FINAL DRAFT

RI/FS Work Plan
LEHR Environmental Restoration
University of California at Davis

September 1994

Volume I

U.S. Department of Energy

Oakland Operations Office
Environmental Restoration

PNL-XXXX
Limited Distribution

Final Draft
RI/FS Work Plan
Volume I

LEHR Environmental Restoration
Davis, California

September ~~March~~ 1994

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for the Oakland Operations Office
under a Related Services Agreement
with the U.S Department of Energy
Contract DE-AC-06-76RLO 1830

Pacific Northwest Laboratory
Richland, Washington 99352

FINAL DRAFT RI/FS WORK PLAN
LEHR ENVIRONMENTAL RESTORATION
DAVIS, CALIFORNIA

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ACRONYM LIST
RI/FS-EA WORK PLAN
LEHR ENVIRONMENTAL RESTORATION
DAVIS, CALIFORNIA

ACGIH	American Conference of Governmental Industrial Hygienists
AEC	Atomic Energy Commission
ALARA	As Low As Reasonably Achievable
ALI	Annual Limit Intake
ANOVA	Analysis of Variance
ANSI	American National Standards Institute
ARAR	"Applicable requirements" and "relevant and appropriate requirements"
ASTM	American Society for Testing and Materials
ATG	Allied Technology Group
atm	atmosphere
BBP	Bloodborne Pathogens
bgs	below ground surface
BNA	Base Neutral & Acid
BOD	Biochemical Oxygen Demand
C	Ceiling
CAM	California Assessment Manual
CARB	California Air Resources Board
Carcinogen	A substance that can cause cancer
cc	cubic centimeter
CC	Continuing Calibration
CCR	California Code of Regulations
CCU	Continuing Calibration Verification
CDFG	California Department of Fish and Game
CEDE	Committed Effective Dose Equivalent
CEQA	California Environmental Quality Act
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CFR	Code of Federal Regulations
cfs	cubic feet per second
CGI	Combustible Gas Indicator
CHP	Certified Health Physicist
Ci	Curie
CIH	Certified Industrial Hygienist
CLP	Contract Laboratory Program
cm^2	square centimeter
CNS	Central Nervous System

COC	Chain-of-Custody
COD	Chemical Oxygen Demand
cpm	counts per minute
CPT	Cone Penetrometer Testing
CQA	Coordinator of Quality Assurance
CRDL	Contract Required Detection Limit
CRQL	Contract Required Quantitation Limit
CRP	Community Relations Plan
CrVI	Hexavalent Chromium
CRZ	Contamination-Reduction Zone
CSM	Conceptual Site Model
CSNI	Chem-Nuclear Systems Inc.
CX	Categorical Exclusion
D&D	Decontamination and Decommissioning
DAC	Derived Air Concentration
DE	Disposable Equipment
DIC	Derived Investigation Level
DL	Detection Limit
DMP	Data Management Plan
DOE	Department of Energy
DOT	Department of Transportation
DPM	disintegration per minute
DQO	Data Quality Objective
DWR	Department of Water Resources
EA	Environmental Assessment
EC	Electrical Conductivity
EH&S	Environmental Health and Safety (University of California-Davis)
EKG	Electrocardiogram
EM	Electromagnetics
EML	Environmental Measurements Laboratory
EMO	Environmental Management Operations
EPA	U.S. Environmental Protection Agency
ER	Environmental Restoration
ESO	Environmental Services Operations
eV	electron volts
F	Fahrenheit
FEMA	Federal Emergency Management Administration
FEV1	Forced Expiratory Volume, one second
FONSI	Finding of No Significant Impact
FS	Feasibility Study
FSP	Field Sampling Plan
FVC	Forced Vital Capacity
FWS	Fish & Wildlife Service
g	gram
GC/MS	Gas Chromatograph/Mass Spectrometer
GC/ECD	Gas Chromatograph/Electron Capture Detector

GFI	Ground Fault Interrupter
gpm	gallons per minute
GPR	Ground Penetrating Radar
HASL	Health and Safety Laboratory — Method Manual, Environmental Monitoring Laboratory, Brookhaven, New York
HMT	Hazardous Materials Training
HR	Heart Rate
HSO	Health and Safety Officer (University of California-Davis)
HSP	Health and Safety Plan
HSU	Hydrostatigraphic Unit
HT	Hold Time
HWCA	Hazardous Waste Control Act
IC	Initial Calibration
ICAP	Inductively Coupled Plasma Spectrophotometer
ICU	Initial Calibration Verification
IIPP	Injury and Illness Prevention Program
IP	Ionization Potential
IRIS	Integrated Risk Information System
IRM	Interim Remedial Measure
IS	Internal Standard
K	Hydraulic Conductivity
Kg	kilogram
kv	kilovolt
K_v	Vertical Hydraulic Conductivity
LCS	Laboratory Control Sample
LEHR	Laboratory for Energy-Related Health Research
LEL	Lower Explosive Limit
LET	Linear Energy Transfer
Lpm	liter per minute
LRDP	Long-Range Development Plan
LSC	Liquid Scintillation Concentrator
m	meter
MCL	Maximum Contaminant Level(s)
mg	milligram
mg/kg	milligrams per kilogram
mg/L	Micrograms per liter
mg/M^3	milligram per cubic meter
mgd	million gallons per day
min	minute
mL	milliliter
mm	millimeter
mph	miles per hour
MQA	Manager of Quality Assurance
mrem	milli-rem = 1E-03 rem
MS/MSD	Matrix Spike/ Matrix Spike Duplicate

MSDS	Material Safety Data Sheet
NCP	National Contingency Plan
NCRP	National Council for Radiation Protection
ND	Not Detected
NEPA	National Environmental Policy Act
NIOSH	National Institute for Occupational Safety and Health
NPL	National Priority List
NRC	Nuclear Regulatory Commission
NTU	Nephlometric Turbidity Units
NVLAP	National Voluntary Laboratory Accreditation Program
OBZ	Operator's Breathing Zone
°C	centigrade
OEL	Occupational Exposure Limit
°F	fahrenheit
OSHA	Occupational Safety and Health Administration
OSWER	Office of Solid Waste and Emergency Response
OVA	Organic Vapor Analyzer (Foxboro-Century)
PARCC	Precision, Accuracy, Representativeness, Completeness and Comparability
PCD	Putah Creek Downstream
pCi/g	pico Curies per gram
pCi/l	pico Curies per liter
pCi/y	picoCuries per year
PCQA	Program Coordinator of Quality Assurance
PCU	Putah Creek Upstream
PEL	Permissible Exposure Limit
PHP	Project Health Physicist
PHSM	Project Health and Safety Manager
PID	Photoionization Detector
PM	Project Manager
ppb	parts per billion
PPE	Personal Protective Equipment
ppm	parts per million
PQL	Practical Quantitative Limit
psi	pounds per square inch
QA	Quality Assurance
QAPjP	Quality Assurance Project Plan
QAPP	Quality Assurance Program Plan
QC	Quality Control
QF	quality factor
R	Roentgen
R.G.	Registered Geologist
RAGS	Risk Assessment Guidance for Superfund

RAO	Remedial Action Objective
RBZ	Radiological Buffer Zone
RCM	Radiological Control Manual
RCT	Radiological Control Technician
REL	Recommended Exposure Limit
rem	roentgen equivalent man
RF	Response Factor
RfD	Reference Dose
RI/FS	Remedial Investigation/Feasibility Study
ROPs	Rollover Protective Structures
RPD	Relative Percent Difference
RRF's	Relative Response Factors
RSD	Relative Standard Deviation
RWQCP	Regional Water Quality Control Board
SAP	Sampling Analysis Plan
SARA	Superfund Amendments and Reauthorization Act
SDAR	Storage, Disposal and Acceptance Record
SDWA	Safe Drinking Water Act
SHPO	State Historic Preservation Office
SID	Solano Irrigation District
SOP	Standard Operating Procedures
SOW	Statement of Work
SSA	Site Safety Auditor
SSO	Site Safety Officer
SSR	Subcontractor's Safety Representative
STEL	Short Term Exposure Limit
STLC	Soluble Threshold Limit Concentrations
STPO	Sewage Treatment Plant Outfall
SVOC	SemiVolatile Organic Compound
SWAT	Solid Waste Assessment Test
SWP	Safe Work Practices
SZ	Support Zone
TDS	Total Dissolved Solids
TETC	The Earth Technology Corporation
TKN	Total Kjeldahl Nitrogen
TLD	Thermoluminicent Dosimeter
TLV	Threshold Limit Value
TOC	Total Organic Carbon
TPHRL	Toxic Pollutant Health Research Laboratory
TTLC	Total Threshold Limit Concentrations
TWA	Time-Weighted Average
U.S.A.	Underground Service Alert
UC	University of California
UCD	University of California - Davis
uCi/m^3	MicroCuries per Cubic Meter
UEL	Upper Explosive Limit
USA	Underground Services Alert

USCS	Unified Soil Classification System
USDA	U.S. Department of Agriculture
USGS	United States Geological Survey
VOC	Volatile Organic Compound
WBS	Work Breakdown Structure
WWTP	Wastewater Treatment Plant
%D	Percent Difference
μCi	micro-Curie = 1E-06 Ci

FINAL DRAFT RI/FS WORK PLAN
LEHR ENVIRONMENTAL RESTORATION
DAVIS, CALIFORNIA

EXECUTIVE SUMMARY

This document presents the Final Draft Work Plan for the Remedial Investigation, Feasibility Study (RI/FS) to be conducted at the Laboratory for Energy-Related Health Research (LEHR) at the University of California (UC) Davis. This Work Plan has been prepared in accordance with the U.S. Environmental Protection Agency (EPA) guidelines for conducting an RI/FS (EPA, 1988a) and includes a Sampling Analysis Plan, (SAP), a Health and Safety Plan (HSP), a Quality Assurance Project Plan (QAPjP), and a Waste Management Plan for Investigation-Derived Wastes (IDW). This Work Plan has been developed in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA).

The EPA became involved with the LEHR site when it was proposed for listing on the National Priority List (NPL). The EPA completed a Preliminary Assessment under the Hazard Ranking System and CERCLA in 1989. The LEHR site was recommended for additional assessment and the EPA collected existing data to complete a Site Investigation in 1991. On May 31, 1994, the LEHR Site was listed on the NPL.

~~A Federal Facility Agreement (FFA) between the U.S. Department of Energy (DOE) and the EPA, which will be the legal document, will be finalized prior to implementation of this Work Plan, assuring that the LEHR site meets the requirements of CERCLA, National Contingency Plan (NCP), Superfund, and applicable State law.~~

The Regional Water Quality Control Board (RWQCB) oversaw completion of a Solid Waste Assessment Test (SWAT) for the landfills at LEHR, has requested corrective action for impacts to groundwater, and has authority in implementing Chapter 15 of the CCR and Porter-Cologne. The Department of Health Services (DHS) and the State Water Resources Control Board (SWRCB) have an agreement in principal with the DOE for oversight of the LEHR environmental restoration. The Department of Toxic Substance Control (DTSC) is involved in Resource Conservation and Recovery Act (RCRA) and CERCLA issues.

This Work Plan identifies activities required to develop the appropriate amount of information to support an informed risk management decision regarding the most appropriate remedial actions to be implemented for areas at the LEHR site. Methods to

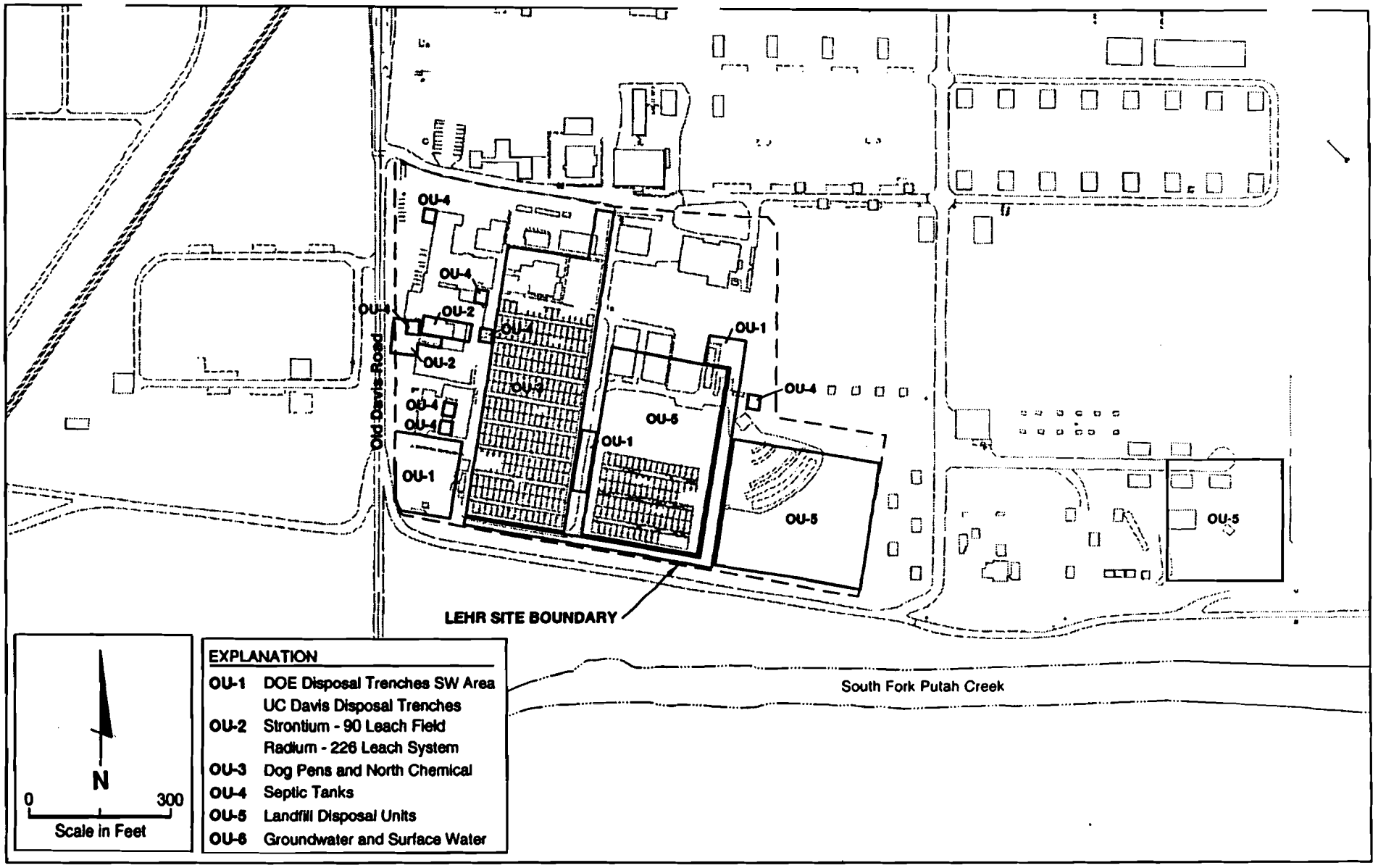
evaluate the potential risk to human health and the environment based on the results of the analytical sampling are presented, and the process for developing and evaluating potentially feasible alternatives for remediation of impacts at LEHR is discussed. Also, implementation of this Work Plan will provide sufficient information to address the intent of the National Environmental Policy Act (NEPA) and the California Environmental Quality Act (CEQA).

The investigation presented in this work plan utilizes a phased approach. Each individual exploration task will build on information obtained in the previous task. To this end, the exact number of trenches, borings, samples, or wells may change. The specific scope of each task will be evaluated in an interactive process between site personnel and the regulatory agencies, as agreed upon prior to the field program.

Ten areas of investigation have been identified at the LEHR site. They are: 1) the DOE disposal trenches, southwest chemical dispensing area, and a disposal unit known as the DOE Disposal Box; 2) the radium-226 treatment system; 3) the strontium-90 treatment system, also known as the Imhoff system; 4) domestic septic tanks; 5) the outdoor dog pen areas and the north chemical dispensing area; 6) the UC Davis disposal trenches; 7) the UC Davis landfill cells; 8) groundwater beneath and adjacent to the LEHR site; 9) surface water in the vicinity; and 10) air quality at the LEHR site. These areas of investigation have been divided into six preliminary Operable Units (OU). The areas of investigation and preliminary OU designations are shown on Figure ES-1.

In addition to EPA guidance for conducting RI/FS programs, appropriate DOE Orders have been used during preparation of this Work Plan. Individual areas of investigation have been outlined based on similar historical uses or similar proposed investigative techniques. Information from previous investigations and aerial photographs have been used to refine the area boundaries and provide background information to develop the rationale for the investigation and to select appropriate investigative methods.

A conceptual site model (CSM) was developed for the LEHR site taking into consideration historical and current source areas. The CSM was developed to address potential sources and migration pathways, and to identify potential receptors for constituents migrating away from the LEHR site. One CSM was developed to cover all the areas of investigation at the LEHR site. The CSM was also developed to identify gaps in the data and identify additional data needs.



INVESTIGATION AREAS

RI/FS Work Plan
LEHR Environmental Restoration
Davis, California

10805-720-044 sjr 2/23/94 5705X

FIGURE ES-1

The investigative methods presented in the Work Plan have been developed using data obtained from previous investigations to address identified data gaps. Additionally, EPA guidance, ASTM methods, and strict EPA, NQA, and DOE quality assurance and quality control protocols are proposed to ensure the quality of the data collected. The investigations will be phased to allow preliminary evaluation of data and modifications to the plan, if necessary. Relatively non-invasive investigative methods will be used initially to obtain screening information and to guide subsequent invasive investigative methods. Soil, water and air data will be collected to evaluate potential impacts from the LEHR site and to support an informed risk management decision regarding the appropriate remedial actions for the various areas of investigation.

The risk assessment procedures are based on EPA guidance documents for conducting human and environmental risk assessments. Additionally, specific guidance has been added to evaluate the inherent uncertainty in this process and how these data will be utilized to assess risk.

Potential applicable or relevant and appropriate requirements (ARARs) have been developed and are presented in this Work Plan. These ARARs will be used to aid in evaluating feasible technologies and remedial actions that may be required to minimize human and environmental risks identified during the risk assessment. The process of evaluating feasible remedial alternatives was developed using the appropriate EPA guidance.

Although the schedule for completion of this RI/FS program is not currently mandated by any regulatory timeline, it is currently anticipated that the RI/FS program presented in this Work Plan will be completed approximately 30 months from the approval date.

FINAL DRAFT RI/FS WORK PLAN
LEHR ENVIRONMENTAL RESTORATION
DAVIS, CALIFORNIA

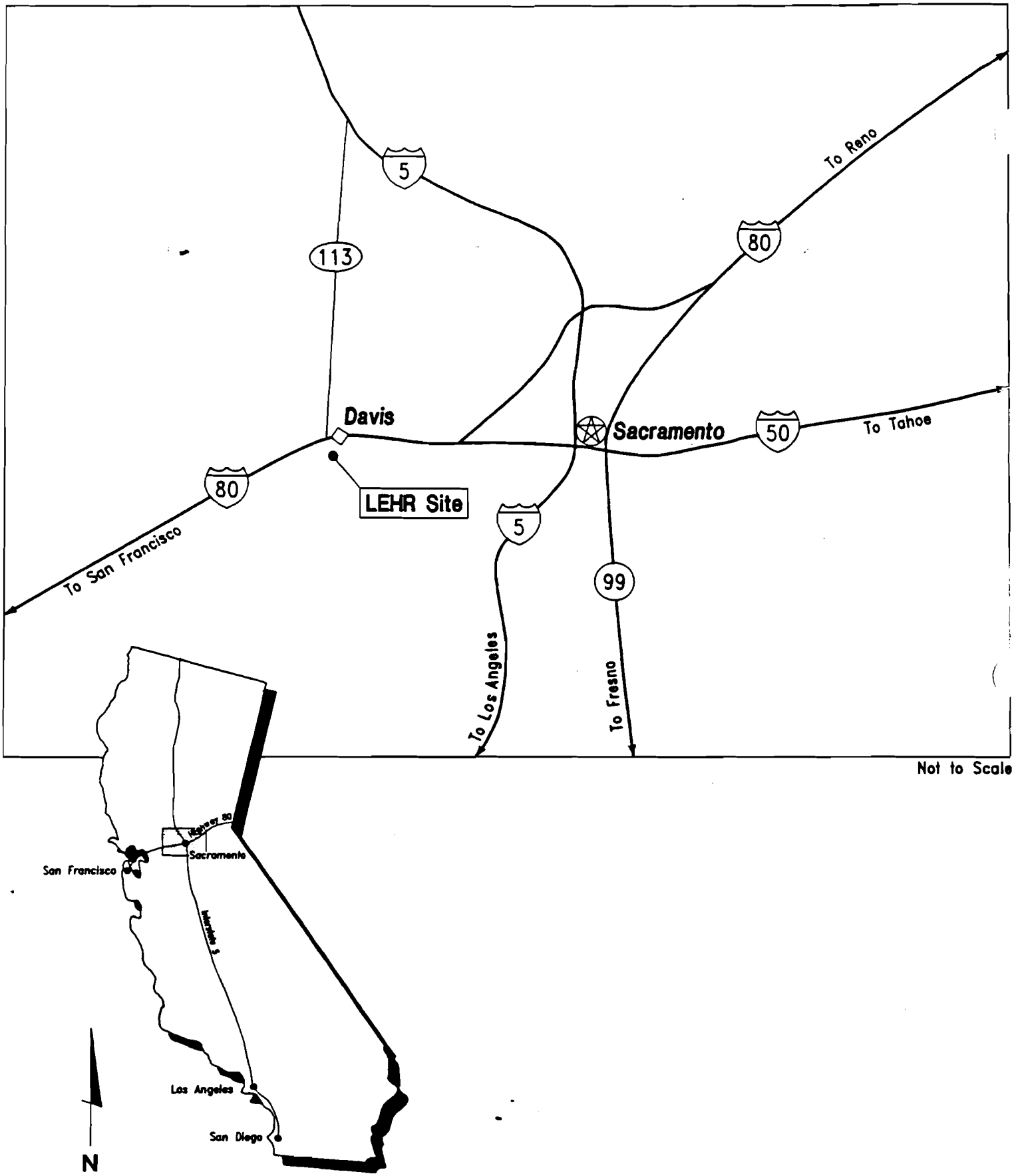
1.0 INTRODUCTION

This Remedial Investigation Feasibility Study (RI/FS) Work Plan presents the rationale and approach for gathering information sufficient to support an informed risk management decision regarding the most appropriate remedial action for impacted areas of the Laboratory for Energy-Related Health Research (LEHR) site at the University of California (UC) Davis (Figure 1.1).

This Work Plan has been developed in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA). Quality assurance and quality control (QA/QC) criteria for the program are based on QAMS-005, NQA-1, and DOE 5700.6C. The Work Plan has been developed using the U.S. Environmental Protection Agency (EPA) document *Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA* (October 1988). On May 31, 1994, ~~January 17, 1994,~~ the LEHR site was listed ~~proposed for listing~~ on the United States Environmental Protection Agency's (EPA) National Priorities List (NPL).

The LEHR RI/FS will be conducted utilizing, to the greatest extent possible, the Streamlining Approach for Environmental Restoration (SAFER) and the Superfund Accelerated Cleanup Model (SACM, EPA, 1992). The SAFER combines the Data Quality Objectives (DQOs) process presented in QAMS-005 with a process for managing uncertainty and planning decision making during the RI/FS for early decision on the appropriate remedy. The SACM focuses on identifying early actions to reduce acute risks and long-term site restoration. These approaches, combined with CERCLA, form the rationale for supporting the scope presented in this Work Plan.

The investigation presented in this Work Plan utilizes a phased approach. Each initial exploration task will build on information obtained in the previous task. To this end, the exact number of trenches, borings, samples, or wells may change. The specific scope of each task will be evaluated in an interactive process between site personnel and the regulatory agencies, as agreed upon prior to the field program.



SITE LOCATION MAP
RI/FS Work Plan
LEHR Environmental Restoration
Davis, California

10805-720-7505-044 sjr 3/24/94 5705J

FIGURE 1.1

1.1 PURPOSE AND SCOPE

As noted above, the purpose of this RI/FS is to develop the appropriate amount of information to support an informed risk management decision regarding the most appropriate remedial actions to be implemented for areas of the LEHR site. This purpose is supported by the objectives and scope specific to the RI, Risk Assessment, and FS, outlined below.

The objectives of the RI are to characterize the nature and extent of impact, to evaluate potential pathways for site constituent migration, and to assess the actual and potential risks those constituents pose to human health and the environment. The RI, which will be conducted in conjunction with the FS, will emphasize data collection analysis and data interpretation to meet acceptable uncertainty levels. The RI will include investigations of groundwater and surface water, soil, sediment, vegetation, and air quality. The scope of the RI has been staged to sequentially build on existing data to the point where the quantity and quality of that data are adequate to complete the Risk Assessment and FS. The Conceptual Site Model (CSM — see Section 3.4) and remedial objectives will be continually updated as new information is gained.

The objective of the baseline Risk Assessment is to provide an evaluation of the current or potential threat to human health and the environment in the absence of remedial action. Acute risks identified at the Baseline Risk Assessment stage may be addressed immediately. The Risk Assessment is also conducted in conjunction with the RI, and is completed prior to the FS in order to provide the basis for determining whether or not remedial action is necessary, and, if so, present the justification for performing remedial actions, either short- or long-term. The baseline Risk Assessment will also be used to support a finding of eminent and substantial endangerment, if appropriate. The major components of the risk assessment include: an exposure and toxicity assessment; risk characterization; an ecological risk assessment, and an uncertainty assessment.

The objective of the FS is to use the information provided by the RI and Risk Assessment in conjunction with an understanding of the applicability of the remedial technologies to establish feasible remedial action alternatives. Initially, the data developed during the RI will be used to develop a comprehensive list of alternative remedial actions. These alternatives will be screened to eliminate those that are not realistic, based on

technical, economic, and environmental considerations, as early in the process as possible. Alternatives that pass the initial screening will be ranked to allow a knowledgeable comparison of the remaining alternatives under consideration. The selection of the preferred alternatives and the development of the preferred remedial action plan for the site will be based on the findings in the FS.

The information developed in the RI/FS and Risk Assessment will be supplemented with an analysis of environmental impacts for the selected remedial action to comply with the intent of the National Environmental Policy Act (NEPA) and the California Environmental Quality Act (CEQA).

The investigation of the LEHR site has been divided into a number of tasks addressing soil, water and air. Soil investigation tasks include:

- Conducting a background study;
- Locating and sampling of DOE disposal trenches in the southwest ~~north~~ chemical dispensing area, and the DOE disposal box;
- Locating and sampling the UC Davis burial trenches;
- Locating and sampling the radium-226 treatment tank and leach system;
- Locating and sampling the strontium-90 treatment tank and leach system;
- Characterizing the two outdoor sets of dog pens and north chemical dispensing area;
- Locating and sampling the UC Davis Landfill units; and
- Evaluating the collected data.

Water investigation tasks include:

- Quarterly groundwater and surface water monitoring;
- Background groundwater assessment;
- Cone penetrometer and Hydropunch™ testing;
- Installing groundwater monitoring wells;
- Conducting aquifer analyses;
- Evaluating surface water conditions; and
- Evaluating storm water runoff.

The quarterly groundwater and surface water monitoring and storm water runoff monitoring will be conducted as described in the Water Monitoring Plan ~~currently being~~ prepared for the LEHR site as part of the Environmental Monitoring and Surveillance

Program specified in DOE Order 5400.1. For completeness, the monitoring task is described in Section 6 of this Work Plan.

Air monitoring tasks include:

- Conducting background monitoring;
- Conducting baseline monitoring on-site;
- Establishing meteorological conditions; and
- Evaluating the collected data.

1.2 ORGANIZATION OF WORK PLAN

This Work Plan consists of 15 chapters, including this introduction, and contains ~~three~~ four appendices. Chapter 2 presents the background for the project and includes a discussion of the physical setting of the facility and a history of operations including waste generation and disposal practices. Chapter 3 presents an initial evaluation of past investigations, including discussions of wastes reportedly disposed of on site, potential pathways for exposure, identification of the areas of investigation, and potential remedial action alternatives. Chapter 4 presents the rationale and approach of the RI/FS, including data needs, data quality objectives, and data evaluation methodologies. Chapter 5 describes the site investigation activities necessary to conduct the soil characterization. Chapter 6 presents investigation activities for groundwater and surface water. Chapter 7 presents the air monitoring plan for human and environmental protection during these remedial investigation activities, and Chapter 8 presents vegetation sampling and potential mammal and fish sampling and analysis planned for this RI.

Chapter 9 presents descriptions of tasks identified to obtain data on environmental and human resources in the site vicinity. The risk assessment tasks and procedures are presented in Chapter 10 and the feasibility study procedures are presented in Chapter 11.

Chapter 12 presents the project Data Management Plan (DMP). Chapter 13 discusses project management responsibilities and the anticipated schedule and deliverables for the project are presented in Chapter 14. Schedule modifications may be made if required by information obtained during project implementation. References for literature cited are provided in Chapter 15.

~~Three~~ Four appendices are also included with this Work Plan. Appendix A is the Field Sampling Plan (FSP), which specifies field sampling methods and procedures, sampling locations, frequencies, and designations. Appendix B, the Quality Assurance Project Plan (QAPjP), specifies the analytical objectives of the investigation, as well as sampling and quality assurance/quality control procedures to be used to ensure that information is of defensible quality and appropriate for the intended purposes. Together, Appendices A and B constitute the Sampling and Analysis Plan (SAP).

Appendix C, the site-specific Health and Safety Plan (HSP), specifies occupational health and safety procedures to maintain the health and safety of personnel involved in project field activities. The plan discusses health and safety objectives for the chemical and radiological constituents anticipated to be encountered at the LEHR site. Additionally, the HSP outlines the safety training requirements for field personnel and their subcontractors.

Appendix D, the Waste Management Plan for Investigation-Derived Wastes (IDW), specifies the approach for proper management of IDW produced during the RI. The approach presented reflects a goal to protect human health and the environment and to minimize waste generated and waste disposal off-site.

1.3 QUALITY ASSURANCE

This RI/FS is being conducted under the Dames & Moore Quality Assurance Program Plan (QAPP) for Battelle Environmental Management Operations (June 1990). The QAPP was developed following the basic format of the Dames & Moore firmwide QA Manual and includes the Battelle Pacific Northwest Laboratories (PNL) Master Services Agreement — Attachment 1, Quality Assurance Requirements. The QAPP is responsive to and in compliance with the following quality assurance documents:

- American Society of Mechanical Engineers, Quality Assurance Program Requirements for Nuclear Facilities (ASME NQA-1-1989)
- U.S. Department of Energy, Quality Assurance Requirements (DOE 5700.6C)
- U.S. Environmental Protection Agency, Guidance for Preparing Quality Assurance Project Plans (QAMS-005/80)

Specifically, the QAPjP identifies project-specific protocols for documentation, data review and validation, training, surveillance, and audits. The QAPjP is thoroughly integrated with the QAPP to ensure consistent application of specific quality assurance procedures. The QAPjP also contains detailed descriptions of EPA analytical support levels (EPA, 1987) for data collected. Quality assurance requirements will be implemented by a project quality assurance (PQA) team that will operate independent of the technical or management team. Quality assurance requirements include analytical laboratory and other subcontractor responsibilities. The Dames & Moore - Battelle PNL Master Agreement also requires that Dames & Moore's subcontractors comply with the Dames & Moore-Battelle QAPP.

1.4 HEALTH AND SAFETY

A site-specific Health and Safety Plan (HSP — Appendix C) has been developed; the HSP complies with the California Occupational Safety and Health Administration (Cal/OSHA) Hazardous Waste Operations and Emergency Response (HAZWOPER) standard (8 CCR 5192), the LEHR Radiological Control Manual (July 1993), and other applicable DOE requirements. The HSP is based on the policies and procedures promulgated in the Dames & Moore Firmwide Health and Safety Program Manual. The HSP was prepared under the direction of a Certified Industrial Hygienist and a Certified Health Physicist.

As required by HAZWOPER, the HSP details the responsibilities of the key personnel associated with this project. Job hazard analyses for the various site activities address the potential hazards associated with chemical, radiological, and physical agent exposures, and the procedures for minimizing such exposures. The exposure monitoring plan describes the industrial hygiene and radiological monitoring procedures for the project. This plan includes area and personal monitoring for chemical agents, and direct exposure controls and area surveys for radiological agents. In the event that engineering and administrative controls cannot maintain exposures below appropriate levels, the HSP describes appropriate personnel protective equipment to be used in specific exposure situations. Personnel and equipment decontamination procedures, as well as site control and work zone criteria, are also described in the HSP.

The HSP also outlines training requirements for site personnel, which include the completion of HAZWOPER 40-hour training and Level II Radiological Worker Training for personnel, including subcontractors, who will be working in the exclusion zone. The medical surveillance program requires the completion of a baseline HAZWOPER-type physical examination and subsequent fit-for-duty certification by a board-certified Occupational Medicine Physician. The HSP requires site personnel to participate in a radiological bioassay program.

Implementation of the HSP will be coordinated by the Site Safety Officer, Site Safety Auditor, and Radiological Control Technician; technical support will be provided by the Project Health and Safety Manager and Project Health Physicist. Radiological safety issues will be coordinated with PNL and the UC Davis Office of Environmental Health and Safety.

1.5 COMMUNITY RELATIONS

In order to maintain two-way communication with interested members of the community during the RI/FS process, procedures for public interaction will be developed and presented in Community Relations Plan (CRP). The CRP will be prepared using the 1992 EPA document Community Relations in Superfund: A Handbook (OSWER Directive 9230). The CRP will identify methods to inform the community of progress and actions underway at the LEHR site. It will also provide a mechanism for input from the community during all aspects of the RI/FS program. Information obtained through the CRP will be used to address NEPA and CEQA issues. ~~The DOE, PNL and UC Davis will be responsible for the implementation of the CRP.~~

2.0 SITE DESCRIPTION AND SETTING

This chapter presents a site description, history of operations, and a description of the physical setting of the LEHR site. The operational history is described in Section 2.2. The physical setting, including site topography, geology, hydrogeology, and proximal surface water, is described in Sections 2.3.1, 2.3.2, 2.3.3, and 2.3.4, respectively. Meteorology of the LEHR site area is described in Section 2.3.5. Environmental resources, including land use and special status species near the site, and human resources are described in Section 2.4.

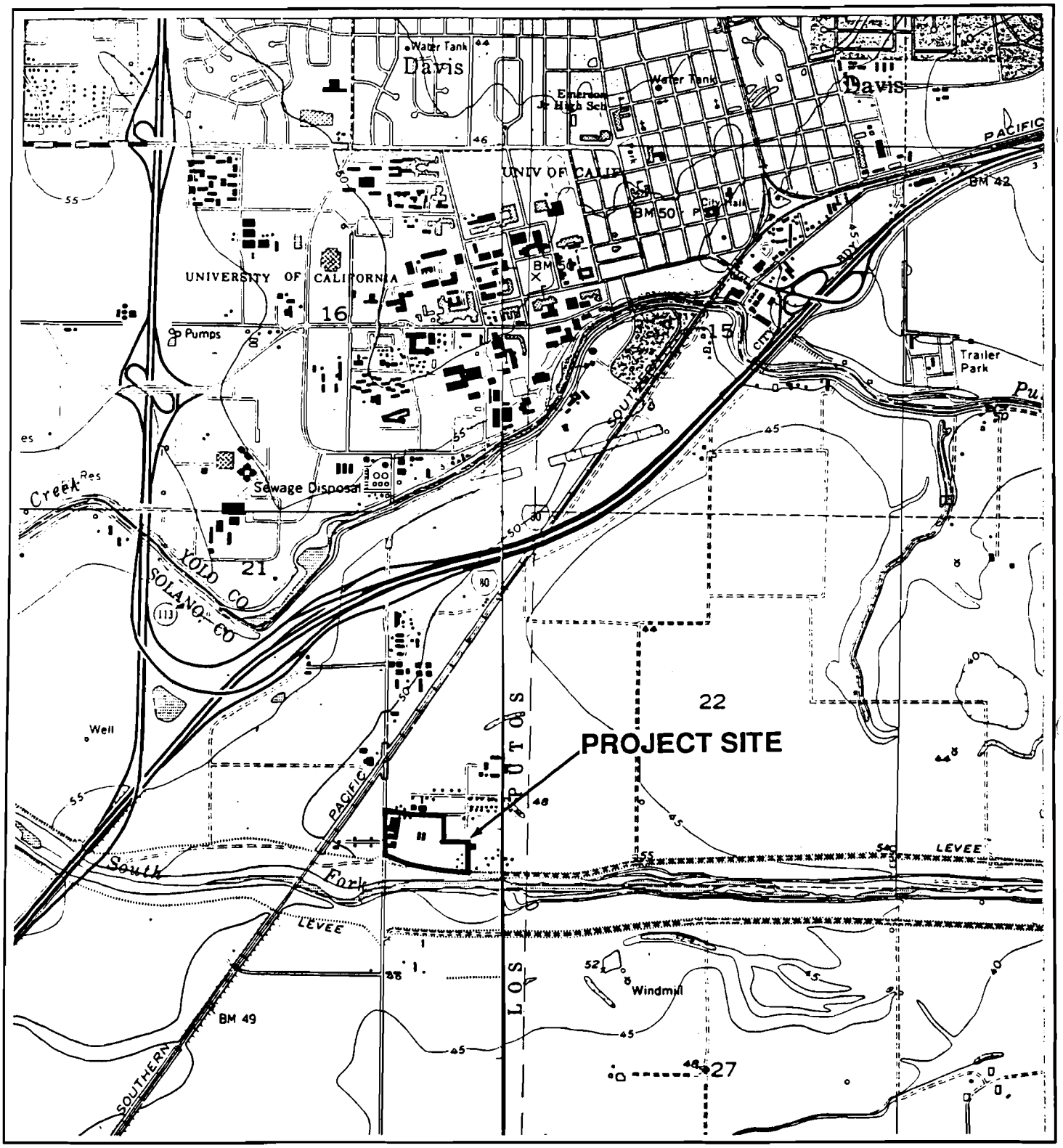
2.1 SITE LOCATION AND DESCRIPTION

The LEHR site is located in the southeast quarter of Section 21, Township 8 North, Range 2 East, Mount Diablo Base and Meridian (MDBM). The site is approximately 1.5 miles south of the main UC Davis campus and the town of Davis and is approximately 0.75 mile south of Interstate 80 on County Road 79 (Old Davis Road) in Solano County, California as shown on Figure 2.1.

The site is located in a rural area in the southeast portion of the UC Davis campus, and is bounded on the west, north, east, and south by UC Davis research facilities. The southern boundary of the LEHR site is the northern levee of the South Fork of Putah Creek (Putah Creek). Private land is adjacent to and surrounds UC Davis property on all sides. Most of the private land is used for agricultural purposes.

Based on the habitat observed in the vicinity, the site and surrounding areas are potentially host to a wide variety of animals including numerous species of birds, mammals (several of which are burrowing species), and snakes. The soil and groundwater contractor will coordinate in writing with the U.S. Fish & Wildlife Service and the California Department of Fish & Game to evaluate the potential for work performed during this investigation to disturb the habitat of listed special status species.

The LEHR site encompasses approximately 15 acres and consists of one- and two-story laboratory and office buildings, and animal-handling facilities. Of the 15 acres, approximately 40 percent (6 acres) is paved with asphalt or concrete, or covered by



REFERENCE: USGS 7.5' Quadrangle Merritt CA, 1981,
Davis CA, 1982

N

0 2000

Scale in Feet

SITE VICINITY MAP

RI/FS Work Plan
LEHR Environmental Restoration
Davis, California

10805-454-044 DOE1

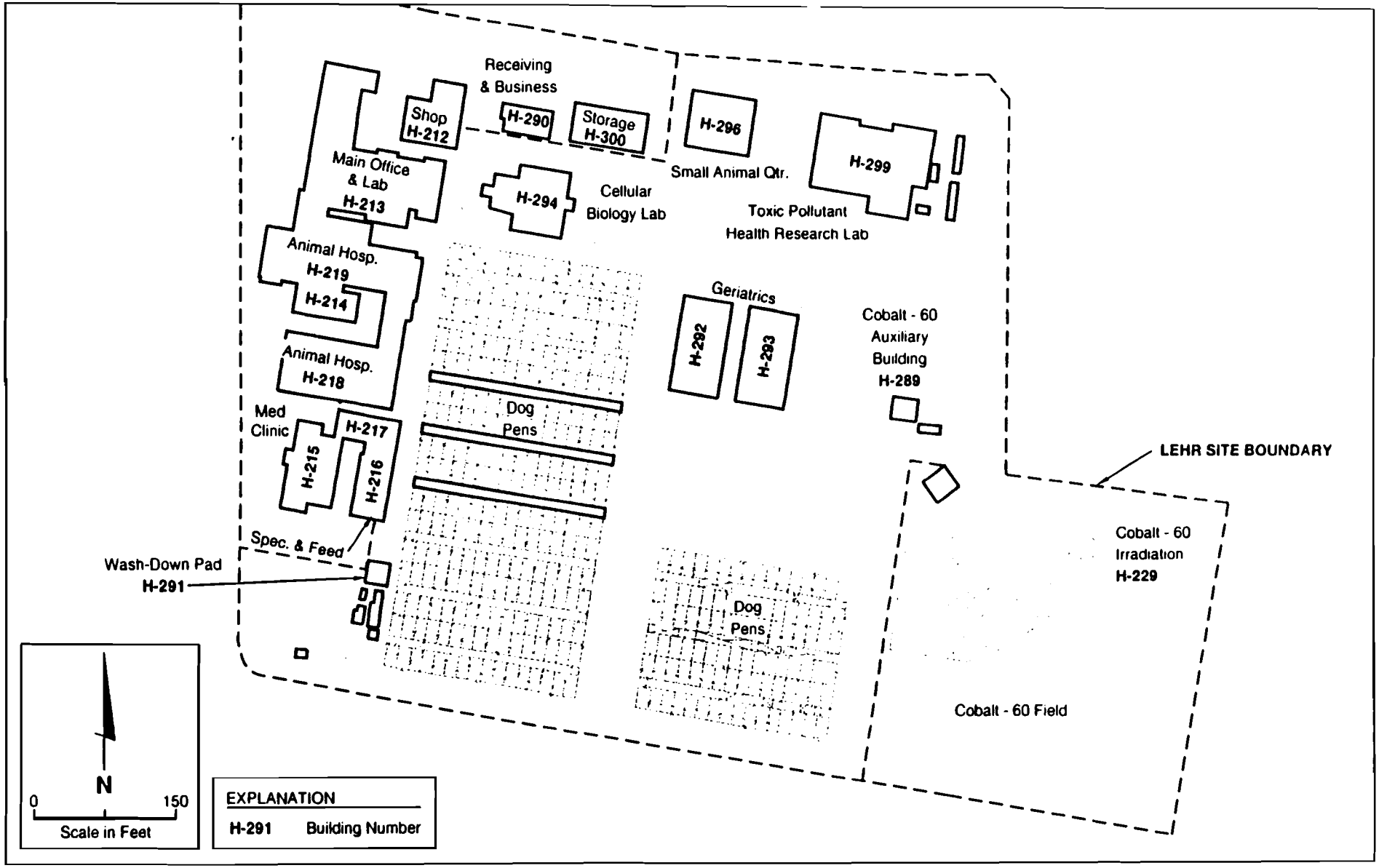
FIGURE 2.1

structures. Approximately 30 percent (4½ acres) is unpaved and kept relatively free of vegetation. Outdoor dog pens occupy approximately 20 percent (3 acres) of the LEHR site and approximately 5 percent (¾ acres) is heavily vegetated with large, deep-rooted vegetation.

Major buildings and structures located at the LEHR site are listed below. Those buildings identified with an asterisk are currently undergoing or scheduled for decontamination and decommissioning (D & D) and final radiologic survey work. Figure 2.2 shows the spatial relationship of the buildings to the LEHR site. The land is owned by the Regents of the University of California and leased to the DOE.

	Building Number	Building Name	Building Number	Building Name
	H-212	Maintenance Shop	H-289	Cobalt-60 Auxiliary Building
	H-213	Main Office and Laboratory	H-290	Receiving and Business
*	H-214	Imhoff	H-291	Washdown Pad
	H-215	Clinical Medicine	H-292	Geriatrics 1
*	H-216	Specimen Storage and Feed Mix	H-293	Geriatrics 2
			H-294	Cellular Biology Lab
	H-217	Pathology Laboratory	H-296	Small Animal Quarters
*	H-218	Animal Hospital 2	H-299	Toxic Pollutant Health Research Laboratory
*	H-219	Animal Hospital 1		
*	H-229	Cobalt-60 Source	H-300	Storage

Also located at the LEHR site are two inactive landfill units: the Old UC Davis Landfill, closed in 1966; and a campus and DOE low-level radioactive waste disposal site, closed in 1974. A third inactive landfill unit is located approximately 600 feet east of the LEHR site below the area currently partially occupied by the UC Davis Raptor Center. ~~Because t~~The landfill units were operated from the early 1940s, and previous investigations have shown that there is some impact to groundwater from the landfill units~~, the University as the landfill operator is a responsible party for the investigation and cleanup~~.



SITE STRUCTURES AND FEATURES

RI/FS Work Plan
LEHR Environmental Restoration
Davis, California

10805-720-044 SJR 2/24/94 5705P

FIGURE 2.2

2.2 HISTORY OF OPERATIONS

UC Davis has conducted radiological studies on laboratory animals for the DOE since the 1950s. The initial studies, conducted for the U.S. Atomic Energy Commission (AEC, now DOE), involved the irradiation of beagles at the UC Davis main campus. Full-scale experimental use of radioactive materials, including strontium-90 and radium-226, began at the LEHR site in 1960. ~~In the initial stages of operation, waste from the LEHR site was handled through a central handling facility on the main campus. However, due to safety concerns, waste handling for LEHR generated waste was returned to the LEHR site in the early 1960s.~~

Portions of the LEHR site had previously been used as the UC Davis campus landfill. At the LEHR site, the landfill consisted of two separate disposal units. Disposal in the oldest unit, Landfill Unit No. 1, began in the 1940s and ceased in the late 1950s to early 1960s, and is now covered by the cobalt-60 irradiator facility at the LEHR site. The next oldest disposal area, Landfill Unit No. 2, received wastes from 1956 to 1967, and is now partially covered with the easternmost of two sets of dog pens used for animal research at the LEHR site. A third landfill disposal unit, located approximately 600 feet east of the LEHR site, Landfill Unit No. 3, was used from 1963 to 1967. The combined total acreage for the three disposal areas is estimated at approximately 6 acres (Dames & Moore, 1990).

Areas around the landfills on the LEHR site were used for disposal of materials primarily from research activities. Tritium, carbon-14, and other chemical wastes were disposed in burial holes and disposal trenches. Also, a large, steel dumpster buried west of Landfill Unit No. 2 was used for disposal of material from specific ~~University~~ LEHR experiments.

In the early 1970s, a cobalt-60 irradiator facility was constructed at the LEHR site to study the effects of chronic exposure to penetrating gamma ray irradiation on bone marrow cells of beagles. The cobalt-60 study was terminated in 1985.

In 1975, a program in basic aerosol science was initiated at the LEHR site to link the evaluation of airborne materials and the laboratory study of these materials utilizing cellular and animal models. The DOE (1988) reported that research activities in this program focused on the potential health effects of release to the atmosphere of combustion products from fossil fuel power plants, with emphasis on coal flyash.

In 1983, construction of the Toxic Pollutant Health Research Laboratory (TPHRL) was completed at the LEHR site. This facility was designed for the study of highly toxic and carcinogenic agents, including both radioactive and chemical materials. Research at the TPHRL included studies of the behavior of plutonium-241 and americium-241 in beagles and monkeys; radioactive and toxic gas-particle mechanistic aerosol studies; monodisperse aerosol inhalation deposition; intratracheal applications of carcinogen-coated particles; and an organic vapor uptake utilizing beagles (DOE, 1988).

2.3 PHYSICAL SETTING

The LEHR site is located in the southern portion of the Sacramento Valley, which extends from the Red Bluff area in the north to the Sacramento-San Joaquin Delta region in the south. The LEHR site sits in a flat-lying or gently sloping area of former farmland.

The LEHR site is located in a rural area, with approximately 75 percent of the surrounding land being used for agriculture. Approximately 40 percent of that land is irrigated. Major crops include fruits, nuts, and grains. Additionally, some of the nearby lands are used for cattle grazing (DOE, 1988). The land is zoned "A-40" for agriculture with a minimum lot size of 40 acres. The Solano County General Plan for the area designates the land as "Intensive Agriculture." According to the Soil Conservation Service, the soils in the area are "Class 102" soil, or Prime Agricultural Soil.

2.3.1 Topography

The regional topography surrounding the LEHR site is typical of the broad, relatively flat Sacramento Valley. The Sacramento River, the primary drainage of the Sacramento Valley, is approximately 12 miles to the east.

The LEHR site is situated on relatively flat-lying land termed the Putah Plain (DWR, 1978). The average elevation at the site is approximately 50 feet above mean sea level. Relief across the site is approximately 2 feet, with the lowest portion in the area of the Cobalt-60 irradiator facility. The land surface slope in the vicinity of the LEHR site is approximately 0.001 foot/linear foot (5 feet per mile) to the east/northeast toward the Sacramento River. The site is not within the 100-year flood plain, as defined in the 1982 FEMA Flood Insurance Maps.

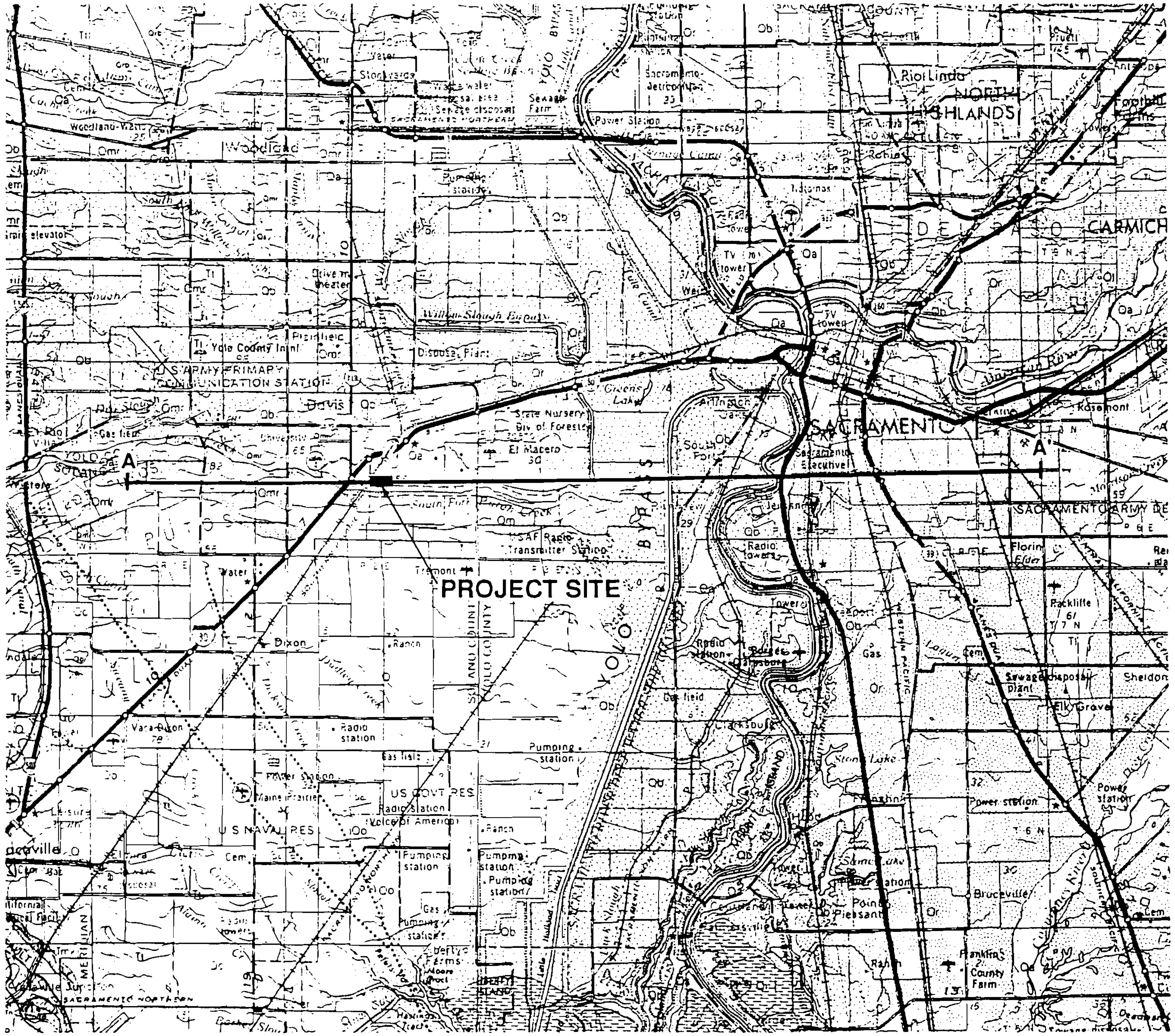
Local drainage on the LEHR site is generally to the south-southwest. According to facility drawings presented in the 1988 DOE Preliminary Report, storm water from the paved area west of the western dog pens is collected in catch-basins and piped to the sanitary sewer. Drainage in the south and southwest area is collected in a stormwater drainage system and routed to the LEHR site stormwater lift station and subsequently pumped to an outfall along the west side of the Old Davis Road where it is discharged to Putah Creek. Storm water that falls along the eastern portions of the LEHR site is allowed to percolate into the soil.

2.3.2 Geology

The Sacramento Valley is characterized by sedimentary deposits of both marine and continental origin. Deformation of these deposits due to uplift of the surrounding mountains has resulted in a regional dip of the sediments from the sides of the valley toward its axis.

2.3.2.1 Regional Geologic Setting

The Sacramento Valley is a large, asymmetrical structural trough bordered by the Coast Ranges to the west, the Klamath Mountains and Cascade Range to the north, and the Sierra Nevada Mountains to the east. The Valley has been filled with sediments derived from both marine and continental sources. Older sediments (Jurassic to Eocene) were deposited primarily in marine environments, whereas younger sediments (Miocene to Recent) were deposited in continental environments including lacustrine, fluvial and alluvial fan environments, as shown on Figure 2.3 (Olmsted and Davis, 1961). Near the eastern margin of the valley, sedimentary deposits form a thin veneer on crystalline basement



SEDIMENTARY AND
METASEDIMENTARY ROCKS

QUATERNARY

Symbol	Unit
Q	Alluvium
i	Mine and dredge tailings
Qa	Levee and channel deposits
Qb	Basin deposits *(Alluvium)*
Qi	Intertidal deposits *(Peaty mud)*
Qs	Dune sand
Ql	Lake deposits
Qo	Older alluvium
Qg	Glacial deposits
Qm	Modesto Formation *(Alluvium)* — Qm_1/Qm_2 Upper and lower members
Qr	Riverbank Formation *(Alluvium)*
Qmr	Modesto-Riverbank Formations *(Arkosic alluvium)*
Qmz	Montezuma Formation *(Poorly consolidated, clayey sand)*
Qtl	Turlock Lake Formation *(Sand, silt, and gravel)*
Qrb	Red Bluff Formation *(Gravel in reddish, silty or sandy matrix)*
Qnm	North Merced Gravel *(Thin pediment veneer)*

TERTIARY

Symbol	Unit
Tt	Tehama Formation *(Sand, silt, and volcaniclastic rocks)*

A —— A' Cross Section Location

REFERENCE: Geologic Map of the Sacramento Quadrangle, CA,
California Division of Mines and Geology, 1981

N

0 — 5
Scale in Miles

REGIONAL GEOLOGIC MAP

RI/FS Work Plan
LEHR Environmental Restoration
Davis, California

FIGURE 2.3

DAMES & MOORE

10805-454-044

Surface Soils

Figure 2.5 presents surface soils in the site vicinity as mapped by the U.S. Department of Agriculture (USDA) Soil Conservation Service for Solano County (Bates, 1977). These soils formed on the surface of alluvial deposits as discussed below and are described as follows:

- Capay silt clay loam (Ca) - Dark grayish-brown to grayish-brown, 40 inches thick over pale brown and yellowish-brown clay loam to 60 inches +;
- Reiff fine sandy loam (Ra, Rw) - Grayish-brown to light yellowish-brown fine sandy loam to greater than 60 inches depth; and
- Yolo loam, loam clay substratum, and silty clay loam (Yo, Yr, Ys) - Dark grayish-brown silty clay loam to approximately 20 inches depth over a brown clay layer approximately 8 inches thick over brown loam to greater than 60 inches in depth.

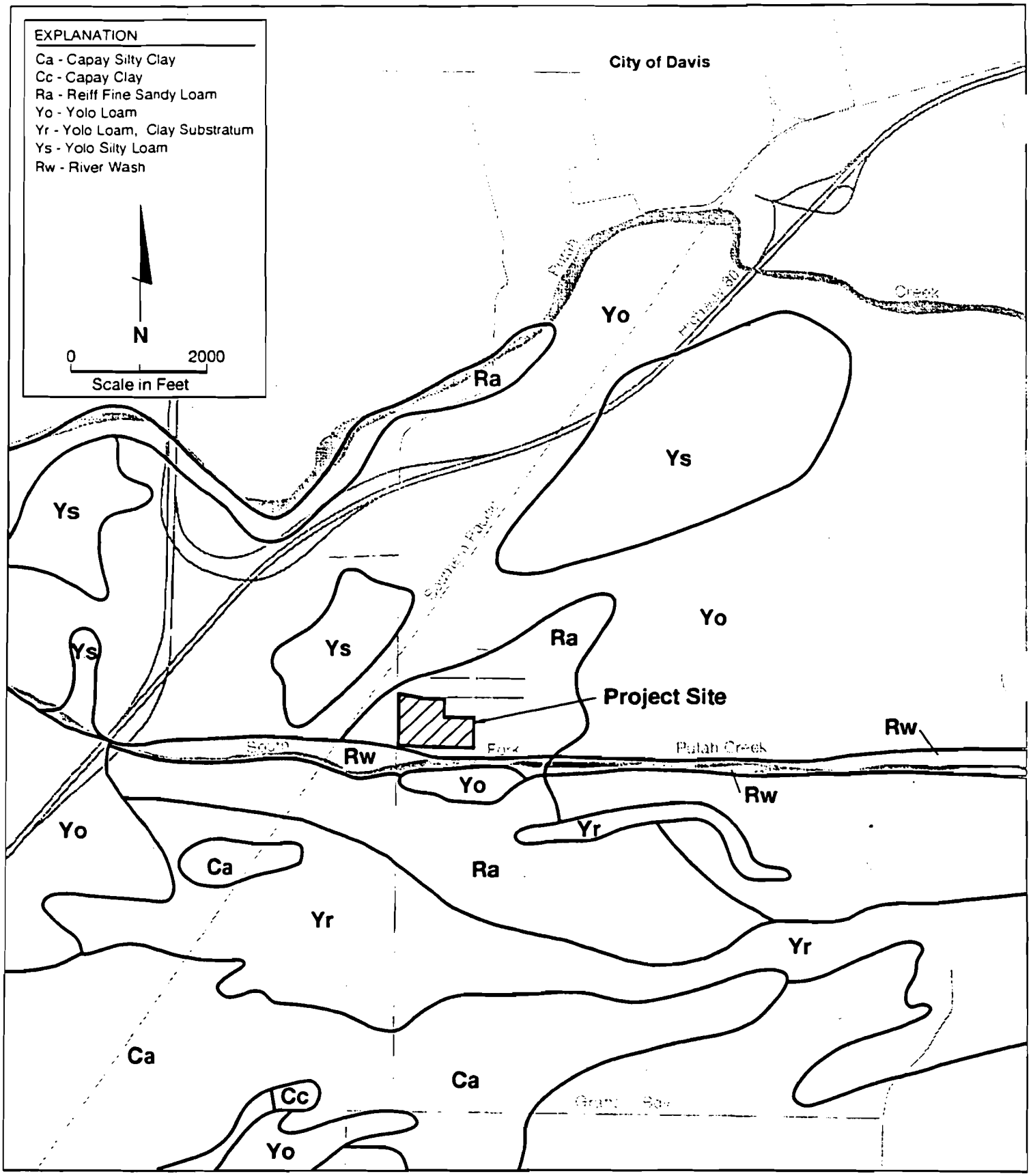
These soils are relatively young, weakly developed soils that formed in alluvial parent material during late Pleistocene to Recent time. The "A" horizons (soil horizon nearest the surface) are relatively thick and organic-rich, which makes these soils valuable for agricultural use (Bates, 1977).

Subsurface Profile

Inferred geological cross sections across the site are shown on Figures 2.6 and 2.6A. Because investigation data locations are up to 500 feet apart, smaller-scale subsurface features may be present which are not shown on the cross sections. The deepest boring drilled at the LEHR site, UCD-17, was completed in Quaternary Alluvium at a depth of approximately 143 feet below ground surface (bgs). No other formal geologic formations have been identified.

The major sedimentary units beneath the site and their nominal depths are:

- 0 to 10 feet: surface soils;



Source:
Soil Survey of Solano County, USDA Soil Conservation Service 1977.

DISTRIBUTION OF SURFACE SOILS IN SITE VICINITY

RI/FS Work Plan
LEHR Environmental Restoration
Davis, California

10805-454-044 sjr 9/2/93 soil-b

FIGURE 2.5

- 10 to 80 feet: interbedded silt, clay and sand with some sand and gravel channel deposits;
- 80 to 135 feet: cobbles and gravels; and
- 135 to 143 feet: clay and some silt.

The major sedimentary units, from the youngest to the oldest, are summarized below. Some of the units contain gradational sequences or more than one lithology. As shown in the cross sections, the units appear to be relatively flat-lying, reflecting the original depositional setting. Depths presented in this section are related to depth below ground surface (bgs).

- The surficial soils discussed above are underlain by a sequence of interbedded clay, silty clay, silt, and sand. This fine-grained unit is shown on the cross sections to be continuous across the site. The unit is typically 80 feet thick and contains some coarser-grained units of coarse sand and gravel. One of the coarse-grained units is present in UCD-15 and UCD-4 at 53 feet bgs. This unit is approximately five feet thick and is similar in composition to the cobbles and gravels encountered at 80 feet bgs. However, gravel was not encountered at this depth in UCD-23, located approximately 100 feet northeast. The groundwater table is found in this stratigraphic unit and varies in depth from approximately 45 to 65 bgs, depending upon season.
- Well-rounded cobbles and gravels are encountered at approximately 80 feet bgs in UCD-7, UCD-14 through UCD-17, and are considered laterally continuous beneath the LEHR site. The thickness of this unit ranges from approximately 35 feet in UCD-15 to 52 feet in UCD-17. The overall lithology of the cobbles and gravels include chert and metamorphic and volcanic clasts. This assemblage suggests that the source area for these materials was the Coast Ranges Geomorphic Province, located to the west.
- Clay and silt underlie the cobbles and gravels and are shown as the lowest unit on the cross sections. The top of this clayey unit was encountered at depths ranging from 120 to 137 feet bgs. maximum penetration into the clayey layer was about five feet. The clayey layer consists of light-brown clay with some silt, which is medium stiff and wet. The contact between this clay layer and the overlying cobble and gravel unit is sharp, and most likely represents an erosional contact due to channel scouring.

2.3.3 Hydrogeology

The major groundwater sources for public and private water supplies in the Sacramento Valley are the unconsolidated deposits of Pliocene and Pleistocene age, and the older alluvium (DWR, 1978). The younger alluvium and stream channel deposits are less frequently tapped as sources of groundwater. Groundwater is recharged through leakage from streams and rivers, and direct infiltration from precipitation and irrigation.

2.3.3.1 Regional Hydrogeology

The hydrogeology of the Sacramento Valley is characterized by both unconfined and confined aquifers in the nearly flat-lying or gently sloping sedimentary deposits in the upper 3,000 feet of section beneath the Valley. No regionally identified confining units exist in the Sacramento Valley (DWR, 1978).

Groundwater flow direction is generally toward the low-lying center of the Valley from the west and east sides. In the vicinity of the LEHR site, regional groundwater flow is generally east from the Coast Ranges towards the Sacramento River. (Dames & Moore, 1990b).

At various depths beneath the Valley floor, fresh water gives way to saline water in the sedimentary deposits as a result of entrapment during deposition of sediments in a marine environment. The depth to the base of fresh water in the Sacramento Valley varies from as little as 400 feet to over 3,000 feet. Shallowest depths to saline water occur at the edges of the Valley and around the Sutter Buttes, where the marine deposits are shallowest. The greatest depths to the base of fresh water are found in the southwest portion of the Valley where the marine deposits are deepest (DWR, 1978). Beneath the Davis area, fresh water gives way to saline water at a depth of approximately 2,600 to 3,100 feet bgs. (DOG, 1982).

2.3.3.2 Site Hydrogeology

For the purposes of this investigation, the saturated zone or uppermost aquifer beneath the LEHR site has been divided into two hydrostratigraphic units (HSU). This

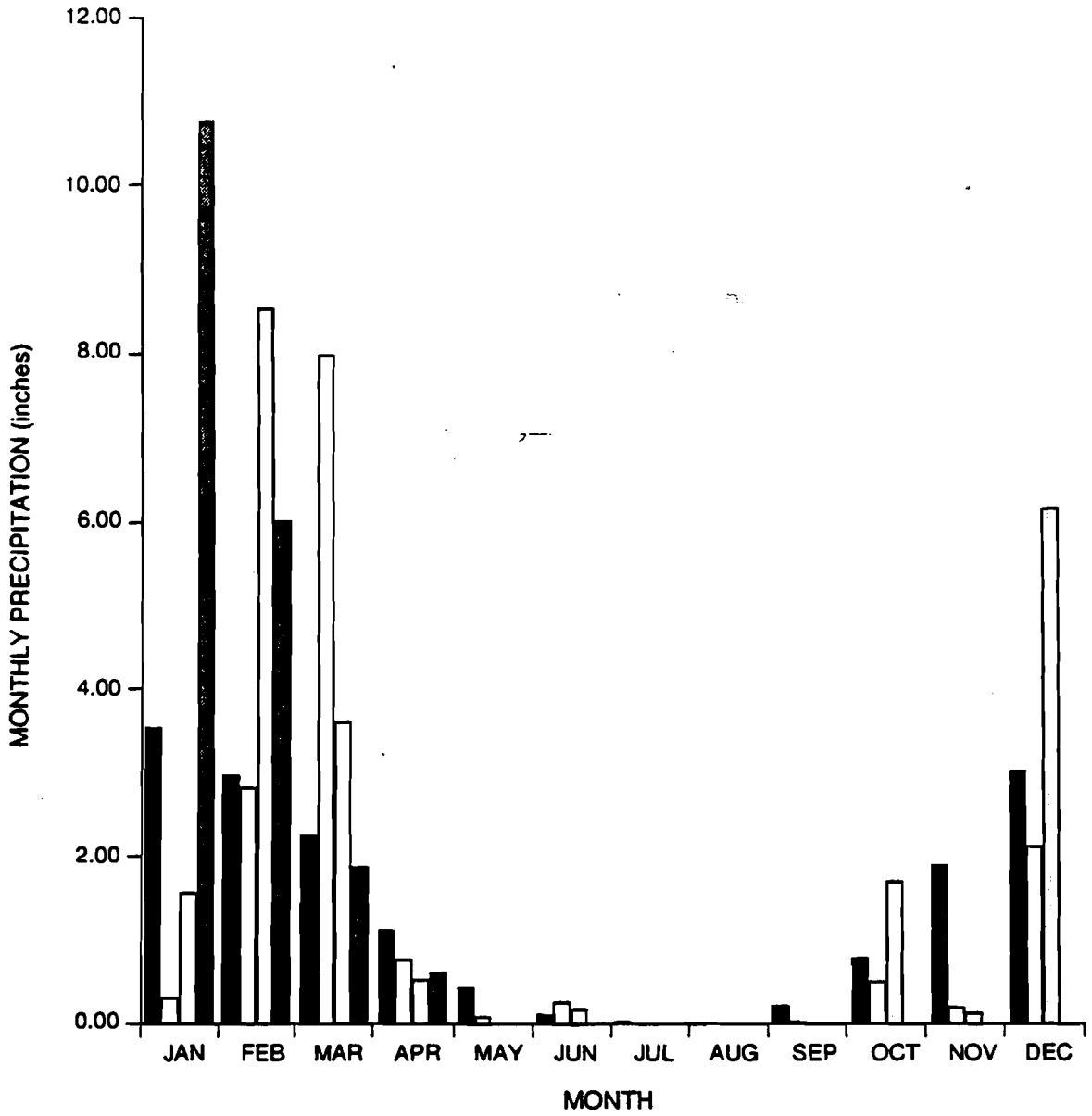
2.3.5 Meteorology

The climate in the region of the LEHR site is temperate, with mild winters and long summers. In winter, the average temperature is 46.9 degrees Fahrenheit (°F), and the average daily minimum temperature is 37.6°F. The lowest recorded temperature of 12.2°F occurred in December 1932. In summer, the average temperature is 73.0 °F, and the average daily maximum temperature is 92.3°F. The highest recorded temperature of 113°F occurred in July 1950 (NOAA, 1985; DOE, 1988).

2.3.5.1 Precipitation

The mean annual precipitation at the Davis 2 WSW station, located approximately 2 miles northwest of the LEHR, site is 17.0 inches, most of which occurs between October and April (National Climatic Data Centers, 1992). The 100-year, 24-hour storm event for this station is 4.45 inches, and the 10-year return period event is 3.15 inches (Personal Communication, March 1992, U.S. Army Corps of Engineers).

From the winter of 1986/1987 until the winter of 1992/1993, most of California, including the Davis area, has experienced drought conditions. During the years 1989 through 1991, the mean annual precipitation recorded at the Davis 2 WSW station was 13.18 inches (NCDC, 1992). Figures 2.10 and 2.11 present mean historical rainfall data and daily rainfall that occurred in the recent past. Regionally, the drought has resulted in decreased aquifer recharge, and groundwater levels have decreased due to drought effects and pumping for agricultural, municipal, and industrial uses. Lower groundwater levels have also been observed locally in the Davis area. Because above-normal rainfall has occurred during the most recent winter, groundwater elevations may change in comparison to the recent past.



EXPLANATION

- Mean Monthly Precipitation (Historic record 1908-1990)
- Monthly Precipitation 1991
- Monthly Precipitation 1992
- Monthly Precipitation 1993 (Jan. - Apr.)

NOTES:
Mean yearly precipitation from 1908 to 1990 = 16.46 inches
1991 total precipitation = 15.22 inches
1992 total precipitation = 22.54 inches
1993 total precipiation as of 4/93 = 19.35 inches

SOURCE: National Climatic Data Center 1993

MEAN AND MONTHLY PRECIPITATION
DAVIS 2 WSW STATIC

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LEHR Environmental Restoration
Davis, California

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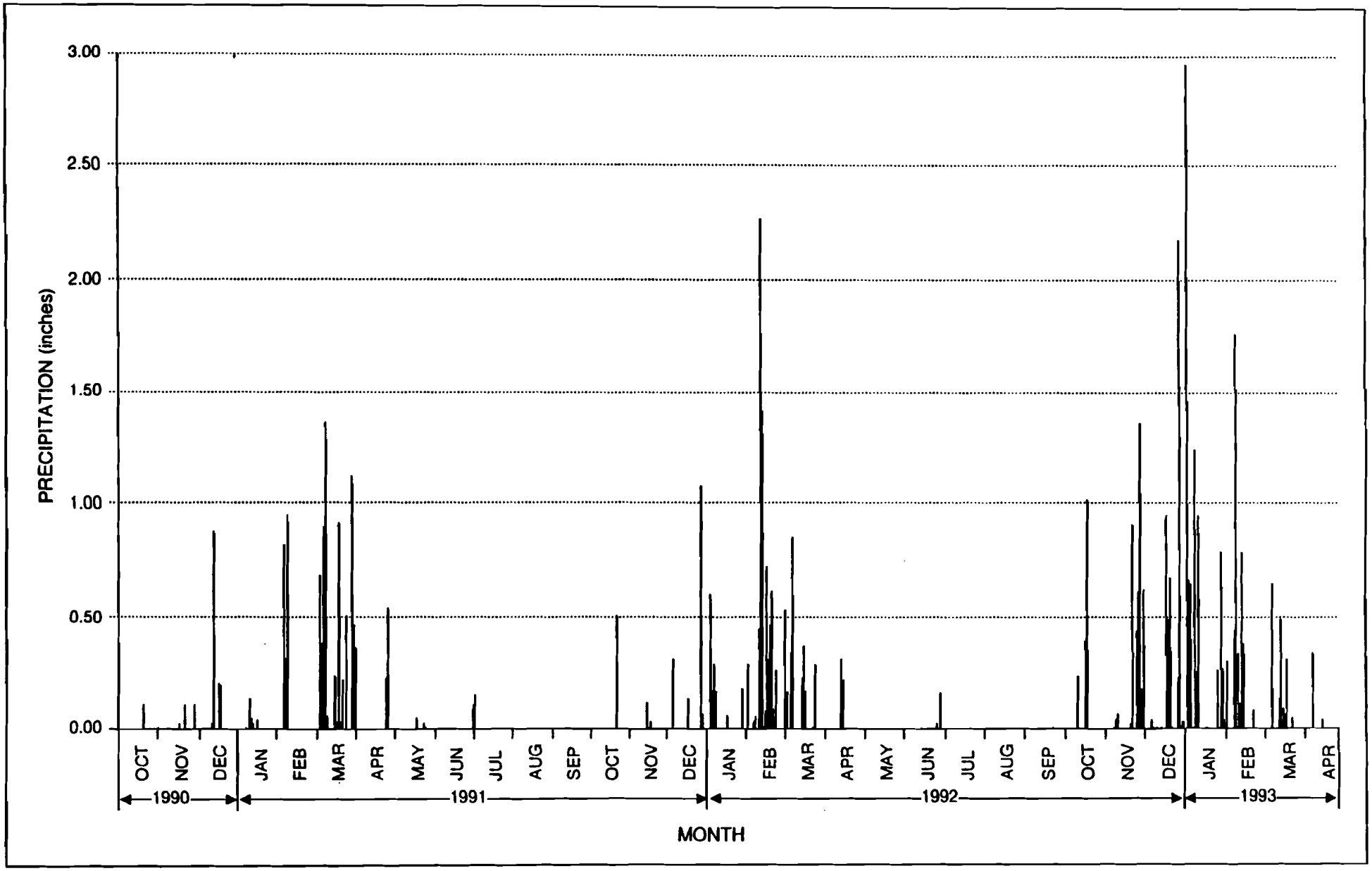
FIGURE 2.10



DAILY PRECIPITATION

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Davis, California

10805-720-044 JDG 6/2 :3 DAI

FIGURE 2.11

2.3.5.2 Local Climate

The climate in the area surrounding the LEHR site is dominated by the semi-permanent Pacific High pressure system, which controls large-scale weather patterns in the region. During summer months, the system drifts northward, diverting storms from California and producing little or no precipitation. With clear skies and warm temperatures during the summer, the Sacramento area is prone to photochemical air pollution when ozone precursor pollutants are present. In the winter, the Pacific High drifts southward, allowing storms to move across California.

A temperature inversion, or a layer of warm air above a layer of cooler air, occurs frequently throughout the year in the LEHR site area, although inversions are most severe, in terms of limited ventilation, during the late summer and fall months. Mean annual morning mixing heights in the LEHR site area are about 1,300 feet; mean annual afternoon mixing heights are about 4,600 feet (Holzworth, 1972).

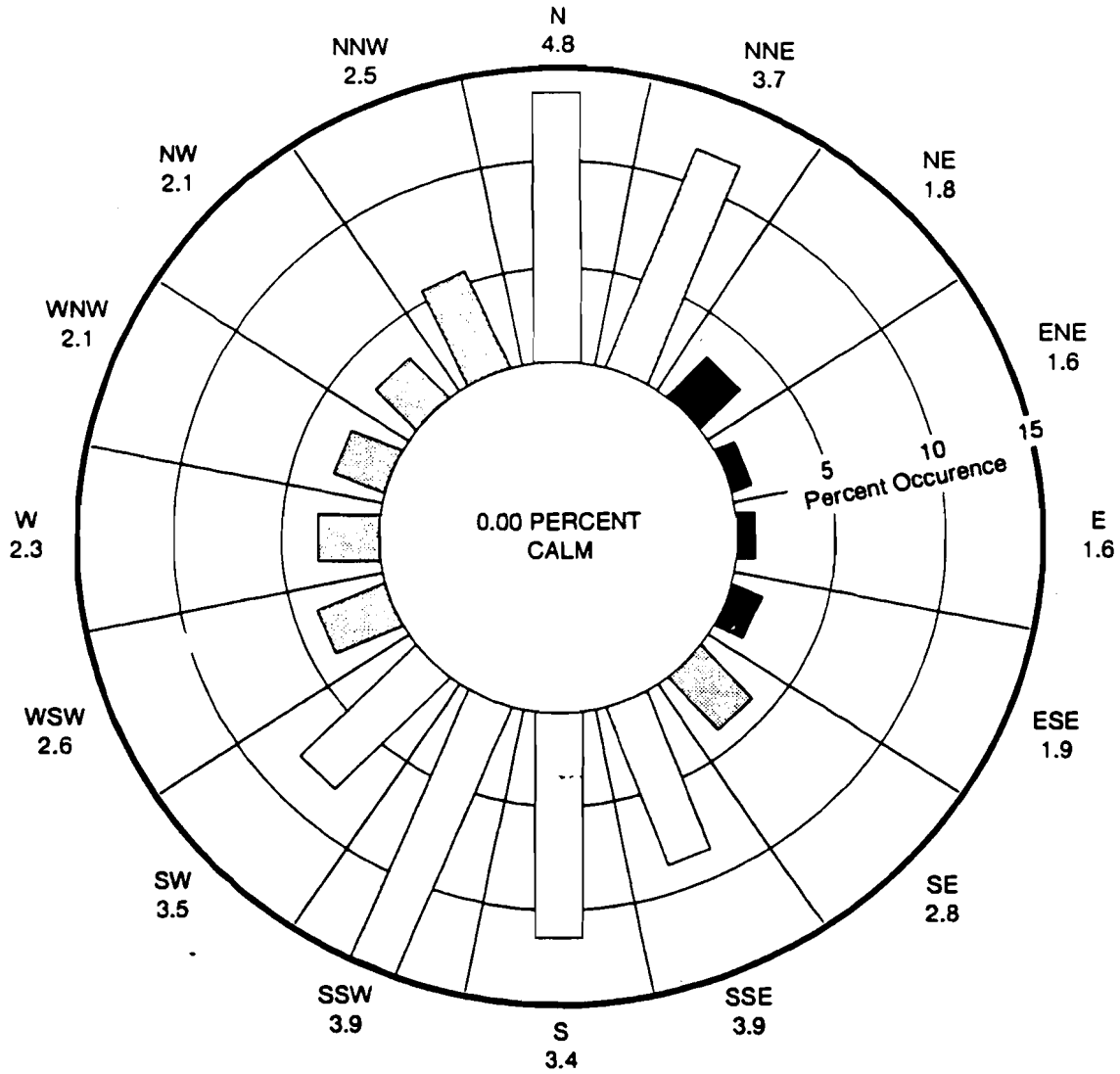
Table 2.2 summarizes wind patterns in the LEHR site area. Predominant winds are from the south, averaging approximately 4 miles per hour. Secondary predominant winds are from the north, averaging about 4 miles per hour (CARB, 1984). These data are also presented on Figure 2.12. Several times per year, strong winds blow from the north, generally following the passage of Pacific storm systems. When winds are present (40 percent of the time) speeds are less than 3.7 mph; 50 percent of the time they are less than 8.1 mph; and exceed 16.2 mph only 10 percent of the time for short periods (NOAA, 1985; DOE, 1988). Figure 2.13 presents the monthly mean windspeed at the Davis 2 WSW station from 1966 through 1987.

The sun shines approximately 95 percent of the time in summer and about 45 percent in winter. Low-lying, locally dense fog is common to the Sacramento Valley in late fall and winter, and obscures the sun up to about 20 percent of the time during those months. The average daily relative humidity is about 80 percent in the winter, and 40 percent in the summer and early fall. Local humidity generally increases at night.

TABLE 2.2 SURFACE WIND SUMMARY FOR DAVIS (1979-1982)[a]

DIRECTION	WINTER (Dec, Jan, Feb)		SPRING (Mar, Apr, May)		SUMMER (Jun, Jul, Aug)		FALL (Sep, Oct, Nov)		ANNUAL	
	% of Time	Mean Speed (mph)	% of Time	Mean Speed (mph)	% of Time	Mean Speed (mph)	% of Time	Mean Speed (mph)	% of Time	Mean Speed (mph)
N	14.8	5.1	16.7	4.5	9.7	4.4	14.8	3.1	14.6	4.8
NNE	12.1	3.8	10.9	3.6	9.1	3.5	17.0	3.1	12.2	3.7
NE	2.7	1.7	1.9	1.5	3.6	2.1	4.1	2.0	2.8	1.8
ENE	1.3	1.5	1.3	1.6	2.7	1.8	2.0	1.8	1.5	1.6
E	1.3	1.6	0.9	1.3	2.3	2.1	1.8	1.8	1.4	1.6
ESE	2.0	1.9	1.3	1.6	2.2	2.2	2.9	1.9	2.0	1.9
SE	4.6	2.9	3.2	2.0	3.0	2.5	4.4	2.3	4.4	2.8
SSE	10.0	4.0	5.3	3.2	5.5	2.3	5.5	3.0	8.8	3.9
S	13.0	3.4	7.6	2.9	2.6	2.3	2.6	2.1	10.8	3.4
SSW	14.9	3.9	16.3	3.7	19.4	4.0	9.7	2.9	15.0	3.9
SW	6.2	3.4	11.6	3.7	16.7	3.8	9.4	3.3	7.8	3.5
WSW	3.0	2.5	4.7	3.2	6.2	2.6	5.1	2.5	3.6	2.6
W	2.5	2.2	4.6	2.8	4.1	2.6	4.5	2.1	3.0	2.3
WNW	2.7	2.1	3.3	2.3	4.5	2.1	3.9	1.9	3.0	2.1
NW	3.3	2.0	4.1	2.3	4.1	2.2	5.4	1.9	3.6	2.1
NNW	5.4	2.6	6.3	2.7	4.3	2.3	6.8	2.0	5.5	2.5
CALM	0.0		0.0		0.0		0.0		0.0	
ALL		3.5		3.3		3.2		2.6		3.4
RESULTANT WINDS										
DIRECTION (degrees):	200		274		238		333		234	
SPEED:	0.3		0.7		0.9		0.5		0.3	
PREDOMINANT WINDS (Alternate Definition)										
DIRECTION:	S		SSW		SW		N		S	
SPEED:	3.8		3.5		3.7		2.9		3.7	
PERCENTAGE:[b]	37.9		35.5		42.3		38.6		34.6	
SECONDARY PREDOMINANT WINDS (Alternate Definition)										
DIRECTION:	N		N		N		SW		N	
SPEED:	4.2		3.9		3.7		3.0		4.0	
PERCENTAGE:[b]	32.3		33.9		23.1		24.2		32.3	

Source: California Air Resources Board June 1984.
[a] Data from the Davis monitoring station.
[b] The percentage frequency is the measure of the number of occurrences of winds in the predominant sector.



EXPLANATION

- 0-1
- 1-2
- 2-3
- 3-4
- >4

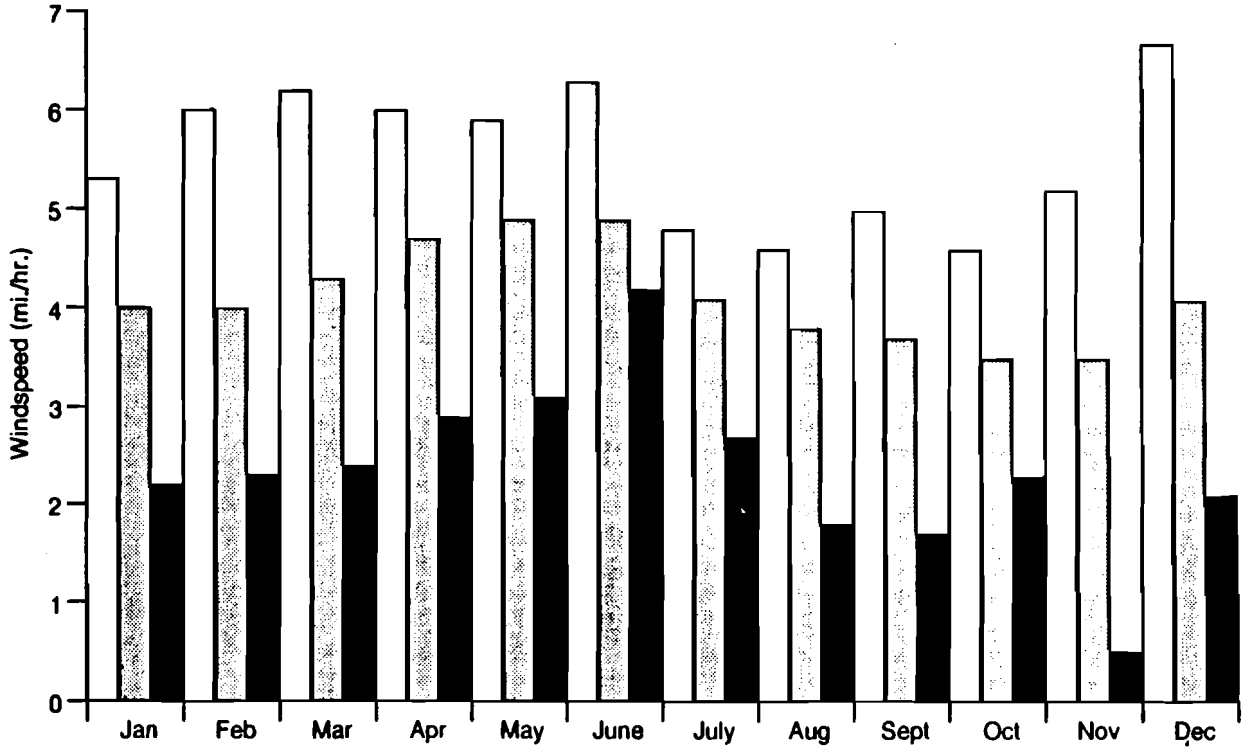
Wind Speed Range m/s mph

WIND ROSE
SURFACE WIND SUMMARY (1979-198

RI/FS Work Plan
LEHR Environmental Restoration
Davis, California

10805-720-044 sjr 5705C 2/17/94

FIGURE 2.12



Davis 2 WSW Station
1966-1987

EXPLANATION

- High
- Average
- Low

MONTHLY MEAN WINDSPEED

RI/FS Work Plan
LEHR Environmental Restoration
Davis, California

10805-720-044 sjr 5705C 2/17/94

FIGURE 2.13.

2.4 ENVIRONMENTAL AND HUMAN RESOURCES

2.4.1 Environmental Resources

Environmental resources in the vicinity of the LEHR site include irrigated croplands, wetlands, and riparian areas. Each of these resources is discussed in the following sections.

2.4.2 Land Use

Land use in the vicinity of UC Davis and the LEHR site is predominantly agricultural. Approximately 78 percent of the land in Yolo County is classified as farmland, and about 38 percent is irrigated cropland. Neighboring Solano County, in which the facility is located, is also an agricultural area. About 60 percent of Solano County's total area is farmland, and 18 percent of the total land is irrigated cropland (United States Department of Commerce, Bureau of the Census, 1989). The major crops in the area are grains, nuts, and fruit. Stock animals are also raised.

2.4.3 Special Status Species

The wetlands and riparian areas of the Yolo Basin serve as a critical wildlife habitat for a number of special status plants and animals, including Swainson's hawk, the giant garter snake, and valley oak. Putah Creek, which parallels the southern boundary of the LEHR site, is a high-quality riparian habitat and provides important nesting and foraging areas for raptors, deer, and other wildlife. Valley oaks, which are covered by State Senate Concurrent Resolution Number 17, and cottonwood trees are an integral part of the habitat (Dames & Moore, 1991). Additionally, the area may contain blue elderberry shrubs, a critical habitat for the valley elderberry longhorn beetle. Table 2.3 presents a list of special status species known to exist at or near the Putah Creek. There are no wetlands or vernal pools on the LEHR site.

TABLE 2.3 SPECIAL STATUS SPECIES NEAR PUTAH CREEK

TAXA	LISTING STATUS: [a]		
	Federal	State	Other
Quercus Lobata Valley oak			CNPS
Desmocerus californicus dimorphus Valley elderberry longhorn beetle	T		
Thamnophis gigas Giant garter snake	T	T	
Pelecanus erythrorhynchos American white pelican			SSC
Casmerodius albus Great egret		TDH	
Buteo swainsoni Swainson's hawk		T	
Circus Cyaneus Northern harrier			SSC
Agelaius tricolor Tricolored blackbird	C-2		SSC
Plegadis chihi White-faced ibis	C-2		SSC
Numenius americanus Long-billed curlew	C-2		SSC
Grus canadensis tabida Greater Sandhill Crane		T	

a Listing Status Codes:

CNPS = California Native Plant Society, List 4
T = Threatened.
SSC = California Natural Diversity Database (CDFG) Species of Special Concern.
TDH = Taxa associated with habitat that is declining in California at an alarming rate.
C-2 = Category 2 Candidate for Federal listing.

Because the LEHR site is in an area that contains critical wildlife habitat, activities undertaken during the LEHR environmental restoration will be coordinated in writing with the U.S. Fish and Wildlife Service and the California Department of Fish and Game. A California Environmental Quality Act (CEQA) Preliminary Study for Site Characterization of the UC Davis Landfill was prepared for the University of California, Davis in February 1990. This study identified the investigation techniques to be used during the characterization of the UC Davis Landfill at the LEHR site and discussed potential environmental impacts from those methods. The study concluded that "Although minor impacts were disclosed in the Environmental Checklist process, all impacts were temporary, consistent with existing land use and less than significant." The investigation techniques to be used during this soil characterization are similar to those described in the above mentioned study, and therefore it is anticipated that environmental impacts will also be temporary, and less than significant.

2.4.4 Human Resources

The LEHR site is located in the southeastern portion of the approximately 5,000-acre UC Davis property. UC Davis has a student population of approximately 21,000 and employs approximately 12,000 full-time faculty and staff (Personal communication, March 1992, Angie Malloy, UC Davis). The current population of Davis, the nearest population center to the LEHR site, is approximately 46,000 and the current total population of Yolo County is about 141,000. This represents a growth rate of 25 percent between 1980 and 1990. The median family income in 1990 was $36,866 and approximately 70 percent of the population is over the age of 18 (Sacramento Area Council of Governments, 1991).

The LEHR site is located in a rural area in northern Solano County just outside of Davis. The immediate vicinity comprises primarily agricultural land. There are a few single-family residences within approximately one mile of the facility, and UC Davis owns some nearby research facilities on all sides of the LEHR site. As of the 1980 census, Solano County has a total population of 340,421 and the median family income in is $46,868. Approximately 71 percent of county residents are over the age of 18 (Personal Communication, May 1993, Bay Area Council of Governments).

The more densely populated and fast-growing metropolitan Sacramento area is approximately 12 miles east of the LEHR site. The current population of Sacramento

County is about 1,040,000, and approximately 370,000 people live in the city of Sacramento.

3.0 INITIAL EVALUATION

This chapter presents an overview of previous investigations and a description of the waste disposal areas identified at the LEHR site. Section 3.1 presents an overview of previous environmental studies, describing selected results reported from those studies. Section 3.2 presents former waste disposal areas including summaries of data from previous environmental studies in those areas. Section 3.3 describes previous and ongoing remedial activities, and a Conceptual Site Model is presented for the LEHR site in Section 3.4. Investigation areas are presented in Section 3.5, and potential remedial actions are identified in Section 3.6.

3.1 PREVIOUS INVESTIGATIONS

Sixteen environmental studies have been conducted at the LEHR site since 1984. The studies have been performed for both UC Davis and the DOE. A listing of these investigations is presented on Table 3.1 and the findings summarized in the following sections. The majority of these investigations have been limited in scope and have focussed on specific objectives. The Phase II Site Characterization is the most comprehensive investigation conducted to date. In addition to the general environmental investigations, several specific sampling events have been completed in the radium-226 and strontium-90 treatment tanks prior to remediation. Additional information on results from previous environmental investigations can be found in Section 3.2 and in the reports for each investigation.

Analytical methods used during previous investigations were primarily EPA methods. Results of these investigations indicate potential chemical and radiologic impacts at the LEHR site. Because the analytical data collected for most of the previous investigations were not collected under any formal QA/QC programs, the results of these previous investigations were used only as a guide during the Phase II Site Characterization. The Phase II Site Characterization data are considered to be equivalent to EPA level III analytical data, and were used in the development of the scope of this RI/FS program.

TABLE 3.1 SUMMARY OF PREVIOUS INVESTIGATIONS

REFERENCE	REPORT TITLE
Rockwell International	Initial Assessment Survey of the DOE LEHR Site; October 1984
U.S. Department of Energy	Environmental Survey Preliminary Report; March 1988
Wahler Associates	Groundwater and Soils Investigation of U.C. Davis Research Facility; December 1988
	Groundwater and Soils Investigation of U.C. Davis Research Facility; May 1989
Dames & Moore	Evaluation of On-Site Wells at UC Davis LEHR site; February 1990
	Final SWAT Report, Old UC Davis Landfill; July 1990
	Contaminant Pathway Analysis for the UC Davis Campus from the LEHR Study Site; July 1990
	Evaluation of Potential Nitrate and Hexavalent Chromium Sources in the Vicinity of the UC Davis LEHR Site; November 1990
	Putah Creek Sediment and Water Sampling; December 1990
	Waste Burial Trench Investigation LEHR Site; July 1991
	CEQA Preliminary Environmental Study for Site Characterization Work at the Inactive UC Davis Landfill; February 1991
	Old UC Davis Landfill Additional Characterization — CPT and Hydropunch Investigation - UC Davis South Campus Inactive Disposal Sites; September 1991
	Second-Round CPT/Hydropunch Investigation; November 1991
	Phase II Site Characterization, LEHR Environmental Restoration, February 1993
UC Davis	Assessment of LEHR Imhoff and Radium Septic Waste: Recommendation for Disposal; December 19, 1989
Chemical Waste Management, Inc.	Final Report for the Liquid and Sludge Removal Project at the LEHR Facility at the University of California at Davis; 1992

3.1.1 Initial Assessment Survey

Rockwell International conducted an Initial Assessment Survey of the LEHR site in October 1984 (Rockwell, 1984) for DOE. A total of 22 soil samples were collected and analyzed for the Initial Assessment Survey. Results of these analyses indicated radium-226 and strontium-90 activity up to 0.204 pCi/g and 0.07 pCi/g, respectively, in the radium-226 dry well area. Strontium-90, radium-226 and carbon-14 activity were reported at levels of 3.94 pCi/g, 17.3 pCi/g and 1.160 pCi/g, respectively, in the southwest disposal area. The highest reported measurement of tritium activity, 208 pCi/g, was from a sample collected in the southeast corner of the eastern dog pens. The pesticides heptachlor, aldrin, and dieldrin were found in containers collected from exploratory trenches south of UCD-13 and UCD-14 (see Table 3.2). Two samples, one from the Imhoff area and one from the area near UCD-24, contained reported concentrations of the common analytical laboratory contaminants methylene chloride and bis(2-ethylhexyl) phthalate.

3.1.2 Environmental Survey Preliminary Report

The DOE prepared an Environmental Survey Preliminary Report in March 1988 (DOE, 1988). The investigation was primarily a document research investigation to assess past site activities so that the site could be priority-ranked by the DOE for future investigation. The 1988 DOE investigation describes past disposal practices at or near the LEHR site, and concluded that areas including the waste burial trenches, the strontium-90, or Imhoff tanks, inactive septic tanks and associated leach fields, the chemical dispensing areas, the dog pen areas, the LEHR sanitary sewer system, and the cobalt-60 irradiator facility, are potential sources of soil and groundwater impacts beneath the site.

