mg/kg | 7.50 |
| | Lead-210 | 6.75 | 61 | pCi/g | 6.35 |
| | Arochlor-1260 | 6.75 | 1300 | ug/kg | 5.20 |
| | Carbazole | 6.75 | 10000 | ug/kg | 4.55 |
| | Lead | 6.75 | 34 | mg/kg | 3.35 |
| | Dibenzofuran | 6.75 | 26000 | ug/kg | 1.86 |
| | Antimony | 6.75 | 1.3 | mg/kg | 1.25 |
| | Benzo(b)fluoranthene | 6.75 | 3200 | ug/kg | 1.23 |
| | Dibenzo(a,h)anthracene | 6.75 | 290 | ug/kg | 1.12 |
| LEHR-S-340-QCDL | Benzo(a)pyrene | 6.75 | 3600 | ug/kg | 15.00 |
| | Benzo(a)anthracene | 6.75 | 16000 | ug/kg | 13.33 |
| | Carbazole | 6.75 | 6800 | ug/kg | 3.09 |
| | Dibenzofuran | 6.75 | 40000 | ug/kg | 2.86 |
| | Benzo(b)fluoranthene | 6.75 | 3500 | ug/kg | 1.35 |

Table H-4a. Soil Samples in the Southwest Trenches Area with concentrations greater than the 10^-6 RBAG

| Sample ID: | Chemical: | Sample Depth: | Concentration: | UNITS: | C/RQ: |
|---|---|---|---|---|---|
| LEHR-S-340DL | Benzo(a)pyrene | 6.75 | 5300 | ug/kg | 22.08 |
| | Benzo(a)anthracene | 6.75 | 19000 | ug/kg | 15.83 |
| | Carbazole | 6.75 | 7500 | ug/kg | 3.41 |
| | Dibenzofuran | 6.75 | 39000 | ug/kg | 2.79 |
| | Benzo(b)fluoranthene | 6.75 | 4100 | ug/kg | 1.58 |
| LEHR-S-341 | Manganese | 6.75 | 760 | mg/kg | 1.01 |
| LEHR-S-342 | Strontium-90 | 3 | 18.7 | pCi/g | 1.81 |
| | Radium-226 | 3 | 1.06 | pCi/g | 1.37 |
| LEHR-S-347 | Tritium | 2 | 91.1 | pCi/g | 16.87 |
| LEHR-S-350 | Cesium-137 | 0.5 | 23 | pCi/g | 150.33 |
| | Lead | 0.5 | 11 | mg/kg | 1.08 |
| LEHR-S-354 | Radium-226 | 6 | 2.26 | pCi/g | 2.92 |
| LEHR-S-355 | Radium-226 | 6 | 2.02 | pCi/g | 2.61 |
| | Strontium-90 | 6 | 13.8 | pCi/g | 1.33 |
| LEHR-S-356 | Radium-226 | 12 | 1.98 | pCi/g | 2.56 |
| | Mercury | 12 | 0.79 | mg/kg | 1.11 |
| LEHR-S-357 | Radium-226 | 14.4 | 1.73 | pCi/g | 2.23 |
| | Manganese | 14.4 | 1000 | mg/kg | 1.32 |
| LEHR-S-359 | Radium-226 | 12 | 1.28 | pCi/g | 1.65 |
| | Lead | 12 | 14 | mg/kg | 1.38 |
| LEHR-S-360 | Radium-226 | 12 | 0.91 | pCi/g | 1.18 |
| | Manganese | 12 | 850 | mg/kg | 1.12 |
| LEHR-S-361 | Strontium-90 | 14.5 | 22.3 | pCi/g | 2.15 |
| LEHR-S-362 | Benzo(a)anthracene | 12 | 710000 | ug/kg | 591.67 |
| | Benzo(a)pyrene | 12 | 140000 | ug/kg | 583.33 |
| | Strontium-90 | 12 | 3690 | pCi/g | 356.18 |
| | Carbazole | 12 | 410000 | ug/kg | 186.36 |
| | Dibenzofuran | 12 | 1600000 | ug/kg | 114.29 |
| | Benzo(b)fluoranthene | 12 | 270000 | ug/kg | 103.85 |
| | Dibenzo(a,h)anthracene | 12 | 18000 | ug/kg | 69.23 |
| | Chrysene | 12 | 640000 | ug/kg | 32.00 |
| | Naphthalene | 12 | 1200000 | ug/kg | 30.77 |
| | Fluorene | 12 | 2400000 | ug/kg | 14.12 |
| | Acenaphthene | 12 | 3300000 | ug/kg | 13.20 |
| | Indeno(1,2,3-cd)pyrene | 12 | 27000 | ug/kg | 10.38 |
| | Pyrene | 12 | 1800000 | ug/kg | 3.67 |
| | Fluoranthene | 12 | 5800000 | ug/kg | 3.22 |
| | Phenanthrene | 12 | 3300000 | ug/kg | 2.75 |
| | Anthracene | 12 | 2100000 | ug/kg | 1.50 |
| | Benzo(k)fluoranthene | 12 | 36000 | ug/kg | 1.38 |
| | Copper | 12 | 88 | mg/kg | 1.13 |
| LEHR-S-362DL | Benzo(a)pyrene | 12 | 180000 | ug/kg | 750.00 |
| | Benzo(a)anthracene | 12 | 660000 | ug/kg | 550.00 |