3.1.3 Phase I Investigation

Wahler Associates performed work for both the DOE and UC Davis in two investigations collectively identified as the Phase I Investigation (Wahler, 1988 and 1989). Work completed for both investigations was conducted concurrently. The Phase I Investigation consisted of drilling 43 soil borings, the installation and sampling

TABLE 3.2 SUMMARY SOIL DATA SOUTHWEST DISPOSAL AREA

		Previous* Investigations	Phase II Site Characterization				
	Parameter	Highest Detected Value	Number Sampled	Number Detected	Highest Detected Value	Mean	Standard Deviation
Semi Volatile Organics (μg/Kg)	Bis 2 Ethylhexylphthalate	NA	22	0	--	--	--
	DI N Butyl Phthalate	NA	22	7	220.00	158.57143	44.50789
Volatile Organics (μg/Kg)	Chloroform	NA	22	0	--	--	--
	1,1 dichloroethene	NA	22	0	--	--	--
	Methylene chloride	NA	22	9	37.60	21.55556	8.21890
Pesticides (μg/Kg)	Chlordane	NA	22	0	--	--	--
	Dieldrin	NA	22	0	--	--	--
	Aldrin	NA	22	0	--	--	--
	Heptachlor	NA	22	0	--	--	--
Radiologic Constituents (pCi/g)	Gross alpha	9 ± 6	22	13	4.00	2.23077	0.96642
	Gross beta	22 ± 3	22	22	8.20	4.59091	1.73258
	Tritium	171 ± 14	22		5.55	3.09	2.43
	Bismuth-214	ND	2	2	1.38	0.90000	0.67882
	Lead-212	ND	6	6	0.69	0.61000	0.12681
	Lead-214	ND	22	0	--	--	--
	Strontium-90	17.3 ± 2	22	6	0.70	0.34333	0.21639
	Potassium-40	11.5 ± 0.6	22	21	16.56000	8.97905	3.54121

TABLE 3.2 SUMMARY SOIL DATA SOUTHWEST DISPOSAL AREA (continued)

		Previous[a] Investigations	Phase II Site Characterization				
	Parameter	Highest Detected Value	Number Sampled	Number Detected	Highest Detected Value	Mean	Standard Deviation
	Cesium-137	0.02 ± 0.01	22	0	--	--	--
	Radium-226	3.94 ± 3	22	5	0.90	0.52400	0.27218
	Thorium-232	0.6 ± 0.06	22	8	5.55	3.09125	2.43389
	Carbon-14	1,160 ± 7	0	0	--	--	--
	Plutonium-241	NA	0	0	--	--	--
Nitrate (mg/Kg)	Nitrate		22	22	220.00	42.65682	68.40655
Metals (mg/Kg)	Antimony	NA	22	0	--	--	--
	Arsenic	NA	22	20	5.10	3.22500	1.23283
	Barium	NA	22	22	181.00	108.10909	31.10956
	Beryllium	NA	22	9	4.80	1.37778	1.78660
	Cadmium	NA	22	18	10.70	1.45000	2.48365
	Cobalt	NA	22	21	35.00	21.30000	7.04471
	Hexavalent chromium	NA	22	12	1.56	0.53000	0.46737
	Chromium (total)	NA	22	21	114.00	64.34762	17.16265
	Copper	NA	22	21	63.00	18.70	21.95
	Mercury	NA	22	22	0.45	0.17714	0.13780

TABLE 3.2 SUMMARY SOIL DATA SOUTHWEST DISPOSAL AREA (continued)

	Previous[a] Investigations	Phase II Site Characterization				
Parameter	Highest Detected Value	Number Sampled	Number Detected	Highest Detected Value	Mean	Standard Deviation
Molybdenum	NA	22	9	57.00	13.00000	18.69492
Nickel	NA	22	21	370.00	200.45717	2.91883
Lead	NA	22	22	9.69	5.73591	1.89626
Silver	NA	22	2	6.00	4.00000	2.82843
Selenium	NA	22	0	--	--	--
Thallium	NA	22	7	2.00	1.61429	0.42201
Vanadium	NA	22	22	53.00	24.62273	8.08278
Zinc	NA	22	22	74.00	55.78182	15.58264

-- Not Applicable
NA Not Analyzed
ND Not Detected
[a] Previous Investigations includes: Rockwell, 1984; and Wahler, 1989

(two rounds) of 9 groundwater monitoring wells (UCD-1 through UCD-9), and the excavation of 16 backhoe trenches. Sample analysis results reported that groundwater wells UCD-8 and UCD-9 contained several volatile organic compounds (VOCs), including chloroform at concentrations up to 41.9 mg/L. Reported concentrations of nitrate in all wells ranged from 1.4 mg/L to 360 mg/L (in UCD-3). Reported concentrations of chromium in groundwater ranged from 0.08 mg/l to 0.19 mg/l; however, it is not known if groundwater samples analyzed for metals were filtered. Strontium-90 and radium-226 activity were reported in soil samples from the radium-226 dry well area at measurements up to 1.6 pCi/g and 1.23 pCi/g, respectively. Strontium-90 activity was reported in samples from soil in the strontium-90 leach field area at measurements up to 0.02 pCi/g. Tritium activity was reported in one sample from UCD-1 in the northwest corner of the site at 102 pCi/g, and one exploratory trench in the southwest disposal area contained measurable activity of radiation up to 2,500 cpm using a hand held survey meter.

3.1.4 Evaluation of On-Site Wells

In June 1989, Dames & Moore evaluated high turbidity levels observed in the nine wells (UCD-1 through UCD-9) previously installed by Wahler Associates during their 1988 and 1989 investigations (Dames & Moore, 1990a). The scope of the evaluation included redevelopment of the wells using swab/surge, bailing, and pumping techniques. In addition to well development, groundwater samples were collected and analyzed for various chemical parameters to assess whether chemical properties of the groundwater and/or soil were the cause of, or contributed to, high turbidity. The report concluded that the high turbidity levels in the wells (UCD-1 through UCD-9) appeared to be due to improper sizing of well construction materials, and not the geochemical character of the groundwater. Information obtained from this study was used to design monitoring wells installed as part of the Phase II Site Characterization. Because of its construction, monitoring well UCD-2 was recommended to be abandoned. It is anticipated that, with the exception of UCD-7, monitoring wells UCD-1, UCD-3 through UCD-6, UCD-8 and UCD-9 will be properly abandoned in accordance with Solano County guidelines. UCD-7, screened in the second HSU, will continue to be used for groundwater monitoring.

An old domestic supply well located beneath the maintenance shop at the LEHR site (Old Shop Well) was also investigated by a downhole video camera survey. The well was

found to be approximately 251 feet deep, with casing perforations from 76 to 130 feet bgs and from 220 to 251 feet bgs. Data from the survey was used to develop recommendations for abandonment of the well. The Old Shop Well was abandoned by UC Davis in 1990.

3.1.5 Solid Waste Assessment Test

The Solid Waste Water Quality Assessment Test (SWAT) Report (Dames & Moore, 1990b) was prepared for UC Davis to assess the possibility of leakage from the three Old UC Davis landfill units located on and adjacent to the LEHR site and the potential impacts to groundwater, surface water, vadose-zone water and soil. During the SWAT investigation, five groundwater monitoring wells were installed (UCD-10 through UCD-14) in the first two saturated zones; one pre-existing monitoring well (UCD-2) was abandoned; four vadose-zone wells (lysimeters LW-1 through LW-4) were installed, and surface water in Putah Creek upgradient and downgradient of the landfill units was sampled.

Analytical results reported from the SWAT showed that groundwater downgradient of Landfill Unit Nos. 1 and 2 contain several VOCs including chloroform up to 17 mg/L, and elevated levels of general water quality parameters. Hexavalent chromium was also elevated (up to 0.38 mg/L) in UCD-11. Groundwater samples from UCD-8 and UCD-13 had measured tritium and carbon-14 activity up to 36,269 pCi/L, and 2,702 pCi/L, respectively. Section 3.2.6 presents additional detail on the results of the SWAT.

3.1.6 Contaminant Pathway Analysis

In July 1990, an analysis of potential constituent migration from the LEHR site and adjacent sites to the main UC Davis campus was conducted to support the environmental documentation for the UC Davis Long Range Development Plan (Dames & Moore, 1990c). The following pathways were identified through which chemical and radiological constituents at the LEHR site could potentially migrate from the site and impact other areas of the campus:

- Direct contact with surface soils at the LEHR site;
- Resuspension and dispersion (to the air) of fugitive dust from surface soils; and

- Migration through soil and groundwater.

Constituents of concern in soil and groundwater from the LEHR site and adjacent sites were identified based on data obtained during the SWAT investigation for the Old UC Davis Landfill. Analysis of the known constituents, using environmental fate and transport models, indicated that impacts from the LEHR site were not expected on the UC Davis campus north of Interstate 80.

3.1.7 Evaluation of Potential Nitrate and Hexavalent Chromium Sources

In March 1990, a study was conducted to assess elevated levels of hexavalent chromium and nitrate as nitrogen in privately owned wells near the LEHR site (Dames & Moore, 1990d). The study was designed to evaluate the potential for various sources, including the LEHR site, as the source for the elevated levels of these constituents. Potential sources of nitrate in domestic wells were speculated to include fertilizers used on crops in the vicinity, discharge from the UC Davis Wastewater Treatment Plant, domestic septic systems, and past or current animal enclosures. Potential sources of hexavalent chromium were speculated to include sediments derived from the Coast Range to the west, geochemical mobilization, incineration ash, and metal-plating wastes. The evaluation concluded that sufficient regional data do not exist to completely evaluate the sources of hexavalent chromium.

3.1.8 Putah Creek Sediment and Water Sampling

In August 1990, sediment and surface water samples were collected from Putah Creek upstream and downstream from the LEHR site (Dames & Moore, 1990e). Results of sample analyses reported some metals, ~~volatile organic compounds~~ (VOCs), ~~semivolatile organic compounds~~ (SVOCs) and radioactivity. Hexavalent chromium was reported in water samples ranging from 0.01 to 0.03 mg/L and in sediment samples from less than 0.1 to 0.3 mg/Kg. Xylenes were reported in water samples ranging from 0.28 to 0.58 μg/L. Bromodichloromethane and chloroform were reported in water samples from 0.54 and 2.50 μg/L respectively. Gross alpha activity was reported up to 6.0 pCi/L in water and 1.5 pCi/g in sediment samples. Gross Beta activity was reported up to 23 pCi/L in water and 2.9 pCi/g in sediment. Strontium-90 activity was reported up to 4.1 pCi/L in

water and was not reported in sediment samples. No tritium activity was reported in water or sediment samples.

3.1.9 Waste Burial Trench Investigation LEHR site

Dames & Moore supervised the excavation of 18 exploratory trenches and a ground penetrating radar (GPR) survey for UC Davis conducted in an attempt to locate and sample the contents of former UC Davis waste burial trenches (Dames & Moore, 1991b). Results of the exploratory trenching suggest that the majority of the documented UC Davis waste burial trenches exist, with the exception of trenches reported to be near the Geriatrics building and UCD-8. Results of soil samples collected from trenches located just north of UCD-12 reported measurements of radium-226 and thorium activity at 0.44 pCi/g and 0.51 pCi/g, respectively. Chlordane and tritium were reported in soil samples analyzed from this same area at 688 μg/kg and 0.61 pCi/g, respectively. Additional information on waste burial trench investigation results is presented in Section 3.2.2.

3.1.10 CEQA Preliminary Environmental Study for Site Characterization

A preliminary environmental study was conducted for UC Davis as part of the ongoing characterization work for the Old UC Davis Landfill in compliance with the California Environmental Quality Act (CEQA) (Dames & Moore, 1991c) in order to assess potential environmental impacts of additional post-SWAT characterization work at the landfill units at the LEHR site. The environmental study evaluated site characterization activities, such as drilling, well installation, development, and sampling that could be performed, vehicles and equipment required, location of the work, and time required to complete the work. The study concluded that impacts from characterization would be temporary, consistent with existing land use, and less than significant, and therefore eligible for categorical exemption under 14 CCR 15306.

3.1.11 Old UC Davis Landfill Additional Characterization

As part of the Old UC Davis Landfill Additional Characterization, two CPT and Hydropunch™ investigations were performed in April 1991 and September 1991 to further evaluate the vertical and lateral extent of site constituents detected in groundwater

samples collected during the SWAT investigation. The CPT and Hydropunch™ investigations consisted of 31 CPT penetrations and collection of 50 Hydropunch™ groundwater samples in areas downgradient of wells in which elevated levels of site constituents were detected during SWAT monitoring.

Results of analysis of Hydropunch™ samples reported maximum concentrations of chloroform at 59.0 mg/L; nitrate at 68.4 mg/L; hexavalent chromium at 0.34 mg/L; and tritium at 2,220 pCi/L, downgradient of Landfill Unit Nos. 1 and 2 in the first HSU. Results of sample analysis in the second HSU show correlative concentrations of constituents similar to those reported in the first HSU, down-gradient of Landfill Unit Nos. 1 and 2. Maximum concentrations of chloroform at 110 ug/L; nitrate at 12.45 mg/L; hexavalent chromium at 0.037 mg/L; and tritium at 517 pCi/L were reported in samples collected from downgradient of Landfill Unit Nos. 1 and 2 in the second HSU.

3.1.12 Phase II Site Characterization

Dames & Moore performed a Phase II Site Characterization of the LEHR site to assess potential sources of site constituents and to evaluate the geologic and hydrogeologic relationships at the site. The purpose was to develop information to produce a conceptual model that identifies interrelationships between site sources and environmental impacts.

The Phase II Site Characterization included the installation of 10 groundwater monitoring wells, 10 soil borings (10 to 30 feet deep), and 28 shallow soil borings (less the 2 feet deep). Soil samples were collected from two borings drilled for installation of background groundwater wells, data from which was used to compare to soil data reported from on-site samples. Over 200 soil samples were collected and analyzed for various chemical and radiological parameters. In addition, groundwater and surface water samples have been collected quarterly since November 1990. The Phase II Site Characterization focused on DOE areas identified during previous investigations as having the potential to impact the environment, but did not include the UC Davis disposal trenches or landfill units. The areas investigated include the southwest corner of the LEHR site, the radium-226 and strontium-90 leach systems, the two sets of outdoor dog pens and the north chemical dispensing area. The results of samples collected at the LEHR site

indicate that there has been some impact to the environment that may be from the DOE source areas identified. Results from the Phase II Investigation are summarized below and presented in more detail in Section 3.2.

Results from samples collected in the southwest area reported the highest detections of gross alpha, gross beta and tritium activity. No ~~volatile organic compounds~~ VOCs were reported and only one ~~semivolatile organic compound~~ SVOC (Di-N-Butyl Phthalate) was reported. Mercury was reported in all soil samples collected from this area at levels greater than the highest levels reported for samples collected in off-site.

The highest detection of nitrate in soil on the LEHR site was reported in samples from the radium-226 area. Reported detections of radium-226 activity were lower than the highest reported detection from samples collected off-site. Strontium-90 activity and hexavalent chromium were reported at levels higher than the maximum levels reported in off-site samples.

In the soil samples from the strontium-90 area, no strontium-90 or tritium activity was reported and radium-226 activity was reported at levels less than the maximum activity levels reported from off-site samples. Hexavalent chromium was reported at levels higher than the maximum levels reported in off-site samples.

Nitrate and chlordane were reported at elevated levels in the dog pen areas. The highest reported activity of radium-226 or strontium-90 was at or below the highest activity levels reported off-site.

In the north chemical dispensing area, chlordane, nitrate and mercury were reported at levels higher than the highest reported detection in off-site samples.

During the quarterly groundwater monitoring, several metals, VOCs, pesticides, nitrate, and tritium have been reported in the first HSU at levels above drinking water standards. Several metals, nitrate, pesticides, and tritium have been detected in the second HSU. The metals and nitrate have been reported above drinking water standards in wells both upgradient and downgradient of the LEHR site. Pesticides have only been reported in three wells along the upgradient border of the LEHR site. VOCs and tritium are

typically above drinking water standards in wells downgradient of the UC Davis landfill units and trenches.

Some organic chemicals, metals, nitrate, and pesticides were reported in surface water samples collected both upstream and downstream of the LEHR site. In some cases these reported detections were above state drinking water levels. Tritium, carbon-14 and strontium-90 were detected sporadically in surface water samples at levels below the drinking water standards.

3.1.13 Assessment of LEHR Imhoff and Radium Septic Waste

In March 1989, UC Davis sampled the liquid and sludge fractions of the strontium-90 (Imhoff) and radium septic tanks for possible hazardous materials in order to characterize the waste for disposal. The sludge was found to contain radioactive materials, primarily radium-226 and strontium-90, in varying concentrations. Several ~~semi volatile organic compounds~~ SVOCs, including naphthalene, fluorene, anthracene, pyrene, and bis-2-ethylhexyl phthalate, were reported in samples collected from the Imhoff tanks. Details of the analytical results from this investigation are presented below in Section 3.2.3.

3.1.14 Final Report of Liquid and Sludge Removal

In 1991 and 1992, the liquid and sludge contained in the Imhoff and radium septic systems were removed, solidified and shipped to the Hanford facility in state of Washington. After the liquids and sludges were removed, the interior surfaces of the tanks were screened for surface contamination.

Samples of the concrete and adjacent soil were collected from each tank and analyzed for radioactivity. Additionally, sludges remaining in the one settling tank of the Imhoff system were analyzed for ~~volatile~~ VOCs and ~~semi-volatile organic compounds~~ SVOCs. Total xylenes were reported up to 9,400 ~~µg/kg~~ mg/kg. Semi-volatile organic compounds, including anthracene at 540 mg/kg, dibenzofuran at 1,300 mg/kg, fluorene at 2,100 mg/kg and pyrene at 1,100 mg/kg, were reported from sludge samples. Additional

details on the results of samples collected during this investigation are found in the original report and are summarized in Section 3.2.3.

3.2 WASTE DISPOSAL AREAS

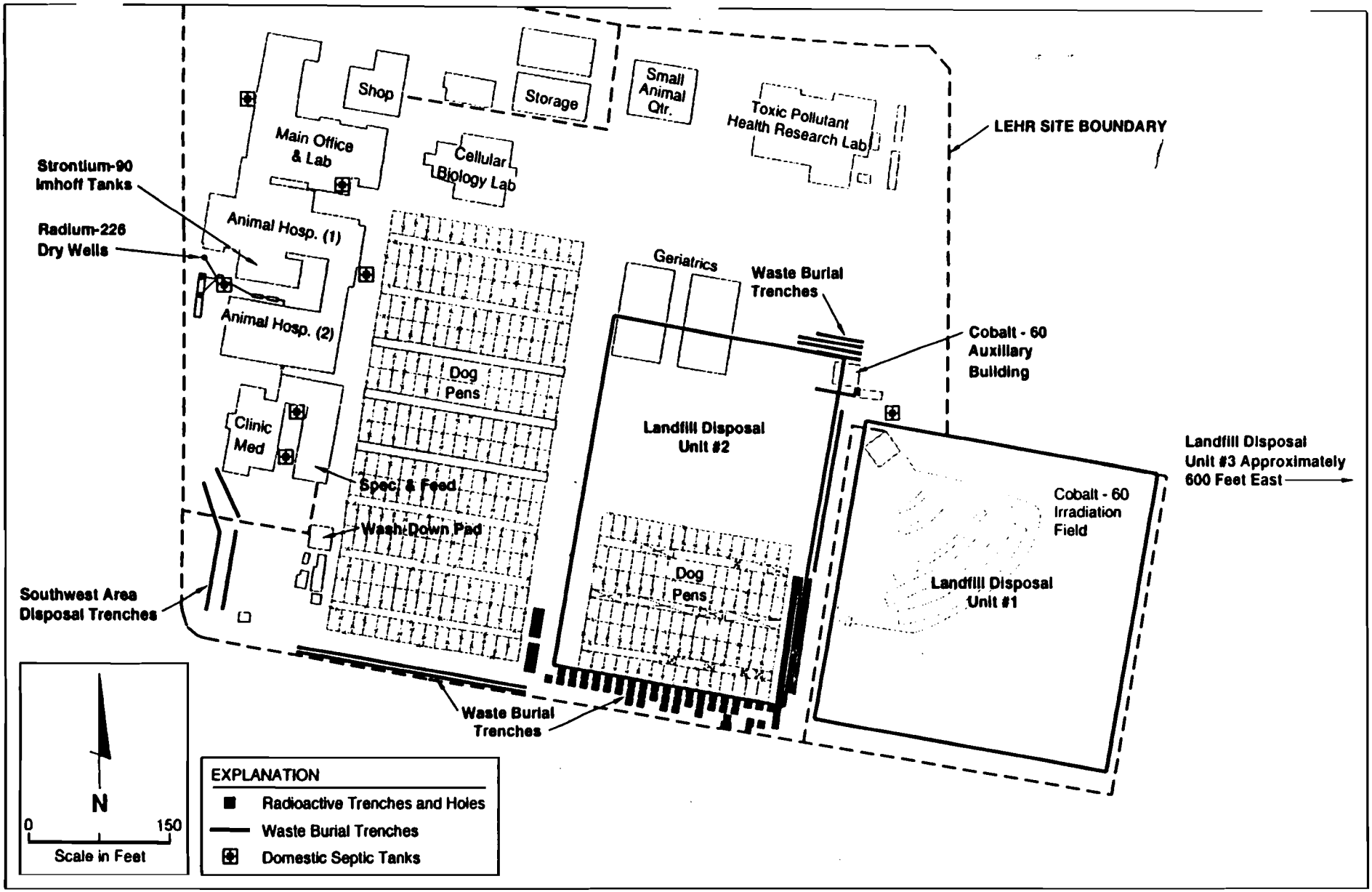
This section presents a discussion of the waste disposal areas identified at the LEHR site. Where available, tabulations of waste disposed in each area are supplied, and environmental impacts from past operations in each area are presented. Figure 3.1 shows the former waste disposal areas at the LEHR site.

For each of the waste disposal areas, a summary of the results from previous investigations is presented. For investigations prior to the Phase II Site Characterization, data have been reviewed and only the highest reported detection from all these studies has been shown on supporting tables. This has been done because most of the previous investigations did not have formal QA/QC programs and, therefore, this data may not be conclusive as a guide for this RI/FS. The Phase II Site Characterization data are more substantial, and are considered to be comparable to EPA Level III analytical data. Because the quantity and quality of this data is greater compared to previous investigations, these data are presented in more detail including the number of samples, the number of detections, the highest detailed value, and the mean and standard deviation for data sets from real areas.

3.2.1 Southwest Disposal Area and DOE Disposal Box

Low-level radioactive solid waste generated by DOE-sponsored research at the LEHR site was disposed in trenches located primarily in the southwest corner of the site (Figure 3.1). Based on historic aerial photo review, several individual trenches existed along the western side of this area, and the area appears to have been disturbed several times subsequent to initial disposal activity. Solid wastes with higher levels of radioactivity were reportedly disposed in the DOE Disposal Box located between the two sets of outdoor dog pens. The DOE Disposal Box is reportedly a steel dumpster-like container. The exact location of this container is not known.

Consistent with results from previous investigations, results reported from soil samples collected and analyzed during the Phase II investigation indicate the highest



FORMER WASTE DISPOSAL AREAS

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FIGURE 3.1

measurements of gross alpha, gross beta, and tritium activity were reported in samples from the southwest disposal area. Generally, measurements reported from previous investigations were higher than measurements reported from the Phase II investigation. During the Phase II Investigation, no VOCs were detected and only one ~~semi-volatile organic compound~~ SVOCs (D-n-butylphthalate) was reported in soil samples from this area. No samples have been collected from the area of the DOE Disposal Box.

Table 3.2 presents summary analytical results of samples collected from the southwest disposal area. The data presented include the highest detections of parameters identified during the previous investigations (Section 3.1), and a limited statistical summary of data collected from the southwest area during the Phase II Site Characterization.

3.2.2 UC Davis Disposal Trenches

UC Davis reportedly disposed of waste in 17 trenches and 49 pits located along the southern boundary and eastern portion of the LEHR site. The UC Davis trenches are reported to have been approximately 2 feet wide and from 33 to 270 feet long. Disposal pits were typically 4 feet by 4 feet wide, and the trenches and pits were reported to be between 8 and 10 feet deep. Wastes from general UC Davis campus activities that potentially contained radiologic materials were reportedly disposed in these trenches and pits. In addition, it was reported by UC Davis personnel that some chemicals and laboratory wastes were disposed in these trenches and pits. Actual volumes, conditions and concentrations of wastes disposed in the trenches and pits is unknown. During previous investigations, some of the wastes were confirmed to be biological (Wahler, 1988; Dames & Moore, 1991b). Warren (1985) estimated the total quantity of waste disposed in trenches and pits to be 30,150 cubic feet. Waste was reportedly covered with up to 4 feet of material. According to Warren (1985), approximately 1.9 curie of radiologic materials are documented to have been buried in the disposal pits. A tabulation of available waste disposal information for the trenches and pits is presented in Table 3.3. Approximate locations of the disposal trenches and pits are shown on Figure 3.2.

TABLE 3.3 LEHR RADIOACTIVE WASTE BURIAL DATA

I. Radioactive Waste Burial Holes

Hole No.	Date	Description and Estimated Radionuclide Quantity
1	Unknown	Radioactive cow buried. Exact location and date not known. Cow buried on a Sunday.
2	1956	Dug in 1956. Exact location not known.
3	5/16/61	Radioactive calves buried 6' -0" deep from Vet. Med., Armstrong Tract. Exact location not known.
4	Unknown	Unknown
5	Unknown	Unknown
6	Unknown	Unknown
7	Unknown	Unknown
8	Unknown	Unknown
9	2/5/63	Not included in original table.
10	4/23/63	Not included in original table.
11	7/9/63	Not included in original table.
12	9/5/63	0.537 nCi ^{14}C
13	9/28/63	.005 mCi ^{59}Fe
14	10/8/63	.03 mCi ^{59}Fe
15	10/18/63	0.102 nCi ^{59}Fe
16	3/3/64	3 nCi ^{45}Ca + 0.05 nCi ^{14}C + 4 nCi ^{32}P
17	6/5/64	2.5 nCi ^{35}S + 4 nCi ^{14}C
18	9/9/64	.4 mCi C14 + .5 mCi ^{35}S + .75 mCi ^{14}C
19	9/20/64	8 mCi ^{45}Ca + .1 mCi ^{3}H
20	12/14/64	.015 mCi ^{85}Sr + .06 mCi ^{137}Cs
21	3/16/64	6 nCi ^{45}Ca + .1 mCi ^{14}C
22	2/1/65	0.5 nCi ^{45}Ca
23	2/12/65	.06 mCi ^{59}Fe
24	4/22/65	0.560 mCi ^{45}Ca, 8 mCi ^{32}P
25	8/17/65	^{14}C-0.2 mCi, ^{3}H-0.1 mCi, ^{35}S-0.01 mCi, ^{59}Fe-0.06 nCi
26	9/8/65	^{3}H-0.005 mCi, ^{35}S-0.05 mCi, ^{85}Zn-0.503 mCi, ^{22}Na-0.02 mCi ^{45}Ca-0.24 mCi, ^{131}I-0.50 mCi, ^{14}C-0.334 mCi, ^{59}Fe-0.99 mCi
27	4/26/66	^{14}C-0.8 mCi
28	10/24/66	^{14}C-0.16 mCi, ^{59}Fe-0.05 mCi, ^{238}U-0.002 mCi, ^{226}Ra-0.018 mCi ^{203}Hg-1.5 mCi
29	2/6/68	^{137}Cs-.05 mCi, ^{14}C-11.174 mCi ^{3}H110.001 mCi, ^{131}I-1.026 mCi
30	6/14/68	^{14}C-32.1992 mCi, ^{60}Co-.23 mCi, unknown .005 mCi
31	7/12/68	^{137}Cs-.15 mCi, ^{3}H-2.21 mCi, ^{60}Co-.003 mCi, ^{14}C 18.276 mCi

TABLE 3.3 LEHR RADIOACTIVE WASTE BURIAL DATA (continued)

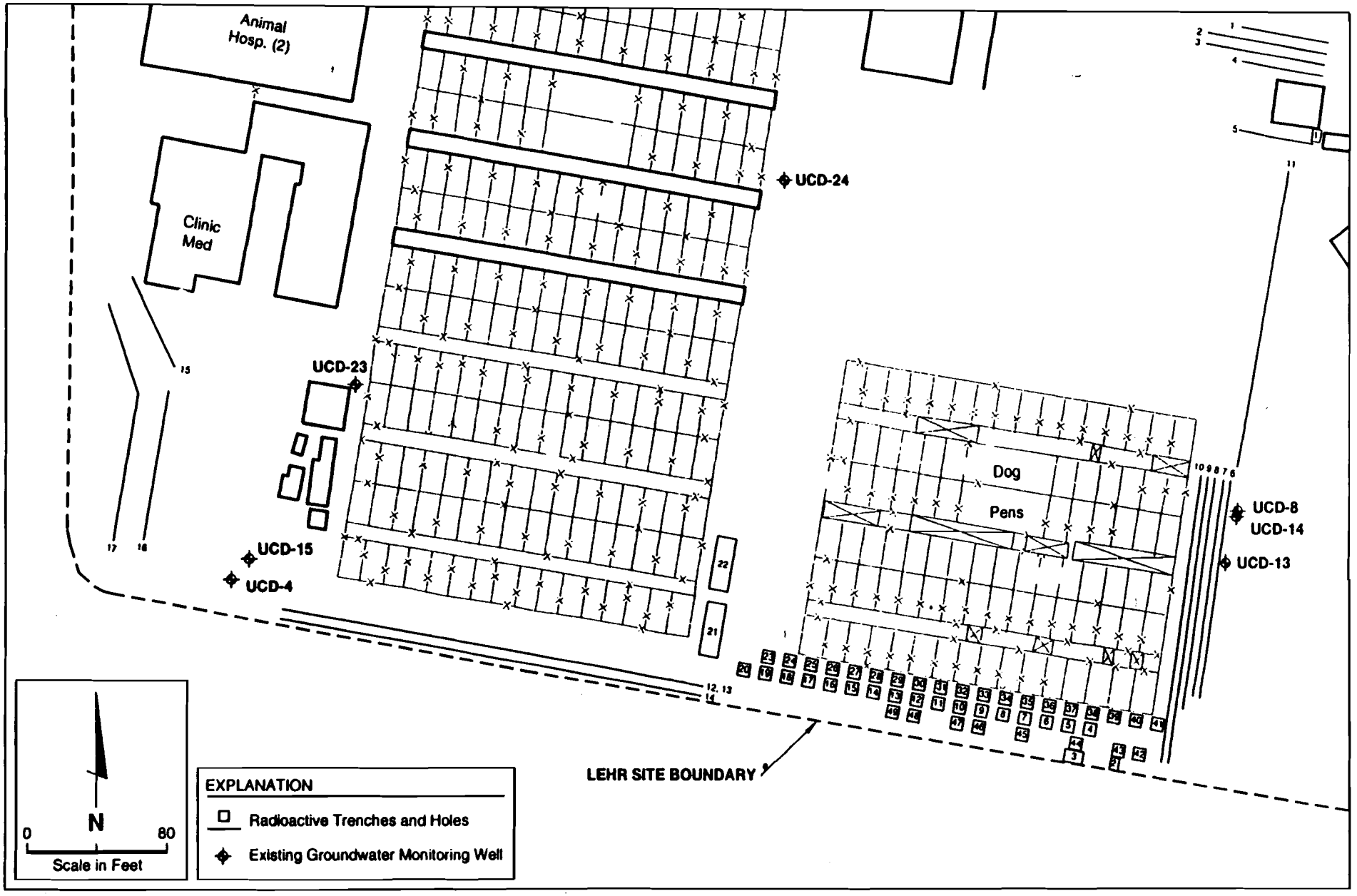
Hole No.	Date	Description and Estimated Radionuclide Quantity
32	7/17/69	^{14}C-44.77 mCi
33	8/7/69	^{14}C-27.033 mCi
34	9/11/69	^{3}H-55.282 mCi, ^{14}C-32.251 mCi
35	3/19/70	^{3}H-26.388 mCi, ^{14}C-42.699 mCi
36	5/21/70	^{3}H-24.903 mCi, ^{14}C-45.2547 mCi, ^{60}Co-.005 mCi
37	6/25/70	^{3}H-4.4083 mCi, ^{14}C-47.9436 mCi, ^{35}S-.5 mCi
38	4/13/71	^{3}H-19.621 mCi, ^{14}C-33.318 mCi, ^{35}S-0.6 mCi
39	1/4/72	^{3}H-24.451 mCi, ^{14}C32.392 mCi, ^{35}S-6.3 mCi, ^{22}Na -1.051 mCi
40	7/14/72	^{3}H-93.4 mCi, ^{14}C-30 mCi
41	8/22/72	^{3}H-38.85 mCi, ^{14}C-33.1 mCi, ^{125}I-1.5 mCi
42	11/2/72	^{14}C-15.294 mCi, ^{3}H-44.035 mCi, ^{125}I-4.5 mCi
43	2/1/73	^{14}C-35.1 mCi, ^{3}H-26.0 mCi, ^{125}I-5.0 mCi
44	4/12/73	^{14}C-60.1 mCi, ^{3}H-75.0 mCi, ^{125}I-5.0 mCi
45	6/5/73	^{14}C-32.55 mCi, ^{3}H-42.7 mCi, ^{32}P-46.66 mCi
46	10/18/73	^{3}H-51.96 mCi, ^{14}C-45.55 mCi, ^{32}P-67.26 mCi
47	2/20/73	^{14}C-28.63 mCi, H-3 30.17 mCi, ^{32}P-90.31 mCi
48	4/4/74	^{32}P-89.401 mCi, ^{3}H-45.286, ^{14}C-25.53 mCi, ^{125}I-.8768 mCi, ^{45}Ca-.31 mCi, ^{22}Na-.1351 mCi, ^{86}Rb-3.8 mCi, ^{57}Co-.0065 mCi, ^{51}Cr/^{75}Se/^{59}Fe/^{99}Mo/^{198}Au/^{133}Xe/^{111}In/^{203}Hg/^{67}Ga (approximately 1.3 mCi each)
49	7/16/74	^{14}C-24.506 mCi, ^{3}H-83.981 mCi, ^{32}P-79.55 mCi, ^{35}S-11.05 mCi, ^{22}Na-.114 mCi, ^{86}Rb-4.2 mCi, ^{75}Se-.2 mCi, ^{45}Ca-.001 mCi, ^{59}Fe-.1 mCi, ^{36}C1-.254 mCi

TABLE 3.3 LEHR RADIOACTIVE WASTE BURIAL DATA (continued)

II. Radioactive Waste Burial Trenches

Trench No.	Date	Description
1	Unknown	2'0" wide, 66'0" long, 10'0" from north fence line, and 3'0" from east fence line. Covered June 10, 1957.
2	6/10/57	2'0" wide, 100'0" long, 16'0" from north fence line, and 3'0" from east fence line. Opened on June 10, 1957 and covered on October 27, 1957.
3	10/25/57	Same dimensions as Radioactive Trench #2. Distance from north fence line not known. Opened on October 25, 1957 and covered on May 9, 1958.
4	5/9/58	2'0" wide, 45'0" long, and 30'0" from north fence line. Opened on May 9, 1958 and on November 1958.
5	5/9/58	2'0" wide, 33'0" long, and 63'0" from north fence line. Opened on May 9, 1958 and on November 1958.
6	11/13/58	Dimensions on plot plan at right. Opened on November 13, 1958 and covered on May 29, 1959.
7	5/29/59	2'0" wide and 123'0" long. Distance from east fence line not known. Trench dug on May 29, 1959 and covered on April 8, 1960.
8	4/8/60	2'0" wide and length to center of rubbish Pit #3. Distance from east fence not known. Opened on April 8, 1960 and covered on September 28, 1960.
9	9/23/60	2'0" wide and to center of rubbish Pit #3. 36'0" from east fence line. Opened on September 23, 1960 and probably closed on November 7, 1960.
10	11/7/60	Exact dimensions and location not known. Opened on November 7, 1960 and closed March 13, 1961.
11	3/13/61	2'0" wide, 180'0" long and 9'0" to center of trench from east fence line. Opened on March 13, 1961. Date closed not known.
12	12/5/58	2'0" wide, 8'0" long, and 55'0" from southwest corner. 9'6" to center of trench from south fence. Charged to University Physician, Job #215160. Opened December 5, 1958. Date closed not known.
13	5/29/59	Continuation of Radioactive Trench #12. Opened on May 29, 1959 and closed on April 8, 1960.
14	4/8/60	2'0" wide. Located between Radioactive Trench #13 and south fence line. Opened on April 8, 1960. Date closed unknown.
15	Unknown	Most likely used between 9/63 and 11/65. Probable contents - radium-226 and strontium-90 from dog fecal waste.
16	Unknown	As #15.
17	Unknown	As #15 and #16

Source: Warren, 1985
NOTE: Radionuclide quantities as recorded in Warren (1985); information not confirmed. Actual volumes of waste not known.



APPROXIMATE LOCATIONS OF WASTE BURIAL TRENCHES

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FIGURE 3.2

Based on information provided by UC Davis (Table 3.3), most burial trenches or pits could contain both chemical and radiologic wastes. Trenches located in the southwest corner and the southern border of the main dog pens are reported to contain primarily LEHR waste. Other trenches between the two dog pens reportedly contain radiologic carcasses and other waste from the LEHR project. Other waste trenches and pits were reported to have been used primarily by UC Davis; however, since these burial sites were open during LEHR site operations, there is the potential they may contain DOE radioactive wastes, too.

Table 3.4 presents summary data from the previous investigations of these disposal trenches (Rockwell, 1984; Wahler, 1988; Wahler, 1989; Dames & Moore, 1991) Analytical results reported from soil samples collected from the UC Davis disposal trench areas indicate low levels of radionuclides comparable to off-site analyses. Tritium was reported in soil samples from these areas at concentrations that exceeded off-site levels. Analytical results for pesticides ~~in Table 3.4~~ included analyses of an intact vessel of concentrated pesticide that contained 68% heptachlor, 4.1% Carbophenathion and 0.38% Dieldrin. ~~Soil samples from the same vicinity reported very low concentrations of these same pesticides.~~ During the Phase II Site Characterization, no samples were collected from the UC Davis trenches.

3.2.3 Radium-226 and Strontium-90 Septic Systems

Radiologic wastes generated from animal experiments using bone-seeking radionuclides were treated using two primary systems. From 1960 to 1987, effluent from strontium-90 experiments was processed through an Imhoff sewage treatment system. From 1982 to 1984, a total of 39.59 μCi of plutonium-241 and 0.136 μCi of americium-241 was processed through the Imhoff treatment system. The Imhoff system utilized the principals of primary sedimentation, aeration, chemical clarification, and filtration prior to passing wastewater through 5 cubic feet of a cation exchange resin (Figure 3.3). According to Goldman, et. al (1963), this system provided a decontamination factor up to 5×10^{-4}. This system was used to treat approximately 200 to 500 gallons of waste per day prior to discharging it to leach fields. The total throughput of strontium-90 to the Imhoff system is estimated at 943.2 mCi. After treatment through the Imhoff system, an estimated 2.55 mCi of strontium-90 was released to the Imhoff leach field and subsurface soil. The half-life of strontium-90 is 29 years.

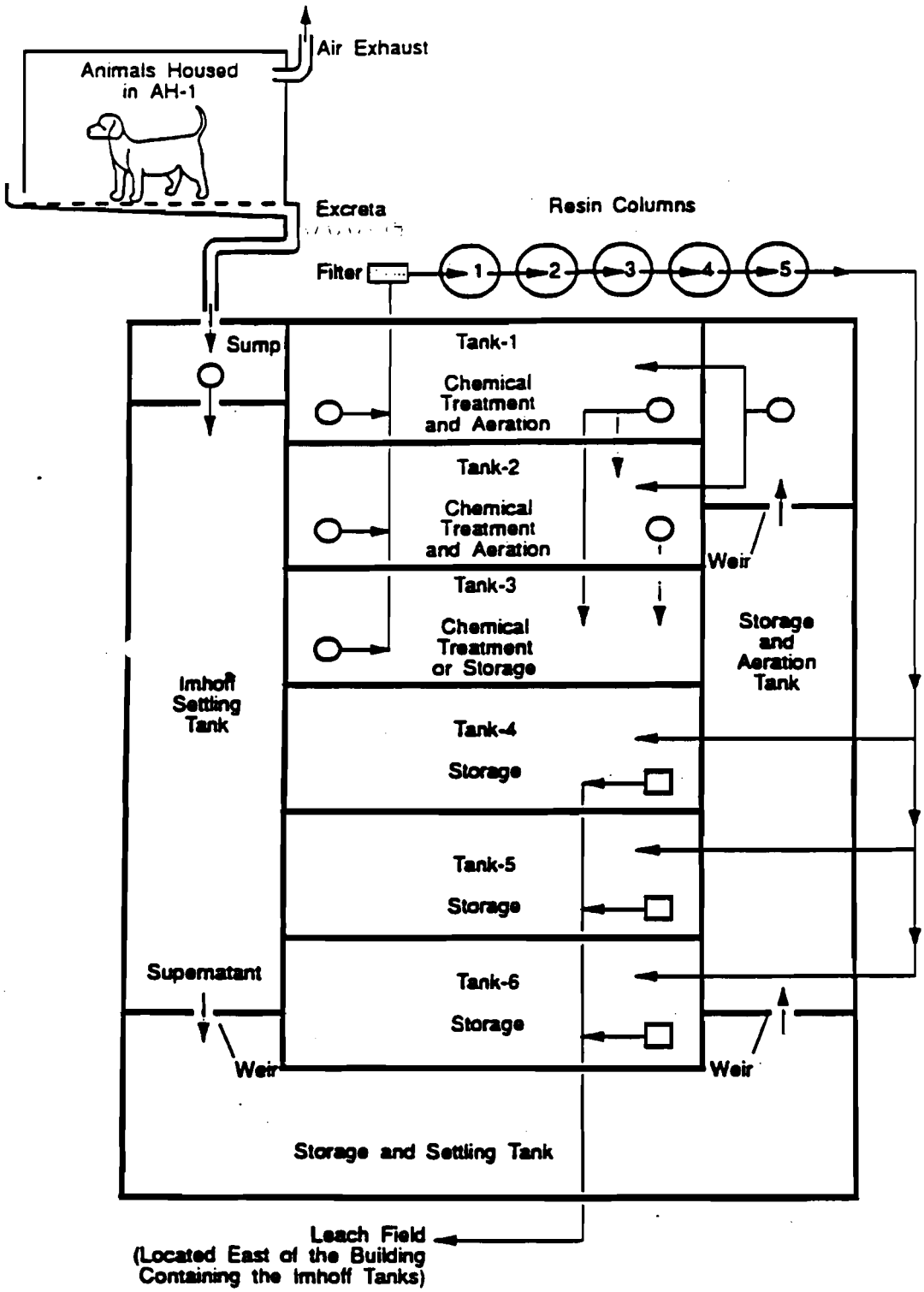
TABLE 3.4 SUMMARY SOIL DATA UC DAVIS DISPOSAL TRENCHES

		Previous[a] Investigations
	Parameter	Highest Detected Value
Semi Volatile Organics (μg/Kg)	Bis 2 Ethylhexylphthalate	ND
	DI N Butyl Phthalate	ND
Volatile Organics (μg/Kg)	Chloroform	NA
	1,1 dichloroethene	NA
	Methylene chloride	NA
Radiologic Constituents (pCi/g)	Gross alpha	5 ± 4
	Gross beta	21 ± 3
	Tritium	4839 ± 110
	Bismuth-214	ND
	Lead-212	ND
	Lead-214	ND
	Strontium-90	3.94
	Potassium-40	11.96 ± 0.6
	Cesium-137	15.1 ± 0.3
	Radium-226	0.52 ± 0.05
	Thorium-232	0.58 ± 0.06
	Carbon-14	794 ± 4
	Plutonium-241	ND
Nitrate (mg/Kg)	Nitrate	ND

TABLE 3.4 SUMMARY DATA UC DAVIS DISPOSAL TRENCHES (continued)

	Parameter	Previous[a] Investigations Highest Detected Value
Metals (mg/Kg)	Antimony	ND
	Arsenic	ND
	Barium	ND
	Beryllium	ND
	Cadmium	ND
	Cobalt	ND
	Hexavalent chromium	ND
	Chromium (total)	ND
	Copper	ND
	Mercury	ND
	Molybdenum	ND
	Nickel	ND
	Lead	ND
	Silver	ND
	Selenium	ND
	Thallium	ND
	Vanadium	ND
	Zinc	ND

NA Not Analyzed
ND Not Detected
[a] Previous Investigations Include: Rockwell, 1984; Wahler, 1988; Wahler, 1989; Dames & Moore, 1991
Note: No Data was collected in this Area during the Phase II Site Characterization



REFERENCE: Goldman, M., et al, 1963

SCHEMATIC REPRESENTATION OF THE IMHOFF TREATMENT SYSTEM

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FIGURE 3.3

The Imhoff tanks are below-grade and lined with concrete sealed with plastic sealant. Total capacity of the Imhoff tanks is 46,000 gallons, and during the years of operation, they filled up with sludge. Sludge was periodically removed by a subcontractor or pumped to a tanker trailer. During system operations, the removed sludge was periodically disposed off-site. ~~All s~~Sludge remaining in the Imhoff system was packaged, transported, and disposed of by DOE in 1992 (Chemical Waste Management, 1992).

The average concentration of strontium-90 reportedly released to the leach field was 3×10^{-7} μCi/ml, in compliance with standards established by the Nuclear Regulatory Commission (NRC). This concentration was recorded to have been occasionally exceeded 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 wastes.

The Imhoff system has been inactive since 1987 when some of the drain lines were purged. During the sludge removal operations (Chemical Waste Management, 1992), the plastic sealant in all tanks were observed to be cracked and blistering, leaving concrete exposed. The integrity of the Imhoff system has never been tested.

Table 3.5 summarizes, by year, the volume and strontium-90 level of inflow and effluent from the Imhoff system discharged to the leach fields, as recorded in DOE files. The table shows the number of batches of effluent treated during each year of system operation, total gallons included in those batches, the resulting clarified waste introduced to the exchange columns, and effluent strontium-90 concentrations.

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 concentrations of radioactivity and ~~semi-volatile organic compounds~~ SVOCs.

In 1991 and 1992, liquids and sludge remaining in the Imhoff tanks was removed, solidified, and disposed at the Hanford facility in the state of Washington. Currently, approximately 500 to 1,000 gallons of sludge are still in the Imhoff Settling Tank. Table 3.6 presents a summary of analytical results from sludge and soil samples collected from

TABLE 3.5 WASTEWATER TABULATION IMHOFF SYSTEM (Sr-90)

Year	No. of Batches	Total Gallons	Clarified Waste (mCi)[a]	Decontamination Effluent (μCi)[b]
1960-1961	16	6,300	4	19
1962	17	8,500	18	5
1963	19	9,400	15	11
1964	57	250,800	48	20
1965	53	226,800	83	216
1966	57	234,900	138	89
1967	70	280,700	144	389
1968	55	245,100	143	248
1969	30	151,200	25	150
1970	35	178,300	10	91
1971	37	192,400	2	181
1972	37	192,200	5	75
1973	37	192,400	2.64	81
1974	35	182,000	2.46	175
1975	33	171,600	1.43	332
1976	31	161,200	1.06	61
1977	26	130,000	0.991	50
1978	10	52,000	0.472	13
1979	25	135,000	0.659	25
1980	15	78,000	0.275	22
1981	7	36,400	0.165	31
1982	4	20,800	0.110	10
1983	4	20,800	0.078	5.5
1984	N/A	41,600	N/A	31
1985	N/A	54,000	N/A	26
1986	N/A	20,800	N/A	65
1987	N/A	15,600	N/A	139.5
Totals	710	3,288,800	645.340	2,555

Source: DOE, 1988

N/A Data not available.

[a] Entering resin columns

[b] Discharged to leach field

TABLE 3.6 SUMMARY SOIL DATA STRONTIUM-90 TREATMENT SYSTEM

		1989 Tank A Sludge	1992 Tank A Sludge	Phase II Site Characterization				
	Parameter	Highest Detected Value	Highest Detected Value	Number Sampled	Number Detected	Highest Detected Value	Mean	Standard Deviation
Semi Volatile Organics (mg/Kg)	Naphthalene	33,000	ND	21	0	--	--	--
	dimethyl Phthalate	890	ND	21	0	--	--	--
	Acenaphthene	9,300	1,600	21	0	--	--	--
	Fluorene	7,000	2,100	21	0	--	--	--
	Phenanthrene	20,000	540	21	0	--	--	--
	Anthracene	2,100	540	21	0	--	--	--
	Fluoranthene	4,600	ND	21	0	--	--	--
	Pyrene	6,800	1,100	21	0	--	--	--
	Bis 2 Ethylhexylphthalate	3,700	ND	21	0	--	--	--
	Chrysene	1,400	190	21	0	--	--	--
	Benzo (k) fluoranthene	2,500	ND	21	0	--	--	--
	2 methylmaphthalene	ND	3,800	21	0	--	--	--
	Acenaphthylene	ND	94	21	0	--	--	--
	Benzo (a) anthracene	ND	220	21	0	--	--	--
	Dibenzofuran	ND	1,300	21	0	--	--	--
Volatile Organics (ug/Kg)	Total xylenes	ND	9,400	12	0	--	--	--
Radiologic Constituents (pCi/g)	Gross alpha	7 ± 3	NA	21	13	2.30	1.41538	0.59840
	Gross beta	60 ± 7	NA	21	21	7.60	3.87619	2.35964
	Tritium	0.04 ± 0.03	313,468 ± 2,463	21	0	--	--	--
	Bismuth-214	ND	NA	2	2	0.39	0.34500	0.06364

TABLE 3.6 SUMMARY DATA STRONTIUM-90 TREATMENT SYSTEM (continued)

		1989 Tank A Sludge	1992 Tank A Sludge	Phase II Site Characterization				
	Parameter	Highest Detected Value	Highest Detected Value	Number Sampled	Number Detected	Highest Detected Value	Mean	Standard Deviation
	Lead-212	ND	NA	13	13	0.64	0.41769	0.07726
	Lead-214	ND	NA	2	2	0.46	0.43500	0.03536
	Strontium-90	1.6 ± 0.2	4.226 ± 54	21	0	--	--	--
	Potassium-40	12.7 ± 0.6	NA	21	21	12.31	8.07190	1.93599
	Cesium-137	6.2 ± 0.3	NA	21	1	0.10	0.10000	0.00000
	Radium-226	0.57 ± 0.05	2.62 ± 0.50	21	7	0.75	0.49571	0.18990
	Thorium-232	0.60 ± 0.06	0.6 ± 0.15	21	2	1.00	0.85000	0.21213
	Carbon-14	NA	NA	0	0	--	--	--
	Plutonium-241	<50	7.2 ± 0.8	0	0	--	--	--
Nitrate (mg/Kg)	Nitrate		80	21	21	92.00	23.75714	27.11407
Metals (mg/Kg)	Antimony	<30	NA	21	0	--	--	--
	Arsenic	1.1	NA	21	21	5.10	3.62857	0.63257
	Barium	46	NA	21	18	152.00	105.41667	35.79198
	Beryllium	<1	NA	21	14	0.050	0.25000	0.14544
	Cadmium	4	NA	21	4	0.90	0.52500	0.43493
	Cobalt	<3	NA	21	21	38.40	28.72857	5.46454
	Hexavalent chromium		NA	21	16	7.00	1.94375	1.97820
	Chromium (total)	<2	NA	21	21	153.20	64.78095	29.25267
	Copper	120	NA	21	19	8.00	6.32105	1.05545

TABLE 3.6 SUMMARY DATA STRONTIUM-90 TREATMENT SYSTEM (continued)

	1989 Tank A Sludge	1992 Tank A Sludge	Phase II Site Characterization				
Parameter	Highest Detected Value	Highest Detected Value	Number Sampled	Number Detected	Highest Detected Value	Mean	Standard Deviation
Mercury	0.14	NA	21	14	0.55	0.18214	0.15403
Molybdenum	<2	NA	21	0	--	--	--
Nickel	76	NA	21	21	271.00	176.47143	66.72987
Lead	34	NA	21	21	8.00	5.90476	1.27180
Silver	<3	NA	21	0	--	--	--
Selenium	<1.4	NA	21	0	--	--	--
Thallium	<30	NA	21	0	--	--	--
Vanadium	<5	NA	21	21	22.00	15.74286	3.02334
Zinc	110	NA	21	21	120.00	60.09524	18.92328

-- Not Applicable
NA Not Analyzed
ND Not Detected

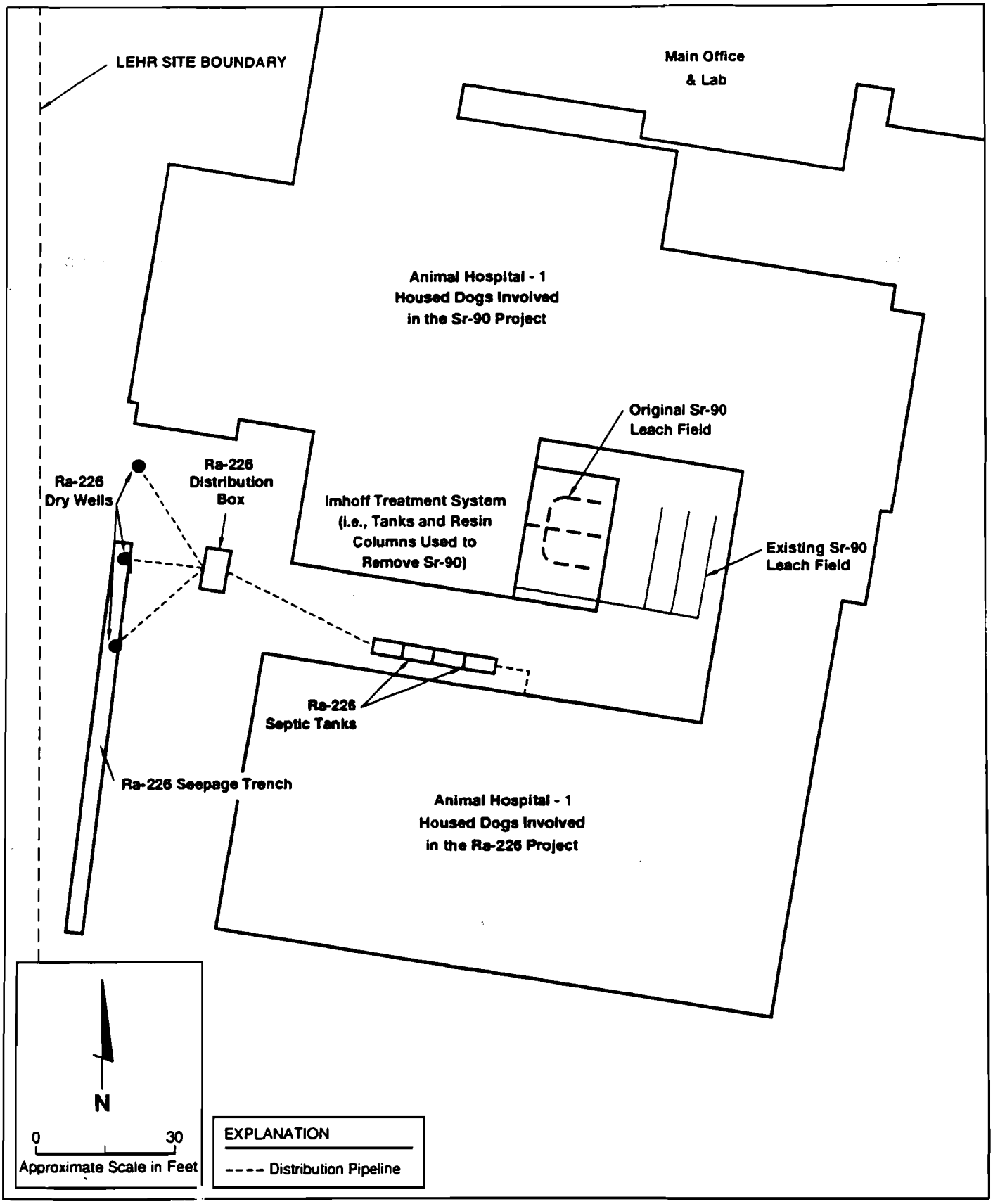
the Imhoff system and adjacent soil. Sludge samples contained a variety of semi-volatile constituents which were not reported in the 21 soil samples collected from the strontium-90 leach field. The Imhoff Settling Tank contained xylene, the only volatile compound detected in the sludge. No volatiles were reported from soil samples collected from the strontium-90 leach field.

Radionuclides were also analyzed in the sludge and surrounding soils. Reported detections in 1992 for strontium-90, tritium, and radium-226 exceeded levels for those constituents analyzed in 1989. Soil samples from the strontium-90 leach fields reported activities consistent with off-site samples analyzed for radionuclides.

Sludge and soil were sampled and analyzed for nitrate and metals. The reported concentrations of copper in sludge exceeded the highest value in soils by 10 times. Other metals and nitrate concentrations were similar in sludge and soils and appeared consistent with off-site samples.

The sludge has reported levels of various organic compounds, including total xylenes up to 9,400 ~~µg/Kg~~ mg/kg, 2-methylnaphthalene up to 3,800 mg/Kg, dibenzofurans up to 1,300 mg/Kg, fluorene up to 2,100 mg/Kg, and pyrene up to 1,100 mg/Kg (Chemical Waste Management, Inc. 1992). Table 3.6 presents summary data of samples collected from the Imhoff system and adjacent soil. Limited statistical data is also presented based on the results of the samples collected during the Phase II Site Characterization.

The second waste treatment system, ~~also~~ located ~~innext to~~ the Imhoff building, consisted of the radium-226 processing system (Figure 3.4). A cumulative total of 6.129 mCi of radium-226 was injected into beagles housed in Animal Hospital 2 (DOE, 1988). Of that 6.129 mCi, approximately 3.827 mCi were subsequently discharged to the radium-226 processing system. This system consisted of septic tanks, dry wells, and a seepage trench as shown on Figure 3.4. The combined capacity of the septic tanks is 14,400 gallons. The septic tanks allowed for the settling of solids, whereas fluids were fed through a distribution box to one of three vertical dry wells (Figure 3.5). After frequent failures with the original system, a 91-foot-long, 14-foot-deep, and 3-foot-wide cobble-lined seepage trench was added in 1965.



LOCATION OF THE IMHOFF AND THE RADIUM-226 TREATMENT SYSTEMS

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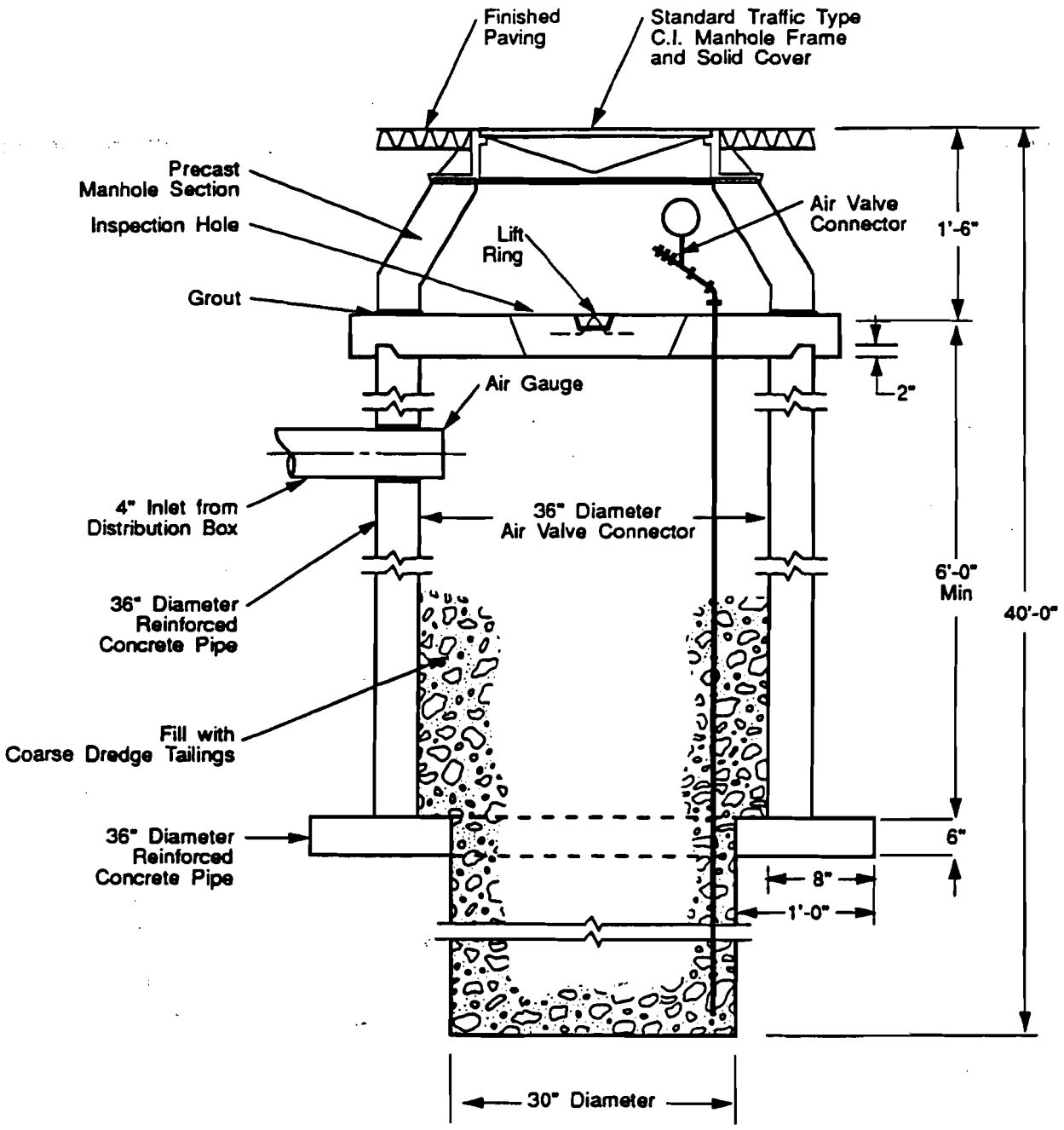
FIGURE 3.4



REFERENCE: ! CD, 1962

CONSTRUCTION DETAILS OF THE RADIUM-226 VERTICAL DRY WELL

RI/FS Work Plan
LEHR Environmental Restoration
Davis, California

10805-454-044 DOE7

FIGURE 3.5

After initial failures, another overflow incident occurred with the radium-226 system in 1985. A sanitary line was blocked causing sewage to back up into the eastern radium-226 septic tank. This material was then pumped directly to the dry wells. Subsequent to this incident, the system was taken out of use. No formal closure has been initiated. During the initial investigation of the LEHR site (Rockwell, 1984), it was observed that one of the radium-226 septic tanks was empty and is speculated to have leaked.

In 1991 and 1992, all sludge remaining in the radium-226 tanks was solidified and disposed at the Hanford facility in state of Washington. Currently, all four of the tanks associated with the radium-226 treatment system are empty.

Table 3.7 presents summary analytical data for samples collected from the radium-226 treatment system and adjacent soil. Statistical data are also presented based on the results of the samples collected during the Phase II Site Characterization. Strontium-90 has been reported up to 1.0 pCi/g in soil samples collected and analyzed proximal to the radium-226 seepage pits. Nitrate was reported up to 736 mg/Kg, which is the highest concentration in soil on the LEHR site from this area.

3.2.4 Domestic Septic Systems

The main office and hospital complex buildings are located along the western portion of the LEHR site (Figure 2.2). Six domestic septic tanks were installed to receive non-radioactive wastes from these facilities. A seventh tank was installed adjacent to the cobalt-60 field building to receive wastes from that building. Accurate documentation on influent sources for each of the tanks has not been located, and may not exist. However, because the domestic septic tanks received wastes from the laboratories, including floor drains and sinks, the potential exists for the domestic septic tanks to have received potentially hazardous or radioactive wastes.

TABLE 3.7 SUMMARY SOIL DATA RADIUM-226 TREATMENT SYSTEM

		Previous[a] Investigations	UCD Sludge (1989)	Phase II Site Characterization				
	Parameter	Highest Value Detected	Highest Value Detected	Number Sampled	Number Detected	Highest Detected Value	Mean	Standard Deviation
Semi Volatile Organics (ug/Kg)	Bis 2 Ethylhexylphthalate	3,300	ND	33	0	--	--	--
	DI N Butyl Phthalate	ND	ND	33	0	--	--	--
Volatile Organics (ug/Kg)	Chloroform	ND	ND	33	0	--	--	--
	1,1 dichloroethene	ND	ND	33	0	--	--	--
	Methylene chloride	12	ND	33	13	44.20	20.05385	8.64404
Pesticides (mg/Kg)	Chlordane	ND	ND	33	0	--	--	--
	Dieldrin	ND	ND	33	0	--	--	--
	Aldrin	ND	ND	33	0	--	--	--
	Heptachlor	ND	ND	33	0	--	--	--
Radiologic Constituents (pCi/g)	Gross alpha	7 ± 3	NA	33	31	2.10	1.14516	0.55126
	Gross beta	62 ± 9	NA	33	33	6.60	4.74848	1.43856
	Tritium	0.04 ± 0.03	2.22 ± 0.56	33	1	0.40	0.40000	0.00000
	Bismuth-214	ND	ND	5	5	3.03	1.48000	1.03904
	Lead-212	ND	ND	10	10	0.93	0.53500	0.19254
	Lead-214	ND	ND	6	6	1.14	0.92667	0.19826
	Strontium-90	1.0 ± 0.2	13.6 ± 0.4	33	12	0.61	0.23667	0.16008
	Potassium-40	14.7 ± 0.7	ND	33	33	17.24	8.72606	4.40221
	Cesium-137	0.09 ± 0.02	ND	33	2	0.26	0.25000	0.01414
	Radium-226	1.23 ± 0.06	205.8 ± 1.4	32	19	1.35	0.78947	0.28011
	Thorium-232	0.71 ± 0.06	3.18 ± 1.44	33	14	1.00	0.72143	0.16257
	Carbon-14	NA	NA	0	0	--	--	--
	Plutonium-241	<50	0.7 ± 0.1	0	0	--	--	--
Nitrate (mg/Kg)	Nitrate		1,640	33	32	736.00	108.84688	194.25337
Metals (mg/Kg)	Antimony	<0.2	ND	33	7	15.50	12.62857	1.96275
	Arsenic	7.4	ND	33	32	4.30	.90313	0.79209
	Barium	230	ND	33	33	262.00	119.60303	51.09605

TABLE 3.7 SUMMARY DATA RADIUM-226 TREATMENT SYSTEM (continued)

	Previous[a] Investigations	UCD Sludge (1989)	Phase II Site Characterization				
Parameter	Highest Value Detected	Highest Value Detected	Number Sampled	Number Detected	Highest Detected Value	Mean	Standard Deviation
Beryllium	<2	ND	33	31	2.40	0.49677	0.42386
Cadmium	<2	ND	33	9	24.10	15.35556	8.98625
Cobalt	33	ND	33	33	38.40	27.40909	6.13547
Hexavalent chromium	NA	ND	33	28	5.00	1.53214	1.41134
Chromium (total)	53	ND	33	33	120.00	47.36667	23.70456
Copper	35	ND	33	33	50.00	15.26970	13.91309
Mercury	<0.5	ND	33	11	0.32	0.12000	0.07975
Molybdenum	<500	ND	33	7	10.90	8.80000	1.68918
Nickel	102	ND	33	33	280.00	166.33636	56.61556
Lead	<13	ND	33	33	19.30	7.19697	5.33898
Silver	<2	ND	33	0	--	--	--
Selenium	<1	ND	33	0	--	--	--
Thallium	<50	ND	33	2	5.50	5.30000	0.28284
Vanadium	<200	ND	33	33	55.00	32.25152	10.30364
Zinc	74.1	ND	33	33	165.00	63.59091	20.00279

-- Not Applicable
NA Not Analyzed
ND Not Detected
[a] Previous Investigations include Rockwell, 1984; Wahler, 1989

According to UC Davis records, the septic tanks were closed in the early 1970s, when the LEHR site was connected to the main UC Davis wastewater treatment plant. However, the cobalt-60 field building septic tank was reported to be in use until 1988. No formal closure documentation has been located, nor does Solano County require permits to close domestic septic tanks. To date, no analytical data have been collected to characterize the contents of the domestic septic tanks or the adjacent leach fields.

3.2.5 Dog Pen Area

Two outdoor dog pen areas containing approximately 350 separate pens are located at the LEHR site. The western set originally contained 304 pens. In 1975, 64 pens were removed to allow for construction of the Cellular Biology Lab (Building H-294; Figure 2.2). These pens reportedly housed the dogs which received the highest dosages of strontium-90 and radium-226. Dogs injected with strontium-90 were housed in Animal Hospital 1 for 540 days during treatment, and an additional 30 days following treatment. The outdoor pens were used to house the dogs after their initial treatments.

Excreta from dogs housed in outdoor pens contained low levels of radiologic constituents. Solids were removed from the pens on a daily basis. Urine would be expected to evaporate rapidly upon contact with pen gravels. An estimated 2 mCi of strontium-90 and 0.5 mCi of radium-226 were potentially excreted in dog urine over the life of the project (DOE, 1988).

Chlordane was used to control fleas on dogs kept in outdoor pens from 1960 until the early 1970s. Chlordane was sprayed on dogs or they were dipped in chlordane, or in chlordane-kerosene, and returned to the dog pen areas. Annual usage of chlordane is estimated to have been between 25 and 50 gallons. Spent chlordane from the dip tanks was recorded to have been disposed in trenches and pits and in the outdoor cages where the dogs were being dipped.

Table 3.8 presents summary data of samples collected from the dog pens. Limited statistical data are also presented, based on the results of the samples collected during the

TABLE 3.8 SUMMARY SOIL DATA DOG PENS

		Previous[a] Investigations	Phase II Site Characterization				
	Parameter	Highest Detected Value	Number Sampled	Number Detected	Highest Detected Value	Mean	Standard Deviation
Semi Volatile Organics (mg/Kg)	Bis 2 Ethylhexylphthalate	NA	27	0	--	--	--
	Diethyl Phthalate	NA	27	5	1200	1040.000	180.4
Volatile Organics (μg/Kg)	Chloroform	NA	27	0	--	--	--
	1,1 dichloroethene	NA	27	0	--	--	--
	Methylene chloride	NA	27	1	120.00	120.00000	0.00000
Pesticides (μg/Kg)	Chlordane	NA	82	17	480.00	67.62412	142.35189
	Dieldrin	NA	82	0	--	--	--
	Aldrin	NA	82	0	--	--	--
	Heptachlor	NA	82	0	--	--	--
Radiologic Constituents (pCi/g)	Gross alpha	6 ± 3	82	81	5.30	1.69012	0.98395
	Gross beta	32 ± 6	82	82	20.20	6.57073	4.27775
	Tritium	0.04 ± 0.03	82	16	1.50	0.60625	0.26949
	Bismuth-214	ND	82	0	--	--	--
	Lead-212	ND	82	0	--	--	--
	Lead-214	ND	82	0	--	--	--
	Strontium-90	ND	82	7	0.30	0.18000	0.06218
	Potassium-40	12 ± 0.6	82	82	30.90	10.52841	4.35130
	Cesium-137	0.05 ± 0.02	82	3	0.20	0.13333	0.05774
	Radium-226	0.61 ± 0.05	82	37	1.40	0.59459	0.20676
	Thorium-232	0.59 ± 0.05	82	35	1.40	0.67714	0.21016
	Carbon-14	NA	0	0	--	--	--
	Plutonium-241	NA	0	0	--	--	--
Nitrate (mg/K)	Nitrate	NA	82	82	168.00	12.55293	24.43786

TABLE 3.8 SUMMARY DATA DOG PENS (continued)

		Previous[a] Investigations	Phase II Site Characterization				
	Parameter	Highest Detected Value	Number Sampled	Number Detected	Highest Detected Value	Mean	Standard Deviation
Metals (mg/Kg)	Antimony	NA	27	26	21.50	14.20654	3.94360
	Arsenic	NA	27	25	5.00	21.65200	1.27250
	Barium	NA	27	27	320.00	154.01852	48.35059
	Beryllium	NA	27	21	0.50	0.25238	0.11233
	Cadmium	NA	27	27	26.70	17.89259	4.48355
	Cobalt	NA	27	27	31.50	21.87037	4.48800
	Hexavalent chromium	NA	27	26	3.98	0.53077	0.75139
	Chromium (total)	NA	27	27	152.00	91.18148	27.32555
	Copper	NA	27	27	69.50	46.47037	10.88121
	Mercury	NA	27	21	0.35	0.11333	0.08416
	Molybdenum	NA	27	25	13.70	10.03240	1.96275
	Nickel	NA	27	27	321.00	178.50741	56.50423
	Lead	NA	27	27	73.10	22.50778	17.32869
	Silver	NA	27	0	--	--	--
	Selenium	NA	27	0	--	--	--
	Thallium	NA	27	10	6.18	5.44500	0.46073
	Vanadium	NA	27	27	63.90	49.77037	10.19871
	Zinc	NA	27	27	397.00	79.88889	72.00800

[a] Previous Investigations Include: Wahler, 1989
-- Not Applicable
NA Not Analyzed
ND Not Detected

Phase II Site Characterization. Concentrations of nitrate above levels detected in samples collected off-site were reported in less than 10 percent of soil from the cages tested. The maximum concentration of nitrate from samples collected in the dog pen area was 168 mg/Kg which exceeds the maximum of 39.8 mg/Kg nitrate reported off-site. Chlordane was also reported in soil samples collected and analyzed from the dog pens.

3.2.6 UC Davis Landfill Disposal Units

As discussed previously, prior to construction and during operation of the current LEHR site, UC Davis disposed sanitary and chemical wastes on and east of the LEHR site in the Old UC Davis Landfill (Figure 3.1). The landfill consisted of three separate units that operated at different times. Two of the landfill units are located at the LEHR site and one is located just east of the site. A more detailed discussion of the Old UC Davis Landfill is presented in the SWAT report prepared for UC Davis (Dames & Moore, 1990b).

The oldest of the three landfill units (No. 1) is presently covered by the cobalt-60 irradiator facility. Disposal reportedly began in this unit in the 1940s and ceased in the 1950s. General campus wastes, possibly including chemical wastes, appear to have been disposed at the Landfill Unit No. 1. Sewage sludge from the adjacent sewage treatment plant was reportedly disposed in this landfill unit, as well (DOE, 1988).

Landfill Unit No. 2 was operated from 1956 to 1967, and consisted of 12 east-west oriented disposal pits. This unit is located in the mid-portion of the LEHR site, and is partially covered with the easternmost of two sets of dog pens. The pits are reported to have averaged 10 feet in depth and are unlined. Types of wastes disposed at this site have not been documented, although it reportedly included general refuse, animal parts, ash from the UC Davis incinerator, and some liquid chemicals.

UC Davis operated a third landfill unit (No. 3) from 1963 to 1967. Landfill Unit No. 3 is located east of the LEHR site and former UC Davis Sewage Treatment Plant. Wastes were placed in two large, pit-like excavations and covered with soil. Landfill Unit No. 3 is outside of the LEHR site boundaries (Dames & Moore, 1990b).

To date, no direct observational or analytical data have been generated to characterize the contents of the landfill units. Soil samples obtained as part of the SWAT investigation (Dames & Moore 1990b) were collected from monitoring well borings installed adjacent to the landfill units. Table 3.9 presents summary results of the analyses conducted on these soil samples.

Monitoring of groundwater downgradient of the three landfill units was conducted as part of the SWAT investigation (See Section 3.1.5) and as a part of the Phase II Site Characterization. Analytical data from downgradient wells show that leakage of several volatile organic compounds and nitrate from Landfill Unit Nos. 1 and No. 2 has impacted groundwater (Table 3.10A).

3.2.7 Groundwater and Surface Water

Monitoring of groundwater and surface water on and in the vicinity of the LEHR site has been conducted since November 1990 as a portion of the Phase II Site Characterization. A discussion of data from November 1990 to November 1991 has been presented in the Phase II Site Characterization Report (Dames & Moore, 1993a). Results of the analyses indicate that the groundwater beneath the LEHR site has been impacted by organic, inorganic and radiologic parameters. Generally, concentrations of hexavalent chromium and nitrate increase in the downgradient direction. However, there is some evidence to suggest that these constituents are present at increased levels on a regional basis (Dames & Moore, 1990d). Radiologic and volatile organic compounds are generally reported downgradient of the disposal trenches and landfill units.

Eight quarters of groundwater monitoring results from 1992 and 1993 are summarized in Table 3.10A. A more comprehensive interpretation of these data is presented in annual and quarterly reports. These data indicate trends similar to the Phase II Characterization report. The principal constituents of interest on the LEHR site appear to be nitrate, and total and hexavalent chromium. Reported concentrations of nitrate and total and hexavalent chromium from downgradient wells exceed concentrations reported

TABLE 3.9 SUMMARY SOIL DATA UC DAVIS LANDFILL UNITS

	Parameter	Previous[a] Investigations Highest Detected Value
Semi Volatile Organics (µg/Kg)	Bis 2 Ethylhexylphthalate	2,800
	DI N Butyl Phthalate	ND
Volatile Organics (µg/Kg)	Chloroform	ND
	1,1 dichloroethene	ND
	Methylene chloride	1,100
Pesticides (µg/Kg)	Chlordane	ND
	Dieldrin	ND
	Aldrin	ND
	Heptachlor	ND
Radiologic Constituents (pCi/g)	Gross alpha	NA
	Gross beta	NA
	Tritium	142 ± 16
	Bismuth-214	0.55 ± 0.39
	Lead-212	0.60 ± 0.54
	Lead-214	1.43 ± 0.98
	Strontium-90	NA
	Potassium-40	NA
	Cesium-137	ND
	Radium-226	1.32 ± 0.88
	Thorium-232	1.11 ± 0.93
	Carbon-14	0.23 ± 0.17
	Plutonium-241	NA
Nitrate (mg/Kg)	Nitrate	19.0

TABLE 3.9 SUMMARY DATA UC DAVIS LANDFILL UNITS (continued)

	Parameter	Previous[a] Investigations Highest Detected Value
Metals (mg/Kg)	Antimony	<30
	Arsenic	8.8
	Barium	460
	Beryllium	0.9
	Cadmium	<3.0
	Cobalt	48
	Hexavalent chromium	1.1
	Chromium (total)	110
	Copper	55.7
	Mercury	0.5
	Molybdenum	50
	Nickel	210
	Lead	45
	Silver	31
	Selenium	1.4
	Thallium	<30
	Vanadium	76
	Zinc	85

[a] Previous Investigations Include: Dames & Moore 1990c; and Rockwell, 1984
NA Not Analyzed
ND Not Detected
Note: No data was collected from the UCD Landfill Units during the Phase II Site Characterization

TABLE 3.10A SUMMARY OF DETECTIONS 1992, 1993 – GROUNDWATER

	PARAMETER	Upgradient Wells				Downgradient Wells			
		Number of Samples & Duplicates	Number of Detections	Maximum Value Detected	Location of Maximum Detection	Number of Samples & Duplicates	Number of Detections	Maximum Value Detected	Location of Maximum Detection
General Chemical Parameters	ALKALINITY TOTAL(AS CACO3) (mg/liter)	18	18	465	UCD-18	136	136	890	UCD-13
	CHEMICAL OXYGEN DEMAND (ug/liter)	13	7	51,900	UCD-18	101	47	65,000	UCD-04
	EC-F (umhos/cm)	18	18	1,205	UCD-18	128	128	4,640	UCD-12
	EH-F (mvolts)	2	2	118	UCD-18	16	16	127	UCD-15
	FORMALDEHYDE (ug/ml)	18	3	500	UCD-18	136	34	500	UCD-13
	TEMPERATURE (degree C)	18	18	19.6	UCD-17	128	128	24.9	UCD-23
	TOTAL DISSOLVED SOLIDS mg/liter)	18	18	887	UCD-18	136	136	2,451	UCD-12
	TOTAL ORGANIC CARBON (mg/liter)	5	3	1.3	UCD-17	35	28	5.8	UCD-10
	TURBIDITY (NTU)	18	18	28.5	UCD-18	136	133	949	UCD-01
	TURBIDITY-F (NTU)	17	17	26.3	UCD-18	126	118	200	UCD-01
	pH-F	18	18	8.06	UCD-17	128	128	8.26	UCD-15
Metals	ANTIMONY (TOTAL)	18	0	-	-	136	6	10	UCD-21
(ug/liter)	ARSENIC (TOTAL)	18	2	10	UCD-17	136	18	10	UCD-21
	BARIUM (TOTAL)	18	18	170	UCD-18	136	134	430	UCD-12
	BERYLLIUM (TOTAL)	18	1	1.5	UCD-18	136	3	3	UCD-22
	CADMIUM (TOTAL)	18	0	-	-	136	1	2	UCD-21
	CHROMIUM (TOTAL)	18	16	50	UCD-18	136	131	450	UCD-11
	CHROMIUM, HEXAVALENT (+6)	18	12	40	UCD-18	136	123	350	UCD-11
	COBALT (TOTAL)	13	1	30	UCD-17	101	2	30	UCD-23
	COPPER (TOTAL)	18	0	-	-	136	10	30	UCD-23
	LEAD (TOTAL)	18	2	8.8	UCD-17	136	22	63	UCD-07
	MERCURY (TOTAL)	18	1	0.4	UCD-17	136	8	2.2	UCD-21
	MOLYBDENUM (TOTAL)	18	5	30	UCD-17	136	27	70	UCD-23
	NICKEL (TOTAL)	18	8	80	UCD-18	136	60	390	UCD-23
	SELENIUM (TOTAL)	18	0	-	-	136	29	26	UCD-10
	SILVER (TOTAL)	18	1	30	UCD-17	136	13	30	UCD-12
	THALLIUM (TOTAL)	18	0	-	-	136	11	130	UCD-12
	VANADIUM (TOTAL)	18	10	30	UCD-17	136	72	40	UCD-04
	ZINC (TOTAL)	18	9	30	UCD-18	136	73	60	UCD-24
Anions and Cations	AMMONIA-NITROGEN	5	1	51	UCD-17	136	0	-	-
(ug/liter)	CALCIUM (TOTAL)	18	18	41,400	UCD-18	136	136	76,600	UCD-12
	CHLORIDE	18	18	41,800	UCD-18	136	136	370,000	UCD-12
	IRON	5	4	171	UCD-18	35	34	338	UCD-13
	MAGNESIUM (TOTAL)	18	18	111,000	UCD-18	136	136	333,000	UCD-12
	NITROGEN, NITRATE (AS N)	18	18	19,800	UCD-18	136	136	65,000	UCD-12
	PHOSPHATE, TOTAL (AS P)	18	10	1,000	UCD-17	136	89	1,000	UCD-12
	POTASSIUM (TOTAL)	18	18	1,290	UCD-18	136	131	44,100	UCD-16
	SODIUM (TOTAL)	18	18	42,800	UCD-18	136	136	190,000	UCD-10
	SULFATE	18	[illegible]	43,600	UCD-18	136	136	697,000	UCD-10

TABLE 3.10A SUMMARY OF DETECTIONS 1992, 1993 – GROUNDWATER (CONTINUED)

PARAMETER		Upgradient Wells				Downgradient Wells			
		Number of Samples & Duplicates	Number of Detections	Maximum Value Detected	Location of Maximum Detection	Number of Samples & Duplicates	Number of Detections	Maximum Value Detected	Location of Maximum Detection
Volatile Organics (ug/liter)	1,1-DICHLOROETHANE	18	0	-	-	136	8	24	UCD-12
	1,1-DICHLOROETHENE	18	0	-	-	136	8	44	UCD-12
	1,2-DICHLOROETHANE	18	0	-	-	136	8	15	UCD-12
	ACETONE	18	0	-	-	35	1	25	UCD-01
	BROMODICHLOROMETHANE	18	0	-	-	136	3	5	UCD-01
	CARBON TETRACHLORIDE	18	0	-	-	136	1	5	UCD-01
	CHLOROFORM	18	0	-	-	136	30	16,000	UCD-12
	METHYLENE CHLORIDE	18	0	-	-	136	9	10	UCD-01
	TOLUENE	18	0	-	-	136	1	13	UCD-15
	TRICHLOROETHENE	18	0	-	-	136	1	5	UCD-01
Semivolatile Organics (ug/liter)	BIS(2-ETHYLHEXYL)PHTHALATE	18	5	10.1	UCD-18	134	38	37	UCD-24
	DI-N-BUTYLPHTHALATE	18	0	-	-	134	5	14.4	UCD-23
Pesticides and PCBs (ug/liter)	4,4'-DDD	18	0	-	-	133	1	0.11	UCD-12
	4,4'-DDT	18	0	-	-	133	1	0.11	UCD-12
	ALPHA-BHC	18	0	-	-	133	2	0.057	UCD-01
	BETA-BHC	18	0	-	-	133	1	0.057	UCD-01
	DIELDRIN	18	0	-	-	133	8	0.11	UCD-12
	ENDOSULFAN I	18	0	-	-	133	1	0.057	UCD-01
	ENDRIN	18	0	-	-	133	6	0.11	UCD-12
	GAMMA-BHC	18	0	-	-	133	4	0.057	UCD-01
	HEPTACHLOR	18	0	-	-	133	2	0.057	UCD-01
Radiochemical Analyses (pCi/liter)	CARBON-14	18	2	500	UCD-17	58	23	2,464	UCD-13
	GROSS ALPHA	18	1	6.8	UCD-18	136	41	40	UCD-20
	GROSS BETA	18	2	7	UCD-18	136	44	24	UCD-20
	RADIUM-226	18	0	-	-	16	2	0.67	UCD-13
	STRONTIUM-90	18	1	1.7	UCD-18	138	18	8.4	UCD-19
	TRITIUM	18	2	965	UCD-18	136	32	29,838	UCD-13

from upgradient wells. Other inorganic, metal, and radiologic parameters were observed in some downgradient and some upgradient wells, as indicated in Table 3.10A. However, trends for parameters other than nitrate and chromium in groundwater have not shown a consistent sitewide pattern.

Eight quarters of surface water monitoring results from 1992 and 1993 are summarized in Table 3.10B. Annual and quarterly monitoring reports provide a more thorough interpretation of trends in surface water. The constituents and reported concentrations in surface water appear to be somewhat different than for groundwater. The seasonal trends in surface water data are more apparent than for groundwater because of the reduced flows in Putah Creek during the long, dry summer months.

3.3 PREVIOUS AND ONGOING REMEDIAL ACTIONS

The following sections describe previous and ongoing remedial activities conducted at the LEHR site. The remedial actions pertain primarily to decontamination and decommissioning of buildings at the LEHR site and removal of radioactive sources.

3.3.1 Biological Waste Removal

Between June and September 1990, 856 biological waste packages were shipped to DOE Hanford facility in the state of Washington. The work was conducted under the approved Storage, Disposal and Acceptance Record (SDAR) 33-IJ-5A-1 (9/10/90).

UC Davis personnel performed inventorying and QA radioactivity level assessment using whole body counting of the biowaste according to the approved Assessment of Radioactivity Levels in Biological Waste Packages Work Plan. Biowastes were packaged in 88 drums for shipment to DOE Hanford site according to an approved work plan.

TABLE 3.10B SUMMARY OF DETECTIONS 1992, 1993 — SURFACE WATER

	PARAMETER	SURFACE WATER			
		Number of Samples & Duplicates	Number of Detections	Maximum Value Detected	Location of Maximum Detection
General Chemical Parameters	ALKALINITY TOTAL(AS CACO3) (mg/liter)	33	33	228	PCU
	CHEMICAL OXYGEN DEMAND (ug/liter)	25	19	55,800	STPO
	EC-F (umhos/cm)	29	29	1,402	STPO
	EH-F (mvolts)	3	3	52	STPO
	FORMALDEHYDE (ug/ml)	33	7	500	STPO
	TEMPERATURE (degree C)	29	29	28.8	STPO
	TOTAL DISSOLVED SOLIDS mg/liter)	33	33	625	STPO
	TOTAL ORGANIC CARBON (mg/liter)	8	8	11	PCU
	TURBIDITY (NTU)	33	33	128	PCU
	TURBIDITY-F (NTU)	26	19	200	PCU
	pH-F	25	25	8.89	PCU
Metals	ANTIMONY (TOTAL)	33	8	10	STPO
(ug/liter)	ARSENIC (TOTAL)	33	5	10	STPO
	BARIUM (TOTAL)	33	31	90	PCU
	BERYLLIUM (TOTAL)	33	3	1	STPO
	CADMIUM (TOTAL)	33	4	50	STPO
	CHROMIUM (TOTAL)	33	11	80	PCD
	CHROMIUM, HEXAVALENT (+6)	33	11	45	STPO
	COBALT (TOTAL)	25	1	30	STPO
	COPPER (TOTAL)	33	3	40	PCU
	LEAD (TOTAL)	33	5	11.2	STPO
	MERCURY (TOTAL)	33	5	0.9	PCU
	MOLYBDENUM (TOTAL)	33	9	110	STPO
	NICKEL (TOTAL)	33	5	310	PCD
	THALLIUM (TOTAL)	33	2	60	STPO
	VANADIUM (TOTAL)	33	3	30	STPO
	ZINC (TOTAL)	33	23	60	STPO
Anions and Cations	AMMONIA-NITROGEN	8	7	8,300	STPO
(ug/liter)	CALCIUM (TOTAL)	33	33	26,900	PCU
	CHLORIDE	33	33	181,000	STPO
	IRON	8	2	112	STPO
	MAGNESIUM (TOTAL)	33	33	36,100	PCU
Anions and Cations:	NITROGEN, NITRATE (AS N)	33	31	11,100	STPO
(continued):	PHOSPHATE, TOTAL (AS P)	33	23	10,000	STPO
	POTASSIUM (TOTAL)	33	33	56,900	STPO
	SODIUM (TOTAL)	33	33	164,000	STPO
	SULFATE	33	33	130,000	STPO
	TOTAL KJELDAHL NITROGEN	8	5	9,200	STPO

TABLE 3.10B SUMMARY OF DETECTIONS 1992, 1993 — SURFACE WATER (CONTINUED)

PARAMETER		SURFACE WATER			
		Number of Samples & Duplicates	Number of Detections	Maximum Value Detected	Location of Maximum Detection
Volatile Organics (ug/liter)	ACETONE	8	3	36	STPO
	BROMODICHLOROMETHANE	33	5	13	STPO
	CHLOROFORM	33	20	33	STPO
	DIBROMOCHLOROMETHANE	33	3	4.8	STPO
	METHYLENE CHLORIDE	33	11	8.2	STPO
Semivolatile Organics (ug/liter)	2-CHLOROPHENOL	33	1	10	PCU
	BIS(2-ETHYLHEXYL)PHTHALATE	33	18	13.3	STPO
	BIS(2-ISOPROPYL)ETHER	21	2	5.7	STPO
	DI-N-BUTYLPHTHALATE	33	3	10	PCU
Pesticides and PCBs (ug/liter)	4,4'-DDD	33	7	0.1	STPO
	4,4'-DDE	33	3	0.1	STPO
	ALDRIN	33	4	0.051	PCD
	ALPHA-BHC	33	15	0.055	PCU
	BETA-BHC	33	2	0.051	PCD
	DELTA-BHC	33	7	0.35	STPO
	DIELDRIN	33	3	0.1	STPO
	ENDOSULFAN I	33	3	0.055	STPO
	ENDOSULFAN II	33	1	0.1	STPO
	ENDRIN	33	1	0.1	STPO
	ENDRIN ALDEHYDE	33	1	0.1	STPO
	GAMMA-BHC	33	6	0.052	STPO
	HEPTACHLOR	33	2	0.051	PCD
Radiochemical Analyses (pCi/liter)	CARBON-14	8	3	122	PCU
	GROSS ALPHA	33	14	12	STPO
	GROSS BETA	33	28	43.5	STPO
	RADIUM-226	4	1	0.38	STPO
	STRONTIUM-90	33	5	6.9	PCU
	TRITIUM	33	8	1,724	STPO

3.3.2 Building Decontamination and Decommissioning

Decontamination of the specimen storage building and animal hospital buildings AH-1 and AH-2 (buildings H-216, H-218, and H-219) has been completed. The scope of work involved dismantlement, removal, and off-site disposal of contaminated equipment, components and structures. Post-decontamination radiation and contamination surveys to verify compliance with DOE and State of California criteria for release to unrestricted use are in progress.

3.3.3 Liquid and Sludge Removal Project

Between May 1991 and March 1992, liquid and sludge wastes were removed from the radium-226 and strontium-90 (Imhoff) septic tanks at the LEHR site. In addition, the inside surfaces of the tanks were surveyed, and limited core samples of tank material were collected from each tank in addition to soils below each tank. All radiological field activities were conducted under appropriate Radioactive Material Licensing.

Liquid and sludge wastes were solidified and placed in drums for transportation and disposal at the DOE Hanford facility in the state of Washington. A total of 174 batches and 2 liners of waste were solidified. Each batch resulted in four to seven drums of solidified waste depending on the volume of waste and type (liquid/sludge). A total of 784 drums of solidified wastes were shipped to the disposal site during this remedial action. Approximately 500 to 1,000 gallons of waste remain in one of the Imhoff tanks. It is anticipated that those wastes will be removed prior to the RI activities for this area.

3.3.4 Cobalt-60 Source Removal

A cobalt-60 source was loaded into the irradiator in 1982. The original source strength was 349 curies, the current estimated strength at the time of removal was below 100 Ci. The source was a double-encapsulated, sealed, stainless-steel pencil type, measuring approximately 0.6-inches long by 0.6 inches in diameter.

A cobalt-60 source removal plan was prepared to describe removal of the source, details specific activities, procedures and phasing to implement the removal. The plan also

identified interface protocols for participants who worked together during the removal process. On January 26, 1993, the cobalt-60 source was removed from the LEHR site and transported to a DOE-approved hot cell in Pleasanton, California for reprocessing. The cobalt-60 source was removed from the source container and the lead shielding. After being surveyed and found clean of radiological contamination, the container and shielding were returned to the LEHR site.

3.3.5 Transfer of Strontium-90 Source

A work plan was prepared to describe the approach used for preparing, packaging, and shipping of 1.7 curies of canned strontium-90 to the Argonne National Laboratory. Argonne National Laboratory requested that UC Davis provide them with the source as an alternative to waste disposal. The scope of work consisted of packaging 16 cans individually, according to DOT Title 49, 1990.

On January 29, 1991, 12 cans containing strontium-90 were packed and shipped to Argonne according to the procedures outlined in the approved work plan. The remaining four cans were packaged and shipped to Argonne on February 14, 1991. Wipes of the boxes were collected and counted at the UC Davis EH&S. No contamination was found on any of the wipes collected. Argonne received the shipment of strontium-90 source without incident.

3.4 CONCEPTUAL SITE MODEL

A review of the site conditions was performed to obtain an initial understanding of potential pathways for constituent migration and potential impacts to human health and the environment. The end result of this review is the Conceptual Site Model (CSM).

A CSM describes the site and its environs to provide an initial understanding of the constituents present, their routes of migration and their potential impacts on human and ecological receptors. The model will be refined as additional data are generated through the RI process. Additional data, as they become available, will be evaluated to determine if there is sufficient information of adequate quality to prepare a Baseline Risk Assessment. The model can then provide a basis for defining data quality objectives, and developing

exposure scenarios. The CSM defines sources of contamination, potentially exposed populations, and exposure pathways, as shown on Figure 3.6. These elements and general contaminant transport mechanisms as they relate to the site are discussed below.

3.4.1 Sources of Contamination

During the 30-year operation of the LEHR site, a variety of wastes were generated and disposed of on-site. These wastes included radioactive, biologic, chemical, municipal, and laboratory debris disposed of in different areas of the site. The disposal areas being addressed during this RI/FS are presented in Section 3.1. A summary of the potential sources is presented in Table 3.11.

Tanks in the Imhoff treatment system were observed to have cracked plastic sealants. Overflow has occurred from the radium-226 processing system. During the initial investigations, one of the radium-226 tanks was observed to be empty and is believed to have leaked. The waste burial trenches and pits contain a total of approximately 30,150 cubic feet of waste and are covered with up to four feet of material. Dogs were housed in the dog pen area after treatment with radionuclides and after chlordane application for treatment of fleas. Six of the domestic septic tanks received presumably non-radioactive liquid wastes from the LEHR site until 1971 (one tank was reported to be in use until 1988). During the backup of the radium-226 system, one of the septic tanks was reported to have received effluent from AH-2, where dogs that had been injected with radium-226 were housed. The septic tanks are reported to have been abandoned and filled with sand, and their influent and effluent lines severed and capped. On-site sewer lines have been reported and could contribute to groundwater impacts at the LEHR site. Three shallow landfill areas on the LEHR site may contain radiologic, chemical, biological and municipal wastes. Figure 3.7 is a schematic diagram of the Conceptual Site Model and shows the LEHR site, potential migration pathways and potential receptors.

SOURCE	PATHWAY	RECEPTORS
Contaminants Concentration Time Location	Media Rate of Migration Time Loss Functions	Type Sensitivity Time Concentration Number
• Source Exists	• Pathway Exists	• Receptors Are Not Impacted by Migration of Contaminants
HYPOTHESES TO BE TESTED: • Source Can Be Contained	• Pathway Can Be Interrupted	• Receptors Can Be Relocated
• Source Can Be Removed and Disposed	• Pathway Can Be Eliminated	• Institutional Controls Can Be Applied
• Source Can Be Treated		• Receptors Can Be Protected

Adapted from report EPA/540/G-87/003 of the U.S. Environmental Protection Agency, *Data Quality for Remedial Response Activities, Development Process, March 1987*

ELEMENTS OF A CONCEPTUAL SITE MODEL

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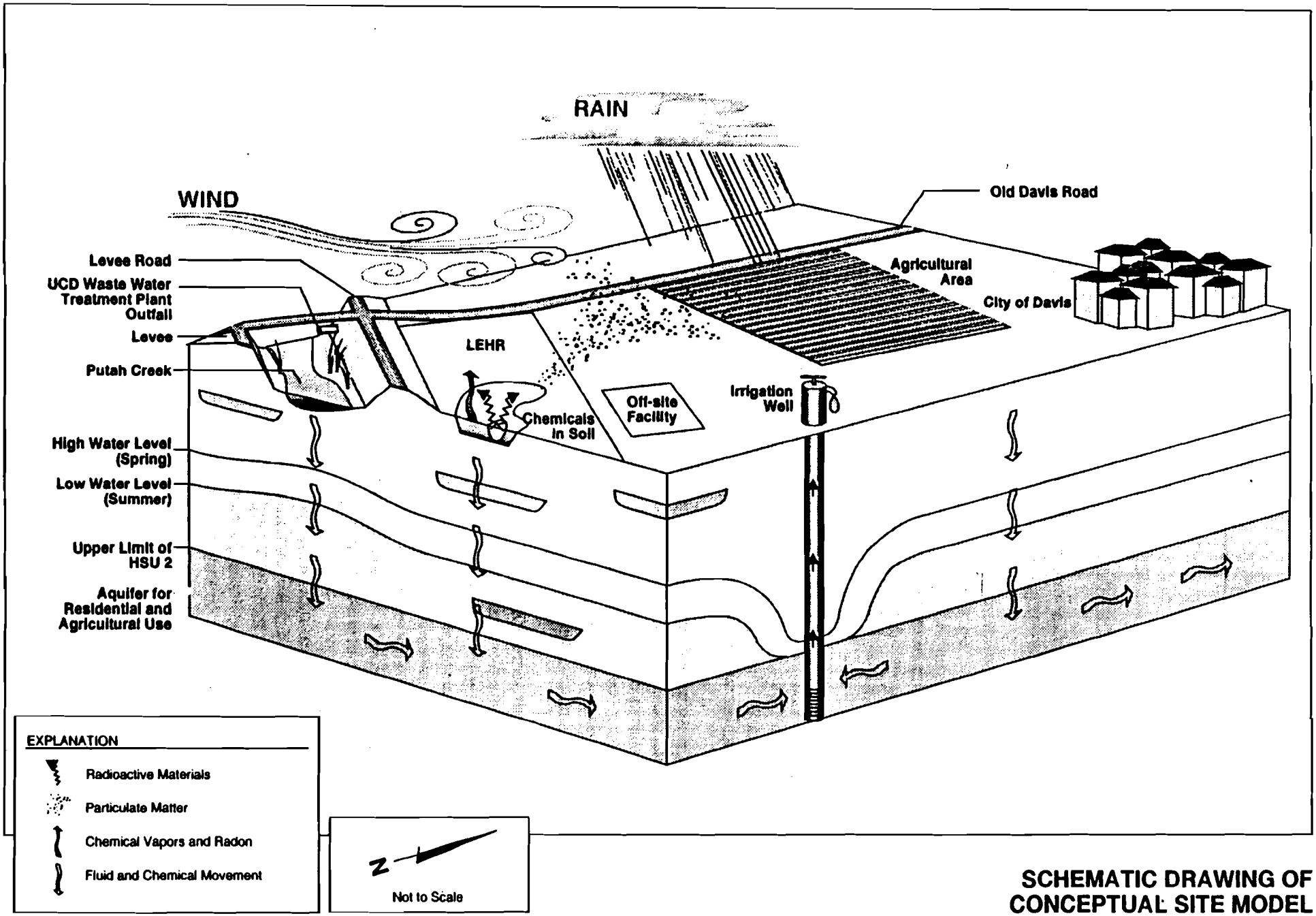
TABLE 3.11 SUMMARY OF POTENTIAL SOURCE AREAS

Potential Source Area	Description	Types of Wastes Potentially Disposed
Waste Systems	Leach systems associated with the Imhoff sewage treatment system and radium-226/strontium-90 processing system	Radiologic wastes (strontium-90, radium-226, plutonium-241 and americium-241)
Waste Burial	Burial trenches and pits in the southwest portion of facility and the UC Davis disposal trenches and pits.	Low-level radioactive solid waste and chemical (including chlordane), laboratory, and biologic wastes (carcasses)
Chemical Dispensing Areas	Two locations where chemicals used during LEHR facility operations were stored	Laboratory chemicals and/or fuels used in operations, possibly chlordane, diesel, kerosene
Dog Pen Area	Western set of dog pens, including the area currently occupied by the Cellular Biology Lab	Excreta contained low levels of radionuclides (strontium-90 and radium-226) and chlordane
Domestic Septic Tanks	Seven septic tanks at the LEHR site, six of which are in the western portion of the site; the seventh is near the Cobalt-60 irradiator facility	Chemical and sanitary wastes; also, radium-226 during backup in beagle housing area AH-2
Landfill Units	Three shallow landfill units in the far eastern, dog pen, and cobalt-60 field disposal areas	~~Low level radiologic,~~ Chemical, biologic and municipal wastes



NOTE: Groundwater generally flows northeast

SCHEMATIC DRAWING OF CONCEPTUAL SITE MODEL

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10805-720-044 s/r 5705H 2/17/94

FIGURE 3.7

3.4.2 Transport Mechanisms

Site constituents can potentially migrate away from the source area through the following fate and transport processes:

- Volatile organic chemicals can be emitted to the air from soils and can be transported off site via dispersion. Chemical diffusion and volatilization are the principal pathways for volatile organic chemical loss from soils, and are complex processes controlled by soil, chemical, and meteorological parameters. These chemicals may be present in the landfill units and the waste burial and septic tank areas.

- Radon generated by the decay of radium-226 can be emitted to the air from impacted soils and buried wastes and subsequently transported off site via dispersion in air. Radon emissions could occur anywhere radium-226 occurs. However, emanation and diffusion properties of the soils and wastes would greatly affect the resulting surface flux of radon.

- Constituents bound to soil particulates can be transported from on-site surface soils to on- or off-site areas via resuspension of dust and subsequent dispersion in air. Impacted surface soil is likely to exist in the dog pen area, and possibly in the waste burial and septic tank areas. Remediation activities or future construction could result in the release of impacted soil particulates to air.

- Constituents leached from soils could potentially contact groundwater. The groundwater flow in the area is typically to the northeast, which means that constituents in site soils could potentially migrate northeast of the site via groundwater movement. Groundwater in the area is used for agricultural, stock, domestic, and municipal purposes. Private and municipal wells near the LEHR site are screened at depths of less than 100 feet bgs to more than 1,400 feet bgs. Potential groundwater constituents could originate from any of the six potential source areas identified in Table 3.11.

- Surface water can become impacted by a number of mechanisms, including surface runoff from site soils. Drainage from the dog pen area in the cobalt-60 irradiation field is collected in catchbasins and piped to the sanitary sewer; drainage from the south and southwestern areas is collected and discharged to Putah Creek. Potential sources of surface water impacts via runoff are the dog pen area and possibly the waste burial area and landfills.

3.4.3 Potentially Exposed Human Populations

The LEHR site is currently used for research activities associated with UC Davis' Institute for Toxicology and Environmental Health (ITEH). ITEH, with research activities that include the study of toxic and carcinogenic agents and occupational health consist of office buildings and laboratory and animal-handling facilities within a 15-acre fenced area. Current land use in the immediate site vicinity (within 1 mile) is primarily agricultural. Several UC Davis research facilities also exist in the vicinity, and Putah Creek lies directly adjacent to the southern border of the LEHR site. A few single-family residences and at least 34 groundwater wells are located within 1 mile of LEHR. These wells are known to be used for irrigation and domestic purposes. The nearest of these wells are found approximately 0.75 of a mile north and southeast of the LEHR site, and are owned by UC Davis or a private owner. One and one-half miles north of the site are central Davis and the main UC Davis campus.

EPA risk assessment guidance (EPA, 1989) states that potential future land use should be considered in addition to current land use when evaluating the potential for exposure to impacts at a site. Even though it is unlikely that land use at the site will change, on-site residential exposure in the future is possible. The residential population in the immediate vicinity is expected to experience average growth in the future. Workers could also experience short-term exposure during future remediation activities, or during development of the site, if such development were to occur.

Because the LEHR site is located in a rural setting and is fenced, trespassers are unlikely to enter the site. On-site workers (under both current and future land use) could potentially become exposed to impacted soil, water, or air at the site. Also, constituents from the site in the form of dust, vapor, and radon emissions or releases to surface water could potentially result in exposures to off-site individuals. Constituents could migrate to groundwater, resulting in exposures from drinking water supplied from groundwater wells if such wells were identified and shown to be impacted by constituents from the site. The human populations that could be potentially exposed can be summarized as follows:

- Current on-site workers;
- Current off-site residents;
- Future on-site remediation workers;
- Future on-site construction workers;
- Future on-site residents; and
- Future off-site residents.

Because the facility consists of several separate buildings, current on-site workers must go outside when they move about the facility. Although many of the common foot-traffic areas are paved, workers may leave the paved areas periodically and encounter surface soils at the facility. Future on-site construction and remediation workers would likely experience more frequent contact with soils, particularly subsurface soils during excavation or remediation. Both on- and off-site receptors, by virtue of their proximity to the site, are potentially exposed to airborne surface soil particulates, radon and volatile compounds. Also, residents in the vicinity may use the nearby Putah Creek as a recreational area or for fishing and therefore may be potentially exposed to contamination.

3.4.4 Potentially Exposed Ecological Receptors

Based on the habitat present near LEHR, the LEHR site is potentially host to a wide variety of animals including numerous species of birds, mammals, and reptiles. Environmental resources in the site vicinity include irrigated croplands, wetlands, and riparian areas. The wetlands and riparian areas of the Yolo Bypass and along Putah Creek serve as a critical wildlife habitat for a number of special status plants and animals, including the Swainson's hawk, the giant garter snake, and the valley oak. Putah Creek is a high-quality riparian habitat and provides important nesting and foraging areas for raptors, deer, and other wildlife. Valley oaks and cottonwood trees are an integral part of the habitat. Additionally, the area contains blue elderberry shrubs, a critical habitat for the valley elderberry longhorn beetle. Other special status species present near Putah Creek include American white pelican, great egret, northern harrier, tricolored blackbird, white-faced ibis, long-billed curlew, and greater sandhill crane. A more in-depth characterization of the flora and fauna at the LEHR site and in the vicinity will be completed during the RI/FS process.

The presence of these and other species will vary with season. On-site species may be disturbed during remediation activities. Species occurring off-site will not be greatly affected by site activities unless off-site habitat is disturbed. Remediation may temporarily affect the Putah Creek habitat via surface runoff from disturbed site soils. However, engineering controls will be implemented to minimize surface runoff and destruction of habitat during remediation.

3.4.5 Exposure Pathways

An exposure pathway describes the mechanism through which a constituent comes into contact with a receptor. There must be a complete exposure pathway from the source of constituents in the environment (e.g., soil, air, groundwater, or surface water) to receptors in order for intake to occur. A complete exposure pathway consists of the following four elements:

- Source of *constituent release* to the environment;
- Environmental *transport medium* (surface water, groundwater, soil gas, soil or ambient air);
- Point of contact (the *exposure point*) with the constituents of concern; and
- *Route of intake* for the constituent into the receptor (*i.e.*, inhalation, ingestion, or dermal contact, and, in the case of radionuclides, external exposure to penetrating radiation).

3.4.5.1 Human Exposure Pathways

Various on-site activities at the LEHR site affect the potential for exposure to constituents. Current activities at the site do not entail the excavation of soils that could expose individual workers to constituents in the source areas. On-site construction or remediation workers involved in the future development of the site, however, could become exposed to subsurface constituents which have become uncovered during excavation. The following are major pathways through which exposure to chemical and radiologic constituents in soils and groundwater by on-site receptors could potentially occur under baseline conditions:

- Incidental ingestion of soil;
- Dermal contact with soil and surface water;
- Inhalation of particulates originating from surface soil;
- Inhalation of vapors or radon emanating from the soil surface into outdoor air; or buildings or from impacted groundwater; and
- External exposure to penetrating radiation from surface soil constituents.

Constituents could migrate off-site via dispersion of particulates in air or via groundwater or surface water movement, providing the following potential exposure pathways for off-site receptors under baseline conditions:

- Inhalation of soil particulates, vapors, or radon originating on site;
- Inhalation of vapors and radon emanating from groundwater via the soil surface or during in-home use;
- Dermal contact with and ingestion of groundwater from off-site wells;
- Dermal contact with and ingestion of surface water in Putah Creek;
- External exposure to penetrating radiation in groundwater or from particulates and radon transported to off-site receptors;
- Ingestion of food and produce cultivated with impacted groundwater; and
- Ingestion of fish obtained from Putah Creek;

The potential major exposure pathways under current (baseline) conditions are summarized in Table 3.12. Other minor exposure pathways will be evaluated as to their applicability.

Remediation activities could potentially affect the transport of constituents to off-site receptors and create new exposure pathways for on-site workers. These activities will primarily increase the probability and degree of exposure during excavation, handling and transportation of on-site samples and wastes via inhalation, external, and dermal contact exposure pathways. In addition, the possible ingestion of secondarily impacted food by on-site workers may occur during remediation. Excavation and movement of wastes and impacted soils will also enhance the release of VOCs and radon held in the soil pore spaces. Table 3.13 summarizes the principal exposure pathways during remediation activities.

TABLE 3.12 POTENTIAL EXPOSURE SCENARIOS UNDER BASELINE CONDITIONS

Potentially Exposed Population	Exposure Route and Medium	Reason for Selection
Current and Future On-site Workers	Dermal contact and ingestion: surface soils	Exposed impacted surface soils exist on site
	Dermal contact: surface water	Surface runoff occurs on site
	Inhalation: VOCs, radon, and resuspended particulates from soil	Exposed impacted surface soils exist on site that could potentially be resuspended into the air; VOCs could be released from soil surface to outdoor air or through cracks in building foundations; radon is released from radium-226 wastes
	Inhalation: VOCs and radon from groundwater	VOCs and radon released to air via soil from impacted groundwater
	External exposure: radiation emanating from impacted soil	Radioactive wastes emitting beta and gamma radiation were disposed of on site
Current and Future Off-site Residents	Inhalation: VOCs and radon from groundwater	VOCs and radon released to air via soil from groundwater, or from groundwater during bathing
	Inhalation: vapors, particulates, and radon transported off site	Off-site transport of constituents in air is possible
	Ingestion: cultivated food	Local agricultural products cultivated with groundwater; foliar deposition of airborne constituents
	Ingestion and dermal contact: groundwater	Drinking and bathing water is obtained from local wells
	Ingestion: fish obtained from Putah Creek	If Putah Creek is found to be impacted and used for fishing
	Ingestion and dermal contact: surface water (Putah Creek)	If Putah Creek is found to be impacted and used for recreation
	External exposure: radiation emanating from groundwater or transported particulates and radon	Radionuclides may translocate through groundwater to homes; transport of air particulates and radon to off-site receptors

TABLE 3.13 EXPOSURE SCENARIOS DURING REMEDIATION

Potentially Exposed Population	Exposure Route and Medium	Reason for Selection
Future On-site Workers	Dermal contact and ingestion: surface and subsurface soils	Exposed impacted surface soils exist on site; impacted subsurface soils will be disturbed during remediation or construction
	Inhalation: VOCs, radon, and resuspended particulates from soil	Resuspension of constituents and release of radon and VOCs from soil pore spaces will occur during remediation or construction
	Inhalation: VOCs and radon in groundwater	VOCs and radon released to air via soil from impacted groundwater during remediation or construction
	Dermal contact: groundwater and surface water	Workers will be in contact with potentially impacted surface water and groundwater on site during sampling or other activities
	Ingestion: food products	Food products could become impacted during on-site activities
	External exposure: radiation emanating from impacted soil	Workers will be exposed to external beta and gamma radiations from impacted soils and wastes during remediation or construction
Future Off-site Residents	Inhalation: VOCs and radon in groundwater	VOCs and radon released to air via soil from groundwater, or from groundwater during bathing
	Inhalation: vapors, particulates, or radon transported off site	Off-site transport of constituents in air is possible
	Ingestion: cultivated food	Local agricultural products cultivated with groundwater; foliar deposition of airborne constituents produced during remediation or construction
	Ingestion and dermal contact: groundwater	Drinking and bathing water is obtained from local wells
	Ingestion: fish obtained from Putah Creek	If Putah Creek is found to be impacted and used for fishing

TABLE 3.13 EXPOSURE SCENARIOS DURING REMEDIATION (continued)

Potentially Exposed Population	Exposure Route and Medium	Reason for Selection
Future Off-site Residents (continued)	Ingestion and dermal contact: surface water (Putah Creek)	If Putah Creek is found to be impacted and used for recreation
	External exposure: radiation emanating from groundwater or transported particulates and radon	Radionuclides may translocate through groundwater to homes where bathing occurs; transport of air particulates and radon to off-site receptors

Table 3.14 summarizes the exposure pathways remaining after remediation. Both future on-site and off-site residents could potentially be exposed to inhalation of remaining VOCs and radon. The exposure from this pathway would, however, be considered insignificant because remediation would minimize releases of these constituents. Residents would still be exposed to impacted groundwater, food products, and surface water (in Putah Creek) following remediation until natural flushing of the aquifers or Creek, or active groundwater restoration took place. It was assumed that institutional and engineering controls would preclude on-site residents from drilling new wells into any impacted groundwater. However, future on-site residents could still be exposed via ingestion of impacted food obtained off-site and ingestion of Putah Creek surface water and fish.

3.4.5.2 Ecological Exposure Pathways

Ecological exposure pathways will approximate those for humans, with a few exceptions. For example, food chain exposures are potentially more significant for ecological receptors. Also, contact with Putah Creek sediments could be a source of constituent exposure. In addition, contact with groundwater constituents would not likely occur for ecological receptors. Special exposure circumstances exist for certain ecological receptors, such as for animals that live in impacted burrows or sediments, or plants that are rooted in impacted soils.

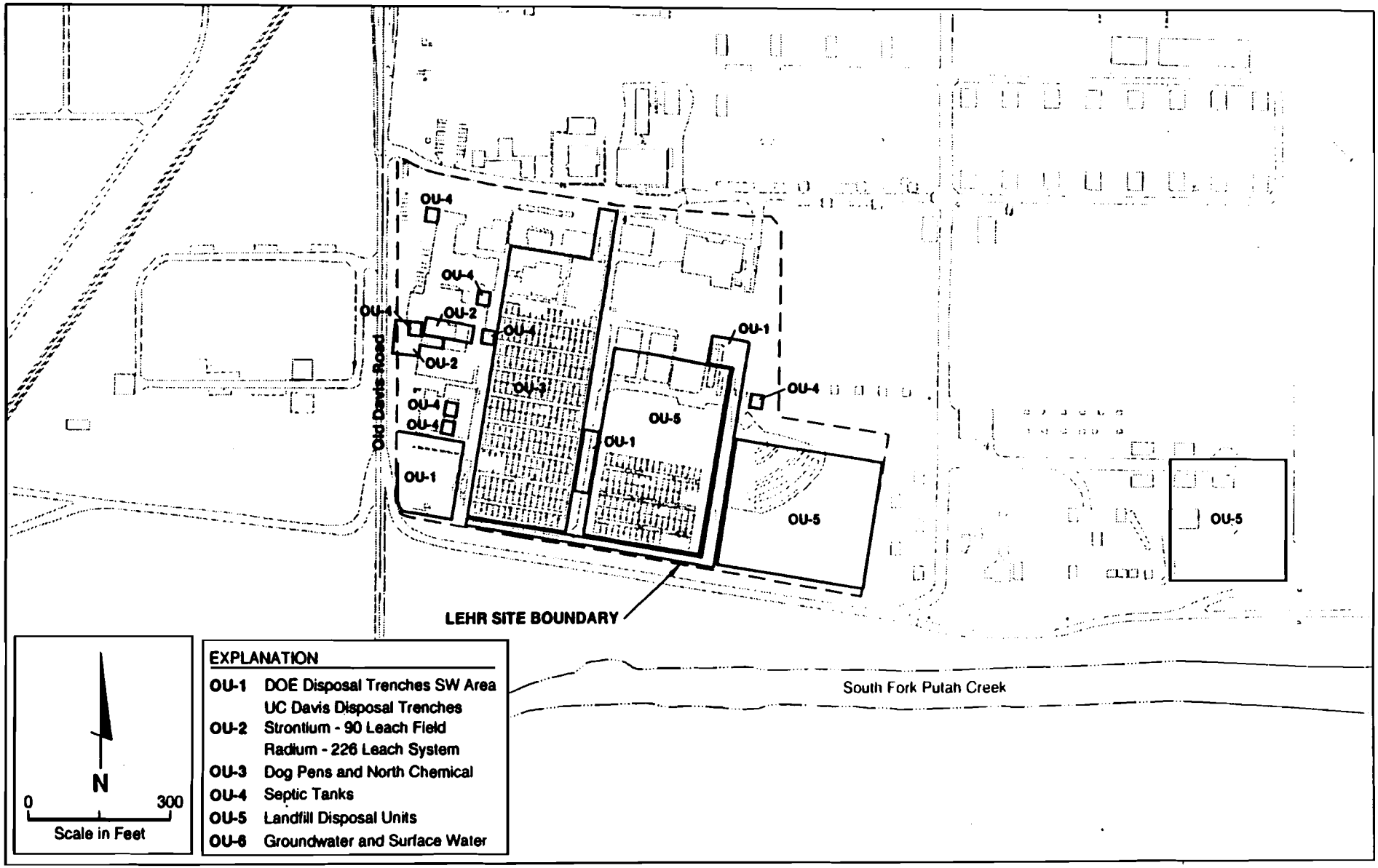
3.5 IDENTIFICATION OF INVESTIGATION AREAS

For the purpose of this Work Plan, the areas identified for characterization are assigned the term "Investigation Area". The investigation areas comprise the preliminary Operable Units. The basis and rationale for development of the investigation areas is to identify areas with similar operational history and chemical and physical characteristics. The locations of the investigation areas by preliminary Operable Unit designation are shown in Figure 3.8 and described in Table 3.15.

The southwest corner of LEHR, is an area that contains the trenches reportedly used by the DOE for disposal of laboratory wastes; the tanker trailer; and the southwest chemical dispensing area. Additionally, there is a report that a strontium-90 treatment

TABLE 3.14 EXPOSURE SCENARIOS AFTER REMEDIATION

Potentially Exposed Population	Exposure Route and Medium	Reason for Selection
Future On-site Residents	Inhalation: VOCs and radon in soil	Radon and VOCs could be released to air via soil from buried wastes
	Inhalation: VOCs and radon in groundwater	VOCs and radon released to air via soil from groundwater
	Ingestion: fish obtained from Putah Creek	If Putah Creek is found to be impacted and used for fishing
	Ingestion and dermal contact: surface water (Putah Creek)	If Putah Creek is found to be impacted and used for recreation
	Ingestion: cultivated food	Local agricultural products cultivated with groundwater
Future Off-site Residents	Inhalation: VOCs and radon in groundwater	VOCs and radon released to air via soil from groundwater, or from groundwater during bathing
	Ingestion: cultivated food	Local agricultural products cultivated with groundwater
	Ingestion and dermal contact: groundwater	Drinking and bathing water is obtained from local wells
	Ingestion: fish obtained from Putah Creek	If Putah Creek is found to be impacted and used for fishing
	Ingestion and dermal contact: surface water (Putah Creek)	If Putah Creek is found to be impacted and used for recreation
Future Off-site Residents (con't)	External exposure: radiation emanating from groundwater	Radionuclides may translocate through groundwater to homes where bathing occurs; radon may be emitted from groundwater via soil surface



INVESTIGATION AREAS

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FIGURE 3.8

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TABLE 3.15 SUMMARY OF INVESTIGATION AREAS

INVESTIGATION AREA	DESCRIPTION
OU-1	The disposal trenches and chemical dispensing area in the southwest corner of the LEHR site and the DOE Disposal Box.
OU-1	The UC Davis trenches located between landfill units number 1 and 2, and along the south side of the dog pens.
OU-2	The radium-226 treatment tank and the associated leach field and dry wells.
OU-2	The strontium-90 treatment tank and associated leach system.
OU-3	The western set of dog pens, including the southern portion of the area currently occupied by the Cellular Biology Lab. The North Chemical Dispensing area is also included.
OU-4	Seven domestic septic tanks at LEHR.
OU-5	The three UC Davis landfill units.
OU-6	Groundwater beneath LEHR.
OU-6	Surface Water includes Putah Creek, and storm water runoff.

system ionization column was uncovered in this area during the construction of the LEHR site parking lot. A disposal unit known as the DOE Disposal Box is reportedly a steel dumpster-like container where the materials with relatively higher levels of constituents were disposed. The exact location of the DOE disposal box is not known.

The next investigation areas is comprised of the area between the Imhoff Building and Animal Hospital 2 and the parking area west of the Animal Hospital 1 and Imhoff Buildings containing the seepage system for the radium-226 treatment system. The seepage system reportedly consists of two tanks, a distribution box, three seepage pits (dry wells) and a seepage trench approximately 91 feet long, 3 feet wide and 14 feet deep.

The Imhoff investigation area is composed of tanks and the courtyard area east of the Imhoff Building containing the leach lines associated with the strontium-90 treatment system. The original leach lines for this system are under the current Imhoff building. It is anticipated that investigation of this area will be conducted after the Imhoff building has been demolished.

The dog pen investigation area includes a portion of the area currently occupied by the Cellular Biology Lab. In 1975, approximately 64 dog pens were removed from this area to allow construction of the lab. The highest levels of chlordane were reported in surface samples collected from the dog pens during the Phase II Site Characterization. Included in this area is the north chemical dispensing area. This area was used to store and dispense chemicals used at LEHR.

The seven domestic septic tanks comprise an investigation area. These seven tanks are located at various location throughout the LEHR site.

The three former UC Davis landfill units, referred to as Landfill Unit Nos. 1, 2 and 3, comprise an investigation area. Landfill Unit Nos. 1 and 2 are located on the LEHR property. Landfill Unit No. 3 is located approximately 600 feet east of LEHR.

The disposal trench investigation area contains the UC Davis trenches and pits located along the southern border of the two sets of dog pens and between Landfill Unit Nos. 1 and 2.

The groundwater system investigation area beneath the LEHR site includes areas with impacts to the groundwater system beyond the LEHR site boundaries. The surface water investigation area is comprised of Putah Creek and storm water runoff. Putah Creek is located south of the LEHR site and is separated from LEHR by a levee. Storm water collected in catch basins located on LEHR is routed to two lift stations. One lift station pumps storm water runoff to an outfall to Putah Creek. The second lift station services a combined stormwater and sanitary sewer system and pumps effluent to the UC Davis Waste Water Treatment Plant.

3.6 RESPONSE OBJECTIVES AND REMEDIAL ACTION ALTERNATIVES

This section presents a discussion of the response objectives and identifies preliminary remedial action alternatives, along with data requirements to effectively evaluate these alternatives.

3.6.1 Response Objectives

Media-specific response objectives will be established for each constituent of concern identified during the RI. The objectives for protection of human receptors will address exposure routes and target constituent levels. The objectives for protection of environmental receptors will address target cleanup levels.

Residual radioactive material guidelines have been derived for the LEHR site (Battelle, 1993). The guideline derivation was based on a dose limit of 100 mrem/year. The DOE residual radioactive material guideline computer code was used in this evaluation. This code uses the methodology described in the DOE manual for implementing residual radioactive material guidelines. The results of the evaluation indicate that the basic dose limit of 100 mrem/year will not be exceeded, provided that the soil concentrations of these radionuclides at the LEHR site do not exceed the scenario-specific values calculated. The derived guidelines are single-radionuclide guidelines and are linearly proportional to the dose limit used in the calculations. In setting the actual residual soil contamination guides for the LEHR site, DOE will apply the as-low-as-reasonably-achievable (ALARA) policy to the decision-making process. Site-specific inputs to the radioactive material guidelines computer code have not yet been fully determined.

In addition to the residual radioactive material guidelines developed by DOE, identified chemical-specific applicable and relevant and appropriate requirements (ARARs), presented in Section 10.1.4, may serve as a basis for establishing target constituent levels for each medium. The ARARs provide a basis for establishing acceptable constituent levels for the protection of human health and the environment. The list of constituents of concern may be modified as additional information is obtained during the RI.

3.6.2 Preliminary Remedial Action Alternatives

Based on available information, several preliminary remedial action alternatives have been developed that would reduce the risk associated with the sources identified. These alternatives have been developed to be used as a guideline for future FS which may involve the investigation areas. As a result, alternatives developed in a later FS may differ significantly from those presented here, depending on the results of further site characterization. A combination of alternatives may be considered to remediate both soil and groundwater, where necessary. Table 3.16 presents a summary of the preliminary remedial action alternatives discussed in the following sections.

3.6.2.1 Preliminary Alternative A — No Action

For soil, groundwater and surface water, this alternative would leave the site in its current condition with no remedial actions. Because this alternative includes no remedial technologies, no changes in the site configuration are required. Ongoing monitoring may be required.

3.6.2.2 Preliminary Alternative B — Limited Action

This alternative would leave the site in its present condition and would apply no remediation to existing impacted soil. It would include 30 years of groundwater monitoring and implementation of a deed restriction. Because this alternative includes no remedial technologies, no changes in the site configuration are required.

This limited-action groundwater monitoring alternative, whereby, groundwater would not be removed or treated (in situ or ex situ), would rely on the groundwater's natural tendency to decrease concentrations of contaminants over time.

TABLE 3.16 SUMMARY OF PRELIMINARY REMEDIAL ALTERNATIVES

PRELIMINARY ALTERNATIVE	ACTION	INVESTIGATION AREA
A - No Action	Leave the LEHR site in its present condition, no remediation	All areas
B - Limited Action	Leave the LEHR site in its present condition, no remediation; monitor groundwater for 30 years	Site groundwater
C - In Situ Containment With Cap[1]	Lateral containment of constituents using slurry walls or grout curtains; Surface cap to minimize rainfall infiltration and reduce fugitive emissions; area graded to prevent ponding of water	Radium-226 and Strontium-90 treatment systems; DOE disposal areas; UC Davis landfill units and trenches; Dog Pens (surface cap only)
D - In Situ Stabilization With Cap[1]	Encasement of contaminants in non-leaching matrix; Surface cap to minimize rainfall infiltration and reduce fugitive emissions; area graded to prevent ponding of water	Radium-226 and Strontium-90 treatment systems; DOE disposal areas; UC Davis landfill units and trenches; Dog Pens (surface cap only)
E - In Situ Soil Flushing	Remove chemicals and radionuclides that are sorbed onto subsurface soils by injecting a flushing agent; Injection and extraction wells for the flushing agent; above ground treatment of contaminated wastes; off-site disposal of residues	Radium-226 and Strontium-90 treatment systems; DOE disposal areas; UC Davis landfill units and trenches; Dog Pens (Above ground washing)
F - Ex Situ Chemical Extraction	Excavated soils cleaned using chemical extractant (acid); Extractant treated to remove constituents of concern; off-site disposal of residues	Radium-226 and Strontium-90 treatment systems; DOE disposal areas; UC Davis landfill units and trenches; Dog Pens
G - Ex Situ Stabilization/ Solidification[1]	Excavated soils encased in stable non-leaching matrix for on-site or off-site disposal	Radium-226 and Strontium-90 treatment systems; DOE disposal areas; UC Davis landfill units and trenches; Dog Pens

(1) This alternative is deemed "likely" to be applied compared to other alternatives. See Section 3.6.2.13 for additional discussion.

TABLE 3.16 SUMMARY OF PRELIMINARY REMEDIAL ALTERNATIVES (continued)

PRELIMINARY ALTERNATIVE	ACTION	INVESTIGATION AREA
H - Excavation and Disposal of Soils at Off-Site Facility	Excavating, packaging and transporting soils to off-site disposal location	Radium-226 and Strontium-90 treatment systems; DOE disposal areas; UC Davis landfill units and trenches; Dog Pens
I - Bioremediation	Excavated soils placed in treatment cell; breakdown of organic constituents accomplished through biodegradation	Soils containing elevated levels of organic compounds
J - D&D of Treatment Tanks(1)	Surface cleaning, scrabbling, possibly high-pressure foam cleaning. Piping surveyed and abandoned in-place or removed	Radium-226 and strontium-90 treatment tanks and domestic septic tanks
K - Ex Situ Groundwater Treatment(1)	Removal of constituents from groundwater by pumping impacted groundwater to the surface and treating; discharge or recharge of treated groundwater	On-site and off-site (if necessary)
L - Groundwater Containment	Contain movement of groundwater through the use of vertical barriers including grout curtains, slurry walls or sheet piling	On-site and off-site (if necessary)

(1) This alternative is deemed "likely" to be applied compared to other alternatives. See Section 3.6.2.13 for additional discussion.

Periodic monitoring of the groundwater would be included in this alternative to determine the direction and rate of movement of the plume and to determine when cleanup levels have been achieved. Deed restrictions would be implemented to prohibit the extraction and use of groundwater during the remediation period. This alternative is potentially applicable and is included for comparison purposes.

3.6.2.3 Preliminary Alternative C – In Situ Containment With Cap

This alternative would contain site constituents, including radionuclides, by surrounding operable units with a containment system to minimize lateral migration of constituents and covering surface soils to minimize the flow of precipitation through impacted subsurface soil. This alternative would eliminate the pathways of direct contact with surface soils, inhalation/ingestion of fugitive dust, and migration of constituents to groundwater.

This alternative consists of the following components:

- **In Situ Grouting**: Slurry walls constructed of a low-permeability soil and bentonite mixture (optionally cement) would be installed around investigation areas to divert ground water flow around impacted areas. Alternately, grout curtains would be used in the same capacity if the surface conditions would not allow for the installation of a slurry wall.

- **Surface Cap**: A natural (low-permeability soil or clay), synthetic (geomembrane), asphalt, or cement cover would be used to eliminate infiltration of precipitation and to reduce fugitive dust emissions.

- **Run-on/Runoff Controls**: Diversion ditches and drains would be used to prevent pooling of water over capped areas. These methods would also be used to divert surface water from the investigation areas.

Assuming that existing buildings in the areas of radium-226 distribution box, dry wells and seepage trench and strontium-90 leach field were to remain intact, grout curtains could be formed around the strontium-90 leach fields. Grout curtains would be easier to implement near buildings (walls and foundations) because they do not require the same level of trenching as do slurry walls. Slurry walls, however, could be utilized around the radium-226 seepage system and the landfill units, radioactive waste trenches and pits because they are more reliable, and installation would be logistically and technically

feasible around these areas. With the exception of the radium-226 dry wells, bottom grouting would not be required because the water table is located far enough below the waste areas (45 to 70 feet below grade) that temporary water level rises would not be expected to impact source areas. Because the radium-226 dry wells extend to very near the water table, controls should be instituted to minimize migration from the dry wells to groundwater.

These areas would then be capped by one of the methods shown above. The cover would be keyed into the grout barriers to provide an effective sealant against precipitation and lateral groundwater flow. Areas which are difficult to access with graders, such as the strontium-90 leach field could be covered with a concrete slab or asphalt cover. In both cases, run-on and runoff controls would be used to divert surface water flow around the capped areas

The dog pens consist of approximately 350 fenced runs which have had the floors lined with dirt and pea gravel. If the impacts present in this operable unit are concentrated in the pea gravel and have not migrated through subsurface soils, then grouting may not be required around the perimeter of the pens. A soil/clay cap (or any of the covers listed above) would be used to cover the entire area once the fencing has been removed. The fencing would be removed, decontaminated, and sent to a municipal landfill (the level of impacts to the fencing will most likely be minimal; steam cleaning could be used if required to dispose of the fencing in a municipal landfill or it could be left in place [for capping] after being lowered).

3.6.2.4 Preliminary Alternative D — In Situ Stabilization With Cap

This alternative would contain site constituents, including radionuclides, by encasing them in a stable, durable, non-leaching matrix. This alternative would eliminate the pathways of direct contact with surface soils, inhalation/ingestion of fugitive dust, and migration of constituents to groundwater.

This alternative consists of the following components:

- **In Situ Stabilization/Solidification:** Grout injection and/or dual-auger (counter-rotating) techniques would be used to mix the impacted subsurface

soils with a chemical, lime/fly ash, melted asphalt, or Portland cement microencapsulating agent.

- **Surface Cap**: A natural (low-permeability soil or clay), synthetic (geomembrane), asphalt, or cement cover would be used to eliminate infiltration of precipitation and to reduce fugitive dust emissions.

- **Run-on/Runoff Controls**: Diversion ditches and drains would be used to prevent pooling of water over capped areas. These methods would also be used to divert surface water from the investigation areas.

In this alternative, the radium-226 and strontium-90 leach fields, and the radioactive waste pits and trenches, would be stabilized/solidified in situ. A portland cement mixture would most likely be used with either of the in situ grout delivery techniques. Mixing with a clamshell or backhoe was not considered due to the locations of the leach fields and their proximity to existing buildings. This type of mixing could be used for the waste pits and trenches to achieve greater homogeneity during the treatment, however, in situ grout injection and dual-auger techniques would avoid bringing impacted soils to the surface and would result in fewer fugitive dust emissions. The dual-auger technique is also preferred over grout injection because the method provides a greater level of confidence in evaluating whether or not complete mixing was accomplished by allowing more control over the pattern of mixing. The resulting monoliths are 36-inch diameter columns which are overlapped to ensure that all of the impacted soils come into contact with the stabilizing/solidifying agent.

The dog pens are assumed to have shallow surface soil impacts only, and therefore do not warrant in situ stabilization/solidification. For this alternative the shallow soils and gravel would be excavated and either disposed of off site, decontaminated, or at least the gravels could be used as an aggregate additive to the in situ grout mixture.

Once the waste material has been stabilized/solidified, the resulting matrix would reduce the mobility of the constituents and inhibit migration to groundwater. Radon produced from the decay of radium-226 would also be contained and would decay to stable daughter products in the matrix before escaping.

Capping and run-on/runoff controls would be used to increase the effectiveness of the stabilized/solidified monolith by reducing the amount of precipitation that could reach

the waste forms. A cap used for this purpose would not be designed to the same degree as would a cap used as a sole source of containment. The cap used for this alternative would most likely consist of a compacted soil/clay, asphalt, or concrete cover.

3.6.2.5 Preliminary Alternative E — In Situ Soil Flushing

This alternative would remove radionuclides, potentially hazardous chemicals, and chemicals that may impact groundwater to a significant degree, which are sorbed onto subsurface soils by injecting a flushing agent in situ. The term used to describe this technology is "soil flushing." Surface soils would have to be "washed" after excavation, as soil flushing is not applicable to surface soils. These actions would eliminate the following pathways with the elimination of the source: direct contact with surface soils, inhalation/ingestion of fugitive dust, and migration of constituents to ground water.

This alternative consists of the following components:

- **Injection and Extraction Wells:** Injection wells are used to introduce a flushing solution to impacted areas and extraction wells or a subsurface drain system are used to collect and extract "spent" flushing solution.
- **Above-Ground Soil Washing System:** A soil washing system comprised of a chemical washing process followed by a multi-stage physical separation process would be used to "clean" impacted gravel.
- **Aqueous Waste Treatment System:** An above-ground aqueous waste treatment system would be required for removing and concentrating constituents which are present in the flushing solution. Several technologies can be used for treatment, such as solvent extraction, reverse osmosis, ion exchange, or precipitation.
- **Disposal:** Off-site or on-site disposal of radium-226 and strontium-90 containing residues, which result from the treatment of the flushing solution.

This alternative would involve "flushing" the radium-226 and strontium-90 leach fields (OU-2), and the waste pits and trenches (OU-1), with an aqueous solution containing either water (most preferable), a dilute acid, a complexing/chelating agent, or a surfactant. The flushing agent would be collected under the treated area via a series of extraction wells (horizontal or vertical) or through the use of subsurface drains although this is

unlikely due to site conditions, and the depth to the water table. The flushing agent would mobilize constituents sorbed onto soil because of their solubility characteristics. The flushing solution would then be treated above ground to remove the constituents. Ion exchange or another of the methods listed above would be used to remove the radium and strontium isotopes by concentrating them in the ion exchange resin or other residual media. These remaining solids would be shipped for off-site disposal in an approved facility or stored on site. The flushing agent which is recovered during the above-ground treatment stage is recycled into the soil flushing injection system.

Soil flushing would not be applicable for the dog pens because it is primarily a subsurface soil treatment technology and the pens are suspected of containing only surface and shallow soil impacts. For these areas, above-ground soil washing would be used to "clean" the excavated gravel.

3.6.2.6 Preliminary Alternative F — Ex-Situ Chemical Extraction

This alternative would extract constituents of concern from excavated waste materials by leaching the impacted matrix with an acid. The acidic extractant would then be treated by ion exchange, solvent extraction, or precipitation to remove the dissolved constituents of concern. This alternative would eliminate the sources for the pathways of direct contact with surface soils, inhalation/ingestion of fugitive dust, and migration of constituents to ground water.

This alternative consists of the following components:

- **Excavation:** Backhoes, clamshells or bulldozers would be used to excavate waste material.
- **Chemical Extraction:** Acid extraction would be used to separate radionuclides from the waste matrix by solubilizing them in either a nitric or hydrochloric acid solution.
- **Aqueous Waste Treatment:** An aqueous waste treatment system would be required for removing and concentrating radionuclides which remain in the acidic solution. Several technologies can be used for treatment, such as solvent extraction, reverse osmosis, ion exchange, or precipitation.

- **Disposal:** Off-site or on-site disposal of radium-226 and strontium-90 containing residues, which result from the treatment of the extractant.

This alternative would involve excavating the radium-226 and strontium-90 leach fields, the material in the radioactive waste trenches and pits (OU-1), and the surface soils (including gravel) from the dog pens. Excavation would be accomplished by backhoe because the materials are at relatively shallow depths. Pea gravel and surface soils from the dog pens would most likely be removed with a scraper or bulldozer.

Materials excavated from investigation units would then be subjected to an acid leaching process to extract chemicals and radiologics. The pregnant, aqueous extractant would be treated by one of the treatment options listed above or by a combination of options, to remove the constituents from solution. Treated extractant would be recycled and reused in the chemical extraction process. Solid residues containing strontium-90 and radium-226 would be either shipped to an off-site disposal facility or stored on site. Solid residues would have to meet the restrictions for free liquid content prior to disposal. If necessary, concentrated residuals could also be stabilized/solidified as in the ex-situ stabilization/solidification alternative. Excavations would be backfilled upon completion of this process.

3.6.2.7 Preliminary Alternative G — Ex-Situ Stabilization/Solidification

This alternative would contain radionuclides by encasing them in a stable, durable, non-leaching matrix for on-site or off-site disposal. Because this alternative involves removing the sources of constituents, the pathways of direct contact with surface soils, inhalation/ingestion of fugitive dust, and migration of constituents to groundwater would be eliminated.

This alternative consists of the following components:

- **Excavation:** Backhoes, clamshells, or dozers would be used to excavate waste material.
- **Stabilization/Solidification:** A chemical, lime/fly ash, melted asphalt, or portland cement microencapsulating agent would be mixed in with

excavated material to form a pumpable slurry. The slurry would then be poured and allowed to cure in molds or disposal containers.

This alternative would involve excavating impacted materials in the waste disposal areas, and the surface soils (including gravel) from the dog pens. Excavation would be accomplished by backhoe because the materials are at relatively shallow depths. Pea gravel and surface soils from the dog pens would most likely be collected with a scraper or bulldozer. A clamshell may be used in situations were the backhoe is unable to excavate to the required depths. All excavations would be backfilled with clean material upon completion of this process.

This alternative would require treating the excavated materials with a stabilizing/ solidifying agent to bind the chemicals and radionuclides present in a solid monolith suitable for off-site disposal or on-site storage. Typical binding agents include chemical, lime/fly ash, melted asphalt, or Portland cement. These reagents are mixed in with excavated materials in ratios that are usually developed during treatability studies conducted on the site-specific material. Treatability studies are generally necessary to ensure that the reagents selected for stabilization/solidification will provide a monolith with appropriate strength, durability, leach-resistance, and set time.

The mixing process would be conducted by a screw-type, batch mixing plant or continuous feed mixer, whichever method is more appropriate for the molds being considered. Continuous feed operations are preferred when large amounts of material are involved, however, batch mixing plants are more suitable to situations where the reagent feed mixtures will vary depending on the material being treated.

Once the waste material has been stabilized/solidified, the resulting matrix would reduce the mobility of the constituents, although total waste volume may increase as a result of the addition of the stabilizing/solidifying agents. Radon produced from the decay of radium-226 would also be contained and would decay to stable daughter products in the matrix before escaping.

3.6.2.8 Preliminary Alternative H — Excavation and Disposal of Soils at Off-Site Facility

This alternative would involve removing impacted soil by excavating, packaging, and then transporting the soils to an off-site location. Similar to previously discussed preliminary alternatives, this would involve removing the sources of impacted soil; thus, the pathways of direct contact with soils, inhalation/ingestion of fugitive dust, and direct contact/ingestion of groundwater impacted due to continued constituent migration would be eliminated.

This alternative consists of the following components:

- **Excavation**: Using backhoes, clamshells, scrapers, or bulldozers.
- **Packaging**: Impacted soils would be packaged in Department of Transportation (DOT) approved containers to allow transport to an off-site storage/disposal facility.
- **Transportation and Disposal**: The impacted soils would be transported to an approved off-site storage/disposal facility.

This alternative could be used in remediation of all of the soil investigation units. The site geology indicates that the surface soil is a fine sandy loam, the upper subsoil is sandy and the dominant lower subsoil is a gravelly sandy loam. This type of geology would be conducive to excavation. A scraper or bulldozer would collect surface soil and upper subsoils while backhoes and clamshells would collect the deeper lower subsoil. After excavation of the impacted soils is completed, the areas would be backfilled with clean material.

Considering the potential depths, excavation may prove to be impractical in some areas primarily due to the volume of soil that would be required to be removed, packaged, and transported off-site. Also, for volatile and semivolatile constituents, excavation can be impractical since disturbance of the impacted soils would likely result in the evaporation of these constituents to the environment.

Packaging of the excavated soil would require use of DOT-approved containers that would then be used for transport to an approved storage/disposal facility. The assumed

storage site is the Hanford facility in the state of Washington; however, the waste should be packaged such that temporary storage on-site is also possible. If on-site temporary storage is required, additional facilities may be needed. The packaging and transport of the impacted soil would require compliance with various administrative state and federal regulations and permits as well as criteria that are specified by the receiving site. Considerations for solid waste acceptance criteria may include: adequate characterization, manifest, and packaging requirements; compliance with waste container criteria; labeling and marking criteria; and documentation requirements.

3.6.2.9 Preliminary Alternative I — Ex-Situ Bioremediation

This alternative is applicable to soils which are not classified as a radioactive or hazardous waste under the DOE, RCRA, and State of California definitions. Bioremediation transforms and/or degrades site constituents, including volatile, semi-volatile, and chlorinated organic compounds in soils. This alternative would eliminate volatile emissions, inhalation/ingestion of fugitive dust, and migration of constituents to groundwater. This alternative consists of the following components:

- **Excavation**: Backhoes, clamshells, or bulldozers would be used to excavate organic waste material.

- **Bioremediation**: Chemical and physical amendments will be added to the soil to optimize the oxygen supply, the soil pH, and nutrient conditions of the soil. Irrigation water will be recirculated throughout the soil bioremediation treatment system, which will include a moisture delivery and leachate collection system. Soil physical amendments may be needed to enhance the permeability of the soil material. The bioremediation treatment system may be covered to reduce emission of volatile organic compounds, and oxygenation of the soil may be enhanced by forcing air through the soil with a system of blowers.

- **Aqueous Waste Treatment**: No solvents or hazardous materials would be added to the circulating liquids. Organic constituents in the liquid would biodegrade in this system. However, metals or other inorganic salts, including nitrate, are not biodegradable and may require ion exchange or other secondary treatment to remove these dissolved constituents.

- **Disposal**: Treated soils which meet DOE, federal, and State of California guidelines and are not classified as designated wastes may be disposed of on site.

This alternative would involve excavating soils with non-hazardous levels of volatile, semi-volatile and chlorinated organic compounds, including primarily non-radioactive organic wastes. Following excavation, the impacted soil would be placed into an above-ground biotreatment cell. Clean fill would be used to backfill and close the excavation.

The biotreatment cell would be engineered to contain all volatile and liquid by-products. Soil amendments would be mixed into the soil or applied in the liquid phase through an irrigation system. The treated soils and liquid would be sampled and analyzed throughout the treatment period. The liquid pH or nutrient concentrations may be adjusted to optimize the biodegradation of the target wastes by maintaining target chemical conditions of the soil pile.

The oxygenation of the soil pile may be enhanced by mixing an organic bulking agent, such as straw or wood chips, into the soil. Additional aeration may be supplied by circulating air through the soil pile with a system of slotted pipe connected to a blower with a manifold system to control flow rates. The soil treatment cell would be covered by 20 to 40 milliliters of UV-resistant plastic which would also reduce the flux of volatile emissions.

When soil monitoring indicates that the organic constituents have been degraded, post-treatment testing of the soils would then be conducted to verify the detoxification of the soil. Based on the results of this testing, the treated soil may be disposed on site or at an appropriate disposal facility that would accept non-hazardous waste.

3.6.2.10 Preliminary Alternative J — D&D of Treatment Tanks

This alternative would decontaminate the Imhoff tanks and radium-226 septic system by surface cleaning, and scabbing, if necessary, to reduce contamination levels to acceptable release limits. After decontamination, the tanks, piping, and other associated equipment would be abandoned in place, or removed and disposed.

NRC Regulatory Guide 1.86 "Termination of Operating Licenses for Nuclear Reactors" and proposed DOE rule 10 CFR 834 "Radiation Protection of the Public and the Environment" give consistent release criteria for radiologically contaminated facilities. The limits are set at average fixed contamination within any 1 square meter of 100 disintegrations per minute (dpm)/100 cm^2, maximum fixed contamination of 300 dpm/100 cm^2, and removable contamination of 20 dpm/100 cm^2 for radium-226. The corresponding limits for strontium-90 are 1000 dpm/100 cm^2, 3000 dpm/100 cm^2, and 200 dpm/100 cm^2 respectively. These limits would be appropriate for free release (i.e., release as clean) of the Imhoff facilities, however, actual remedial goals for this area will be risk based.

Imhoff Tanks

Surface cleaning, and potentially scabbing, may be required to bring the Imhoff tanks to the free-release criteria. At surfaces where the condition is smooth and sealed, cleaning with high-pressure water or foam may be sufficient to achieve adequate decontamination. Other surfaces will likely require scrabbling. After decontamination operations, the tanks would be surveyed to determine if they can be free released. The tanks would then be removed or abandoned in place. If the tanks are to be removed, they would be sectioned through standard demolition procedures and disposed as clean concrete waste. Any piping would be surveyed for contamination. If the piping is determined to be clean, it could be excavated and or abandoned in place. If the piping is contaminated, it would be packaged as low-specific-activity (LSA) waste and shipped for off-site disposal. Piping and tanks left in place would have all openings and penetrations sealed. The tank could be backfilled with clean fill. All waste to be removed from the site would be surveyed to ensure compliance with free-release limits.

Radium-226 Septic System

The radium-226 septic system would be decontaminated in the same manner as the Imhoff tanks. After decontamination, the tanks, distribution box and dry wells would be surveyed and free-released if possible. If the system is surveyed as clean and it is to be removed, the tanks, piping, and other equipment can be sectioned and disposed as clean waste. If the tanks are removed, the waste would be scanned prior to removal from the site to insure compliance with release limits. If the system surveyed as clean and is to be

abandoned in place, all process piping would be disconnected and sealed. Also, all penetrations into the tanks would be sealed. The tanks and dry wells would be backfilled with clean fill and a cement cap would be placed over the area. Portions of the system that are unable to be decontaminated to free-release criteria would be packaged as LSA waste and shipped for off-site disposal.

3.6.2.11 Preliminary Alternative K — Ex Situ Groundwater Treatment

This alternative would remove constituents currently present in groundwater, including radionuclides, by pumping impacted groundwater to the surface and instituting a treatment process to remove constituents. The treated groundwater would then be discharged or recharged to the subsurface. This alternative would remove constituents from the groundwater and eliminate the pathways of direct contact or ingestion of impacted groundwater.

This alternative consists of the following components:

- **Groundwater Removal:** Pumping of groundwater would be achieved by using an extraction well(s).

- **Groundwater Treatment:**
  - Impacted groundwater could be treated by a variety of ex-situ techniques utilizing physical, chemical, and biological processed.
  - Physical treatment of groundwater includes air stripping for VOCs.
  - Chemical treatment includes ion exchange for metals, UV oxidation for destruction of organic compounds, and reverse-osmosis for removal of salts.
  - Biological treatment includes denitrification of nitrate-impacted surface water or groundwater, bioremediation of organic compounds including VOCs, and potentially chlorinated organic compounds in water.

    Treated water may be discharged via reinjection or to surface water.

- **Disposal:** If necessary disposal of solid residues resulting from the treatment of groundwater would be performed.

Constituents consistently found in the groundwater at levels above background include: VOCs such as 1,1-dichloroethane, 1,1-dichloroethene, 1,2-dichloroethane, and chloroform; nitrates; metals such as selenium, chromium, and hexavalent chromium; and

radionuclides such as tritium, strontium-90, and carbon-14. A combination of several treatment technologies may be incorporated due to the variety of constituents: for example, chemical precipitation for metals, biological denitrification for the nitrates, ion exchange for the radionuclides and metals, and air stripping for the VOCs. Such a treatment system would consist of units and subsystems for each technology. Treatment effluents would include both air and liquid discharges. Pretreatment of the liquid stream is usually required to remove suspended solids prior to entering an air stripping tower. Suspended solids or precipitates may accumulate within a tower and decrease the overall efficiency of the air stripping unit.

Packaging and disposal of the treatment residues would require the use of DOT approved containers that would allow shipment to the Hanford facility in the state of Washington or temporary storage on-site. The transportation option would require compliance with state, federal, and receiving site requirements. These criteria include requirements for characterization, manifest, waste containers, labeling, marking, and documentation. On-site temporary storage may require additional facilities.

3.6.2.12 Preliminary Alternative L – Groundwater Containment

Alternative L would use a containment system to minimize movement of contaminated groundwater from the affected area. The groundwater containment alternative consists of the following components:

- **Grout Curtains, Slurry Walls, or Sheet Piling**: Grout curtains, slurry walls, or sheet pilings (vertical barriers) would be installed around the areas where ground water is to be contained. The vertical barriers would be keyed into the base of the second HSU to provide a closed containment system. This would minimize the movement of contaminated ground water under the vertical barriers and out of the containment system.

- **Surface Cap**: A surface cap would be used to prevent infiltration of precipitation into the containment area. Several options are possible for the cap. A multi-layer cap could be used that might include a natural (low-permeability soil or clay) material, a synthetic (geomembrane) layer, a drainage layer of sand and gravel, and a vegetative cover. An asphalt or concrete cap could be used to simplify installation particularly in areas harder to access. Use of a cap in conjunction with the vertical barriers described

above would prevent collection of precipitation waters in the containment area and eliminate a "bath tub" effect.

- **Run-on/Run-off Controls:** Diversion ditches and drains would be used to direct flow around the capped areas and off of the caps to prevent pooling of water over capped areas.

Assuming that the existing buildings in the areas of radium-226 distribution box, dry wells and seepage trench and strontium-90 leach field are to remain intact, grout curtains or sheet pilings may be used in those areas. Grout curtains and sheet pilings would be easier to implement near buildings (walls and foundations) because they do not require as large trenches as do slurry walls. Slurry walls, however, would be utilized in other areas because they are more reliable, and installation would be feasible. Bottom grouting would not be required because the vertical barriers would be keyed into the base of the second HSU. The actual materials, configurations, locations, lengths, and depths of the grout curtains, slurry walls, or sheet pilings would be evaluated during the feasibility study.

After installation of the vertical barriers, the area would be capped using either a multi-layer cap, asphalt, or concrete. The cover would be keyed into the vertical barriers to seal against infiltration of precipitation or surface water run-on. Areas which are difficult to access with graders, such as the strontium-90 leach field, or small areas where installation of a multi-layer cap is difficult, could be covered with a concrete slab or asphalt. In all cases, run-on and run-off controls would be used to divert surface water flow around and off of the capped areas. As with the vertical barriers, the materials, configurations, locations, size, and slopes of the caps would be evaluated in the feasibility study.

3.6.2.13 Identification of the Mostly Likely Alternatives for Site Remediation

The preliminary listing of alternatives includes those which are deemed likely to be applied at the LEHR site and some which are less likely , subject to further consideration as more information becomes available. The most likely alternatives are identified in Table 3.16 and listed below. These Alternatives are considered the best candidates for future implementation because:

- results of previous studies conducted at the site, and preliminary evaluation of the potential health and environmental risks associated with chemicals detected at the site, indicate that the groundwater and soil containment are likely to be effective means of reducing many of the potential risks;

- the Alternatives' proposed technologies:

  - have been proven in similar applications;
  - are considered acceptable for handling of radiologic wastes;
  - may be necessary to achieve compliance with applicable requirements; and,
  - are considered potentially acceptable to local, state, and federal regulators and the community.

The Alternatives considered most likely for future implementation are:

Alternative C-in Situ Containment with Cap
Alternative D-in Situ Stabilization with Cap
Alternative G-Ex Situ Stabilization/Solidification
Alternative J-D & D of Treatment Tanks
Alternative K-Ex Situ Groundwater Treatment

The RI/FS is designated to obtain data sufficient to support a thorough evaluation of the most likely alternatives.

3.6.3 Data Requirements

The following data requirements apply to the preliminary alternatives discussed above. The results of the data generated will provide sufficient information to allow for a preliminary screening of alternatives. Detailed analysis of remedial action alternatives may require additional data that would be developed during treatability studies or the remedial action.

Data which are particularly important to evaluation of the preliminary alternatives for soil and groundwater are:

- Hydrogeologic data, including hydraulic gradient and conductivity, permeability, and aquifer transmissivity;

- Soil parameters, including grain size, moisture content, liquid and air permeability;

- Soil chemistry - total organic carbon (for adsorption potential) and pH;

- Residential bacteriological populations for bioremediation potential;

- Waste characteristics in terms of compatibility with grout (may require treatability work);
- Post-treatment characterization for stabilized/solidified products would include bulking factor, unconfined compressive strength, leachability (ANSI/ANS 16.1), permeability, durability (freeze/thaw) and shear strength (optional);
- Lateral and vertical extent of constituents of concern;
- Environmental behavior of the constituents of concern; and
- Toxicity of the constituents of concern.

4.0 WORK PLAN RATIONALE

This chapter presents the RI/FS Work Plan rationale and describes the development of the Data Quality Objectives (DQOs). The project approach is also presented to illustrate how the described activities will satisfy the data needs.

Section 4.1 presents the components of the DQO development process. Section 4.2 describes the types of decisions that may be made with the data. Section 4.3 identifies the data uses and general needs, and Section 4.4 describes the basic design of the data collection program. In order to describe how the data needs will be met, Section 4.5 outlines the RI/FS Work Plan approach.

As noted in previous sections, the LEHR RI/FS will utilize to the greatest extent possible the SAFER and SACM processes. The DQO process presented in QAMS-005 and CERCLA has been further enhanced with an iterative process by which DQOs are modified based on current information. Some DQOs for selected areas may be further modified to support short-term remedial actions, if appropriate.

4.1 DATA QUALITY OBJECTIVES DEVELOPMENT

As specified in the EPA data quality objectives guidance document (EPA, 1993), data collected during the RI process must satisfy CERCLA requirements. These data are necessary to characterize the nature and extent of contamination, support the risk assessment, support the evaluation of corrective/remedial action, and assist in the development and evaluation of remedial alternatives.

DQOs have been specified for each data collection activity, and work will be conducted and documented in a manner whereby data collected are of sufficient quantity and quality for their intended uses (EPA, 1993) (Table 4.1). DQOs are qualitative and quantitative descriptions of the data required to support decisions made during remedial

TABLE 4.1 RI/FS DATA QUALITY OBJECTIVES

Activities Supporting RI/FS Objectives and Specific Data Needs	Data Type	Sampling/Analysis Activity	Analytical Level[a]	Data Use
Delineation of the Areal Extent and Location of Each Area of Interest	Complete literature review, remote sensing, test pits	Remote sensing and test pits to locate disposal trenches, seepage systems, landfill units	I, II, III, IV, V	Exact locations incorporated into the site geodetic survey; estimate volumes of waste
Assess the horizontal nature and extent of surficial soil impacts				
• Characterize surficial soils	Radiation survey data	Perform field radiation survey[b] at each area of interest	II	Worker Safety; source/soil characterization; external exposure rates; decontamination
	Surficial soil contamination data	Collect and analyze surficial soil samples at areas of interest; analyze for chemical and radiologic parameters appropriate for each area of interest	IV (V for radiological analysis)	Environmental evaluation; exposure risk
	Surficial soil physical properties data	Collect and analyze surficial soil samples for physical characteristics	II, III	Exposure risk; evaluation of remedial alternatives

[a] EPA Analytical Levels defined in Table 4.1a.

[b] Field survey meters may include an Eberline Rate Meter, a Ludlum 12 Rate Meter, and a Micro Tip.

[c] EPA Level IV and V data will be obtained for samples submitted to the laboratory. Approximately 10 percent of data will be validated using National Functional Guidelines; the remaining 90 percent will be subject to limited validation as described in Appendix B.

NA EPA analytical levels not appropriate for data type.

TABLE 4.1 RI/FS DATA QUALITY OBJECTIVES (continued)

Activities Supporting RI/FS Objectives and Specific Data Needs	Data Type	Sampling/Analysis Activity	Analytical Level[a]	Data Use
Evaluate the vertical nature and extent of impacts in the soil column beneath each area of interest and potential for impacted soil to affect surface water and groundwater				
• Characterize presence or absence of subsurface utilities/structures	Existing utilities maps/UC Davis Physical Plant/ interviews	Conduct clearance survey at areas of interest that may have subsurface contamination and investigations	I	Worker and environmental protection, assess potential contaminant migration pathways
• Characterize presence or absence of soil impacts at each area of interest	Soil chemical, radiologic, and physical properties data	Conduct soil gas surveys at disposal trenches and landfill units; analyze vapor samples for volatile organic compounds (VOCs) and radiologic parameters	II, III	Evaluate VOC and radiologic hot spots in landfill units; confirm with soil samples; risk assessment inhalation pathway
		Collect and analyze soil samples directly from sources at all areas of interest	IV (V for radiological analysis)	Source characterization; risk assessment; feasibility study
		Collect and analyze soil sample from offsite locations for a background evaluation		

[a] EPA Analytical Levels defined in Table 4.1a.

[b] Field survey meters may include an Eberline Rate Meter, a Ludlum 12 Rate Meter, and a Micro Tip.

[c] EPA Level IV and V data will be obtained for samples submitted to the laboratory. Approximately 10 percent of data will be validated using National Functional Guidelines; the remaining 90 percent will be subject to limited validation as described in Appendix B.

NA EPA analytical levels not appropriate for data type.

TABLE 4.1 RI/FS DATA QUALITY OBJECTIVES (continued)

Activities Supporting RI/FS Objectives and Specific Data Needs	Data Type	Sampling/Analysis Activity	Analytical Level[a]	Data Use
		Collect and analyze core samples along depth profiles below and lateral to sources; analyze for chemical and radiologic parameters appropriate for each area of interest	IV (V for radiological analysis)	Evaluation of lateral and vertical extent of constituents identified in sources; risk assessment, feasibility study
		Collect soil samples for analysis of physical properties; conduct in situ permeability and hydraulic conductivity testing; radon diffusion and emanation	I, II	Fate and transport modeling input parameters; risk assessment pathway analysis; feasibility study
• Characterize subsurface stratigraphy	Geologic parameters	Drill borings, excavate test pits, and log subsurface geology	I	Source/soil, groundwater characterization; baseline risk assessment; evaluation of remedial alternatives;

[a] EPA Analytical Levels defined in Table 4.1a.

[b] Field survey meters may include an Eberline Rate Meter, a Ludlum 12 Rate Meter, and a Micro Tip.

[c] EPA Level IV and V data will be obtained for samples submitted to the laboratory. Approximately 10 percent of data will be validated using National Functional Guidelines; the remaining 90 percent will be subject to limited validation as described in Appendix B.

NA EPA analytical levels not appropriate for data type.

TABLE 4.1 RI/FS DATA QUALITY OBJECTIVES (continued)

Activities Supporting RI/FS Objectives and Specific Data Needs	Data Type	Sampling/Analysis Activity	Analytical Level[a]	Data Use
Determine if groundwater beneath the areas of interest has been affected by impacts in the subsurface soil				
• Characterize presence or absence of groundwater impacts	Groundwater chemical and radiologic data	Collect and analyze groundwater samples using sampler and monitoring wells including verification of background groundwater quality.	III, IV (V for radiological analysis)	Groundwater Characterization; assess extent of impacts; provide validation and input for modeling; baseline risk assessment; environmental evaluation; evaluation of remedial alternatives
Assess the groundwater migration potential beyond LEHR boundaries				
• Characterize groundwater flow regime	Water level data	Obtain water level measurements from existing monitoring wells	I	Evaluate hydraulic gradients and flow directions throughout the hydrologic cycle; risk assessment; feasibility study
	Compliance monitoring locations and aquifer parameters	Install monitoring wells at LEHR as appropriate to define the lateral and vertical extent of impacts and conduct pumping test; evaluate regional groundwater extraction and irrigation	I	Define extent of impacts; fate and transport modeling; risk assessment; feasibility study; verification monitoring

[a] EPA Analytical Levels defined in Table 4.1a.

[b] Field survey meters may include an Eberline Rate Meter, a Ludlum 12 Rate Meter, and a Micro Tip.

[c] EPA Level IV and V data will be obtained for samples submitted to the laboratory. Approximately 10 percent of data will be validated using National Functional Guidelines; the remaining 90 percent will be subject to limited validation as described in Appendix B.

NA EPA analytical levels not appropriate for data type.

TABLE 4.1 RI/FS DATA QUALITY OBJECTIVES (continued)

Activities Supporting RI/FS Objectives and Specific Data Needs	Data Type	Sampling/Analysis Activity	Analytical Level[a]	Data Use
Assess surface water quality and the potential for impacts from stormwater runoff				
• Characterize surface water pathways	Surface water pathway mapping	Identify surface water flow pathways	I	Evaluate surface water flow pathways
• Characterize surface water impacts and stormwater discharge point sources at LEHR	Surface water chemical and radiological data	Collect and analyze surface water samples from locations upstream and downstream of LEHR	IV (V for radiological analyses)	Surface water characterization; extent of impacts; risk assessment pathway and receptor evaluation; feasibility study
	Storm water flow paths, chemical and radiological data	Collect and analyze storm water samples from the two lift stations that service the LEHR site. Samples will be collected during significant storm events.	IV (V for radiological analyses)	Surface discharge characterization; environmental protection; risk assessment; feasibility study
	Information on additional potential off-site sources of site constituents other than LEHR	Literature review; interviews; site vicinity reconnaissance	NA	Identify additional discharge points upstream of the LEHR site to evaluate impacts from LEHR
	Quantify leakance from surface water to first and second Hydrostratigraphic Units (HSUs)	Putah Creek flow data; physical characteristics of vadose zone, and first and second HSUs	I, II	Fate and transport modeling; evaluation of impacts to groundwater from surface water;

[a] EPA Analytical Levels defined in Table 4.1a.

[b] Field survey meters may include an Eberline Rate Meter, a Ludlum 12 Rate Meter, and a Micro Tip.

[c] EPA Level IV and V data will be obtained for samples submitted to the laboratory. Approximately 10 percent of data will be validated using National Functional Guidelines; the remaining 90 percent will be subject to limited validation as described in Appendix B.

NA EPA analytical levels not appropriate for data type.

TABLE 4.1 RI/FS DATA QUALITY OBJECTIVES (continued)

Activities Supporting RI/FS Objectives and Specific Data Needs	Data Type	Sampling/Analysis Activity	Analytical Level[a]	Data Use
Assess air quality at the LEHR site				
• Characterize ambient air quality and meteorological conditions	Perimeter monitoring	Install sampling stations; collect and analyze samples for VOC, radon and particulate emissions	IV	Site characterization; risk assessment exposure pathways; baseline conditions; impacts analysis; NEPA/CEQA documentation; verification monitoring
	Personal and ambient monitoring	Field monitoring during RI activities	II	Personal Health and Safety; Worker exposure; Environmental monitoring
	Meteorological data	Literature review; site specific data; precipitation; wind speed and direction	II	Risk assessment exposure pathways; baseline modeling; impacts analysis; NEPA/CEQA documentation; verification monitoring

[a] EPA Analytical Levels defined in Table 4.1a.

[b] Field survey meters may include an Eberline Rate Meter, a Ludlum 12 Rate Meter, and a Micro Tip.

[c] EPA Level IV and V data will be obtained for samples submitted to the laboratory. Approximately 10 percent of data will be validated using National Functional Guidelines; the remaining 90 percent will be subject to limited validation as described in Appendix B.

NA EPA analytical levels not appropriate for data type.

TABLE 4.1 RI/FS DATA QUALITY OBJECTIVES (continued)

Activities Supporting RI/FS Objectives and Specific Data Needs	Data Type	Sampling/Analysis Activity	Analytical Level[a]	Data Use
Additional Information needs				
	Demographics	Literature review	NA	Risk assessment receptor locations and densities; impacts analysis; NEPA/CEQA documentation
	Transportation data	Literature review	NA	Transportation risk modeling; impacts analysis; NEPA/CEQA documentation; feasibility study
	Vegetation and tissue analysis	Literature review; site observations	III, IV	Risk assessment receptor locations; impacts analysis; NEPA/CEQA documentation
	Ecological analysis	Literature review; site observations	NA	Impacts analysis; NEPA/CEQA documentation; risk assessment; ecological modeling
	Archaeological resources	Literature review; site observations	NA	Impacts analysis; NEPA/CEQA documentation
	Community/Regulatory input	Public Meetings; interviews; and surveys throughout the RI/FS process	NA	SAFER process; address community interests and concerns

[a] EPA Analytical Levels defined in Table 4.1a.

[b] Field survey meters may include an Eberline Rate Meter, a Ludlum 12 Rate Meter, and a Micro Tip.

[c] EPA Level IV and V data will be obtained for samples submitted to the laboratory. Approximately 10 percent of data will be validated using National Functional Guidelines; the remaining 90 percent will be subject to limited validation as described in Appendix B.

NA EPA analytical levels not appropriate for data type.

response activities. The DQOs have been developed and are incorporated into the data collection activities presented in the Field Sampling Plan (FSP) (Appendix A) and the Quality Assurance Project Plan (QAPjP) (Appendix B). DQOs have been developed using a three-step process as follows:

- identification of decision types;
- identification of data uses, types, and needs; and
- design of the data collection program.

These steps, described below embody the DQO process for the RI/FS for the LEHR site.

4.2 IDENTIFICATION OF DECISION TYPES

The first step in the development of the DQOs is to identify decision types. They include:

- identifying and involving the data users;
- evaluating available data;
- developing a site Conceptual Site Model (CSM); and
- specifying objectives and decision types that will be made during the RI/FS process.

Available data must be obtained and evaluated during this stage of the project to aid in the development of DQOs and to develop a conceptual site model (CSM) (EPA, 1987). The CSM presented in Section 3.4 identifies the sources, release mechanisms, transport pathways, exposure routes, and receptors. The components of this process are outlined below.

4.2.1 Identification and Involvement of Data Users

Data users have been divided into three general groups: decision makers, program management staff, and technical personnel. The principal decision makers for the LEHR site RI/FS are Federal officials responsible for RI/FS operations and the Federal and State regulatory officials responsible for environmental protection. These decision makers include the DOE Office of Environmental Restoration and Waste Management, the University of California, EPA Region IX, the State Water Resources Control Board, the California Regional Water Quality Control Board, the Department of Health Services Radiologic Health Branch, and the California Department of Toxic Substances Control.

Program managers of each discipline in this RI/FS investigation (modeling, risk, and remediation) and technical personnel have been brought into the RI/FS process during planning stages to help define data quality requirements. The Work Plan has been reviewed by the data users and their comments have been incorporated in the Work Plan structure.

4.2.2 Evaluation of Available Data

The history of operations at the LEHR site, described in Section 2.2, and previous investigations described in Section 3.0, constitute the evaluation of available data. Existing soil boring, groundwater, and surface water analytical data from locations in or adjacent to the LEHR site, are summarized in Section 3.0 and in the Phase II Site Characterization Report. These data were used in the development of this Work Plan, including the development of the CSM, the DQOs, and the HSP.

4.2.3 Development of Conceptual Site Model (CSM)

An integral part of the DQO process is the development of a CSM to identify areas of potential contamination, and contaminant pathways to support data collection needs. A CSM for the LEHR site has been developed based on the site physical characteristics and available data. The CSM presented in Section 3.4, includes descriptions of historical and current sources of wastes, release mechanisms, contaminant migration pathways, exposure routes, and receptors. This CSM will most likely be refined as specific chemical, radiologic and physical data are collected during the RI process.

4.2.4 RI/FS Objectives and Decisions

The primary objectives of the RI/FS are to characterize the nature and extent of contamination for each area of investigation and the LEHR site as a whole, to provide information necessary to determine the risk associated with the contamination, and to provide information to evaluate potential remedial action alternatives.

4.3 IDENTIFICATION OF DATA USES, TYPES, AND NEEDS

The second step of the DQO process is comprised of the following components:

- identification of data uses;
- identification of data types;

- identification of data quality needs;
- identification of data quantity needs;
- evaluation of sampling and analysis options; and
- review of precision, accuracy, representativeness, comparability, and completeness (PARCC) parameters.

Also included in this step is the selection of the sampling approach and the analytical options for the task, including the economic and technical feasibility of chosen technique. The following sections discuss each of the six components.

4.3.1 Identification of Data Uses

For the sampling effort to address the objectives outlined in Section 4.1, the anticipated uses for the data must be specifically stated. Data collected during the RI will be used to characterize the physical features, the nature and extent of contamination, support the baseline risk assessment and environmental evaluation, and evaluate remedial alternatives. Additionally, data will be used to characterize some investigation-derived wastes for proper disposal. Areas of interest identified for characterization include the surface of the site, soils, groundwater, and potentially, surface water, air, and biota. Samples will be collected to assess the extent and type of impacts present at each area of interest. Data will also be collected to evaluate the physical characteristics of the media for use in transport and pathways analyses. Data will be used to modify DQOs, the CSM, and remedial objectives during the RI/FS.

4.3.2 Identification of Data Types

The specific data types have been identified by the intended users of the data. Data types will consist of data generated from field survey and laboratory analytical results of samples for each objective. For the most part, physical media will be sampled during the RI. The physical media include soils, soil gas, air, groundwater, and surface water. Additionally, limited radiation surveys will be performed at each area of interest. The analytical requirements are dictated by the intended use of the data (Table 4.1A).

A list of analytical methods for each physical media and area of interest has been developed and is presented in the FSP (Appendix A). The criteria used to develop the list include documentation from LEHR, existing analytical data, and data required to conduct fate

TABLE 4.1A APPROPRIATE ANALYTICAL LEVELS – BY DATA USE

	Site Characterization (including Health & Safety)	Risk Assessment	Evaluation of Alternatives	Engineering Design of Remedial Action	Monitoring During Implementation of Remedial Action	PRP* Determination
Analytical Level I	✓				✓	
Analytical Level II	✓		✓		✓	
Analytical Level III	✓	✓	✓	✓	✓	✓
Analytical Level IV		✓	✓	✓		✓
Analytical Level V		✓		✓		✓
Other				✓		

*PRP Potential Responsible Party

From: EPA, 1987, Data Quality Objectives for Remedial Response Activities.

and transport modeling. The available historical information and evaluation of existing data suggest that, to be conservative, analysis should be conducted for several chemical and radiologics during the field sampling program.

4.3.3 Identification of Data Quality Needs

Supportability of analytical methods must be evaluated to establish DQOs. The parameters for which an analytical method is valid or limited, and any special considerations which will affect data quality must be understood in order to select appropriate methods. Table 4.1B lists the analytical levels appropriate for the intended data uses, according to the EPA's Data Quality Objectives for Remedial Response Activities Development Process (EPA, 1987). We anticipate that DQOs will be revised as additional information is developed during the RI.

4.3.4 Identification of Data Quantity Needs

Data quantity needs are based on the level of data that provides acceptable uncertainty and for providing input to the risk assessment and assessment of remedial alternatives. Data presently available are not complete enough to adequately evaluate potential source terms with regard to types and concentrations of suspected contaminants. As such, these data do not meet the objectives of the RI/FS; therefore, the collection of additional data from the source areas is warranted. Additional data requirements for the risk assessment and FS are presented in Section 10.0, and Sections 3.6 and 11.0, respectively.

4.3.5 Evaluation of Sampling and Analysis Options

The RI for the LEHR site will use a staged, multi-task field screening and soil sampling approach to direct subsurface data collection activities. This approach maximizes collection of available data and surficial soil sampling and field screening techniques prior to intrusive sample collection. This approach minimizes the volume of generated waste material that may require special management, the potential exposure of field personnel to waste material, and the overall time and efficiency of field activities.

Field sampling activities are described in detail in Appendix A. Appendix B of this Work Plan discusses the analytical program requirements for LEHR. Appendix B of this Work Plan, the Quality Assurance Project Plan (QAPjP) lists the CLP analytes and detection/quantification limits for target compounds including volatile and semivolatile organics, metals, radionuclides,

TABLE 4.1B EPA ANALYTICAL SUPPORT LEVELS

Level	Description
I	Field screening or analysis using portable instruments. Results are often not compound specific and not quantitative, but they are available in real time. This is the least costly of the analytical options. Instruments may not respond to all compounds and may not be able to identify compounds. If the instruments are calibrated properly and data are interpreted correctly, Level I techniques can provide an indication of contamination.
II	Field analyses using more sophisticated portable analytical procedures (such as gas chromatography for organics and atomic absorption or x-ray fluorescence for metals). The instruments may be set up in a mobile on site laboratory. Results are available in real time or within several hours, and may provide tentative identification of compounds or be analyte specific. Data are typically reported in concentration ranges, and detection limits may vary from low parts per million to low parts per billion. Data quality depends on the use of suitable calibration standards, reference materials, sample-handling procedures, and training of the operator. In general, Level II techniques and instruments are mostly limited to volatiles and metals.
III	All analyses performed at an off-site analytical laboratory. Level III analyses may or may not use Contract Laboratory Program procedures, but do not usually use the validation or documentation procedures required of Contract Laboratory Program Level IV analysis. Detection limits and data quality are similar to Level IV, but results will generally be available in a shorter time.
IV	The Contract Laboratory Program routine analytical services. All analyses are performed in an off-site Contract Laboratory Program analytical laboratory following Contract Laboratory Program protocols. Generally, low microgram-per-liter detection limit for substances on the Hazardous Substance List (EPA 1986a), but also may provide identification of non-Hazardous Substance List compounds. Sample results may take several days to several weeks, and additional time may be required for data validation. Level IV results have known data quality supported by rigorous quality assurance and quality control protocols and documentation.
V	Analysis by nonstandard methods. All analyses are performed in an off-site analytical laboratory that may or may not be a Contract Laboratory Program laboratory. Method development or method modification may be required for specific constituents or detection limits, and additional lead time may be required. Detection limits and data quality are method specific. The Contract Laboratory Program special analytical services are Level V.

and other soil, water, and air sampling parameters. These analytical methods are appropriate to meet the data quality requirements for EPA analytical Levels I through V during the RI/FS (Table 4.1).

4.3.6 Review of PARCC Parameter Information

The PARCC parameters (precision, accuracy, representativeness, comparability, and completeness) are indicators of data quality. The end use of the measurement data typically define the necessary objectives for the PARCC parameters. The PARCC goals are specified in the QAPjP of this Work Plan (Appendix B). The PARCC parameters are defined below. Analyte-specific precision and accuracy objectives are also listed in the QAPjP.

The PARCC parameters are defined as:

- Precision measures the reproducibility or degree of agreement among replicate measurements under a given set of conditions;
- Accuracy measures the bias in a measurement system;
- Representativeness expresses the degree to which sample data accurately and precisely represent a characteristic of a population, parameter variations at a sampling point, or an environmental condition;
- Completeness is defined as the percentage of measurements made that are judged to be acceptable; and
- Comparability is a qualitative measure defined by the confidence with which one data set can be compared to another.

4.4 DESIGN OF DATA COLLECTION PROGRAM

The third and final step in the development of DQOs is the design of a data collection program. The data collection program has been prepared for LEHR and is presented in the SAP, Appendices A and B of this Work Plan. The SAP also includes a detailed list of samples to be collected, including media and sample type, and sample location maps for each area of interest. A listing of the type and frequency of quality control (QC) samples to be collected is also provided.

The QAPjP (Appendix B) describes the policy, organization, functional activities, and QA and QC protocols necessary to achieve the DQOs dictated by the intended use of the data.

4.5 WORK PLAN APPROACH

The tasks developed for the collection and analysis of data are presented in Chapters 5, 6, 7, and 8 and Appendix A of this Work Plan. The tasks will be conducted in a phased approach, although some tasks may be conducted concurrently to optimize efficiency in the field. Each initial investigation task will build on information obtained in the previous task. To this end, the specific scope of certain tasks will not be finalized until the results of the previous tasks have been evaluated. The final scope of second-phase field tasks will be evaluated and determined by site personnel and the regulatory agencies as agreed upon prior to the field program. As changes are made to the Work Plan, they will be documented using the Change Notice form included in the QAPjP (Appendix B). The following sections describe the general approach and methodologies that will be used to conduct the RI/FS at the LEHR site.

4.5.1 Use of Existing Data

Data collected during the Phase II Site Characterization, and existing data from the Phase I and other previous investigations have been used in the preparation of this Work Plan. Data from the Phase II Site Characterization have been used in a quantitative sense whereas data collected prior to the Phase II Investigation have been used in a qualitative sense. Because of the unknown level of QA/QC documentation associated with the data collected during some of the earlier investigations at LEHR (Pre-Phase II), these data were used primarily as a guide for identifying potentially impacted areas.

Available data and records pertaining to the LEHR site will be reviewed to further assess the types and quantities of chemicals and radionuclides used, and their methods of disposal. In addition, other published and unpublished data regarding regional and local hydrologic, hydrogeologic, and geologic data will be reviewed. The data review and evaluation, in conjunction with data collected during this RI will be used to assess the

physical environment of the LEHR site and evaluate potential sources, pathways, and transport mechanisms.

4.5.2 Collection of Data for Specific Needs

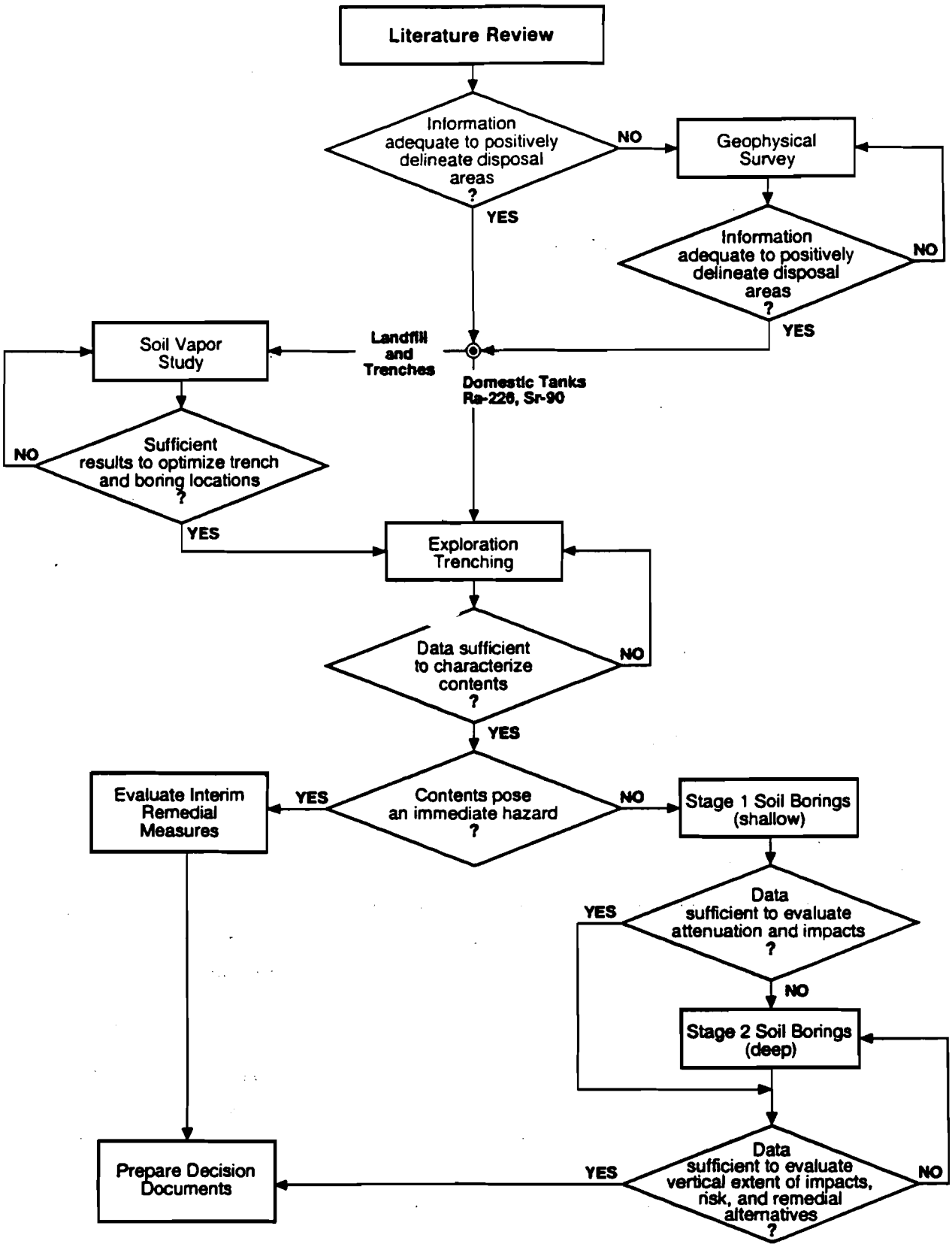
During the RI, data will be collected for specific needs as identified in the Conceptual Site Model (CSM) (Section 3.4). Therefore, the data-gathering program presented in this Work Plan has been refined to focus on the specific requirements for collecting the identified set of data. Based on evaluation of the data collected, additional data may be needed during the RI, FS, or RA phase.

4.5.3 Site-Specific Investigations

This RI consists of a number of investigations of specific areas suspected or known to have the potential to release or transport constituents to the environment. Discussion of the investigation methodologies and sampling parameters for each of these areas of investigation are presented in Chapters 5, 6, 7, and 8 and in Appendix A.

4.5.4 Phased Investigation

This RI will be conducted in a phased manner to allow integration of data as it is collected resulting in a more efficient completion of identified tasks and modification of the CSM, DQOs, and remedial objectives during the process. The approach is to first perform the literature review tasks for each of the areas. This may bring to light information that would require a change in sampling methods, locations, or parameters. The second phase will be to more accurately locate the areas of investigation, such as disposal trenches, seepage pits, and leach lines. The third step is to collect appropriate samples to evaluate the nature and extent of site constituents based on existing information. As analytical results are received, data will be validated as described in the QAPjP and the data will be included in order to modify subsequent phases of work as necessary. A flow diagram that identifies investigation tasks and key decision points is found on Figure 4.1. Scheduling information is presented in Chapter 14 of this Work Plan.



SOIL INVESTIGATION DIAGRAM

RI/FS Workplan
LEHR Environmental Restoration
Davis, California

10805-72-044.jdg.2/23/94.prerifs.3

FIGURE 4.1

4.5.5 Specific Data ~~N~~eeds

This RI is designed to provide sufficient chemical and physical soil data to evaluate the vertical and lateral extent of site constituents in the specific areas of investigation ~~to an acceptable uncertainty level~~. Additionally, the data will be useful for human and environmental risk assessment, feasibility studies and NEPA/CEQA documentation for remediation of the LEHR site ~~and to evaluate DOE liability for non-DOE areas~~. Investigative methods are described in Chapters 5, 6 and 7 of this Work Plan and detailed in Appendix A.

4.5.6 Investigation Methodologies

This RI program will incorporate several different methodologies to evaluate the physical and environmental conditions at the site. The investigation methodologies planned for this RI include:

- literature review and personnel interviews;
- geophysical surveys;
- soil gas and radiologic surveys;
- soil borings;
- exploration trenching;
- cone penetrometer testing and hydropunch;
- groundwater monitoring well installation;
- aquifer testing (slug tests and pump tests);
- sampling of plants;
- surface water and storm water runoff evaluation;
- baseline air monitoring; and
- meteorological evaluation.

4.5.7 Data Evaluation Methodologies

Data gathered during this RI will be evaluated using various statistical, graphical and tabular methods. Statistical methods will be used to compare potential on-site impacts with background levels of soil, water and air established for this RI/FS program. Graphical and tabular methods will be used to present the analytical and physical data obtained. The data will be documented and summarized to describe chemical, radiological and physical

characteristics of the areas of investigation. Additionally, vadose zone and groundwater modeling will be performed to simulate contaminant fate and transport. Final data evaluation will be performed after the field information and laboratory results are compiled and will be presented in the RI Report.

4.5.8 Minimizing Generation of Wastes

A variety of impacted or potentially impacted wastes will be generated during this investigation. These materials will consist mostly of cores from soil borings, purged and development water, used personal protective equipment (PPE), and decontamination products. The investigative methods described in Chapters 5, 6 and 7 have been designed to minimize waste generation and, where feasible, to segregate wastes. Additionally, during the field investigation, efforts will be made to further reduce generated wastes without affecting the quality of the data generated, or endangering the health and safety of site personnel. Wastes generated during this investigation will be temporarily stored, transported, and disposed in an appropriate manner as described in the Waste Management Plan for Investigation Derived Waste (Appendix D).

5.0 SOIL INVESTIGATION

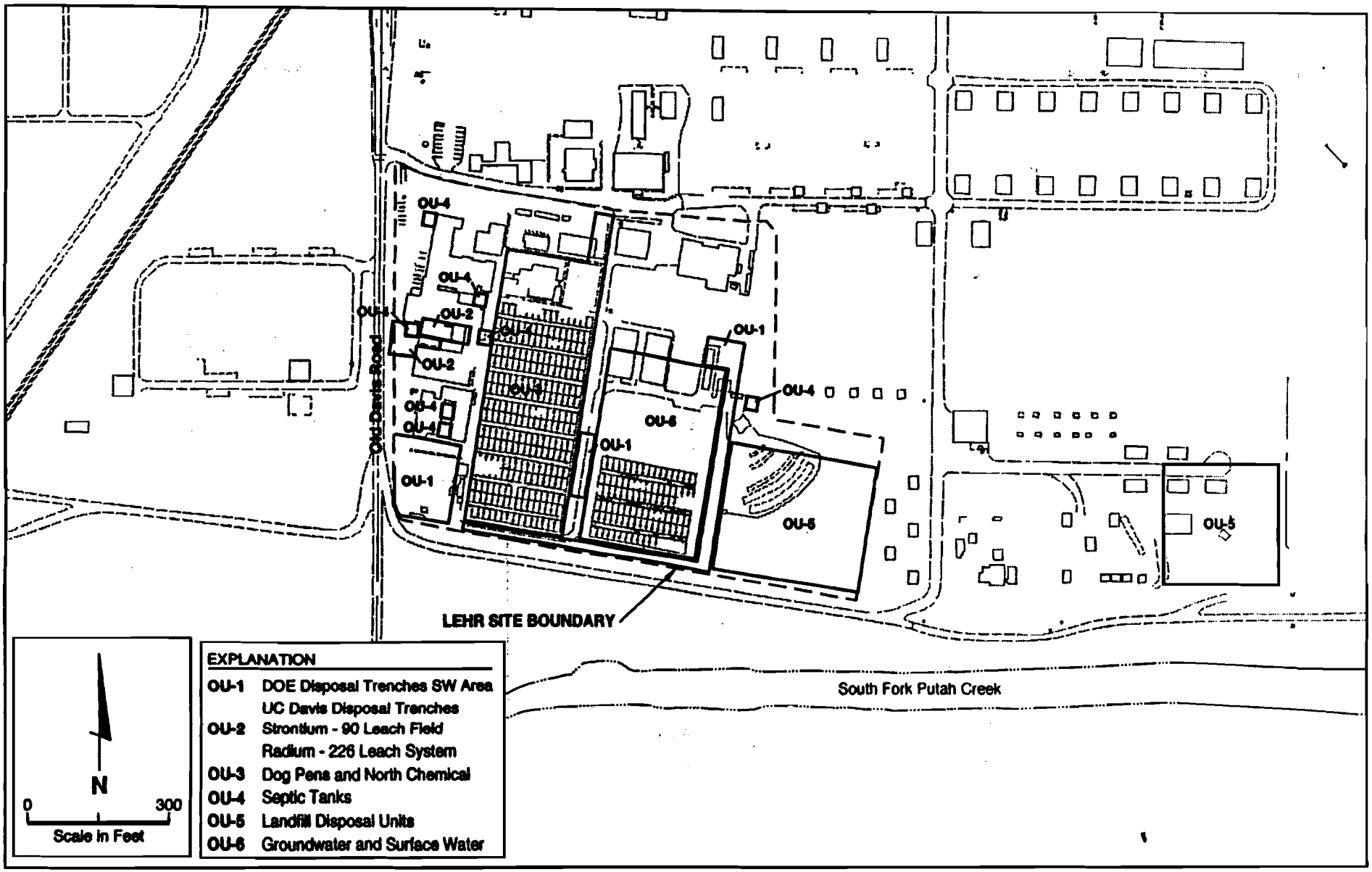
This chapter presents a description of the tasks to be conducted for characterization of soils at each of the Investigation Areas identified at the LEHR site, as shown on Figure 5.1. Specific activities and sample collection techniques that will be performed during the completion of each investigation task are described. Additionally, the rationale for sample location, sampling points, and the analytical parameters are presented. The soil investigations described in this chapter include:

- Calculating background concentrations.
- Locating and sampling the DOE burial areas and trenches and the southwest chemical dispensing area.
- Locating and sampling the radium-226 treatment tank and leach system.
- Locating and sampling the strontium-90 treatment tanks and leach system.
- Locating and sampling the domestic septic tanks and leach fields.
- Characterizing the western set of dog pens and the north chemical dispensing area.
- Locating and sampling the UC Davis burial trenches.
- Locating and sampling the UC Davis landfill units.
- Evaluating data.

The data and interpretations will be presented in the RI Report, as discussed in Chapter 14.