Table H-4a. Soil Samples in the Southwest Trenches Area with concentrations greater than the 10^-6 RBAG

| Sample ID: | Chemical: | Sample Depth: | Concentration: | UNITS: | C/RQ: |
|---|---|---|---|---|---|
| LEHR-S-362DL | Carbazole | 12 | 350000 | ug/kg | 159.09 |
| | Dibenzofuran | 12 | 2100000 | ug/kg | 150.00 |
| | Naphthalene | 12 | 2600000 | ug/kg | 66.67 |
| | Benzo(b)fluoranthene | 12 | 96000 | ug/kg | 36.92 |
| | Chrysene | 12 | 630000 | ug/kg | 31.50 |
| | Fluorene | 12 | 3100000 | ug/kg | 18.24 |
| | Acenaphthene | 12 | 3300000 | ug/kg | 13.20 |
| | Benzo(k)fluoranthene | 12 | 240000 | ug/kg | 9.23 |
| | Pyrene | 12 | 3900000 | ug/kg | 7.96 |
| | Phenanthrene | 12 | 9500000 | ug/kg | 7.92 |
| | Fluoranthene | 12 | 4000000 | ug/kg | 2.22 |
| | Anthracene | 12 | 1500000 | ug/kg | 1.07 |
| LEHR-S-378 | Radium-226 | 2.5 | 0.86 | pCi/g | 1.11 |
| LEHR-S-379 | Mercury | 3 | 0.94 | mg/kg | 1.32 |
| LEHR-S-381 | Lead | 2.5 | 21 | mg/kg | 2.07 |
| | Radium-226 | 2.5 | 1.16 | pCi/g | 1.50 |
| | Manganese | 2.5 | 880 | mg/kg | 1.16 |
| LEHR-S-383 | Radium-226 | 10.5 | 0.96 | pCi/g | 1.24 |
| LEHR-S-466 | Dieldrin | 17.5 | 26 | ug/kg | 1.73 |
| LEHR-S-468 | Radium-226 | 9 | 0.92 | pCi/g | 1.19 |
| | Lead | 9 | 12 | mg/kg | 1.18 |
| LEHR-S-470 | Radium-226 | 5 | 1.18 | pCi/g | 1.52 |
| | Lead | 5 | 11 | mg/kg | 1.08 |
| LEHR-S-471 | Radium-226 | 6.5 | 2.44 | pCi/g | 3.15 |
| LEHR-S-473 | Manganese | 21 | 860 | mg/kg | 1.14 |
| LEHR-S-476 | Manganese | 6 | 910 | mg/kg | 1.20 |
| | Radium-226 | 6 | 0.84 | pCi/g | 1.08 |
| LEHR-S-478 | Manganese | 15 | 800 | mg/kg | 1.06 |
| LEHR-S-480 | Mercury | 25 | 0.84 | mg/kg | 1.18 |
| LEHR-S-481 | Radium-226 | 29 | 1.07 | pCi/g | 1.38 |
| | Manganese | 29 | 940 | mg/kg | 1.24 |
| | Lead | 29 | 11 | mg/kg | 1.08 |
| LEHR-S-482 | Radium-226 | 3 | 0.79 | pCi/g | 1.02 |
| LEHR-S-483 | Mercury | 3 | 5.2 | mg/kg | 7.32 |
| LEHR-S-484 | Dieldrin | 3.5 | 70 | ug/kg | 4.67 |
| | Gamma-Chlordane | 3.5 | 1900 | ug/kg | 2.35 |
| | Alpha-Chlordane | 3.5 | 1700 | ug/kg | 2.13 |
| | Mercury | 3.5 | 0.72 | mg/kg | 1.01 |
| LEHR-S-485 | Dieldrin | 3 | 29 | ug/kg | 1.93 |
| | Lead | 3 | 11 | mg/kg | 1.08 |
| LEHR-S-486 | Mercury | 3 | 0.98 | mg/kg | 1.38 |
| | Dieldrin | 3 | 19 | ug/kg | 1.27 |

Table H-4a. Soil Samples in the Southwest Trenches Area with concentrations greater than the 10^-6 RBAG

| Sample ID: | Chemical: | Sample Depth: | Concentration: | UNITS: | C/RQ: |
|---|---|---|---|---|---|
| LEHR-S-488 | Radium-226 | 3 | 1.06 | pCi/g | 1.37 |
| LEHR-S-489 | Manganese | 3 | 910 | mg/kg | 1.20 |
| LEHR-S-490 | Heptachlor Epoxide | 4 | 1.3 | ug/kg | 2.28 |
| LEHR-S-493 | Mercury | 3.17 | 0.72 | mg/kg | 1.01 |
| LEHR-S-494 | Mercury | 3 | 1.1 | mg/kg | 1.55 |
| LEHR-S-495 | Radium-226 | 3 | 0.88 | pCi/g | 1.14 |

RBAG = Risk Based Action Goal
C/RQ = Concentration/Risk Quotient

Table H-4b. Soil Samples in the Ra/Sr Treatment Systems with concentrations greater than the 10^-6 RBAG

| Sample ID: | Chemical: | Sample Depth: | Concentration: | UNITS: | C/RQ: |
|---|---|---|---|---|---|
| LEHR-S-389 | Radium-226 | 4.5 | 0.8 | pCi/g | 1.03 |
| LEHR-S-391 | Radium-226 | 9.5 | 0.87 | pCi/g | 1.12 |
| LEHR-S-401 | Radium-226 | 10 | 0.79 | pCi/g | 1.02 |
| LEHR-S-407 | Radium-226 | 6 | 0.99 | pCi/g | 1.28 |
| LEHR-S-412 | Radium-226 | 13 | 0.88 | pCi/g | 1.14 |
| LEHR-S-417 | Radium-226 | 6.5 | 1.06 | pCi/g | 1.37 |
| LEHR-S-419 | Radium-226 | 11.5 | 0.85 | pCi/g | 1.10 |
| LEHR-S-420 | Radium-226 | 6 | 1.63 | pCi/g | 2.11 |
| LEHR-S-422 | Radium-226 | 9.5 | 14.7 | pCi/g | 18.99 |
| LEHR-S-424 | Radium-226 | 14 | 0.81 | pCi/g | 1.05 |
| LEHR-S-425 | Radium-226 | 14 | 0.79 | pCi/g | 1.02 |
| LEHR-S-426 | Radium-226 | 11 | 0.81 | pCi/g | 1.05 |
| LEHR-S-427 | Radium-226 | 6 | 106.2 | pCi/g | 137.17 |
| LEHR-S-435 | Radium-226 | 8 | 2.42 | pCi/g | 3.13 |
| LEHR-S-437 | Radium-226 | 18 | 8.19 | pCi/g | 10.58 |
| | Cesium-137 | 18 | 0.434 | pCi/g | 2.84 |
| LEHR-S-439 | Radium-226 | 29 | 1.38 | pCi/g | 1.78 |
| LEHR-S-440 | Lead-210 | 6 | 12 | pCi/g | 1.25 |
| | Radium-226 | 6 | 0.92 | pCi/g | 1.19 |
| LEHR-S-441 | Radium-226 | 8 | 0.93 | pCi/g | 1.20 |
| LEHR-S-442 | Radium-226 | 15 | 1.23 | pCi/g | 1.59 |
| LEHR-S-443 | Radium-226 | 17 | 3.83 | pCi/g | 4.95 |
| LEHR-S-444 | Radium-226 | 20 | 0.84 | pCi/g | 1.08 |
| LEHR-S-445 | Radium-226 | 22 | 1.04 | pCi/g | 1.34 |
| LEHR-S-446 | Radium-226 | 28 | 1.5 | pCi/g | 1.94 |
| LEHR-S-447 | Benzo(a)pyrene | 7 | 30000 | ug/kg | 125.00 |
| | Benzo(b)fluoranthene | 7 | 34000 | ug/kg | 13.08 |
| | Benzo(a)anthracene | 7 | 13000 | ug/kg | 10.83 |
| | Dibenzo(a,h)anthracene | 7 | 1900 | ug/kg | 7.31 |
| | Radium-226 | 7 | 3.69 | pCi/g | 4.77 |
| | Lead-210 | 7 | 15 | pCi/g | 1.56 |
| | Indeno(1,2,3-cd)pyrene | 7 | 3900 | ug/kg | 1.50 |
| | Carbazole | 7 | 2400 | ug/kg | 1.09 |
| LEHR-S-447DL | Benzo(a)pyrene | 7 | 22000 | ug/kg | 91.67 |
| | Benzo(a)anthracene | 7 | 25000 | ug/kg | 20.83 |
| | Dibenzo(a,h)anthracene | 7 | 3600 | ug/kg | 13.85 |
| | Benzo(b)fluoranthene | 7 | 15000 | ug/kg | 5.77 |
| | Indeno(1,2,3-cd)pyrene | 7 | 8500 | ug/kg | 3.27 |
| | Chrysene | 7 | 28000 | ug/kg | 1.40 |
| | Carbazole | 7 | 2900 | ug/kg | 1.32 |