For the purpose of this soil investigation, the site has been divided into five preliminary operable units (OU). The soil OUs are made up of the Areas of Investigation described in previous sections and as shown on Figure 5.1. The preliminary soil OUs are defined as:

- OU-1 — DOE burial areas, trenches and disposal box, southwest chemical dispensing area, and UC Davis burial trenches;
- OU-2 — Radium-226 and strontium-90 treatment systems;
- OU-3 — Western dog pens and north chemical dispensing area;
- OU-4 — Domestic septic tanks; and
- OU-5 — the landfill units.



INVESTIGATION AREAS

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'IGURE 5.1

It is anticipated that a variety of exploration and sampling methods, including geophysical and soil gas surveys, backhoe excavation, soil borings, and wipe sampling, will be used. Tables 5.1A and 5.1B present the anticipated sampling techniques, and approximate number of samples that ~~will~~ may be collected~~, respectively~~. Table 5.1C presents a summary of the soil chemical and radiologic analytical parameters that ~~will~~ may be analyzed in one or more site area(s), and a brief rationale for the inclusion of each analyte. Details of field sampling activities and decontamination procedures are presented in the FSP, Appendix A, and Health and Safety Procedures are presented in Appendix C.

The soil investigation program utilizes a phased approach. Each initial exploration task will build on information obtained in the previous task. To this end, the exact number of trenches, borings, samples or chemical parameters may change. The specific scope of each task will be evaluated and determined by site personnel and the regulatory agencies, as agreed prior to the field program. As changes are made to the Work Plan, they will be documented using the Change Notice form included in the QAPjP (Appendix B).

Prior to initiating field investigation activities, a site walk with UC Davis Physical Plant, Institute of Toxicology and Environmental Health (ITEH), and LEHR personnel will be conducted to assess the work areas associated with each Investigation Area and potential disruptions to current site activities. Information sought will include location of overhead and underground utilities, potential access difficulties, type of work area pavements, and potential disruptions to current site activities/operations. UC Davis Physical Plant personnel and ITEH engineers will be asked to locate all underground utilities and clear all designated underground work areas at the LEHR site prior to investigation. Underground Service Alert (USA) will be notified to locate public utilities prior to conducting any intrusive investigations for this RI.

Appropriate drilling and well installation permits will be obtained from Solano County Environmental Health Department prior to drilling of soil borings. For work conducted within 10 feet of the landward side of the north levee of Putah Creek, permits will be obtained from the State of California, Resources Agency Reclamation Board.

Upon completion of each investigation activity, including geophysical lines, soil vapor points, exploration trenches and soil borings, a wooden stake with the appropriate

TABLE 5.1A SUMMARY OF SOIL INVESTIGATION ACTIVITIES

Areas of Interest	Vapor Probes/ Samples	Backhoe Excavation/Samples	Soil Borings/Samples		Concrete Coring		Wipe Samples
			First Stage	Second Stage	Concrete	Soil	
Background Study	NA	NA	6/24 (2)	NA	NA	NA	NA
DOE Disposal Trenches and Southwest Chemical Disposing Area	22/44 (2)	4-6/20-30 (2)	5/15 (1)	TBD	NA	NA	NA
DOE Disposal Box	5/10 (1)	3/9 (1)	3/9 (1)	TBD	NA	NA	NA
UC Davis Disposal Trenches	39/78 (3)	8/32 (1)	19/57 (6)	TBD	NA	NA	NA
Redium-226 Treatment System	NA	8/17 (2)	6/24 (2)	NA	10	6	12 (1)
Strontium-90 Treatment System	NA	2/10 (1)	6/24 (2)	NA	10	6	6
Western Dog Pen Area and North Chemical Dispensing Area	NA	NA	19/31 (2)	NA	NA	NA	NA
Domestic Septic Tanks	NA	14/14 (1)	21/49 (3)	NA	NA	NA	21 (1)
UC Davis Landfill Units	68/204 (11)	NA	16/64 (4)	TBD	NA	NA	NA
TOTALS[1]	134 PROBES 336 SAMPLES + 17 QA/QC	41 TRENCHES 112 SAMPLES + 8 QA/QC	101 BORINGS 297 SAMPLES + 23 QA/QC	TBD	20 SAMPLES	12 SAMPLES	41 SAMPLES + 2 QA/QC

NA No samples anticipated.
Number in parentheses indicates number of QA/QC samples collected.
TBD - To be determined.
(1) Sample numbers shown are the anticipated maximum number of samples to be s mitted for chemical analysis. The actual number of samples submitted for analysis may vary and will be determined in the field and after eva Jon of initial data.

TABLE 5.1C SUMMARY OF ANALYTICAL PARAMETERS

Constituent	Rationale*	Constituent	Rationale*	Constituent	Rationale*
Gross Alpha	6,7,8,9	Cobalt-60	1,4,7,8,9	Nitrate	2,4,5,6,7,8,9,11
Gross Beta	6,7,8,9	Chlorine-36	1,4,7,8,9	Alkalinity	6,7,8,9,10
Gamma Spec	3,4,5,6,7,8,9	Metals	3,4,5,7,8,9,10	Total Kjeldahl Nitrogen	4,6,7,8,9,10,11
Strontium-90	1,3,4,5,7,8,9	Hexavalent Chromium	2,4,7,8,9	Ammonia	4,6,7,8,9,10,11
Radium-226	1,4,5,7,8,9	Pesticides	1,3,4,5,7,8,9	Anions	4,6,7,8,9,10
Carbon-14	1,2,4,7,8,9	Formaldehyde	1,3,4,7,8	Sulfide	6,7,8,9,10
Tritium	1,2,4,5,7,8,9	VOCs	1,2,4,5,7,8	Total Organic Carbon	6,8,9,10
Cesium-137	1,3,4,7,8,9	VOCs	1,3,4,5,7,8	pH	6,7,8,9,10
Sodium-22	1,4,7,8,9	Diesel	1 4,7,8	Electrical Conductivity	6,8,9,10
Uranium-238	1,4,7,8,9	Kerosene	1,4,7,8	Bacteriological Count	6,8,9,10,11
Americium-241	1,4,5				

* **Rationale Key:**

1 Known constituent used or disposed on site.
2 Suspected site constituent based on consistent detections in groundwater.
3 Suspected site constituent based on sporadic detections in groundwater.
4 Suspected site constituent based on previous disposal practices.
5 Suspected site constituent based on detections in previous soil investigations.
6 Indicator parameter for other constituent.
7 Data needed for Risk Assessment.
8 Data useful for FS.
9 Data needed to establish background versus on-site concentration.
10 Influences mobility of other constituents.
11 May contribute to nitrate loading.

TABLE 5.1B SUMMARY OF PHYSICAL TESTS BY AREA OF INVESTIGATION

Physical Test	ASTM Method Number	DOE Trenches and DOE Disposal Box	UC Davis Trenches	Radium-226 Area	Strontium-90 Area	UC Davis Landfill Units	TOTALS[1]
Hydrometer	D-422	5	5	5	2	11	28
Grain Size	C-136	5	5	5	2	11	28
Permeability	D-2434	4	4	3	2	6	19
Moisture Release	D-3152 and D-2325	4	4	3	2	6	19
Moisture Content	D-2216	25	25	20	20	50	140
Mineralogy	XRD	3	2	2	2	3	12
Specific Gravity	D-854	3	3	3	2	6	17
Atterberg Limits	D-4318	10	10	10	5	15	50
Dry Bulk Density	D-4531	10	10	10	5	15	50
Down-hole Permeability Tests	Hazen, 1991	2	2	2	0	4	10
Double-Ring Infiltrometer Tests	D3385	1	1	1	0	2	5

XRD - X-Ray Diffraction
ASTM - American Society of Testing and Materials
(1) Sample numbers shown are the anticipated maximum number of samples to be submitted for physical analysis. Actual number of samples submitted for analysis may vary and will be determined in the field.

identification will be driven into the soil at the surface location. The horizontal and vertical coordinates will be surveyed, by a registered surveyor, to the nearest 0.3 and 0.01 foot, respectively, and incorporated into the site geodetic survey.

Investigation-Derived Wastes will be field screened for volatile organic compounds and radioactivity. Results will be compared to the established health criteria presented in the Waste Management Plan for Investigation-Derived Waste (IDW). If screening levels are below the established criteria, soil wastes will be placed in shallow, lined excavations near the boring and covered with native materials. However, if field screening indicates the presence of organic or radiologic constituents above established health criteria, the materials will be placed in 55-gallon drums, pending analytical characterization under the Waste Management Plan for IDW. Selected materials encountered during exploration trenching, such as intact containers, will be left in place and marked for a removal action at a later date. ~~It is anticipated that all materials removed during exploration trenching will~~ Additional details on the Management of IDW are presented in the Waste Management Plan for IDW at LEHR.

5.1 BACKGROUND STUDY

A background study will be conducted to establish background concentrations of metals, and chemical and radiologic constituents of concern for comparison to those previously reported in soils at the LEHR site. Preliminary background concentrations were established during the Phase II Investigation based on soil samples collected from UCD-17 and UCD-18. The background levels established during this study will provide the basis to develop remedial objectives for the site. The background study will consist of the following four specific activities:

- literature review;
- vadose zone soil sampling;
- analysis of selected soil samples; and
- development of background levels.

Each of these activities is discussed below.

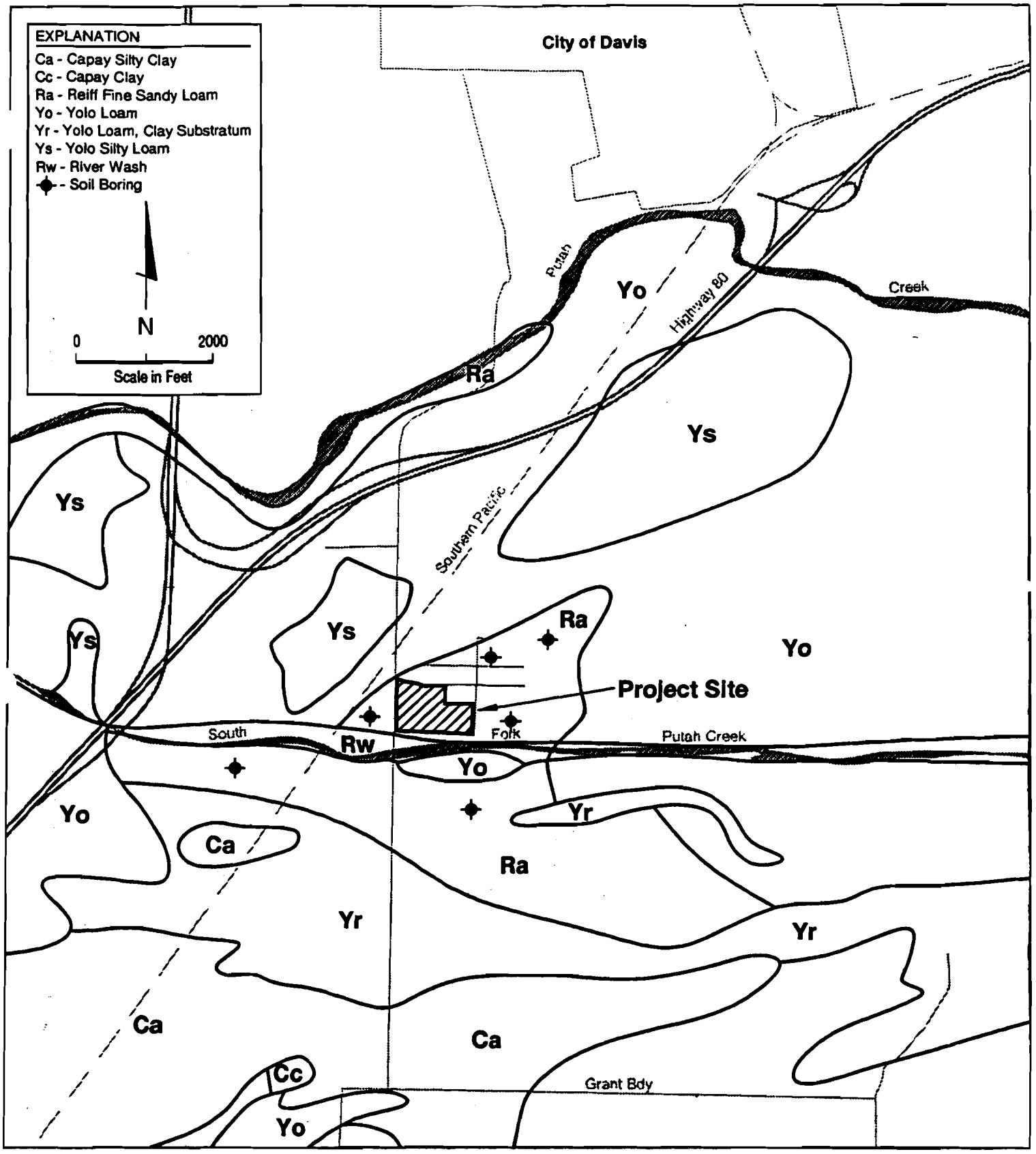
5.1.1 Literature Review

Available literature will be reviewed including Shacklette and Boerngen, 1984 and Dragun and Chaisson, 1991, to identify published regional background concentrations of naturally-occurring metals and radiologic parameters in the soils. This task will also consist of a review of literature regarding the geology and soils of the Coast Ranges Geomorphic Province to identify potential naturally-occurring sources of metals or radiologics that have been detected during previous investigations at the LEHR site.

5.1.2 Vadose Zone Soil Sampling

Twenty-four vadose zone soil samples (plus two replicates for QA/QC purposes, 26 total) will be collected and analyzed from the six off-site locations identified on Figure 5.2. These soil boring locations are considered to be background locations and, for consistency with Title 23 requirements for vadose zone monitoring, have been selected to be representative of the soil type present at the LEHR site. Off-site chemical and radiological analytical data collected during the Phase II Site Characterization were evaluated using Masons Formula for estimation of required number of samples. The six borings are located east, west, north and south of the LEHR site in areas of differing land use, including agricultural, flood plain and other UC Davis research functions. Locations were selected to represent similar soil types as seen on the LEHR site. In the exact location of each off-site soil sample, land use will be considered. The physical and chemical nature of each location will be assessed and potentially used to account for more localized impacts (e.g., railroad tracks). Each location will be described in detail in the field notes and will be considered in the Background Study.

Borings will be drilled to a depth of approximately 40 feet bgs. This depth was selected in order to be consistent with the maximum investigation depth planned for on-site soil borings, and to terminate borings above the groundwater table. Borings will be continuously cored and drive samples will be collected using a California Modified split spoon or similar type sampler. Each boring will be screened in the field for VOCs and radiologic activity. The borings will be logged according to the Unified Soil Classification



Source:
Soil Survey of Solano County, USDA Soil Conservation Service 1977.

LOCATION MAP
BACKGROUND SOIL BORINGS

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FIGURE 5.2

System by a geologist under the supervision of a California Registered Geologist. Samples to be submitted for analysis will be collected at the surface, 5, 20 and 40 feet bgs. Two replicate samples will also be submitted for analysis. Additional samples will be collected from 10, 15, 25, 30 and 35 feet bgs for archiving. Following completion, each soil boring will be grouted from total depth to the ground surface using a cement/bentonite grout. Details of drilling and sampling procedures are presented in the Field Sampling Plan (FSP), Appendix A. The data from the samples to be collected and analyzed may be supplemented by the analyses of soil samples from off-site wells UCD-17 and UCD-18 installed during the Phase II Investigation.

Based on anticipated variances in the analytical results, 24 samples from these background areas should provide a statistically appropriate number of samples for background analysis. Additional samples may be required to complete the background study if the observed variability exceeds the preliminary estimates of variability calculated from samples from previous studies.

For off-site soil sample constituents with a 50% or higher proportion of detections, parametric and non-parametric statistical tests will be performed. If the data are not normally distributed, or cannot be transformed to achieve a normal distribution, additional samples may be collected for analysis. When the appropriate quantity of off-site data are obtained to properly complete the analysis of an upper confidence limit (UCL) value will be calculated for each off-site constituent in soils with the adequate proportion of detections. The minimum detectable difference will be 20%; a 90% power ($1-\beta$), and a 90% confidence level ($1-\alpha$) will be used as suggested by the EPA (1989). Spatial correlation of the data is not anticipated at this time because of the large off-site area which is being investigated. Geostatistical methods will be considered if additional off-site sample locations are close enough to support variagram analysis.

Off-site soils contain a variety of natural inorganic and radiologic constituents throughout the soil profile. The off-site soil concentrations should be sampled at similar depths as on-site soils, if meaningful statistical analysis is to be performed. Inorganic chemicals include metals, nitrates, chlorides, carbonates, other inorganic salts; naturally-occurring radionuclides such as Potassium-40 are expected in off-site soils. Off-site samples will be analyzed for these constituents in order to adequately characterize off-site

soil constituent concentrations. As discussed in the text, the surface 10 feet of soils are expected to be influenced by soil-forming factors and off-site human activity. Therefore, samples from 0 to 10 feet bgs will be compared to samples from 10 to 40 feet bgs in order to test this hypothesis. If off-site surface 0-to-10-feet-bgs soils are statistically different from 10-to-40-feet-bgs soils, additional samples from one or more depth intervals may be obtained in order to achieve the desired off-site soil sample population.

5.1.3 Analysis of Selected Soil Samples

Soil samples collected for the background study will be shipped by overnight courier to the analytical laboratory for radiological and chemical testing. Soil samples will be analyzed for parameters identified in Table 5.2. The background study will include naturally occurring uranium, thorium, and their breakdown, or daughter, products which include radium-226. The objective for the analysis of both parent and daughter products in background soils is to assess the ratio of parent to daughter product activities in unaffected soils. A similar analysis of the ratio of parent to daughter products in onsite soils would be complicated by the use of daughter products such as radium-226 onsite, and therefore such an analysis will not be attempted. Analytical methods, required detection limits, QA/QC protocol and data validation documentation are discussed in the QAPjP (Appendix B). The analyte list was developed to characterize the nature of chemicals and radiologic constituents present in natural or background conditions in areas that have not been affected by operations at the LEHR site. Rationale for selection of the analytical parameters is provided in Table 5.1C. The inclusion of specific radionuclides for analyses is based on historical records of disposal (Table 3.1), whether or not the material would have decayed, and an evaluation of the half-lives for those nuclides. Parameters not included in Table 5.2 will be considered at detection limits for the background study.

U.S. Environmental Protection Agency (EPA) Contract Laboratory Program (CLP) or CLP equivalent QA/QC documentation will be obtained for all of the samples analyzed. Reported analytical results will be validated as described in the QAPjP.

TABLE 5.2 LABORATORY ANALYSIS FOR BACKGROUND SOIL SAMPLES

Background Study	
Analyte	26 Soil Samples [a]
Metals [b]	✓
Hexavalent Chromium	✓
Organochlorine Pesticides (EPA 8080)	✓
Nitrates (as Nitrogen)	✓
Total Alkalinity	✓
Total Kjeldahl Nitrogen	✓
Ammonia	✓
Water Soluble Anions	✓
EC	✓
Sulfide	✓
pH	✓
Total Organic Carbon	✓
Gross Alpha	✓
Gross Beta	✓
Tritium	✓
Carbon 14	✓
Radium 226	✓
Strontium 90	✓
Isotopic Thorium	✓
Cesium 137	✓
Isotopic Uranium	✓
Cobalt 60	✓
Gamma Spectranalysis	✓
Bacteriological Count	✓ (6)

[a] Includes 24 primary samples and 2 replicates.
[b] Metals include 17 CAM Metals, Mg, Ca, Mn, and Fe.

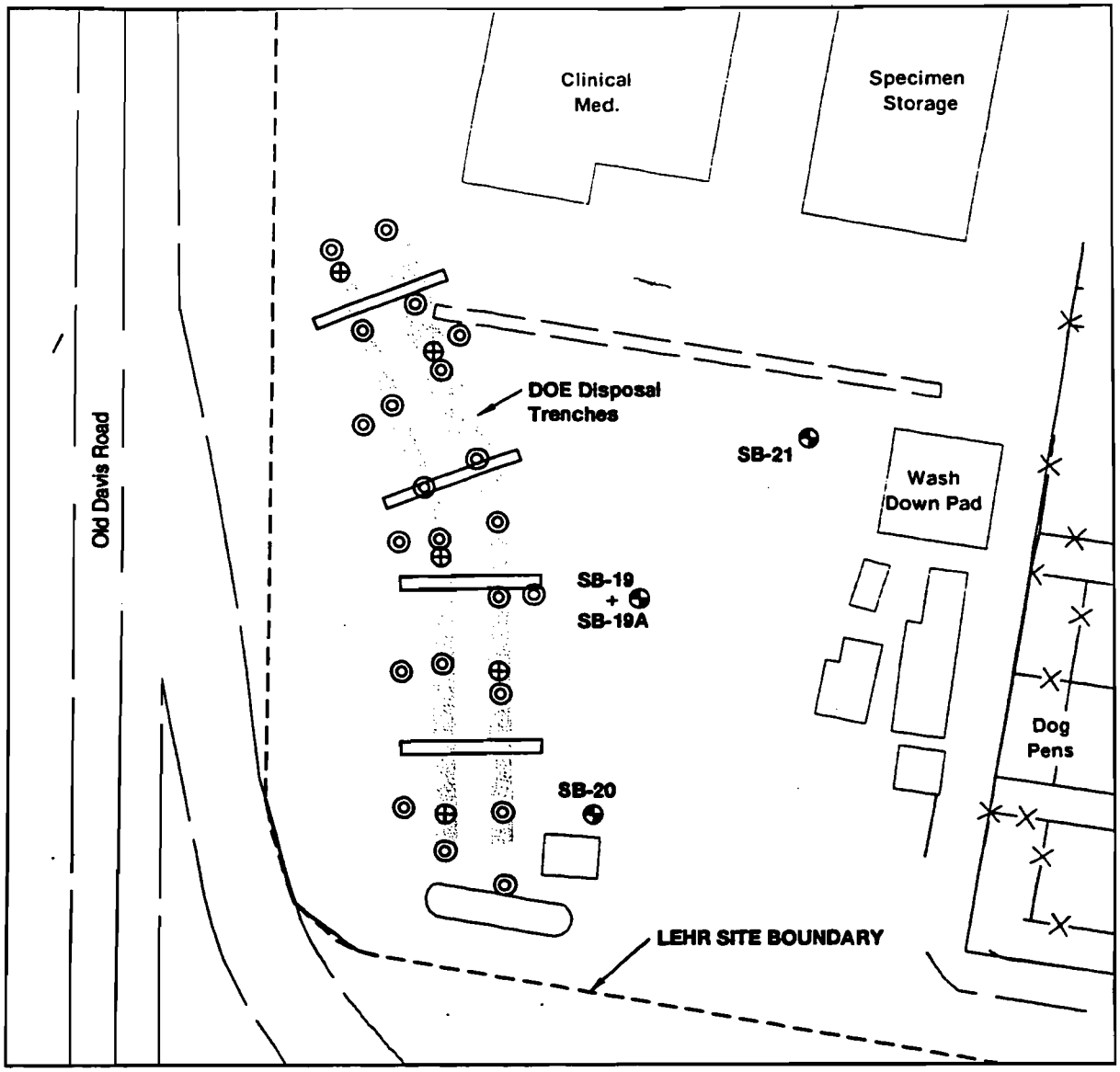
5.1.4 Development of Background Levels

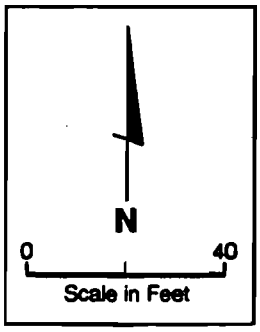
Based on analytical results received from soil samples collected during this task and the background data from the Phase II Investigation, background levels will be developed. Background levels for some parameters (see 5.1.3) will not be developed by statistical analysis, but will be considered to be at or below the analytical detection limit. Background levels will be used to establish the levels of site constituents that occur naturally or are present regionally, such as pesticides, nitrate and metals. State ARARs and other State and Federal guidance and advisories will also be considered.

5.2 DOE DISPOSAL TRENCHES, AND THE DOE DISPOSAL BOX (OU-1)

The DOE disposal trenches are located in the southwest corner of the LEHR site as shown on Figure 5.3A and are part of preliminary OU-1. The trenches are reported to be approximately 120 feet long, and oriented roughly in a north/south direction. The exact number, location and depth of the trenches is not known. The DOE Disposal Box is reportedly a steel dumpster-like container located east of the western set of dog pens, as shown on Figure 5.3B. The DOE disposal trenches are reported to have received primarily LEHR-generated low-level radioactive waste, fecal material, organic chemicals, and laboratory wastes. The DOE Disposal Box reportedly received LEHR-generated wastes with higher levels of radioactivity.

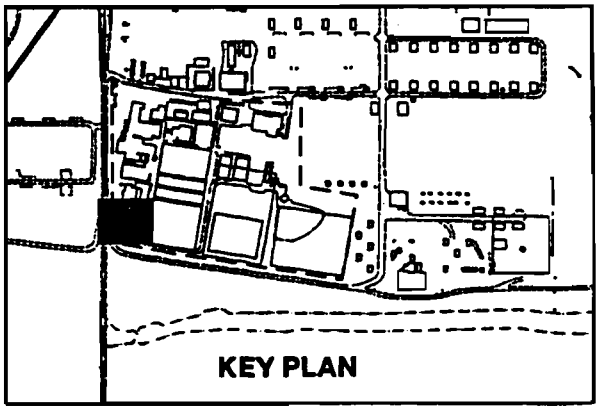
Records or information on the types of materials disposed in the trenches and DOE disposal box are lacking; however, it is reported that an ionization column from the Imhoff system was buried in the DOE disposal trenches. Based on reported disposal practices, the possibility exists that the trenches and DOE disposal box contain radioactive, hazardous, and potentially mixed wastes. Currently, there are limited analytical data — radiologic or chemical — from the area of the DOE disposal trenches. Accurate locations of the DOE disposal trenches are also unknown. A summary of analytical data collected from the DOE disposal trenches during previous investigations is presented in Section 3.2.2. To date, the exact location of the DOE Disposal Box is not known, and no sampling or analysis has been conducted in the area.





EXPLANATION

- Proposed Stage 1 Soil Borings
- Existing Soil Borings
- Proposed Soil Vapor Probes
- Proposed Exploration Trenches



APPROXIMATE LOCATION MAP DOE DISPOS TRENCHES SAMPLING POI

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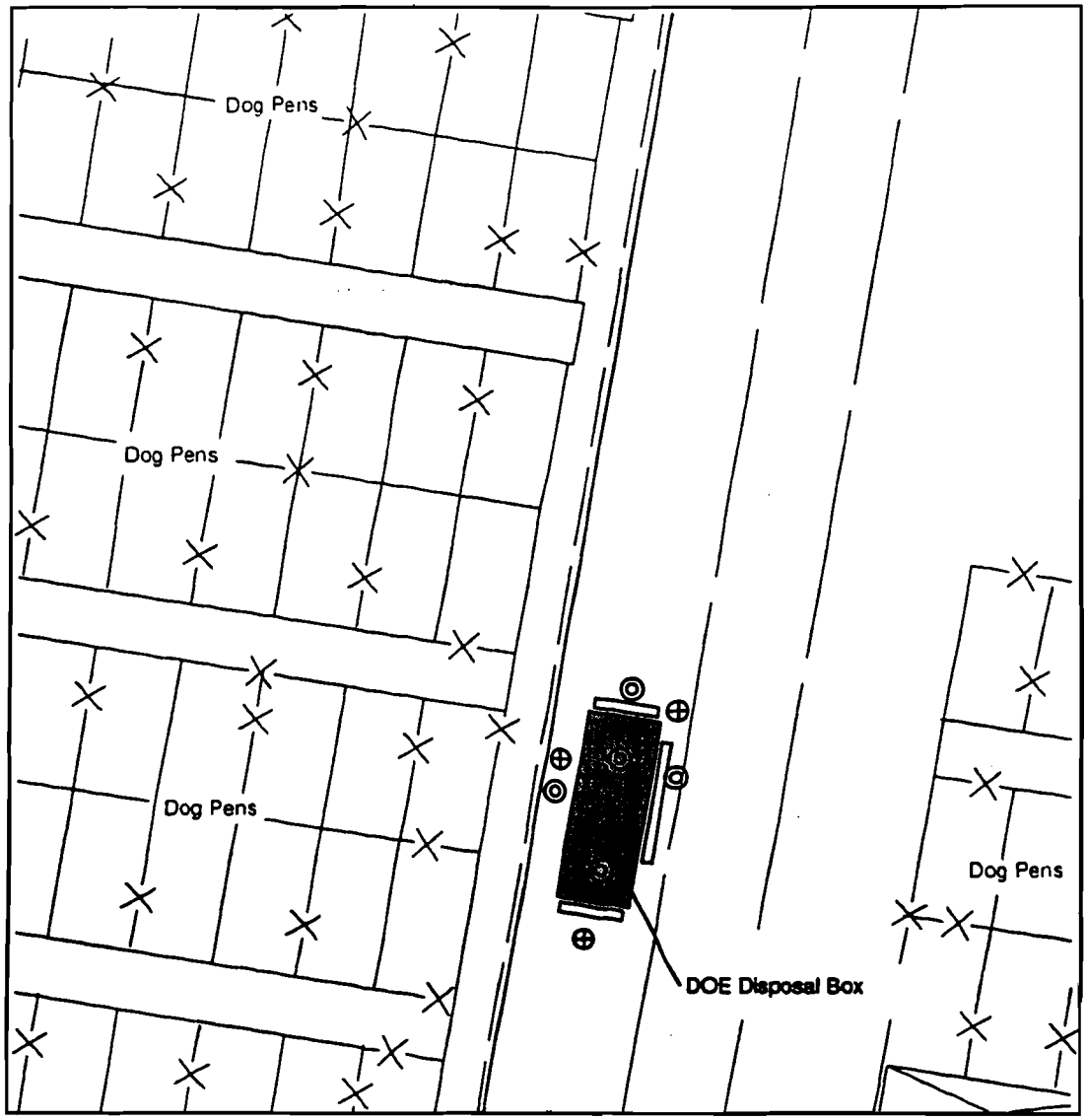
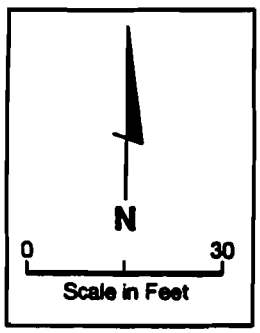
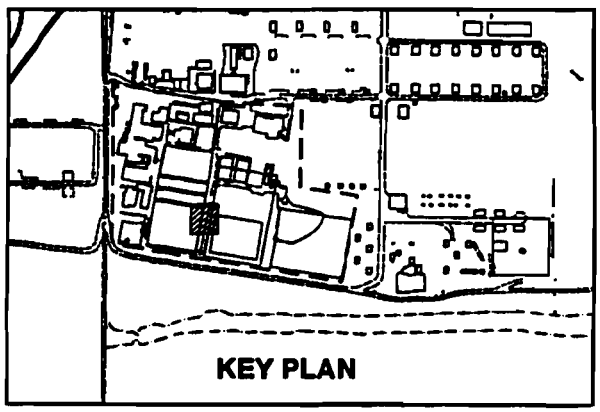
FIGURE 5.3A





EXPLANATION

- ⊕ Proposed Soil Borings
- ◎ Proposed Vapor Probes
- ▭ Proposed Exploration Trenches



LOCATION MAP
DOE DISPOSAL BOX

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FIGURE 5.3B

During the previous investigations near the DOE disposal trenches, tritium and carbon-14 were reported up to 208 and 1.16 pCi/g, respectively. Additionally, nitrate was reported up to 220 mg/Kg, and hexavalent chromium was reported up to 1.56 mg/Kg (see Table 3.2). However, the limited sampling and analysis programs in these previous investigations did not fully evaluate the contents of the trenches (source terms). Nor did the sampling density adequately evaluate the magnitude or vertical and lateral extent of constituents of concern. Because of the lack of data from the potential sources, statistical evaluation of potential impacts based on the previous information would probably be biased low. Therefore, it is necessary to acquire additional data regarding source strengths and vertical and lateral extent of impacts. Data collected during the Phase II investigation have been used to provide supplemental lateral control of constituents that may be present in the area of the DOE disposal trenches and to focus the current investigation.

The DOE disposal trenches and DOE Disposal Box will be evaluated to: accurately locate the disposal areas, and collect samples for analytical testing; protect investigators and the environment from unknowns that may have been buried in these areas; and develop sufficient data to characterize the magnitude and extent of impacts, evaluate potential human and environmental risks, and potential remedial alternatives for these disposal areas.

Because of the known, and more importantly, the unknown materials that may have been disposed in these trenches, and the associated human and environmental health and safety concerns, the investigation and sample collection tasks will be completed in a phased approach starting with the least invasive methods. Information from activities conducted early in the investigation will be evaluated quickly and used to guide subsequent more invasive exploration and sampling activities.

Initially, relatively non-invasive techniques, including a literature review and geophysical surveys, will be used to refine the location of the trenches and DOE Disposal Box. Due to the lack of information on the contents of the disposal areas, a soil gas and radiologic survey will then be conducted to obtain screening information on the contents. The information will be used to identify "hot spots," if any, and to optimize locations for exploration trenches and soil borings. This information will also be used for health and

safety screening prior to invasive activities. Based on the above information, exploration trenching with a backhoe will be used to verify disposal area locations and to evaluate the nature and characteristics of the disposed material (e.g., sludge, etc.). Samples within the disposal areas will then be collected and analyzed to assess the chemical and physical properties of the waste material. Shallow soil borings approximately 25 feet bgs ~~(<15 feet deep),~~ and deeper soil borings approximately 40 feet bgs ~~(>15 feet)~~ may be drilled and sampled to further evaluate the nature and extent of site constituents to assess potential impacts to soil below and adjacent to the trenches and to support the evaluation of remedial alternatives. All sampling locations will be incorporated into the site geodetic survey by a registered surveyor to assist in permanently locating the disposal areas and in estimating volumes of impacted materials, if necessary. Decontamination of all equipment will be conducted according to procedures outlined in Appendix A.

Because of the relatively unknown contents of the DOE disposal trenches and disposal box, and the potential for a variety of radiologic and chemical wastes to have been disposed, a comprehensive analytical program has been developed and is presented in Section 5.2.6. Radioactivity, volatile and semi-volatile organic compounds, and metals will be assessed because these groups of constituents were most likely used in the laboratories in the form of radionuclides, solvents, acids, and various solutions required by the research. Pesticides will be assessed due to the extensive use of chlordane at the site and previous detections of pesticides in the UC Davis disposal trenches. Nitrate will be analyzed to evaluate the trenches as a potential contributing source for the nitrate that has impacted groundwater beneath the LEHR site. General chemical data such as anions and cations, and physical data such as grain size and hydraulic conductivity, will be gathered to evaluate potential constituent fate and transport mechanisms.

As presented above, evaluation of the DOE disposal trenches will consist of the following specific activities:

- personnel interviews and literature review;
- geophysical surveys;
- gas and radiologic surveys;
- backhoe exploration;
- soil borings;
- chemical testing;

- physical testing; and
- geodetic surveying.

Each of these activities is described in the following sections. Detailed field procedures are provided in the FSP.

5.2.1 Personnel Interviews and Literature Review

Past workers at the LEHR site will be interviewed to obtain information on the location of the disposal areas of concern and potentially undocumented areas that may have been used for disposal of LEHR site wastes. Assistance from UC Davis personnel will be requested to identify the appropriate people for these interviews.

Available UC Davis and DOE records will be reviewed to further identify the location of the DOE trenches and burial areas reported to be in the southwest corner of the LEHR site, and identify the location of the DOE Disposal Box, which is thought to be on the east side of the western set of dog pens. This task will include review of documents and facility drawings that may not have been reviewed during the Phase II Investigation, and/or review of those documents for a second time in order to reconfirm the location of those trenches and burial areas. Documents will also be reviewed to evaluate underground utilities in the disposal areas. The utility locations will be identified to evaluate the potential for the utility trenches to act as pathways of migration for constituents in the disposal areas.

Additionally, historic aerial photographs will be acquired and interpreted to assess locations of the disposal areas. The photographs will also be reviewed in order to evaluate disposal methods and other site activities in the vicinity.

5.2.2 Geophysical Surveys

If the trenches or the DOE Disposal Box cannot be identified adequately to scope subsequent phases of investigation ~~to an acceptable level of confidence~~, a geophysical survey will be conducted. The geophysical survey will include one or more methods such as metal detection, ground penetrating radar (GPR), or electromagnetics (EM). Details of the proposed geophysical techniques are presented in the FSP.

It is anticipated that a minimum of eight GPR transects will be conducted to locate the DOE trenches. Transects will be run perpendicular to the trenches to maximize the potential for identification. The lines will be spaced approximately 20 feet apart along the anticipated length of the disposal trenches. The difference in electrical properties between the trench contents and native soil should be sufficient to identify trench locations by GPR. However, if the data are inconclusive, an EM survey will also be conducted.

If the DOE Disposal Box cannot be positively located through personnel interviews or the literature review, a geophysical survey consisting of metal detection, GPR, and possibly EM, will be conducted. The DOE Disposal Box was reportedly constructed of steel and should provide an adequate mass for detection purposes. A grid pattern consisting of approximate 10-foot spacings will be used in the area where the DOE Disposal Box is expected to be located. The grid pattern may be modified based on information obtained during the file review task.

5.2.3 Gas and Radiologic Survey

A gas and radiological survey will be conducted to obtain screening information on the contents of, and the area immediately adjacent to, the trenches and the DOE Disposal Box. This information will be used to potentially identify significant subsurface sources and to optimize locations for confirmation test pits and soil borings described below in Sections 5.2.4 and 5.2.5. This information will also be used as safety screening information prior to the invasive activities. Proposed gas survey locations are shown on Figures 5.3A and 5.3B and are based on the anticipated size and location of the target areas. The locations are spaced approximately 20 feet apart along the trenches. Using this spacing, it is anticipated that 22 locations will be sampled in the DOE disposal trenches and five locations will be sampled in the area of the DOE Disposal Box. Methodology is presented in the FSP.

Gas samples collected during the survey will be analyzed for chemical constituents. The gas samples will be collected by driving a reusable 1¾-inch-diameter stainless steel probe with a retractable tip into the ground. At each location, two depths, approximately 2 and 6 feet bgs, will be tested. These sampling depths have been proposed in order to

obtain samples of gas near the top and base of the disposal trenches and the DOE Disposal Box.

The probe will be driven to the first sampling depth, and a gas sample will be collected by applying a slight vacuum to the probe and collecting a sample for real-time detection of VOCs, carbon dioxide, methane, and oxygen. This will be accomplished using a mobile laboratory equipped with a gas chromatograph. For five percent of the sample locations, a larger volume sample will be collected in a passivated stainless steel summa canister for laboratory analysis of organic constituents. The laboratory analysis will be used as a quality check on the field data. The probe will then be driven to the second sampling depth and the sampling procedure repeated. It is anticipated that 44 samples and 2 replicates will be analyzed from the disposal trench area and 10 samples, and 1 replicate from the DOE Disposal Box area.

Once the second gas sample has been collected, the probe will be removed from the hole and decontaminated. After the probe has been removed, a 1-inch-diameter Geiger-Mueller tube will be placed in the open hole and gross beta and gamma activity will be measured and recorded. The probe hole will then be grouted using a cement/bentonite slurry, the equipment will be moved to the next location, and the next probe hole will be advanced. Results of the gas and radiologic survey will be tabulated and a map of each of the two depths will be developed showing concentration contours of identified constituents in relation to geophysical survey results. These maps will be used to evaluate exploration trench soil boring locations.

5.2.4 Backhoe Exploration

Based on the geophysical, gas, and radiologic surveys described above, a limited number of exploration trenches will be excavated to visually identify the DOE disposal trenches and the DOE Disposal Box, to collect samples of and adjacent to potential source materials, and to obtain data on source strengths and constituent types. It is anticipated that ~~four~~ up to six east/west-trending exploration trenches will be excavated to cross the north/south-oriented DOE disposal trenches, as shown on Figure 5.3A. Approximately three exploration trenches will be excavated adjacent to the DOE Disposal Box, as shown on Figure 5.3B.

During excavation of each trench, materials will be segregated as soil cover, native soil, and waste, and stockpiled on visqueen. The trenches will be logged by a geologist or soil scientist under the supervision of a California Registered Geologist. The trenches will be logged according to the Unified Soil Classification System, with comments regarding the type and condition of the waste noted on the logs. Photographs of the trenches will also be taken for additional documentation. The materials in the trenches will be screened for VOCs and radiologic activity. This information will be recorded on the trench logs. While the exploration trenches are open, soil samples will be collected from the trench bottom and sidewalls for chemical analysis. Because of health and safety concerns, no site personnel will enter trench excavations greater than 5 feet deep, or, if the trench is considered unsafe based on physical characteristics, VOC, and radiologic field monitoring readings, described in the Health and Safety Plan, Appendix C, soil samples from greater than 5 feet deep will be collected from the backhoe bucket, or an extended drive sampler, as appropriate. Upon backfilling of each trench, materials will be placed back in approximately the same areas and depth from which they were excavated. Excavation, logging, and sampling procedures are described below and detailed in the FSP.

The information gathered during the backhoe exploration will be used to guide the subsequent soil boring investigations.

5.2.4.1 DOE Disposal Trenches

~~Four~~ Up to six exploration trenches will be excavated to a depth of approximately 1 to 2 feet below the disposal trench-natural soil interface to evaluate the depth of the disposal trenches. It is anticipated that the exploration trenches will be up to 30 feet in length and extend to a maximum depth of 12 to 15 feet.

During exploration trenching, soil samples will be collected from the identified disposal trenches. Samples will be collected using hand sampling techniques as described in detail in Appendix A. It is anticipated that a maximum of 32 ~~approximately 17~~ soil samples (up to five ~~four~~ from each exploration trench plus two ~~one~~ for QA/QC purposes) will be collected using this method. In each exploration trench: two samples of impacted disposal trench material, as identified by the field screening, ~~will~~ would be collected; one sample ~~will~~ would be collected approximately 2 feet below the base of the disposal

trenches; and two ~~one~~ samples would ~~will~~ be collected lateral to each side of the disposal trenches. Analytes are presented in Section 5.2.6.

5.2.4.2 DOE Disposal Box

Up to three trenches will be excavated to a total depth of 12 to 15 feet bgs around the perimeter of the DOE Disposal Box to evaluate its condition, and possibly its contents. During excavation, three ~~two~~ samples per backhoe trench, plus one replicate, will be collected in locations adjacent to the DOE Disposal Box. The condition of the container will be evaluated by excavating materials away from the sides and examining for signs of loss of integrity such as severe rust or obvious holes. Observations on the condition of the DOE Disposal Box and surrounding materials will be documented in photographs, a field memorandum, and trench logs prepared by the site geologist.

5.2.5 Soil Borings

It is anticipated that two stages of soil borings will be conducted in the DOE disposal trenches and adjacent to the DOE Disposal Box. First-stage soil borings will be drilled to collect samples of potential source materials, evaluate vertical extent of identified constituents, and to obtain data on source strengths and constituent types. Based on first-stage analytical results, second-stage borings may be drilled to further evaluate lateral and vertical extent of identified constituents and to obtain data on the physical characteristics of soils beneath the sources. The second-stage borings would also be used to collect data that will be useful in evaluating fate and transport mechanisms and remedial alternatives. Drilling, logging, and sampling procedures are described below and detailed in the FSP. A summary of the number of laboratory analyses is shown in Table 5.1A.

5.2.5.1 First-Stage Soil Borings

The first-stage borings will be drilled based on the results of the soil gas and radiologic survey, and the exploration trenching. It is anticipated that approximately five soil borings will be drilled in and near the DOE disposal trenches, and three borings near the DOE Disposal Box. Locations will be biased toward "hot spots" or anomalies identified during the gas and radiologic survey and exploration trench program. If no "hot spots" or

anomalous areas are identified, then borings will be drilled on approximate 50-foot spacing along the disposal trenches and immediately adjacent to three sides of the DOE Disposal Box. Tentative locations of the first-stage soil borings are shown on Figures 5.3A and 5.3B.

The soil borings will be drilled through the trench materials and terminate ~~approximately 2 feet below the base of the trench,~~ approximately 25 ~~8 to 12~~ feet bgs. The borings will be drilled using resonant drilling techniques and will be continuously ~~sampled~~ cored. The borings will be logged and samples of the trench contents will be collected at 2½-foot intervals using standard split spoon sampling techniques described in the FSP. Upon completion, each boring will be grouted to the surface with a cement/bentonite grout.

~~It is anticipated that four to six samples will be collected from each of the first-stage borings. The s~~Samples of trench waste material collected from each boring will be screened in the field for VOCs and radiological activity. Considering past disposal practices and ~~the overall goal of the investigation~~ that discrete samples are being collected during the exploration trenching, trench samples from soil borings will be ~~submitted to the laboratory where they will be~~ composited prior to analysis. ~~and analyzed for the parameters listed below in Section 5.2.6.~~ Due to the heterogeneous nature of waste, waste samples composited should generate representative data.

~~In addition, two to three~~ Samples of native soil will be collected from each boring at approximately 5 foot intervals below the base of the disposal trenches and adjacent to the DOE Disposal Box. One sample of soil collected from each boring adjacent to the DOE Disposal Box will be submitted for laboratory analysis. Up to two native soil samples from each boring below the trenches will be submitted for laboratory analysis. Two replicate samples will also be submitted for analysis. Samples will be analyzed for only those parameters detected in samples collected from the exploration trenches discussed in Section 5.2.4. Additional rationale on sample analyses may be found in the FSP, Appendix A.

5.2.5.2 Second-Stage Soil Borings

Second-stage borings may be drilled to more fully evaluate feasibility study needs and the likelihood for impact at depth at a particular area. The locations of the second-stage borings will be based on the laboratory analytical results of samples collected from the soil vapor study, exploration trenches and the first-stage borings. The selection of boring locations will be based on input from regulatory agencies as part of the phased approach to the RI/FS. Second-stage borings will be located in the areas with detected levels of site constituents above established background levels. It is anticipated that ~~a minimum of~~ up to four second-stage borings ~~will~~ may be drilled in the disposal trench areas and one near the DOE Disposal Box. These second-stage borings ~~will~~ may be drilled through the trenches to approximately 40 feet bgs ~~to the first encountered groundwater, approximately 45 to 70 feet bgs~~. Borings will be continuously cored using resonant drilling techniques and drive samples will be collected at approximately 5-foot intervals. The cores will be archived in core boxes on-site for future use, if required. Cores and samples will be screened in the field for VOCs and radiologic activity. Details of drilling and sampling procedures are presented in the FSP. Upon completion, each boring will be grouted to the surface with a cement bentonite grout.

Up to four samples from each second ~~phase~~stage boring will be submitted to the analytical laboratory for chemical and radiologic testing. The surface sample from each boring will be submitted for analysis to assess fugitive dust concerns. The remaining three samples from each boring will be selected in the field by the project geologist and the technical lead, and will be based on stratigraphy and material type, and field screening results.

As discussed in Sections 5.2.6 and 5.2.7, analytical parameters for second-stage soil borings will be modified to focus on only the constituents detected above background in the first-stage sample analyses. The sample analyses will be used to evaluate vertical and lateral extent of identified site constituents. In addition to chemical and radiologic testing, physical testing will be conducted on selected samples to assist in correlating the stratigraphy, refining the conceptual site model and providing information on properties of soil beneath the trenches and the DOE Disposal Box for use in fate and transport modeling and remedial design work.

5.2.6 Chemical Testing

Soils collected from the trenches and adjacent to the DOE Disposal Box during the exploration trenching and soil borings will be submitted to the analytical laboratory for chemical and radiologic testing. The samples will be analyzed for the list of parameters provided in Table 5.3. Analytical methods, required detection limits, QA/QC protocol and data validation documentation is discussed in the QAPjP, Appendix B. The analyte list was developed to characterize the nature of chemicals and radiologic constituents present, and assess the general chemistry of the soil that may affect fate and transport. Some specific analytes, identified in Table 5.3 in parentheses, will be assessed in certain soil samples to support fate and transport, and FS needs. These samples will be selected based on waste characteristics, soil types, field screening, and visual observations during drilling or excavation (see Field Sampling Plan—Appendix A). As discussed above, the list of analytes identified for first- and second-stage boring samples will be modified to focus on the constituents identified above background levels in the exploration trench and first-stage boring samples.

5.2.7 Physical Testing

Selected soil samples will be submitted and analyzed for the physical parameters listed in Table 5.4. This table also provides the anticipated minimum number of samples to be submitted for each analysis. These data will be used to evaluate the physical characteristics of the soil samples collected above, beneath and adjacent to the trenches and the DOE Disposal Box. Sample locations will be selected to obtain information from various material types (silty clay, clay, and sand), at various depths. In order to accomplish this goal, samples from both first- and second-stage borings will be used.

In addition to physical tests on discrete soil samples, two down-hole permeability tests and one double-ring infiltrometer test will be conducted in the area of the DOE disposal trenches. These tests will be conducted to assess in-situ infiltration rates and saturated conductivity to aid in refining the conceptual site model and the fate and transport evaluation. Detailed procedures for these field tests are presented in the FSP.

TABLE 5.3 ANALYTICAL PARAMETERS FOR DOE TRENCHES AND DOE DISPOSAL BOX SAMPLES

Description	Exploration Trenches[a]	First-Stage Samples[b]	Second-Stage Samples[c]
Metals[d]	✓	✓[f]	
Hexavalent Chromium	✓	✓	✓[g]
Nitrates (as Nitrogen)	✓	✓	✓
Organochlorine Pesticides	✓	✓	
Volatile Organic Compounds	✓	✓	✓
Semi-Volatile Organic Compounds	✓	✓	✓
Formaldehyde	✓	✓	✓
Kerosene	✓ (16)	✓ (10)	✓ (16)
Total Alkalinity	✓ (8)	✓ (5)	✓ (15)
Total Kjeldahl Nitrogen	✓ (8)	✓ (5)	✓ (15)
Ammonia	✓ (8)	✓ (5)	✓ (15)
Water Soluble Anions	✓ (8)	✓ (5)	✓ (15)
pH	✓ (8)	✓ (5)	✓ (15)
Total Organic Carbon	✓	✓	✓
Gross Alpha & Gross Beta[e]	✓	✓	✓
Tritium	✓	✓	✓
Carbon-14	✓	✓	✓
Radium-226	✓	✓	✓
Strontium-90	✓	✓	✓
Gamma Spectranalysis	✓	✓	✓
EC	✓ (8)	✓ (5)	✓ (15)
Sulfide	✓ (8)	✓ (5)	✓ (15)
Bacteriological Count	✓ (3)	✓ (3)	✓ (2)

Except for Kerosene, numbers in parentheses indicate number of soil samples to be analyzed for specific analytes that will be used to support fate and transport needs.

[a] A maximum of 32 ~~24~~ samples will be submitted for analysis.

[b] A maximum of 26 ~~18~~ samples will be submitted for analysis.

[c] A maximum of 21 samples will be submitted for analysis.

[d] Metals include 17 CAM Metals, Mg, Ca, Mn, and Fe.

[e] If Gross Alpha or Gross Beta are measured at two or more standard deviations greater than background, analyses for cesium-137, sodium-22, uranium-238, cobalt-60, or chlorine-36, may be performed.

[f] The list of analytes identified for first-stage boring samples will be modified to focus on the constituents identified above background levels in the exploration trench samples.

[g] The list of analytes identified for second-stage boring samples will be modified to focus on the constituents identified above background levels in the exploration trench and first-stage boring samples.

TABLE 5.4 SUMMARY OF PHYSICAL TESTS DOE TRENCHES AND THE DOE DISPOSAL BOX

Physical Test	ASTM Method Number	Number of Samples
Hydrometer	D-422	5
Grain Size	C-136	5
Permeability	D-2434	4
Moisture Release	D-3152 and D-2325	4
Moisture Content	D-2216	25
Mineralogy	XRD	3
Specific Gravity	D-854	3
Atterberg Limits	D-4318	10
Bulk Density	D-4531	10

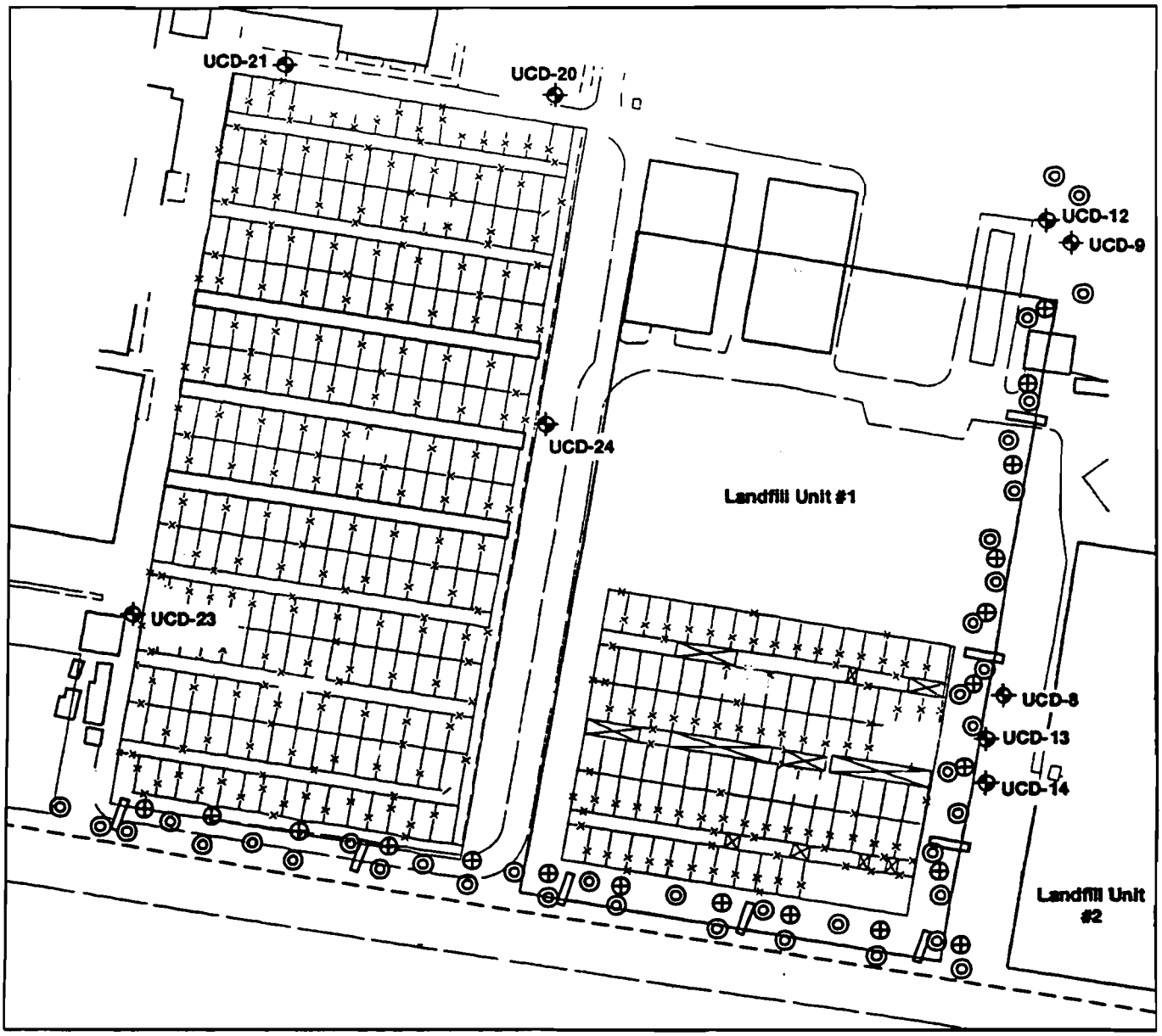
XRD - X-Ray Diffraction

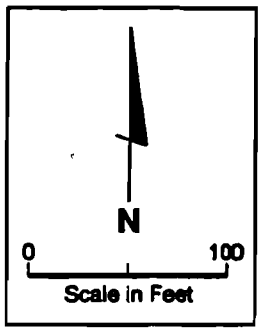
5.3 UC DAVIS BURIAL AREAS (OU-1)

The UC Davis disposal trenches are reportedly located along the southern boundary of the LEHR site and between UC Davis Landfill Unit Nos. 1 and 2, as shown on Figure 5.4, and are part of preliminary OU-1. According to UC Davis records, there are approximately 19 trenches and 49 disposal pits approximately 6 to 10 feet deep. However, the exact number, location and depth of the trenches and pits have yet to be determined. Although these trenches and pits are reported to have received campus-generated low-level radioactive waste, organic chemicals, and a variety of laboratory wastes, because they were open during LEHR operations, the potential exists that they may have received LEHR-generated wastes also.

Currently, there are limited analytical data — chemical or radiologic — from the UC Davis disposal trenches. Accurate location of the disposal trenches is also unknown. Records or information regarding the type of materials disposed in these trenches is very limited. Available information regarding the contents of some of the UC Davis trenches is provided in Table 3.4. A summary of analytical data collected from the UC Davis trenches during previous investigations is presented in Section 3.2.2. Based on reported disposal practices, the possibility exists that these trenches contain hazardous, radioactive and potentially mixed wastes.

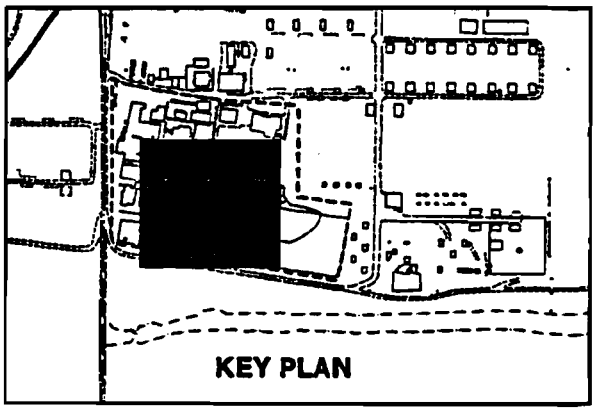
During the Phase I Investigation (Wahler, 1988, 1989) the pesticides dieldrin, carbophenathion and heptachlor were found in nearly pure concentration, and chlordane was reported up to 688 mg/Kg in an intact container ~~one~~ in one of the UC Davis disposal trenches. Tritium and radium-226 were also reported up to 0.61 pCi/g and 0.44 pCi/g, respectively. However, the limited sampling and analysis program did not fully evaluate the contents of the trenches (source terms), nor did the sampling density adequately evaluate the extent of impacts. Therefore, it is necessary to acquire additional data regarding source strengths and vertical and lateral extent of impacts.





EXPLANATION

- Proposed Soil Borings (First Stage Borings) Based On Results of Soil Vapor Survey
- Existing Monitoring Well
- Proposed Soil Vapor Probes
- Proposed Exploration Trenches



LOCATION MAP UC DAVIS DISPOSAL TRENCH SAMPLING POINTS

RI/FS Work Plan
LEHR Environmental Restoration
Davis, California

10805-720-044 sjr 2/23/94 5705AG

FIGURE 5.4

The UC Davis trenches will be evaluated to: accurately locate and collect samples for analytical testing from these areas; protect investigators and the environment from unknowns that may have been buried in these areas; and develop sufficient data to evaluate potential responsibilities associated with contents of these disposal areas. Additionally, the data are necessary to evaluate risks and potential remedial alternatives for the disposal trenches.

Because of the known, and more importantly, the unknown materials that may have been disposed in these trenches, and the associated human and environmental health and safety concerns, the investigation and sample collection tasks will be completed in a phased approach starting with the least invasive methods. Information from activities conducted early in the investigation will be evaluated quickly and used to guide subsequent more invasive exploration and sampling activities.

A variety of investigation techniques will be used to evaluate UC Davis disposal trenches. Initially, relatively non-invasive techniques including a review of available literature and geophysical survey methods will be used to refine the location of the trenches and pits. A soil gas and radiologic survey will be conducted to obtain screening level information on the trench contents. The screening level information will be used to identify "hot spots" or anomalies and to optimize locations for exploration trenches and soil borings. This information will also be used for health and safety screening prior to invasive activities. Exploration trenching with a backhoe and hand sampling techniques will be used to evaluate the nature and characteristics of the trench contents. Shallow soil borings approximately 25 feet bgs ~~(<15 feet deep)~~ will then be used to collect additional data to characterize the contents and vertical and lateral impacts to soil ~~and will be used for the evaluation of DOE/UC Davis responsibilities~~. Deep soil borings approximately 40 feet bgs ~~(>15 feet deep)~~ may be drilled to assess potential lateral and vertical impacts to soil at depths below the trenches and to support the evaluation of remedial alternatives. Chemical analyses will be used to characterize the nature of potential impacts and physical analyses of soil will be used to assess potential remedial alternatives, if warranted. Sampling locations will be incorporated into the site geodetic survey, by a registered surveyor to allow subsequent confirmation sampling and assist in estimating volumes of contaminated materials. Decontamination of sampling equipment will be conducted between locations according to the procedures presented in the FSP, Appendix A.

Because of the relatively unknown contents of the UC Davis trenches, and the potential for a variety of chemical and radiologic wastes to have been disposed, a comprehensive analytical program has been developed and is presented in Section 5.7.6. Volatile and semi-volatile organic compounds, radioactivity, and metals will be assessed because these constituents were used in the laboratories in the form of solvents, acids, and various solutions required by the research. Pesticides will be assessed due to the extensive use of chlordane at the site and previous detections of pesticides. Nitrate will be evaluated to evaluate the trenches as potential sources for nitrate that has impacted groundwater beneath the LEHR site. General chemical data on various anions and cations is necessary to evaluate contaminant fate and transport mechanisms for use in modelling.

Evaluation of the UC Davis trenches will consist of the following activities:

- personnel interviews and literature review;
- geophysical surveys;
- gas and radiologic surveys;
- backhoe exploration;
- soil borings;
- chemical testing;
- physical testing; and
- geodetic surveying.

Each of these activities is described in the following sections. Detailed field procedures are provided in the FSP.

5.3.1 Personnel Interviews and Literature Review

Past workers at UC Davis and the LEHR site will be interviewed to obtain information on the specific locations of the UC Davis disposal trenches and potentially undocumented areas that may have been used for disposal of UC Davis wastes. Assistance from UC Davis personnel will be requested to identify the appropriate people for these interviews.

Available UC Davis and LEHR records will be reviewed to further evaluate location of the trenches. This will include review of documents and facility drawings that may not

have been reviewed during the Phase II Investigation, or review of those documents for a second time in an attempt to better identify location of trenches and burial areas.

Documents will also be reviewed to evaluate underground utilities in the areas of the UC Davis disposal trenches. Utility locations will be identified to evaluate the potential for the utility trenches to act as pathways of migration for site constituents and assess potential hazards from invasive work.

5.3.2 Geophysical Survey

If the trenches cannot be identified to an acceptable level of confidence through the literature review, a geophysical survey using GPR and possibly EM will be conducted to identify the limits of the UC Davis trenches. Previous GPR surveys conducted for UC Davis were able to identify some of the UC Davis disposal trenches. The difference in electrical properties between the trench contents and native soil should be sufficient for either method of identification. However, it should be noted that in some cases the trench contents may consist of disturbed native material and therefore may not provide adequate contrast for identification using these methods. Assuming that a geophysical survey is necessary, up to 20 GPR transects will be run.

The GPR transects will be run perpendicular to the trenches to maximize the potential for identification; however, fencing at the site will limit the length and orientation of transects. An EM survey will also be conducted in areas where the data from the GPR survey is inconclusive. Details on the proposed geophysical methodology is presented in the FSP.

5.3.3 Gas and Radiologic Survey

A soil gas and radiologic survey will be conducted to obtain screening information on contents of, and the area immediately adjacent to, the UC Davis trenches. Additionally, this information will be useful to identify "hot spots" or anomalies and to optimize locations for test pits and soil borings described below in Sections 5.3.4 and 5.3.5. This information will also be used for health and safety screening prior to invasive activities. Proposed survey locations are shown on Figure 5.4 and are based on the anticipated size

and location of the trenches. The locations are staggered every 50 feet along two parallel lines. Using this spacing, it is anticipated that approximately 40 locations will be sampled in the UC Davis trenches. This spacing may be modified after more accurate dimensions and locations of the UC Davis trenches are established.

Vapor samples collected during the survey will be analyzed for chemical constituents. Soil gas will be collected by driving a reusable 1¼-inch-diameter stainless steel probe with a retractable tip into the disposal trenches. Two depths at each location will be tested to evaluate soil gas near the top and base of the disposal trenches. In the trenches, samples will be collected at approximately 2 and 6 feet bgs, and in the disposal pits, along the south edge of the eastern dog pen area, samples will be collected at 3 and 10 feet bgs. At each location, the probe will be driven to the appropriate depth, and a vapor sample will be collected by applying a slight vacuum to the probe and collecting a sample for real-time analyses for VOCs, carbon dioxide, methane, and oxygen. This will be accomplished using a mobile lab equipped with a gas chromatograph. For approximately five percent of the sample locations, a sample will be collected in a stainless steel summa canister for laboratory analysis of VOCs. This will serve as a QA check on the field data. After the sample has been collected at the first depth the probe will then be advanced to the second depth and the sampling process will be repeated. Through this procedure, it is anticipated that approximately 83 samples, including three replicates, will be collected and analyzed.

After sampling is completed, the probe will be removed and a three ¼-inch geiger mueller tube will be placed in the open hole and gross beta and gamma activity will be measured and recorded. The probe will be deconaminated and the probe hole will then be grouted using a cement/bentonite slurry.

Results of the gas and radiologic survey will be tabulated and maps will be developed showing concentrations of identified constituents. These maps will be used in conjunction with geophysical data to guide the exploration trenching and soil boring investigations. The data will also be used as human and environmental protection information for the invasive activities.

5.3.4 Backhoe Exploration

Based on the gas and radiologic survey and the literature review, a limited number of exploration trenches will be excavated in the UC Davis disposal area. The exploration trenches will be excavated primarily to identify the location, view the contents, and collect samples of materials within and adjacent to the disposal trenches. It is anticipated that three exploration trenches will be excavated in an attempt to intersect the UC Davis trenches, between Landfill Unit Nos. 1 and 2, and five trenches will be excavated along the south side of the dog pens, as shown on Figure 5.4. The exact location of the trenches will be based on "hot spots" or anomalies identified during the soil vapor and radiological survey.

During excavation of each trench, materials will be segregated as soil cover, native soil, and waste, and stockpiled on visqueen. The trenches will be logged by a geologist or soil scientist under the supervision of a California Registered Geologist. The trenches will be logged according to the Unified Soil Classification System, with comments regarding the type and condition of the waste noted on the logs. Photographs of the trenches will also be taken for additional documentation. The materials in the trenches will be screened for VOCs and radiologic activity. This information will be recorded on the trench logs. Upon backfilling of each trench, materials will be placed in the same areas from which they were excavated. Excavation, logging, sampling, and decontamination procedures are described below and detailed in the FSP, and Health and Safety Procedures are presented in the Health and Safety Plan, Appendix C.

Trenches will be excavated to a depth of approximately 1 to 2 feet below identified disposal trench-natural soil interface. The trenches will be excavated to a maximum depth of 12 to 15 feet bgs and will be up to 15 to 30 feet in length.

During exploration trenching, samples will be collected from within, below, and adjacent to, disposal trenches. It is anticipated that approximately four discrete soil samples from each trench will be collected. One sample will be collected of the waste material with the highest field screening levels, and one sample will be collected from approximately 2 feet below the base of the waste/native soil interface. Two samples will be collected in areas lateral to the disposal trenches. If the trenches are greater than

5 feet deep, soil samples will be collected from the backhoe bucket. The 33 samples, including 1 replicate, will be submitted to the analytical laboratory for analysis of chemical and radiologic parameters, as discussed in Section 5.7.6. Figure 5.5 is a schematic representation of sample collection points for the trenches.

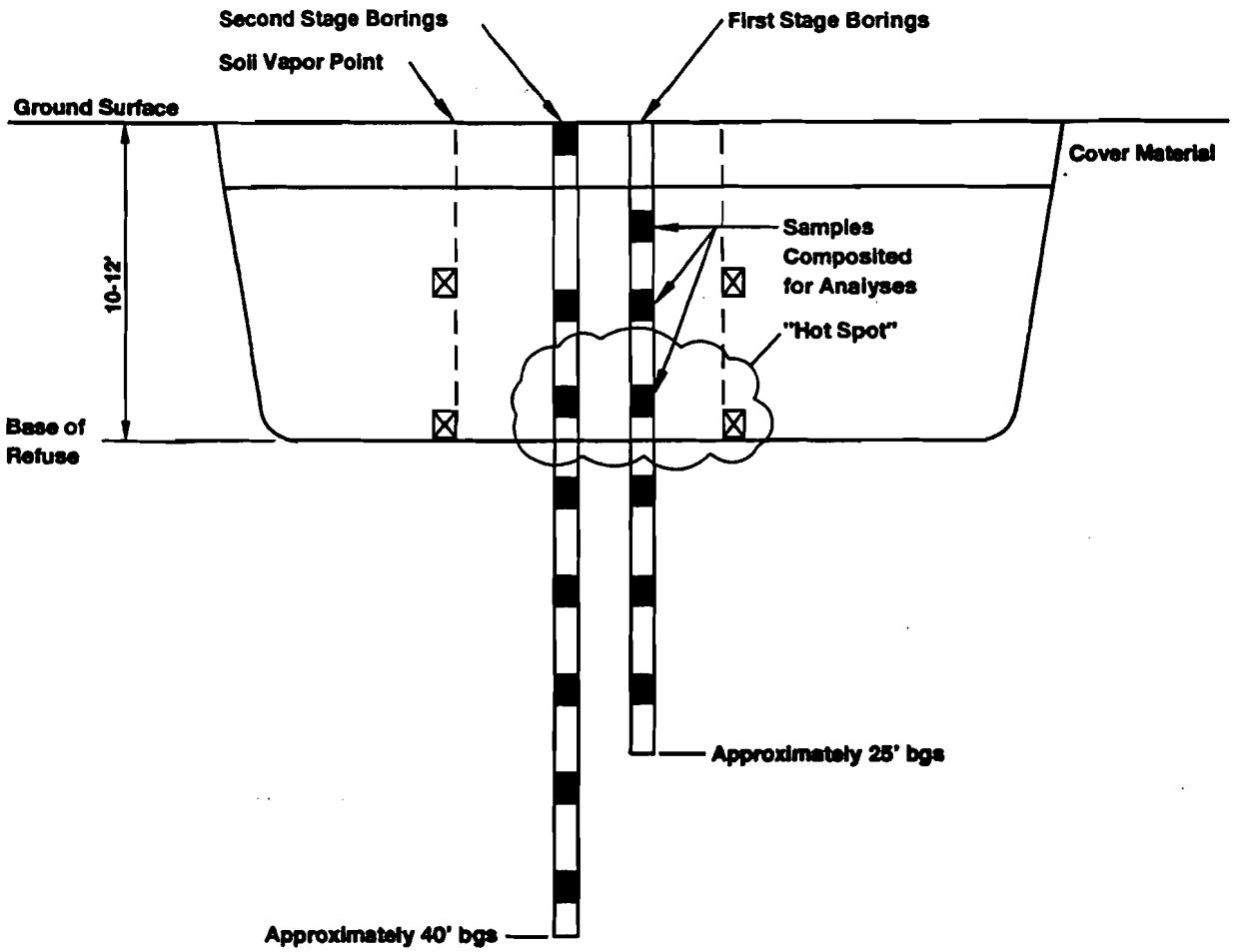
The information gathered during the backhoe exploration will be used to guide the subsequent soil boring investigations.

5.3.5 Soil Borings

It is anticipated that two stages of soil borings will be conducted in the areas of the UC Davis trenches. First-stage soil borings will be drilled to collect samples of potential source materials to obtain data on source strengths and constituent types. The anticipated locations of the first-stage borings are shown on Figure 5.4. Locations will be refined based on the results of the soil gas and radiologic survey. Based on first-stage soil boring sample analytical results, second-stage borings may be drilled to evaluate lateral and vertical extent of identified constituents and to obtain data on the physical characteristics of soils beneath the trenches. Drilling and logging procedures are described below and presented in the FSP.

5.3.5.1 First-Stage Soil Borings

It is anticipated that ~~approximately~~ up to 19 first-stage soil borings will be drilled in the area of the UC Davis trenches. Locations will be biased toward "hot spots" or anomalies identified during the soil gas survey and the backhoe exploration. If no "hot spots" are identified, then borings will be drilled on a spacing to intercept the disposal trenches and pits. The first-stage soil borings will be drilled through the disposal trench and pit materials to a depth of approximately 25 feet bgs ~~and terminate approximately 2 feet below the base of the trench or pit (8 to 12 feet bgs.)~~. The borings will be drilled using resonant drilling methods and will be continuously sampled. Samples of the trench contents will be collected at 2½ foot intervals using standard split spoon sampling techniques, and the samples will be field screened and logged, as described in the FSP.



EXPLANATION

⊠ Discrete Vapor Samples

■ Discrete Soil Samples

Not To Scale

SCHEMATIC DRAWING DISPOSAL TRENCHES AND LANDFI SAMPLING POI

RI/FS Work
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FIGURE 5.5

Upon completion, each boring will be backfilled from total depth to the ground surface with a cement/bentonite grout, and all drilling and sampling equipment will be decontaminated prior to being moved to the next location.

It is anticipated that, in each boring, between three and six discrete samples will be collected from the waste materials. Due to the heterogenous nature of the waste, and that discrete samples are being collected during the exploration trenching, waste samples from soil borings will be composited ~~These samples will be composited~~ into one sample at the laboratory prior to analysis ~~and analyzed for the parameters listed below in Section 5.3.6.~~ In each boring, two ~~one~~ samples of native soil below the trenches will be analyzed ~~collected for chemical and radiological analysis~~. The native soil samples will be collected from approximately 2 feet below the base of the trenches and from the bottom of the borehole. ~~A total of~~ Up to 63 ~~41~~ samples, including six ~~three~~ replicates, will be submitted for analyses, as discussed in Section 5.3.6. The list of analytes for first-stage soil borings will be modified to focus on the constituents identified above background levels in the exploration trench samples. Additional rationale on sample selection is found in the FSP, Appendix A.

5.3.5.2 Second-stage Soil Borings

Second-stage borings may be drilled to more fully evaluate feasibility study needs, responsibility determination, and the likelihood for impact at depth in a particular area. The second-stage borings will be based on the analytical results of samples from the soil vapor survey exploration trenches and the first-stage borings. Second-stage borings will be located in the areas with identified levels of site constituents above established background concentrations. It is anticipated that up to five second-stage borings may be drilled. The second-stage borings will be drilled through the trenches to approximately 40 feet bgs ~~the first encountered groundwater~~. The borings will be continuously cored using resonant methods and soil samples will be collected using drive sampling techniques at 5-foot intervals. The cores and samples will be screened in the field for VOCs and radioactivity, and the cores will be archived in core boxes for future use, if required. Details of drilling and sampling procedures are presented in the FSP. ~~F~~Up to four soil samples from each second-stage boring, for a total of 21 samples, including 1 replicate, will be submitted to the analytical laboratory for chemical and radiologic testing. The

surface sample from each boring will be submitted for analysis. The remaining three samples from each boring will be selected in the field by the project geologist and the technical lead, and will be based on stratigraphy, material type and field screening results. Upon completion, each boring will be backfilled from total depth to the ground surface with a cement/bentonite grout, and all drilling and sampling equipment will be decontaminated prior to being moved to the next location.

As discussed in Section 5.3.6, analytical parameters for second-stage soil borings ~~may~~will be ~~modified~~ based on exploration trench and first-stage sample analytical results. In addition to chemical and radiologic testing, physical tests will be conducted on selected samples.

5.3.6 Chemical Testing

Solids collected from the UC Davis trenches during exploration trenching and first- and second-stage soil borings will be submitted to the analytical laboratory for chemical and radiologic testing. The samples will be analyzed for the list of parameters provided in Table 5.5. If information is obtained during the investigative tasks that requires a modification of the analytical parameters, the project team will be notified and a contingent analytical plan will be evaluated. Planned analytical methods, required detection limits, QA/QC protocol and data validation documentation is discussed in the QAPjP, Appendix B. The analyte list was developed to characterize the nature of chemicals and radiologic constituents present, and assess how the general chemistry of the soil may affect fate and transport. Some specific analytes, identified in Table 5.5 in parentheses, will be assessed in certain soil samples to support fate and transport, and FS needs. These samples will be selected based on waste characteristics, soil types, field screening, and visual observations during drilling and excavation. The list of analytes identified for first- and second-stage soil boring samples ~~may~~will be modified based on the results of ~~first-stage~~exploration trench sample analyses.

TABLE 5.5 LABORATORY ANALYSIS FOR UC DAVIS TRENCH SAMPLES

Description	Exploration Trench Samples[a]	First-stage Samples[b]	Second-stage Samples[c]
Metals[d]	✓	✓[f]	✓[g]
Hexavalent Chromium	✓	✓	✓
Nitrates (as Nitrogen)	✓	✓	✓
Organochlorine Pesticides	✓	✓	✓
Volatile Organic Compounds	✓	✓	✓
Semi-Volatile Organic Compounds	✓	✓	✓
Formaldehyde	✓	✓	✓
Total Alkalinity	✓(12)	✓ (20)	✓(10)
Total Kjeldahl Nitrogen	✓(12)	✓ (20)	✓(10)
Ammonia	✓(12)	✓ (20)	✓(10)
Water Soluble Anions	✓(12)	✓ (20)	✓(10)
pH	✓(12)	✓ (20)	✓(10)
Total Organic Carbon	✓(12)	✓ (20)	✓(10)
Gross Alpha & Gross Beta[e]	✓	✓	✓
Tritium	✓	✓	✓
Carbon-14	✓	✓	✓
Radium-226	✓	✓	✓
Strontium-90	✓	✓	✓
Gamma Spectranalysis	✓	✓	✓
EC	✓(12)	✓ (20)	✓(10)
Sulfide	✓(12)	✓ (20)	✓(10)
Bacteriological Count	✓(3)	✓(3)	✓(3)

Numbers in parentheses indicate number of soil samples to be analyzed for specific analytes and used to support fate and transport and FS needs.

a A maximum of 33 Exploration trench samples collected

b A maximum of 53 ~~41~~ First-stage samples collected

c A maximum of 21 Second-stage samples collected

d Metals include 17 CAM Metals, Mg, Ca, Mn, and Fe.

e If Gross Alpha or Gross Beta are measured at two or more standard deviations greater than background, analyses for cesium-137, sodium-22, uranium-238, cobalt-60, technetium-99, or chlorine-36, may be performed.

f The list of analytes identified for first-stage boring samples will be modified to focus on the constituents identified above background levels in the exploration trench samples.

g The list of analytes identified for second-stage boring samples will be modified to focus on the constituents identified above background levels in the exploration trench and first-stage boring samples.

5.3.7 Physical Testing

Selected soil samples will be submitted and analyzed for the physical parameters listed in Table 5.6. This table also provides the anticipated minimum number of samples to be submitted for each test. These data will be used to evaluate the physical characteristics of the soils above and beneath the UC Davis trenches. The information will be used to help correlate stratigraphy and refine the conceptual site model, as input for fate and transport modeling, and may be used in remedial design work. Sample locations will be selected to obtain information from various material types at various depths.

In addition to physical tests on discrete soil samples, two down-hole permeability tests and one double-ring infiltrometer test will be conducted in the area of the UC Davis disposal trenches. These tests will be conducted to assess in-situ infiltration rates and saturated conductivity to aid in refining the conceptual site model and fate and transport evaluation. Detailed procedures for these field tests are presented in the FSP.

5.4 RADIUM-226 TREATMENT TANK AND LEACH SYSTEM [OU-2]

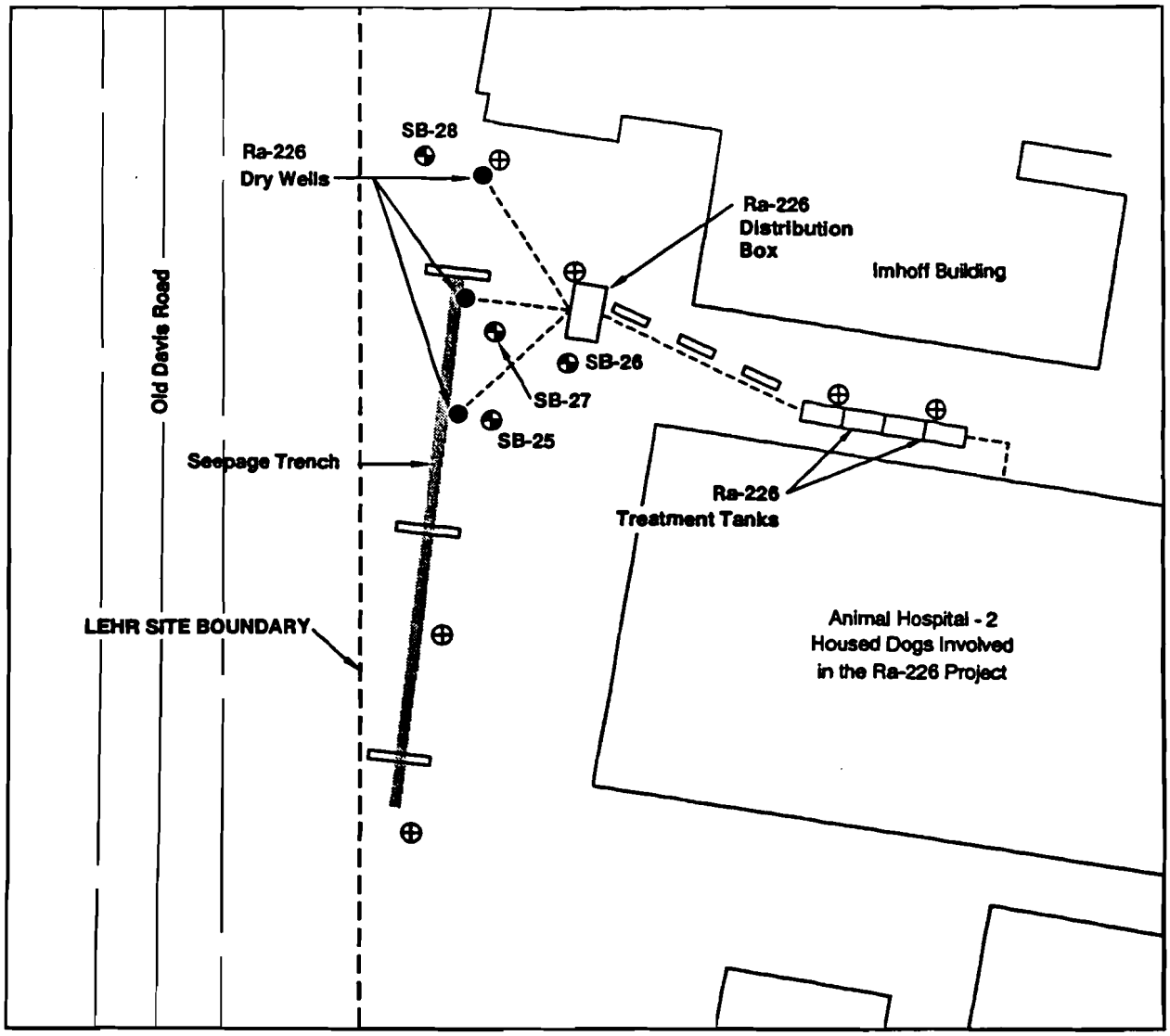
The radium-226 treatment tanks are located underground between the Imhoff Building and Animal Hospital-2 (AH-2) as shown on Figure 5.6. The associated distribution box, dry wells and seepage trench, collectively identified as the leach system, are reportedly located in the parking area west of the Imhoff Building. The radium-226 treatment system, [part of preliminary OU-2] reportedly received radioactive waste, including fecal material and washdown water from facilities in AH-2.

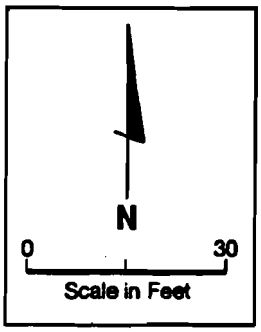
The radium-226 leach system is comprised of three dry wells and a seepage trench; the dry wells are each approximately 30 inches in diameter and 40 feet deep, as shown on Figure 5.7, while the seepage trench is approximately 91 feet long, 3 feet wide and 14 feet deep. A description of these leach systems is presented in Section 3.2.

TABLE 5.6 SUMMARY OF LEACH FIELD WIPE SAMPLE LOCATIONS

Number of Samples	Location
6*	Radium-226 dry-well access areas
1	Radium-226 system distribution box
1	Influent line to radium-226 distribution box
1	Effluent line from radium-226 distribution box
3	Radium-226 leach line
2	Coarse Dredged tailings

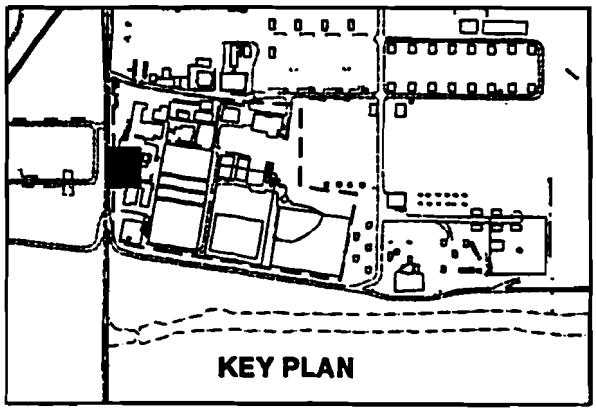
* One replicate sample will also be collected.





EXPLANATION

- Proposed Stage 1 Borings
- Existing Borings
- Proposed Exploration Trenches
- Distribution Pipelines



LOCATION MAP RADIUM 2
TREATMENT SYSTEM SAMPLING POIN

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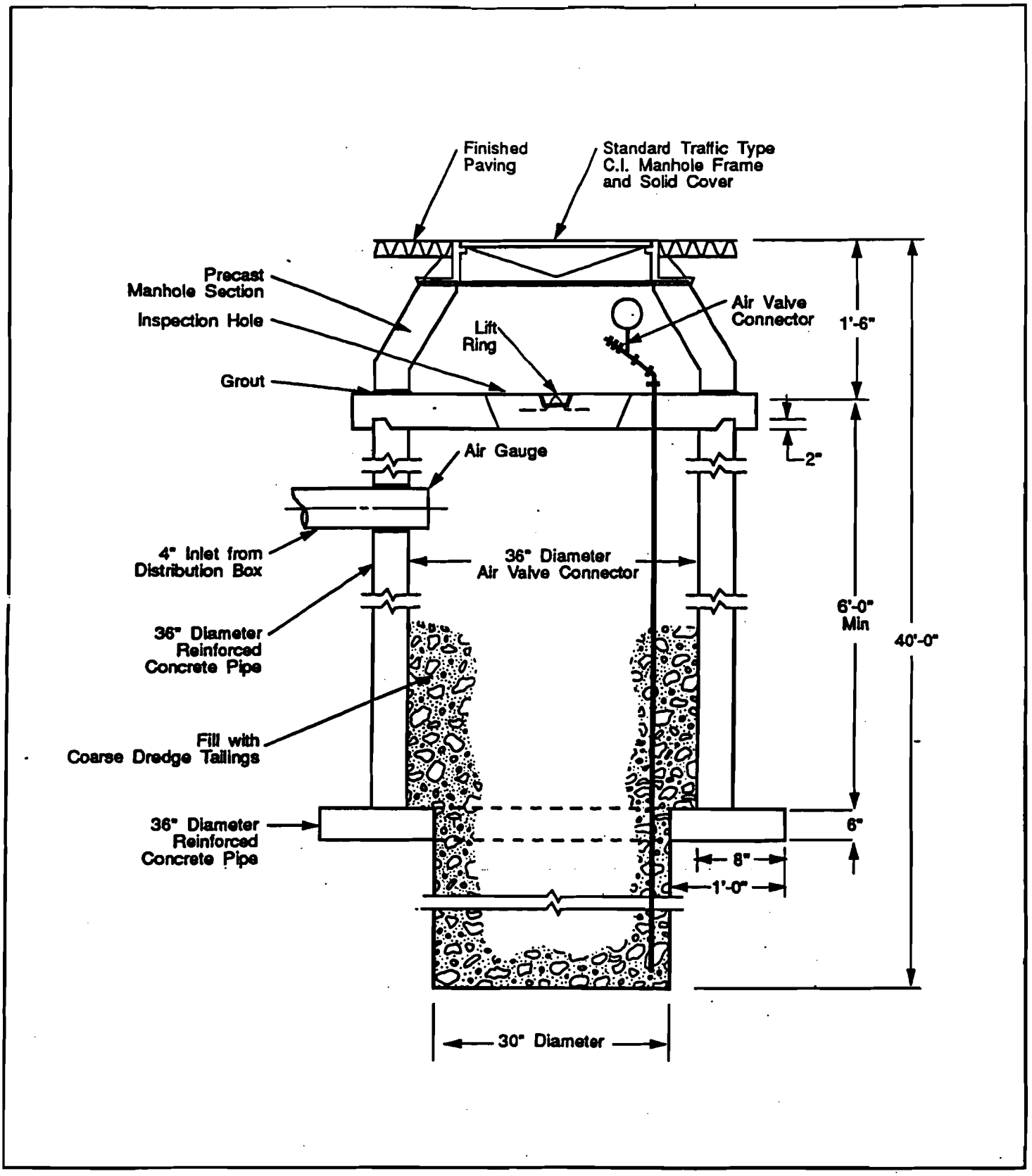
FIGURE 5.6



REFERENCE: UCD, 1962

CONSTRUCTION DETAILS OF THE RADIUM-226 VERTICAL DRY WELLS

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Analytical results of initial sampling of the contents by UC Davis in 1989 reported detections of radium-226 up to 205.8 pCi/g, strontium-90 up to 13.6 pCi/g and Thorium-232 up to 3.18 pCi/g (see Table 3.7). Because no semi-volatile organic compounds or pesticides were reported above the detection limits, and metals were reported at levels below EP toxicity, the liquids and sludges were not classified as hazardous and treated as radioactive wastes. Results of soil samples collected from below the tanks during the liquids and sludge removal project reported radium-226 up to 1.62 pCi/g, strontium-90 up to 0.77 pCi/g, and thorium-232 and thorium-228 up to 1.66 and 2.1 pCi/g, respectively. Additionally, tritium was reported up to 0.63 pCi/g (Chemical Waste Management, 1992).

In 1992, liquids and sludge remaining in the treatment tanks were characterized, removed, solidified and shipped to the Hanford facility in Washington State (Chemical Waste Management, 1992). Additionally, cores of the concrete tanks and soil samples from adjacent to the tanks were taken and analyzed for radiologic constituents.

Previous environmental investigations of the radium-226 leach system area focused on the general area near the dry wells. No samples were collected from, or immediately adjacent to the dry wells or the seepage trench. Analysis of the data collected during the previous investigation shows reported nitrate up to 620 mg/Kg and radium-226 and strontium-90 were reported up to 1.35 pCi/g and 1.60 pCi/g, respectively. Methylene chloride was reported up to 44.2 μg/Kg, and no detections of pesticides or semivolatile organic compounds have been reported (See Table 3.7). However, it is suspected that these data may be biased-low because sample locations may have been located too far away from suspected sources. Therefore, it is necessary to acquire additional data regarding source strengths and lateral and vertical extent of impacts. A summary of the analytical data obtained from this area is presented in Section 3.2.3.

The radium-226 treatment system will be evaluated to: collect representative samples of the treatment tanks (concrete) and soil adjacent to the tanks and associated dry wells and seepage trench; protect investigators and environment from unknowns that may have been disposed through these treatment systems; and evaluate potential environmental and human health risks and remedial alternatives.

Initially, relatively non-invasive techniques including a literature review and geophysical survey will be used to accurately locate the radium-226 seepage systems so that representative soil samples can be collected from, adjacent to, and from within the leach system areas. Because the tanks were positively located during the liquid and sludge removal project, only the leach systems remain to be accurately located.

Following location of the leach systems, soil samples will be collected for chemical and physical analysis. Samples will be collected from backhoe trenches and soil borings located in and immediately adjacent to the seepage trench and dry wells. Additionally, wipe samples from within the structures will be collected for radiologic screening purposes. The radium-226 tanks will be further characterized by collecting concrete core samples from the top and base of the tanks and soil samples from immediately below the tanks. Chemical analysis results will be used to evaluate the nature and extent of potential site constituents in these systems and physical analysis results will be used to evaluate physical properties of the soil for use in fate and transport modeling and risk assessment. Analytical data from the concrete cores will be used to develop remedial alternatives such as no action, removal, or abandonment in place. Decontamination of sampling equipment between locations will be conducted according to procedures presented in the FSP, Appendix A. All sample locations will be surveyed by a registered surveyor and incorporated into the site geodetic coordinate system.

Because of the potential for a variety of wastes to have been disposed through these systems, in addition to the expected radionuclides, a comprehensive analytical program has been developed and is presented below in Section 5.4.7. Volatile and semi-volatile organic compounds, radioactivity, and metals will be assessed because these groups of constituents were used in the laboratories in the form of solvents, acids, and various solutions required by the research. Pesticides will be assessed due to the extensive use of chlordane at the site. Nitrate will be evaluated to assess impacts from the sewage. General chemical data on various anions and cations are necessary to evaluate contaminant fate and transport mechanisms for use in modelling.

Assessment of the radium-226 treatment system will be accomplished through the implementation of specific activities including:

- literature review;
- geophysical survey;
- backhoe exploration;
- concrete coring;
- soil borings;
- wipe sampling;
- chemical testing;
- physical testing; and
- geodetic surveying.

Each of these activities is discussed in the following sections.

5.4.1 Literature Review

Design plans, construction drawings and the radium-226 sludge removal reports will be reviewed to assist in locating the leach systems associated with the radium-226 treatment system. It is anticipated that these drawings and reports will be available from the UC Davis physical plant or PNL.

Documents will also be reviewed to evaluate underground utilities in the area of the radium-226 tanks and leach system. The utility locations will be identified to evaluate the potential for the utility trenches to act as pathways of migration for site constituents and to assure safety during drilling operations.

5.4.2 Geophysical Survey

Geophysical methods such as metal detection, EM and GPR will be used to locate the tops of the radium-226 dry wells and the radium-226 seepage trench. Based on available design drawings, the tops of the dry wells are covered with a standard traffic-rated manhole frame and steel cover, as shown on Figure 5.7. The covers are currently inaccessible because they were covered with asphalt during paving of the LEHR parking area. The dry well tops were approximately located during previous investigations by UC Davis physical plant personnel; however, the locations were not surveyed. The metal

detection survey will be conducted on roughly a 5-foot grid in the area of the dry wells, distribution box, and associated piping.

It is anticipated that the radium-226 seepage trench can be located using GPR or EM. The seepage trench is reportedly 3 feet wide, 91 feet long, 14 feet deep and filled with cobbles. The difference between the cobble filled trench and the surrounding clayey sediments should provide an adequate electrical property and radar reflection contrast for these methods. It is anticipated that five GPR and EM transects, spaced 20 feet apart, will be adequate to locate the seepage trench. Transects will be run perpendicular to the seepage trench to maximize the potential for identification. Geophysical survey procedures are presented in the FSP.

5.4.3 Backhoe Exploration

Based on the results of the literature review and geophysical survey, a backhoe exploration program will be conducted. Materials from above the distribution box and the dry wells will be removed using the backhoe. Then, three east-west trending backhoe trenches will be excavated to identify the seepage trench and allow for collection of samples of the seepage trench contents, and up to five trenches will be excavated along the pipeline from the tanks to the distribution box. The trenches in the seepage trench will be up to 20 feet long and up to 15 feet deep. The competency of the material within the seepage trench will dictate the total depth excavated. Trenches along the pipeline will be 2 to 4 feet deep and 3 to 5 feet long. The anticipated locations of these trenches are shown in Figure 5.6. The trenches will be logged according to the Unified Soil Classification System by a geologist or soil scientist under the supervision of a California Registered Geologist. The logs will include comments regarding type and condition of seepage trench contents and will include the results of field screening for VOCs and radiologic activity. The excavated material will be placed in segregated stockpiles on visqueen. Following completion of trenching, the materials will be backfilled into approximately the same depths and areas from which they were removed. The asphalt parking areas affected by the excavations will be resurfaced following completion of the investigation. Details of the backhoe exploration program, sampling, and decontamination procedures are described in the FSP, Appendix A.