Table H-4b. Soil Samples in the Ra/Sr Treatment Systems with concentrations greater than the 10^-6 RBAG

| Sample ID: | Chemical: | Sample Depth: | Concentration: | UNITS: | C/RQ: |
|---|---|---|---|---|---|
| LEHR-S-449 | Radium-226 | 20 | 0.89 | pCi/g | 1.15 |
| LEHR-S-451 | Radium-226 | 29 | 1.13 | pCi/g | 1.46 |
| LEHR-S-453 | Radium-226 | 12 | 1.35 | pCi/g | 1.74 |
| LEHR-S-456 | Manganese | 25 | 860 | mg/kg | 1.14 |
| | Copper | 25 | 82 | mg/kg | 1.05 |
| LEHR-S-457 | Manganese | 29 | 870 | mg/kg | 1.15 |
| | Radium-226 | 29 | 0.87 | pCi/g | 1.12 |
| LEHR-S-458 | Radium-226 | 6.5 | 2.43 | pCi/g | 3.14 |
| LEHR-S-459 | Radium-226 | 13 | 5.89 | pCi/g | 7.61 |
| LEHR-S-460 | Radium-226 | 19 | 1.11 | pCi/g | 1.43 |
| LEHR-S-461 | Radium-226 | 23 | 1.68 | pCi/g | 2.17 |
| LEHR-S-462 | Copper | 23 | 160 | mg/kg | 2.05 |
| LEHR-S-463 | Copper | 28.5 | 92 | mg/kg | 1.18 |
| LEHR-S-497 | Radium-226 | 0.83 | 1.22 | pCi/g | 1.58 |
| LEHR-S-498 | Radium-226 | 0.83 | 1.73 | pCi/g | 2.23 |

RBAG = Risk Based Action Goal
C/RQ = Concentration/Risk Quotient

Table H-4c. Soil Samples in the Domestic Septic Tanks with concentrations greater than the 10^-6 RBAG

| Sample ID: | Chemical: | Sample Depth: | Concentration: | UNITS: | C/RQ: |
|---|---|---|---|---|---|
| LEHR-S-428 | Manganese | 7 | 790 | mg/kg | 1.04 |
| LEHR-S-430 | Radium-226 | 12 | 0.85 | pCi/g | 1.10 |
| LEHR-S-433 | Manganese | 13 | 770 | mg/kg | 1.02 |
| LEHR-S-434 | Radium-226 | 13 | 0.78 | pCi/g | 1.01 |
| LEHR-S-T1A03(7.5) | Manganese | 7.5 | 776 | mg/kg | 1.03 |
| LEHR-S-T1A04(12.0 | Radium-226 | 12 | 0.9 | pCi/g | 1.16 |
| LEHR-S-T1A05 | Heptachlor Epoxide | | 2.2 | UG/KG | 3.86 |
| LEHR-S-T1A06 | Heptachlor Epoxide | | 2.1 | UG/KG | 3.68 |
| LEHR-S-T1A07 | Heptachlor Epoxide | | 2 | UG/KG | 3.51 |
| LEHR-S-T303 | Radium-226 | 15.5 | 1.45 | pCi/g | 1.87 |
| | Manganese | 15.5 | 808 | mg/kg | 1.07 |
| LEHR-S-T304 | Heptachlor Epoxide | | 2 | UG/KG | 3.51 |
| LEHR-S-T305 | Heptachlor Epoxide | | 1.9 | UG/KG | 3.33 |
| LEHR-S-T306 | Heptachlor Epoxide | | 2 | UG/KG | 3.51 |
| LEHR-S-T401 | Mercury | 5.5 | 1.52 | mg/kg | 2.14 |
| | Lead | 5.5 | 12 | mg/kg | 1.18 |
| LEHR-S-T404 | Heptachlor Epoxide | | 2 | UG/KG | 3.51 |
| | Mercury | | 0.99 | MG/KG | 1.39 |
| LEHR-S-T404DUP | Mercury | | 0.95 | MG/KG | 1.34 |
| | Mercury | | 0.95 | MG/KG | 1.34 |
| LEHR-S-T405 | Heptachlor Epoxide | | 2.1 | UG/KG | 3.68 |
| LEHR-S-T406 | Heptachlor Epoxide | | 2 | UG/KG | 3.51 |
| LEHR-S-T601 | Mercury | 5.5 | 49.4 | mg/kg | 69.58 |
| LEHR-S-T604 | Heptachlor Epoxide | | 2.2 | UG/KG | 3.86 |
| LEHR-S-T605 | Heptachlor Epoxide | | 2.1 | UG/KG | 3.68 |
| LEHR-S-T606 | Heptachlor Epoxide | | 2.2 | UG/KG | 3.86 |

RBAG = Risk Based Action Goal
C/RQ = Concentration/Risk Quotient

# APPENDIX I

## TRANSPORTATION IMPACT ANALYSIS

# I. TRANSPORTATION IMPACT ANALYSIS

Transportation impacts of the proposed alternatives are discussed in this appendix. The level of detail in this discussion is commensurate with the anticipated impacts, as directed by DOE NEPA guidance.

## I.1 Background

Historical data on radionuclide concentrations at the LEHR site were reviewed as a basis for projections on the potential radionuclide concentrations of future removal action waste shipments at DOE Areas. Historical data on radionuclide concentrations is available from Hanford waste certification records for DOE area waste shipments in 1996. Radionuclides of interest for assessing routine transportation impacts are those which present direct radiation exposure hazards to drivers of the truck transporting the waste, or members of the public. These would include Cesium-137, Radium-226 and Thorium-234. The waste content for the DOE Box Waste shipments for the LEHR site to Hanford are presented in Table I-1. The data from the Draft Final Site Characterization Report was also reviewed. Radionuclide concentrations as measured by radioactivity were somewhat higher than those observed in 1996 shipment. The data representing the highest Site activities from either the Southwest Trenches Area or the Ra/Sr Treatment Systems Area is shown in Table I-2. The number of waste shipments from 1993 to September 1997 is presented in Table I-3. The annual number of shipments is expected to increase if any of the removal action alternatives for the LEHR Environmental Restoration/Waste Management project is implemented.

## I.2 Removal Actions

Waste shipments from the Southwest Trenches Area, the Ra/Sr Treatment Systems Area, and the Domestic Septic System Areas are anticipated as part of the removal alternatives. The various alternatives and estimated volumes of excavated soil for these alternatives are described in this EE/CA. Briefly, these encompass a range of removal actions and off-site shipment of waste. For this transportation analysis the most conservative alternative was selected, which involved the largest volume of soil to be removed and transported, for evaluation in order to provide an estimate of the highest likely associated risk. Estimated truck shipments of low-level radioactive waste for each DOE area, alternative, and risk level are shown in Table I-4.

## I.3 Transportation Impacts

The highest observed concentrations in soil being excavated from the Southwest Trenches and Radium/Strontium Treatment Unit at the Site (Table I-2) were used to estimate radiation exposure during transportation activities.

Excavated waste soils will be transported by trucks contracted solely for DOE shipments of radioactive material. The shipping containers will be specially constructed boxes which meet the Department of Transportation requirements for "strong, tight" containers required to transport low specific activity radionuclides. Each box will hold 96 cubic feet of excavated material having an assumed density of 90 pounds per cubic foot. There will be a maximum of four boxes per truckload. The total activity of each radionuclide of interest per truckload is also shown in Table I-2.