Up to 19 ~~A total of 13~~ soil samples will be collected and analyzed from up to eight ~~the four~~ exploration trenches (four samples per trench in the seepage pit area and one per trench along the pipeline, plus two ~~one for~~ replicates for QA/QC purposes). In each test pit along the seepage trench, one sample will be collected of the waste material; one sample will be collected directly below the trench; and one sample will be collected on either side of the trench. Because some exploration trenches will be greater than 5 feet deep, samples of the trench materials will be collected from the backhoe bucket using methods described in the FSP. Based on the disposal method, it is anticipated that constituents of concern would be distributed throughout the seepage trench; therefore, in each associated exploration trench, samples will be collected from near the top and base of the seepage trench and on either side of the seepage trench. Analytes are presented Section 5.4.7. Analytical results will be used to evaluate chemical and radiological constituents present within the trench and to guide the subsequent soil boring program.

5.4.4 Concrete Coring

It is anticipated that ten concrete core samples from the radium-226 tanks will be sufficient to characterize the tanks. ~~F~~Up to four samples will be collected from the top and up to six samples will be collected from the base. More samples will be collected from the base because the sludges accumulated at the base. Because of the inherent, relative homogeneity of sludges and sampling logistics, no samples will be collected from the side walls. Additionally, soil samples will be collected from immediately beneath the concrete core locations. These data will be useful to evaluate the abandoned in-place remedial alternative for the tanks. The locations of the samples will be chosen based on results of wipe samples and cores collected during the liquid and sludge removal project conducted in 1992 (Section 3.3.3) and the preliminary observation that Tank No. 3 of the radium-226 tanks may have leaked in the past (DOE, 1988). The concrete core and soil samples will be analyzed for the chemical and radiologic constituents listed in Table 5.7.

Four of the concrete core samples will be collected by coring through the top of the radium-226 tanks. The coring tool is designed to retain the core so that it will not drop out after the tool has penetrated the concrete. The six concrete cores from the base of the tanks will be collected using the same type of coring tool with some modifications. After an access hole has been drilled through the top of the radium-226 tanks, a Schedule

TABLE 5.7 LABORATORY ANALYSIS RADIUM-226 LEACH SYSTEM SAMPLES

	Leach Systems		Tanks
Analyte	Trench Samples[a]	Soil Borings[b]	Concrete Samples
Metals[c]	✓	✓[c]	
Hexavalent Chromium	✓	✓	
Nitrates (as Nitrogen)	✓	✓	
Organochlorine Pesticides	✓	✓	
Volatile Organic Compounds	✓	✓	
Semi-Volatile Organic Compounds	✓	✓	
Formaldehyde	✓	✓	
Total Alkalinity	✓ (19)	✓ (15)	
Total Kjeldahl Nitrogen	✓ (19)	✓ (15)	
Ammonia	✓ (19)	✓ (15)	
Water Soluble Anions	✓ (19)	✓ (15)	
pH	✓ (19)	✓ (15)	✓
Total Organic Carbon	✓ (19)	✓ (15)	
Gross Alpha & Gross Beta[d]	✓	✓	✓
Tritium	✓	✓	✓
Carbon 14	✓	✓	✓
Radium 226	✓	✓	✓
Strontium 90	✓	✓	✓
Plutonium-241	✓	✓	
Americium-241	✓	✓	
Gamma Spectranalysis	✓	✓	✓
EC	✓ (19)	✓ (15)	
Sulfide	✓ (19)	✓ (15)	
Bacteriological Count	✓ (19)	✓ (6)	

Numbers in parentheses indicate number of soil samples to be analyzed for specific analytes that will be used to support fate and transport needs.

- [a] A maximum of 13 trench samples submitted for analysis.
- [b] A maximum of 32 soil boring samples submitted for analysis.
- [c] Metals include 17 CAM Metals, Mg, Ca, Mn, and Fe.
- [d] If Gross Alpha or Gross Beta are measured at two or more standard deviations greater than background, analyses for cesium-137, sodium-22, uranium-238, cobalt-60, or chlorine-36, may be performed.
- The list of analytes identified for soil boring samples will be modified to focus on the constituents identified above background levels in exploration trench and concrete core samples.

80 PVC casing will be lowered through the access hole to the base of the tank (approximately 17 feet) and secured. This casing will act as a guide for the coring tool and minimize the potential for the tool to "walk around" at the base of the tank. An extension will be used to lower the coring tool through the casing to the base of the tank. The power source for the coring tool will remain above ground. After the concrete has been cored, the coring tool will be retrieved and the core will be removed from the tool and a wipe sample will be collected and counted. The core will then be placed in plastic bag, sealed and labeled appropriately as described in Appendix A in preparation for shipment to the laboratory.

5.4.5 Soil Borings

Six soil borings will be drilled in locations shown in Figure 5.6. The borings will be continuously cored using resonant methods and drive samples will be collected at 5-foot intervals. The borings will be field screened, logged, and sampled as described in the FSP. One soil boring will be drilled to approximately ~~the groundwater table~~ 40 feet bgs immediately adjacent to one of the three dry wells. Based on the method of effluent distribution, it is anticipated that contaminants would be evenly distributed among the three dry wells. Two soil borings will be drilled to approximately 25 feet bgs adjacent to the radium-226 seepage trench. It is anticipated that the trench is filled with cobbles and gravel which probably are not able to be sampled using conventional drilling methods. One soil boring will be drilled to approximately 25 feet bgs adjacent to the distribution box. Two soil borings, one to the groundwater table and one to 25 feet bgs, will be drilled adjacent to the radium-226 septic tanks to evaluate potential leakage from those tanks.

~~Approximately~~Up to 26 samples will be collected from the six soil borings (four samples per boring plus 2 replicates for QA/QC purposes) and submitted for chemical and radiological analysis ~~described below in Section 5.4.7~~. Additional samples will be collected for physical analysis described below in Section 5.4.8. Samples submitted to the laboratory will be selected in the field by the site geologist or soil scientist and will be based on stratigraphy, material type, and field screening results. The selected soil samples will be analyzed to evaluate the lateral and vertical extent of site constituents. The list of analytes identified for soil boring samples will be modified to focus on the constituents identified above background levels in exploration trench and concrete core samples. If

evaluation of the data indicates that the lateral and vertical extent of constituents has not been delineated, a second stage of soil borings may be required.

Approximately six soil samples will be collected from immediately beneath the radium-226 tanks. The samples will be collected in conjunction with the concrete sampling described above in Section 5.4.4. While the PVC casing used to guide the concrete coring tool is still in place, a sample of the soil from immediately beneath the tank will be collected using hand sampling techniques. A steel hand-driven sampler containing stainless steel sample sleeves will be lowered through the PVC casing and a relatively undisturbed soil sample will be collected. The sampler will be retrieved and the stainless steel sleeves will be removed from the sampler and each soil sample will be screened for radiologics and prepared for shipment to the analytical laboratory. Prior to pulling the casing out of the tank, the hol :.. the base of the tank will be grouted with a bentonite/cement mixture using the PVC casing as a tremmie pipe. All equipment will be decontaminated prior to being moved to the next location.

5.4.6 Wipe Samples

To screen for potential residual radiologic constituents present in leach lines, distribution boxes, and dry well access areas, approximately 14 wipe samples (plus 1 replicate QA/QC sample) will be collected from the areas listed in Table 5.6. Wipe samples will be collected from the interior surfaces of the leach lines, distribution boxes, dry well access areas, and tailings using cotton wipes soaked in high-grade alcohol, as described in the FSP. Access to the areas will be obtained during the backhoe excavation of the treatment system components as discussed in Section 3.3.3. The backhoe may be used to open the distribution box and the dry well access areas.

The interior condition of these structures will be noted on field memoranda. Photographs of the structures will also be taken.

5.4.7 Chemical Testing

Solids and wipe samples collected in the area of the radium-226 leach system will be sent via overnight courier to the analytical laboratory for chemical and radiological

testing. Table 5.7 lists the parameters that will be requested for samples collected. The list of analytes is designed to provide information on levels of constituents of concern, as well as information on general chemical properties. VOCs and SVOCs are included for radium tank sample analyses because chlordane was used on dogs housed in cages that drained to this system and cleaning compounds were used in cages. Some specific analytes, identified in Table 5.7 in parentheses, will be assessed in certain soil samples to support fate and transport, and FS needs. These samples will be selected based on waste characteristics, soil types, field screening, and visual observations during drilling and excavation. As discussed above, the list of [illegible] tified for soil boring samples will be modified to focus on the constituents identified above background levels in exploration trench and concrete core samples. Analytical methods, required detection limits, QA/QC protocol and data validation documentation are discussed in the QAPjP.

5.4.8 Physical Testing

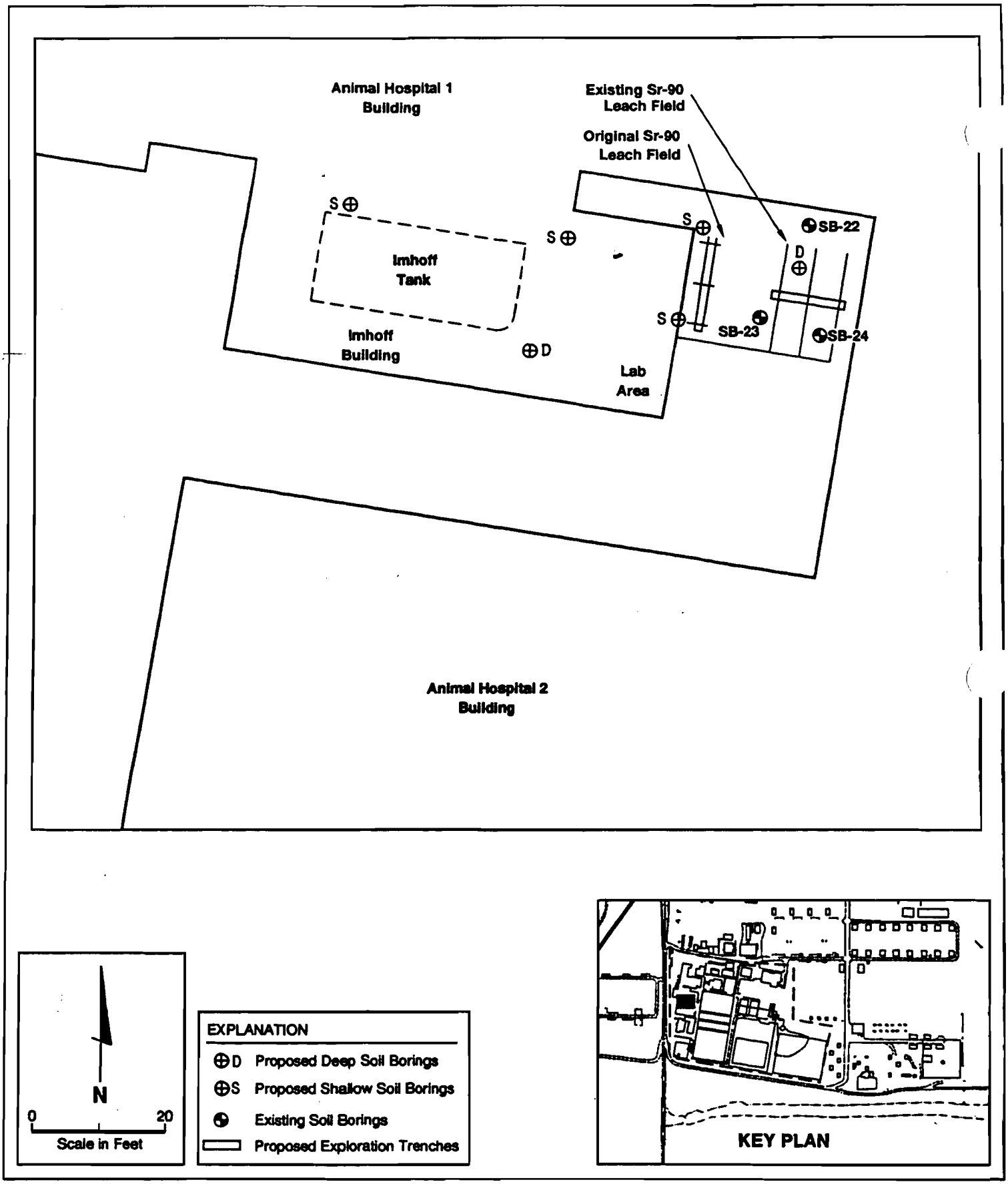
Selected soil samples will be submitted for physical testing. The data will be used to evaluate the physical characteristics of the soils in the vicinity of the seepage systems. The information will be used to help correlate stratigraphy, refine the conceptual site model and, as input for fate and transport modeling. Table 5.8 provides the physical parameters and the minimum number of samples to be submitted for each parameter. Sample locations will be selected to obtain information from representative material types (silty clay, clay and sand) at various depths.

In addition to physical tests on discrete soil samples, two down-hole permeability tests and one double-ring infiltrometer test will be conducted in the area of the radium-226 treatment system. These tests will be conducted to assess in-situ infiltration rate and saturated conductivity. Detailed procedures for these field tests are presented in the FSP, Appendix A. Because of the proximity of the radium-226 system to the strontium-90 treatment system, data obtained from these tests will be useful in evaluating both systems.

TABLE 5.8 SUMMARY OF PHYSICAL TESTS FOR RADIUM-226 AREA

Physical Test	ASTM Method Number	Number of Samples
Hydrometer	D-422	5
Grain Size	C-136	5
Permeability	D-2434	3
Moisture Release	D-3152 and D-2325	3
Moisture Content	D-2216	20
Mineralogy	XRD	2
Specific Gravity	D-854	3
Atterberg Limits	D-4318	10
Bulk Density	D-4531	10

XRD - X-Ray Diffraction



LOCATION MAP STRONTIUM-90 (IMHOF
TREATMENT SYSTEM SAMPLING POIN

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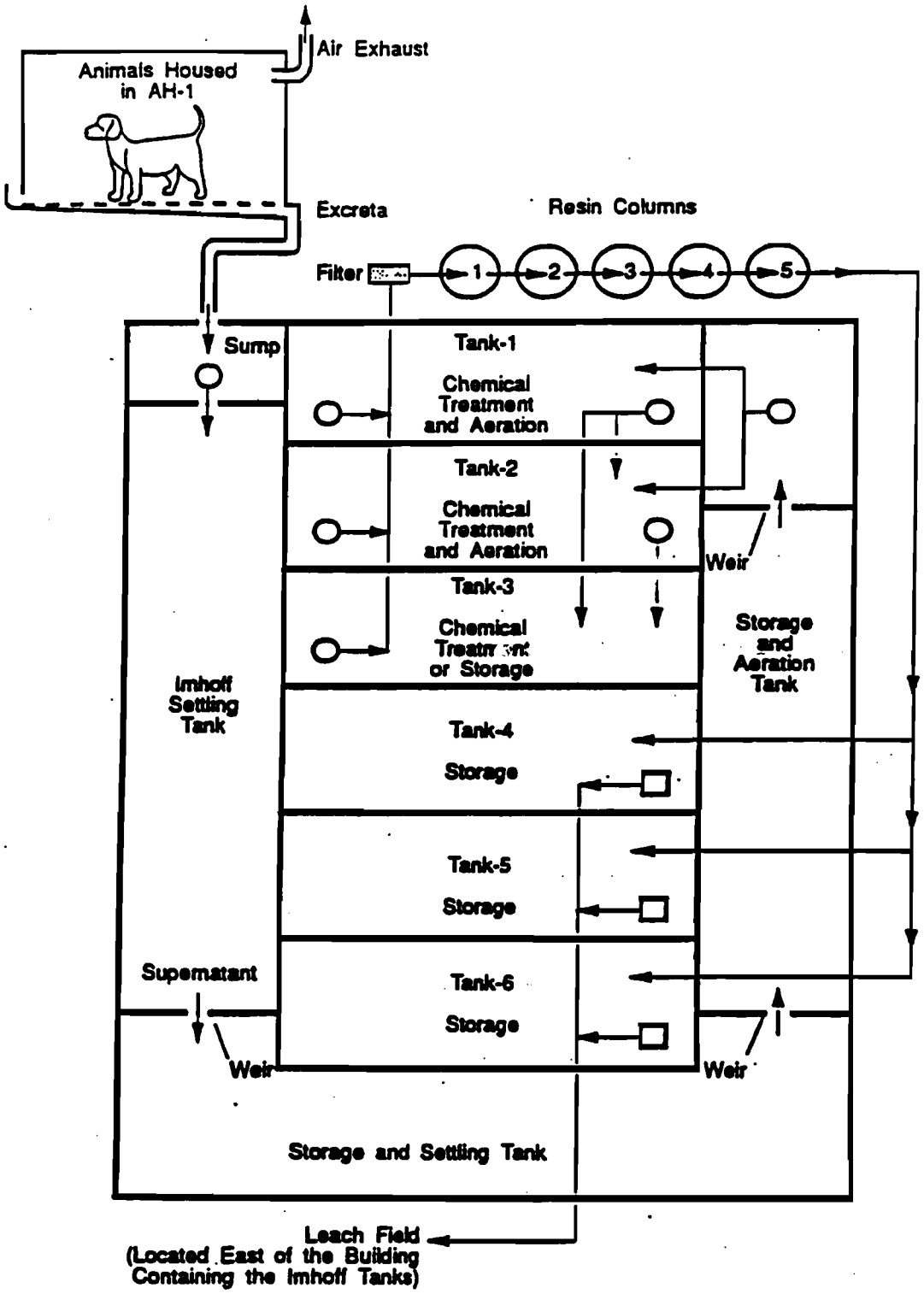
FIGURE 5.8



REFERENCE: Goldman, M., et al, 1963

SCHEMATIC REPRESENTATION OF THE IMHOFF TREATMENT SYSTEM

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FIGURE 5.9

Phase I and Phase II investigations of the Imhoff system area focused on the general area near the second leach system, located east of the Imhoff Building. No samples were collected from, orimmediately adjacent to the Imhoff tanks. Analysis of data collected during the previous investigation indicate that levels of suspected site constituents are relatively consistent throughout the area. Nitrate was reported up to 80 mg/Kg and strontium-90 and radium-226 have been reported up to 1.6 pCi/g and 0.75 pCi/g, respectively. Volatile and semi-volatile organic compounds have been reported sporadically. It is suspected that the data from the Phase I and Phase II investigations may be biased-low, because sample locations may have been located too far away from suspected sources. Therefore it is necessary to acquire additional data regarding source strengths and lateral and vertical extent of impacts. A summary of the analytical data obtained from this area is presented in Section 3.2.3 and Table 3.6. The Phase II Site Characterization data will be used to supplement data generated during this RI and provide additional lateral control for site constituents that may be identified.

Sludge and liquids in the Imhoff treatment tanks were removed and solidified during previous RA activities as part of the LEHR ER program (Section 3.3.3). Additional characterization information is required to evaluate potential impacts to the environment and closure options for these tanks and the associated leach fields. As discussed above, discrete soil samples have been collected from the areas of the leach field, although no samples were collected directly beneath the leach lines.

The Imhoff system will be evaluated to: collect representative samples of the Imhoff tanks (concrete) and soil adjacent to the tanks and associated leach systems; protect investigators and environment from unknowns that may have been disposed through these treatment systems; and evaluate potential environmental and human health risks and remedial alternatives.

Initially, relatively non-invasive techniques including a literature review and geophysical survey will be used to accurately locate the strontium-90 seepage systems so that representative soil samples can be collected from, adjacent to, and from within the leach system areas. Because the tanks were positively located during the liquid and sludge removal project, only the leach systems remain to be accurately located. Following location of the leach systems, Backhoe excavations will be completed and soil borings will

be drilled to collect soil samples for chemical and physical analysis. Additionally, wipe samples from within the structures and piping will be collected for radiologic screening purposes. The Imhoff tanks will be further characterized by collecting concrete core samples from the top and base of the tanks and soil samples from immediately below the tanks. Chemical analysis results will be used to evaluate the nature and extent of potential site constituents in these systems and physical analysis results will be used to evaluate physical properties of the soil for use in fate and transport modeling and risk assessment. Analytical data from the concrete cores will be used to develop remedial alternatives such as no action, removal, or abandonment in place. Reusable sampling equipment will be decontaminated between locations, according to the procedures in the FSP, Appendix A. All sampling locations will be surveyed by a registered surveyor and incorporated into the site geodetic coordinate system.

Because of the past analytical results of sludge and liquid samples collected from the Imhoff tanks and the potential for a variety of wastes to have been disposed through this system, a comprehensive analytical program has been developed and is presented below in Section 5.3.7. Volatile and semi-volatile organic compounds, radioactivity, and metals will be assessed because these groups of constituents were used in the laboratories in the form of solvents, acids, and various solutions required by the research. Pesticides will be assessed due to the extensive use of chlordane at the site. Nitrate will be evaluated to assess impacts from the sewage. General chemical data on various anions and cations are necessary to evaluate contaminant fate and transport mechanisms for use in modelling.

As presented above, the evaluation of the Imhoff system will be accomplished through the implementation of specific activities including:

- literature review;
- geophysical survey;
- backhoe exploration;
- concrete coring;
- soil borings;
- wipe sampling;
- chemical testing;
- physical testing; and
- geodetic surveying.

Each of these activities is discussed in the following sections.

5.5.1 Literature Review

The locations of the Imhoff tanks are known. However, the location of the leach fields associated with the Imhoff system is not known. Available design plans, construction drawings, and the strontium-90 sludge removal report will be reviewed to assist in locating the Imhoff system leach fields. It is anticipated that available drawings and reports will be supplied by the UC Davis physical plant or PNL.

Documents will also be reviewed to evaluate underground utilities in the area of the strontium-90 treatment tanks and leach system. The utility locations will be identified to evaluate the potential for the utility trenches to act as pathways of migration for site constituents and to assess concerns with the intrusive investigation procedures.

5.5.2 Geophysical Survey

If, through the literature review, the specific locations of the leach fields and associated piping cannot be identified, a ground penetrating radar (GPR), and potentially electromagnetics (EM) survey will then be conducted. Typically, leach lines associated with a septic system are backfilled with cobbles or gravel. The difference in electrical and reflective properties between the backfilled trenches of the leach fields, the system piping, and the surrounding clayey sediments should provide an adequate contrast for detection by these methods.

Approximately two GPR transects will be conducted in the area of each leach field. The orientation of the GPR transects will be perpendicular to the leach lines. Additional transects will be located to identify the associated piping to the treatment tanks. If GPR does not adequately define the locations of the leach fields and piping, then an EM survey will be conducted. Details of the geophysical techniques are provided in the FSP.

5.5.3 Backhoe Exploration

Based on the results of the literature review and geophysical survey, a backhoe exploration program will be conducted to identify, evaluate, and sample the leach lines and associated distribution box.

Two exploration trenches will be excavated to locate the two leach fields associated with the Imhoff treatment system and expose the piping and distribution boxes. The trenches will each be up to 20 feet long and up to 15 feet deep, and will be oriented perpendicular to the leach fields. The trenches will be excavated to 2 to 3 feet below the base of the leach fields, if possible. The trenches will be screened for VOCs and radiologic activity, and will be logged and photographed. The excavated material from each exploration trench will be placed in segregated stockpiles on visqueen. Following completion of trenching, the material will be backfilled into the excavations in approximately the same depth and area from which they were removed. The anticipated locations of the two trenches are shown on Figure 5.8. Details of backhoe exploration program, including sampling and decontamination, are described in the FSP, Appendix A.

Up to Five ~~Two~~ soil samples from each exploration trench will be submitted to the laboratory for chemical and radiological testing. Two samples will be collected from the materials in each leach field. If necessary, one sample will be collected in the native soil within 2 feet of the base of the leach trenches, and one sample will be collected in the native soil on either side of the leach field. Samples will be analyzed to evaluate the presence and source strengths of site constituents, primarily strontium-90 and nitrate. Analytical results will be used to evaluate chemical and radiological constituents present within the leach fields and to guide the subsequent soil boring program. The rationale for selecting samples for analysis is presented in the FSP (Appendix A).

5.5.4 Concrete Coring

It is anticipated that up to ten concrete core samples will be collected from the Imhoff tanks, four from the top, and six from the base of the tanks. More samples will be collected from the base because the sludges accumulated at the base. Because of the inherent relative homogeneity of sludges and sampling logistics, no samples will be collected from the sidewalls. Additionally, up to six soil samples will be collected from immediately beneath the six concrete core locations. These data will support evaluation of

the abandonment in-place remedial alternative for the tanks. Soil sampling is discussed below in Section 5.5.5. The locations for the concrete core samples will be chosen based on results of wipe samples collected during the liquid and sludge removal project conducted in 1992 (Section 3.3.3). The concrete core samples will be analyzed for the chemical and radiologic constituents listed in Table 5.9.

Four of the concrete core samples will be collected by coring through the top of the Imhoff tanks. The coring tool is designed to retain the core so that it will not drop out after the tool has penetrated the concrete. The six concrete cores from the base of the tanks will be collected using the same type of coring tool with some modifications. After an access hole has been drilled through the top of the Imhoff tanks, a Schedule 80 PVC casing will be lowered through the access hole to the base of the tanks and secured. This PVC casing will act as a guide for the coring tool and minimize the potential for the tool to "walk around" at the base of the tanks. An extension will be used to lower the coring tool through the PVC casing to the base of the tanks. The power source for the coring tool will remain above ground. After the concrete has been cored, the coring tool will be retrieved and the core will be removed from the tool and a wipe sample will be collected and counted. The core will then be placed in plastic bag, sealed and labeled appropriately as described in Appendix A in preparation for shipment to the laboratory. After the concrete cores have been collected, soil samples will be obtained using hand sampling techniques described below in Section 5.5.

5.4.5 Soil Borings

Six soil borings will be drilled in the area of the Imhoff tanks and leach fields. Two borings, one in the leach field area and one near the Imhoff tanks, will be drilled to approximately 40 feet bgs. Four borings, two near the Imhoff tanks and two in the leach fields, will be drilled to approximately 25 feet bgs. The locations of the borings will be refined based on the geophysical and trenching data; approximate locations are shown on Figure 5.8. The borings will be continuously cored and drive samples will be collected at 5-foot intervals. Upon completion, each boring will be backfilled from total depth to the ground surface using a cement/bentonite grout. The borings will be field screened, logged, and sampled, as described in the FSP, Appendix A. All drilling and sampling equipment will be decontaminated prior to being moved to the next sampling location. Decontamination procedures are described in Appendix A.

TABLE 5.9 LABORATORY ANALYSIS STRONTIUM-90 TREATMENT SYSTEM SAMPLES

Analyte	Trench Samples[a]	Soil Borings[b]	Concrete Samples
Metals[c]	✓	✓[e]	-
Hexavalent Chromium	✓	✓	
Nitrates (as Nitrogen)	✓	✓	
Organochlorine Pesticides	✓	✓	
Volatile Organic Compounds	✓	✓	
Semi-Volatile Organic Compounds	✓	✓	
Formaldehyde	✓	✓	
Total Alkalinity	✓		
Total Kjeldahl Nitrogen	✓ (1)	✓ (7)	
Ammonia	✓ (1)	✓ (7)	
Water Soluble Anions	✓ (1)	✓ (7)	
pH	✓ (1)	✓ (7)	✓
Total Organic Carbon	✓ (1)	✓ (7)	
Gross Alpha[d]	✓	✓	✓
Gross Beta[d]	✓	✓	✓
Radium-226	✓	✓	✓
Tritium	✓	✓	✓
Carbon-14	✓	✓	✓
Strontium-90	✓	✓	✓
Plutonium-241	✓	✓	
Americium-241	✓	✓	
Gamma Spectranalysis	✓	✓	✓
EC	✓ (1)	✓ (7)	
Sulfide	✓ (1)	✓ (7)	
Bacteriological Count	✓	✓ (7)	

Numbers in parentheses indicate number of soil samples to be analyzed for specific analytes.
[a] 4 trench samples submitted for analysis that will be used for fate and transport needs.
[b] 32 soil boring samples taken.
[c] Metals include 17 CAM Metals, Mg, Ca, Mn, and Fe.
[d] If Gross Alpha or Gross Beta are measured at two or more standard deviations greater than background, analyses for cesium-137, sodium-22, uranium-238, cobalt-60, or chlorine-36, may be performed.
[e] The list of analytes identified for soil boring samples will be modified to focus on the constituents identified above background levels in exploration trench and concrete core samples.

~~Approximately~~Up to 26 samples will be collected from the 6 soil borings (4 samples per boring plus 2 replicates for QA/QC purposes) for chemical and radiological analysis ~~described below in Section 5.5.7~~. The list of analytes identified for soil boring samples will be modified to focus on the constituents identified above background levels in exploration trench and concrete core samples. Samples will be selected in the field by the project geologist and the technical lead, and will be based on stratigraphy, material type and field screening results. In addition to chemical and radiologic testing, physical tests will be conducted on selected samples, as described in Section 5.5.8. If evaluation of the laboratory data indicates that the lateral and vertical extent of site constituents have not been delineated, a second stage of soil borings may be initiated.

~~Approximately~~ Up to six soil samples will be collected from immediately beneath the Imhoff tanks. The samples will be collected in conjunction with the concrete sampling described above in Section 5.5.4. While the PVC casing used to guide the concrete coring tool is still in place, a sample of the soil from immediately beneath the Imhoff tanks will be collected using hand sampling techniques. A steel hand-driven sampler containing stainless steel sample sleeves will be lowered through the PVC casing and a relatively undisturbed soil sample will be collected. The sampler will be retrieved and the stainless steel sleeves will be removed from the sampler and each soil sample will be screened for VOCs and radiologics and prepared for shipment to the analytical laboratory. Prior to pulling the PVC casing out of the Imhoff tanks, the hole in the base of the tanks will be grouted with a bentonite/cement mixture using the PVC casing as a tremmie pipe.

5.5.6 Wipe Samples

To screen for residual radiologic constituents that may be present in leach lines and distribution boxes, ~~approximately~~ six wipe samples, plus one replicate QA/QC sample, will be collected. Wipe samples will be collected from the interior surfaces of the leach lines and distribution boxes as presented in Table 5.10. Wipe samples will be collected as described in the FSP.

The interior condition of the distribution box and leach lines will be noted on field memoranda. Photographs of the structures will also be taken.

TABLE 5.10 SUMMARY OF STRONTIUM-90 LEACH LINE WIPE SAMPLE LOCATIONS

Number of Samples	Location
1	Strontium-90 distribution box
1	Influent line to strontium-90 distribution box
1	Effluent line from strontium-90 distribution box
3*	Strontium-90 leach lines

* Plus 1 replicate sample.

5.5.7. Chemical Testing

Solids and wipe samples collected in the area of the strontium-90 treatment system will be submitted to the analytical laboratory for chemical and radiologic testing. The samples will be analyzed for the list of parameters presented in Table 5.9. The analyte list was developed to characterize the nature of chemicals and radiologic constituents present, and assess the general chemistry of the soil for use in fate and transport modeling. Some specific analytes, identified in Table 5.9 in parentheses, will be assessed in certain soil samples to support fate and transport, and FS needs. These samples will be selected based on waste characteristics, soil types, field screening, and visual observations during drilling and excavation. As discussed above, the list of analytes identified for soil boring samples will be modified to focus on the constituents identified above background levels in exploration trench and concrete core samples. Analytical methods, required detection limits, QA/QC protocol and data validation documentation are discussed in the QAPjP, Appendix B.

5.5.8 Physical Testing

Selected soil samples will be submitted and analyzed for the physical parameters listed in Table 5.11. This table also provides the number of samples to be submitted for each analysis. The data will be used to evaluate the physical characteristics of the soils in the vicinity of the Imhoff system, to refine the conceptual site model, and as input for fate and transport modeling. Sample locations will be selected to obtain information from representative material types at various depths.

5.6 WESTERN DOG PENS AND NORTH CHEMICAL DISPENSING AREA (OU-3)

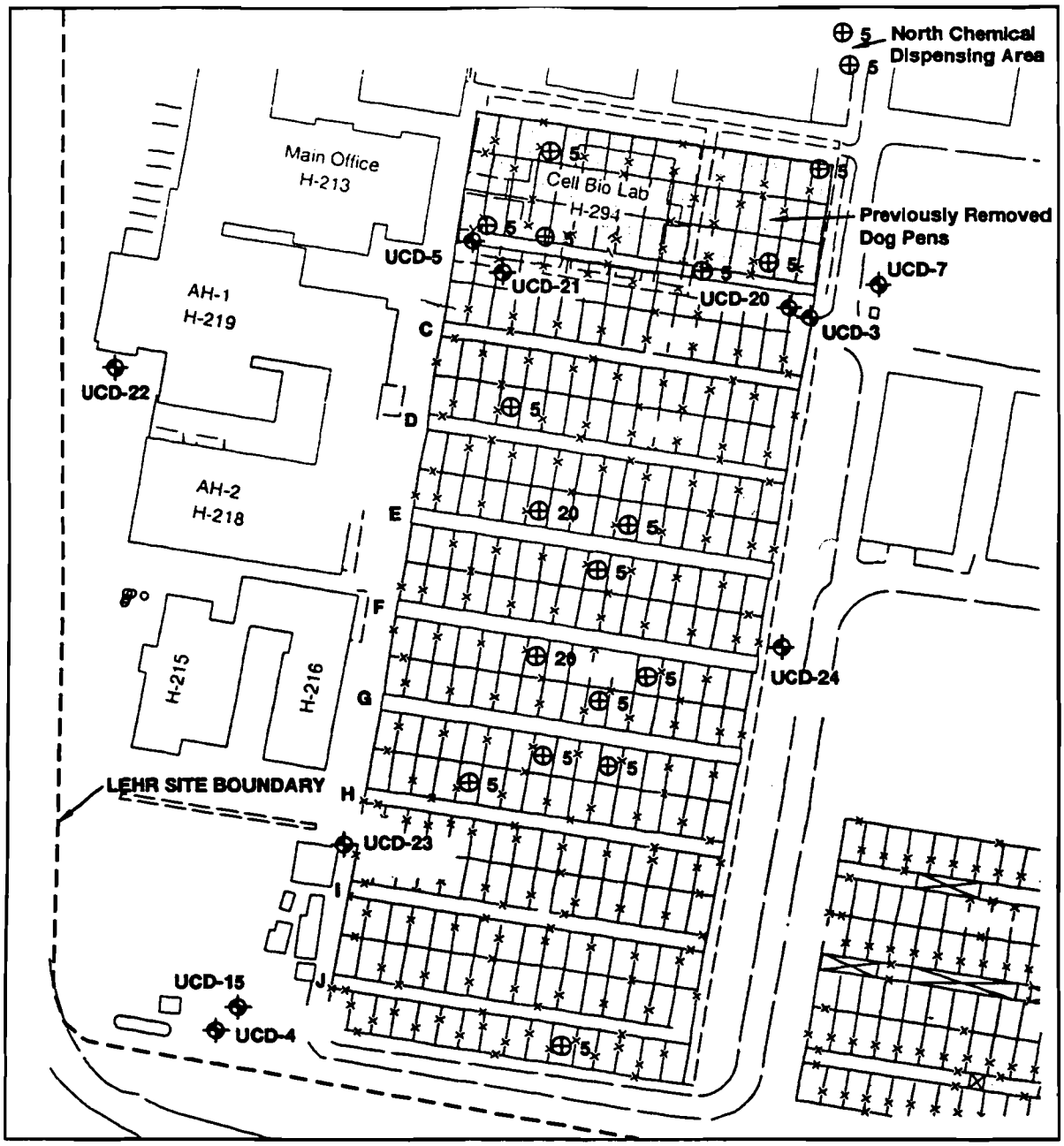
Preliminary OU-3 consists of the western set of dog pens and the north chemical dispensing area. The western set of outdoor dog pens (Figure 5.10) was used to house dogs involved in the radium-226 and strontium-90 research activities at the LEHR site. The western set of dog pens originally contained 320 pens. Sixty-four of the dog pens were removed from the western set of dog pens in 1975 to allow for construction of the Cellular Biology Laboratory. These pens reportedly housed the dogs which received the highest dosages of strontium-90 and radium-226. Dogs involved in the research were typically kept in indoor cages in Animal Hospital-1 and -2 for a specified period of time and then moved to the outdoor pens after the dogs received their initial treatment.

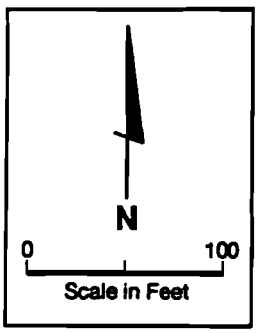
The pesticide chlordane was used on dogs kept in the outdoor pens to control fleas. The chlordane was sprayed on the dogs or they were dipped in chlordane or a chlordane-diesel mixture. Bulk storage of the chlordane and diesel is reported to have been at the north chemical dispensing area located immediately north of the dog pens. Spent chlordane was reported to have been disposed in trenches and pits in the southwest area or to the surface of the outdoor pens.

TABLE 5.11 PHYSICAL TESTS FOR STRONTIUM-90 TREATMENT SYSTEM SAMPLES

Physical Test	ASTM Method Number	Number of Samples
Hydrometer	D-422	2
Grain Size	C-136	2
Permeability	D-2434	2
Moisture Release	D-3152 and D-2325	2
Moisture Content	D-2216	20
Mineralogy	XRD	2
Specific Gravity	D-854	2
Atterberg Limits	D-4318	5
Bulk Density	D-4531	5

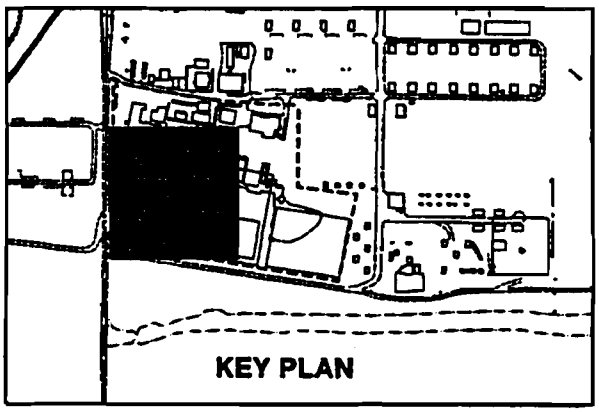
XRD - X-Ray Diffraction





EXPLANATION

UCD-4	Existing Monitoring Well Location
5	Proposed 5 Foot Soil Borings
20	Proposed 20 Foot Soil Borings



LOCATION M
WESTERN DOG PEN AREA SAMPL

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FIGURE 5.10

Results of the Phase II Site Characterization indicate some impacts from chlordane and nitrate in the dog pen area. Based on preliminary statistical evaluation of these data, lateral sampling density appears adequate from a risk assessment perspective, although vertical delineation of impacts still needs to be evaluated. Additionally, a thorough sampling of soil from the area currently occupied by the Cellular Biology Laboratory building is necessary.

Construction of the Cellular Biology Laboratory building is such that the building and landscaping covers approximately one-half the area originally occupied by the former dog pens. This area was not specifically evaluated during the Phase II Site Characterization; however, two groundwater monitoring wells, UCD-20 and UCD-21, were installed in areas occupied by the former dog pens. Results of soil samples collected during installation of these two wells show that elevated levels of chlordane (up to 360 μg/Kg) were detected.

During the Phase II Site Characterization, 82 soil samples were collected from the existing dog pen areas (Figure 5.10). Thirty four samples were collected from the western set of dog pens and sixteen samples were collected from the eastern set of dog pens. Additionally, six soil samples were collected from the vicinity of the north chemical dispensing area. The samples from these areas were collected from the surface and approximately 12 to 18 inches below ground surface to evaluate potential impacts to shallow soil. Results of the chemical and radiologic analyses indicate some impacts to the soil in the dog pens, including chlordane (up to 480 μg/Kg) and nitrate (up to 168 mg/Kg). Chlordane and nitrate were also reported in samples from the north chemical dispensing area up to 70 μg/Kg and 49 mg/Kg, respectively.

Additional characterization of the western set of dog pens during this RI focusses on vertical delineation of areas previously identified as having elevated levels of chlordane and nitrate and an assessment of an area of previously removed dog pens that have yet to be investigated. The focus of investigation in the north chemical dispensing area is to collect samples from beneath the chemical storage area. Based on review of aerial photographs of the north chemical dispensing area during preparation of this Work Plan, it was determined that the Phase II Site Characterization sample locations may not have been located in the area that contained the majority of the chemical storage containers.

Therefore, additional samples are proposed to be collected from the newly identified area of the chemical storage containers.

Because of previous reported detections of site constituents in these areas, and the goals of the RI, a comprehensive analytical program has been developed and is presented below in Section 5.6.3. For the dog pen areas and the north chemical dispensing area, pesticides, radioactivity, metals and general chemical data will be assessed. Pesticides will be assessed due to the use and storage of chlordane at the site. Radiologic constituents will be assessed to confirm detections reported from samples collected during the Phase II. Metals will be assessed in the dog pen areas to obtain baseline information for this area. No metals analyses were conducted on samples collected from this area during the Phase II Site Characterization. General chemical data on various anions and cations are necessary to evaluate contaminant fate and transport mechanisms for use in modelling. Nitrate will be evaluated to assess impacts from the excreta. With the exception of diesel, volatile and semi-volatile organic compounds will be assessed only in the north chemical dispensing area to assess potential impacts from management and storage of these constituents. Diesel will be assessed in the dog pen areas to evaluate impacts from the process of controlling fleas using a diesel/chlordane mixture. Reusable sampling equipment will be decontaminated between sampling locations, according to the procedures presented in the FSP, Appendix A. Sample locations will be surveyed by a registered surveyor and incorporated into the site geodetic coordinate system.

Analytical data will be obtained from the current dog pen area, the Cellular Biology Laboratory building area and the north chemical dispensing area. These data will be used to evaluate the nature and extent of hazardous or radioactive materials. Data from these areas are necessary to fully evaluate the potential for these areas to act as continuing source areas and to evaluate potential environmental and human health risks. Additionally, these data will be used to evaluate potential remedial alternatives such as no action, removal or capping. Additional information on potential remedial alternatives for the dog pens is presented in Section 3.6.

The eastern set of dog pens is located on UC Davis Landfill Unit No. 1. Further evaluation of the soil beneath these pens is addressed in the investigation of the surface soil of the landfill units.

The western dog pen area and the north chemical dispensing area will be further characterized through the implementation of the following specific activities:

- literature review;
- soil borings;
- chemical testing; and
- geodetic surveying.

Each of these activities are discussed in the following sections.

5.6.1 Literature Review

The purpose of the literature review is to gather pertinent information on the western dog pen area that will allow better identification of the types and locations of potential site constituents present in the area. This information will be used to characterize the soils in the dog pen area and refine the soil sampling locations. Facility drawings provided by UC Davis, regarding the dog pens and available inventories of chemical and radiologic constituents that may have been used in that area as a result of the research activities will be reviewed. It is anticipated that the literature can be supplied by the LEHR research staff and/or the UC Davis Physical Plant. Based on the results of the literature review, locations for soil borings in the area of the Cellular Biology Laboratory will be refined.

Documents will also be reviewed to evaluate underground utilities in the areas of the dog pens. Utility locations will be identified to evaluate the potential for the utility trenches to act as pathways of migration for site constituents.

5.6.2 Soil Borings

Based on a preliminary evaluation of the analytical data collected during the Phase II Investigation, it appears that the current sampling density within the dog pen area is sufficient for a lateral evaluation of the distribution of constituents in shallow soils. In the area of the Cellular Biology Laboratory, up to 12 samples (plus 1 replicate QA/QC sample) will be analyzed from six borings drilled in the area of the previously existing dog pens

adjacent to the Cellular Biology Laboratory, as shown on Figure 5.10. As discussed above in Section 5.6.1, the locations of the six borings may be refined based on the literature review. Six soil borings in this area will provide a similar sampling density as in the adjacent dog pen area evaluated during the Phase II Site Characterization. Borings will be drilled using hand augering techniques or a portable drilling rig, as described in the FSP, Appendix A. Soil samples will be collected from each boring at the surface, 2½ feet bgs, and 5 feet bgs for potential chemical and physical testing. The surface sample and the samples collected at 2½ feet bgs will be submitted to the laboratory for chemical and radiological analysis. The 5-feet-bgs samples will be archived in the laboratory for additional testing if results from the surface and 2½-feet-bgs samples warrant it.

Eleven ~~Ten~~ additional soil samples (plus one replicate QA/QC sample) will be collected from 11 ~~ten~~ borings at a depth of 6 ~~five~~ feet bgs in the existing western dog pen area, as shown on Figure 5.10. In addition to the 11 ~~9~~ samples collected from 6 ~~5~~ feet bgs, two borings will be continued and soil samples will be collected at 10 and 20 feet bgs. The locations of the 11 ~~9~~ samples are beneath areas previously identified as having elevated levels of chemicals or radioactivity. The two deeper soil borings are located in areas with the highest reported levels of nitrate identified in samples collected during the Phase II Investigation. The purpose of these samples is to allow evaluation of the vertical extent of site constituents, primarily chlordane and nitrate. Soil samples obtained during this task will be collected using hand augering or portable drilling techniques described in the FSP. Statistical comparisons will be conducted when analytical data are received. At that time, if additional samples are required to meet the DQOs for the area, they will be collected.

Four soil samples will be collected from two soil borings drilled in the north chemical dispensing area at the locations shown on Figure 5.10. Samples will be collected from each of the borings at 2½ and 5 feet bgs for chemical testing.

Upon completion of each boring greater than 6 ~~5~~ feet bgs~~deep~~, the borehole will be backfilled from total depth to the ground surface with a cement/bentonite grout. The borings will be drilled, and samples will be collected and field screened for VOCs and radiologic activity, using drilling and sampling techniques as described above and detailed

in the FSP. All drilling and sampling equipment will be decontaminated prior to being moved to the next sampling location.

5.6.3 Chemical Testing

Samples collected from the western dog pen and north chemical dispensing areas will be shipped via overnight courier to the analytical laboratory for chemical and radiologic testing. Samples will be analyzed for the parameters listed in Table 5.12. The list of analytes is designed to provide information on levels of constituents of concern, as well asto develop obtain information for evaluation of impacts and use in the risk assessment and evaluation of remedial alternatives. Some samples, identified in Table 5.12 in parentheses, will be selected based on waste characteristics, soil types, field screening, and visual observations during drilling and excavation.

5.7 DOMESTIC SEPTIC TANKS (OU-4)

There are seven known domestic septic tanks located at the LEHR site (Figure 5.11), and together they constitute preliminary OU-4. These domestic septic tanks served the office and laboratory buildings prior to the facility being connected to the UC Davis Wastewater Treatment Plant at the main campus. When the facility was connected to the wastewater treatment plant, the domestic septic tanks were reportedly abandoned and filled with sand; however, there are no formal closure records to confirm this activity. Although sewage is not considered hazardous, because the domestic systems were the only treatment systems that serviced the LEHR facility and received influent from laboratory sinks and floor drains, the potential exists that hazardous or radioactive materials were disposed through these systems during operation of the LEHR facility.

Three of the seven tanks (Tanks 1, 3, and 5 on Figure 5.11) were positively located as part of preliminary work conducted during the Phase II Site Characterization. Based on observations made during this activity, it is suspected that the tanks were not closed as reported. For example, one of the tanks was partially destroyed and filled with soil and tank rubble, and another tank was only partially filled with pea-gravel, not sand. Also,

TABLE 5.12 LABORATORY ANALYSIS FOR WESTERN DOG PEN AND NORTH CHEMICAL DISPENSING AREA SOIL SAMPLES

Analyte	Western Dog Pens[a]	North Chemical Dispensing[b]
Metals[c]	✓	✓
Hexavalent Chromium	✓	✓
Nitrates (as Nitrogen)	✓	✓
Volatile Organic Compounds		✓
Semi-Volatile Organic Compounds		✓
Formaldehyde (Only in Northern Chemical Dispensing Area		✓
Diesel		✓
Kerosene	✓	✓
Organochlorine Pesticides	✓	✓
Total Alkalinity	✓ (12)	✓
Total Kjeldahl Nitrogen	✓ (12)	✓
Ammonia	✓ (12)	✓
Water Soluble Anions	✓ (12)	✓
pH	✓ (12)	✓
Total Organic Carbon	✓ (12)	✓
Gross Alpha & Gross Beta[d]	✓	✓
Tritium	✓	✓
Carbon-14	✓	✓
Radium-226	✓	✓
Strontium-90	✓	✓
Gamma Spectranalysis	✓	✓
EC	✓ (12)	✓
Sulfide	✓ (12)	✓
Bacteriological Count	✓ (5)	✓ (1)

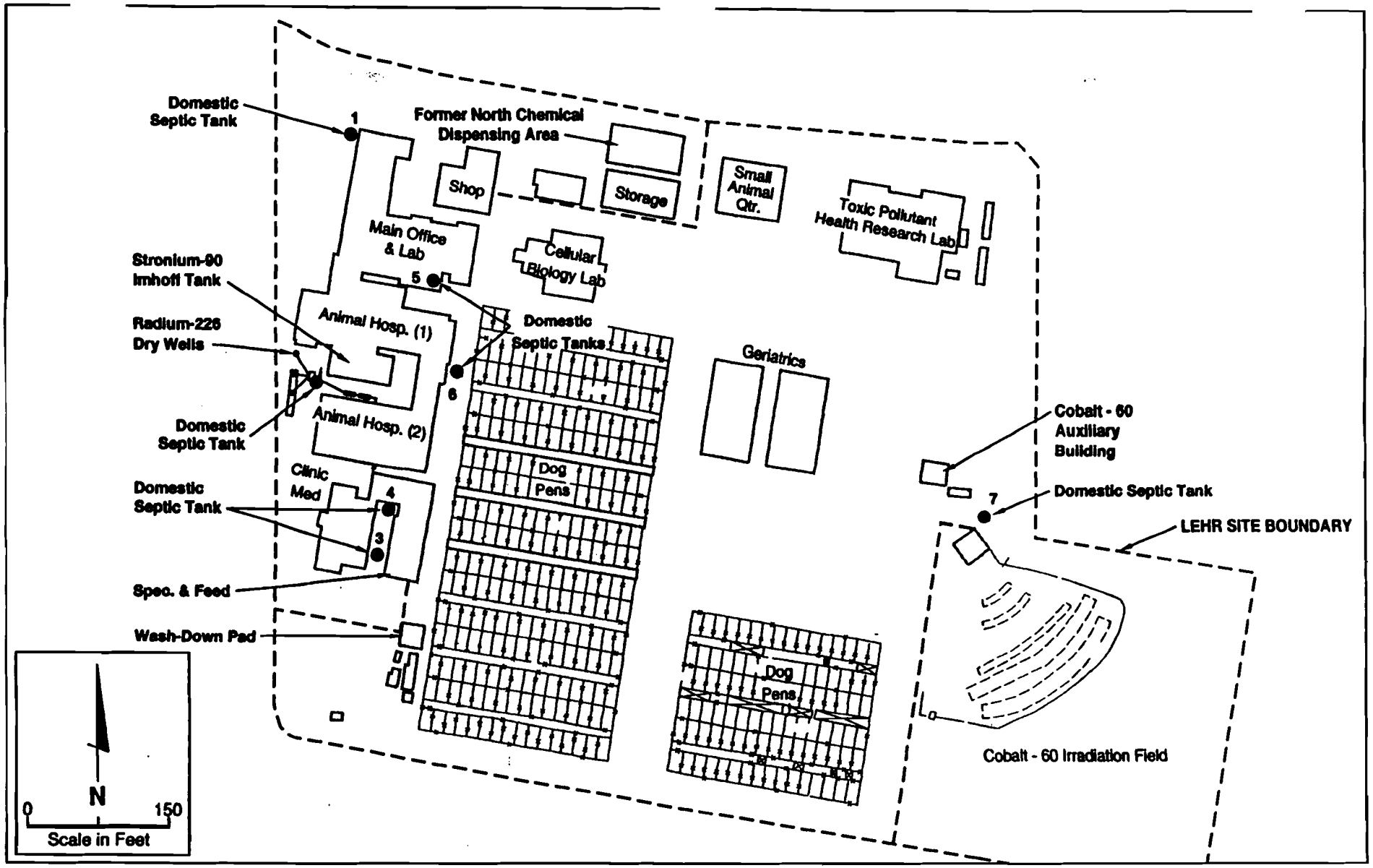
Numbers in parentheses indicate number of soil samples to be analyzed for specific analytes.

a 13 ~~30~~ samples from the Western Dog Pens submitted for analysis that will be used for fate and transport needs.

b 4 samples from the north chemical dispensing area submitted for analysis.

c Metals include 17 CAM Metals, Mg, Ca, Mn, and Fe.

d If Gross Alpha or Gross Beta are measured at two or more standard deviations greater than background, analyses for cesium-137, sodium-22, uranium-238, cobalt-60, or chlorine-36, may be performed



APPROXIMATE LOCATIONS OF DOMESTIC SEPTIC TANKS AT LEHR

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FIGURE 5.11

since none of the associated leach fields were evaluated during the Phase II Site Characterization and no soil or sediment samples have been collected from any of the seven tanks, adjacent soil or appurtenant leach systems, there are no analytical data to characterize the contents or evaluate the potential impacts to the environment from these systems.

The seven domestic septic tanks will be evaluated to: accurately locate the seven domestic septic tanks and associated leach fields at the LEHR site; assess reported closure methods and characterize current tank contents; assess soil adjacent to tanks and associated leach fields to check for potential contaminants that may have been disposed through the systems; and develop remedial alternatives or closure plans for these tanks. Considering that there has been no investigation of these tanks in the past, it is difficult to anticipate the specific evaluation or remediation requirements for these tanks. However, it is anticipated that the approach provided in this Work Plan should provide sufficient data for these evaluations.

A variety of investigation techniques will be used to evaluate the domestic septic systems. Initially, relatively non-invasive techniques including a review of available construction, chemical use, or other file information, and a geophysical survey will be used to refine the location of the tanks and leach fields. Exploration trenching with a backhoe and hand sampling techniques will then be used to assess closure methods and characterize tank contents. Additionally, exploration trenching will be used to assess soil adjacent to the leach fields. Wipe samples will be collected from the interior of the leach field piping for screening of radioactivity, and soil borings will be used to assess potential impacts to soil at depth below the leach fields. Reusable sampling equipment will be decontaminated between sampling locations, according to the procedures presented in the FSP, Appendix A. Sample locations will be surveyed by a registered surveyor and incorporated into the site geodetic coordinate system.

Chemical analyses will be used to characterize the nature of potential impacts, and physical analyses of soil will be used to assess mobility and potential remedial alternatives, if warranted. Because of unknown contents of these systems and the potential for a variety of wastes to have been disposed through these systems, a comprehensive analytical program has been developed and is presented in Section 5.7.5. Volatile and

semi-volatile organic compounds, radioactivity, and metals will be assessed because these groups of constituents were used in the laboratories in the form of solvents, acids, and various solutions required by the research and could have been disposed down the laboratory drains. Pesticides will be assessed due to the extensive use of chlordane at the site. Nitrate will be evaluated to assess impacts from the sewage. General chemical data on various anions and cations are necessary to evaluate contaminant fate and transport mechanisms for use in modelling.

Analytical data will be obtained from each component of these systems including the tank, any identified distribution boxes, piping and leach fields. These data will be used to evaluate the potential presence of hazardous or radioactive materials. Data from the systems are necessary to fully evaluate the potential for these systems to act as continuing source areas and to evaluate potential environmental and human health risks. Additionally, these data will be used to evaluate potential remedial alternatives such as no action, removal, or abandonment in-place. Additional information on potential remedial alternatives for these domestic septic tanks is presented in Section 3.6.

Based on information developed during the initial evaluation, some of the systems have limited access and therefore may require differing access and sampling methods. Details on the location and sampling procedures are described in the following sections and in Appendix A.

Assessment of the seven domestic tanks will consist of the following activities:

- literature review;
- geophysical survey;
- backhoe exploration;
- wipe sampling;
- soil borings; and
- chemical testing.

Each of these activities is described below.

5.7.1 Literature Review

Design plans, and construction drawings and files will be reviewed to gather information concerning the location and possible condition of the domestic septic tanks and associated leach fields. This will consist of a review of available DOE, UC Davis and Solano County records pertaining to septic system construction, including as-built drawings, and abandonments, if available. Documents will also be reviewed to evaluate underground utilities in the areas of the domestic septic systems. The utility locations will be identified to evaluate the potential for the utility trenches to act as pathways of migration for potential site constituents and to assess potential hazards associated with planned intrusive work.

Interviews with knowledgeable UC Davis personnel will also be conducted to obtain as much information as possible relating to septic tank and leach field location, design, and history. UC Davis will be asked to identify knowledgeable site personnel.

5.7.2 Geophysical Survey

Following the literature review, a geophysical survey will be conducted to locate the septic tanks, piping, and leach fields. The geophysical survey may use such methods as metal detection, GPR, and EM to locate the structures. It is anticipated that the geophysical survey will positively identify the septic system; however, subsurface utilities and other cultural features may cause interference. Details of the geophysical methods are presented in the FSP.

After the area of each septic system has been identified, it will be checked and cleared for underground utilities by UC Davis Physical Plant personnel. An initial attempt to locate the septic tanks using a hand-driven steel probe will then be made.

5.7.3 Backhoe Excavation

Backhoe excavation will be used to confirm the location and allow access to the domestic septic tanks. In the event that the presence of utilities, proximity to buildings, or restricted working space prevents the use of a backhoe, excavation may be performed

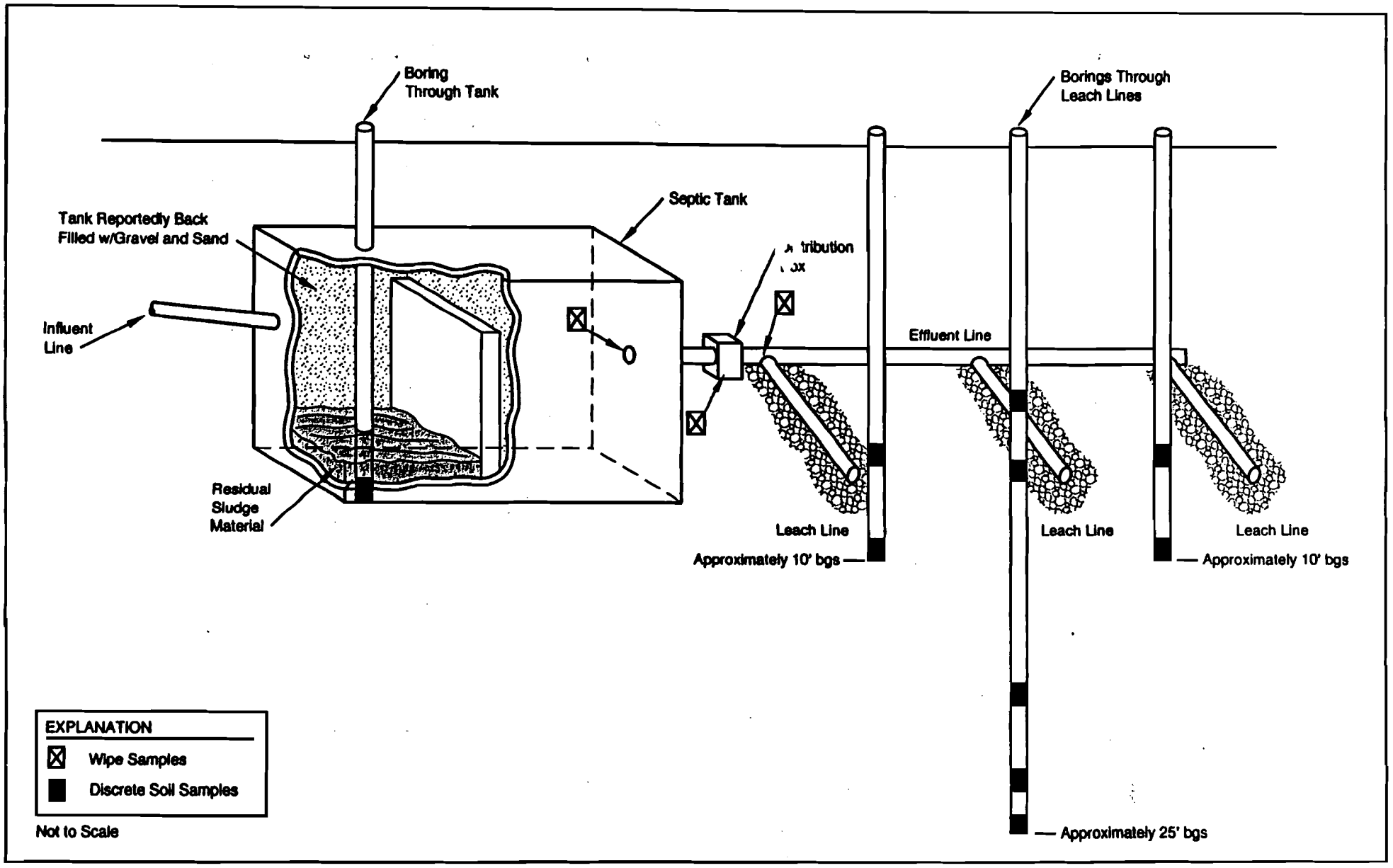
using hand implements. If a tank is not identified in the initial area of excavation, additional materials may be excavated in adjacent areas. If a suspected tank still cannot be located using this method, the project team, including the contractor's Project Manager, the PNL Project Manager, and the field technical lead, will be notified and alternative courses of action will be evaluated. Alternatives may include: no further exploration for a specific tank; additional file review; additional geophysical surveys; or additional excavation.

UC Davis utilities records indicate that Tank 4, located between the office and the clinic buildings, is potentially overlain by four utilities, including water, gas, electric, and sewer lines. Due to the presence of these utilities, it will be necessary to uncover and remove contents from this tank by hand. UC Davis Physical Plant personnel will be present for guidance, should problems arise. Sampling procedures for this tank will depend on accessibility to the tank and proximity of underground utilities and will be determined in the field.

Pavement and soil overlying the tanks will be removed for purposes of evaluating the tank's condition and gaining access to the tanks. Enough material will be removed from above each tank to assess the tank's condition, and also to access the tank for sample collection. All materials removed will be placed on plastic sheeting and screened for radioactivity and volatile organic compounds.

A sample of material found at the bottom of the influent side of each tank (fill, sediment, sludge, or liquid), if any, will then be collected. If a tank contains no material, a wipe sample will be collected from the base of the tank's influent side. Figure 5.12 is a schematic representation of a typical septic tank and shows a potential sampling scenario. Methods are described in detail in the FSP; health and safety requirements are presented in the HSP. Tank contents samples will be analyzed for chemical and radiologic constituents described in Section 5.7.5.

After the septic tanks have been opened and sampled, the effluent line leading to the leach field will be identified, if possible. A wipe sample will then be collected from the inside surface of the effluent line.



CONCEPTUAL DIAGRAM OF DOMESTIC SEPTIC TANK SAMPLING LOCATIONS

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LEHR Environmental Restoration
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The distribution box to the leach field will then be excavated. If the distribution box has not been previously located, then a metal wire (snake) will be inserted into the effluent line. The snake can then be traced on the surface using a metal detector to the distribution box.

After the distribution box has been opened and its contents visually evaluated, a sample of the contents will be collected, provided a sufficient volume of material exists. If an insufficient volume of material or no material exists in the distribution box, a wipe sample will be collected. If no box exists and a junction is found, the junction may be opened and a wipe sample collected.

The leach field distribution lines, beyond the distribution box or junction in the effluent line, will be assessed in the same manner described above for the effluent line and distribution box. A wipe sample will be collected from inside one of the leach field distribution lines using the techniques described above.

All digging equipment will be decontaminated prior to being moved to the next location. Decontamination procedures are described in Appendix A.

5.7.4 Soil Borings

Three ~~A~~ soil borings will be drilled and sampled at each septic tank and leach field. The purpose of collecting soil samples from the septic tanks and leach fields is to evaluate whether impacts to the soil have occurred due to leakage of material from the tanks or infiltration of material from the leach fields.

After the material at the bottom of the tanks has been sampled, the tanks and excavation will be backfilled.

Three ~~A~~ soil borings will also be drilled within each identified leach field. Two borings will be drilled and sampled to 10 feet bgs, and one boring will be drilled and sampled to approximately 25 feet bgs. Soil samples will be collected at 5-foot intervals to the groundwater table. Two samples from each 10-foot boring and three samples from

each 25-foot boring ~~Samples from the base of the leach field, midway to the groundwater, and near the groundwater table~~ will be submitted to the laboratory for chemical and radiological analysis. After samples have been collected, the boring will be grouted to the surface with a cement bentonite grout to minimize the potential for downward migration of constituents. Details of drilling, sampling, and decontamination procedures are provided in the FSP; health and safety requirements are presented in the HSP.

5.7.5 Chemical Testing

Soil and wipe samples collected from the septic systems will be submitted to the laboratory for analysis of the chemical and radiologic parameters listed in Table 5.13. Soil samples collected for physical testing will be analyzed for parameters listed in Table 5.14. Analytical methods, required detection limits, QA/QC protocol and data validation documentation are discussed in the QAPjP. The analyte list was developed to assess the nature of chemicals and radiologic constituents present, and assess the general chemistry of the soil for use in fate and transport modeling. Some specific analytes, identified on Table 5.13 in parentheses, will be assessed in certain soil samples to support fate and transport, and FS needs. These samples will be selected based on waste characteristics, soil types, field screening, and visual observations during drilling and excavation.

5.8 UC DAVIS LANDFILL UNITS (OU-5)

The three UC Davis landfill units (Figure 5.13), which constitute preliminary OU-5, reportedly received UC Davis campus wastes from the 1940s through the 1960s. Although the landfill units reportedly received primarily municipal wastes from the UC Davis campus, the potential exists that they may have received campus-generated or LEHR-generated low-level radioactive waste, organic chemicals, and general laboratory wastes.

While receiving wastes, the UC Davis landfill units were reportedly excavated approximately 10 to 12 feet below grade, then backfilled with refuse. Some of the landfill units contained individual disposal trenches and pits and some contained larger excavations. Approximately 3 to 4 feet of cover material was reportedly placed over the refuse material. None of the three landfill units have an engineered cover or cap. The eastern set of the dog pens was constructed on top of Landfill Unit No. 2, and the

TABLE 5.13 LABORATORY ANALYSIS FOR DOMESTIC SEPTIC TANKS

Domestic Septic Systems		
Analyte	Trench Samples[a]	Soil Borings[b]
Metals[c]	✓	✓
Hexavalent Chromium	✓	✓
Nitrates (as Nitrogen)	✓	✓
Organochlorine Pesticides	✓	✓
Volatile Organic Compounds	✓	✓
Semi-Volatile Organic Compounds	✓	✓
Formaldehyde	✓	✓
Total Alkalinity	✓ (8)	✓ (24)
Total Kjeldahl Nitrogen	✓ (8)	✓ (24)
Ammonia	✓ (8)	✓ (24)
Water Soluble Anions	✓ (8)	✓ (24)
pH	✓ (8)	✓ (24)
Total Organic Carbon	✓ (8)	✓ (24)
Gross Alpha[d]	✓	✓
Gross Beta[d]	✓	✓
Tritium	✓	✓
Carbon-14	✓	✓
Radium-226	✓	✓
Strontium-90	✓	✓
Gamma Spectranalysis	✓	✓
EC	✓ (8)	✓ (24)
Sulfide	✓ (8)	✓ (24)
Bacteriological Count	✓	✓ (24)

Numbers in parentheses indicate number of soil samples to be analyzed for specific analytes.

a 15 trench samples submitted for analysis that will be used for fate and transport needs.

b A maximum of 52 ~~44~~ soil boring samples submitted for analysis.

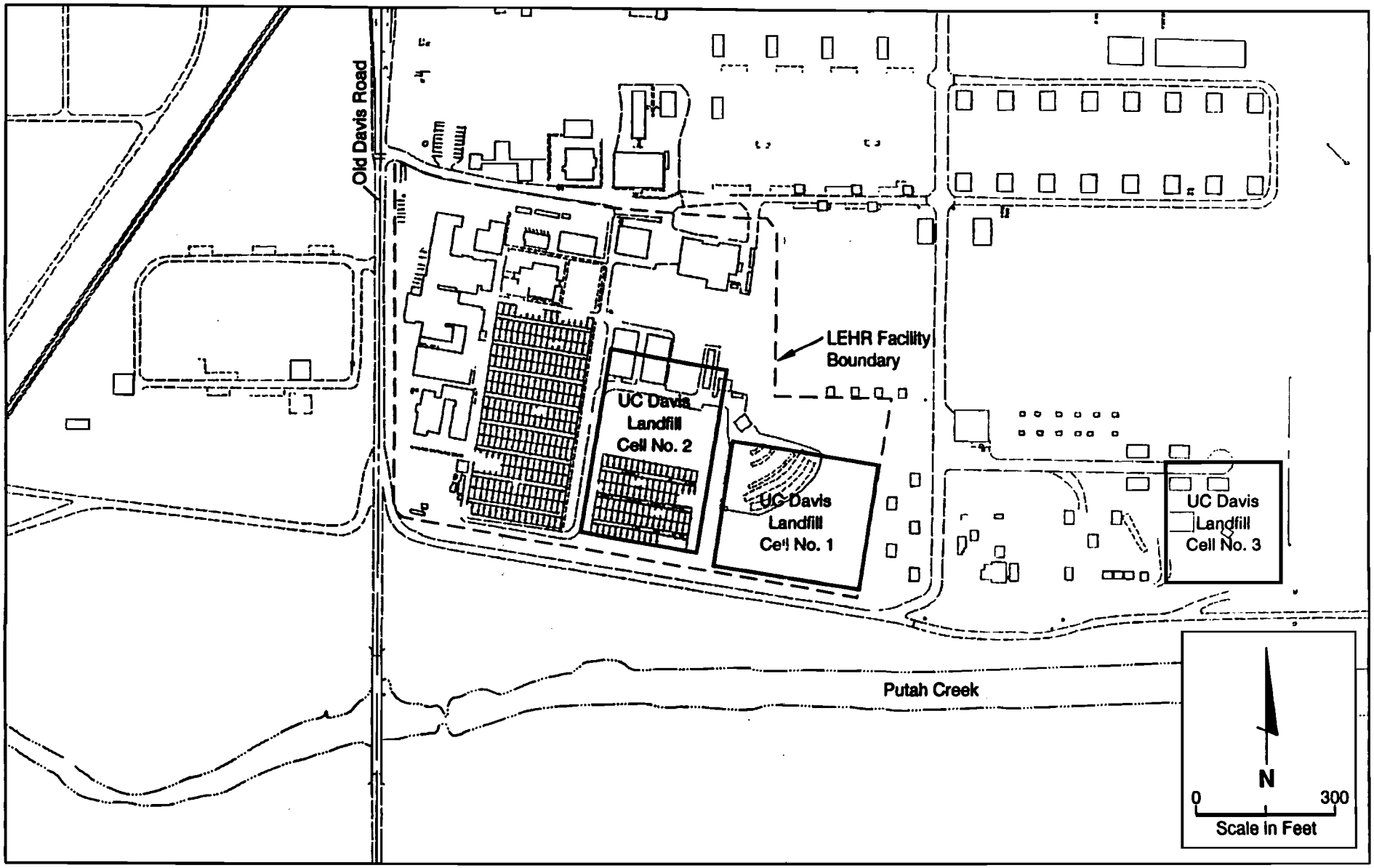
c Metals include 17 CAM Metals, Mg, Ca, Mn, and Fe.

d If Gross Alpha or Gross Beta are measured at two or more standard deviations greater than background, analyses for cesium-137, sodium-22, uranium-238, cobalt-60, or chlorine-36, may be performed.

TABLE 5.14 PHYSICAL TESTS UC DAVIS TRENCHES

Physical Test	ASTM Method Number	Number of Samples
Hydrometer	D-422	5
Grain Size	C-136	5
Permeability	D-2434	4
Moisture Release	D-3152 and D-2325	4
Moisture Content	D-2216	25
Mineralogy	XRD	2
Specific Gravity	D-854	3
Atterberg Limits	D-4318	10
Bulk Density	D-4531	10

XRD - X-Ray Diffraction



LOCATION MAP
LANDFILL DISPOSAL UNITS

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10805-454-044 JBS 6/3/93 LAND

FIGURE 5.13

cobalt-60 irradiator building and irradiator field were constructed on top of Landfill Unit No. 1. Landfill Unit No. 3 lies outside the LEHR site boundary approximately 600 feet east.

Currently, there are no analytical data — chemical or radiologic — from the landfill contents and only the general location for each unit is known. Landfill disposal records are not available, however, based on reported disposal practices, the possibility exists that the landfill units do contain hazardous, radioactive and potentially mixed wastes. To date, the lateral size of the landfills has been interpreted from aerial photos only.

Data collected during the Solid Waste Assessment Test (SWAT) (Dames & Moore, 1990b) conducted for UC Davis on the landfill units indicate that VOCs, including: chloroform, up to 17,000 ug/L; 1,1, dichloroet[illegible] up to 31 ug/L; and 1,1,1-trichloroethane up to 36 ug/L have impacted groundwater beneath LEHR, downgradient of the landfill units. Nitrate up to 100 mg/L and some metals including hexavalent chromium up to 0.38 mg/L were also reported in groundwater samples. No characterization data were obtained on the contents of the landfill units, although limited soil data are available from samples collected during installation of the monitoring wells adjacent to the landfill units. Characterization of potential chemical and radiologic constituents in the UC Davis landfill units, or a complete evaluation of the lateral or vertical extent of migration has not been conducted.

The UC Davis landfill units will be evaluated to: accurately locate, and collect samples for analytical testing from these areas; protect investigators and the environment from unknowns that may have been buried in these areas; and develop sufficient data to evaluate DOE/UC Davis responsibilities associated with contents of these landfill units. Additionally the data are necessary to evaluate human and environmental risks and potential remedial alternatives for the landfill units.

Because of the known, and more importantly, the unknown materials that may have been disposed in the landfill units, and the associated human and environmental health and safety concerns, the investigation and sample collection tasks will be completed in a phased approach starting with the least invasive methods. Information from activities

conducted early in the investigation will be evaluated and used to guide the subsequent more invasive exploration and sampling activities.

A variety of investigation techniques will be used to evaluate UC Davis landfill units. Initially, relatively non-invasive techniques including a review of literature and geophysical methods will be used to refine the boundaries of the landfill units. A soil gas and radiologic survey will then be conducted to obtain screening level information on the landfill contents. The screening level information will be used to identify "hot spots" or anomalies, and to optimize locations for exploration soil borings. This information will also be used for health and safety screening prior to the more invasive activities. Shallow soil borings approximately 25 feet bgs ~~(< 15 feet deep)~~ will be used to collect data to evaluate the nature and characteristics of the landfill contents and for the evaluation of DOE/UC Davis responsibilities. Deep soil borings approximately 40 feet bgs ~~(> 15 feet deep)~~ may be drilled to assess potential impacts to soil at depths below the landfill units and evaluate potential remedial alternatives. Chemical analyses will be used to characterize the nature of potential impacts and physical analyses of soil and will be used to assess potential remedial alternatives, if warranted. Sampling locations will be incorporated into the site geodetic survey, by a registered surveyor, to allow subsequent confirmation sampling and assist in developing volumes of contaminated materials. Reusable sampling equipment will be decontaminated between sampling locations, according to the procedures presented in the FSP, Appendix A.

Because of the relatively unknown contents of the UC Davis landfill units, and the potential for a variety of chemical and radiologic wastes to have been disposed, a comprehensive analytical program has been developed and is presented in Section 5.8.6. Volatile and semi-volatile organic compounds, radioactivity, and metals will be assessed because these groups of constituents have been identified in groundwater beneath LEHR and were used in the UC Davis campus and LEHR laboratories in the form of solvents, acids, and various solutions required by the various research activities. Pesticides will be assessed due to the extensive use of chlordane at the site and previous detections of pesticides in nearly pure form in the nearby UC Davis disposal trenches. Nitrate will be evaluated to further assess the landfill units as potential sources for nitrate that has impacted groundwater beneath the LEHR site. General chemical data on various anions

and cations are necessary to evaluate contaminant fate and transport mechanisms for use in modelling.

Evaluation of the UC Davis landfill units will consist of the following activities:

- personnel interviews and literature review;
- geophysical surveys;
- gas and radiologic surveys;
- soil borings;
- chemical testing;
- physical testing; and
- geodetic surveying.

Each of these activities is described in the following sections. Detailed field procedures are provided in the FSP.

5.8.1 Personnel Interview and Literature Review

Past workers at UC Davis and the LEHR site will be interviewed to obtain specific information on the methods and types of disposal in the landfill units. Assistance from UC Davis personnel will be requested to identify the appropriate people for these interviews.

Available UC Davis and LEHR site records will be reviewed to further identify disposal methods and wastes in the landfill units. This will include review of UC Davis and LEHR documents and facility drawings that may not have been reviewed during the Phase II Investigation, or reviewing those documents a second time for the specific purpose of refining the locations of the disposal areas in the landfill units. Documents will also be reviewed to evaluate underground utilities in the areas of the UC Davis landfill units. The utility locations will be identified to evaluate the potential for the utility trenches to act as pathways of migration for site constituents and to assess hazards associated with planned invasive work.

Additionally, historic aerial photographs will be acquired and interpreted to assess specific locations of the disposal areas within the landfill units. The photographs will also be assessed to evaluate disposal methods and other activities in the vicinity.

5.8.2 Geophysical Survey

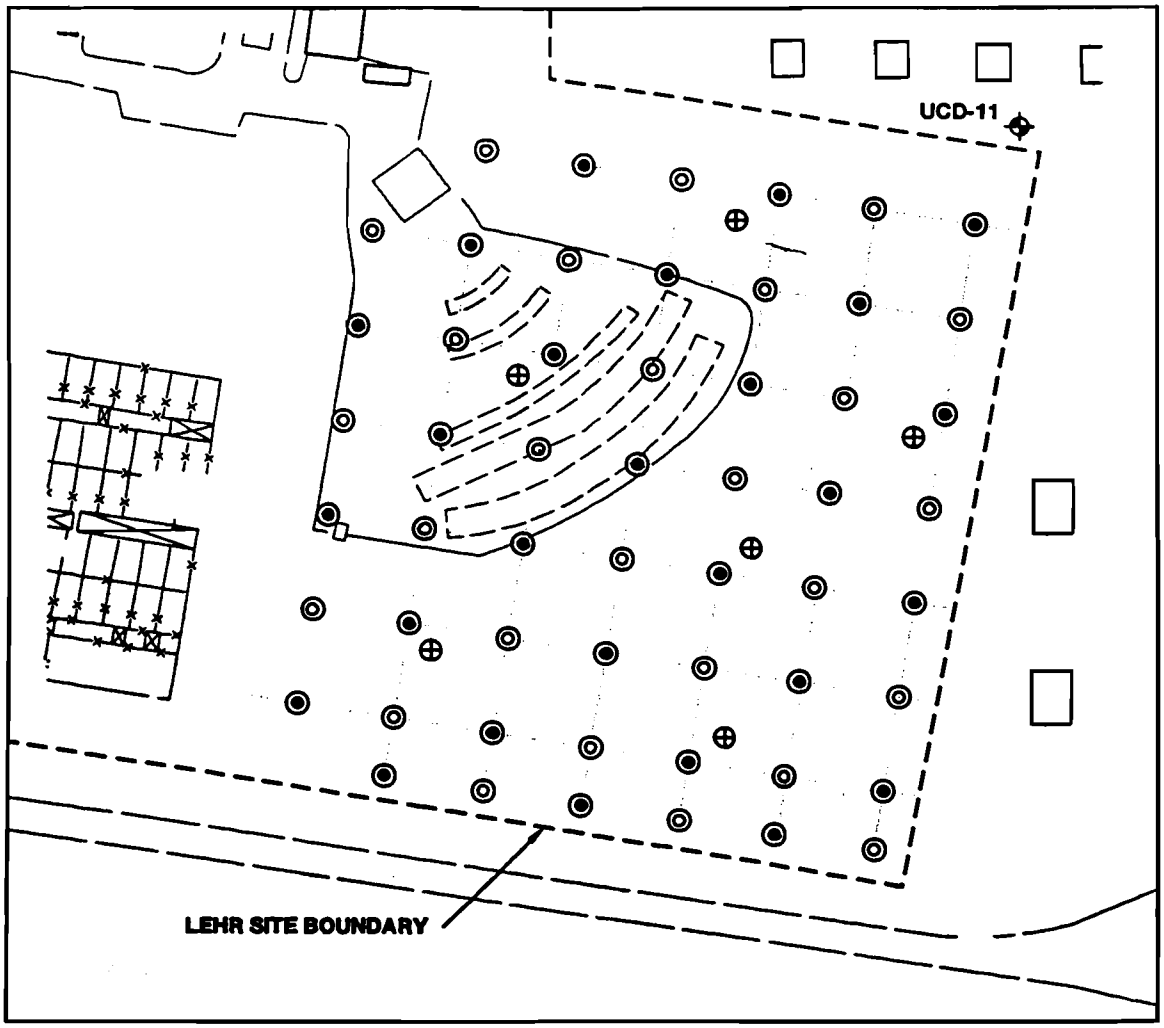
It is anticipated that the literature review task described in Section 5.8.1 will be adequate to locate disposal areas within the landfill units so that a soil, gas, and radiologic survey can be conducted. However, if the units cannot be identified to an acceptable level of confidence, geophysical surveys will be conducted. Geophysical methods, including GPR and EM will be conducted to identify the areas of waste disposal within the three landfill units.

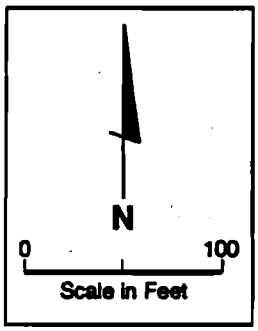
A grid will be established over each landfill unit requiring a geophysical survey, and transects will be run to maximize the potential to intersect individual disposal areas within the landfill units. Details of the geophysical investigation are included in the FSP.

5.8.3 Landfill Gas and Radiologic Survey

After the landfill units have been located using the methods described above, the location of the disposal areas within the units will be surveyed and incorporated into the site geodetic survey. Additionally, an appropriate grid will be surveyed on each of the cells to reflect the orientation of the individual disposal areas within the landfill units. This grid will be used to identify locations for the soil gas and radiological survey and the subsequent soil borings.

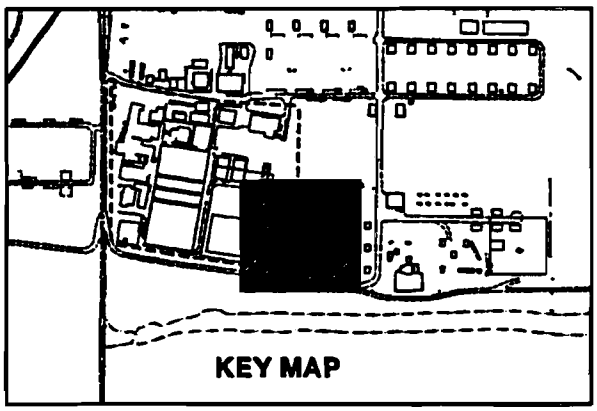
A soil gas and radiologic survey will be conducted to obtain chemical and radiologic screening information on the contents of, and the area immediately adjacent to, the landfill units. This information will be used to identify areas with elevated field readings and to optimize locations for confirmation soil borings described below in Section 5.8.5. Proposed landfill gas survey locations are shown on Figures 5.14A, B and C and are based on the anticipated size and location of the landfill units. These locations will be refined based on the literature review, aerial photograph interpretation, and the geophysical survey. The initial soil vapor locations will be set-up on a grid spacing of approximately 100 feet. Using this spacing, it is anticipated that ~~approximately~~up to 25 locations will be sampled in landfill units number one and two, and 18 locations will be sampled in Landfill Unit No. 3.





EXPLANATION

- Monitoring Well
- Proposed Boring Location (To Be Based On Soil Gas Survey Results)
- Proposed Primary Soil Vapor Points
- Proposed Secondary Soil Vapor Points



LOCATION MAP LANDFI
UNIT NO. 1 SAMPLING POIN

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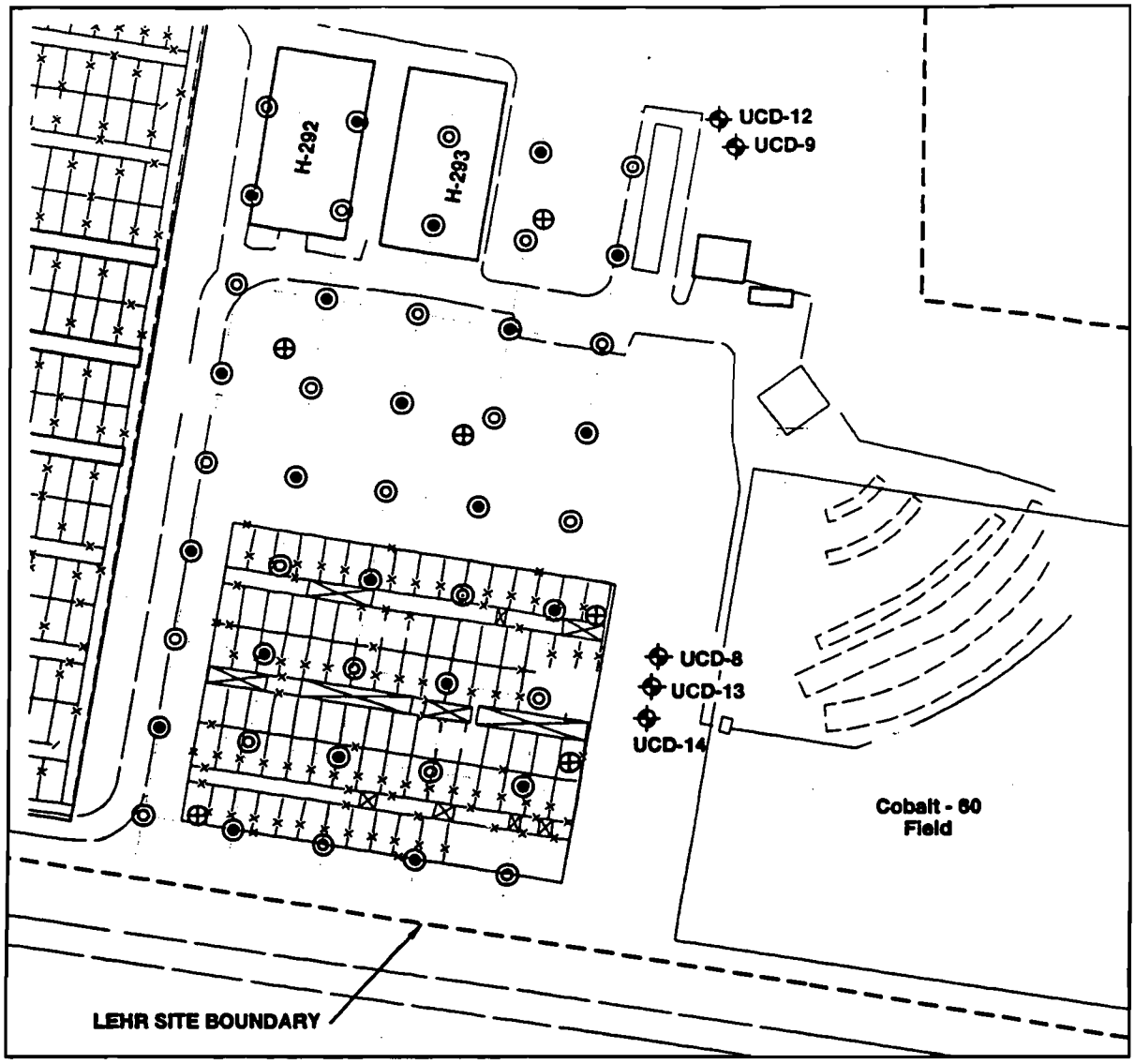
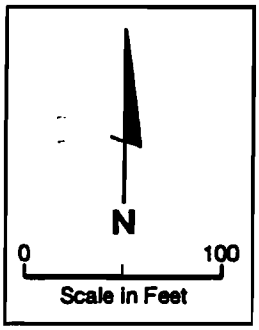
10805-720-044 sjr 2/23/94 5705AE

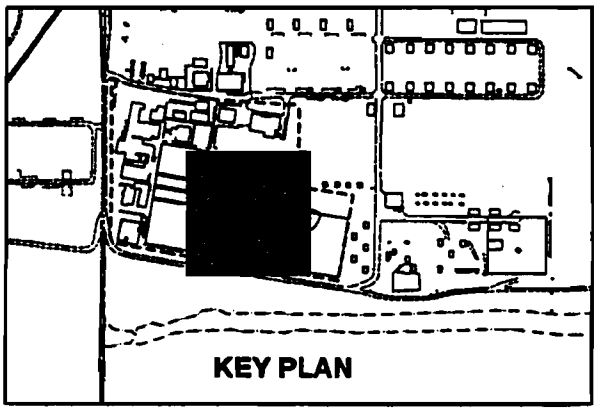
FIGURE 5.14A





EXPLANATION

- Monitoring Well
- Proposed Soil Boring Location (To Be Based On Soil Gas Survey Results)
- Proposed Primary Soil Vapor Points
- Proposed Secondary Soil Vapor Points



LOCATION MAP UC DAVIS LANDFILL UNIT NO. 2 SAMPLING POINTS

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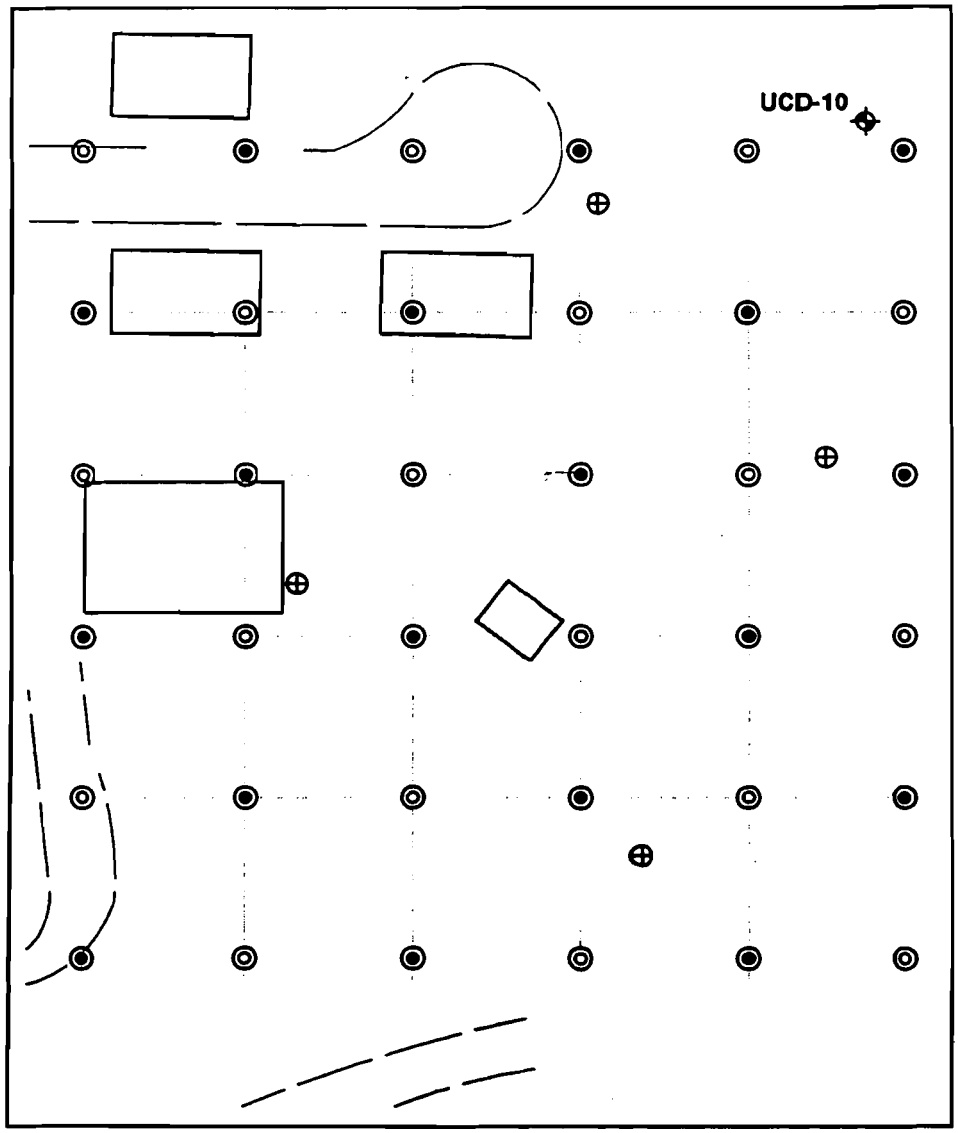
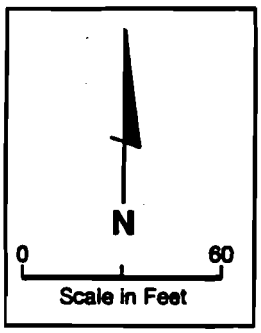
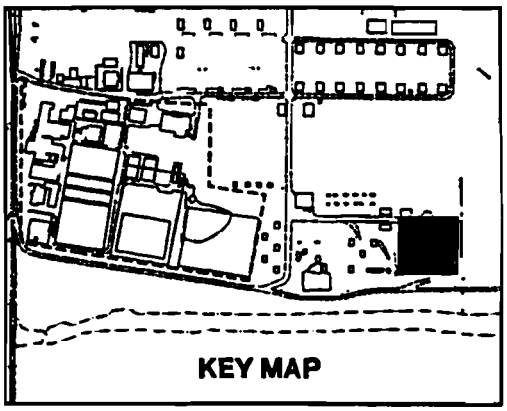
FIGURE 5.14B





EXPLANATION

- Monitoring Well
- Proposed Soil Boring Location (To Be Based On Soil Gas Survey Results)
- Proposed Primary Soil Vapor Points
- Proposed Secondary Soil Vapor Points



LOCATION MAP UC DAVIS LANDFILL UNIT NO. 3 SAMPLING POINTS

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10805-720-044 sjr 2/23/94 5705AF

FIGURE 5.14C

It may be necessary to conduct additional sampling to confirm "hot spots" or anomalous readings. If this is necessary, additional survey locations in 50-foot centers will be conducted. Additional survey locations will be located and sampled based on field analyses of survey information and will be conducted in one phase.

Gas samples collected during the survey will be analyzed for chemical constituents. The gas samples will be collected by driving a reusable 1-inch diameter stainless steel probe with a retractable tip into the refuse. Three depths at each location will be tested, approximately 4, 8 and 12 feet bgs, to obtain information from near the top, middle and base of the refuse material.

The probe will be driven to the first sampling depth, and a gas sample will be collected by applying a slight vacuum to the probe ~~and concentrations of CO_2, met~~ ~~and dissolved oxygen will be field screened~~. Real time analyses for volatile organic compounds CO_2, methane, and oxygen will be conducted using a mobile lab equipped with a gas chromatograph. For approximately five percent of the sample locations, a sample will be collected in a stainless steel canister for laboratory analysis of VOCs. This will serve as a QA check on the field data. After the canister has been filled, the probe will be pushed to the second and third sampling depth and the sampling process will be repeated. After sampling the third depth, the probe will be removed and a three ¼-inch geiger mueller tube will be placed in the open hole and gross beta and gamma activity will be measured and recorded. The probe holes will then be grouted using a cement/bentonite slurry. Field procedures are presented in the FSP.

Results of the gas and radiologic survey will be tabulated and maps will be developed showing concentration contours of identified constituents. These maps will be used to guide subsequent probe locations during the soil gas investigation and select appropriate soil boring locations.