The resulting radiation exposure rate at a distance of one meter from any B-25 package would be 0.08 millirem per hour. Since geometry would limit exposure to the equivalent of contributions from two boxes at any given location around the truck or 0.16 millirem per hour. These levels are well below DOT limits in 49 CFR 173.441 for exclusive use radioactive materials shipments.

The total distance per shipment is approximately 900 miles from UC Davis to Hanford, via primarily interstate routes (I-80 east to I-5 north to I-84 east at Portland, Oregon, to I-82 north into Washington State and to Richland). Therefore, assuming an average speed of 45 miles per hour, the duration of exposure to a driver would be 20 hours. The total exposure to each driver in a two driver team would be less than 1.6 millirem per trip.

The total number of truck shipments depends on the total excavated volume of soil to be shipped. The maximum number of shipments would occur with the greatest assumed volume of excavated soil. If the lowest level of acceptable risk-based cleanup levels are assumed, the total number of shipments would be about 400. This would result in a total project occupational transportation exposure of 2.4 person-rem assuming two drivers per trip. The associated increased lifetime risk of incurring a fatal cancer associated with this exposure level would be approximately $0.6 \times 10^{-4}$ per driver, assuming the same driver made all 400 trips.

Exposure to a member of the public would be minimal since the radiation exposure rate is low. The rate would be at least 10 times less than the 1.6 millirem-per-trip driver exposure based on distance from the truck, even if the same car followed the truck for the entire distance.

Radiation exposure risks associated with accidents would be insignificant. Over the total life of the project, assuming 400 total shipments, the accident frequency is projected to be less than one accident for the entire project. This is based on assuming the route traveled is 10 percent on urban interstates and 90 percent on rural interstates. According to a Federal Highway Administration study at Oak Ridge National Laboratory (Miaou, 1991), associated accident rates are 1.86 for urban interstate and 0.88 for rural interstate per million truck miles. These accidents were moderately severe, resulting in a vehicle being towed from the accident site. Accordingly, the total number of projected accidents, over 900 miles per trip and 400 trips, would be 0.35. Alternative waste disposal facilities would also be designated for some wastes based on waste acceptance criteria of disposal facilities. Any site within the same distance as Hanford, or closer, would have the same or fewer

accidents. Statistically, it is unlikely that an accident resulting in any release or significant exposure would occur. The industrial B-25 boxes would tend to contain the excavated soil even during an accident. The radioactivity of the soil being transported is low. There would be limited receptors for any accidental release based on the primarily rural routing of the shipments.

Fatalities not associated with exposure to radioactive contaminants in the soil being transported for disposal dominate transportation risks. The probability of a highway accident resulting in a fatal injury has been computed using historical data from California and Oregon highway departments. These rates are 2.6 x 10-8 per kilometer in California and 1.1 x 10-8 in Oregon for freight shipments on rural highways (Saricks, C. and T. Kvitek, 1994). Using an average of these rates, 1.85 x 10-8 fatalities/shipment- kilometer, the total actuarial fatalities for 400 shipments over 1,665 kilometers per trip (900 miles) is 0.012. This is much larger than the potential risk of incurring a fatal cancer from exposure to radiation during transport.

Similarly, the risk of latent fatalities from exposure to diesel exhaust and entrained road dust for residents along the highway in urban areas is larger than risks from radiation exposure and has been estimated to be 1 x 10-7 fatalities per kilometer (Rao et al, 1982). This project would also, therefore, have associated potential for causing a 0.007 increase in the risk of dying from exposure to exhaust and road dust for people in urban areas, assuming as much as 10% travel though urban areas.

If the No Action alternative is selected, no low-level radioactive waste will be generated nor will any waste shipments occur, thereby resulting in no impact in the area of transportation.

## I.4 Summary of Transportation Impacts

The assumptions used to determine potential impacts from transportation of waste from the site to Hanford were conservative, thus exaggerating adverse conditions to ensure a conservative transportation impact analysis. The conclusion of the transportation impact study is that no significant adverse impacts would result from transportation of waste to disposal facilities.

## I.5 Reference

Miaou, S.; Hu, P.; Wright, T.; Davis, S.; and Rathi, A., 1991, Development of the Relationship Between Truck Accidents and Geometric Design, Federal Highway Administration, August 1991.

Saricks, C. And T. Kvitek, 1994. Longitudinal Review of State-Level Accident Statistics for Carriers of Interstate Freight, July. ANL/ESD/TM-68, Argonne, IL: Argonne National Laboratory.

Rao, R.K., E.L. Wilmot, and R.E. Luna, 1982. Non-Radiological Impacts of Transporting Radioactive Material. SAND81-1703. TTC-0236, Albuquerque, N.M.: Sandia National Laboratories.

Table I-1. Concentration Range of Radionuclides from DOE Box Waste Shipment to Hanford, 1996

| Analyte<br>Radionuclides Analyte Group | Concentration Range<br>(picoCuries/gram) |
|---|---|
| Ac-228 | 0.40-0.68 |
| Bi-212 | 0.25-0.49 |
| Bi-214 | 0.41-2.15 |
| K-40 (natural) | 3.0-12.1 |
| Pb-210 | <1.3-2.5 |
| Pb-212 | 0.26-0.52 |
| Pb-214 | 0.47-2.51 |
| Ra-226 | 0.29-9.7 |
| Th-234 | <0.53-1.97 |
| TI-208 | 0.11-0.17 |
| Cs-137 | <0.02-0.038 |
| C-14 | <0.38-2.16 |
| Sr-90 | <0.67-36.7 |
| H-3 | <5.8-400 (picoCuries/liter) |

Source: "Waste Certification Summary, "Generator: LEHR, UC Davis, DOE Box" Trench," ID Number WSRD 100-00A, September 10, 1996, Westinghouse, Hanford.

Table I-2. Radionuclide Concentration of Waste from LEHR

| Radionuclide | Highest Observed Concentration (pCi/g)[a] | Maximum Activity per Shipment (mCi) |
|---|---|---|
| Cs-137 | 23.0 | 0.036 |
| Ra-226 | 106.2 | 0.16 |
| Th-234 | 39.5 | 0.60 |

Notes:

[a] = Draft Final Site Characterization Summary Report for the U.S. Department of Energy Areas at the Laboratory for Energy-Related Health Research, University of California at Davis, California, 1997. These concentrations represent the highest noted activity observed for waste at either the Southwest Trenches Area or the Ra/Sr Treatment Systems Area.

Table I–3. Waste Shipments by Truck from the LEHR Site - 1993 to September, 1997

| Year | Disposal Site | Number of shipments | Volume (cubic yards)* |
|---|---|---|---|
| 1993 | Hanford (Richland, Washington State) | 15 | 491 |
| 1994 | None | Not applicable | Not applicable |
| 1995 | DSSI, Kingston, Tennessee | 1 | 3 |
| 1995 | Hanford (Richland, Washington State) | 12 | 257 |
| 1996 | Hanford (Richland, Washington State) | 23 | 403 |
| 1996 | Envirocare of Utah | 1 | 5 |
| 1997 | Hanford (Richland, Washington State) | 1 | 3 |

Notes:

* = Rounded to the nearest whole number
Source: Compiled from the transportation manifests documented in files at the on-site LEHR library (from 1993 to September, 1997).

Table I-4. Estimated Truck Shipments of Low-Level Radioactive Waste Generated by Removal Alternatives

| DOE Areas | Southwest Trenches Area | | | | | | | Ra/Sr Treatment Systems Area | | | | Domestic Septic System Areas | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Alternatives | 1 | 2 | | | 3 | | | 1 | 2 | | 3 | 1 | 2 |
| Risk Level | NA | A | B | C | A | B | C | NA | A | C | C | NA | C |
| Estimated Volume of Impacted Soil (in cubic yards)* | NA | 1,841 | 3,064 | 3,324 | 1,401 | 1,531 | 1,791 | NA | 1,568 | 2,181 | 1,018 | NA | 34 |
| Total Waste Shipments by Truck** | NA | 123 | 205 | 222 | 94 | 103 | 120 | NA | 105 | 146 | 86 | NA | 3 |

Notes:

* = Based on estimated volumes identified in EE/CA
** = Based on 15 cubic yards of waste (shipped in B 25 containers); rounded to the next whole number
Alternative 1 = No Action
Alternative 2 = Excavation and Off-Site Disposal
Alternative 3 = Excavation, Off-Site Disposal, and Institutional Controls
Risk Levels A, B, and C as defined in the EE/CA
Volumes presented are *ex-situ* cubic yards computed by applying a 1.3 multiplier to in-situ cubic yards.