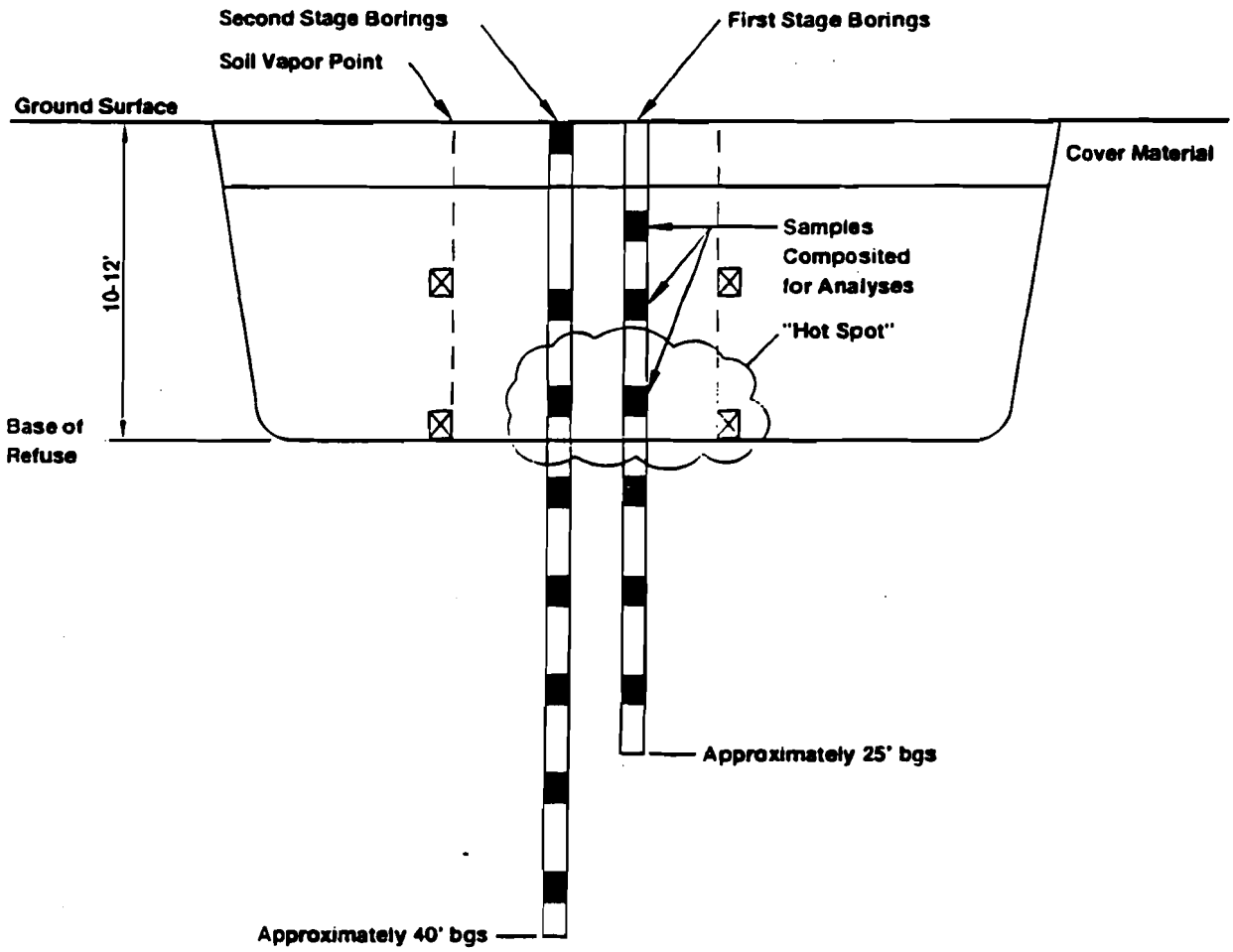
5.8.4 Soil Borings

It is anticipated that two stages of soil boring investigation will be conducted in the areas of the UC Davis landfill units, as shown on Figure 5.15. The first-stage soil borings will be drilled to collect samples of refuse from within the disposal units, and native soil ~~directly~~ underlying refuse to a depth of 25 feet bgs. The data will be used to evaluate source strengths and constituent types, and to evaluate the presence or absence of leachate. Based on first-stage soil boring sample analytical results, second-stage borings may be drilled to evaluate lateral and vertical extent of identified constituents of concern and obtain data on the physical characteristics of soils beneath the landfills. Borings to assess lateral migration from the landfills were drilled during the SWAT investigation and converted to lysimeters. Additional care will be taken to minimize the potential downward migration of hazardous materials when drilling through and sampling landfill wastes. All borings will be pressure grouted from the base to the ground surface.

5.8.4.1 First-Stage Soil Borings

First-stage soil borings will be drilled based on the results of the landfill gas survey ~~and exploration trench samples~~. Up to six soil borings will be drilled in Landfill Unit No. 1; up to six soil borings will be drilled in Landfill Unit No. 2; and up to four soil borings will be drilled in Landfill Unit No. 3. Locations will be biased in "hot spots" or anomalies identified during the soil, gas, and radiologic survey. If no "hot spots" or anomalies are identified, then a maximum of five borings will be drilled on random spacing within each landfill disposal cell. The soil borings will be drilled through the refuse and terminate at approximately 25 ~~2~~ feet ~~below the base of the waste approximately 12 to 15 feet~~ bgs. Samples of the refuse will be collected at 2½-foot intervals.

~~four~~ Up to eight discrete samples of the refuse will be collected from each boring. Due to the heterogeneity of waste, refuse samples will be composited into one sample at the laboratory and analyzed for the parameters discussed in Section 5.8.5. Up to three ~~One~~ discrete samples of the underlying native soil will be collected in each boring below the base of the refuse and submitted for chemical and radiologic analysis.



EXPLANATION

⊠ Discrete Vapor Samples

■ Discrete Soil Samples

Not To Scale

SCHEMATIC DRAWING DISPOSAL TRENCHES AND LANDFILL SAMPLING POINTS

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If free liquid leachate is encountered in the first-stage soil borings, leachate samples will be collected using a clean polyethylene bailer. The sample will be collected from the open boring after the lead drill bit has been pulled up from the base of the hole a minimum of 2 feet. The leachate samples collected will be submitted to the analytical laboratory for the analyses identified in Section 5.8.5.

5.8.4.2 Second-Stage Soil Borings

Second-stage borings may be drilled to more fully evaluate feasibility study needs, responsibility determination, and the likelihood for impact at depth for a particular area. Second-stage boring locations will be based on the analytical results of samples from the soil vapor survey, ~~exploration trenches~~ and first-stage borings. Second-stage borings will be located in the areas with reported levels of site constituents above established background concentrations. If necessary, up to three second--stage borings will be drilled through refuse in each landfill to 40 feet bgs. Drive samples will be collected at 5-foot intervals.

Up to four samples from each second-stage boring will be submitted to the analytical laboratory for chemical and radiologic testing. One of the samples from each boring will be from the surface cover material. The remaining three samples will be collected from below the base of the refuse. Samples will be selected in the field by the project geologist and the technical lead, and will be based on stratigraphy, material type and field screening results. Analytical parameters for second-stage soil borings may be modified based on first-stage sample analytical results. In addition to chemical and radiologic testing, physical tests will be conducted on selected samples.

It is anticipated that first- and second-stage borings will be drilled using resonant drilling techniques to minimize generation of wastes. All borings will be continuously cored and the cores will be archived on-site for future use, if required. Soil samples will be collected using split-spoon sampling techniques. Samples and cores will be field screened for radioactivity and VOCs. If a temporary surface casing has been installed, it will be removed. Upon completion, all borings will be grouted to the surface with a cement/bentonite grout. Details of drilling, sampling, and decontamination procedures are presented in the FSP.

5.8.5 Chemical Testing

Solids and leachate samples collected from the landfill units during first- and second-stage borings will be submitted to the analytical laboratory for chemical and radiologic testing. The samples will be analyzed for the list of parameters provided in Table 5.15. Analytical methods, required detection limits, QA/QC protocol and data validation documentation are discussed in the QAPjP. The analyte list was developed to characterize the nature of chemicals and radiologic constituents present, and assess how the general chemistry of the soil may affect fate and transport. Some specific analytes, identified in Table 5.15 in parentheses, will be assessed in certain soil samples to support fate and transport, and FS needs. These samples will be selected based on waste characterization, soil types, field screening, and visual observations during drilling and excavation. As discussed previously, the list of analytes identified for second-stage boring samples may be modified based on the results of first-stage sample analyses.

5.8.6 Physical Testing

Selected soil samples will be submitted and analyzed for the physical parameters listed in Table 5.16. This table also provides the anticipated minimum number of samples to be submitted for each analysis. These data will be used to evaluate the physical characteristics of the soils used as cover material and soil beneath the landfill units. Sample locations will be selected to obtain information from various material types (silty clay, clay, and sand), at various depths. Samples for testing will be selected in the field by the site geologist and the technical lead.

In addition to physical tests on discrete soil samples, four down-hole permeability tests and two double-ring infiltrometer tests will be conducted in the areas of the UC Davis landfill units. These tests will be conducted to assess in-situ infiltration rate and saturated conductivity to aid in refining the conceptual site model and the fate and transport evaluation. Additionally, the data may be useful for remedial design work. Detailed procedures for these field tests are presented in the FSP.

TABLE 5.15 LABORATORY ANALYSIS FOR UC DAVIS LANDFILL UNIT SAMPLES

Description	First-stage Samples[a]	Second-stage Samples[b]	Leachate Samples
Metals[c]	✓	✓	✓
Hexavalent Chromium	✓	✓	✓
Nitrates (as Nitrogen)	✓	✓	✓
Organochlorine Pesticides	✓	✓	✓
Volatile Organic Compounds	✓	✓	✓
Semi-Volatile Organic Compounds	✓	✓	✓
Formaldehyde	✓	✓	✓
Total Alkalinity	✓ (22)	✓ (15)	✓
Total Kjeldahl Nitrogen	✓ (22)	✓ (15)	✓
Ammonia	✓ (22)	✓ (15)	✓
Water Soluble Anions	✓ (22)	✓ (15)	✓
pH	✓ (22)	✓ (15)	✓
Total Organic Carbon	✓ (22)	✓ (15)	✓
Gross Alpha & Gross Beta[d]	✓	✓	✓
EC	✓ (22)	✓ (15)	✓
Sulfide	✓ (22)	✓ (15)	✓
Tritium	✓	✓	✓
Carbon-14	✓	✓	✓
Radium-226	✓	✓	✓
Strontium-90	✓	✓	✓
Gamma Spectranalysis	✓	✓	✓
Bacteriological Count	✓ (9)	✓ (9)	✓

Numbers in parentheses indicate number of soil samples to be analyzed for specific analytes.

a. A maximum of 64 ~~35~~ first-stage samples submitted for analysis to be used in fate and transport evaluation.

b. A maximum of 38 second-stage samples to be submitted for analysis. ~~May be modified based on first-stage samples analytical results.~~

c. Metals include 17 CAM Metals, Mg, Ca, Mn, and Fe.

d. If Gross Alpha or Gross Beta are measured at two or more standard deviations greater than background, analyses for Cesium-137, Sodium-22, Uranium-238, cobalt-60, or Chlorine-36, may be performed.

e. The list of analytes identified for second-stage soil boring samples will be modified to focus on the constituents identified above background levels in first-stage soil boring samples.

concentrations, and correlating relationships between several data sets or variables. Appropriate statistical applications will be defined based on the data collected.

5.9.2 Assessment of Vadose Zone Transport

Site-specific data will be used to assess the fate and transport of site constituents through the vadose zone. These data include:

- soil chemical data;
- soil moisture;
- soil physical properties, including grain size, density-specific gravity, and porosity;
- unsaturated hydraulic conductivity;
- in-situ permeability testing, including double-ring infiltrometer, and borehole permeability testing;
- chemical analysis of soil pore liquid from existing lysimeters;
- general inorganic soil chemical parameters;
- soil organic carbon analyses;
- bulk mineralogy; and
- rainfall and other meteorologic information.

It is anticipated that infiltration of rainfall is the principal driving force for transport of site constituents through the vadose zone. Retardation factors including biological degradation, geochemical transformation and immobilization processes may reduce or retard the movement of these solutes moving in the soil pore liquid phase reducing the mass of site constituents which may ultimately reach groundwater. As a result, the assessment of vadose zone transport will involve two steps as outlined below.

The first step is to evaluate the behavior of water within the vadose zone or, more specifically, to attempt to quantify the pore water velocity from the soil surface to groundwater. The second step is to evaluate the various retardation factors associated with microbiological degradation and adsorption of solutes as these dissolved constituents move toward groundwater. Both steps require analytical solutions as well as numerical models to fully evaluate the fate and transport of site constituents in the vadose zone.

The most appropriate combination of analytical testing and computer modeling will be developed after baseline soil chemical and soil physical data have been obtained.

5.9.2.1. Vadose Zone Hydraulic Model

A vadose zone hydraulic model will be developed to help evaluate the fate and transport of site parameters. The first step in addressing vadose zone modeling is the development of a vadose zone stratigraphic model. This model is constructed using lithologic logs from borings. The site stratigraphic model thus describes the vertical arrangement of soil horizons from the ground surface to groundwater. The vertical arrangement of soil horizons is called a "soil column." Each soil column consists of a different combination of soil strata, that usually vary in physical properties and hydraulic conductivity because of differences in soil texture, soil structure, and anthropogenic influences including deposition of wastes or other imported fill.

Samples for the determination of soil physical properties for different soil and subsurface horizons are being collected as part of this work plan as described in Sections 5.1 to 8.5. Physical properties that will be determined include the following: grain size, moisture content, laboratory saturated hydraulic conductivity, specific gravity, density, and mineralogy. In addition, unsaturated conductivity will be calculated from moisture release values.

In-situ testing will be used to refine saturated hydraulic conductivity estimates calculated from laboratory values. Two types of tests will be performed on key soil horizons: double-ring infiltration tests for surface and subsurface horizons to approximately 5 feet below ground surface (bgs), and borehole permeability tests for soil horizons located at depths greater than 5 feet bgs. Both types of in-situ tests produce saturated hydraulic conductivity measurements in soil that account for macropores, sand channels and other irregularities encountered in the field.

Accurate information on the in-situ saturated hydraulic conductivity improves the calibration of unsaturated hydraulic parameters which cannot be measured directly in the field. Figure 5.16 shows the locations of surface and downhole permeable tests that will be used to evaluate vadose zone parameters. These locations were selected based on

TABLE 5.16 PHYSICAL TESTS UC DAVIS LANDFILL UNITS

Physical Test	ASTM Method Number	Number of Samples
Hydrometer	D-422	11
Grain Size	C-136	11
Permeability	D-2434	6
Moisture Release	D-3152 and D-2325	6
Moisture Content	D-2216	50
Mineralogy	XRD	3
Specific Gravity	D-854	6
Atterberg Limits	D-4318	15
Bulk Density	D-4531	15

XRD - X-Ray Diffraction

5.9 DATA EVALUATION

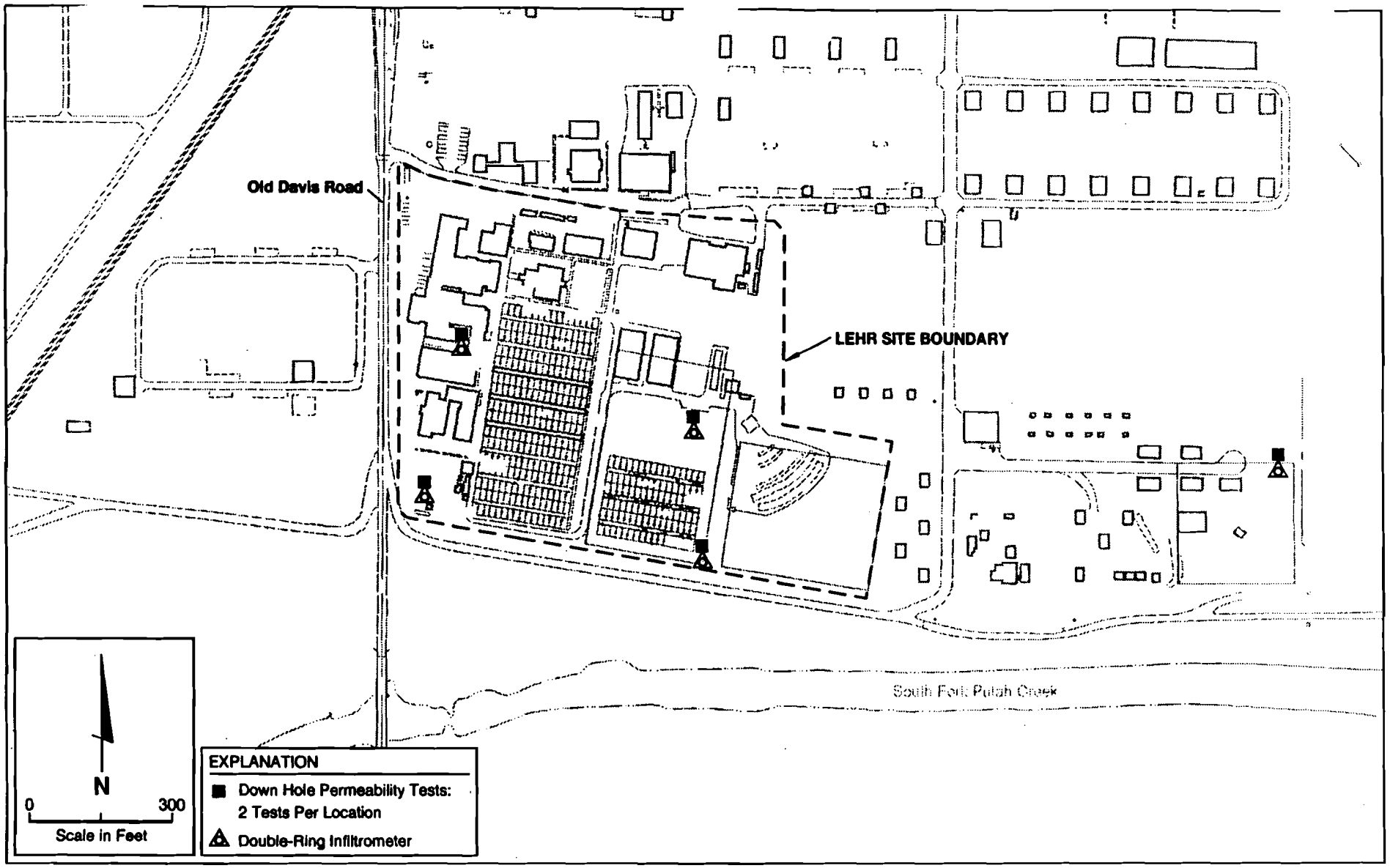
The following sections present the data validation procedures, the anticipated statistical methods that will be used to evaluate the collected laboratory data and methods for vadose zone and fate and transport analyses. To ensure that the quality of the data is sufficient for its intended use, the validation procedures outlined in the QAPjP will be followed. After the data have been validated, they will be analyzed to support characterization of the site, the Risk Assessment and the FS. Statistical analysis of the data will be conducted to establish background levels of site constituents and to compare on-site soil concentrations with these background levels. Results of the data evaluation will be presented in the RI, Risk Assessment, and FS reports as discussed in Chapter 13.

Data will be collected and analyzed to minimize the amount of uncertainty in making decisions related to LEHR site remediation goals. In some cases, after data are evaluated, additional data collection and analysis may be necessary to better make directional decisions. In other cases, objective analyses may not be adequate to make the appropriate risk management decision and more subjective evaluation criteria may be considered. In all cases, all available information and criteria will be considered in order to arrive at the selection of the highest confidence.

5.9.1 Statistical Methods

Statistical methods of evaluating analytical data will be dependent on several variables including: the number of non-detects; stratification; and spatial distribution of the data. Based on these variables, the decision as to which method is appropriate for the data set(s) will be made after the data sets have been collected and validated. The 1992 EPA document, Draft Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities, Addendum to Interim Final Guidance, will be used as a guide for statistical analysis. The statistical methods that may be used include: Shapiro-Wilk test; Probability Plot; Coefficient of Variance; Student-T Test; Test of Proportions; Cohen's Method; or other robust parametric or non-parametric methods as appropriate.

Statistical methods will be used for several purposes. These include establishing background levels, evaluating trends in water levels, assessing changes in chemical



LOCATION MAP
DOUBLE RING/DOWN HOLE PERMEABILITY TESTS

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LEHR Environmental Restoration
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FIGURE 5.16

available information on soil types and will be further defined prior to testing after initial phases of the field investigation. This information will be combined with laboratory data to calculate representative unsaturated hydraulic conductivity values.

When all of the above information has been evaluated, an assessment will be made of whether or not enough information exists to permit construction of representative soil columns in which the hydraulic properties for all key soil horizons is reasonably quantified. If the necessary hydraulic information is not available, additional archived samples may be selected for additional physical and unsaturated hydraulic conductivity testing.

When the representative soil columns have been described in sufficient hydraulic detail, numerical modeling of vadose zone water flow can begin. One- and two-dimensional models will be considered for the numerical modeling, including UNSAT 1, UNSAT 2, SWMS2D, and VS2DT. These models incorporate saturated and unsaturated permeability into a numerical solution for the pore liquid velocity through each key horizon.

5.9.2.2 Geochemical/Microbiological Model

The geochemical/microbiological model will be used to quantify the types and concentrations of dissolved site constituents moving in the vadose zone soil pore liquid. After the velocity of pore liquids in the vadose zone is quantified, the geochemical/microbiological information will be used to identify constituent concentrations and retardation factors which may delay or eliminate migration of some of the constituents dissolved in the vadose zone pore liquid.

Given the variety of programs available to conduct vadose zone modeling, ~~flexibility in~~ the choice of computer codes may vary ~~is required~~. For example, modeling the fate and transport of organic site constituents such as chloroform may require detailed information on partitioning between gaseous, liquid and adsorbed soil phases predicted by VLEACH. Modeling nitrate will require detailed unsaturated flow velocities using VS2DT and perhaps biological modeling of nitrogen transformations. For chromium speciation and other metals, MINTEQ will be used. Although specific models may be recommended at this time, new models are constantly being developed for specific applications (e.g.,

CHROMAT, which predicts the chemical species of chromium under certain conditions). As such, other appropriate models may be available and may be considered at the time the modeling is performed.

The modeling process is typically initiated by assessing the lateral and vertical extent of site constituents, and the concentrations in soil pore liquid. Once these constituents are identified, geochemical modeling of the soil pore liquid combined with soil mineral analysis will be used to assess which solid phases might be controlling the dissolved concentration of constituents in the pore liquid.

The adsorption of constituents also delays or retards the movement of the constituents in pore liquid. Adsorption or distribution coefficients will be measured by direct experimentation with site soils in the laboratory or estimated from published literature values. If laboratory analysis is deemed necessary, then archived samples will be tested. The "retardation factor" of a certain constituent is dependent on its chemical properties as well as the soil adsorptive properties. When the retardation factors for site constituents are multiplied by the pore liquid velocity estimated in vadose zone hydraulic modeling, the actual velocity of constituent movement in the vadose zone can be approximated.

The final factor to be considered in the geochemical/microbiological model is the rate of compound microbial degradation. This factor is most important for organic constituents, but may also apply to certain inorganic constituents which are transformed by oxidation-reduction reactions. Literature values for the degradation half-lives for many compounds are available; however, the value for any given compound may vary considerably. When a value for the half-life of a constituent is obtained by direct experimentation, or from the literature, a first-order decay model is usually applied to the concentration of the constituent in pore liquid to estimate the actual concentration which reaches groundwater.

The end result of the vadose zone modeling will be an approximation of the movement of site constituents and water through the vadose zone. This information will then be combined with the groundwater modeling to evaluate solute flux. It should be noted that there will be inherent uncertainties in the model results based on the variable nature of many of the input parameters.

6.0 GROUNDWATER AND SURFACE WATER INVESTIGATION (OU-6)

This chapter presents the tasks to be conducted to characterize preliminary OU-6, groundwater and surface water at the LEHR site, and includes sample collection techniques that will be performed during the completion of each task. Additionally, the rationale for selecting sampling locations and the number of samples is presented. Details of field tasks proposed for the groundwater and surface water investigation are presented in the FSP, Appendix A.

DOE operations at the LEHR site ceased in 1988; therefore, water monitoring activities focus primarily on environmental surveillance activities for non-operational facilities as defined in DOE 5400.1. Quarterly monitoring of groundwater and surface water, which constitutes a surveillance activity, has been conducted since November 1990 as a portion of the Phase II Site Characterization (Dames & Moore, 1993a). The groundwater and surface water investigation tasks described in this chapter are intended to supplement the Water Monitoring Plan (Dames & Moore, 1993b) submitted as part of the sitewide environmental monitoring program.

The objectives of groundwater and surface water investigation are to: (1) characterize baseline surface water and groundwater conditions at the LEHR site; (2) identify the vertical and lateral extent of impacts to groundwater and surface water which may have been derived from operations at the LEHR site; (3) provide data to support future site activities including, but not limited to, an RI/FS, Risk Assessment, remedial actions, and decontamination and decommissioning of the site; and (4) comply with applicable Federal, state, and local regulations.

The following activities will be conducted to meet these objectives:

- Quarterly monitoring of the existing groundwater monitoring network and surface water will continue.
- An additional background groundwater assessment will be conducted.
- A screening level CPT/Hydropunch™ investigation will be conducted downgradient of the LEHR site to evaluate the lateral extent of impacts in the first and second HSUs. The information obtained from Hydropunch

samples will be used to optimize the locations for perimeter monitoring wells.

- Sixteen ~~Eleven~~ new groundwater monitoring wells will be installed to define the lateral and vertical extent of impacts from the LEHR site in the first and second HSUs, and a geophysical survey will be conducted to evaluate stratigraphy;

- Aquifer analysis, including slug tests ~~will be completed on all new monitoring wells, installed at the LEHR site;~~ and a pumping test, will be conducted on a selected well to assess aquifer properties.

- A surface water study will be conducted to evaluate potential upstream sources to and leakage from Putah Creek.

- Storm water samples will be collected during storm events to evaluate the quality of surface water runoff from the LEHR site.

The groundwater investigation utilizes a phased approach. Evaluation of quarterly monitoring data and assessment of aquifer parameters have been used to initially scope the Hydropunch™ and the monitoring well installation program. The Hydropunch program, which may expand or change based on initial field results, will be used to assess the best location and number of downgradient groundwater monitoring wells. The need for additional upgradient monitoring wells will be evaluated based on a regional groundwater quality assessment and further analyses of groundwater from existing background monitoring wells UCD-17 and UCD-18. After assessment of the second HSU using Hydropunch™ data, groundwater monitoring wells, and the geophysical survey, the need for wells in the third HSU will be determined. The final scoping of groundwater investigation tasks will be completed by the site team and the regulatory agencies, as agreed upon prior to the field program.

Table 6.1 presents a summary of the groundwater chemical and radiologic analytical parameters that will be analyzed one or more times from groundwater, surface water, or stormwater samples; a brief rationale for the inclusion of each analyte is also provided at the bottom of the table. The data and interpretations will be presented in the RI Report as discussed in Chapter 14.

TABLE 6.1 SUMMARY OF GROUNDWATER ANALYTICAL PARAMETERS

Constituent	Rationale*	Constituent	Rationale*	Constituent	Rationale*
Gross Alpha	6,7,8,9	Metals	3,4,5,7,8,9,10	TOC	6,8,9,10
Gross Beta	6,7,8,9	Hexavalent Chromium	2,4,7,8,9	pH	6,7,8,9,10
Gamma Spec	3,4,5,6,7,8,9	Pesticides	1,3,4,5,7,8,9	Electrical Conductivity	6,8,9,10
Strontium-90	1,3,4,5,7,8,9	Formaldehyde	1,3,4,7,8	Eh	6,8,9,10
Radium-226	1,4,5,7,8,9	VOCs	1,2,4,5,7,8	Turbidity	6,8,9,10
Carbon-14	1,2,4,7,8,9	Semi VOCs	1,3,4,5,7,8	TDS	6,7,8,9,10
Tritium	1,2,4,5,7,8,9	Nitrate	2,4,5,6,7,8,9,11	Chemical Oxygen Demand	6,8,9,10
Cesium-137	1,3,4,7,8,9	Alkalinity	6,7,8,9,10	Total Suspended Solids	6,8,10
Sodium-22	1,4,7,8,9	TKN	4,6,7,8,9,10,11	Total Oil & Grease	1,6,8
Uranium-238	1,4,7,8,9	Ammonia	4,6,7,8,9,10,11	Dissolved oxygen	6,8,9,10
Cobalt-60	1,4,7,8,9	Anions	2,4,6,7,8,9,10	Biological Oxygen Demand	6,8,9,10
Chlorine-36	1,4,7,8,9	Cations	2,4,6,7,8,9,10	Bacteriological Count	6,8,9,10
Plutonium-241	1,4,9	Americium-241	1,4,9		

* **Rationale Key:**

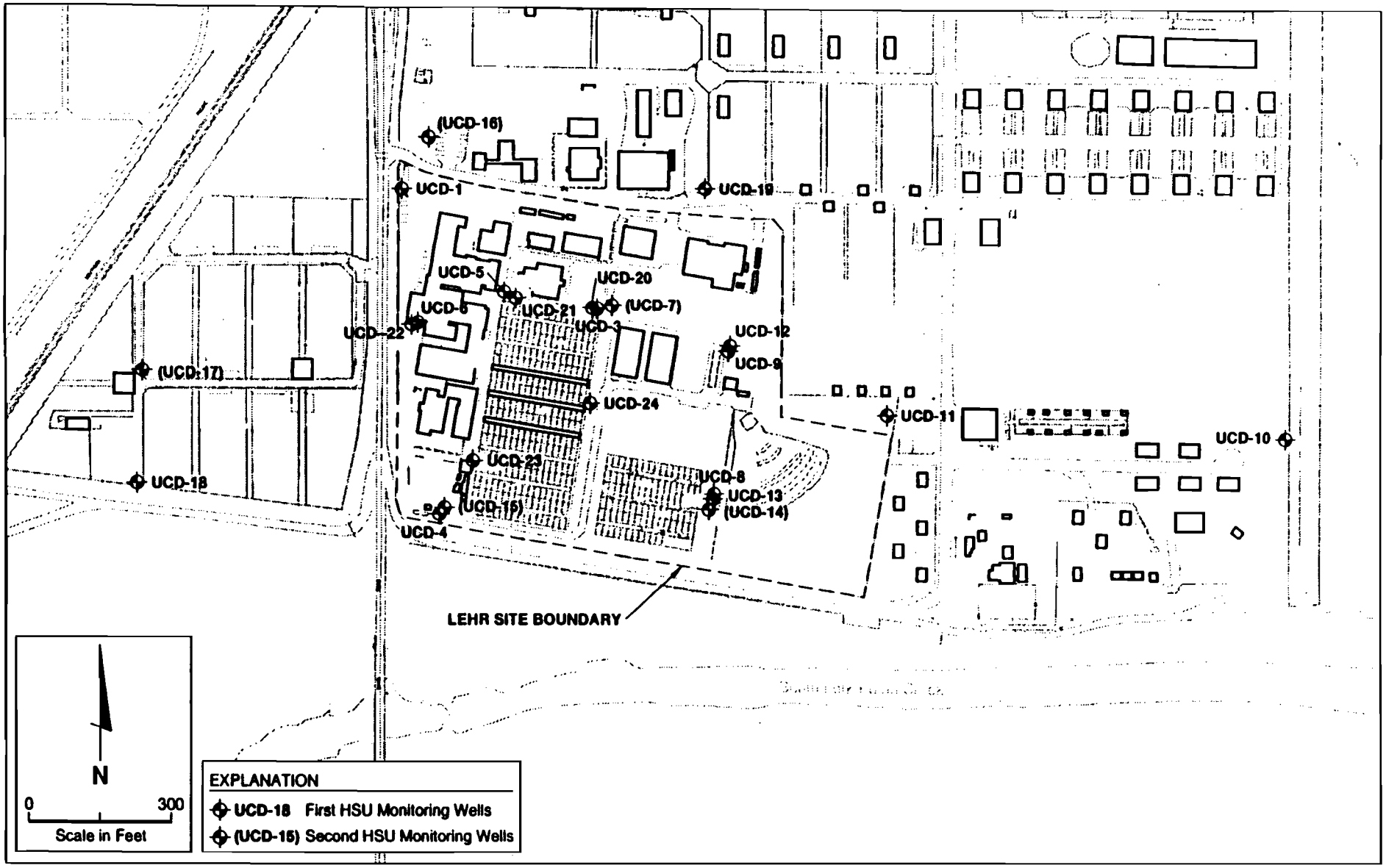
1 Known constituent used or disposed on site.
2 Suspected site constituent based on consistent detections in groundwater.
3 Suspected site constituent based on sporadic detections in groundwater.
4 Suspected site constituent based on previous disposal practices.
5 Suspected site constituent based on detections in previous soil investigations.
6 Indicator parameter for other constituent.
7 Data needed for Risk Assessment.
8 Data useful for FS.
9 Data needed to establish background versus on-site concentration.
10 Influences mobility of other constituents.
11 May contribute to nitrate loading.

6.1 QUARTERLY MONITORING — GROUNDWATER

Quarterly monitoring will be continued through the RI/FS process under the Water Monitoring Plan (Dames & Moore, 1993b). The quarterly monitoring program presented in this Work Plan is modified from the Water Monitoring Plan. These modifications are pending concurrence from the regulatory agencies and are presented here for completeness. The procedures used to collect water samples and the requested analyses are presented in the following sections and in detail in the FSP, Appendix A. QA/QC and data validation procedures are presented in the QAPjP, Appendix B.

The current groundwater monitoring system at the LEHR site is comprised of 23 groundwater monitoring wells (Figure 6.1) that have been installed during previous investigations. Eighteen wells are screened in the first HSU and five wells are screened in the second HSU. Table 6.2 presents construction information on the 23 wells and the date each was completed. Because of large fluctuations in groundwater elevation and questionable construction, five of these wells are typically dry and have not been included in the quarterly sampling. As such, 18 wells have been sampled on a quarterly schedule since November 1990, as presented in Table 6.3. Two of these wells, UCD-17 and UCD-18, currently serve as upgradient or background wells. The five wells that have not been sampled (UCD-3, -5, -6, -8, and -9) have been used to collect water-level information only. Currently, UC Davis collects water levels weekly from the monitoring network.

Three wells from the Phase I Investigation, UCD-1, -4, and -7, have been included in the quarterly monitoring program. However, because of slightly elevated turbidity in monitoring wells UCD-1 and UCD-4, and because these wells are typically dry in the summer, it is proposed that these two wells be removed from the quarterly sampling schedule. Water levels will continue to be measured in these wells until they are abandoned at a later date. UCD-1 would be replaced with a new well located adjacent to well UCD-16. Because monitoring well UCD-23 is located within 100 feet downgradient of UCD-4 and is also screened in the first HSU, no replacement well is proposed for UCD-4. Monitoring well UCD-7, installed in the second HSU, consistently meets the desired less-than-5-NTU criteria for turbidity, and will continue to be monitored for chemical and radiologic constituents.



LOCATION MAP FIRST AND SECOND HSU GROUNDWATER MONITORING WELLS

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FIGURE 6.1

TABLE 6.2 SUMMARY OF MONITORING WELLS

Well Number	Total Depth (feet bgs)	Screened Interval (feet bgs)	HSU	Investigation	Date Completed
UCD - 1	56.5	46.5 - 56.5	First	Wahler Associates 1989	10/09/87
UCD - 3	49.0	39.0 - 49.0	First	Wahler Associates 1989	10/23/87
UCD - 4	57.2	45 - 55	First	Wahler Associates 1989	10/14/87
UCD - 5	48.0	38.0 - 48.0	First	Wahler Associates 1989	10/22/87
UCD - 6	50.0	40 - 50	First	Wahler Associates 1989	10/21/87
UCD - 7	90	80 - 90	Second	Wahler Associates 1989	11/05/87
UCD - 8	53.5	43.5 - 53.5	First	Wahler Associates 1988	11/03/87
UCD - 9	50.0	40.0 - 50.0	First	Wahler Associates 1988	11/04/87
UCD - 10	70.0	54 - 69	First	Dames & Moore, UCD SWAT	10/11/89
UCD - 11	63.5	50 - 65	First	Dames & Moore, UCD SWAT	10/17/89
UCD - 12	65.0	49.5 - 64.5	First	Dames & Moore, UCD SWAT	10/19/89
UCD - 13	65.0	50 - 65	First	Dames & Moore, UCD SWAT	10/26/89
UCD - 14	85	75 - 85	Second	Dames & Moore, UCD SWAT	11/15/89
UCD - 15	120.5	91 - 116	Second	Dames & Moore, DOE Phase II	03/28/90
UCD - 16	122	92 - 117	Second	Dames & Moore, DOE Phase II	04/04/90
UCD - 17	143	88 - 113	Second	Dames & Moore, DOE Phase II	04/10/90
UCD - 18	70	54 - 69	First	Dames & Moore, DOE Phase II	10/04/90
UCD - 19	74.5	56.5 - 71.5	First	Dames & Moore, DOE Phase II	10/01/90
UCD - 20	73	57 - 72	First	Dames & Moore, DOE Phase II	10/09/90
UCD - 21	73	57 - 72	First	Dames & Moore, DOE Phase II	10/11/90
UCD - 22	73	57 - 72	First	Dames & Moore, DOE Phase II	10/25/90
UCD - 23	73	56.5 - 71.5	First	Dames & Moore, DOE Phase II	10/17/90
UCD - 24	73	57 - 72	First	Dames & Moore, DOE Phase II	10/22/90

HSU = Hydrostratigraphic Unit
UCD-2 was abandoned in 1990 by UC Davis

TABLE 6.3 GROUNDWATER SAMPLING SCHEDULE

Well	11/90	2/91	5/91	8/91	11/91	2/92	5/92	8/92	11/92	2/93
UCD-1	SB	S	S	DRY	SB	SB	SB	DRY	SB	SB
UCD-4	DRY	S	S	DRY	SB	SB	SB	DRY	DRY	SB
UCD-7	S	S	S	S	S	S	S	S	S	S
UCD-10	S	S	S	SP	S[a]	S	S	DRY	S	S
UCD-11	S	S	S[a]	DRY	S	S	S	DRY	S	S
UCD-12	SB	S[a]	S	DRY	S	SB	SB	DRY	S	S
UCD-13	SB	S	S	DRY	S	S	S	DRY	S	S
UCD-14	S	S	S	S[a]	S	S[a]	S	S	S	S
UCD-15	S[a]	S	S	S	S	S	S[a]	S	S	S
UCD-16	S	S	S	S	S	S	S	S[a]	S	S
UCD-17	S	S	S	S	S	S	S	S[a]	S	S
UCD-18	DS	S	S	S	S	S	S	S	S	S
UCD-19	DS	S	S	SB[a]	S	S	S	SB	S	S
UCD-20	DS	S	S	S	S	S	S[a]	S	S	S
UCD-21	DS	S	S	S	S	S	S	S	S	S[a]
UCD-22	DS	S[a]	S	S	S[a]	S	S	S	S[a]	S
UCD-23	DS	S	S[a]	S	S	S	S	S	S[a]	S
UCD-24	DS[a]	S	S	S	S	S	S	S	S	S[a]

Wells UCD-3, -5, -6, -8, and -9 were not sampled during quarterly sampling for the Phase II Investigation.

S - Well purged and sampled with dedicated bladder or submersible pump. A full suite of samples was obtained.
[a] - Replicated well.
DS - Well was developed with a submersible pump, then sampled with a disposable bailer.
SB - Well was purged and/or sampled by bailer due to low water levels.
DRY - No water in well; no sample obtained.
SP - Only a partial sample suite recovered due to low water levels.

New submersible electric pumps were installed in UCD-1 and UCD-4 to see if there is an affect on turbidity, and to standardize the sample collection process for all wells at the LEHR site. Previously, UCD-1 and UCD-4 were fitted with dedicated bladder pumps. As part of the RI, new wells will be installed and developed using methods similar to those used during installation of the Phase II Site Characterization wells. All of the Phase II wells typically yield water with less than 5 NTU turbidity.

Monitoring wells installed as part of this RI/FS will be included in the quarterly monitoring program. The new wells will be both sampled for laboratory analysis, and included in the water-level measurement program.

6.1.1 Sample Collection

Groundwater monitoring consists of water-level measurements, field measurements and the collection of groundwater samples. Monitoring procedures are described in the FSP, Appendix A. Prior to beginning sampling activities, water-level measurements will be recorded in all wells on the same day to minimize potential variations in elevations that may occur due to external conditions.

Groundwater sampling will be conducted by purging and sampling the 18 monitoring wells using dedicated sampling systems. The dedicated systems all use the exact same type of submersible electric pumps that are used in all monitoring wells in the sampling network. New wells installed as part of the RI/FS, including the replacement well for UCD-1, will be fitted with dedicated electric submersible pumps. If the static water level drops below the level of a pump, the well will not be sampled. Wells that are "dry" (due to a low water table) will be confirmed by comparing field well depth measurements to well construction specifications, and documented in the field notebook. Purging and sampling procedures are described in Appendix A. Purging will be accomplished by removing groundwater from the monitoring wells using electric submersible pumps at flow rates (approximately 10 percent of development rates) that do not result in continued development of increased turbidity (i.e., greater than 5 NTU). The use of bailers to purge monitoring wells is generally to be avoided because research has shown that the "plunger effect" created by continually surging the water results in turbid samples and overdevelopment of the wells.

The rate at which groundwater is removed from the well during purging ideally should be less than approximately 0.2 to 0.3 L/min (Puls and Powell, 1992; Puls, et al., 1992; Puls and Barcelona, 1989; Barcelona, et al., 1990) for:

- older wells not constructed according to ASTM D5092-standards; or
- wells that are difficult to develop and contain a high amount of suspended solids that results in typically high NTU levels (Barcelona and Helfrich, 1992; Robin and Gillham, 1987).

Practical limits are site-specific and well-specific for LEHR. For example, the first HSU is generally far more turbid and more difficult to develop than the wells in the coarser, relatively silt-and-clay-free second-HSU aquifer. Although an acceptable purge rate of 20 L/min may be acceptable for second-HSU wells, a lower rate of 1 to 10 L/min may be required for first-HSU wells. Most of the newer first-HSU and all of the second-HSU wells have consistently lower turbidity and can be purged at rates of 10 to 20 L/min year-round without adversely affecting the water samples collected. However, all of the older first-HSU wells not constructed consistent with ASTM D5-92-90 probably should be purged at rates of 0.2 to 1.0 L/m to minimize turbidity to below 5 NTU throughout the purging cycle. In any case, wells will be purged at discharge rates and vertical flow velocities a fraction of the highest or average rates used to develop the well to prevent further development of the well, to prevent damage to the well, and to avoid disturbing accumulated corrosion or reaction products in the well (Kearl, et al., 1992; Puls, et al., 1992; Puls and Barcelona, 1989; Barcelona, 1985; Barcelona, et al., 1988; Panko and Barth; 1988). When practicable, wells also will be purged at or below their recovery rate so that migration of water in the formation above the screened interval does not occur.

At no time will a well be purged to dryness if recharge causes the formation water to cascade down the side of the well screen, as this may cause an accelerated loss of volatiles of up to 70 percent (Barcelona and Helfrich, 1992; Robin and Gillham, 1987, draft EPA TEGC, 1994).

To eliminate the need to dispose of large volumes of purge water, and to reduce the amount of time required for purging, wells will be purged (as a minimum requirements) with the pump intake above the well screen three to five well diameters for second-HSU

wells, and near the bottom of the screened interval for first-HSU wells. This procedure for second-HSU wells eliminates the need to purge the column of stagnant water located above the well screen (Barcelona, et al., 1985; Robin and Tillham, 1987; Barcelona and Helfrich, 1982, and Kearl, et al., 1992; Schalla, 1992; Unwin and Maltby, 1988; Maltby and Unwin, 1992). The primary consideration for all second-HSU wells at LEHR is the isolation of stagnant water above the well screen via low purge rates and even lower sampling rates, or via packers to minimize the number of equivalent volumes, which is the volume of water within the well screen interval when the procedures proposed herein are used, to be purged from the well. This volume may be further reduced by displacement for isolation devices (Schalla, 1992; Barcelona and Helfrich, 1992; Maltby and Unwin, 1992; Schalla, 1993). Ideally, location of the pump intake for wells screened in first-HSU would be opposite the most permeable sand layer with the highest concentration of contaminants of concern, but this is not practical because of low water levels in first-HSU during the summer months. Therefore, the pump intakes in first-HSU wells must be located in the bottom half of the screened interval to allow for year-round sampling. In first-HSU wells where hydrogeology-based sampling would be best (Gibbs, et al., 1993; Barcelona and Helfrich, 1992; Biggs and Imbrigiotta, 1990), but is not possible, site experience and empirical data published by others must guide purging and sampling protocols. First-HSU wells should be pumped at rates that permit removing a consistent number of purge volumes from each well prior to sampling without causing substantial drawdown from the mid-screen portion of a well. The minimum number of purge volumes for all monitoring wells should be two equivalent volumes (note: 1.2 is possible, but this is not considered a practical lower limit for LEHR) if indicator parameters (i.e., turbidity, redox potential, pH, electrical conductivity and/or dissolved oxygen in in-line [flow-through] or actual contaminants of interest) have stabilized within approximately 10 percent over at least two measurements (Garske and Schock, 1986; Biggs and Imbrigiotta, 1990). Up to five or more equivalent volumes may be required for key parameters to stabilize in a few wells at LEHR, during certain times of the year.

Groundwater samples will be collected directly from the sampling pumps into sample containers supplied by the laboratory. Samples will be collected each quarter and analyzed for the chemical and radiologic parameters presented in Section 6.1.2. Sample containers will be labelled with site name, well identification, date, time, requested

analyses, and preservation method. Samples will be shipped daily to the analytical laboratory by overnight courier.

6.1.2 Chemical Analysis and Schedule

Groundwater sampling and analysis will continue on a quarterly schedule under the RI/FS. Results of the Phase II Site Characterization (Dames & Moore, 1993a) have shown that pesticides and semi-volatiles have only been detected sporadically in samples collected in both upgradient and downgradient wells. Additionally, based on the Phase II Site Characterization data, metals, with the exception of hexavalent chromium, have been detected in most site wells at concentrations that appear to be consistent with levels detected in upgradient or background conditions. Therefore, annual sampling is proposed for pesticides, semi-volatiles, metals, with the exception of hexavalent chromium and general chemical parameters.

Three types of parameters are identified for measurement or collection and analysis: field parameters, quarterly parameters, and annual parameters. Field parameters, including pH, electrical conductivity, temperature, turbidity, Eh and water levels, will be measured and recorded in the field for each well during every quarterly sampling round. Quarterly parameters will be collected and analyzed during each quarterly monitoring round (spring, summer, fall, winter). Annual parameters will be collected and analyzed during the spring quarter when water levels have historically been at their highest point. The list of field, quarterly, and annual parameters for existing groundwater wells is presented in Table 6.4, and detailed in Appendix A and Appendix B.

Analysis of samples collected from new wells or piezometers added during the RI/FS program will be conducted on a quarterly basis for all parameters for a minimum of one year (four quarters). After one year of monitoring, analytical requests for samples of new wells will be reduced as appropriate.

Additionally, following installation of the new wells, one groundwater monitoring round will include additional analytes that will be used to aid in the characterization of groundwater and in the feasibility study. These additional analyses will be conducted

TABLE 6.4 ANALYTICAL PARAMETERS GROUNDWATER SAMPLES [a]

Field	Quarterly	Annual
To be measured every quarter	To be collected every quarter (spring, summer, fall, and winter)	To be collected one quarter per year (spring)
pH Electrical Conductivity Temperature Turbidity Eh Water Level	Volatile Organic Compounds Tritium, Strontium-90, Radium-226, Gross Alpha, Gross Beta, Gamma Emitters, and Carbon-14 Americium-241 Plutonium-241 Total Chromium Hexavalent Chromium Nitrate TKN Ammonia Total Organic Carbon Total Dissolved Solids Formaldehyde Turbidity	Semi-Volatile Organic Compounds Pesticides and PCBs Antimony, Arsenic, Barium, Beryllium, Cadmium, Copper, Cobalt, Iron, Lead, Manganese, Mercury, Molybdenum, Nickel, Selenium, Silver, Thallium, Vanadium, and Zinc Alkalinity Cations Anions Chemical Oxygen Demand Biological Oxygen Demand

[a] UCD-1, UCD-4, UCD-7, UCD-10, UCD-11, UCD-12, UCD-13, UCD-14, UCD-15, UCD-16, UCD-17, UCD-18, UCD-19, UCD-20, UCD-21, UCD-22, UCD-23, UCD-24. New wells added during the RI/FS will be monitored for all quarterly and annual parameters on a quarterly basis for a minimum of one year (four quarters).

during the spring round of sampling when the annual parameters are collected in each of the wells. The additional analytes will include, but may not be limited to, field measurement of dissolved oxygen, and laboratory analyses for:

- Biological oxygen demand;
- Iron;
- Manganese; and
- Bacteriological count.

6.1.3 Background

Based on analytical results received from groundwater samples collected from UCD-17 and UCD-18 during this task, data from the Phase II Investigation, and the background groundwater assessment task presented below, background levels will be developed. Background levels will be used to establish the levels of constituents that occur naturally or are present regionally, such as pesticides, nitrate and metals. State ARARs and other state and Federal guidance and advisories will also be considered.

6.2 ADDITIONAL BACKGROUND GROUNDWATER ASSESSMENT

In order to further evaluate regional groundwater quality and flow versus site background groundwater quality and flow, three additional tasks will be conducted. These tasks include:

- A data review of available information;
- Additional analyses of parameters reported in current background wells that could have originated on-site; and
- Installation of a piezometer between UCD-18 and Putah Creek.

Information developed from the tasks presented above will be used in conjunction with groundwater monitoring data to evaluate the adequacy of the existing wells to monitor background groundwater quality. If this information indicates the need, additional background groundwater monitoring wells will be installed.

6.2.1 Background Data Review

In order to further evaluate background and regional groundwater quality and flow, the following information will be evaluated:

- historical flow records for Putah Creek (as far back as records are available);
- records on discharge from the sewage treatment plant to Putah Creek;
- available information on location, pumping, and groundwater pumping from wells located within 1 mile of LEHR;
- historical records of on-site effluent discharge and on-site water usage; and
- historical precipitation hydrographs.

These data will be compiled in the first six months of the RI field program. Data will be used in conjunction with groundwater monitoring data to evaluate background conditions. Results of this review will be presented in a memorandum to file.

6.2.2 Additional Groundwater Analysis

Duplicate groundwater samples will be collected from background wells and analyzed for selected constituents. The duplicate groundwater samples will be collected during two quarters from wells UCD-17 and UCD-18, and analyzed for the following:

- gross alpha;
- gross beta;
- carbon-14;
- strontium-90; and
- tritium.

It is anticipated that duplicate samples will be analyzed by Lawrence Livermore Laboratory or another laboratory in addition to the current contract laboratory. Data reported from duplicate analyses will be presented in the quarterly monitoring reports.

6.2.3 Piezometer Installation

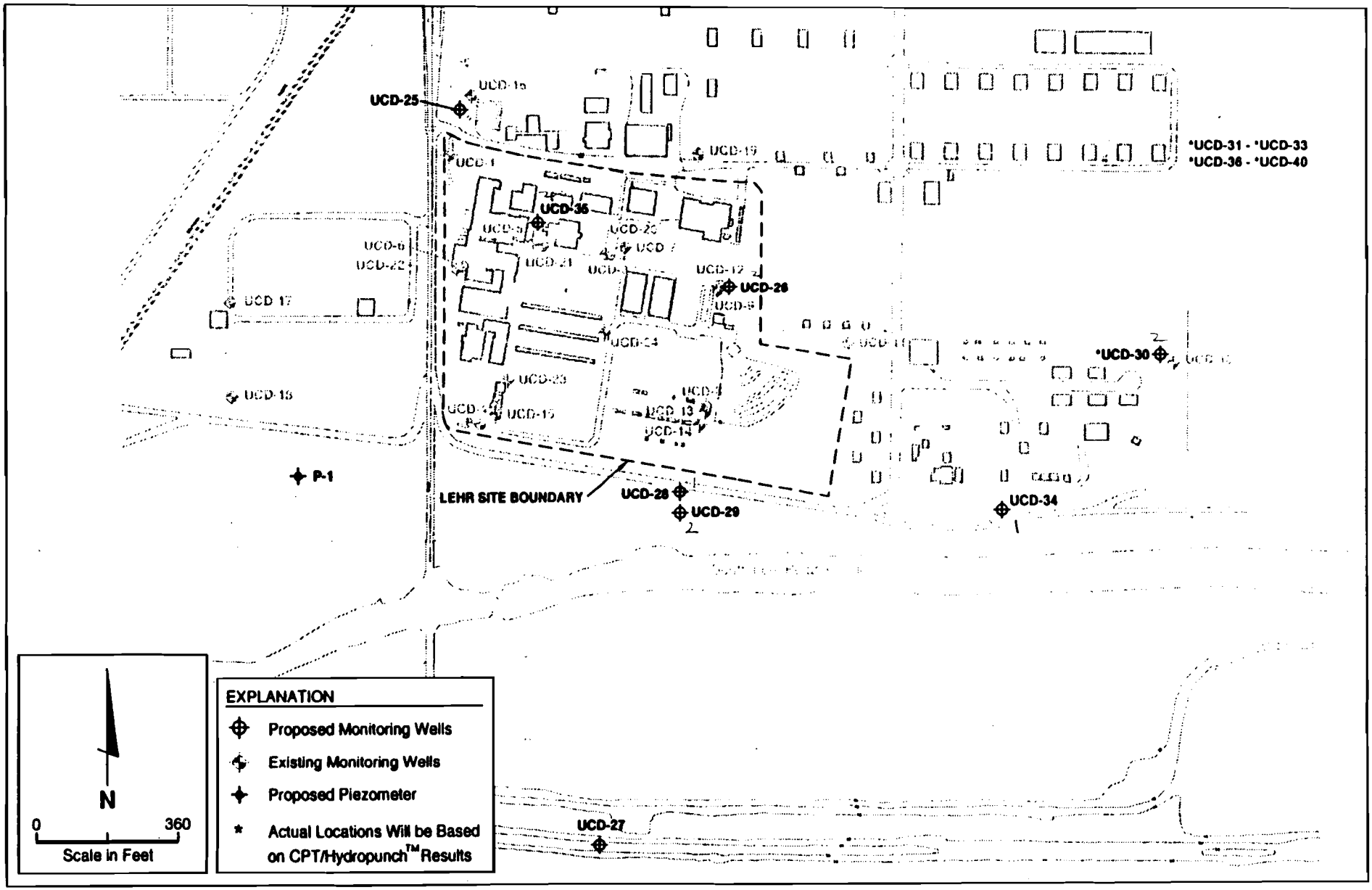
One piezometer will be installed between Putah Creek and well UCD-18 to monitor groundwater elevations in this area and to assess the impact of Putah Creek on shallow groundwater. The piezometers will be installed in the first HSU. Piezometers will be 2 inches in diameter, but otherwise will follow monitoring well installation procedures specified in the FSP. The location of the piezometer is shown on Figure 6.2.

Water-level elevations will be monitored in the piezometer on a quarterly basis. If necessary, groundwater samples may be collected from the piezometer during selected monitoring rounds to assess groundwater quality between Putah Creek and monitoring well UCD-18. If samples are collected, sampling and analysis procedures will be as specified for the groundwater monitoring program.

6.3 CONE PENETROMETER TESTING/HYDROPUNCH

Cone penetrometer testing (CPT) and in-situ groundwater sampling (Hydropunch™) will be conducted as a screening investigation to evaluate the lateral extent of impacts in the first and second HSUs downgradient of the LEHR site. CPT and Hydropunch™ data will be used to optimize locations for monitoring wells for delineation of the lateral extent of impacts in the first and second HSUs.

This method was used during the additional characterization work performed for UC Davis as part of the SWAT for the landfill units at the LEHR site. Data from that investigation have been used to guide the proposed CPT/Hydropunch™ investigation for the RI/FS. Target areas and analytes are described below.



LOCATION MAP
PROPOSED GROUNDWATER MONITORING WELLS

RI/FS Work Plan
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Davis, California

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JRE 6.2

6.3.1 Sample Collection

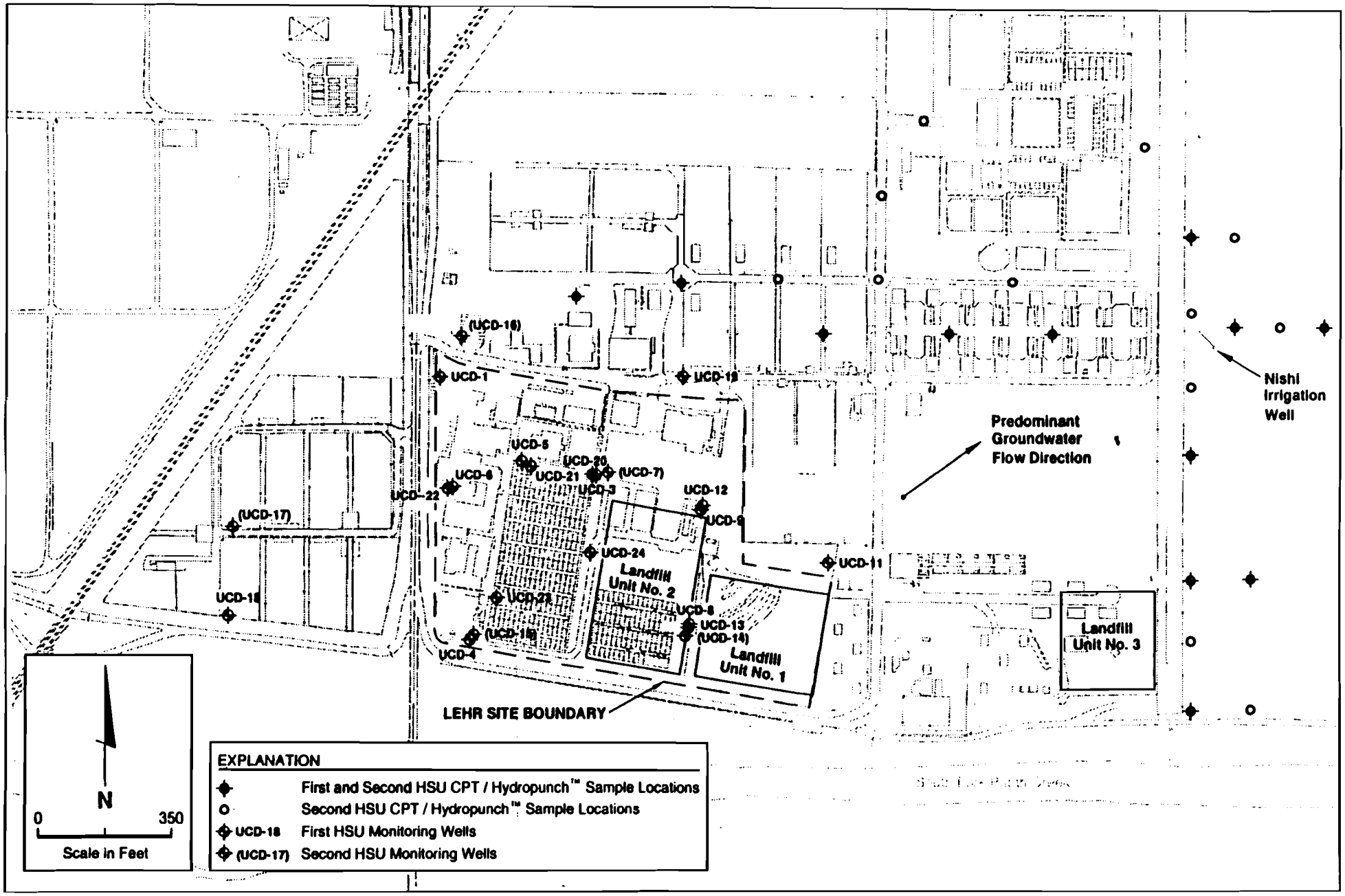
Twenty four ~~Twelve~~ CPT and Hydropunch™ locations have been identified downgradient of the LEHR site. Approximately five of these locations are downgradient of Old UC Davis Landfill Unit No. 3, eight locations are east of the site, and 11 are north-northeast of the LEHR site ~~located northeast of the LEHR site~~. Based on preliminary calculations of groundwater flow in the first and second HSUs, the CPT/Hydropunch™ locations have been chosen to define the downgradient extent of impacts at the LEHR site.

The CPT/Hydropunch™ investigation will focus on the second HSU, which has more extensive lateral impacts than the first HSU. However, in-situ groundwater samples will be collected from the first HSU at 12 ~~seven~~ locations, as shown on Figure 6.3. The shallow samples will be used to evaluate the lateral extent of site constituents in the first HSU, and for comparison of water quality between the two HSUs. Details of CPT and Hydropunch™ sampling techniques are provided in Appendix A.

6.3.2 Chemical Analysis

Because the volume of water collected using Hydropunch™ is limited, the analytical requests have been reduced from the full suite of groundwater analyses. The analytical requests have been developed on a priority basis based on anticipated site constituents and mobility of those constituents. These analyses are presented below in order of priority:

- volatile organic compounds;
- total chromium and hexavalent chromium;
- nitrate and total nitrogen;
- tritium;
- pH, EC, and TOC;
- carbon-14; and
- strontium-90.



LOCATION MAP PROPOSED CPT / HYDROPUNCH ™ LOCATIONS

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Detailed analytical methods are provided in the FSP, Appendix A, and the QAPjP, Appendix B. Locations of groundwater monitoring wells will be selected based on analytical results from the Hydropunch™ samples. Discussion of the proposed groundwater monitoring wells is provided below in Section 6.5.

6.3.3 Geodetic Surveying

Upon completion of each CPT/Hydropunch™, a wooden stake will be driven into the soil at the probe location. Upon completion of the CPT/Hydropunch™ program, the locations will be surveyed to the nearest 0.01 foot vertically and 0.3 foot horizontally and incorporated into the site geodetic survey. All surveying will be completed by a California licensed surveyor.

6.4 MONITORING WELL INSTALLATION

Sixteen ~~Eleven~~ 4-inch-diameter groundwater monitoring wells are currently planned to be ~~will be~~ installed and added to the existing groundwater monitoring system at the LEHR site. It is planned that 4 wells will be installed in the first HSU, and 12 ~~seven~~ wells will be installed in the second HSU. Table 6.5 identifies the wells to be installed and the associated hydrostratigraphic units in which they will be screened. Additionally, the rationale for each well is presented. Proposed locations of these wells are shown in Figure 6.2. Final locations of UCD-31 through -33 and UCD-36 through -40 anticipated to be located north and ~~, UCD-32, and UCD-33, located~~ east of the LEHR site, will be determined based on CPT/Hydropunch™results. These eight wells, one proposed in the first HSU and seven proposed in the second HSU, will be located in the best suited areas to monitor downgradient migration of groundwater impacts. Most of the wells are proposed to be installed in the second HSU, as this zone has a much higher lateral gradient than the first HSU. One well is anticipated to be necessary in the first HSU, possibly north to northeast of well UCD-19. Downgradient wells in the second HSU will be installed in order to monitor variation in concentration of constituents as well as for detection purposes.

TABLE 6.5 SUMMARY OF PROPOSED MONITORING WELL INSTALLATIONS

Well Number	Planned Total Depth	Screen Length	HSU	Rationale
UCD-25	60-70	15	First	Replacement well for UCD-1, northwest corner of LEHR.
UCD-26	120-140	15-25	Second	To evaluate potential impacts in the second HSU in the area below first HSU well UCD-12.
UCD-27	110-120	15-25	Second	To monitor groundwater quality between the LEHR site and the nearest resident, and to evaluate groundwater gradient south of Putah Creek.
UCD-28	60-70	15	First	To evaluate lateral extent of site constituents; to assess interaction with Putah Creek.
UCD-29	120-140	15-25	Second	To evaluate lateral extent of impacts; to assess interaction with Putah Creek.
UCD-30	110-120	15-25	Second	To evaluate extent of potential impacts to the second HSU downgradient of Old Landfill Unit 3.
UCD-31[a]	110-120	15-25	Second	To evaluate downgradient extent of impacts in the second HSU.
UCD-32[a]	110-120	15-25	Second	To evaluate downgradient extent of impacts in the second HSU.
UCD-33[a]	60-70	15	First	To evaluate downgradient extent of impacts in the first HSU.
UCD-34	60-70	15	First	To assess interaction with Putah Creek; to serve as a monitoring point upgradient from Old UC Davis Landfill Unit No. 3.
UCD-35	110-120	15-25	Second	To assess potential impacts in the second HSU downgrauient of the Imhoff and Radium-226 Treatment Systems
UCD-36[a]	40-70	15	First	To evaluate downgradient extent of impacts in the second HSU.

TABLE 6.5 SUMMARY OF PROPOSED MONITORING WELL INSTALLATIONS (continued)

Well Number	Planned Total Depth	Screen Length	HSU	Rationale
UCD-37[a]	110-120	15-25	Second	To evaluate downgradient extent of impacts in the second HSU.
UCD-38[a]	110-120	15-25	Second	To evaluate downgradient extent of impacts in the second HSU.
UCD-39[a]	110-120	15-25	Second	To evaluate downgradient extent of impacts in the second HSU.
UCD-40[a]	110-120	15-25	Second	To evaluate downgradient extent of impacts in the second HSU.

All wells will be 4-inch-diameter.

[a] Actual locations will be based on CPT/Hydropunch™ results.

In addition to the new monitoring wells, 2-inch-diameter piezometers may be installed along the south side of Putah Creek, if necessary. These piezometers would be used to obtain water-level data for evaluation of groundwater gradient south of the Putah Creek. The piezometers may be installed in the second HSU using the same installation techniques used for monitoring wells. The following sections describe the drilling methods, sampling procedures, and well installation techniques to be used. If piezometers are deemed necessary, a plan for monitoring the piezometers would be incorporated into the Work Plan.

6.4.1 Geophysical Survey

A geophysical survey will be conducted to further evaluate the stratigraphy in the site vicinity. The geophysical method to be used is transient electromagnetics (TEM). The TEM method provides a quick and relatively inexpensive indication of the change in material resistivity with depth, and is especially useful when evaluating the extent of clay and gravel layers. Zones of contrasting resistivity often represent lithologic boundaries, while areas with similar resistivity are indicative of similar materials. TEM, when accompanied with existing lithologic logs, can be used to evaluate stratigraphic changes with depth. By conducting TEM measurements at several stations along one or more transects, a resistivity(s) profile can be constructed which can be used to evaluate changes in stratigraphy. Identification of stratigraphic changes will aid in the evaluation of the extent and thickness of different lithologic intervals ~~aquifers and aquitards~~ which can affect contaminant migration and remediation design.

The objectives of using TEM in the vicinity of the LEHR site are four-fold, aiding in: (1) the evaluation of the presence and lateral extent of the second and third HSUs; (2) the evaluation of the vertical extent of the third HSU; (3) the evaluation of potential areas where an aquitard anticipated to be between the second and third HSUs may pinch out; and (4) the refinement of the site conceptual model and the understanding of groundwater fate and transport parameters. Transect locations will be selected based on existing lithologic logs from the installation of agricultural and production wells around the LEHR site and the lithology from the on-site second-HSU wells. Additionally, these lithologic logs will be used to correlate resistivity to lithologic zones. Procedures for the TEM survey are presented in the FSP, Appendix A.

It should be noted that the usefulness of TEM may be limited due to interferences from a number of sources, including fences, buildings, underground powerlines, or other utilities. The presence of these potential "noise" sources will be evaluating prior to conducted the TEM survey.

6.4.2 Well Drilling

Borings for groundwater monitoring wells will be drilled under the supervision of a California State Registered Geologist. Details of drilling, and sampling methods, are outlined below and presented in the FSP, Appendix A. Wastes generated during drilling will be handled according to the Waste Management Plan, described below in Section 6.10.

6.4.2.1 First Hydrostratigraphic Unit

Borings for the four proposed monitoring wells in the first HSU (UCD-25, UCD-28, UCD-33, and UCD-34) will be drilled using a truck-mounted drilling rig equipped with 8- and 10-inch-diameter hollow-stem augers and continuous core capabilities. Pilot holes will be continuously cored and relatively undisturbed drive samples will be collected at 5-foot intervals. Cores will be archived on-site in core boxes, and selected drive samples will be submitted for chemical, radiological, and physical testing as discussed in Section 6.4.7.1. Upon reaching total depth and assessing the appropriate screen interval, each boring will be reamed with the 10-inch-diameter augers for completion of a 4-inch-diameter monitoring well.

6.4.2.2 Second Hydrostratigraphic Unit

Borings for the 12 ~~seven~~ monitoring wells in the second HSU, UCD-26, ~~and -27~~, UCD-29 through UCD-32, and UCD-35 through UCD-40 ~~-30, -31, -32, and -35~~ will be drilled using resonant coring and air-rotary/casing-hammer drilling methods. A pilot hole will be continuously cored to the base of the second HSU at each location, and drive samples will be collected at approximately 10-foot intervals from the ground surface to total depth. Cores will be logged and archived in core boxes, and selected samples will be submitted for chemical, radiologic, and physical testing as described in Section 6.4.7.1.

Each monitoring well boring will then be reamed by air-rotary/casing-hammer methods using 10-inch-diameter drive casing for completion of a 4-inch-diameter monitoring well. Two-inch-diameter piezometers will be constructed in the continuously cored boreholes.

6.4.3 Soil Sample Collection

The borings for groundwater monitoring wells will be continuously cored and drive soil samples will be collected at specified intervals and at identified lithologic changes. After samples have been collected, they will be screened for radiologics and volatiles, sealed, and labeled with the appropriate information. Selected samples will be submitted to the laboratory for chemical, radiologic, and physical testing.

Cores, soil cuttings and soil samples will be logged in the field by the site geologist. The log will contain a complete and detailed lithologic description of materials using the Unified Soil Classification System (USCS). Additionally, logs will contain information on sample collection, consistency of materials, penetration rates, and field screening data. Cores will be archived for potential future evaluation. Details of sampling and logging procedures are provided in the FSP, Appendix A.

6.4.4 Monitoring Well Installation

Groundwater monitoring wells will be installed in accordance with state and local regulations and the "Standard Practice for Design and Installation of Groundwater Monitoring Wells in Aquifers" (ASTM D5092-90). Solano County well permits will be acquired for all wells. Procedures for well installation are presented in the FSP, Appendix A.

6.4.4.1 First-HSU Wells

Because of the large seasonal fluctuation in groundwater levels at the site, up to 25 feet annually, the 4 first-HSU monitoring wells will be installed at depths similar to first-HSU wells installed during the Phase II Site Characterization. It is anticipated that first-HSU wells will be installed to a depth of approximately 70 feet bgs with 15-foot screened sections. Fifteen-foot screened sections will maximize the potential for collection of

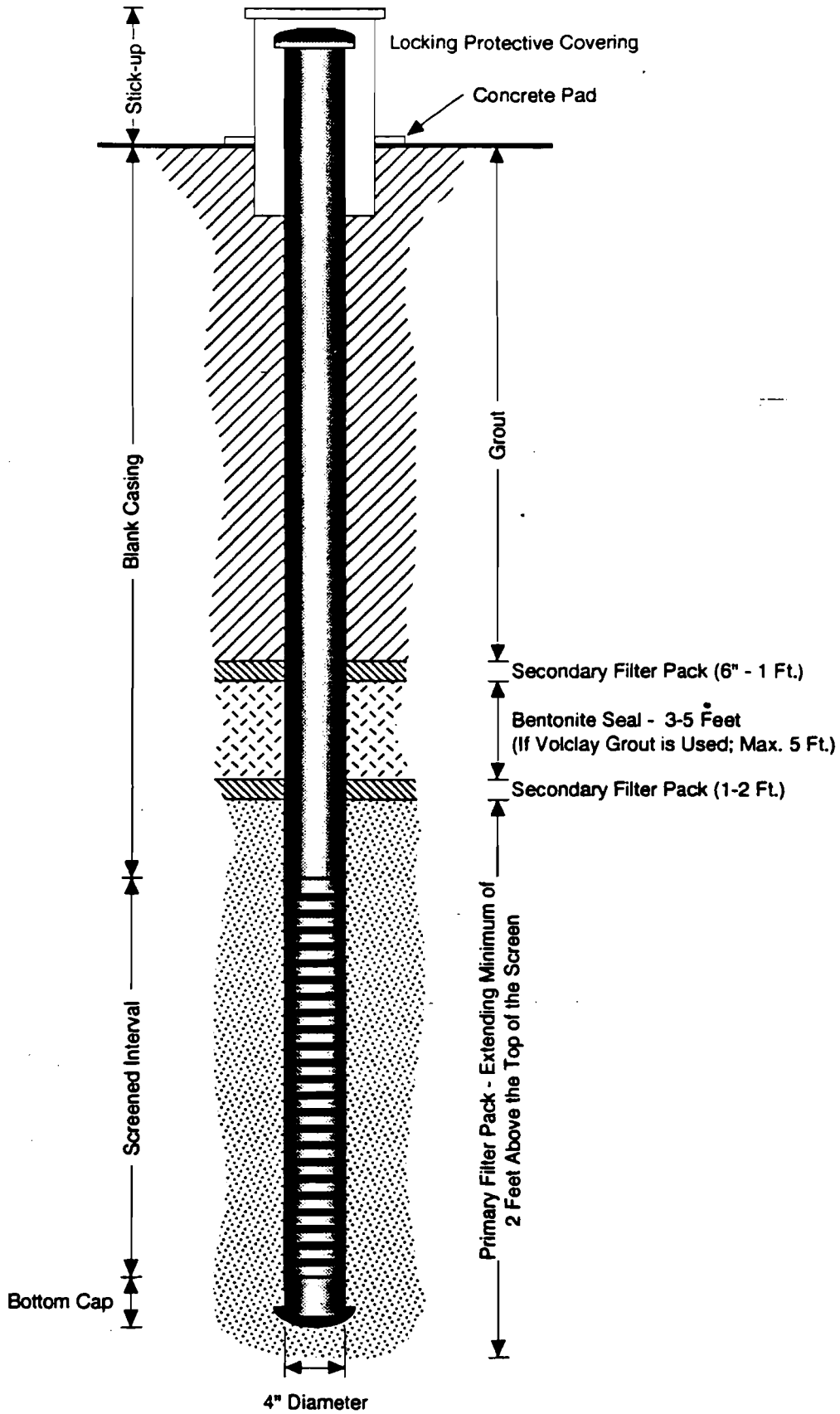
samples representative of water in the first HSU, recognizing the large fluctuation in groundwater levels.

6.4.4.2 Second-HSU Wells

It is anticipated that the 12 ~~seven~~ second-HSU wells proposed for this RI will be installed to a depth of approximately 120 feet bgs with 15-foot screened sections. The top of the well screen will be placed 2 to 3 feet below the top of the second HSU and the filter pack will be brought up level with the top of the second HSU. Because of the relative homogeneous nature of the second-HSU sediments, and the nature of the constituents of concern, stratification or dilution is not considered to be a controlling factor in constituent concentrations. However, lithologic information obtained during the coring of the second-HSU wells will be evaluated to test these assumptions, and modifications to the installation design will be made if warranted.

6.4.5 Well Construction Materials

The new monitoring wells will be constructed of 4-inch-diameter, stainless steel, continuous wire-wrap screen and schedule 40 blank PVC. All PVC casing and stainless steel screen will be steam cleaned prior to installation. An appropriate filter pack, as recommended in ASTM D5092-90 will be placed to approximately 2 feet above the screen. A 1-foot secondary filter pack, 3 feet of bentonite, and a second 1-foot secondary filter pack will be placed above the primary filter pack. A sanitary seal of cement/ bentonite grout will be placed from the top of the secondary seal up to the ground surface. Figure 6.4 presents a schematic representation of construction details for a typical groundwater monitoring well. Monitoring wells will be completed with an above-grade, locking, steel, protective casings or flush-mount, water-tight, locking well boxes. Flush-mount completions will be installed in high traffic areas. At each well, the ground surface will be graded away from the well head to minimize the potential for downward migration of water from precipitation or runoff. After completion, the elevation and location of new monitoring wells will be surveyed into the site geodetic survey. Details of proposed monitoring-well construction are presented in the FSP, Appendix A.



BASIC MONITORING WELL CONSTRUCTION SCHEMATIC DIAGRAM

RI/FS Work Plan
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FIGURE 6.4

6.4.5.1 First Hydrostratigraphic Unit

For the Phase II groundwater monitoring well installations, grain-size distribution analyses were used to select the appropriate filter pack and well screen size. Well design for the 4 first-HSU wells during this RI will generally be the same as the Phase II Investigation wells; however, the appropriate screen and filter pack will be confirmed based on field analysis of grain size distribution. For the first-HSU monitoring wells, it is anticipated that 15-foot lengths of 4-inch-diameter, stainless-steel, wire-wrap screen with 0.010-inch slots will be used. Schedule 40 blank PVC casing will be used from the top of the screened interval to the ground surface. Lonestar 1C sand will be used as the primary filter pack material for these wells. The secondary filter packs consisting of a 1-foot layer of 30-mesh sands will be placed above the primary filter pack. Approximately 3 feet of 1/4-inch diameter bentonite pellets will be placed on top of the secondary filter pack and hydrated. A 1-foot-thick secondary filter pack of 30 mesh sand will then be placed on top of the bentonite. The remaining annulus will be grouted to the surface by tremmie methods with a 2- to 5-percent bentonite/cement grout mixture.

6.4.5.2 Second Hydrostratigraphic Unit

Well design for the twelve second-HSU wells and ~~one~~ any necessary piezometers installed during this RI will generally be the same as the Phase II wells with the appropriate screen and filter pack to be confirmed based on field analysis of grain size distribution. It is anticipated that second HSU, wells will be constructed using 4-inch-diameter, stainless steel, continuous wire-wrap screen with 0.020-inch-wide openings and with a No. 2/12 sand as the primary filter pack. Piezometers will also be constructed of 2-inch-diameter stainless steel, continuous wire-wrap screen and similar filter pack. Schedule 40 blank PVC casing will be used from the top of the screened interval to the ground surface. The secondary filter pack consisting of a 1-foot layer of 30 mesh sand will be placed above the primary filter pack. A 3-foot-thick layer of volclay grout and bentonite slurry will be used instead of bentonite pellets to avoid potential bridging problems. A second 1-foot thick secondary filter pack of 30 mesh sand will be placed on top of the volclay grout seal. The remaining annulus will be grouted to the surface by tremmie methods with a 2- to 5-percent bentonite/cement grout mixture.

6.4.6 Well Development

The new monitoring wells will be developed in accordance with ASTM standards (ASTM D 5092-90) using a well development rig equipped with a surge block, bailers, an air lift, and a submersible pump. Development of the monitoring wells will be observed by a geologist working under the supervision of a California State Registered Geologist.

Development will be done in two stages. The first stage of development occurs after placement of the well screen and filter pack, but before placement of the bentonite and grout. The purpose of the first stage is primarily to settle the sand pack and minimize the amount of settlement and eliminate voids developing during the second stage of development that occurs a few days after the well construction has been completed. First stage development consists of surging the well screened interval using a vented surge block. The second stage is to continue development of the filter pack and reduce the amount of fine sediment, thereby reducing the turbidity to the desired level of 5 NTU or less. The general sequence for monitoring well development includes the following steps:

- Surging the well screened interval using a vented surge block;
- Bailing the well to remove coarse-grained sediments;
- Surging the screened interval a second time;
- Bailing the well to remove coarse-grained sediments;
- Pumping the well using a submersible pump, varying the pumping rate and elevation of the pump in the well; and
- If necessary, an air lift will be used to purge fine-grained sediments from the well.

During pumping, pH, electrical conductivity (EC), turbidity, EH, and temperature of the groundwater will be measured at regular intervals. Development will continue until consecutive measurements of pH, temperature, and conductivity measured within 10 percent of previous readings and turbidity readings are below 5 NTU. Water produced during monitoring-well development will be placed in drums or tanks, and placed in the designated storage area. The containers will be labeled to indicate monitoring-well number and date. The disposition of each container of development water will be evaluated as described in the Waste Management Plan currently being prepared for investigation derived wastes during the RI.

6.4.7 Analytical Requests

Soil and groundwater samples from each well will be analyzed for select parameters. The analytical requests are presented in the following sections.

6.4.7.1 Soil Analytical Requests

Selected soil samples from each monitoring well will be submitted to a laboratory for chemical, radiological, and physical testing. The field geologist and technical lead will select the samples to be submitted for analysis. Criteria used to select samples for analysis will include: changes in lithology or moisture content; visual evidence of staining or discoloration; above-background readings on field screening instruments; and the presents of fine-graine . organic materials that may be more likely to retain site constituents. ~~The decision will be based on stratigraphy, field screening information, and material type.~~

It is estimated that an average of two soil samples from each monitoring well will be submitted for chemical and physical testing. The chemical and physical tests to be performed are presented on Table 6.6.

6.4.7.2 Groundwater Analytical Requests

Groundwater monitoring wells installed during the RI will be included into the quarterly water sampling schedule. The groundwater samples will be collected as part of the Water Monitoring Plan (Dames & Moore, 1993b). Samples will be analyzed for the full suite of field, quarterly, and annual chemical and radiologic parameters listed in Table 6.4 for a minimum of four quarters. After that time the frequency of analysis for the new wells will be re-evaluated and reduced,if appropriate.

TABLE 6.6 MONITORING WELL ANALYTICAL REQUESTS FOR SOIL

Chemical Tests	Physical Tests	Number of Samples
Nitrate	Grain size	20
Pesticides	Atterberg Limits	20
Total Chromium	Permeability	20
Total Organic Carbon (TOC)	Porosity	20
pH	Moisture Content	20
EC	Bulk Density	20

6.4.8 Geodetic Surveying

Following completion of well installation, the ground surface and the top of each well will be surveyed both horizontally and vertically to the nearest 0.3 and 0.01 foot, respectively. The surveyed locations will be incorporated into the site geodetic grid. All surveying will be done by a surveyor licensed in the State of California.

6.5 AQUIFER ANALYSIS

Aquifer properties including hydraulic conductivity, transmissivity, and storage coefficients will be evaluated through data generated from slug and pumping tests. Site characterization will include estimates of groundwater velocity and identification of the most permeable strata within each HSU to identify the primary pathways and groundwater flow rates and rates of contaminant transport. Slug and pumping tests do not fully address this issue; therefore, single-well tracer tests that can accurately measure groundwater velocity and effective porosity, and that can yield a vertical profile of hydraulic conductivity in an aquifer are proposed for selected wells. The data gathered during the RI will be supplemented by data and modeling conducted for the Phase II Investigation and evaluated through further computer modeling.

6.5.1 Slug Tests

Slug tests will be conducted on the monitoring wells installed during the RI. Rising and falling head tests will be conducted to evaluate hydraulic conductivity in the immediate area around the new monitoring wells. The principal behind the slug tests is to quickly change the water level in a well, either by addition or removal of a known volume or slug and then measuring the resulting fall or rise in water level over a period of time as the water level equilibrates. Graphical procedures, based on groundwater flow equations, use plots of the measured changes in water level versus time to estimate hydraulic conductivity. Detailed procedures for slug tests are included in the FSP, Appendix A.

6.5.2 Pumping Tests

The Phase II Site Characterization Report (Dames & Moore, 1993a) indicates that the second HSU is the primary water-bearing stratigraphic interval ~~aquifer~~ beneath the site. In addition, changes in water levels and groundwater movement within the first HSU are influenced directly by changes within the second HSU. Thus, it is appropriate that a pumping test be conducted in the second HSU to obtain information on aquifer parameters. However, because of the anticipated logistical difficulty and cost of disposal of potentially contaminated water generated from a pumping test, and the potential to accelerate migration or temporarily alter the general groundwater flow direction, a pumping test within the bounds of the LEHR site becomes problematic.

Several options are available that would also permit gathering of second-HSU aquifer hydraulic data. Three options include: (1) performing a pumping test on an upgradient monitoring well screened in the second HSU; (2) performing a pumping test on a nearby UC Davis agricultural well, of known integrity and under UC Davis' control, screened in the second HSU; and (3) performing a pumping test on an existing agricultural well near LEHR. Each option will be evaluated for technical and financial feasibility and a preferred alternative will be presented to PNL.

Option 1 would involve pumping an upgradient second-HSU monitoring well, such as MW-17 and monitoring MW-18 and on-site wells. Prior to implementation of this option, simulations would be conducted to identify appropriate pumping rates and durations to ensure that impacted groundwater is not pulled upgradient and extracted during the pump test. As such, with the appropriate monitoring, the produced water could possibly be discharged to the UC Davis Wastewater Treatment Plant or to the surface.

Option 2 would include the installation of first and second-HSU monitoring wells adjacent to a UC Davis agricultural well located away from the LEHR site. The pumping test would be conducted and the water disposed at the surface. The new wells would be monitored during the test.

Option 3 would involve conducting a pumping test on a nearby private irrigation well screened to the second HSU. Observation wells would be installed near the irrigation

wells for monitoring water levels during the pumping test. Produced water would be discharged to the surface. If construction details of the irrigation were not available, it could be necessary to conduct a video survey of the well to confirm the screened interval, well depth, and overall condition of the well.

With any of the three options, a step-drawdown test would be conducted prior to a constant-rate test. The constant-rate test for the first two options would run for 72 hours to 1 week. The pumping rate for the third option would remain constant for at least 1 week. Data from the pumping test will be analyzed using interpretation methods appropriate for the hydrogeologic conditions and well construction.

All three options would require additional negotiations with the appropriate parties and an evaluation of feasibility. Therefore, additional discussions will be initiated and an amendment to this Work Plan will be prepared after an acceptable option has been selected.

6.5.3 Single-Well Tracer Tests

Site characterization will include estimates of groundwater velocity and identification of the most permeable strata within each HSU unit to identify the potential primary pathways and groundwater flow rates and rates of contaminant transport.

Recent articles have described a new type of single-well tracer tests that can accurately measure groundwater velocity and effective porosity, and that can yield a vertical profile of hydraulic conductivity in an aquifer (Hall, et al., 1991; Hall and Raymond, 1992; Hall, 1993). Further, these methods are very cost-effective. After the hydraulic gradient and well transmissivity have been determined using conventional means (aquifer and slug tests), a bromide tracer (e.g., as KBr) is introduced into the well bore. A point-dilution test is conducted by measuring tracer concentration in the well as a function of both depth and time, yielding a profile of relative hydraulic conductivity. A downhole ion-selective electrode instrument (Hydroprobe) is used to measure the bromide concentration.

The tracer is then allowed to drift away from the well bore for a period of time, usually a few days. Finally, the tracer is recovered by pumping the well while monitoring

the effluent stream for the tracer ("Drift-and-pumpback" test). Both the effective porosity and groundwater velocity are then calculated as a function of the amount of time required to recover the tracer.

6.5.4 Groundwater Modeling

A numerical groundwater flow model for part of the site has been developed using the U.S. Geological Survey, Modular Three-Dimensional Finite-Difference Groundwater Flow Model (MODFLOW) (MacDonald and Harbaught, 1988). MODFLOW is a modular three-dimensional finite-difference groundwater flow model. The modular structure consists of a main program and a series of highly independent subroutines called "modules." The division of the program into modules permits the user to examine specific hydrologic features of the model independently. Each module deals with a specific feature of the hydrologic system which is to be simulated, such as flow from rivers or flow into drains, or with a specific method of solving linear equations which describe the flow system.

MODFLOW simulates flow in three dimensions. The groundwater flow is simulated using a block-centered finite-difference approach. Layers can be simulated as confined, unconfined, or a combination of confined and unconfined. As previously stated, flow associated with external stresses, such as wells, areal recharge, evapotranspiration, drains, and streams, can also be simulated. The finite difference equations can be solved using either the strongly implicit procedure, or the slice-successive overrelaxation.

Model input and results of modeling runs are described in the Phase II Site Characterization Report (Dames & Moore, 1993). The groundwater flow model was used to accomplish the following:

- Establish the flow relationships in the uppermost aquifer and the degree of hydraulic connection between the first HSU and second HSU;
- Simulate the direction and gradient of groundwater flow beneath the LEHR Site;
- Emulate the seasonal fluctuations of the piezometric surfaces in the first HSU and second HSU;

- Assess the changes in vertical gradients between the first HSU and second HSU, over time; and

- Assess the amount of hydrologic interconnection between Putah Creek and the first HSU and second HSU.

The conceptual groundwater flow model consists of two layers, which were assigned hydrogeologic properties representative of the first HSU and second HSU, respectively. Groundwater flow gradients were established using a steady-state flow simulation, with no pumping wells activated. After the steady-state groundwater gradient was established, transient groundwater flow simulations with active pumping wells were used to assess the seasonal groundwater elevation fluctuations. Groundwater elevations can vary as much as 25 feet, over a 1-year period, in both hydrostratigraphic units.

The transient groundwater flow conditions were simulated for a period of 20 years, into the future, to predict the long-term groundwater flow conditions. The results of the groundwater flow modeling effort are as follows:

- The model simulated groundwater elevations closely emulated the actual groundwater elevations for a one year period.

- A groundwater mound exists under Putah Creek, and recharges water into the first HSU. The mound may persist year round.

- Seasonal fluctuations in the groundwater elevations in the first HSU are partially due to pumping and recovery in the second HSU.

- Through an iterative process, horizontal and vertical hydraulic gradients were simulated for both HSUs, and the vertical gradients between the first HSU and second HSU were predicted.

- After 20 years of simulation, groundwater elevations in the second HSU are lower than groundwater elevations in the first HSU.

- The local variations in gradient in the first HSU could not be accurately simulated.

The next phase of the groundwater modeling effort to be conducted during this RI, will be to complete an aquifer pumping test to further define the hydrologic properties of

the aquifer system. The pumping test data and other data collected will be used to help refine the model criteria, including:

- The model boundary conditions;
- The vertical and horizontal hydraulic conductivity values;
- The specific storage and storativity values;
- The amount of surface water infiltrating due to irrigation;
- The amount of evapotranspiration;
- The amount of recharge to the aquifers depending on the irrigation and evapotranspiration estimates; and
- The amount of infiltration to the uppermost aquifer from Putah Creek.

After these data are analyzed, the flow model will be recalibrated. The recalibrated flow model will demonstrate the accuracy and validity of the conceptual model by simulating observed responses of the groundwater system using data collected and used as input to development of both models.

After recalibration of the flow model has been completed, a contaminant transport model will be generated. At this time, Dames & Moore plans to use the MT3D contaminant model which was developed for use with flow models like MODFLOW (the groundwater flow model being used for the LEHR site). MT3D was selected for use because it is compatible with MODFLOW, it is virtually free of numerical dispersion and oscillation, and it can be applied to a variety of field conditions such as:

- Confined, unconfined or variably confined/unconfined aquifer systems;
- Inclined model layers and variable cell thickness with a given hydrostratigraphic layer;
- Specified concentration or mass flux boundaries; and
- The solute transport effects of external sources and sinks such as wells, drains (Putah Creek), rivers, areal recharge and evapotranspiration.

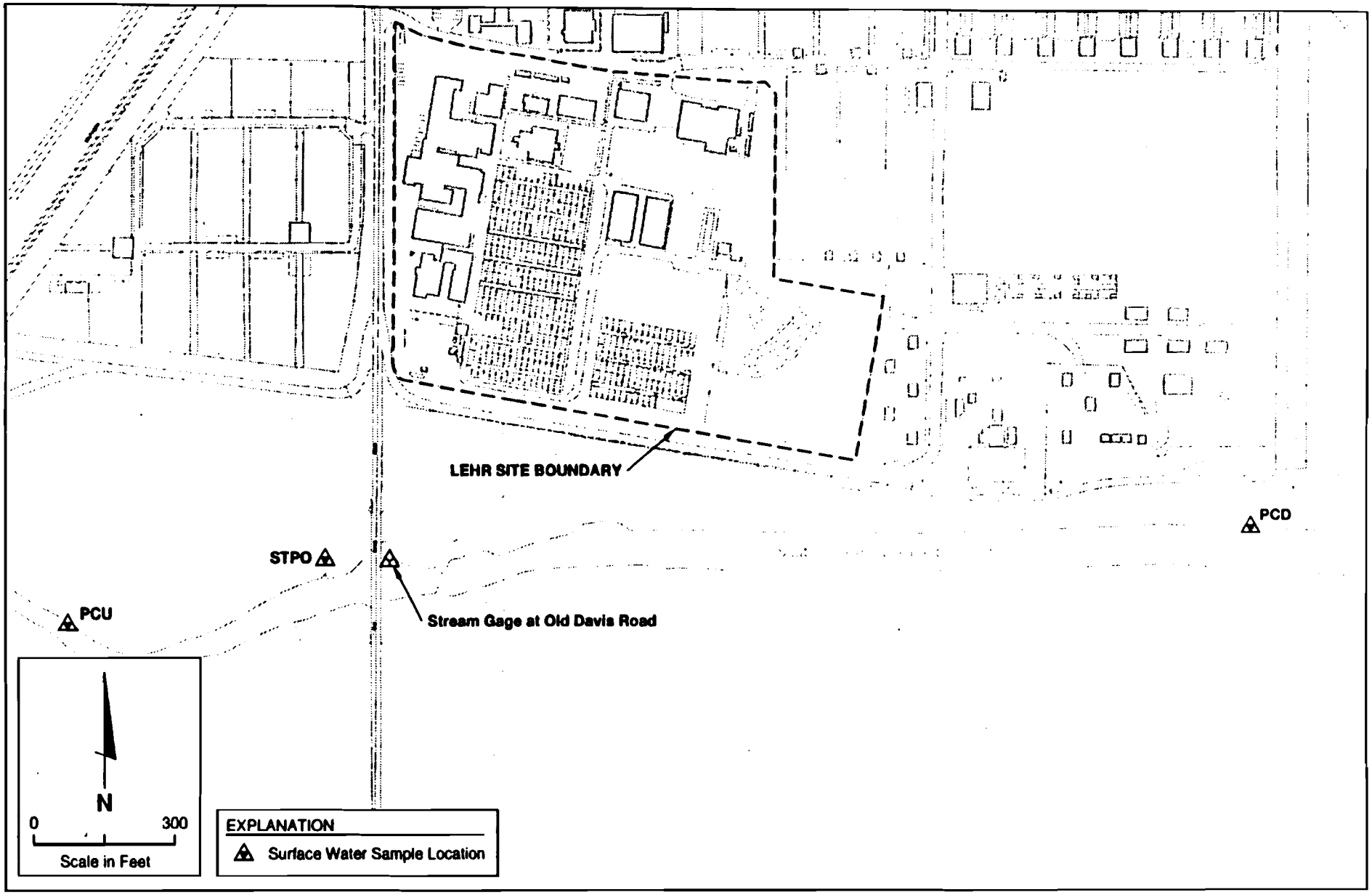
The chemical reactions that the model can simulate include equilibrium-controlled linear or nonlinear sorption and first-order irreversible decay or biodegradation. In addition, flexibility exists to add more sophisticated chemical reactions without changing the code.

It is envisioned that the contaminant transport model will be used to predict contaminant transport rates and concentrations. In addition, the model can be used to estimate the spatial and temporal configurations of contaminants in groundwater, as well as predicted concentrations of contaminants extracted form individual wells. These estimates can be used to evaluate risk to potential receptors and to design remediation systems. Configurations of remedial extraction wells can be simulated in order to ideally design a cost effective and efficient groundwater remediation system.

6.6 SURFACE WATER

Surface water monitoring will be conducted quarterly at three locations along Putah Creek: the UC Davis Wastewater Treatment Plant outfall tributary (designated STPO); upstream of the LEHR site (designated PCU); and downstream of the LEHR site (designated PCD), as shown on Figure 6.5. Based on previous studies, during the summer months, Putah Creek does not flow in the vicinity of the LEHR site and most water present at the PCU and PCD locations is apparently stagnant. During these times, the primary source of water in Putah Creek is from the UC Davis Wastewater Treatment Plant. Monitoring of Putah Creek has been conducted quarterly since November 1990 as part of the Phase II Site Characterization (Dames & Moore, 1993a).

Sampling will be conducted to identify potential impacts (1) from the site and surrounding areas on Putah Creek; and (2) from Putah Creek to groundwater. In addition to the quarterly sampling, a reconnaissance of Putah Creek will be conducted to identify additional potential discharge sources located upstream of the LEHR site. Each of these tasks is described in more detail below.



LOCATION MAP SURFACE WATER MONITORING POINTS

RI/FS Work Plan
LEHR Environmental Restoration
Davis, California

10805-7 SJR 2/24/94 5705L

URE 6.5

6.6.1 Surface Water Reconnaissance

During the RI, a reconnaissance will be conducted to identify and locate additional potential sources that discharge to Putah Creek. Agricultural pumps that withdraw water from Putah Creek will also be identified. A quarterly reconnaissance will be conducted to identify the upstream and downstream limits of standing water in the reach of Putah Creek adjacent to the LEHR site. The water elevation at the stream gage on Old Davis Road will also be measured quarterly in conjunction with the water monitoring. This measurement will include observations of whether the Creek is flowing or is stagnant. Information regarding the gage of Putah Creek at Old Davis Road will be obtained from the Solano County Irrigation District. This information will include flow data, stream profile, and monitoring frequency, and will be used to evaluate and quantify flow in the Creek adjacent to the LEHR site.

Surface water and storm water pathways within and surrounding the LEHR site will be evaluated through analysis of topographic maps, facility drawings, and site reconnaissance. The resulting information will be compiled on a topographic base map of the LEHR vicinity. The map will show: surface water flow pathways; accumulation points; discharge and conveyance structures; and areas of exposed soil, paved areas, and structures.

Information obtained from these evaluations will be used to assess the potential for sites to impact the groundwater beneath the LEHR site through a surface water to groundwater migration pathway. Additionally, an assessment of the amount of leakance will be performed using the collected information and physical data obtained from the soil borings drilled at the LEHR site.

6.6.2 Quarterly Monitoring, Surface Water

Surface water monitoring will be conducted quarterly at three locations along Putah Creek: the UC Davis Wastewater Treatment Plant outfall tributary (designated STPO); upstream of the LEHR site (designated PCU); and downstream of the LEHR site (designated PCD), as shown on Figure 6.5. The quarterly monitoring will be conducted following the Water Monitoring Plan (Dames & Moore, 1993b). Grab water samples will be collected in

clean glass jars and transferred to the appropriate sample containers. Samples will be packaged and shipped to the laboratory via overnight courier. Sampling procedures are presented in the FSP, Appendix A. Surface water monitoring points are shown on Figure 6.5.

6.6.3 Chemical Analysis

Each surface water monitoring location will be sampled quarterly in conjunction with groundwater monitoring. Surface water monitoring will consist of taking field measurements and collecting samples for quarterly and annual parameters. Samples will be collected for quarterly parameters and field measurements will be recorded each quarter (spring, summer, fall, winter) for all three surface water monitoring locations. As with the groundwater data, the results of the Phase II Site Characterization have shown only sporadic detections of semi-volatile compounds and metals. Therefore, sampling of these parameters will be reduced to an annual frequency, and will be collected during the spring quarter each year at each location. Table 6.7 presents a summary of surface water sample field, quarterly, and annual parameters. The FSP, Appendix A, presents sample analysis methods, and required laboratory detection limits.

6.7 STORM WATER RUNOFF MONITORING

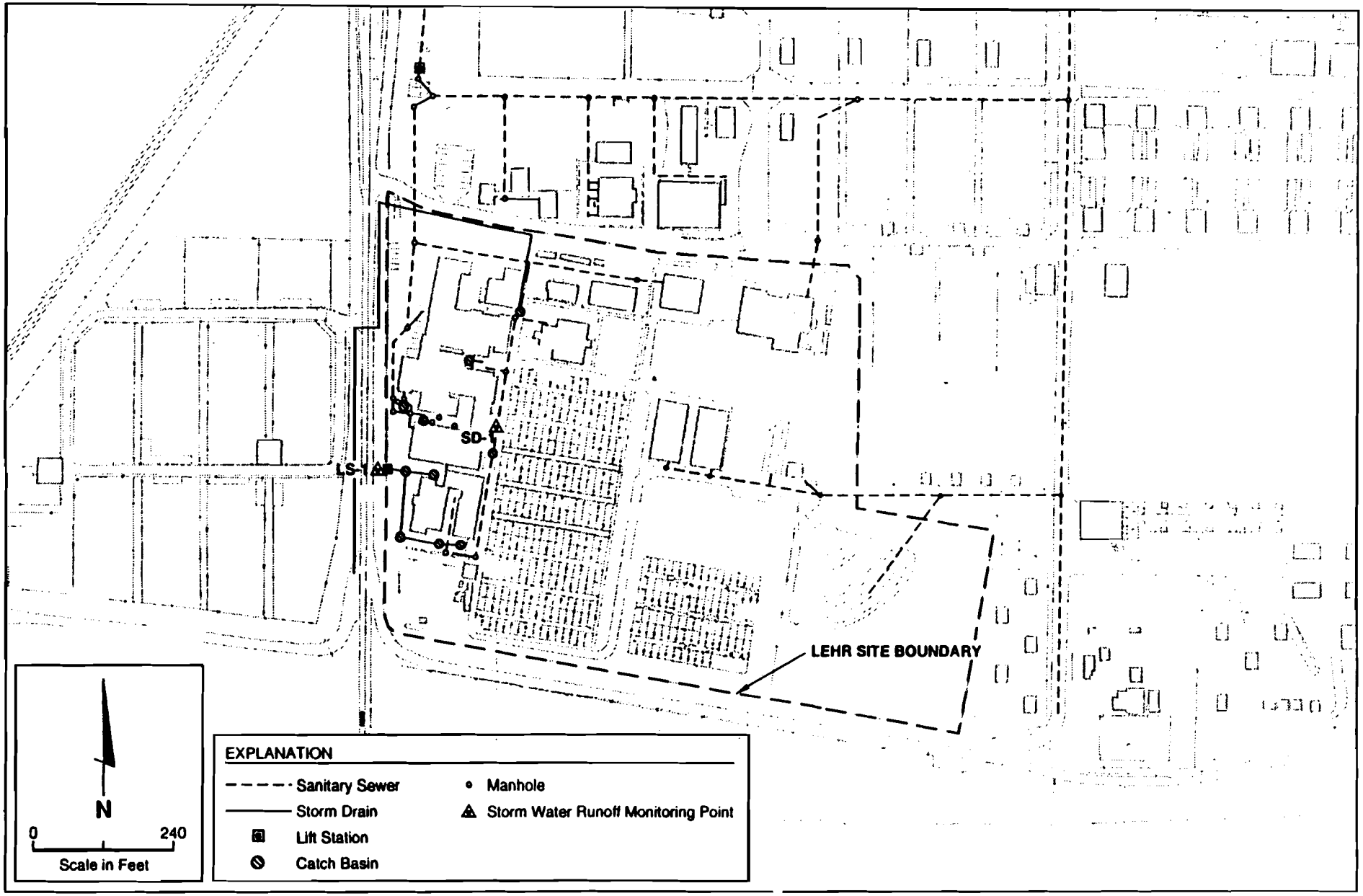
Two storm water runoff monitoring points will be added to the water monitoring program to evaluate the quality of storm water runoff generated from the LEHR site. Storm water runoff monitoring has not been conducted previously at the LEHR site. Storm water runoff from the LEHR site collects at various on-site storm drains and is removed from the site in two areas, as shown on Figure 6.6. One collection area is a lift station located along the west side of the site which pumps runoff under Old Davis Road where it is routed to Putah Creek. The second area collects storm water from the central portion of the LEHR site and routes runoff into a combined storm water/sanitary sewer which directs storm water runoff and sewage wastes from the LEHR, ITEH, and UC Davis facilities to the UC Davis Wastewater Treatment Plant.

TABLE 6.7 SURFACE WATER MONITORING PARAMETERS [a]

Field	Quarterly	Annual
To be measured every quarter	To be collected every quarter (spring, summer, fall, and winter)	To be collected one quarter per year (spring)
pH Electrical Conductivity Temperature Turbidity Eh Approximate Flow Rate[b]	Volatile Organic Compounds Pesticides and PCBs Tritium, Strontium-90, Radium-226 Gross Alpha, Gross Beta, Gamma Emitters, and Carbon-14 Americium-241 Plutonium-241 Total Chromium Hexavalent Chromium Nitrate Total Organic Carbon Total Dissolved Solids Formaldehyde Turbidity Alkalinity Cations Anions	Semi-Volatile Organic Compounds Antimony, Arsenic, Barium, Beryllium, Cadmium, Cobalt, Lead, Mercury, Molybdenum, Nickel, Selenium, Silver, Thallium, Vanadium, and Zinc Chemical Oxygen Demand Biological Oxygen Demand

[a] To be collected at locations PCD, PCU, and STPO.

[b] STPO discharge rates will be obtained from UC Davis; flow measurements for Putah Creek will be obtained from the Solano County Irrigation District.



REFERENCE: FROM ENVIRONMENTAL SURVEY PRELIMINARY REPORT DOE MARCH 1988

LOCATION MAP
STORM WATER RUNOFF MONITORING POINTS

RI/FS Work Plan
LEHR Environmental Restoration
Davis, California

6.7.1 Monitoring Locations

Storm water runoff monitoring will be conducted at two on-site locations. Field measurements and samples will be collected directly from the lift station (designated LS-1) located in the southwest corner of the LEHR site, and from a storm drain (designated SD-1) located along the western side of the main dog pen area. The lift station monitoring location (LS-1) will monitor storm water that runs off the southwest corner of the LEHR site and is pumped directly to an outfall in Putah Creek. The storm drain monitoring location (SD-1) will monitor storm water that runs off of the southern portion of the LEHR site and the dog pen area. The exact location of the SD-1 sample will be selected so that runoff is monitored before it mixes with sanitary sewage from current ITEH facilities. This assessment will be conducted in conjunction with the surface water reconnaissance presented in Section 6.7.1.

6.7.2 Monitoring Schedule and Parameters

Monitoring for the parameters listed on Table 6.8 will be conducted during two separate rainfall events per year. The first storm water runoff sampling event will occur early in the rainy season (November or December) in order to sample runoff that may carry material that accumulated on the ground surface during the summer months. Based on the rainfall event, intensity, and density, an attempt will be made to collect samples during the first event of the year. The second sampling event will occur late in the rainy season (April or May). Because storm water runoff monitoring has not been conducted previously, samples will be analyzed for the entire list of parameters shown on Table 6.8 during each sampling event for the first two years. After the first 2 years, the list of analytes will be re-evaluated and reduced as appropriate. Procedures for collection and analysis of samples are presented in the FSP, Appendix A.

6.8 WASTE MANAGEMENT

Wastes produced as a result of water monitoring activities will be managed as described in the Waste Management Plan currently being prepared for RI activities at the LEHR site. Wastes associated with the water monitoring tasks include: soil cuttings; produced water from well drilling; purge water from well development, water sampling and

TABLE 6.8 ANALYTICAL PARAMETERS STORM WATER RUNOFF [a]

Field	Each Storm Event
To be collected during two storm events per year from both locations	To be collected two storm events per year from both locations
pH Electrical Conductivity Temperature Turbidity Eh Approximate Flow Rate	Total Oil and Grease Volatile Organic Compounds Semi-Volatile Organic Compounds Pesticides and PCBs Tritium, Strontium-90, Radium-226, Gross Alpha, Gross Beta, Gamma Emitters, and Carbon-14 Antimony, arsenic, Barium, Beryllium, Cadmium, Cobalt, Lead, Mercury, Molybdenum, Nickel, Selenium, Silver, Thallium, Vanadium, and Zinc Americium-241 Plutonium-241 Total Chromium Hexavalent Chromium Nitrate Alkalinity Cations Anions Total Organic Carbon Total Suspended Solids Total Dissolved Solids Formaldehyde Chemical Oxygen Demand Turbidity

After two years of monitoring (four events) several parameters may modified.

a LS-1 and SD-1.

aquifer tests; decontamination activities; and personal protective equipment (PPE). It is anticipated that these wastes will be screened in the field for volatiles and radioactivity. Based on criteria established in the Waste Management Plan, soil wastes will be either contained in 55-gallon DOT-approved drums, tanks, or roll-off bins pending characterization or redisposed in lined surface excavations adjacent to the source of the waste material. Most water wastes will be contained in Baker tanks pending characterization. However, it is anticipated that pumping test water will be discharged to the surface. Disposition of the wastes will be determined based on analytical results of soil and water samples collected from the respective boring and monitoring well, and any additional analyses that may be required as described in the Waste Management Plan.

6.9 DATA EVALUATION

To ensure that the quality of the hydrogeologic and analytical data sufficient for the data's intended use, the validation procedures outlined in the QAPjP will be followed. After the data have been validated, they will be analyzed to support characterization of the site, the Risk Assessment and the FS. Statistical analysis of the data will be conducted to establish background levels of site constituents and to compare on-site groundwater concentration with these background levels. Statistical methods of evaluating analytical data will be dependent on several variables including the number of non-detects, stratification, and spatial distribution of the data. Based on these variables, the decision as to which method is appropriate for the data set(s) will be made after the data sets have been collected and validated. The statistical methods that may be used include: Coefficient of Variance; Student-T Test; Test of Proportions; Cohens Method; or other robust parametric or non-parametric methods as appropriate.

Statistical methods will be used for several purposes, including establishing background levels, evaluating trends in water levels, assessing changes in chemical concentrations, and correlating relationships between several data sets or variables. Appropriate statistical applications will be defined based on the data collected. Results of the data evaluation will be presented in the RI, Risk Assessment, and FS reports as discussed in Chapter 14.

7.0 BASELINE AIR MONITORING INVESTIGATION

This chapter describes the local meteorology, air sampling locations and rationale, sampling and analysis and methodologies to be incorporated in the air monitoring program. DOE regulations state that the ambient air should be monitored to document the effects, if any, of DOE activities on the on-site and off-site environment. This monitoring data will also be used to characterize potential air impacts from the LEHR facility, and provide data for the RA and the FS.

7.1 OBJECTIVES

The air monitoring program has been developed to fulfill the following objectives:

- Document existing off-site, background air concentrations for selected potential contaminants of concern.
- Support a quantitative risk assessment by measuring air intake concentrations.
- Detect, characterize and report unplanned releases and evaluate effectiveness of any effluent treatment and control programs.
- Identify potential environmental problems and evaluate the need for remedial actions if necessary.
- Allow assessment of airborne impacts during subsequent remedial actions and post remedial reductions in releases.
- Establish local meteorological conditions at the site.
- Verify compliance with applicable federal, state and local regulations and DOE Orders.

7.2 SAMPLING PARAMETERS, LOCATIONS, AND NUMBERS

The parameters to be measured in this air monitoring program include both radiologic and non-radiologic parameters. Generally, a radionuclide or chemical will be more readily detected in soil, surface water, or groundwater samples than in air samples.

The air monitoring program will not, therefore, include sampling and analyses for materials whose presence has not been noted at the site, either based on historical use information or based on data from previous soil, surface water, or groundwater investigation programs. The parameters to be measured in the air monitoring program will be limited to contaminants that either: (1) have been noted to be used extensively at the site; or (2) have been detected in previous soil, surface water, or groundwater measurement programs.

Similarly, the location of air monitoring stations will be based on historical records of site activities, planned investigation activities, and soil and water monitoring data, as well as wind direction characteristics at the site.

Due to the seasonal changes at the site (characterized as hot, dry summers and cool, rainy winters) and the resulting potential for a wide range of emission rates of various constituents, the air monitoring program will include sample collection at various times throughout the year. Details of the sampling parameters to be measured, the location of the air monitoring stations, and the number of samples to be collected are presented below.

Since radionuclides have an affinity to water, air monitoring during "wet" months of the year should result in higher values than during the dry months of the year. Therefore, monitoring during the winter months should present the worst-case conditions. As such, our proposed monitoring program is designed to provide a phased approach to sampling frequency. In general, an ambient air monitoring program will have a reduced sampling frequency if the initial monitoring period analytical results are non-detectable and represent wet conditions.

7.2.1 Parameters

The following section provides information on meteorological and analytical data to be collected. Additionally, sampling frequency information is provided.

7.2.1.1 Meteorological

During the air monitoring program, meteorological data would be collected from established sources where possible. If these data do not provide the necessary information to conduct the appropriate modeling, an on-site meteorological station may be needed. Use of off-site data, collected at the UC Davis 20-meter climatological data center was considered. However, measurements at this station currently do not include wind speed, wind direction, or stability class, which are meteorological parameters of primary concern when evaluating risk to nearby populations, including on-site workers and nearby residents. Additionally, the meteorological data currently being collected by the UC Davis station is recorded only once per day which does not accurately record the diurnal wind conditions at the site.

An on-site meteorological station will be located at appropriate distances from buildings according to EPA siting criteria. The station will provide measurement of wind speed and wind direction at an elevation of 2 to 6 meters above ground surface. Sensors will have a starting threshold wind speed of 0.22 meter per second (0.5 mile per hour) and 0.45 meter per second (1 mile per hour) and $\pm$ 5° in azimuth for wind direction. Hourly-average measurements will be recorded with an automated data acquisition system and data will be summarized with standard spreadsheet software.

7.2.1.2 Radiologic Parameters

A number of potential radionuclides of concern identified in past studies at the LEHR site may be of significance to the air monitoring program. However, many of these radionuclides were reported at what appears to be typical background concentrations in surface and subsurface soils. Tritium (H-3) was detected in groundwater collected at the LEHR site in concentrations above 20,000 pCi/L).

Radionuclides will be analyzed on the basis of: (1) their detection in soil or groundwater in typical above-background concentrations; (2) past site history and use; and (3) their relative importance in terms of potential dose to man and the environment. Radionuclides from four main categories were selected for measurement: (1) gamma-emitting radionuclides cobalt-60, cesium-137 and radium-226; (2) isotopic uranium and

thorium to assess the presence of uranium-238 and thorium-232 decay chain radionuclides; (3) both tritium and strontium -90 beta-emitting radionuclides; and (4) radon-222 to assess possible impacts from the decay of radium-226 wastes. Gross alpha, gross beta, and gamma measurements will be collected to assess general activity levels and to detect potential excess activity not found by specific radionuclide analyses.

7.2.1.3 Non-Radionuclide Parameters

Concentrations of non-radionuclides in the ambient air will also be monitored for use in evaluation of risk. Parameters to be measured will include selected metals, pesticides, and volatile organic compounds (VOC). Selection of these parameters is based on: (1) historical use of chemicals on site; and (2) analyses of soil, surface water, or groundwater.

Metals to be measured include chromium, antimony, beryllium, copper, molybdenum, and selenium. Of 212 analyses of soil samples collected during the Phase II Characterization, these metals were reported at concentrations that may be above regional levels.

Concentrations of the pesticide chlordane in the ambient air will be measured. Chlordane was stored and used at the site and has been reported in soil samples.

The ambient air monitoring will include measurement of chloroform and methylene chloride. Both are common laboratory solvents and both have been reported in soil or surface water samples at the site.

In addition to the chemical parameters identified above, air samples will be analyzed for total particulates. Baseline information on particulates will be used to evaluate potential increases in fugitive dust emissions during remedial actions.

7.2.2 Perimeter and Off-site Sampling, Locations and Numbers

Five permanent perimeter air sampling locations will be positioned to the north and south of the LEHR site as shown on Figure 7.1. Sampling locations were selected using local meteorology, available power sources, avoidance of turbulent air flow by nearby buildings and proximity to potential on-site sources. Placement of sampling locations followed the recommendations provided in DOE/EH-0173T to the extent practicable. Samplers will be located at least 15 meters from dirt roads and away from public locations to minimize vandalism and fugitive dust.

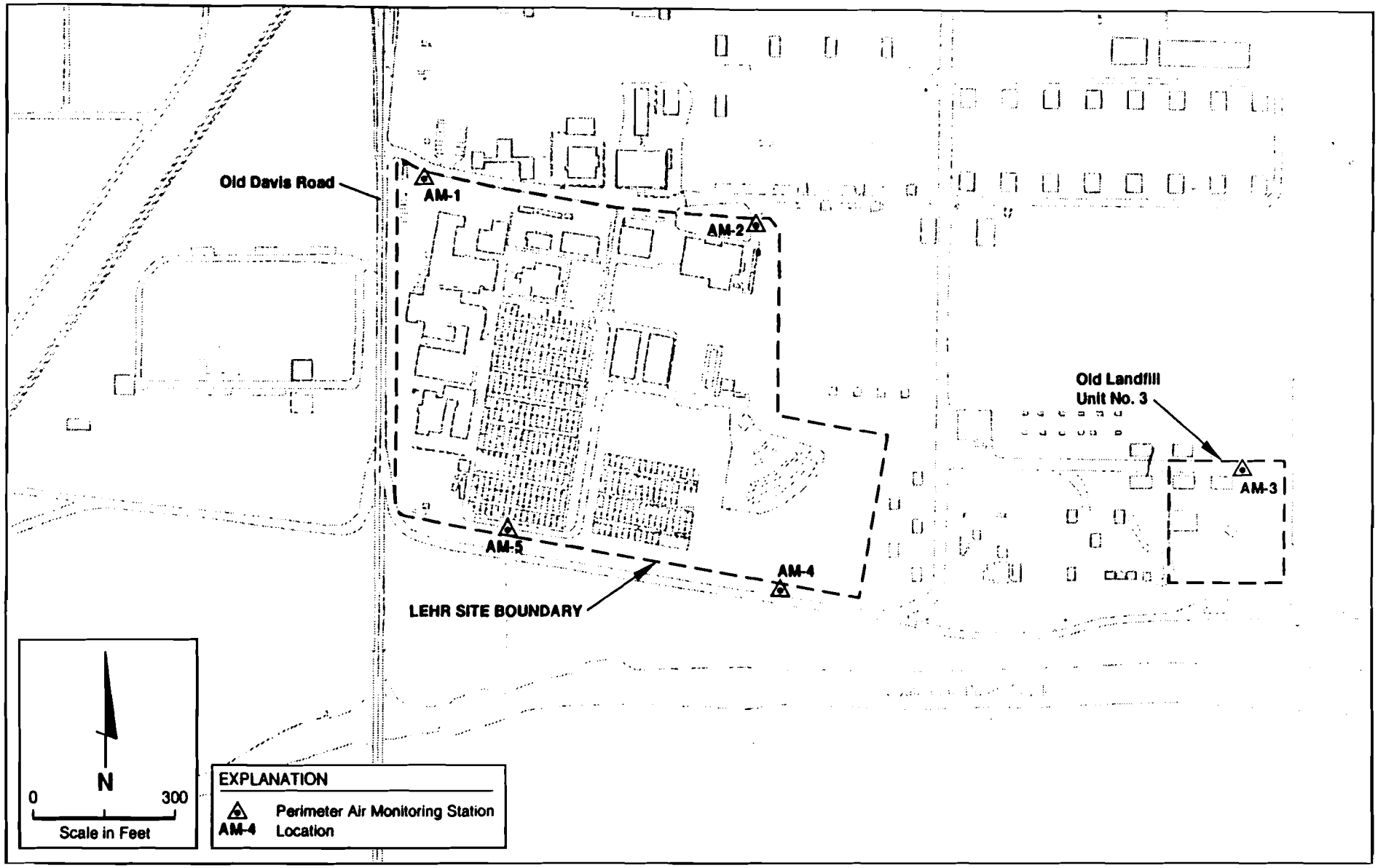
In addition, per DOE/EH 0173T, three off-site background or control measurement air sampling stations will be placed approximately 10 kilometers to the west (least prevalent wind direction) of the LEHR site. The exact location of these background stations will depend upon available electricity, permission from current property owners, and location of chemical interferences, such as pesticide use, buildings and trees. The general locations of the proposed background air sampling stations are shown on Figure 7.2.

7.3 AIR SAMPLING AND ANALYSIS

Sampling and analysis methods proposed for the air monitoring program are presented below. Radiological and chemical methods and sampling frequency are also discussed.

7.3.1 Radiological Sample Collection and Analysis

Sampling methodologies are consistent with the requirements specified in DOE 5400.1, DOE 5400.5 and the Environmental Regulatory Guide For Radiological Effluent Monitoring and Environmental Surveillance (DOE, 1991). As required by DOE (1991), methodologies should provide sufficient accuracy, precision, and completeness to evaluate if airborne radiologic emissions would result in exposures that exceed 0.1 millirem (mrem) per year [effective dose equivalent (EDE)] to a member of the public under realistic

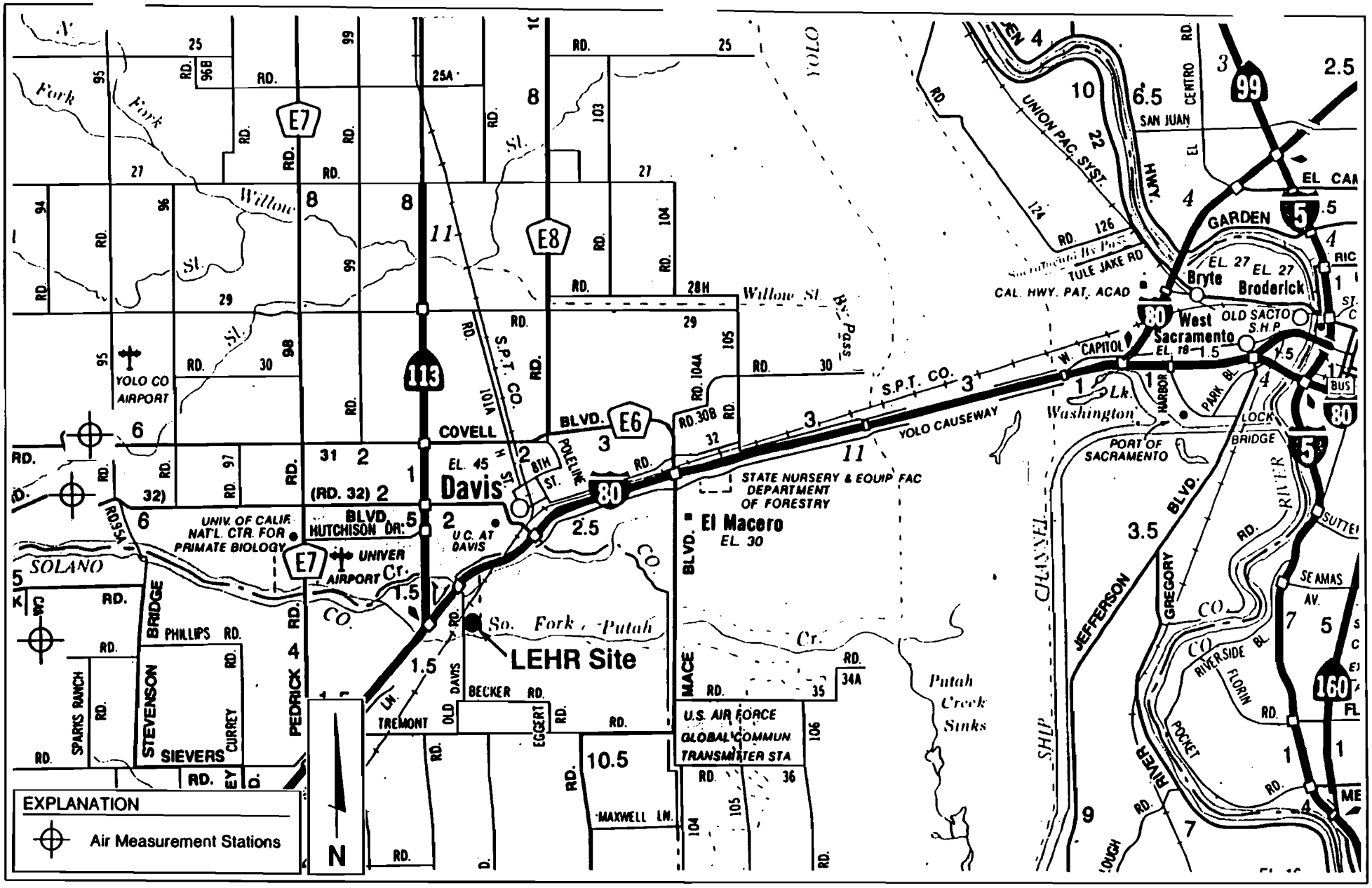


LOCATION MAP
PERIMETER AIR
MONITORING STATIONS

RI/FS Work Plan
LEHR Environmental Restoration
Davis, California

10805-720-044 SJR 2/24/94 5705T

FIGURE 7.1



LOCATION MAP
BACKGROUND AIR MEASUREMENT STATIONS

RI/FS Work Plan
LEHR Environmental Restoration
Davis, California

10805-454-044 JBS 8/27/93

FIGURE 7.2

exposure conditions. If the 0.1 mrem EDE threshold is exceeded, continuous monitoring of emission points, identification of contributing radionuclides, and confirmatory monitoring may be required.

7.3.1.1 Sampling Equipment and Methods

Particulate sampling Particulate air samples will be collected by drawing air through a 47mm 0.45 micron type A/E glass fiber filter at an average maintained flow rate of 40 L/min (1.5 ft^3/min). A Kurz Series-251 brushless motor or equivalent will be utilized to collect air particulate samples. A Series-505 Linear Mass flow meter will be used to determine actual flow rates in the field for each air sampler. The accuracy of the air sampler will be 4 percent over an ambient temperature range of -20 to 80 degrees C. Air intake will be collected by the sampler head at a height of approximately 2 meters above the ground surface to approximate the average human breathing zone. Each air sampler will have a calibration certificate that is NBS traceable and will be housed in a weather-proof outdoor enclosure.

The air sampling train configuration will consist of a filtration sampling head for collection of air particulates, a desiccant column for collection of water vapor, a rotameter or mass flow meter, a dry-gas or mass flow totalizer, possibly an elapsed time indicator and an air pump capable of sustaining continuous flow through the system at an established rate. A tritium silica-gel column will be attached to the particulate sampling system to collect ambient air at an average flow rate between 300 and 600 ml/min depending on local relative humidity.

In air sampling situations, accurate air flow rate, totalizer, and calibration factors are required to determine the total volume of air sampled. The accuracy of radionuclide analysis depends directly upon the accuracy of the volume sampled.

The flow rate through the desiccant columns is adjustable to compensate for seasonal changes in relative humidity. To collect an adequate sample and to prevent "breakthrough" (saturation of the desiccant), the flow rate will be increased to 500 milliliters per minute (mL/min) or higher during the dry summer months (less than 25

percent relative humidity) or reduced to approximately 250 mL/min during the humid (greater than 75 percent relative humidity) winter months.

Flow rates may need adjustment weekly. When compensating for humidity levels, all ambient tritium samplers will be adjusted to approximately equal rates on the same day in order to maintain consistency among sampling locations. Each tritium column will be immediately sealed following collection to prevent loss of moisture potentially containing tritiated water vapor.

Radon-222 will be measured at all permanent air sampling locations using passive alpha track detectors. The detectors will have a sensitivity of 0.1 pCi/L for one month collection periods. Two individual detectors will be deployed at each location and collected monthly. Each radon-222 detector will be sealed following collection and submitted for laboratory analysis within one week.

7.3.1.2 Sampling Frequency

Air particulate and tritium column samples will be collected on a weekly basis unless local weather conditions or dust loading require that samples be collected on a more frequent basis. Weekly samples will be composited to form monthly samples that will be submitted for specific radionuclide analyses. Monthly composites from each of the five perimeter monitoring stations and three background monitoring stations will be analyzed. The sampling frequency will initially be once per month. If the initial three months of monitoring have non-detectable analytical results, the sampling frequency will be adjusted to once every three months. Radon detectors will be collected on a monthly basis from all locations and submitted individually for analysis.

7.3.1.3 Laboratory Analytical Methods

Laboratory analytical methods will be consistent with procedures described in the HASL-300 Environmental Measurements Laboratory Manual (HASL, 1993), 40 CFR 61 Appendix B (EPA, 1989), EMSL-LV-0539-17 (EPA, 1979), and by the American Public Health Association Intersociety Committee (APHA, 1977).

Water collected in tritium column silica-gel will be analyzed by standard liquid scintillation counting methods following dissolution in a scintillation solution and detection by a photomultiplier tube (40 CFR 61 Method B-5).

Gross alpha, beta and gamma measurements will be conducted on all air filters to assess the general activity level of the samples and to properly guide subsequent radiochemical and counting procedures. These measurements will also provide a screening to detect any possible excess activity not found by specific radionuclide analyses. Gross alpha and gross beta measurements will be made using a gas-proportional counter. Gross gamma measurements will be made using gamma-ray spectrometers.

Air particulate filters will be analyzed by low-background direct gas-proportional counting for gross alpha and gross beta following a 7-day holding time to remove interference from naturally-occurring, short-lived radon and thoron daughters (40 CFR 61 Methods A-4 and B-4, respectively). Radon-222 will be measured in ambient air using passive alpha track detectors with plastic scintillators, followed by chemical etching of the alpha penetrations (40 CFR 61 Method A-7). Detectors will be enclosed with plastic and a filter to allow measurement of only radon-222 and its short-lived daughter products.

Gamma emitting radionuclides such as cobalt-60 and cesium-137 will be measured directly using sodium iodide thallium activated crystals, lithium-drifted germanium diodes or hyper-pure germanium-type detectors (40 CFR 61 Methods G-1, G-2, and G-3). Alpha emitting radionuclides such as uranium-238 and thorium-232 decay chain radionuclides will be measured using high-resolution alpha spectrometry with a silicon surface barrier detector, if possible (40 CFR 61 Method A-3). However, if air particulate samples are too thick or non-uniform, alpha spectrometry will be conducted on electro-deposited samples derived from radio-chemical dissolution and separation solutions (40 CFR 61 Method A-1). Radium-226 may also be determined by radon de-emanation procedures. Beta-emitting radionuclides such as strontium-90 will be determined by radiochemical separation followed by direct beta counting (40 CFR 61 Method B-3).

7.3.1.4 Detection Limits

Detection limits to air filter analysis for specific radionuclides are shown on Table 7.1. Minimum detection limits were established using a flow rate of 40 L/min or 4×10^8 ml for a weekly collection of particulates and 3×10^6 ml for the tritium column at a flow rate of 300 cm^3/min. In addition, a minimum detection limit for radon-222 of 0.1 pCi/L will be used.

7.3.1.5 Data Reporting

Analytical results will be reported to 2-sigma uncertainty limits, calculated from counting and other analytical sources of error.. The concentrations will be reported as calculated even when they are less than the error limits or negative, because these concentrations are necessary for meaningful statistical analysis of the data. In all cases, the error limit will be given so that a detection limit can be inferred. The results for short-lived radionuclides will be decay-corrected to the midpoint of the sample-collection interval.

7.3.2 Non-Radionuclide Chemicals

7.3.2.1 Sampling and Analytical Methods and Equipment

Selected metals (chromium, antimony, beryllium, copper, molybdenum, and selenium) will be measured using sampling methods outlined by 40 CFR part 50, Appendix J. This method is used to measure the concentration of PM_{10} in the ambient air for evaluating attainment of the National Ambient Air Quality Standard for PM_{10}. Samples will be collected with PM_{10} samplers manufactured by General Metals Works. Aliquots of the filters for metals analysis will be prepared according to the method outlined by 40 CFR part 50, Appendix G.

TABLE 7.1 MINIMUM DETECTION LIMITS FOR RADIONUCLIDES

NUCLIDE	MINIMUM DETECTION LIMIT (uCi/sample)
Gross Alpha	3E-7
Gross Beta	3E-7
H-3[a]	2E-7
Co-60	5E-6
Sr-90	3E-7
Cs-137	3E-6
Ra-226	1E-6
U-238	3E-7
Th-232	4E-8

[a] Minimum detectable activity for H-3 in uCi/ml of total water collected from the silica gel column.

Metal analysis methods will follow the NIOSH Manual of Analytical Methods (NIOSH, 1984). These methods require digestion of the filter and metals with concentrated acids followed by analysis by either atomic adsorption spectrophotometry with graphite furnace, atomic adsorption spectrophotometry with high temperature flame, or inductively coupled argon plasma (ICAP) spectrophotometry.

Chlordane analysis will follow Method TO-4 (US EPA, 1987). This method includes the adsorption of pesticides on polyurethane foam (PUF) followed by solvent extraction of the PUF and chlordane analysis with a gas chromatograph equipped with an electron capture detector. The high-volume sampler equipped with the PUF sampling head, manufactured by General Metals Works, will be used to collect the samples.

Chloroform and methylene chloride analysis air will follow Method T-14 (US EPA, 1988). This method includes collection of an evacuated, passivated stainless steel canister, followed by cryogenic trapping to concentrate contaminants prior to analysis by gas chromatography/mass spectroscopy (GC/MS).

7.3.2.2 Sampling Frequency

Samples will be collected from each of the eight sampling sites for one 24-hour sampling period, one day per month. The air monitoring program will include monthly sampling and analysis for a 12-month period.

If the sample analytical results are non-detectable over the initial 3-month period, the sampling frequency will be adjusted to one day each 3 months over a 12-month period.

7.3.2.3 Detection Limits

Detection limits for each of the measured chemical parameters are based on limits published in the method descriptions. Table 7.2 presents a summary of the minimum detection limits for each of the parameters to be measured.

TABLE 7.2 MINIMUM DETECTION LIMITS FOR NON-RADIONUCLIDES

Chemical	MINIMUM DETECTION LIMIT ($\mu g/m^3$)
Chromium	0.002
Antimony	0.01
Beryllium,	0.0003
Copper	0.003
Molybdenum	0.01
Selenium	0.06
Chlordane	0.01
Chloroform	0.11
Methylene chloride	1.7

7.3.2.4 Data Reporting

Reported data will include the results of the perimeter samples and a statistical comparison with measured background samples (measured by the three off-site samplers). Measurements will be evaluated with respect to quality control samples (field blanks, field duplicates, laboratory blanks, etc.). Additionally, measured ambient air concentrations will be compared with other background air toxics data collected by the California Air Resources Board. The data and interpretations will be presented in the RI, FS and RA Reports as discussed in Chapter 13.

7.4 QA/QC REQUIREMENTS

The air monitoring program at the LEHR site will include a quality assurance program that is consistent with DOE Orders 5400.1, 5400.5, 5700.6C and the Environmental Regulatory Guide for Radiological Effluent Monitoring and Environmental Surveillance (DOE/EH-0173T). In addition, the QA/QC program will be consistent with the applicable 18-element format of ANSI/ASME NQA-1 which will be considered the preferred standard for radiological monitoring programs. As specified in DOE Order 5400.1 the QA/QC program will include the following programmatic elements: organization responsibility; program design; written procedures; field quality control; laboratory quality control; human factors; record keeping; chain-of-custody procedures; radiological audits; performance reporting; and independent data verification.

The QA/QC Plan is presented in Appendix B of this Work Plan. As discussed in the QAPjP, periodic audits will be performed to verify compliance of air monitoring activities with required QA/QC procedures. Audit results will be documented and appropriate actions taken when necessary.

As required in DOE 5400.5, the analytical laboratory will participate in the DOE QA program for radionuclides regularly measured at the LEHR site on air filters or silica gel. Participation in the interlaboratory program such as the EIA Environmental Radioactivity Laboratory Intercomparison Studies Program may also be required.

An independent verification program will be established prior to submittal of air monitoring samples to an approved analytical laboratory. In addition to participation in interlaboratory programs, duplicate, spiked or blank samples may be submitted to properly assess laboratory performance and completeness of the data. Audits may be performed to ensure that proper QA/QC procedures are adhered to at contracted laboratories and that sample cross-contamination is avoided.

Site-specific QA/QC procedures and administrative controls will be implemented to ensure proper calibration and maintenance of air measuring devices on a pre-approved frequency. Documentation of calibration and vacuum leak testing will be required and routine rotameter readings will be recorded at each permanent air sampling station. Abnormal operations of air sampling equipment will also be reported and documented.

7.5 NESHAP ASSESSMENT

A NESHAP Assessment will be conducted to evaluate compliance with 40 CFR 61, subpart H regulations limiting the committed effective dose equivalent (CEDE) to any individual to 10 mrem/y. It is anticipated that this assessment will utilize environmental air monitoring data and any on-site information for release rates of radionuclides from discrete and diffuse sources. Local meteorology, agricultural usage and demographic data will also be required as input parameters to estimate the annual CEDE to both a maximally exposed off-site individual and the collective population within an 80-kilometer (50-mile) radius. This assessment, using collected environmental air data, will be accomplished using the CAP88PC computer code. This air dispersion code estimates the CEDE for the ingestion, inhalation, air immersion and ground surface exposure pathways. A NESHAP Assessment will be conducted on an annual basis to determine compliance with 40 CFR 61, subpart H requirements and to assess any trends in CEDE to an off-site individual. Results of the NESHAP Assessment will also be utilized to fine-tune the environmental monitoring program by identifying the maximally exposed off-site individual and the critical exposure pathways, as well as radionuclides and chemicals contributing to the CEDE.

8.0 BIOTA INVESTIGATION

This chapter presents a description of the biotic sampling and analysis which could be performed at the LEHR site. Vegetation sampling will be conducted after assessment of the Stage 1 soil sampling programs. Additional detail on the specifics of that sampling will be developed after assessment of the Stage 1 soil sampling programs discussed in Chapter 5. Other sampling programs which could be performed, such as sampling of mammals and fish, are contingent upon the results of the Stage 1 soil sampling programs and the vegetation sampling program. ~~The sampling and analysis as well as sample collection techniques for biota will be described in this section.~~

The objectives of the vegetation and biota sampling program will be to: (1) characterize relevant aspects of the local ecosystem; (2) determine if exposure to chemicals at the LEHR site could pose a hazard to ecological receptors including, threatened and endangered (T&E) species and/or critical habitats and populations; and (3) determine the spatial and temporal extent of potential ecological effects in selected species that could occur on the LEHR site. The biota investigation can be used to determine if site-related chemicals are migrating through the food chain or have affected terrestrial or aquatic ecosystems. ~~If biota data is collected,~~ Sampling collection points will be selected to represent major terrestrial and aquatic habitats at the LEHR site. ~~The three major types of sampling which could be performed are:~~

- ~~Vegetation;~~
- ~~Mammals; and~~
- ~~Fish.~~

Collection of site-specific analytical data for vegetation and possibly biota will ~~may~~ be necessary for the development of realistic site-specific parameters for the Risk Assessment and to identify the extent of chemical impacts on the ecosystem. Assessing the magnitude of human and environmental exposure to contaminants through the food chain depends largely on being able to assess the uptake and bioaccumulation of contaminants in the aquatic and terrestrial food chains. For most contaminants, estimating exposure to chemicals present in the food chain is accomplished through the use of various predictive equations which may overestimate actual exposures. By obtaining site-specific measured data for vegetation and biota, the level of uncertainty associated with these predictive equations can be reduced. If soil, groundwater, surface water and

sediment indicate the potential for food chain transfer of chemicals or if chemical-specific data (e.g., root uptake factors) are not available, then biotic sampling may be necessary. The conditions under which vegetation, mammals and aquatic organisms at the LEHR site could be sampled are described in the following paragraphs.

Vegetation potentially impacted by chemicals originating from the LEHR site can be characterized into two broad categories: produce and terrestrial food resources. Sampling and analysis of agricultural produce from nearby crops may be indicated if soil, groundwater, surface water or sediment indicate off-site contamination of radionuclides is currently or could have historically occurred. Similarly, sampling and analysis of terrestrial food resources will be performed on-site if sufficient on-site vegetation is available and if screening level of analysis of soil levels, root uptake factors and bioaccumulation factors indicate potential impacts to terrestrial receptors could occur.

If evaluations of chemical analytical data in soil or vegetation indicate the potential for adverse impacts to terrestrial receptors, then mammals may be collected for chemical tissue analyses.

Fish in Putah Creek may be collected and undergo chemical analysis if analytical data indicate elevated contaminants in surface water in excess of the ambient water quality criteria (AWQC) for protection of freshwater aquatic life, or AWQC for protection of human health, or if sediment levels are found in excess of sediment quality criteria. Whole-body fish analyses would be performed for the ecological component of the risk assessment, whereas chemical analyses of the fillets would be performed for the human health evaluation.

Fish in Putah Creek will be collected and submitted for chemical analysis only if analytical data in surface water and sediments indicate elevated contaminants levels. Fish tissue will be collected if the following conditions are met:

1. Chemical levels are found in surface water in excess of the ambient water quality criteria (AWQC) for proitection of freshwater aquatic life.

2. Sediment contamination levels are found in excess of sediment quality criteria.

3. Chemical levels in surface water are in excess of AWQC for protection of human health from seafood ingestion; i.e., if a screening level evaluation of the chemical concentrations multiplid by a chemical-specific bioconcentration factor indicate potential health risks to humans ingesting fish from Putah creek. Generally, chemical concentrations in fish predicted using BCFs overpredict concentrations found in biota under field conditions. As such, if adverse impacts are predicted under this conservative approach, actual tissue data can be helpful in confirming or negating predicted adverse impcts.

4. Chemical-specific bioconcentration factors are not available in the literature and cannot be reasonably estimated.

If conditions 1 or 2 are met, then whole-body fish analyses would be performed for the ecological component of the risk assessment. If conditions 3 or 4 are met, chemical analyses of the fillets would be performed for the human health evaluation.

In summary, the goals of this sampling program are to characterize pertinent aspects of the local ecology and evaluate potential effects of chemical migration on terrestrial, including humans, and aquatic biota through the food chain.

8.1 VEGETATION

Reconnaissance surveys will be performed to provide a consistent and encompassing view of area habitats and to provide qualitative observations for relative comparisons among vegetation/land use types. Reconnaissance surveys will also be used to identify habitats of the indicator species. Examples of vegetation types could include old field, grassland, wetland, and riparian. The principal vegetation components to be considered in the risk assessment are the native and disturbed vegetation at the LEHR site and, possibly nearby agricultural fields. Terrestrial ecological investigations will focus on the primary floral and associated faunal components of the LEHR site and, if indicated, off-site impacted areas. Produce from nearby fields may be collected if off-site migration of chemicals is reasonably expected to occur (e.g., irrigation with impacted groundwater). Selection of sampling sites will be completed after additional site information is collected and terrestrial ecological receptors are selected.

8.1.1 Sample Collection

Prior to beginning sample collection, a detailed map of the sampling locations shall be prepared. Sampling locations will be defined in terms of area landmarks, in order to ensure consistent layout of the sampling grid for current and future sampling.

Vegetables (produce) ~~may~~will be collected from agricultural areas where permission can be obtained. Produce can potentially be contaminated by two routes: root uptake and adherence of contaminants deposited from the air. If possible, to ensure that the plants sampled reflect contamination from both the root uptake and deposition pathways, leafy above-ground crops (e.g., lettuce and spinach) as well as root crops (e.g., carrots and onions) will be sampled. Leafy vegetables are more likely to reflect deposition of chemicals, while root uptake is expected to be greater for root crops. Only edible plant portions will be sampled, and samples will be cleaned of loose soil but will not be washed before analysis.

Types of vegetation and portions of the plants (e.g., flowers, twigs, etc.) to be collected for terrestrial ecological receptors will be identified based on the dietary preferences or requirements of the indicator species. Vegetation types may also be selected based on availability among the various vegetation/land use types, utility as forage or food for receptor organisms, and representativeness of the major life forms common to the vegetation types in the study area (grasses, forbs, and shrubs). Vegetation types which occupy sufficient acreage to form a major proportion of the LEHR site or otherwise have an ecological importance (i.e., wetlands and riparian areas have disproportionate ecological importance because of the aquatic/upland influence on floral and faunal diversity and density) will be included in the sampling program. In addition, depending on the distribution of site contaminants, several plant types could be collected and composited for analyses to represent a specific area. The specific methods for collection of the vegetation samples is described in the vegetation sampling SOP in Appendix A.

8.1.2 Chemical Analysis

In general, the chemical analytes will be selected based on the chemical types found in soil for that area. Terrestrial vegetation samples could be analyzed for metals, pesticides, and radionuclides. VOCs will not be analyzed for since these compounds do not tend to accumulate in vegetation. ~~However, p~~Produce will only be analyzed for radionuclides, since agricultural practices could have resulted in pesticide and metal contamination of the produce. Extraction procedures will follow EPA-approved methods.

Quality Assurance/Quality Control (QA/QC) duplicate and split samples will be collected to provide essential comparison data. These samples will represent at least 10 percent of the total number of samples. The duplicate sample will receive full analysis and the split sample will receive radiological analysis.

8.2 MAMMALS

If chemical analytical data in soil or vegetation indicate the potential for adverse impacts to terrestrial receptors, then mammals may be collected for chemical tissue analyses. Because a primary objective of the biota program is to track analyte migration through the food web, characterization and reconnaissance efforts for mammals may be collocated with the vegetation sampling. If the mammal sampling is deemed necessary, a revision to the work plan presenting details on this sampling will be prepared.

Chemical analytical data in soil and/or vegetation will be used to evaluate the need for sampling of mammalian tissue in order to assess the potential for adverse impacts to terrestrial receptors. Mammalian tissue will only be collected if the following conditions are met:

1. If vegetation data are not available for selected chemicals, chemical data for soils combined with root uptake factors will be used to determine the potential for plants to sequester chemicals in concentrations and cause adverse impacts to species ingesting the plants.

2. A screening analysis of concentrations in vegetation multiplied by chemical-specific bioaccumulation factors indicate the potential for adverse effects to occur in terrestrial species or their predators.

3. Chemical-specific uptake and bioaccumulation factors are not available in the literature and reasonable surrogate values cannot be estimated.

If biota is collected, characterization and reconnaissance efforts for mammals may be collocated with the vegetation sampling, because a primary objective of the biota program is to track analyte migration through the food web.

8.2.1 Sample Collection

If mammal sampling is necessary, the three areas to be evaluated will be the Dog Pens, Landfill Disposal Unit #2/Dog Pens, Landfill Disposal Unit #1. At each area of concern, a short small-mammal trapline or grid will be established consisting of Sherman live traps (to facilitate capture of larger species such as rats) and museum special snap traps. For a trapline configuration, traps will be placed at intervals along a line, with alternating live and snap traps. For a grid configuration, traps will be placed at intervals along parallel lines spaced apart with alternating live and snap traps. Traps will be baited with a mixture of oats and peanut butter and will remain set for a period of two to three nights. Traps will be inspected each day for captives and reset. Captures will be recorded by species, method of capture, sex, age, general physical condition, and other pertinent observations (e.g., lactating female, lesions, open sores, etc.). Animals which are to be released will be marked to facilitate identification of recaptures. It is anticipated that white-footed mice will be the most common species captured. After collection of sufficient animals for tissue analysis, all remaining captures will be released. If an insufficient number of mice have been captured during the first two to three nights of effort, traps will be left in place for up to an additional three nights to improve the opportunity for a complete composite sample. However, traps will not be left for longer than six days because immigration from surrounding areas becomes more likely with time, therefore, yielding potentially biased information. If possible, at least two specimens will be retained from each area of concern. Collected animals (if not from a snap trap) will be dispatched by cervical dislocation; recorded as to species, location of collection, and other pertinent data (e.g., weight, general health); and bagged for immediate freezing.

A reference location near agricultural fields will also be sampled to determine background levels of metals and pesticides associated with agricultural practices in the region. These samples will be collected and analyzed in the same manner as the on-site locations.

A subsample from each location may be segregated for separate body component analyses. These subsamples will be surgically separated into four distinct groups for analysis: (1) external fur, (2) main digestive tract and contents, (3) principal skeletal tissue (i.e., long bones), and (4) all remaining soft body tissues. The intent of this component body analysis is to allow a determination of true body burden levels in mice (to facilitate application to whole-body tissue samples) and eliminate the inclusion of chemical contamination from food items which normally pass out of the animal or which may be attached externally to the fur, both of which would be included during whole-body analyses. In addition, to allow a realistic evaluation of actual potential for exposure to the higher trophic levels of hawks, owls, and other predators, bone tissue must be segregated since bones are typically regurgitated by, or passed through, the predators of mice.

8.2.2 Chemical Analysis

The chemical analytes will be selected based on the chemical types found in soil or vegetation for that area. The mammalian tissue samples could be analyzed for inorganics (EPA Method 6010 and for some metals, the 7000 series), pesticides (EPA 8080) and radionuclides. Extraction procedures will follow EPA-approved methods.

Quality Assurance/Quality Control (QA/QC) samples will be collected to provide essential comparison data. These samples will represent at least 10 percent of the total number of samples. The duplicate sample will receive full analysis and the split sample will receive radiological analysis.

8.3 FISH

The purpose of the aquatic sampling program is to: (1) collect tissue samples for analysis, and (2) characterize fish inhabiting nearby surface water bodies. A site

reconnaissance will be conducted to document the availability and quality of aquatic habitat. Putah Creek is expected to be the only potentially impacted aquatic system.

8.3.1 Sample Collection

Fish sampling may be used to document fish species occurrence, relative abundance, and to determine bioaccumulation levels of compounds in muscle tissue and whole bodies of fish species. The Putah Creek sampling locations will be selected based on the surface water sampling locations (Section 6.6), but may be adjusted based on the occurrence of the fish. Because the primary water source for Putah Creek is the UC Davis wastewater treatment plant in summer months, fish collections should occur in the spring or late fall or winter. In addition, because of the presence of nearby agricultural fields, collection of a fish at a reference site may be necessary to document background conditions.

Fish may be collected at each sample location by using a variety of methods including gill netting, seining, minnow trapping, and electroshocking, depending on Putah Creek conditions at the time of sampling. To the extent possible, fish sampling will be standardized for each area sampled. Collected fish will be retained alive until processing, but not longer than 8 hours to avoid depuration. Depending on the relative abundance of fish species, species with different feeding habits may be selected for analysis (e.g., bottomfeeder versus pelagic species). Bottomfeeders have a tendency to potentially ingest contaminated sediments, while pelagic forms represent those species which consume various aquatic vertebrates. Individual fish from each respective group could be randomly selected for tissue analysis.

If fish sampling is performed, whole-body (without skin) fish samples will be collected from each sample location. Additionally, samples of fillet from edible species (e.g., carp) will also be collected. Both whole bodies and fillets will be analyzed in order to provide data which represent the dose potentially obtained by higher trophic organisms which feed on fish inhabiting the LEHR site, including humans. Thus, the proposed samples will represent both table fare consumed by humans and forage consumed by higher trophic level organisms.

All collected fish will be identified, weighed, and measured. Data will be entered into a field logbook following completion of the sampling. Additionally, any signs of stress including abnormal conditions of skin, eyes, gills, and fins will be documented on the standard field form.

8.3.2 Chemical Analysis

The chemical analytes will be selected based on the chemical types found in sediment or surface water for that area. Because of the mobility of fish and the proximity of Putah Creek to agricultural fields, as well as the influence of the wastewater treatment plant discharge, the fish tissue samples will likely only be analyzed for radionuclides and hexavalent chromium. However, if surface water data indicate chemicals are found in Putah Creek near the LEHR site, but not in upgradient areas, then fish tissue analyses of metals, VOCs and SVOCs, and pesticides may also be performed.

Quality Assurance/Quality Control (QA/QC) duplicate and split samples will be collected to provide essential comparison data. These samples will represent at least 10 percent of the total number of samples. The duplicate sample will receive full analysis and the split sample will receive radiological analysis.

9.0 ENVIRONMENTAL AND HUMAN RESOURCES

This chapter describes the scope of environmental characterization efforts necessary to assure compliance with the intent of the National Environmental Policy Act (NEPA) as required by DOE 5400.4 and subsequent guidance memoranda such as the Secretary of Energy memorandum on NEPA, dated June 13, 1994. The majority of characterization information needed to adequately evaluate remedial alternatives will be generated during efforts described in Chapters 5, 6, 7, and 8. Data collected during the CERCLA RI process will ensure that sufficient data are obtained to evaluate FS options under CERCLA and as such will comply with the intent of NEPA. Data will be acquired not only to characterize soil, water, air and ecological impacts, but also to support evaluation of migration and release pathways, risk analysis, and ultimately an impact analyses of existing conditions and future remediations.

The scope of this chapter is limited to the additional elements of environmental characterization that will be conducted to meet specific requirements of NEPA and/or CEQA, but which may not be explicit requirements of a CERCLA RI/FS. These activities include:

- baseline characterization of the existing flora and fauna on and adjacent to the site, including an evaluation of threatened or endangered species assessment and their critical habitat;
- wetland and floodplain characterization;
- characterization of cultural, historical or archaeological resources;
- land use;
- socioeconomic, infrastructure and demographic characterization; and
- characterization of noise, population, housing, transportation, public service, energy, utilities, human health, aesthetics, and recreation.

Baseline characterization of the potentially affected environment on and around the LEHR site will be necessary to support the evaluation of impacts that could result from implementation of remedial alternatives evaluated in the FS.

Adequate characterization for most environmental considerations has been conducted previously for the Decommissioning and Decontamination (D&D) of LEHR facilities. These analyses and the assessment of impacts from the D&D project were presented in an EA, DOE/EA-0785, (DOE, 1992) and a finding of no significant impact (FONSI) was issued. Additionally, some CEQA information was developed during the Preliminary Study for site characterization of the UC Davis landfill at the LEHR site (Dames & Moore, 1991c). From these documents, information relevant to the evaluation of remedial alternatives for site cleanup will be identified for use in the RI/FS. In some instances additional information may be generated as described below. This information will be included to support the RI, Risk Assessment, and used to evaluate environmental impacts for the preferred remedial alternative.

9.1 BIOLOGICAL RESOURCES

Available references and DOE/EA-0785 characterize the biological resources potentially affected by proposed remediation actions. Based on conclusions in DOE/EA-0785, there are no sensitive, rare threatened or endangered species within the LEHR site boundaries. During site characterization activities for the RI/FS, the applicability of this conclusion to potential FS actions will be confirmed through consultation with local, State and Federal agencies, such as the Fish and Wildlife Service (FWS). These contacts will serve to confirm expected conclusions of no impact to biological resources and also fulfill the NEPA and CEQA requirement to consult with relevant agencies in the preparation of the NEPA section of the FS document. Unless the range of remediation alternatives evaluated in the FS includes actions significantly outside the current facility boundaries, no additional site specific characterization of biological resources will be conducted.

9.2 CULTURAL RESOURCES

Based on DOE/EA-0785, there are no cultural resources, historical or archaeological sensitive areas at the LEHR site. Therefore, the D&D activities would not have any impact on these types of resources. However, due to potential ground disturbing actions included in the FS evaluation of remedial alternatives, the D&D EA committed to a complete survey for these types of resources in the NEPA-CEQA documentation prepared for the RI/FS. As part of the RI, specialists in these technical areas will review the available literature on the

site, conduct site specific surveys, and consult with the local, State and Federal experts. Formal contacts will be made and documented with the State Historic Preservation Officer (SHPO). Based on previous studies, it is anticipated that such reviews will generate a conclusion of no impact and concurrence by the SHPO.

9.3 INFRASTRUCTURE

Based on DOE/EA-0785 the existing infrastructure around the LEHR site was adequate to support D&D project needs. It is anticipated that remediation alternatives evaluated in the FS would not place significantly different demands upon the infrastructure system. Baseline infrastructure information gathered for DOE/EA-0785 appears to be adequate to support the impact assessment of the RI/FS or NEPA-CEQA section of the FS for remediation of the site. It is expected that the same references will be utilized and that no original characterization activities will be required.

9.4 LAND USE

Land use within a 1-mile radius of the LEHR site was characterized in DOE/EA-0785. Unless characterization activities identify the need for remediation actions beyond this distance, the existing data base should be adequate to support assessment in the RI/FS documents. Specific environmental issues of concern such as wetlands and floodplains have been evaluated in the EA and found not to exist at the LEHR site. Limited efforts will be required to confirm the applicability of these conclusions to remedial alternatives. Land use information will also be taken into consideration during the risk assessment.

9.5 PUBLIC HEALTH AND SAFETY

Baseline conditions were established in DOE/EA-0785 for exposure levels during D & D work at the fenceline. These data will be used to supplement monitoring data obtained during the RI to document the lack of offsite consequences from existing conditions. In addition, the same approach for radiological impact assessment to the offsite public used in DOE/EA-0785 is proposed for the RI/FS. This approach calculates the maximum radiation dose to the public for both routine operations and accident

conditions rather than assessing the exposure to the total adjacent population. Data obtained during the RI will be used to generate activity specific source terms for each remedial alternative and to calculate the dose consequences to both workers and the public. Use of this approach during the DOE/EA-0785 resulted in exposures that were well below acceptable limits, thus justifying a FONSI and eliminating the need for detailed characterization of population distribution around the LEHR site.

9.6 SOCIOECONOMICS

Sufficient information exists in DOE/EA-0785 and available references to assess the socioeconomic impacts of remedial alternatives. No additional information is required.

9.7 TRANSPORTATION

Most baseline information and assumptions needed to assess the consequences from remedial alternatives that involve transportation of wastes to the Hanford site are provided in DOE/EA-0785. The same route assumptions and characteristics used in the D&D EA analyses will be utilized for this evaluation. In addition, action-specific parameters such as activity levels, numbers and types of shipping containers, and numbers of trips will be generated for each remedial alternative requiring transportation of wastes to other disposal sites such as the Hanford facility or any other DOE-approved disposal facility. Dose calculations to workers and the public will be generated for normal operations and credible transportation accidents.

It is assumed that the disposal of wastes at the Hanford facility from the LEHR site remedial activities is adequately addressed by the EIS for Hanford Waste Management Operations and that no disposal impacts will need to be addressed in the RI/FS for the LEHR site remediation. This approach was utilized by DOE for the D&D wastes shipped to Hanford. This policy decision is specifically referenced in the EM response to the State of Washington's comment letter on the pre-approval draft EA (see S.A. Mann to R.A. Stanley 6/17/92 letter in comment resolution appendix of DOE/EA-0785). This same approach is proposed for the RI/FS documents.

10.0 RISK ASSESSMENT

A risk assessment addresses both human health and ecological impacts of a site under current baseline, active remediation, and post-remediation conditions. Three separate assessments are typically required and submitted as individual subtask deliverables. A baseline risk assessment is used to evaluate a no-action remedial alternative and may be completed using existing data. The second and third risk assessment deliverables are completed after the RI to evaluate risk during and after remedial activities. The following sections describe the approach to development of a risk assessment for the LEHR site.

Section 300.430(d) of the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) (*Federal Register* 55/46/8709) states that as part of the remedial investigation, a risk assessment must be conducted to determine whether, in the absence of remedial action, constituents of concern identified at the site pose a current or potential risk to human health and the environment.

The overall technical approach to this Risk Assessment is based on the *Risk Assessment Guidance for Superfund* (RAGS) Volume I, Human Health Evaluation Manual, Part A (EPA, 1989a) and Volume II, Environmental Evaluation Manual (EPA, 1989b). The DTSC has proposed technical guidance standards for risk assessments to supplement the existing RAGS guidance. Should the DTSC standards become finalized before this baseline Risk Assessment is completed, this document will reflect adherence to these DTSC standards as well. The major tasks involved in the health and ecological risk assessments are as follows:

- Data collection and evaluation;
- Exposure assessment;
- Toxicity assessment;
- Risk characterization;
- Ecological risk assessment; and
- Uncertainty assessment.

The LEHR site has a variety of potential chemical and radioactive constituents. This Work Plan provides a methodology to assess the nature and extent of radioactive and

hazardous materials identified in previous investigations. It also describes how potential constituents of concern and exposure pathways are determined, and how exposure concentrations are estimated. This section of the Work Plan will also specify a method to collect toxicity information to determine appropriate toxicity values, followed by a characterization of the potential for effects to occur following human and ecological exposure to and intake of constituents. Uncertainty will be evaluated through each step of the Risk Assessment culminating in an overall quantitative uncertainty summary which will be included in the Risk Assessment Report.

10.1 DATA COLLECTION AND EVALUATION

The objective of the data collection task is to summarize all data available for use in preparation of further data evaluation activities, if necessary. This step identifies relevant historical data, assembles RI data, and establishes formats to facilitate data evaluation. The following data attributes, as they relate to the Risk Assessment, are important to this step:

- Sample design with sample locations and numbers;
- Analytical methods and detection limits;
- Results for each sample including qualifiers and error terms;
- Sample detection limits for nondetects;
- Sample mass, type and collection times and dates;
- Field conditions; and
- Sample documentation, chain-of-custody and Standard Operating Procedures.

Subtasks to be performed as part of the data evaluation task include the following:

- Review of available site data obtained during all phases of the RI;
- Identification of data gaps;
- Analysis of chemicals and radionuclides detected at the site and their frequency of detection;
- Statistical testing of collected data;
- Preliminary identification of potential exposure pathways;

- Development of a data set for use in the Risk Assessment; and
- Identification and selection of appropriate toxicity criteria.

10.1.1 General Data Requirements

Data needs and Data Quality Objectives (DQO) have been formulated to specifically identify the data collection and evaluation required to fully assess all potential exposure pathways, where possible. Specific site characterization data to be collected to support a human health and ecological risk assessments are outlined below.

- **Surficial Soils:** Surface soil data will be used to estimate exposure and risk through ingestion, dermal contact, and estimate airborne particulate concentrations for subsequent inhalation exposures. Dose rate measurements will also be obtained for purposes of estimating external exposures to penetrating radiation originating in surface soils.
- **Soils:** Constituent concentrations as a function of depth will be used to assess whether geostatistical methods, such as spatial correlation or deterministic statistics (triangles or polygons), should be employed. These data will also be utilized to quantify the source terms of each area under investigation at LEHR and provide materials to determine necessary geotechnical and geochemical data to be used in fate-and-transport analysis.
- **Surface Water and Sediments:** Constituents in surface water will be used to evaluate fate and transport and estimate risk from ingestion or dermal contact with surface water and sediments. Inhalation of sediments and consumption of fish may also be assessed.
- **Groundwater:** Site-specific hydrogeology and potential constituents in groundwater will be used to evaluate fate and transport and estimate exposure and risk from ingestion, inhalation, external exposure, or dermal contact with groundwater.
- **Air:** Resuspension and dispersion of contaminated surficial soils will be used to evaluate fate and transport and estimate risk from inhalation, ingestion of deposited contaminants and external exposure pathways. Measured concentrations will be used to support the exposure assessment.

Data collected during the RI process in conjunction with land use and population locations will be evaluated for use in developing the preliminary exposure scenarios for the

LEHR site. Particular attention will be paid to the selection and evaluation of background levels of radionuclides and chemicals, since only health risks resulting from site activities will be quantified. In general, synthetic organic chemicals detected at a site are typically assumed to have zero background concentrations because they are produced by human activities and do not occur in nature. However, there are other activities adjacent to the LEHR site which may contribute organic and inorganic chemicals to the system. In contrast, metals occurring at the site have natural background concentrations not resulting from LEHR site activities. The proper and careful assessment of background concentrations will therefore be important in the subsequent attribution of risks to the site.

10.1.2 Identification of Data Gaps

Since humans and the environment can potentially be impacted by constituents in soils, surface waters, groundwater, sediments, air particulates and biotic compartments, existing sampling data for the LEHR site will be examined to ensure that a statistically adequate number of sample data are available for Risk Assessment activities. It should be noted that in the case of air data, dispersion modeling can be used to estimate contaminant concentrations at selected receptor locations not specifically monitored. Identified data gaps will be filled by specifically developed or modified RI tasks.

10.1.3 Statistical Testing

Methodologies provided in RAGS (EPA, 1989a) will be used in evaluating detection limits, qualifiers on analytical results, inclusion or exclusion of Tentatively Identified Compounds, and comparison of site concentrations with background samples. All data collected during the RI process will be analyzed statistically by using standard normal or nonparametric tests. Statistical calculations will be used to estimate analyte concentrations at the site. Both the arithmetic average and the 95-percent upper confidence limit (UCL) on the arithmetic average will be calculated. Environmental Protection Agency guidance for risk assessment (EPA, 1989a) specifies that the 95-percent UCL on the arithmetic average should be used to represent the exposure concentration. Distributional tests will be used to determine whether the data are normally distributed, or whether the lognormal model provides better estimates of the arithmetic average and 95-percent UCL concentrations. Geostatistical techniques will be utilized to

assess contaminant concentrations at depth in LEHR site soils and assist in developing defensible cleanup criteria.

10.1.4 ARAR Analysis

Applicable or Relevant and Appropriate Requirements (ARARs) and To-be-Considered (TBC) guidelines will be identified, selected and applied according to guidance described in *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA* (EPA, 1988). Chemical-specific ARARs and other health-based criteria will be addressed in the Risk Assessment. ARARs and TBCs will be developed ~~identified~~ from the range of chemicals and pathways identified during various phases of ~~in~~ the RI and other Risk Assessment tasks. Factors that will be considered in selecting health-protective criteria will include:

- Chemical and radionuclides present;
- Affected media (air, soil, surface water, groundwater, biotic);
- Specific goals and objectives of the criteria;
- Specific regulatory and legal considerations; and
- Circumstances under which an ARAR may be waived.

Waivers for ARARs include implementation of interim remedial measures and circumstances in which compliance with an ARAR would result in greater health risks than would be obtained using a risk assessment. An ARAR analysis report will be a required subtask deliverable.

10.1.5 Potential Constituents of Concern

Potential constituents of concern that may be evaluated during the Risk Assessment have been identified from existing analytical data resulting from preliminary remedial investigation at the LEHR site. Tables 10.1 through 10.3 list potential constituents of concern detected in soil, surface water, and groundwater during some of the previous investigations. The constituents of concern are summarized as radionuclides, organic chemicals or inorganic chemicals.

TABLE 10.1 POTENTIAL CONSTITUENTS OF CONCERN DETECTED IN SOIL

Pen Soil Samples

Radionuclides
Cesium-137
Potassium-40
Radium-226
Strontium-90
Thorium-232
Tritium

Organic Chemicals
Chlordane

Inorganic Chemicals
Nitrogen (nitrate)

Soil Boring Samples

Radionuclides
Bismuth-214
Cesium-137
Lead-210
Lead-212
Lead-214
Potassium-40
Radium-226
Strontium-90
Thorium-232
Tritium

Organic Chemicals
Chlordane
Di-N-butylphthalate
Methylene chloride

Inorganic Chemicals
Arsenic
Barium
Beryllium
Cadmium
Chromium (total)
Chromium (hexavalent)
Cobalt
Copper
Lead
Mercury
Molybdenum
Nickel
Nitrogen (nitrate)
Thallium
Vanadium
Zinc

Monitoring Well Soil Samples

Radionuclides
Actinium-228
Cesium-137
Cobalt-60
Lead-212
Lead-214
Manganese-54
Potassium-40
Radium-226
Strontium-90
Thallium-208
Thorium-232
Tritium

Organic Chemicals
Chlordane
Diethyl phthalate
Methylene chloride

Inorganic Chemicals
Antimony
Arsenic
Barium
Beryllium
Cadmium
Chromium (total)
Chromium (hexavalent)
Cobalt
Copper
Lead
Mercury
Molybdenum
Nickel
Nitrogen (nitrate)
Selenium
Silver
Thallium
Vanadium
Zinc

TABLE 10.2 POTENTIAL CONSTITUENTS OF CONCERN DETECTED IN SURFACE WATER

Radionuclides	Organic Chemicals	Inorganic Chemicals
Strontium-90	2-Chlorophenol	Antimony
Tritium	4,4'-DDD	Barium
	4,4'-DDE	Beryllium
	4,4'-DDT	Cadmium
	Aldrin	Calcium
	Alpha-BHC	Chloride
	Beta-BHC	Chromium (total)
	Bis(2-ethylhexyl)phthalate	Chromium (hexavalent)
	Bis(2-isopropyl)ether	Cobalt
	Bromodichloromethane	Copper
	Chloroform	Lead
	Delta-BHC	Magnesium
	Di-N-butylphthalate	Mercury
	Dibromochloromethane	Molybdenum
	Dieldrin	Nickel
	Endosulfan I	Nitrogen (nitrate)
	Endosulfan II	Phosphate (total)
	Endrin	Potassium
	Gamma-BHC	Selenium
	Heptachlor	Silver
	Methylene chloride	Sodium
	Toluene	Sulfate
		Thallium
		Vanadium
		Zinc

TABLE 10.3 POTENTIAL CONSTITUENTS OF CONCERN DETECTED IN GROUNDWATER

Radionuclides	Organic Chemicals	Inorganic Chemicals
Carbon-14	1,1,1-Trichloroethane	Antimony
Strontium-90	1,1-Dichloroethane	Barium
Tritium	1,1-Dichloroethene	Beryllium
	1,2-Dichloroethane	Cadmium
	4,4'-DDE	Calcium
	Aldrin	Chloride
	Alpha-BHC	Chromium (total)
	Benzyl butyl phthalate	Chromium (hexavalent)
	Beta-BHC	Cobalt
	Bis(2-ethylhexyl)phthalate	Copper
	Bromodichloromethane	Lead
	Chloroform	Magnesium
	Delta-BHC	Mercury
	Di-n-butylphthalate	Molybdenum
	Dieldrin	Nickel
	Endrin	Nitrogen (nitrate)
	Endrin aldehyde	Phosphate (total)
	Gamma-BHC	Potassium
	Heptachlor	Selenium
	Methylene chloride	Silver
	Toluene	Sodium
	Trichloroethene	Sulfate
	Trichlorofluoromethane	Thallium
		Vanadium
		Zinc

Detected radionuclides included tritium, carbon-14, cobalt-60, strontium-90, potassium-40, cesium-137, and radionuclide members of the uranium-238 and thorium-232 decay chains. Since tritium, carbon-14, potassium-40, and the decay chain radionuclides are present as natural constituents, these potential constituents of concern will only be included in the Risk Assessment process if they are found at concentrations above established background. If both decay chains are found at concentrations above background, then a complete set of all radionuclides present in the decay chains will be included unless site characterization data can be utilized to limit inclusion of these radionuclides.

Similarly, many inorganic constituents of concern will only be quantitatively considered if documented to be elevated above background concentrations. Organic chemical constituents of concern include a wide list of constituents.

Analytical results from field sampling will be used to select those contaminants that will most likely contribute significantly to risk of the general public and the environment. These constituents of concern will represent the most toxic, mobile and persistent contaminants at the LEHR site. Because there will be a phased approach to field sampling and data evaluation programs, the evaluation of constituents of concern will be continually developed as new data is collected.

Guidance on statistical methods include RAGS (EPA, 1989a), *Guidance for Data Useability in Risk Assessment* (EPA, 1990), *Statistical Methods for Environmental Pollution Monitoring* (Gilbert, 1987), and *Statistical Analysis of Ground-Water Monitoring Data at RCRA Facilities — Interim Final Guidance* (EPA, 1989). To ensure against omissions, chemicals will be considered to be potentially elevated above background concentrations unless all of the site concentrations are clearly the same as background. All of the data will be plotted for a visual comparison of site and background concentrations. Statistical methods will include distributional tests, transformation of the data, if appropriate, and comparison of site and background concentrations by an appropriate normal or nonparametric method.

The screening process begins with site-specific analytical results for contaminants. The data will be evaluated according to RAGS Section 5.9.3 to determine if the detection

frequency is greater than 5 percent. The constituent will be considered for ". . . elimination from the quantitative risk assessment if: (1) it is detected infrequently in one or perhaps two environmental media; (2) it is not detected in any other sample media, or at high concentrations; and, (3) there is no reason to believe that the chemical may be present" (EPA, 1989a). Constituents with a detection frequency less than or equal to 5 percent will be evaluated to assess whether they are likely to be sampling or analytical artifacts. Constituents that do not appear likely to be present at the site, and that are not found at concentrations that would contribute significantly to risk, will be eliminated from further consideration. Constituents with a detection frequency greater than 5 percent will be retained for further screening.

The next step in the screening process is to assess if the constituent is considered a carcinogen. EPA guidance will be employed to identify constituents that are classified as Group A, B, or C carcinogens. All carcinogens with detection frequencies above 5 percent and statistically elevated above background concentrations will be included in the Risk Assessment.

The final screening step is to assess if any of the constituents retained in the screening process are essential human nutrients. As stated in RAGS Section 5.9.4, "chemicals that are (1) essential human nutrients (2) present at low concentration only slightly elevated above naturally occurring levels, and (3) toxic only at very high doses much higher than those associated with contact at the site need not be considered further in the quantitative risk assessment (EPA, 1989a). Examples of such chemicals are iron, magnesium, calcium, potassium, and sodium." Consequently, constituents that meet the essential nutrient criteria will not be considered further.

Constituents retained through the screening process represent the most prevalent toxic, persistent, or mobile constituents at the LEHR site. A list of constituents of concern that will be used in the quantitative risk assessment will be summarized and submitted as a subtask deliverable.

10.2 EXPOSURE ASSESSMENT

The exposure assessment estimates the magnitude, frequency, duration, and route of exposure to humans. The magnitude of exposure is typically evaluated by measuring or estimating the amount of a constituent available at exchange boundaries such as the lungs, gastrointestinal tract, or skin during a specified time. Contact with the agent may lead to absorption, the magnitude of which is of great importance in applying dose-response data for assessing health risks.

Exposure assessments are performed using scenarios that define the conditions of exposure to constituents at a site. An exposure scenario quantitatively defines the human populations that may be exposed, frequencies and durations of exposure, pathways of exposure such as inhalation, drinking water, or dermal contact with soil, levels of constituents in the air, water, or soil that contact the population through exposure pathways, and the assumptions used in estimating intake rates in humans.

Exposure assessments are developed by obtaining the following information:

- Identification and characterization of present and future exposed populations;
- Development of applicable exposure scenarios for present and future populations;
- Characterization of site parameters that control environmental mobility and constituent transport;
- Identification and evaluation of exposure pathways for each exposure scenario;
- Estimation of exposure point concentrations for each applicable pathway at the receptor location for each credible exposure scenario; and
- Quantification of constituent intakes for each applicable pathway for each credible exposure scenario.

In accordance with guidance (EPA, 1989), and to provide a conservative health-protective estimate of risks, future land use will be assumed to be residential. Such an assumption will provide estimates of risk for the most sensitive human receptors (e.g., children, pregnant women, and the elderly).

10.2.1 Identification and Characterization of Exposed Populations

Identifying and characterizing exposed populations include an estimate of present and future population size, characteristics, and spatial patterns relative to the site. Potentially exposed populations include the following:

- Current on-site workers;
- Current off-site residents;
- Future on-site remediation workers;
- Future on-site construction workers;
- Future on-site residents; and
- Future off-site residents.

Section 2.4, Conceptual Site Model, describes the potentially exposed populations, land and groundwater use, and the general exposure setting of the LEHR site. A matrix of the current and future populations as a function of direction and distance from the LEHR site will be constructed using current demographic data.

The baseline Risk Assessment guidance requires that potential risks associated withfuture use of the site also be quantitatively evaluated. LEHR representatives will be consulted on potential future use of the site, and worst-case exposure scenarios consistent with such use will be developed in the Risk Assessment. It should be noted that, in keeping with EPA guidance, future risks from the site must be evaluated on the assumption that the site may be developed for residential purposes unless there is evidence to the contrary.

10.2.2 Development of Potential Exposure Scenarios

Potential exposure scenarios will be defined according to guidance provided in RAGS. Reasonable maximum exposure scenarios will be defined considering realistic applications involving contaminant migration and receptor intake. Primary worst-case exposure scenarios for present and future populations are discussed below under baseline, remediation/construction, and post-remediation conditions.

- **Baseline Conditions:** Current and future on-site workers at the LEHR site could potentially be exposed to constituents via inhalation of VOCs and

radon from soil or groundwater, inhalation of resuspended soil particulates, dermal contact with surface soils and surface water, ingestion of surface soils, or external exposure to penetrating radiations.

Current and future off-site residents near the LEHR site could potentially be exposed to constituents via inhalation of VOCs and radon from groundwater or on-site soils, inhalation of dispersed particulates, ingestion of cultivated food irrigated with impacted groundwater, dermal contact with and ingestion of impacted groundwater or surface water in Putah Creek, ingestion of fish from Putah Creek, or external exposure to penetrating radiations emanating from groundwater, radon, constituents in site soils, or deposition of air particulates.

- **During Remediation or Construction:** Future on-site workers could be exposed by all of the above baseline scenarios for current on-site workers. However, the potential for exposure, duration of exposure, and potential constituent intake would all increase. Engineering and procedural health and safety measures will be implemented to limit such theoretical increases in potential exposures to on-site workers. Remediation or construction workers will also have potential exposure to subsurface contaminants in soil or groundwater during active excavation or remediation, and from ingestion of impacted food products on site.

  Future off-site residents will potentially be exposed by the same scenarios as discussed for off-site residents under baseline conditions. However, potential exposures will increase due to remediation activities such as release of airborne particulates and radon from impacted source areas and possible transportation of impacted materials off site.

- **Post Remediation:** Following remediation, future on-site residents could be exposed to constituents via inhalation of VOCs and radon released from buried wastes or groundwater, ingestion of cultivated food, fish and surface water impacted by unremediated groundwater, and dermal contact with surface water and sediments. Given the nature of the site and because it is serviced by the UC Davis water supply system, it is unlikely that drinking water wells would be installed on site in the future, so exposure to constituents remaining in groundwater would not occur for future on-site residents.

  Future off-site residents would potentially be exposed by these scenarios, as well as ingestion and dermal contact with impacted groundwater and external exposure to radionuclides in groundwater.

In both exposed populations, the inhalation of VOCs, radon, and particulates from soil, and external exposure to penetrating radiations from surface and subsurface soils would be controlled or eliminated. Remediation, mitigation, or natural flushing of contaminants in groundwater and surface water will also effectively reduce or eliminate exposure to contaminants in these media as a function of time. Resulting risk from these pathways would be expected to decrease exponentially.

10.2.3 Characterization of Site Parameters

Physical and chemical characteristics of exposure pathway media can greatly affect the potential transport and rate of movement of specific contaminants. Such characteristics must be quantified and utilized as input parameters in environmental fate-and-transport models. Air modeling parameters would include meteorological data such as a joint frequency distribution of wind speed and direction as a function of stability class. The determination of the soil and subsoil particle size distribution would also be crucial since activity or concentration of contaminants for the respirable fraction and its relative abundance in terms of mass would have to be quantified. Since radon and VOCs are potential constituents of concern at the LEHR site, knowledge of the percent saturation, porosity and density of the soils would be developed in order to effectively model movement of these contaminants through the soil matrix. In addition, the diffusion and emanation of radon would have to be measured in a laboratory setting to properly estimate and model surface flux of radon available for downwind dispersion from each of the LEHR site source areas. Radon parameters would also be critical in determining the remediation alternative requirements affecting the construction of a radon barrier or off-site transportation of wastes containing radium-226.

Groundwater modeling parameters would include meteorological data such as annual precipitation, runoff, flow rates, and aquifer flow rates. The K_d partition coefficients for contaminants would also be critical since this parameter is very sensitive in determining transport and resulting exposure following the transfer from the soil column to the vadose or pore fluids available for groundwater transport. Because the LEHR site is not in the 100-year flood plain, potential impacts from flooding do not need to be addressed.

All necessary transport model parameters will be summarized for each exposure pathway media type to provide necessary input data to adequately model environmental transport of contaminants. In most instances, it is anticipated that EPA- or DOE-recommended default parameters will be used for the baseline Risk Assessment until site-specific input parameters have been determined (EPA, 1991a).

10.2.4 Identification and Evaluation of Exposure Pathways

Once potentially exposed populations and exposure scenarios have been identified and characterized, exposure pathways can be traced from the site to identified receptor locations. Each exposure pathway describes a mechanism by which a hypothetical receptor is exposed to contaminants originating from the LEHR site. Exposure pathways consist of the following four elements:

- Source of *constituent release* to the environment;
- Environmental *transport medium* (surface water, groundwater, soil gas, soil or ambient air);
- *Exposure point* contact with constituents of concern; and
- *Route of intake* for constituents into the receptor (inhalation, ingestion, or dermal contact, and, in the case of radionuclides, external exposure to penetrating radiation).

Section 3.4, Conceptual Site Model, describes potential exposure pathways for the LEHR site and summarizes routes of intake and exposure media for various exposure scenarios under baseline conditions, during remediation and following remediation. Only those exposure pathways found to be complete where a plausible route of exposure can be demonstrated to be possible will be quantitatively evaluated in the Risk Assessment. During the course of the remedial investigation at the LEHR site, exposure pathways may be refined, added, or eliminated based upon newly acquired data and resultant modifications to the Conceptual Site Model.

10.2.5 Estimation of Exposure Point Concentrations

Accurate estimates of constituent concentrations at points of human or ecological exposure are a prerequisite for evaluating intake in potentially exposed receptors. For some media, direct measurement of concentrations may not be feasible, accurate, or cost-

effective. As described below, environmental fate-and-transport models will be used to estimate exposure point concentrations in such situations.

Potential receptors at the LEHR site may be exposed to air emissions from either subsurface volatile organic compounds (VOCs) or surface particulates. Alternatives, such VOCs in groundwater may also serve as a source of human exposure. If such compounds are detected in these media at the site, then exposure may occur via indoor or outdoor air. In either case, vapor emission modeling using EPA-approved approaches such as the Jury's Behavior Assessment Model or the Landfill Air Emissions Estimation Model may be used. These models and their applications are discussed in the Air Superfund National Technical Guidance Study Series (EPA, 1993; 1992, 1991). Selection of one or more specific models must await detailed chemical data from the site, and a more complete understanding of soil and groundwater conditions to establish if such pathways of exposure are complete. An EPA-approved dispersion model, such as the Industrial Source Complex Short Term (ISCST) Model, will be used to evaluate vapor or particulate dispersion to receptors greater than 100 m from the source (e.g., nearby residents or off-site workers).

For radionuclides, the CAP88PC code will be utilized to model site emissions and assess their associated impacts to workers and the public. The RESRAD code will be used to develop and evaluate cleanup criteria for radionuclides, and an appropriate code will be selected to assess impacts resulting from accident release scenarios, if necessary.

Concentrations of constituents of concern in soil, air, and water may be measured or approximated using detection equipment, calculations, or computer models. Constituent concentrations may be measured at discrete points or as volume estimates using geostatistics or other determinate methodologies. Estimated concentrations of constituents of concern in each environmental medium will then be used to calculate the resulting intake and health risk to a receptor.

Concentrations of constituents of concern in soil will be estimated either by direct sampling at representative locations or by radiological detection equipment calibrated to soil radioactivity in picocuries per gram (pCi/g) as a function of exposure rate. Depending on the spatial variability and degree of variance of impacts, various statistical

methodologies will be utilized to assess average concentrations in source areas at the LEHR site. These concentrations will then be used as input data to assess resuspension, dispersion, and deposition of soil-associated impacts as they are transported from source areas to receptor locations.

Receptor exposures may result from direct or indirect contact with soil. For example, direct exposure may result from ingestion or inhalation of soil particulates or from penetrating radiation emitted by soil-bound constituents. Indirect exposure may result from inhalation of soil particulates or volatilization of constituents transported by air dispersion and deposition of impacted soil particulates on potential food products.

Air is an effective transport medium for constituents and can carry constituents of concern at the particulate level or molecular level over large distances to receptors. Due to atmospheric dispersion and depositional processes, concentrations of constituents of concern in air will decrease with distance from the source of impacts. The assessment of potential health risks from a site due to inhalation exposure requires the prediction of airborne chemical concentrations. Depending on the populations of these constituents, estimates of airborne contaminant concentrations may be needed at the site of emissions, at some off-site distance away from the site of emissions, or both. The selected emission models will be used to estimate the transfer of constituents of concern from soil to air. The model may be calibrated using data collected from the baseline air monitoring program. The magnitude of this emission will depend on both the concentrations measured in soil, meteorological conditions, soil particle size properties and the possible volatilization of contaminants. The selected dispersion model will then be used to estimate concentrations of airborne constituents of concern at exposure locations that are not monitored. These concentrations will be used in conjunction with estimates of intake to drive scenario-specific exposure estimates.

Groundwater modeling will also be conducted to estimate exposure point concentrations at off-site locations from the LEHR site. Such modeling will evaluate the potential migration of contaminants from source area soils and wastes to groundwater transported to receptor wells. Specification of chemicals and radionuclides, K_d values, and aquifer flow rates will all be important parameters to quantify.

Constituents can be transferred from air to other media by deposition on soil or vegetation. Concentrations of constituents of concern in soil, vegetation, meat, and milk are a function of the calculated concentrations in air, deposition rates, and various transfer functions. Therefore, the calculated airborne and non-air transfer of constituents will be used as input to assess intake of constituents in the food chain. For purposes of calibration, modeling estimates will be compared with field monitoring data, where possible. Since ecological receptors will also be considered in the LEHR site Risk Assessment, appropriate methods will be used to calculate exposure point concentrations.

10.2.6 Quantification of Contaminant Intake

As discussed above, environmental fate-and-transport modeling and/or monitoring data are used to estimate constituent concentrations in transport media at the point of contact with the receptor. Such contact constitutes human or ecological exposure. Exposure is expressed in terms of intake, and defined as the amount of a contaminant taken into the body per unit body weight per unit time. Intake rates are calculated separately for exposures to contaminants in each environmental medium via soil, air, groundwater, surface water, and food. Then, for each exposed population, intake rates are summed for dermal, oral, and inhalation exposure routes. Intakes are typically expressed in units of milligram of substance per kilogram of body weight per day (mg/kg-day), or picocuries per year (pCi/y) for radionuclides. Adjustments for absorption efficiency may be required for dermal routes of exposure. The adjustments include toxicity values from administered to absorbed doses, and an adjustment for medium of exposure.

The following assumptions and calculations are used to estimate intake in humans from exposure to contaminants present in soil, air, groundwater, and surface water. The magnitude of exposure is influenced by frequency and duration of contact with these media. Also, the age of the potentially exposed individual will influence the extent of contact with these chemicals. Three categories of parameters can be used to estimate intake:

- Contaminant-related parameters (concentration);
- Characteristics of the exposed population (contact rate, frequency, and duration of exposure, inhalation rate, soil ingestion rate, drinking water consumption rate, skin surface area, and body weight, among others); and

- Duration of exposure (time).

Concentrations used in the intake calculations will be derived from statistical calculations estimating arithmetic and 95-percent upper confidence limit values for site contaminants. Standard statistical measures will be used to evaluate collected data as described in Section 10.1.3.

Contact rate reflects the amount of impacted medium to which an individual is exposed per unit time or event. Professional judgment will be used to estimate these parameters based on site-specific considerations, and on a review of the pertinent scientific literature and EPA guidance documents. Any deviations from standard EPA default assumptions will be clearly noted in the text of the Risk Assessment document along with the rationale for its use. A brief discussion of the pertinent literature is presented in the following sections to support proposed parameter values.

Exposure frequency and duration are site-specific parameters that will be estimated following characterization of potentially exposed populations. The population characterization data will be combined with EPA estimates of residence time to obtain an estimate of duration (EPA, 1991). Exposure frequency will consider human activity patterns. Studies of human activity patterns indicate that, for employed individuals, a relatively large proportion of time is spent in activities within one's home, in transit, or in one's workplace. A relatively small proportion of time is spent in all other activities. Under current and future use scenarios, this study will use the best available data for site-specific population dynamics. The assumptions made for frequency of potential exposure will attempt to account for this information. If a long-term average contact rate is indicated by the exposure scenario being evaluated, then a daily exposure frequency will be used.

Intake rates will differ for different age groups since body weight and inhalation rates change during a lifetime. For some exposure pathways, such as soil ingestion, exposure can occur throughout life, but the majority of significant exposure occurs during childhood due to higher contact rates and lower body weights of children. In these cases, exposures will be calculated separately for each age group. Lifetime exposure is calculated by taking the time-weighted average of exposure estimates over all age groups. Data

obtained from *RAGS Supplemental Guidance* (EPA, 1991) will be used to obtain body weights and inhalation rates for different age groups.

Estimates of human intake for each pathway will be calculated based on equations from RAGS (EPA, 1989a) and other standard reference sources. Calculations will be based upon the pathways and exposure scenarios developed for inclusion in the Risk Assessment and will use estimated contaminant concentrations derived from environmental fate-and-transport modeling.

10.3 TOXICITY ASSESSMENT

Toxicity assessment is the process of characterizing the relationship between the dose or intake of a substance and the incidence of an adverse effect in the exposed population. Toxicity assessments evaluate results from studies with laboratory animals or from human epidemiological studies. These evaluations are used to extrapolate from high levels of exposure where adverse effects are known to occur, to low levels of environmental exposures where effects can only be predicted based on statistical probabilities. The results of these extrapolations are used to establish quantitative indicators of toxicity. Toxic effects are divided into two classes for purposes of establishing quantitative indicators of toxicity: noncarcinogens and potential carcinogens.

Health risks from all routes of exposure identified in Section 7.2 will be characterized by combining the chemical intake information with numerical indicators of toxicity. These health-based toxicity criteria will be obtained in the form of EPA-developed reference doses or slope factors. These criteria are available from the following:

- The Integrated Risk Information System (IRIS), a data base made available by the Environmental Criteria and Assessment Office (ECAO) (EPA, 1993); and
- The Health Effects Assessment Summary Tables (HEAST), a manual compiled by the Office of Solid Waste and Emergency Response (OSWER) (EPA, 1992a).

Toxicity criteria from IRIS are given priority over those from HEAST. If these sources of information do not contain health-based toxicity criteria for a particular contaminant, a

health-protective number may be derived in the toxicity assessment task using established procedures as listed in RAGS (EPA, 1989a).

The Risk Assessment will include a toxicological profile for each chemical and radionuclide detected at source areas at the LEHR site. Toxicological profiles will be submitted to PNL and subsequently to pertinent regulatory authorities for review and final approval. These profiles will discuss the following:

- Acute and chronic toxic effects of these chemicals in humans;
- Uncertainty associated with values (uncertainty factors, modifying factors, and weight of evidence for potential carcinogens, if available); and
- Environmental fate and transport (degradation process, products, mobility within each medium, and potential means of transport from one medium to another).

10.3.1 Noncarcinogenic Chemicals

Reference Doses (RfD) are used to evaluate the potential for adverse noncarcinogenic effects due to potential chemical exposures at a site. The RfD is based on the assumption that thresholds exist for certain non-cancerous toxic effects such as cellular necrosis, but may not exist for other toxic effects such as cancer. In general, the RfD is an estimate of a daily exposure to the human population that is likely to be without an appreciable risk of deleterious effects during a lifetime of exposure. RfDs were derived by including sensitive subgroups and have an inherent uncertainty that can span an order of magnitude.

10.3.2 Carcinogenic Chemicals and Radionuclides

Evidence of carcinogenicity of a contaminant comes from two sources: life-time studies with laboratory animals, and human studies where excess cancer risk is associated with exposure. Unless evidence to the contrary exists, if a carcinogenic response occurs at the exposure levels studied, it is assumed that a similar response will occur at all lower doses. Exposure to any level of a carcinogen is therefore considered to have a finite risk of inducing cancer. This approach assumes a linear non-threshold model to predict health effects as a function of dose.

Since risks at low levels of exposure cannot be quantified directly from either animal or epidemiological studies, mathematical models are used to extrapolate from high to low doses. The linearized multi-stage model procedure for low-dose extrapolation is recommended by EPA (EPA, 1986b). Use of the linearized multi-stage model leads to a plausible upper-bound estimate of risk.

The linearized multi-stage model incorporates procedures for estimating the largest possible effect and resultant risk at low doses that is consistent with the experimental dose-response data. The animal data used for extrapolation are taken from the most sensitive species studied. The risk estimates made with this model should therefore be regarded as health-protective and representative of the most plausible upper limit of risk.

Numerical estimates of cancer potency are presented as Slope Factors (SF). Under the assumption of dose-response linearity at low doses, the SF defines the cancer risk due to continuous lifetime exposure to one unit of carcinogen. Cancer risk assessment involves calculating upper-bound estimates. Individual cancer risk will be calculated as the product of exposure to a carcinogen and the SF for that carcinogen. Cancer risks from exposure to multiple carcinogens and multiple pathways will be assumed to be additive (EPA, 1986b).

10.4 RISK CHARACTERIZATION

Risk characterization involves estimating the magnitude of the potential adverse effects under study, and presents summary judgments of the impacts to public health and the environment. Characterization of risk involves combining the results of the exposure and toxicity assessments to provide numerical estimates of health risk. These estimates are comparisons of exposure levels with appropriate RfDs or estimates of lifetime cancer risk with a particular intake. Risk characterization also considers the nature and weight of evidence and the magnitude of uncertainty surrounding risk estimates.

10.4.1 Quantification of Health Risks

Health risks from each constituent may be calculated using two methods: one to determine carcinogenic effects, and another to determine noncarcinogenic effects. The

following calculations will be used to obtain quantitative estimates of lifetime cancer risks for carcinogenic chemicals and radionuclides:

$$Risk = Intake \times SF \tag{1}$$

where:

Risk	=	Potential cancer risk adjusted for lifetime exposure (unitless)
Intake	=	Chemical intake (mg/kg/day)
SF	=	Slope factor $(mg/kg/day)^{-1}$

The potential for carcinogenic effects from non-radiological constituents will be estimated by calculating excess lifetime cancer risks from the lifetime average exposure and cancer SFs. For radionuclides, the committed effective dose equivalent (CEDE) will be calculated using estimates of the annual intake of each radionuclide and specific dose conversion factors. The CEDE will then be used to calculate lifetime cancer risk estimates with slope factors for inhalation, ingestion, air immersion and external irradiation pathways.

Cancer risks will be summed across all carcinogens considered in the risk assessment. This summation of risk assumes independence of carcinogens in their ability to cause an effect and that a synergistic or multiplicative effect will not occur.

Noncarcinogenic effects will be evaluated by calculating a hazard quotient. The hazard quotient is the ratio of the intake rate to the RfD. Hazard quotients will be summed as hazard indices for those chemicals known to produce similar adverse effects in the same target organ using the following equation:

$$HI = \sum \frac{E_i}{RfD_i} \tag{2}$$

where:

HI	=	Hazard index
E_i	=	Exposure level intake for toxicant i

RfD_i = Reference dose for toxicant i

E and RfD are expressed in the same units and represent the same exposure period. Limitations on the application of this procedure are discussed in RAGS (EPA, 1989a).

Finally, risks from individual constituents and exposure pathways will be summed for noncarcinogens if it is determined that the same individual or population receptor could plausibly be exposed to more than a single constituent via multiple pathways. This summation will therefore result in an estimate of the total risk from the overall exposure to all constituents. If a reasonable exposure pathway combination is identified, and consistent target organs and mechanism of toxicity are present, then the cancer risks and hazard indices will be summed separately. Adjustments for absorption efficiency may be required for dermal routes of exposure (EPA, 1992). The adjustments include toxicity values from administered to absorbed doses and an adjustment for medium of exposure.

The Risk Assessment will present the chemical and radiological risk estimates separately. The Risk Assessment will also include a discussion on the additivity potential for these risks.

10.4.2 Dose Assessment

Since DOE 5400.5 and 5480.11 both stipulate dose limits for radiological constituents, a dose assessment will also be conducted to demonstrate compliance with these requirements. Specifically, compliance with the 100 mrem/y and 5,000 mrem/y to a member of the public and an on-site worker will be addressed, respectively. Estimates of CEDE will be determined from existing radionuclide concentrations in environmental media for relevant exposure pathways. Computer models such as CAP88PC and RESRAD will be utilized to quantify does estimates to on- and off-site receptors and populations. Predicted dose to individuals will be compared quantitatively with limits stipulated by DOE Orders. Appropriate dose conversion factors from EPA (1988b) or DOE (1988b) will be utilized. Unless otherwise specified, all doses will be reported as 50-year CEDE following an annual uptake of radiological contaminants via ingestion, inhalation, and external exposure.

10.5 ECOLOGICAL RISK ASSESSMENT

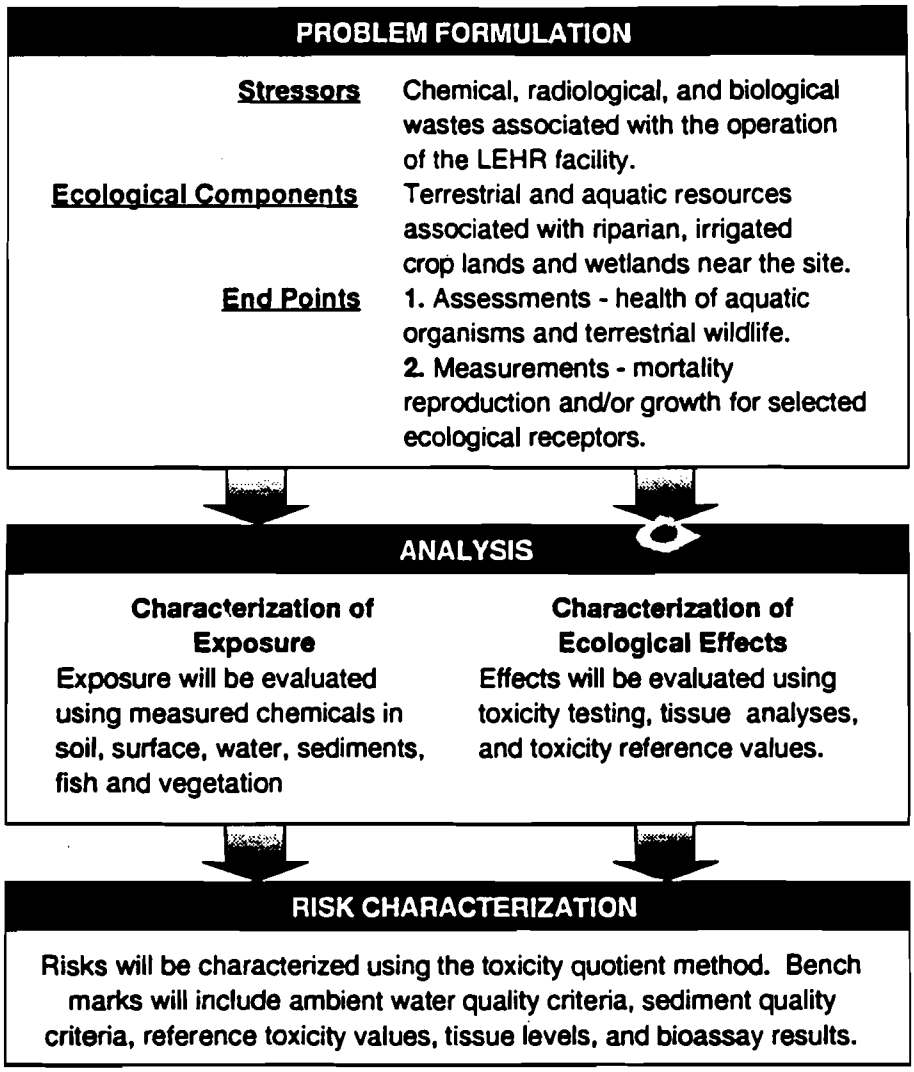
EPA guidelines require that risks to non-human receptors also be evaluated in a baseline Risk Assessment (EPA, 1989b). This approach is also endorsed by DTSC. The ecological risk assessment will qualitatively and quantitatively assess the actual and potential impacts of constituents on the ecological community present at the LEHR site and its vicinity. A site-specific ecological risk assessment will also assess impacts resulting from all remedial action alternatives, and will be utilized to assist in the development of effective remediation cleanup criteria. The ecological risk assessment would be conducted following general procedures outlined in RAGS Volume II, Environmental Evaluation Manual (EPA, 1989b), and in the *Framework for Ecological Risk Assessment* (EPA, 1992b). The ecological risk assessment will present the constituents of concern and other stressors, endpoints to be evaluated, conceptual exposure model, key ecological receptors, ecological characterization data, toxic effects assessment, risks associated with exposures, an uncertainty analysis including a discussion of assumptions, and the likelihood of ecological recovery. This assessment will be comprised of three steps:

1) Problem Formulation - defines the stressors (e.g., chemicals, habitat alteration, etc.), the ecosystems potentially affected, and the endpoints to be evaluated.

2) Analysis - consists of the characterization of exposure and ecological effects.

3) Risk Characterization - evaluates the likelihood that adverse ecological effects occurred or will occur when exposed to a stressor. The toxicity quotient method will be used.

An overview of the approach to the ecological risk assessment is presented in Figure 10.1. The major decision points in the ecological risk assessment are summarized in Figure 10.2. Each of these steps are discussed further in the following sections.

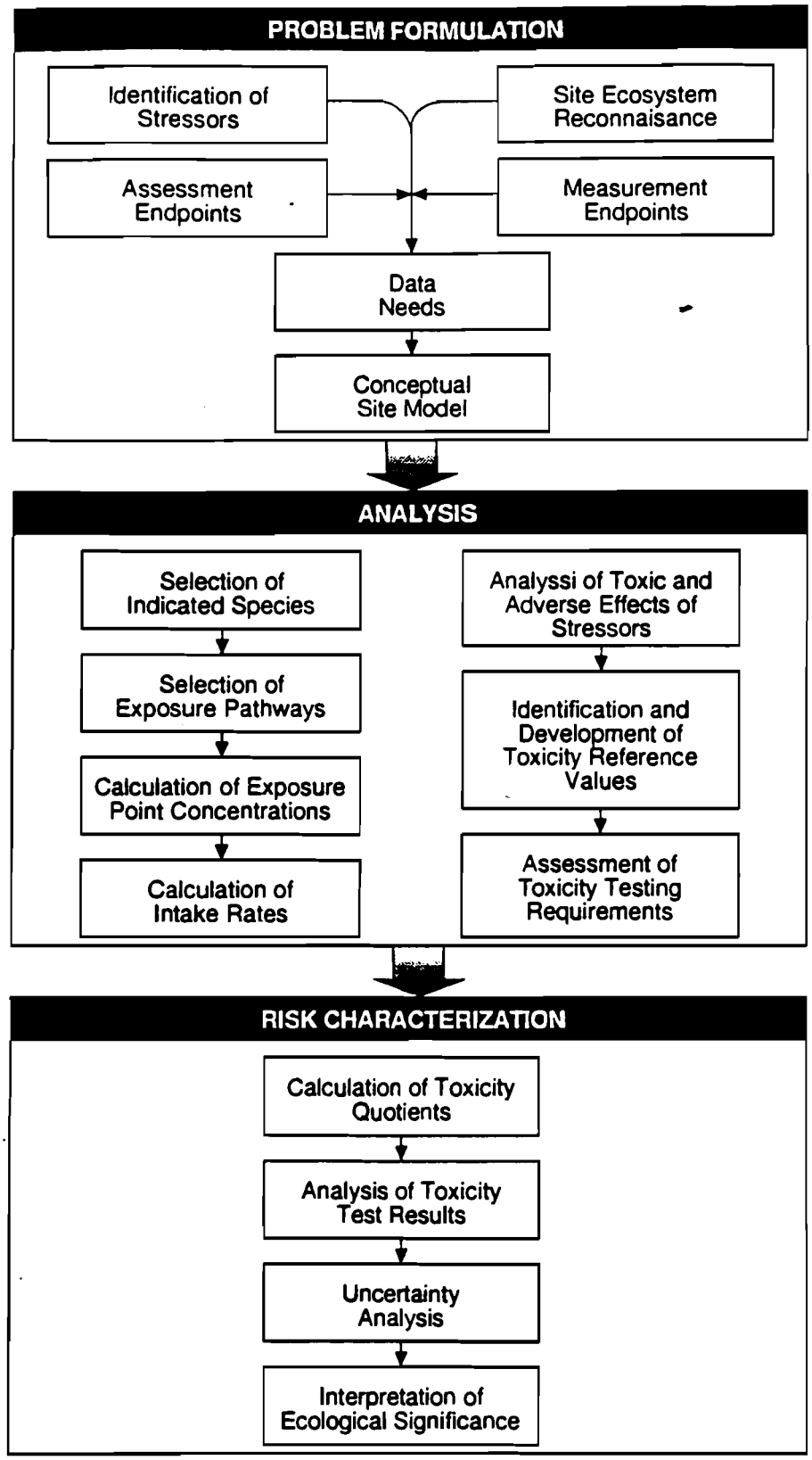


OVERVIEW OF ECOLOGICAL RISK ASSESSMENT APPROACH

RI/FS Workplan
LEHR Environmental Restoration
Davis, California

10805-72-044.jdg.2/24/94.eco.0

FIGURE 10-1



FLOW CHART OF MAJOR DECISION POINTS IN THE ECOLOGICAL RISK ASSESSMENT

RI/FS Workplan
LEHR Environmental Restoration
Davis, California

10.5.1 Problem Formulation

The first phase of the ecological risk assessment is problem formulation. This step establishes the goals and focuses the remedial investigation. This step will assess ecological resource contact with constituents of concern and evaluate the potential for adverse impacts to individual species and ecosystems resulting from such contact. All constituents of concern will be identified and the need for any additional data requirements documented in this step. Since the National Environmental Policy Act (NEPA) also requires an assessment of environmental impacts, data and program requirements should be carefully coordinated to avoid redundancy and to ensure that characterization will supply required data for both concerns. Additional information on ecological resources is presented in Chapter 9 of this Work Plan and the DOE/EA-0785. The outcome of this step will be a conceptual model describing the data needs and the potential impacts of the stressors on the ecosystem. The basic steps in problem formulation are:

- Identification of stressors (chemical, physical or biological);
- Identification of ecosystems potentially at risk (sensitive populations, habitat types, etc.);
- Endpoint selection (measurement and assessment)

The stressors to be considered in the baseline Risk Assessment will include chemical, radiological and biological wastes in soil, surface water, sediment, vegetation, and fish associated with disposal and other operations at the LEHR facility. Contaminant levels in groundwater are unlikely to significantly impact the ecological risk assessment. As indicated in the CEQA Preliminary Environmental Study (Dames and Moore, 1991c), environmental impacts from characterization would be temporary; therefore, physical stressors associated with site characterization activities will not be evaluated in the ecological risk assessment.

Sensitive populations are discussed in Sections 2.4.3 and 3.4.4 and are summarized in Table 2.3. Types of habitat located near the LEHR facility include riparian, irrigated croplands and wetlands. Given the potential presence of chlorinated pesticides

(e.g., chlordane, DDT), species high on the food chain (e.g., raptors, piscivorous birds) may be particularly susceptible to site-related contamination.

There are two types of endpoints considered in the ecological risk assessment: assessment endpoints and measurement endpoints. For the LEHR site, the assessment endpoint is the health and condition of selected ecological components. Measurement endpoints at the LEHR site will include comparison of measured concentration of constituents of concern in site-related surface water, soils, sediments, vegetation and, possibly biological tissue levels to concentrations measured in a reference area or to toxicological levels known to cause adverse chronic effects in key species of concern. In addition to currently proposed site characterization data, ambient water quality criteria developed by the USEPA (EPA, 1992) may be used to determine if chemical analyses in other target media (e.g., algae, rodents, vegetation) may be required. Chemical levels in water or sediment in conjunction with bioconcentration factors can also be used as a screening tool. Limited fish sampling may be conducted if surface water or sediment samples in Putah Creek indicate chemical impacts have occurred.

The final product of the problem formulation step will be a site-specific conceptual exposure model that will identify potential pathways for exposure of on-site ecological receptors. This model will also identify potential pathways for off-site transport of radioactivity and hazardous chemicals.

10.5.2 Analysis

The analysis phase consists of two components: characterization of exposure and characterization of ecological effects. Characterization of exposure evaluates the interaction (co-occurrence) of the stressor and the ecological component. Characterization of ecological effects describes the relationship between the stressor and the measurement and assessment endpoints. The four basic components of the characterization of exposure are:

- Selecting of key receptors;
- Identifying complete pathways of exposure;
- Estimating exposure-point concentrations; and

- Exposure profile (dose estimation).

The two components of the characterization of ecological effects step are:

- A summary of relevant toxicity effects; and
- Development of toxicity reference values.

The first step in the characterization of exposure component of the analysis phase is to characterize the ecological resources at the site as follows:

- Perform a comprehensive site survey to assess the presence of species and the extent of their habitat;
- Evaluate collected information such as aerial photos, maps and existing remedial investigation data relating to ecological resources;
- Document the presence or absence of threatened and endangered species and critical habitat required for continued propagation of key or unique species of concern; and
- Determine ecological resources potentially utilized by man or capable of exporting contaminants off site.

As indicated previously, NEPA also requires an assessment of environmental resources. These data will be utilized in this step. Once the ecological receptors are identified, indicator species will be selected. The following criteria will be used in the selection of key receptors:

- Threatened and endangered species should be included in the list of species, as they are of special concern (e.g., Swainson's Hawk, Great Egret).
- Species that are vital to the structure and function of the food web. (e.g., rodents are a food resource for both raptors and snakes).
- Species that exhibit a marked toxicological sensitivity (vulnerability) to the constituents of concern (e.g., raptors and DDT).

- Species that have life histories and/or feeding habits that enhance exposure (e.g., high trophic level species - raptors and fish-eating birds and mammals or burrowing species such as ground squirrels).

- Species for which toxicological data are readily available in the scientific literature (e.g., mallards, rodents).

- Species of economical or recreational importance (e.g., fish and deer).

- Given the presence of multiple habitats, species that are ubiquitous across habitats (e.g., Canada Geese can be found in agricultural fields as well as aquatic habitats).

As noted in Chapter 9, the Environmental Assessment (EA) completed for the decommissioning and decontamination of contaminated facilities at the LEHR site (DOE, 1992) identified potential biological resources. Based on conclusions in the EA, there are no sensitive, rare or endangered species within the LEHR site boundaries. During the RI, this will be confirmed through consultations with local, state and Federal agencies, such as the U.S. Fish and Wildlife Service. Potential impacts to off-site sensitive resources will be evaluated if contamination has migrated off-site.

Once the indicator species are selected, complete exposure pathways will be identified for each species. The elements of a complete exposure pathway are presented in Section 10.2.4. In general, food chain pathways and direct contact or ingestion of chemicals in soil tend to be significant pathways for terrestrial receptors, while direct contact with sediment and surface water tend to be the most significant exposure pathways for aquatic resources.

Direct measurement of constituents of concern in target taxa or key environmental transport media will be conducted. Exposure point concentrations will be the 95-percent upper confidence limit (UCL) for sediment, soil, surface water, fish tissue and vegetation or the maximum detected concentration. The maximum detected concentration will be selected when the sample size is too small for statistical analyses.

Dietary dose estimation for birds and mammals will be calculated using the following equation:

$$DailyDose = \frac{Ct \times IR}{BW} \quad (3)$$

where,

Ct	=	Plant concentration from vegetation or fish tissue concentration (mg/kg or pCi/g)
IR	=	Ingestion rate (kg/day)
BW	=	Body weight (kg)

If appropriate, exposure frequency and duration may be considered in the dose estimation equation (e.g., if a migratory bird or a mammal with a large territory is selected as an indicator species). A similar equation will be used for incidental soil ingestion and water ingestion, if applicable. Incidental soil ingestion and water ingestion are not expected to be significant for some species where feeding habitats minimize these exposures (e.g., hawking songbirds such as flycatchers).

The first step in the characterization of ecological effects component of the analysis phase is to identify the toxic effects of the stressors. Effects that may be observed include mortality, reproductive or behavioral impairment, and reduced growth. These effects may be available in the technical literature, or may be observed in site-specific toxicity studies.

Toxicity testing of impacted media may be conducted in an accredited laboratory to assess toxic effects of collected site surface waters, soils, and sediments on selected indicator species. These tests could include a direct sediment bioassay test using the amphipod *Hyalella azteca* in a 10-day subchronic test based on Nebeka et al. (1984), and a sediment elutriate test using the cladoceran *Ceriodaphnia* sp. in a seven-day test using reproduction and mortality endpoints (EPA 1989c). The intent of these tests is to determine if sediments and associated pore water from the LEHR site are toxic to these indicator species. These tests would be conducted according to Good Laboratory Practices (GLP) as defined in 40 CFR 792 (CFR, 1992). Resulting toxicity data would also be utilized to assess required cleanup levels of contaminants in soil and water.

The conditions under which toxicity testing will be required include:

1) Analytical data indicate elevated contaminants in excess of the ambient water quality criteria for protection of aquatic life or sediment concentrations statistically elevated above background; and

2) Toxicity data for plants from the literature indicate phytotoxicity may be observed.

The second step in the characterization of ecological effects component of the analysis phase is the identification of benchmarks. For radionuclides, the CRITR code (PNL, 1992) will be used to assess compliance with the one-rad/day dose limit established for aquatic animals. For other chemical stressors, toxicity reference values (TRV) may be exposure concentrations (e.g., ambient water quality criteria) or toxicity data collected from the laboratory (e.g., no effect levels) or field (e.g., tissue concentrations). A TRV is an exposure estimate for a receptor group, including sensitive subgroups, that is not likely to cause appreciable deleterious effects in exposed organisms. Typically, it is assumed that if the TRV is not exceeded, then the species of interest will be protected (Suter *et al.*, 1983).

Benchmarks for non-radionuclide chemicals will include:

- Chemical-specific ambient water quality criteria for the protection of freshwater organisms (EPA, 1992);
- Sediment quality criteria (EPA, 1988, 1990, 1993);
- Phytotoxicity data for chemicals in soil taken from the literature and PHYTOTOX (a phytotoxicity database through the University of Oklahoma);
- U.S. Fish and Wildlife criterion for the protection of birds and mammals (Eisler, 1988-1991);
- NOELs;
- No adverse effect levels (NOAELs);
- Low effect levels (LOELs) adjusted to NOELs

- Maximum acceptable toxicant concentrations (MATCs), and, if necessary,
- Acute endpoints such as LD_{50}s, LC_{50}s, EC_{50}s adjusted to chronic NOELs used to evaluate the significance of chemical levels at the site to terrestrial and aquatic wildlife.

In some cases, extrapolation between species (intertaxon variability), endpoint extrapolation, exposure duration (acute versus chronic) and responses may be necessary based on the available toxicity data. In those cases, adjustment factors for the TRVs will, in general, range from 1 to 3 with a maximal adjustment factor of 500.

10.5.3 Risk Characterization

Information collected in the characterization of ecological resources and ecotoxicological investigations will be used to assess the probability or risk of an adverse effect resulting from exposure of ecological receptors to site constituents. Toxicity tests for aquatic species, if performed, and toxicity data in the literature will be used to quantitatively evaluate potential impacts to ecological receptors. The three major components of the risk characterization process include:

- Toxicity quotient approach;
- Uncertainty; and
- Summary and interpretation (likelihood of recovery).

The toxicity quotient (TQ) method is the direct arithmetic comparison of a concentration from a laboratory toxicity test with an expected or measured environmental concentration (Barnthouse and Suter, 1986). TQs are defined as the exposure point concentration or dose divided by the Toxicity Reference Values (TRVs) from the analysis section as exemplified in the following equation:

$$Toxicity\ Quotient = \frac{Exposure\ Concentration\ /\ DailyDose}{Toxicity\ Reference\ Value} \quad (2)$$

Exposure concentrations may be concentrations in surface water or sediment with corresponding TRVs of Ambient Water Quality Criteria for the protection of freshwater

organisms, no adverse effect levels, or maximum acceptable toxicant concentration (MATC) sediment quality criteria. Analytical data for soil may also be used as an exposure concentration for terrestrial vegetation and will be compared to MATCs from the Phytotox database and other literature sources. Daily doses may be estimated using analytical data for soil, sediment, surface water, plant, fish and rodent tissue for terrestrial receptors. Alternatively, surface water and bioconcentration factors can be used to estimate fish tissue levels. Soil and root uptake factors can be used to estimate concentrations in vegetation and, in combination with bioaccumulation factors, may be used to estimate rodent tissue. TRVs for terrestrial receptors will be selected as described in the analysis section.

For the radionuclides, to comply with DOE Order 5400.5, the CRITR code (PNL, 1992) will be used to assess compliance with the one-rad/day dose limit established for aquatic animals. Sufficient Putah Creek sediment and water sampling data will be evaluated at locations adjacent and downstream of the site and at background (reference) locations to adequately support CRITR code input requirements. A summary of all input/output data will be completed to describe the results of the CRITR code analysis and included in the ecological risk assessment.

An important component of the ecological risk assessment is the uncertainty analysis. A qualitative evaluation of the key areas of uncertainty will be included in the risk characterization section of the ecological risk assessment including a weight of evidence discussion. Additional areas of uncertainty associated with both the human and ecological risk assessment is discussed in Section 10.6.

The interpretation of ecological significance will include a discussion of any predicted adverse effects in the context of the nature and magnitude of the effects and the recovery potential.

11.0 FEASIBILITY STUDY

The purpose of the Feasibility Study (FS) is to identify and evaluate remedial alternatives potentially applicable to the LEHR site. The FS will follow the procedures presented in the Interim Final Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA (EPA, 1988a). The characterization data obtained during the RI phase of the study, and the calculations performed to evaluate potential health and environmental risks associated with site conditions will form the basis for the selection of remedial options.

The FS will be conducted in three main phases: 1) identification and screening of technologies; 2) development and screening of alternatives; and 3) detailed analysis of alternatives. Two separate technical memoranda, in addition to the draft FS Report, will be prepared to document this process. The first memorandum, to be entitled *Technical Memorandum No. 1: Identification and Screening of Remedial Technologies*, will identify potential Applicable or Relevant and Appropriate Requirements (ARAR) and remedial technologies which may be suitable for use in site remediation. The second memorandum, to be entitled *Technical Memorandum No. 2: Development of Remedial Alternatives*, will illustrate how technologies are combined to form potentially applicable remedial alternatives. These technical memoranda will provide the project teams with an opportunity to comment on the FS at an early stage of the process and can also provide the basis for early discussion of ARARs, technologies and alternatives with the EPA and state agencies. The FS Report will present the remedial alternatives. The following subsections describe the scope of work and methodology proposed for conducting the FS for the LEHR site. Remedial technologies deemed most likely for implementation at the LEHR site have been identified in Section 3.0.

11.1 IDENTIFICATION AND SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS

The identification and screening of remedial technologies is a multi-step process which begins with the development of ARARs and remedial action objectives (RAO). RAOs are media-specific or area specific goals for protecting human health and the environment. They will be based on ssessment of ARARs and preliminary development of exposure assumptions. After remedial action objectives have been developed, general response actions will be identified to satisfy each remedial action objective. These may consist of no action, containment, treatment, disposal, or a combination of these. Finally,

remedial technologies will be identified to satisfy general response actions. These technologies will be screened against the criteria of effectiveness, implementability, and cost. Technologies which will not enable achievement of RAOs will be eliminated from further consideration. These steps are described below.

11.1.1 Identification of Potential ARARs

Both the National Contingency Plan (NCP) (EPA, 1990), and the Comprehensive Environmental Response and Cleanup Liability Act (CERCLA) (42 U.S.C. 962.1), as amended by the Superfund Amendments and Reauthorization Act (SARA), (42 U.S.C., Section 9601 et. seq.) require that response actions comply with applicable or relevant and appropriate Federal, state, and local environmental and public health regulations. Section 121 of CERCLA, added by Congress in SARA in 1986, in effect codifies the EPA's approach to compliance with other laws.

The Federal, state and local environmental and public health requirements, criteria, guidance and advisories to which this approach applies fall into two categories: (1) requirements that are potentially applicable or relevant and appropriate; and (2) other criteria, advisories, guidance and standards to be considered.

"Applicable" requirements are those requirements that would be legally applicable, whether directly, or as incorporated by a Federally authorized state program, if the response actions were not undertaken pursuant to CERCLA Section 104 or 106. These requirements include cleanup standards, standards of control, and other substantive environmental protection requirements, criteria or limitations promulgated under Federal or state law that specifically address a hazardous substance, pollutant, contaminant, remedial action, location or other circumstance at a CERCLA site.

"Relevant and Appropriate" requirements are those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria or limitations promulgated under Federal or state law that, while not "applicable" to a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site, address problems or situations sufficiently similar to those encountered at the CERCLA site that their use is well suited to the particular site. For example, RCRA 40 CFR 264, Subpart F, Groundwater Protection Standards would be applicable to the management or cleanup of hazardous wastes in groundwater from hazardous waste

management facilities if such action were not taken pursuant to CERCLA Section 104 or 106. Yet RCRA Subtitle C regulations, while not applicable to hazardous wastes disposed prior to the effective date of those regulations (November 19, 1980), could be relevant and appropriate to CERCLA response actions regardless of when the wastes were disposed or managed.

The following steps will be taken to tentatively identify and develop the preliminary ARARs for the LEHR site:

- Identify and list potential contaminants of concern; consider the characteristics of the LEHR location; consider the proposed remedial alternatives;
- Review environmental statutes, regulations, other regulatory requirements, and the EPA CERCLA Compliance with Other Laws Manual (EPA, 1988b and 1988c), and identify potential ARARs;
- Determine if ARARs are applicable; and
- Determine if ARARs are relevant and appropriate.

First, pertinent facts concerning the site status or the operable unit (if applicable) are identified. These facts will include the type of substance located; when the substance was placed at the site; the nature of the site and its specific location; what persons are potentially affected by activities at the site; what response actions or technologies have been identified; and what areas of interest are under consideration.

Second, the provisions of each potentially applicable requirement are listed. These included the substance, time period, types of facilities, persons, and actions covered. The pertinent facts about the chemicals present, and the location and types of action/ technologies under consideration are compared to the prerequisites for each regulatory requirement. If all the pertinent provisions of the requirements are met, this requirement is determined to be applicable. If all of the pertinent provisions are not met, the assessment is continued as to whether the requirement is relevant and appropriate.

ARARs may be classified as chemical-specific, location-specific or action-specific. Chemical-specific ARARs are usually technology- or activity-based requirements or limitations on actions taken with respect to hazardous wastes. These requirements are

triggered by the particular remedial activities that are selected to accomplish a remedy. Location-specific ARARs are restrictions placed on the concentration of hazardous substances or the performance conduct of activities solely because they occur in special locations. Action-specific ARARs are usually technology- or activity-based requirements or limitations on action taken with respect to hazardous wastes. These requirements are triggered by the particular remedial activities that are selected to accomplish a remedy.

In addition to legally binding laws and regulations, many Federal and state environmental and public health programs also develop criteria, advisories, guidance and proposed standards that are "To Be Considered." These are not legally binding, but may provide useful information or recommended procedures.

Tables 11.1A through 11.1E identify potential location-specific, action-specific, and chemical- and radiologic-specific ARARs identified for the LEHR EA facility program. Early determination of ARARs will enable the project team to discuss these important issues with representatives of Federal and state regulatory agencies. The results of this analysis will be reported in Technical Memorandum No.1 and will be available for use in discussion with agencies if desired.

11.1.2 Remedial Action Objectives

Preliminary Remedial Action Objectives (RAO) describing goals for remediation are provided in Table 11.2.

Once the FS is under way, RAOs will be reviewed again, based on data collected during the RI. The RAOs used in the FS will be medium-specific or area-specific goals for protecting human health and the environment. RAOs will be consistent with guidance contained in the NCP and CERCLA.

TABLE 11.1A POTENTIAL LOCATION-SPECIFIC ARARs FOR LEHR

REQUIREMENT	DESCRIPTION	CITATION
National Historic Preservation Act of 1966 (NHPA)	Established to preserve historic properties. Property must be included or eligible for the National Register of Historic Places	36 CFR 800 16 USC 470
Endangered Species Act of 1973	Established to conserve endangered or threatened species. Requires protection or mitigation of impacts to endangered species identified at the site.	16 USC 1931
Wilderness Act	Establishes requirements to preserve designated wilderness areas. The area in question must be a Federally owned area designated as a wilderness area.	16 USC 1131
Wild and Scenic Rivers Act	Prohibits activities (including discharges) that have a direct adverse effect on a designated scenic river.	16 USC 1271
Located within 61 meters (200 feet) of a fault displaced in Holocene time	Prohibits new treatment, storage or disposal of RCRA or TSCA (PCB) hazardous waste near seismic fault zones.	40 CFR 264.18 (a)
Located within 100-year floodplain	Requires RCRA and TSCA facilities to be designed, constructed, operated & maintained to avoid washout.	40 CFR 264.18 (b) 40 CFR 761.75

TABLE 11.1B POTENTIAL ACTION-SPECIFIC ARARs LEHR PROJECT

ACTION	REQUIREMENT	CITATION
Capping of solid waste landfills	Specific requirements for final cover of landfills. Detailed design of cover as regards cap layers, grading requirements, structural integrity, leachate collection, etc.	Title 23 CCR, Chapter 15 Article 8 (Landfill Closure Requirements)
	Requires information to be included in closure & post-closure maintenance plans, including description of physical characteristics of cover, precipitation control, drainage & leachate control.	(Closure and post-closure)
	Similar requirements to Title 23 CCR Chapter 15, but adds requirement for control of trace gases.	Title 14 CCR, Chapter 3 Article 7.8 (California Integrated Waste Management Board Regulations for Solid Waste Landfills)
Capping of RCRA hazardous waste landfills	Cap design specifications, including drainage and permeability, maintenance, integrity and effectiveness, leachate collection, monitoring, etc.	40 CFR 264.310 (a)
	Closure & post-closure care: requires elimination of free liquids by removal or solidification prior to capping.	40 CFR 264.228 (a)
	Post-closure care - use of property is restricted to prevent damage to cover.	40 CFR 264.117
Capping of hazardous waste landfill	If hazardous wastes were disposed after November 1990, Title 22 applies, including requirements for preparation of closure plan, post-closure care and use of property.	Title 22 CCR, Chapter 15, Article 7 (Hazardous Waste Landfill Closure Requirements)
	Details requirements for closure & post closure care, including cap specifications, maintenance, foundations and drainage.	Article 11
	Closure & post-closure care of landfills.	Article 14

ACTION	REQUIREMENT	CITATION
Excavation & disposal	Areas from which hazardous wastes are excavated may require cleanup to levels established by closure requirements.	10 CFR 264 (Disposal & Closure Requirements)
	Land disposal restrictions regulate off-site disposal of hazardous wastes.	40 CFR 268 (Subpart D)
	Fugitive emissions and odors must be controlled. Total emissions of VOCs may not exceed specified levels.	Clean Air Act Section 101 & 40 CFR 52
	Regulates transportation of hazardous materials in California.	Title 22 CCR, Chapter 30 (Hazardous Waste Haulers Act)
	Sets standards applicable to transporters of hazardous waste.	40 CFR 263
	Establishes standards for working conditions and health and safety for employees and workers at the site.	Title 8 CCR Sections 1500, 2300, 3200 et seq. (OSHA)

TABLE 11.1B POTENTIAL ACTION-SPECIFIC ARARs LEHR PROJECT (continued)

ACTION	REQUIREMENT	CITATION
Extraction and treatment of groundwater	Effluent discharges to surface water must have a NPDES permit, setting limitations and monitoring requirements.	40 CFR 122 (NPDES Permit)
	Discharge of listed chemicals to sources of drinking water prohibited.	22 CCR 127055 & 12711 (Proposition 65)
	Existing water quality must be maintained and discharges to drinking water must meet waste discharge requirements.	SWRCB Resolution 68-16
	Controls discharges of effluent and waste to land. Requires protection of water quality during post-closure maintenance period.	Porter Cologne Water Quality Control Act
	Sets applicable requirements for groundwater monitoring & cleanup.	Title 23, Chapter 15, Article 5
	Prohibits recharge of fluids containing contaminants into or above a drinking water formation.	40 CFR 144.13 (c), 144.26-27, 146.51-52 (Underground Injection Control - UIC) Safe Drinking Water Act
	Regulates use of water injection wells for disposal of waste.	Health & Safety Code Section 25159.24 (a) (California Toxic Injection Well Act)
In situ Treatment	Sets requirements that hazardous constituents must be degraded, transformed or immobilized within the treatment zone. Also specifies maximum allowable depth of treatment zone and maximum distance to water table.	40 CFR 264.271

TABLE 11.1B POTENTIAL ACTION-SPECIFIC ARARs LEHR PROJECT (continued)

ACTION	REQUIREMENT	CITATION
Radionuclides	Sets standards for cleanup of land and buildings contaminated with residual radioactive materials.	40 CFR 192 Standards for Remedial Actions at Uranium Processing Sites
	Sets standards for sites operating under the Uranium Mill Tailings Radiation Control Act	42 USC 2022 Radiation Control Act
	Contains licensing, siting and technical requirements for disposal of radioactive wastes.	10 CFR 61 Subpart D (Technical Requirements for Land Disposal Facilities)
	Sets standards for protection against radiation.	10 CFR 20

TABLE 11.1C POTENTIAL CHEMICAL-SPECIFIC ARARs, LEHR PROJECT

Chemical	State MCLs ppb[a]	EPA MCLs ppb	EPA MCLGs ppb
Chloroform	100	100	--
1,1-Dichloroethane (1,1-DCA)	5	--	--
1,1-Dichloroethylene (1,1-DCE)	6	7	7
cis 1,2-Dichloroethylene (1,2-DCE)	6	70	70
Vinyl Chloride	5	2.0	0
Chromium (total)	50	100	100
Trans 1,2-Dichloroethylene (1,2-DCE)	10	100	100
Tetrachloroethylene (PCE)	5	5	0
1.1.1-Trichloroethane (1,1,1-TCA)	200	200	200
Trichloroethylene (TCE)	5	5	0
Toluene	--	1000	1000
Methylene chloride	--	5	--
Xylenes	1750	10,000	--
Chlordane	.1	2.0	0
Di(2-ethylhexyl)phthalate	4	--	0
Benzene	1	--	0
1,2-Dichloroethane (1,2-DCA)	.5	--	0
Ethylbenzene	680	--	--
Monochlorobenzene	30	--	--

[a] ppb = parts per billion (μg/l)

TABLE 11.1D POTENTIAL ARARS FOR RADIONUCLIDES FROM 40 CFR 141.15 AND TITLE 17 CCR

Chemical	Current Federal and State MCL (pCi/l)	Current Federal MCLG	Proposed Federal MCLG	Current State MCLG
Total gross alpha activity (including radium-226, but excluding radon and uranium)	15		0	Background[a]
Total gross beta activity	50		0	Background
Combined radium-226 and radium-228	5		0	Background
Strontium-90[b]	8			Background
Tritium[b]	20,000			Background
Uranium 234-238	20		0	Background
Radon	30			Background
Radon-222	--		0	Background

[a] From Title 23, Chapter 15, Article 5 "Background" applies unless RWQCB approves a less stringent concentration limit.

[b] If two or more radionuclides are present, sum of annual dose must be less than 4 millirems/year (40 CFR 141.16 (b)).

TABLE 11.1E REFERENCES FOR ARARS

- Safe Drinking Water Act (SDWA) Maximum Contaminant Levels (MCL) for groundwater
- Safe Drinking Water Act (SDWA) Maximum Contaminant Levels Goals (MCLG) for drinking water.
- Safe Drinking Water Act (SDWA) Secondary Maximum Contaminant Levels
- Clean Water Act (CWA) Ambient Water Quality Criteria for groundwater
- Federal Water Quality Criteria (FWQC) - Clean Water Act
- Office of Drinking Water Health Advisories
- RCRA, Part 264, Subpart F, Groundwater Concentration Limits (40 CFR 264.94) for groundwater.
- Hazardous Waste Control Act (HWCA), Criteria for Identifying Hazardous Waste.
- Title 22 CCR - Primary Maximum Contaminant Levels (MCL)
- Title 22 CCR - Secondary MCLs
- California Safe Drinking Water Act, Title 22 CCR, Division 4, Chapter 14 - Drinking Water Standards for Public Water Supply Systems
- Clean Air Act - National Emission Standards for Hazardous Air Pollutants
- Ambient Air Quality Standards - Mulford-Carrell Air Resources Act - California H&SC
- U.S. Nuclear Regulatory Commission (NRC) Standards for Protection Against Radiation - Atomic Energy Act and Atomic Energy Reorganization Act - 10 CFR 20
- Licensing requirements for Land Disposal of Radioactive Waste - 10 CFR 61
- National Emission Standards for Radionuclide Emission from DOE Facilities - 40 CFR 61.90
- Primary and Secondary Ambient Air Quality Standards - 40 CFR 50

TABLE 11.2 PRELIMINARY REMEDIAL ACTION OBJECTIVES

Remedial Action Objective	Media
Minimize ingestion of, and direct contact with soil having contaminant concentration(s) in excess of Applied Action Level(s) (AAL) which have been developed for soil for the protection of human health or that would result in significant excess cancer risk.	S
Minimize migration of contaminants that would result in groundwater concentration(s) in excess of AALs which have been developed for water for the protection of human health and the environment, or in excess of maximum contaminant levels (MCL), or that would result in significant excess cancer risk.	GW
Minimize offsite migration of contaminants to environmental receptors via air, surface water, and groundwater pathways.	S,GW
Minimize the generation of airborne dust and/or vapors that would result in significant excess cancer risk.	S,GW
Minimize the generation of airborne dust and/or vapors having contaminant concentration(s) in excess of AALs which have been developed for air for the protection of human health or that would result in significant excess cancer risk.	S,GW

S = Soil
G = Groundwater

11.1.3 General Response Actions

General response actions will be designed to address site-specific issues and achieve the RAOs by reducing the likelihood of exposure to chemicals of concern at the LEHR site. General response actions for soil and groundwater, based on a preliminary assessment of conditions at the LEHR site, may include:

- No Action;
- Containment;
- Treatment; and
- Disposal/Discharge.

If additional media of concern (i.e., soil gas, waste, surface water, etc.) are identified during the RI, general response actions will be expanded to include these additional media.

No Action

In accordance with the National Contingency Plan, the no-action response must be considered as a potential remedy for all CERCLA sites. It serves as a baseline against which the health risk remaining after the use of other general response actions and/or alternatives can be compared to determine the reduction of risk which is achievable with each action. The no-action response may be appropriate for certain or all areas of interest, depending upon the results of the RI and subsequent decision-making based upon the risk assessment.

Containment

Containment response actions restrict the movement of the contaminants, or restrict exposure to them. A variety of containment methods are available. Examples include slurry walls for soil and groundwater contamination, hydraulic barriers for groundwater contamination, or engineered caps and liners to act as physical barriers for soil contamination, use of diversion ditches or soil covers to keep water away from soil contamination, or use of engineered caps or soil covers to reduce exposure to soil contamination.

Treatment

Using treatment, contaminants are degraded or detoxified, removed, or separated from environmental media. Treatment can be rendered following physical removal/ collection of the affected media from the ground (ex situ) or in-place (in situ).

Disposal/Discharge

Disposal/discharge typically involves the disposal of untreated contaminated soil following excavation in an appropriate landfill or above-ground discharge of untreated groundwater to a storm drain or POTW via a sanitary sewer. Existing land ban restrictions require that some pretreatment be instituted with soil that is being disposed in a landfill. Furthermore, discharge of untreated water to the storm drain often requires a permit from the California Regional Water Quality Control Board and discharge to a sanitary sewer requires a permit from the local sanitation district.

11.1.4 Identification of Technologies

Technologies are general categories of similar treatment, containment, or disposal. Process options refer to specific methods, equipment or materials used for the purposes of implementing a technology. For instance, composting and slurry biodegradation are two available process options that can be used to implement the type of technologies known as biological treatment.

An "innovative technology" is one which is fully developed but which requires full-scale field testing before it is considered proven and available for routine use. Innovative and emerging technologies will be considered when such technologies offer the potential for superior treatment performance or lower costs for performance similar to that of traditional and proven technologies.

11.1.5 Screening of Technologies

The intent of screening is to eliminate those technologies and process options that are clearly incompatible with site conditions and RAOs. Technologies will be screened on the basis of their effectiveness, implementability, and relative cost. The screening criteria are described below.

Effectiveness

Each technology will be evaluated for effectiveness in providing protection of human health and the environment. Protection will be measured in terms of reductions in toxicity, mobility, or volume of contaminants. Both short- and long-term components of effectiveness will be evaluated; "short-term" refers to the construction and implementation period, and "long-term" refers to the period after the remedial action is complete.

Implementability

Each technology will be evaluated with respect to its ability to be implemented given site-specific conditions. Implementability is a measure of both the technical and administrative feasibility of constructing, operating, and maintaining a remedial alternative. The determination that a technology is not technically feasible, not available, or not administratively feasible, will usually preclude it from further consideration unless steps can be taken to change the conditions responsible for this determination.

Cost

Bases for screening cost estimates will include cost curves, generic unit costs, vendor information, conventional cost-estimating guides, and prior estimates developed for costs estimation at other, similar sites. Both capital and O&M costs will be considered, where appropriate, during the screening of technologies.

11.1.6 Technical Memorandum No. 1

After technology screening, a technical memorandum will be prepared and submitted to the project team. This memorandum will identify the ARARs, RAOs, potential remedial technologies which were considered, screening criteria employed, and the outcome of the process. A tentative outline of the memorandum is presented in Table 11.3.

TABLE 11.3 TECHNICAL MEMORANDUM OUTLINE IDENTIFICATION AND SCREENING OF REMEDIAL TECHNOLOGIES

EXECUTIVE SUMMARY

1.0 INTRODUCTION

2.0 PURPOSE AND SCOPE

3.0 IDENTIFICATION OF ARARs

4.0 PRELIMINARY REMEDIAL ACTION OBJECTIVES

5.0 GENERAL RESPONSE ACTIONS

6.0 IDENTIFICATION AND SCREENING OF REMEDIAL TECHNOLOGIES

7.0 EVALUATION OF TREATABILITY STUDY NEEDS

8.0 REFERENCES

11.2 DEVELOPMENT AND SCREENING OF PRELIMINARY REMEDIAL ALTERNATIVES

Development and screening of remedial alternatives will commence immediately after submittal of Technical Memorandum No. 1. The first step will be to identify areas and estimate volumes of impacted media to which remedial technologies will be applied during full-scale remediation. Once this is done, remedial technologies will be combined to form remediation alternatives. These alternatives may later be used to develop site-wide alternatives. Once development of alternatives is complete, alternatives will be screened. Those which survive screening will be retained for detailed analysis.

11.2.1 Estimation of Areas/Volumes of Impacted Media

Based on the soil and groundwater data obtained during the various RI phases, and preliminary remediation goals, concentration contours which correspond with the goals will be developed on a site-wide basis for soil and groundwater and used for estimating areas to be remediated. The volume and area(s) of impacted media will be estimated and identified.

11.2.2 Development of Alternatives

Proposed remedial alternatives must include a range of alternatives that satisfy the requirements of Section 300.430(e)(3) of the NCP. Furthermore, SARA includes a statutory preference for the use of treatment technologies, including innovative and resource recovery technologies as remedies. Therefore, the analysis will include: (1) a range of alternatives from no action to complete cleanup; (2) treatment technologies that can permanently and significantly reduce the toxicity, mobility, or volume of the contaminants; and (3) proposed remedies that use permanent solutions, and/or innovative or resource recovery technologies to reduce risks.

Alternative development will be documented in appropriate text and figures to clearly define and illustrate the range of potential remedial alternatives, including the locations of areas to be excavated or contained, the approximate volumes of waste, soil and/or groundwater to be excavated and collected, and other factors needed to describe the alternative adequately and to document the logic behind the assembly of remedial technologies. The descriptions of the alternatives will provide sufficient quantitative

information to allow differentiation among alternatives with respect to effectiveness, implementability, and cost.

11.2.3 Screening of Alternatives

Initial screening of the remedial alternatives developed will include evaluations of short-term and long-term effectiveness, implementability and relative cost. The intent of the screening process will be to eliminate those alternatives that are not adequately effective in providing protection of human health, welfare and the environment, are not feasible and those that are significantly more costly than other alternatives without providing significantly greater protection. The end result of the screening will be a reduced number of site-specific alternatives that will undergo a more thorough and detailed analysis. Descriptions of the screening criteria are included below.

Short-Term Effectiveness

Short-term effectiveness is related to the overall performance of each alternative in eliminating, reducing or controlling any risks that may be posed to human health and the environment by contaminants at the site during the construction and implementation of the alternative. For example, there could be potential risk to workers through inhalation and direct contact with contaminants during construction and implementation, or environmental impacts. Proper control and health and safety protection may need to be implemented to mitigate these risks.

Long-Term Effectiveness

Long-term effectiveness is a measure of the overall performance of each alternative in eliminating, reducing or controlling potential risks posed by the site over time. This criterion applies after the remedial action objectives have been met. For example, contaminated groundwater may be collected and treated while the contaminated soil remains capped; however, the source of contamination remains, presenting a possible future risk that the contamination could leach to groundwater through surface water infiltration. Long-term maintenance of the cap would therefore be required to ensure integrity of the cap.

Implementability

Implementability refers to the degree of difficulty associated with the actual construction of each alternative. It includes technical, administrative, and logistical problems that affect the time necessary for the alternative to complete the remedial action. Technical implementability of an alternative, including the ability to construct and/or operate the alternative, and its reliability, may depend on the treatability of the contaminated material. For example, technical difficulties are likely when using incineration for wastes that are high in metals or radiologics; technical implementability of an alternative could be affected by the lack of space on the site for materials handling and/or equipment; or there might be a need to consider the ability to monitor the effectiveness of an alternative particularly if it involves in situ treatment. In addition, a site's location and accessibility to goods and services may influence technical implementability.

Administrative implementability refers to the relative difficulty of coordinating and obtaining approval from regulatory agencies to perform certain activities. For example, the administrative implementability of an alternative might be considered to be poor if the local sanitation district refuses to accept contaminated groundwater for treatment at the local POTW.

Cost

Costs will be estimated for each alternative. Cost estimates will include capital or construction costs and the costs of operating and maintaining the alternative over time. The cost estimates produced for the FS will have an accuracy of +50 percent to -30 percent.

The estimates will be derived from current standard estimating guides such as Means Cost Data Manuals, contacts with vendors, recent Superfund projects and other published cost information. Operation and maintenance costs will be discounted to present worth value using historical trends of interest rates.

11.2.4 Technical Memorandum No. 2

A technical memorandum summarizing the results of the alternative development and screening process will be submitted to the project team at the end of this work. A list of alternatives considered, retained and eliminated, will be included, as well as an explanation as to why alternatives have been eliminated. An outline of the technical memorandum is presented in Table 11.4.

11.3 DETAILED ANALYSIS OF ALTERNATIVES

Detailed analysis of alternatives builds upon previous evaluation during the development and screening process. In this step, the alternatives which survived screening will undergo detailed analysis using nine evaluation criteria. The alternatives will then be compared to each other to analyze their relative ability to satisfy the nine criteria. During the detailed analysis of the alternatives, the criteria will be considered individually and will be equally weighted for importance. This allows evaluation of each alternative's advantages and disadvantages.

The purpose of the detailed analysis is to provide sufficient information to compare alternatives adequately, demonstrate compliance with the CERCLA remedy selection requirements, and assist decision-makers in the selection of the site remedy.

The nine evaluation criteria are included in the NCP and described in the EPA guidance on the RI/FS process (EPA, 1988a). They have been divided into three groups based on the function of the criteria during remedy selection. The three groups include the threshold category, the balancing category, and the modifying category.

TABLE 11.4 TECHNICAL MEMORANDUM OUTLINE DEVELOPMENT AND SCREENING OF REMEDIAL ALTERNATIVES

EXECUTIVE SUMMARY

1.0 INTRODUCTION

2.0 PURPOSE AND SCOPE

3.0 AREAS AND VOLUME OF MEDIA REQUIRING REMEDIATION

4.0 DEVELOPMENT AND SCREENING OF REMEDIAL ALTERNATIVES

5.0 REFERENCES

Threshold Category

There are two criteria under this category that each alternative must satisfy in order to be eligible for selection as the remedy for the LEHR site. These are:

- "Overall protection of human health and the environment," which evaluates how well alternatives achieve and maintain protection of human health and the environment; and,
- "Compliance with ARARs."

Balancing Category

This category includes the technical criteria that must be considered during the detailed analysis. The technical criteria listed below are used to weight trade-offs between the alternatives.

- "Long-term effectiveness and permanence." Each alternative must be evaluated to assess its ability to effectively maintain long term protection of human health and the environment after remedial action objectives have been met. The magnitude of residual risk (i.e., the risk which remains after the alternative is implemented), and the adequacy and reliability of controls in monitoring this risk, are part of this evaluation.
- "Reduction of toxicity, mobility, or volume." Each alternative must be evaluated to assess the anticipated performance of the specific technologies used. This evaluation includes review of the volume of contaminants and/or contaminated material destroyed or treated; the degree of expected reduction in toxicity, mobility or volume; the degree of irreversible treatment; and the type, quality and quantity of post-treatment residuals left on-site.
- "Short-term effectiveness" includes an assessment of effectiveness in protecting human health and the environment during implementation of the alternative.
- "Implementability" includes assessment of the technical and administrative feasibility of the alternative and the availability of required goods and services. Other factors considered include the technology's reliability, and the ability to monitor its effectiveness after implementation.

- "Cost" including the present worth capital and operation and maintenance costs. Cost estimates typically will have an accuracy of +50 percent and -30 percent and an appropriate rate of return will be used to calculate the present worth cost of each alternative.

Modifying Category

The criteria under this category are:

- "State acceptance," and
- "Community acceptance."

Though the modifying criteria will be taken into account and formally assessed during public comment periods, state or community acceptance will not be described in detail. Communications with the state/support agencies and community will be initiated during project scoping and will continue throughout the duration of the RI/FS.

Comparative analysis of the alternatives will be conducted to evaluate the ability of each alternative to satisfy each evaluation criterion. Presentation of the comparative analysis may include a matrix and a narrative discussion describing the strengths and weaknesses of the alternatives relative to one another with respect to each evaluation criterion. It will also include a discussion of how uncertainties in the anticipated performance of some alternatives may affect their ability to satisfy the criteria.

The draft FS report will describe the methods used to develop, screen and analyze the remedial action alternatives and summarize the results and conclusions. If treatability studies are performed, their findings will be reflected in the report, as well. An outline of the report is presented in Table 11.5.

11.4 TREATABILITY STUDIES

During the feasibility study process, the need for conducting certain bench or pilot-scale treatability studies for affected media will be evaluated. Treatability studies are used

TABLE 11.5 DRAFT FEASIBILITY STUDY REPORT OUTLINE LEHR SITE

EXECUTIVE SUMMARY

1.0 INTRODUCTION
- 1.1 OBJECTIVES OF THE FS
- 1.2 PURPOSE AND ORGANIZATION OF REPORT
- 1.3 BACKGROUND INFORMATION
  - 1.3.1 Site Description
  - 1.3.2 Site History
  - 1.3.3 Nature and Extent of Contamination
  - 1.3.4 Contaminant Fate and Transport

2.0 IDENTIFICATION OF ARARs

3.0 IDENTIFICATION AND SCREENING OF TECHNOLOGIES
- 3.1 REMEDIAL ACTION OBJECTIVES
- 3.2 GENERAL RESPONSE ACTIONS
- 3.3 IDENTIFICATION AND SCREENING OF TECHNOLOGY TYPES AND PROCESS OPTIONS.
  - 3.3.1 Identification of Technologies/Process Options
  - 3.3.2 Screening of Technologies/Process Options
    - 3.3.2.1 Effectiveness
    - 3.3.2.2 Implementability
    - 3.3.2.3 Cost

4.0 DEVELOPMENT AND SCREENING OF ALTERNATIVES
- 4.1 DEVELOPMENT OF ALTERNATIVES
- 4.2 SCREENING OF ALTERNATIVES
  - 4.2.1 Effectiveness
  - 4.2.2 Implementability
  - 4.2.3 Cost

5.0 DETAILED ANALYSIS OF ALTERNATIVES
- 5.1 ALTERNATIVE #1
- 5.2 ALTERNATIVE #2
- 5.3 ALTERNATIVE #3

6.0 COMPARATIVE ANALYSIS OF ALTERNATIVES

7.0 REFERENCES

to evaluate the effectiveness of remedial technologies on the site-specific media and contaminants of concern and assist in the detailed evaluation of alternatives in the FS process. The data obtained from these studies will be used during identification and screening of technologies and/or alternatives.

The need for treatability studies may arise during the FS process because certain candidate technologies cannot be adequately evaluated on the basis of available information. If the need for treatability study arises, one or more treatability study work plans, will be prepared and submitted to the project team. This (these) work plan(s) will describe the treatability studies in sufficient detail for evaluation by the project team. The work plan(s) will discuss the type of treatability testing recommended (e.g., bench versus pilot), the standards to be used for measurement of performance, analytical methods to be used during testing, data management, and analysis and DQOs.

At the LEHR site, treatability studies are most likely to be needed for soil treatment technologies such as fixation and soil washing, because the effectiveness of these techniques is highly dependent on soil chemistry and types, which in turn is site-specific.

Treatability studies may also be useful for evaluations of treatment techniques for groundwater remediation and analysis of residuals produced by treatment techniques. For instance, precipitation or ion exchange may be necessary to remove radiologics from groundwater, and analysis of the handling difficulties and disposal costs of the solid residuals will have a large impact on cost evaluations. Information on costs of waste disposal can be improved through effective treatability testing. A recommendation on whether or not to conduct these studies will be documented in Technical Memorandum No. 1.

11.5 INTERIM REMEDIAL MEASURES

During the course of the RI, the project team may perceive a need to institute immediate removal and/or treatment arises in certain locations. If such a need or advantage is identified, then interim remedial measures (IRM) may be recommended. Such a recommendation will be developed by the project team in the form of a technical memorandum which will describe the relevant data from the RI, the rationale behind the recommendation for instituting the IRM and the type of IRM that is recommended. If

approved, a Work Plan will be developed which includes the design, implementation, operation and maintenance of the IRMs.

IRMs may be appropriate, at a minimum, for areas containing unlined disposal trenches where water accumulates during storm events. These areas primarily include the southern portion of the site adjacent to the north levee for Putah Creek. If an IRM is implemented to address this area, the primary purpose will be reduction of potential infiltration from precipitation through suspected sources and to protect public health and the environment.

12.0 DATA MANAGEMENT PLAN

This chapter presents the Data Management Plan (DMP). It has been prepared to document procedures that will be used to manage and organize data collected during RI/FS activities at the LEHR site. The objectives of the DMP are to identify and establish data documentation materials and procedures, project file requirements, and project-related progress reporting procedures and documents. This DMP also includes examples of the formats to be used to present raw data and conclusions of the investigation.

The DMP encompasses procedures for receiving, storing, and reporting data derived from field activities and laboratory analyses. Procedures for receiving data include filing, sample tracking, and data qualification. Data storage includes entry of data into a computer database, verification of entered data, and backup procedures. Data reporting procedures include the processes for extracting information from the database into tabular, graphic, and other informational forms.

The following sections describe methods implemented to manage the data and include:

- Data receipt, sample tracking, and data validation;
- Data storage;
- Reporting formats for chemical analytical data and groundwater elevation data; and
- Organizational duties of database personnel.

12.1 DATA RECEIPT

This section describes procedures for receiving analytical data, tracking and validation procedures.

12.1.1 Data Receiving

A computer database will be maintained to store results of chemical analyses and groundwater level measurements. The results of these analyses and field investigations will be received primarily on standardized data forms, designed to fulfill the needs of both the technical and data management staffs. These data forms are illustrated in the QAPjP (Appendix B). The completed forms will be sent to the project office with copies retained by the originators. When the data forms are received, they will be stamped with the date of receipt, copied,and filed. A log will be maintained to document the progress and status of the data from receipt through storage in the computer database. Each entry will be dated and initialed by the individual performing the particular task described on the form.

12.1.2 Sample Tracking

Sample tracking procedures are used to indicate whether analytical samples collected at the LEHR site are analyzed according to chain of custody designated EPA methods and within required holding times. The sample tracking form is used to verify that analyses requested for each sample listed on the chain-of-custody were performed by the analytical laboratory and that results have been received. The form is maintained in the computer ~~spreadsheet format~~ and automatically calculates laboratory turnaround times and sample holding times to aid in the data validation process.

12.1.3 Data Validation

Daily quality assurance/quality control (QA/QC) for field sampling will be the primary responsibility of the On Site Field Supervisor (OFS). At the end of each day, all completed data forms will be submitted to the OFS who will check them for completeness, accuracy, and adherence to sampling protocols. Validation of all laboratory data will be performed by a designated QA officer. The QA officer will be responsible for developing a QA/QC report for each analytical portion of the study, and assigning data qualifier flags. QA review data qualifier flags and definitions are listed in Tables 12.1A through 12.1D. These flags will be stored in the computer database in addition to any flags assigned by

TABLE 12.1A QA REVIEW – DATA QUALIFIER DEFINITIONS

Flag	Data Qualifier Definition
U	The analyte was analyzed for, but was not detected above the reported sample quantitation limit.
J	The analyte was positively identified; the associated numerical value is the approximate concentration of the analyte in the sample.
N	The analysis indicates the presence of an analyte for which there is presumptive evidence to make a "tentative identification".
NJ	The analysis indicates the presence of an analyte that has been "tentatively identified" and the associated numerical value represents its approximate concentration.
UJ	The analyte was not detected above the reported sample quantitation limit. However, the reported quantitation limit is approximate and may or may not represent the actual limit of quantitation necessary to accurately and precisely measure the analyte in the sample.
R	The sample results are rejected due to serious deficiencies in the ability to analyze the sample and meet QC criteria. The presence or absence of the analyte cannot be verified.

TABLE 12.1B QA REVIEW – DATA QUALIFIER DEFINITIONS VALIDATION REASON CODES – GC/MS ORGANICS

Validation Reason Codes* – GC/MS Organics	
Flag	**Reason Code Description**
a	Analytical sequence deficiency or omission.
c	Calibration failure; poor or unstable response.
d	Matrix spike/matrix spike duplicate imprecision.
e	Laboratory duplicate control sample imprecision.
f	Field replicate or duplicate imprecision.
g	Poor chromatography.
h	Holding time violation.
i	Internal standard failure.
j	Poor mass spectrographic performance.
l	Laboratory control sample recovery failure.
m	Matrix spike/matrix spike duplicate recovery failure.
r	Linearity failure in initial calibration.
s	Surrogate spike recovery failure.
t	Instrument tuning failure.
w	Relative retention time failure.
x	Field blank contamination.
y	Trip blank contamination.
z	Method blank contamination
Q	Other.

* Reason code is used in combination with data qualifier; i.e., Uz = non-detect due to method blank contamination.

TABLE 12.1C QA REVIEW — DATA QUALIFIER DEFINITIONS VALIDATION REASON CODES — GC ORGANICS

Validation Reason Codes[a] — GC Organics	
Flag	**Reason Code Description**
a	Analytical sequence deficiency or omission.
b	Gross compound breakdown (4,4'-DDT/Endrin).
c	Calibration failure; poor or unstable response.
d	Matrix spike/matrix spike duplicate imprecision.
e	Laboratory duplicate control sample imprecision.
f	Field replicate or duplicate imprecision.
g	Poor chromatography.
h	Holding time violation.
i	Internal standard failure.
l	Laboratory control sample recovery failure.
m	Matrix spike/matrix spike duplicate recovery failure.
q	No valid quantitation column present.
r	Linearity failure in initial calibration.
s	Surrogate spike recovery failure.
u	No confirmation column present.
w	Retention time (RT) outside of RT window.
x	Field blank contamination.
z	Method blank contamination.
Q	Other.

[a] Reason code is used in combination with data qualifier; i.e., Uz = non-detect due to method blank contamination.

TABLE 12.1D QA REVIEW – DATA QUALIFIER DEFINITIONS VALIDATION REASON CODES – METALS/INORGANICS

Validation Reason Codes[a] – Metals/Inorganics	
Flag	**Reason Code Description**
a	Analytical sequence deficiency or omission.
c	Calibration verification failure.
d	Matrix duplicate imprecision.
e	Laboratory duplicate control sample imprecision.
f	Field replicate or duplicate imprecision.
h	Holding time violation.
k	Serial dilution imprecision.
l	Laboratory control sample recovery failure.
m	Matrix spike recovery failure.
n	Interference check sample recovery failure.
o	Calibration blank contamination.
p	Preparation blank contamination.
r	Linearity failure in calibration or Method of Standard Additions analysis.
v	Post digestion spike failure.
x	Field blank contamination.
z	Laboratory storage blank contamination.
Q	Other.

[a] Reason code is used in combination with data qualifier; i.e., Uz = non-detect due to method blank contamination.

the analytical laboratory. Data qualifiers and definitions which will be used by the analytical laboratory are shown in Tables 12.2A through 12.2C. All supporting documentation related to validation of laboratory and field data will be maintained in the project office. Details of analytical data validation procedures are described in the QAPjP and summarized below.

Analytical data is subjected to two levels of validation. Initially, all data packages are given a preliminary screening by a database technician. This screening includes holding times and completeness. If the package passes this preliminary screening, it is entered into a temporary input file. In the second level of validation, the data package is subjected to more thorough QA review by the QA officer. The progress of these validation steps is documented on a Data Package Tracking Form.

Analytical data are evaluated by verifying the analytical methods followed and reviewing the laboratory QC test results for compliance with the control limits specified in the QAPjP.

The critical components of data quality are: sample integrity; analytical detection limits; potential sample contamination; analytical accuracy; analytical precision; and sample reproducibility. Evaluation of sample integrity primarily consists of reviewing field documentation, such as chain-of-custody forms or field notes, to assess whether sampling and sample handling procedures were performed in accordance with the QAPjP. The potential for cross contamination of the samples during sampling, transportation, or in the laboratory during preparation and analysis, is assessed by reviewing the analytical results of field equipment rinse blanks, trip blanks, and method or preparation blanks. The collection methods and frequency, and subsequent analyses of these blanks are specified in the QAPjP. The analytical detection limits reported by the laboratory are compared to the limits prescribed in the QAPjP, including the Practical Quantitation Limits (PQL) cited in the method reference.

• Reason code is used in combination with data qualifier; i.e., Uz = non-detect due to method blank contamination.

TABLE 12.2A
LABORATORY DATA QUALIFIERS DATA QUALIFIERS FOR INORGANIC ANALYSES

DATA QUALIFIERS FOR INORGANIC ANALYSES	
For Use on the Analytical Data Reporting Forms	
B	***For CLP Analyses Only*** — Reported value is less than the contract required detection limit (CRDL) but greater than or equal to the instrument detection limit (IDL).
C	***For Routine, Non-CLP Analyses Only*** — Any constituent that was also detected in the associated blank whose concentration was greater than the reporting detection limit (RDL).
D	Presence of high levels of interfering constituents required dilution of sample which increased the RDL by the dilution factor.
E	Estimated value due to presence of interference.
H	Sample analysis performed outside of method or client-specified maximum holding time require ıe: *.
M	***For CLP Analyses Only*** — Duplicate injection precision criterion was not met.
N	matrix spike recovery exceeded acceptance limits.
S	Reported value was determined from the method of standard addition.
U	***For CLP Reporting Only*** — Constituent was analyzed for but not detected (sample quantitation must be corrected for dilution and percent moisture).
W	***For AAS Only*** — Post-digestion spike for Furnace AAS did not meet acceptance criteria and sample absorbance is less than 50% of spike absorbance.
X, Y, or Z	Analyst-defined qualifier.
*	Relative percent difference (RPD) for duplicate analysis exceeded acceptance limits.
+	Correlation coefficient *(r)* for the MSA is less than 0.995.
For Use on the QC Data Reporting Forms	
a[1]	The spike recovery and/or RPD for matrix spike and matrix spike duplicates cannot be evaluated due to insufficient spiking level compared to the elevated sample analyte concentration.
b[1]	The RPD cannot be computed because the sample and/or duplicate concentration was below the RDL.

(1) Used as footnote designations on the QC summary form.

TABLE 12.2B LABORATORY DATA QUALIFIERS DATA QUALIFIERS FOR ORGANIC ANALYSES

DATA QUALIFIERS FOR ORGANIC ANALYSES	
For Use on the Analytical Data Reporting Forms	
A	***For CLP Analyses Only*** — The TIC is a suspected aldol-condensation product.
B	Any constituent that was also detected in the associated blank whose concentration was greater than the practical or reporting detection limit (PQL or RDL).
C	Constituent confirmed by GC/MS analysis *[pesticide/PCB analyses only].*
D	Constituent detected in the diluted sample. It also indicates that an accurate quantitation is not possible due to *surrogates* being diluted out of the samples during the course of the analysis.
E	Constituent concentration exceeded the calibration range.
G	The quantitation is not gasoline or diesel, but believed to be some other combination of hydrocarbons.
H	Sample analysis performed outside of method or client-specified maximum holding time requirement.
J	***Estimated Value*** — (1) constituent detected at a level less than the RDL or PQL and greater than or equal to the MDL; (2) estimated concentration for TICs ***[for CLP Reporting Only].***
N	***For CLP Reporting Only*** — Tentatively identified constituents (TICs) identified based on mass spectral library search.
P	***For CLP Reporting Only*** — The percent difference between the concentrations detected on both GC columns was greater than 25 percent ***[pesticide/PCB analyses only].***
U	***For CLP Reporting Only*** — Constituent was analyzed for but not detected (sample quantitation must be corrected for dilution and percent moisture).
X, Y, or Z	Analyst-defined qualified.
For Use on the QC Data Reporting Forms	
*	QC data (i.e., percent recovery data for matrix spike, matrix spike duplicate, laboratory control standard, or surrogates; and RPD for matrix spike duplicate or unspiked duplicate) exceeded acceptance limits.
a(1)	The spike recovery and/or RPD for matrix spike and matrix spike duplicates cannot be evaluated due to insufficient spiking level compared to the elevated sample analyte concentration.
b(1)	The RPD cannot be computed because the sample and/or duplicate concentration was below the RDL.

(1) Used as footnote designations on the QC summary form.

TABLE 12.2C LABORATORY DATA QUALIFIERS DATA QUALIFIERS FOR RADIOCHEMICAL ANALYSES

DATA QUALIFIERS FOR RADIOCHEMICAL ANALYSES	
For Use on the Analytical Data Reporting Forms	
B	Any constituent that was also detected in the associated blank whose concentration was greater than the reporting detection limit (RDL) and/or minimum detectable activity (MDA).
C	Presence of high TDS in sample required reduction of sample size which increased the MDA.
D	Constituent detected in the diluted sample.
E	Constituent concentration exceeded the calibration or attenuation curve range.
F	***For Alpha Spectrometry Only*** — FWHM exceeded acceptance limits.
H	Sample analysis performed outside of method-specified maximum holding time requirement.
Y	Chemical yield exceeded acceptance limits.
For Use on the QC Data Reporting Forms	
*	QC data (i.e., percent recovery data for laboratory control standard and matrix spike; and RPD for replicate analyses) exceeded acceptance limits.
a(1)	The spike recovery and/or RPD for matrix spike and duplicates cannot be evaluated due to insufficient spiking level compared to the elevated sample analyte concentration.
b(1)	The RPD cannot be computed because the sample and/or duplicate concentration was below the MDA.

(1) Used as footnote designations on the QC summary form.

Analytical accuracy and precision are evaluated by comparing the data reported by the laboratory for QC samples to the appropriate quantitative limits of acceptability. Analytical accuracy is measured by percent recovery (% recovery) of laboratory control samples (field and/or laboratory matrix and surrogate spikes) relative to the known, spiked concentrations. Percent recovery is calculated as follows:

$$\frac{measured\ concentrations}{known\ concentrations} \times 100 = \%\ recovery \qquad (1)$$

Recovery of target compounds spiked in control samples must be within laboratory limits for the data to be considered accurate. The range of control limits represents the laboratory's accumulated data on the control matrix and are within the limits established in SW-846 as acceptable for the particular method. In addition to the laboratory control matrix, every sample is spiked with known concentrations of one or more surrogate compounds and the recovery is assessed as a quantitative measure of each sample's matrix interference. Field matrix spikes are samples from the site, spiked in the laboratory with known concentrations of predetermined compounds.

The precision of analyses is assessed in the laboratory by calculation of the relative percent difference (RPD) between duplicate analyses of laboratory control samples. The relative percent difference between two values is calculated according to the QAPjP as follows:

$$\frac{(A-B)}{(A+B)/2} \times 100 = relative\ percent\ difference\ (RPD) \qquad (2)$$

where :

A = Analytical result for original sample, and,

B = Analytical result for duplicate or replicate.

Laboratory limits for acceptable precision range from zero (identical analytical values), to either the average of accumulated RPD + 3 standard deviation units, established SW-846 limits, or EPA advisory limits.

The QAPjP specifies that the acceptable limits are those published in the EPA Contracts Laboratory Program (CLP) for metals and VOCs. However, the laboratory typically has its own internal limits of acceptability for accuracy (percent recovery of matrix spikes) and precision (relative percent difference of duplicate analyses) based on accumulated data for laboratory QC samples. These laboratory limits are typically stricter than those presented in SW-846 or the CLP. Consequently, the acceptance limits of the laboratory are used to evaluate the acceptability data presented in this report.

The reproducibility of the samples analyses is evaluated by assessment of the quantitative differences between analytical results of blind duplicate samples. The limits of acceptable analytical reproducibility are defined in the QAPjP.

12.2 DATA STORAGE

Following receipt, data are entered and stored in the Database Management System, a key element of the LEHR site DMP. The desktop computer based system was originally developed to meet the data management needs of the Phase II Site Characterization (Dames & Moore, 1993). It has since been enhanced through use in the LEHR Quarterly Monitoring Program. Features of the system include management of chemical and physical data for soils, groundwater, surface water, and production of a variety of reports meeting EPA requirements. Other general features of the system include data sorting, querying, and statistical analysis. Data subsets may be exported to other applications for graphical or specialized computational needs. Chemical distribution maps may be prepared through direct export of data into AutoCad, or via intermediate contouring packages.

The Database Management System consists of a set of commercial and Dames & Moore proprietary software program modules that work together to provide accurate, efficient, and flexible maintenance and reporting of the data. The underlying databases are maintained in a dBase format. This format allows for data exchange with other database

systems.~~written in the Clipper programming language, a compiled language which is an extension of dBase. The advantages of Clipper include speed, flexibility, and compatibility with the standard dBase file format. Extensions available in the Clipper language facilitate menu and window features which help to provide a "user friendly" interface. The modular programming structure allows for easy addition of features. The program modules manipulate the data files which constitute the database, and which are in an "X-Base" format. This format allows for data exchange with other database systems.~~

~~Each primary program module addresses a specific application, from data entry through report generation. The six modules which currently comprise the system are:~~

~~1. ENTRY — Manual data entry;~~
~~2. DATACON — Electronic data entry;~~
~~3. CLEANUP — Data validation;~~
~~4. REPGEN — Report generation;~~
~~5. GWEL — Groundwater levels; and~~
~~6. DATAMAST — Editing and statistics.~~

Listed below are some of the specific types of information which will be maintained in the database:

(1) Chemical data for sampling:

- Name of analytical laboratory;
- Laboratory sample ID#;
- Type of sample (i.e., soil, water and air);
- Sample name;
- Date sample was collected;
- Date sample was analyzed;
- Depth (for soil samples);
- Identification of QA samples (field duplicates and blanks);
- Laboratory's data qualification code;
- QA review data qualification code;
- Parameter analyzed;
- Levels detected and detection limits;
- EPA method; and
- Appropriate units.

(2) Measured groundwater elevations in monitoring wells:

- Monitoring well number;
- Measured depth to water;
- Depth measured;
- Notes or comments from field personnel; (e.g., well dry or obstructed);
- Top of well casing elevation;
- Calculated groundwater elevation; and
- Measured depth to well bottom.

(3) Construction details for soil borings, groundwater extraction and monitoring wells:

- Well/boring name;
- Diameter (well);
- Depth to screen (top and bottom);
- Constructed well depth;
- Present well depth;
- Date constructed;
- Screen elevation (top and bottom);
- Boring depth;
- Casing depth;
- Lithography at screen;
- Screen length;
- Top of casing elevation;
- Ground elevation; and
- Surveyed easting and northing coordinates.

(4) Air sampling:

- Air sampling locations;
- Meteorological conditions;
- Sampling dates; and
- Sample collection duration.

12.2.1 Data Entry

Data are entered into the database either manually or by direct download of laboratory-supplied electronic data. Regardless of the method of data entry, data entry QC is maintained through several levels of data verification. This data verification is carried out prior to importing ~~merging~~ the temporary input file into ~~with~~ the master database ~~file~~. Verification involves direct comparison of hardcopy listings of the temporary input

database to the hardcopy laboratory or field reports. If corrections are required, they will be written directly on the printout. Once the correction is made, a revised printout will be placed with the original to document the change. Notations will be made of the date and the initials of the reviewer. After the corrections are completed, the log will be dated and initialed. Following correction of any inconsistencies in either the data file or the laboratory reports, the temporary input file is imported into the ~~merged to a proxy~~ master database ~~file~~. Regular ~~This proxy file is used as a daily working file, and~~ backups of intermediate working files ~~it~~ as well as the master database ~~file~~ are maintained.

12.2.2 Chemical and Radiologic Data

Chemical and radiologic data received from the analytical laboratory, and water level data received from the field technicians are entered into the LEHR site data base. Data can be loaded manually or downloaded from an electronic source.

12.2.2.1 Manual Data Entry

The ~~ENTRY module of the~~ Database Management System includes a data-entry module that is used to manually enter field parameters (pH, temperature, electroconductivity, turbidity) and data supplied in hardcopy reports. This system provides customized data entry screens which match the data arrangement on the original hardcopy forms to help minimize keying errors. Keystrokes are minimized through access to customized databases of compound names, detection limits, units, EPA method numbers, and other repetitive parameters.

12.2.2.2 Electronic Data Entry and Back-Up

For analytical data supplied by the laboratory in electronic format on floppy disk, a data-conversion module ~~the module DATACON~~ is used. This module ~~system~~ converts data from the laboratory-supplied format into the dBase format used by the Database Management System. For safety, all electronic data will be backed up and stored in a fire-resistant safe. Additionally, the approved analytical laboratory will be required to maintain archived copies of all electronic and hard data, and supporting QA/QC documentation.

12.2.3 Water Level Data

Groundwater level data is entered manually into the database~~ using the GWEL module~~. Listings are ~~This subsystem~~ provides ~~listings~~ for quality assurance checks, and ~~calculates~~ water level elevations based on elevation survey data for each well.

12.2.4 Air Monitoring Data

Components of the air monitoring data will be entered into the data base manually. Typically the duration for each sample collected (hourly, weekly, monthly) will be entered manually from the field sample collection notes. The system allows correlation of sampling times to reported analytical results.

12.3 DATA REPORTING

The database format allows numerous types of data reports to be produced. The following sections briefly describe the various methods of data reporting that may be used during the RI/FS program.

12.3.1 Chemical and Radiological Data

The Database Management System includes a variety of flexible reporting formats. Raw data tables can be generated showing either samples or analytical parameters as column headings with the other variable listed vertically down the page. Laboratory data qualifiers, data validation qualifiers, detection limits, and regulatory criteria can be included as desired. Summary tables of detected compounds, compounds exceeding regulatory criteria, and comparisons of recent data to historical values can be generated. Statistical summary tables include means, extremes, variances, and other relevant information. All tables can be organized by parameter class, date ranges, locations sampled, purpose of sampling, etc. In addition, customized table formats can be easily developed as specific requirements dictate. Tabular reports can be printed or exported as spreadsheet or word processing files.

~~The report generation module REPGEN produces two principal report formats. The "generic" format lists parameter names as column headers, with sample ID's listed vertically on the left side of the page. This format is generally used for miscellaneous parameters which are reported in a variety of units. The "vertical" format permits parameter names to be listed in a vertical column on the left side of the page, and sample ID's as column headers across the top of the page. This format is used to produce reports specific to an EPA method. Besides filtering data to a specific EPA method, REPGEN also allows reporting of data for specific sampling locations, date ranges, depths, concentration ranges, and coordinate ranges. Both formats provide for QA documentation, sample depth, collection date, and reporting limits. General and record specific footnotes may be included. Record specific footnotes will be used to report laboratory and QA review data validation qualifiers. Sorting and querying is automatic. Both dot matrix and HP Laserjet printers are supported. Regulatory criteria, such as remedial objectives, discharge requirement, MCLs, TTLCs, and STLCs may optionally be included within the body of the report for comparison with sample results.~~

12.3.2 Water Level Data

Water level data reporting includes ~~is handled within the GWEL module. Output from this module includes~~ both a quarterly and a ~~or~~ cumulative format. The cumulative format allows specification of a date range and wells to be listed. Other output options include data files for input to commercial graphing or contouring packages for production of hydrographs and potentiometric surface contour plots.

12.3.3 Statistics

Statistical parameters, including arithmetic and geometric means, standard deviation, high and low range, variance, 95-percent confidence interval, will be ~~are~~ calculated with several ~~the DATAMAST~~ modules of the Database Management System. In addition, in the case of analytical data, the total number of analyses and the number of detections is determined. Customizable reports may be printed as hardcopy or exported to spreadsheet or word processing compatible files.

12.4 DATABASE MANAGEMENT PERSONNEL

To avoid duplication of effort and to reduce the potential for data loss or miscoding, one individual will be responsible for the management of the RI data maintained on the Database Management System. This individual, called the Database Manager, will report to the Project Manager and have responsibility for all aspects of the Database Management System. The Database Manager will maintain the computer files, supervise the data entry and editing, and provide assistance in the data analysis and reporting. It will be the responsibility of the Database Manager to ensure that all data entered onto the computing system have been checked and verified with the original forms. Access to the database may be obtained by principal investigators and staff, but any changes, deletions, or additions to the data base will be performed only by the Database Manager. The Database Manager will be assisted by a limited number of trained Database Technicians.

12.5 PROJECT FILES

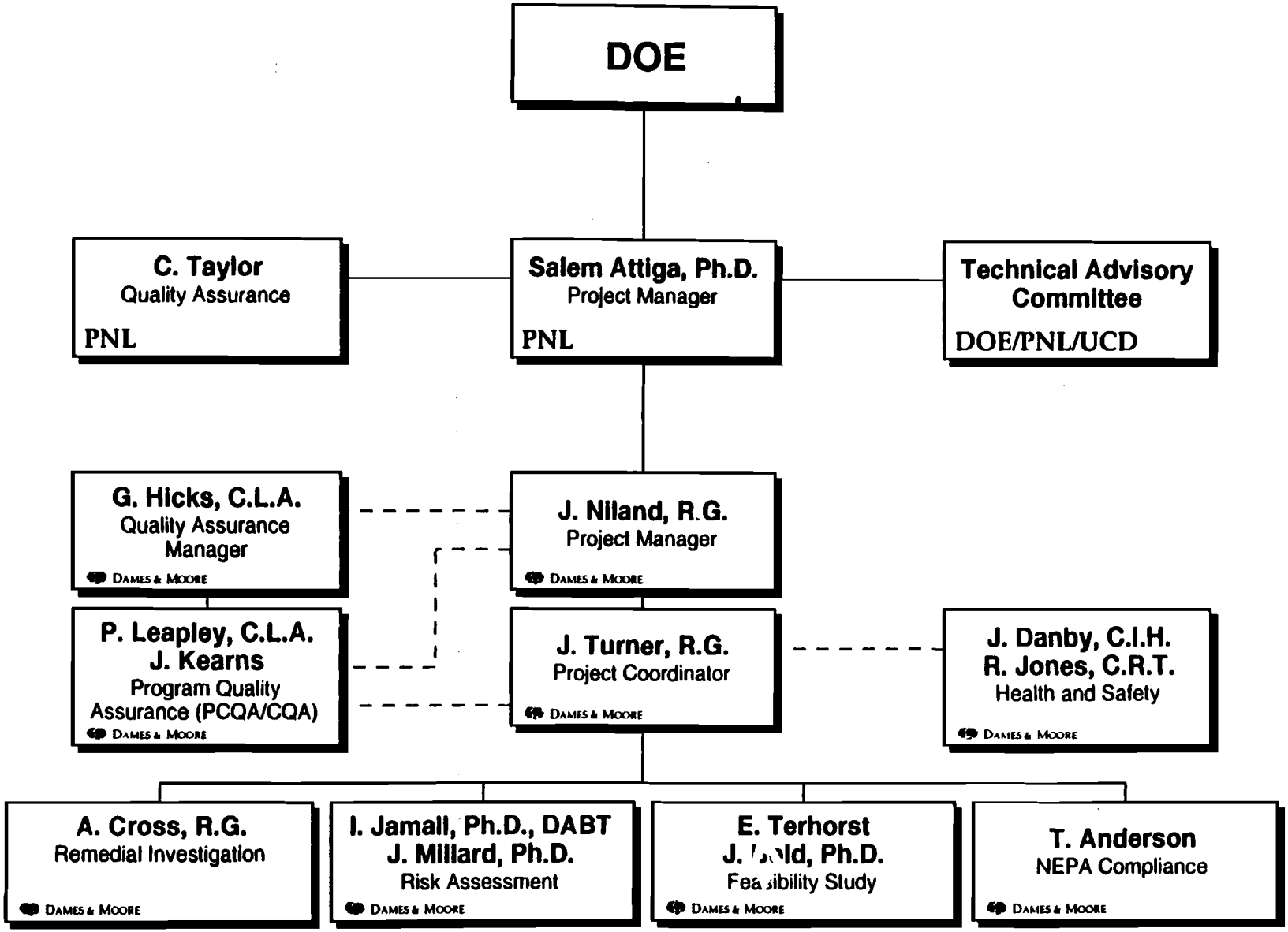
Master project files will be maintained in the project office. As work proceeds, working files will be established either in the project office, or other appropriate offices central to individual tasks. All filing will be guided by the DOE/LEHR Project File Index developed during the Phase II Site Characterization and modified by this Work Plan.

13.0 PROJECT MANAGEMENT

The Project Management Plan described in this section will be used to direct the RI/FS activities. The RI/FS activities will be conducted by Dames & Moore under the Master Service Agreement (number 071941-A-D8) between Battelle PNL and Dames & Moore. The RI/FS is an integral part of the overall LEHR Remedial Action Subproject of the ER program. As such, this activity will be managed/controlled in accrodance with the LEHR ER Project Plan and Project Management Plan in compliance with DOE 4700.1 (Project Management System) and NL Notice 4700.5 (Project Control System). The purpose of this section is to describe the administrative tasks necessary to support the RI/FS.

13.1 PROJECT ORGANIZATION

The Project Organization to be used during the RI/FS at the LEHR facility is presented in Figure 13.1. Dr. Salem Attiga will be the Project Manager for PNL. The technical management and staff will be provided by Dames & Moore. The RI/FS tasks will be administered by the Dames & Moore Project Manager. The Dames & Moore Project Manager and Project Coordinator will be responsible for technical quality of the project, controlling costs and the work schedule, and reviewing all technical reports. Project management personnel will be responsible for coordinating the tasks as outlined in this Work Plan and for interacting with PNL, UC Davis and IT personnel. The Dames & Moore Project Manager will lead the daily activities of the characterization, providing technical direction to each Work Breakdown Structure (WBS) element of the project. Weekly status reports and monthly progress reports regarding schedules and costs will be submitted to PNL. Dames & Moore QA/QC staff will be responsible for implementing the appropriate quality assurance procedures as described in Appendix B of this Work Plan. The QA/QC personnel will operate independently of the technical staff. Coordination between the QA staff and technical staff will be the responsibility of the Dames & Moore Project Manager. In addition, Dames & Moore will be responsible for providing the Site Health and Safety Officer and the QA/QC personnel.



PROJECT ORGANIZATION CHART

RI/FS Work Plan
LEHR Environmental Restoration
Davis, California

13.1.1 Project Manager

The Project Manager will be responsible for overseeing the technical quality of the project and appropriate QA/QC procedures, and reviewing technical reports. In addition, he will oversee all activities performed by Dames & Moore and selected subcontractors as well as interact with the PNL Project Manager. The Project Manager will also provide direction for each phase of the RI/FS and be responsible for coordination with PNL and DOE as required.

13.1.2 Project Coordinator

The Dames & Moore Project Coordinator will be responsible for the overall technical management of the RI activities. The Dames & Moore Project Coordinator will coordinate with the PCQA and Health and Safety officer, and coordinate the activities of the Dames & Moore Technical Managers, and will provide a liaison between them and the Project Manager.

The Dames & Moore Project Coordinator will also be responsible for the following:

- Scheduling, committing, and coordinating appropriate Dames & Moore and subcontractor resources.
- Providing project leadership and direction.
- Monitoring and meeting schedule and budgetary goals.
- Ensuring acceptability and timely submission of project deliverables.
- Assuring implementation of QAPjP requirements.

13.1.3 Dames & Moore Technical Managers

The Technical Managers will be responsible for assisting the Project Manager and the Project Coordinator in coordination of the RI/FS activities. They will also be responsible for the daily operations of the project including the following:

- Management of technical personnel.

- Reporting progress to the Project Manager.
- Conducting field activities.
- Compliance with the Health and Safety Plan and QA/QC Plan procedures.

13.1.4 Health and Safety Officer

The Health and Safety officer will be responsible for overseeing the health and safety aspects of the field activities associated with the RI/FS activities. This responsibility will include implementing Site-specific Health and Safety Plan and Contingency Plans, if necessary. The Health and Safety officer will coordinate with the Project Manager and Project Coordinator. Additionally, the Health and Safety Officer has the authority to stop work for health and safety violations or concerns.

13.1.5 Quality Assurance Management

The Program coordinator for quality assurance (PCQA) will be responsible for overseeing that field, office, and laboratory activities associated with this project are conducted in accordance with the QAPjP prepared for this Work Plan. The PCQA will also be responsible for coordinating the periodic Performance Audits and System Audits, specified in the QAPjP, to assess whether the data meets QA/QC requirements. Non-conforming activities will be documented in writing and corrective actions will be instituted, as necessary. The PCQA will report directly to the firm-wide Manager of Quality Assurance (MQA) and indirectly to the Dames & Moore Program Manager and will be independent from the technical staff. The PCQA will coordinate on a regular basis with the Project Coordinator to assess upcomming project activities and schedule surveillances and audits.

13.2 HEALTH AND SAFETY CONSIDERATIONS

The Health and Safety Plan (HSP) developed for this project is based on past investigative activities at the LEHR site, probable conditions based on Phase II Site Characterization analytical results and the LEHR Radiological Control Manual. The HSP is presented as Appendix C of this Work Plan. The HSP has been prepared in compliance with the Occupational Safety and Health Administration (OSHA), Hazardous Waste

Operations and Emergency Response Standard (29 CFR 1910.120), and the LEHR Radiological Control Manual. The purpose of the HSP is to:

- Provide health and safety protection and procedures for field crews and subcontractors.
- Provide adequate training and equipment to conduct expected tasks.
- Provide ongoing LEHR site monitoring to verify preliminary safety requirements and revise specific protection levels as required.
- Protect the general public and the environment.

The level of protection required for personnel working on the project during the majority of the field work is expected to be level C or D. Periodic monitoring during field activities will be conducted. The level of protection may be modified at any time in accordance with new data acquired during the course of the project. Key elements of the requirements established have been included in the HSP (Appendix C).

13.3 CONTRACTOR, LABOR, AND EQUIPMENT AVAILABILITY CONCERNS

The concerns regarding availability of contractors, labor, and equipment are related to the basic concerns of performance within the project schedule. The availability of qualified contractors with an adequately skilled and trained labor pool are factors critical to timely and competent performance of the project.

The project is located in an area with an excellent choice of contractors skilled in the particular types of work required to complete this project. This includes contractors specializing in:

- earthwork;
- drilling;
- remote sensing;
- concrete coring;

- paving; and
- soil vapor investigation.

The project has the availability of contractors serving the Sacramento area and beyond, while at the same time having access to process and other specialized companies based in the San Francisco Bay area. Therefore, it is not anticipated that major problems, such as schedule delays, will occur with regard to contractor or labor availability during the project.

The availability of materials and equipment is a concern not directly under the control of the project management team. Therefore, two strategies will be pursued to minimize any potential delays to the schedule due to the availability of materials and equipment. First, there will be an emphasis for the early procurement of subcontractors, equipment needs. Second, backup sources of materials and equipment will be identified and solicited during the process of procurement and supplier selection.

13.4 STRATEGY TO IMPLEMENT THE RI/FS QUALITY ASSURANCE PROJECT PLAN

A Quality Assurance Project Plan (QAPjP) has been prepared for work involving RI/FS activities. The "U.S. EPA Region 9 Guidance for Preparing Quality Assurance Project Plans for Superfund Remedial Projects" (EPA, September 1989) was used to prepare the QAPjP for work to be performed on the LEHR Project. The QAPjP is presented in Appendix B of this Work Plan.

This RI/FS Work Plan and QAPjP will be considered the project controlling documents. Work on the project will be conducted according to the methods described in the most current version of these documents. The technical staff and the quality assurance (QA) staff will receive controlled copies of all work plans and revisions. The QA staff will be responsible for issuing all work plans and revisions and for preparing and issuing controlled copies of the QAPjP. It will be the responsibility of each individual in the technical and QA staff to incorporate all revisions to the work plan and QAPjP in a timely manner.

The QA staff is independent, and will not have technical responsibility on the project. The Coordinator of Quality Assurance (CQA), reports directly to the Dames & Moore Manager of Quality Assurance (MQA) and Project Manager, and indirectly to the Dames & Moore Project Coordinator. The CQA has the authority and responsibility to stop work if the QA objectives are not met.

To assess that data quality is known, documented, and satisfies the DQOs specified in the QAPjP, surveillances will be scheduled and performed for selected tasks. These surveillances will be conducted by the QA staff, or qualified individual, with no project responsibility and who reports to the CQA. The purpose of these surveillances will be to document that the performance of the selected tasks are in compliance with the Work Plan and QAPjP. These surveillances are specified in the QAPjP. In addition, audits will be performed on the project by a certified Lead Auditor. The number of audits performed is presented in the QAPjP. The audits are intended to evaluate the effectiveness of the QA program and to verify compliance with the stated QA objectives.

14.0 PROJECT SCHEDULE AND DELIVERABLES

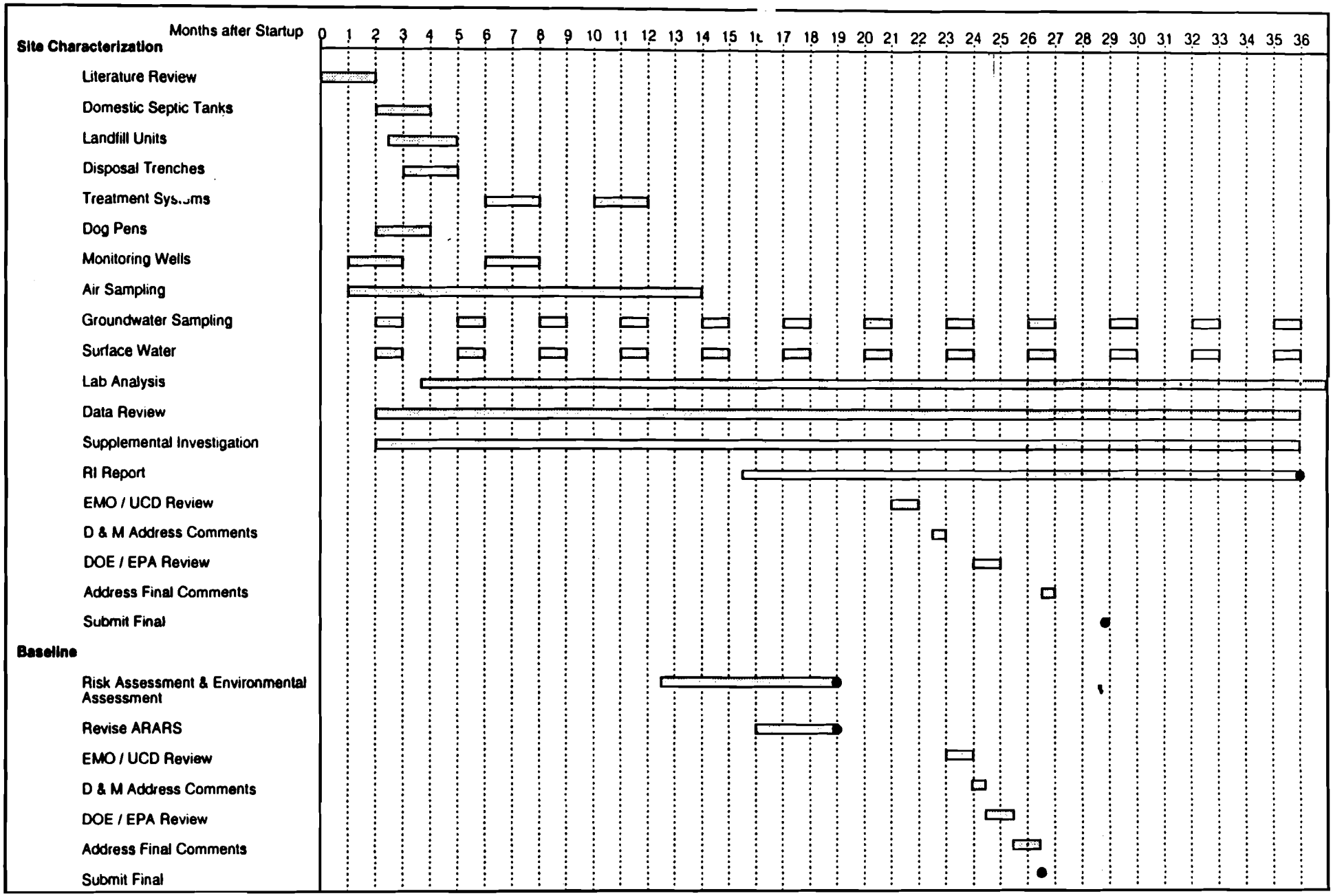
The LEHR facility does not currently have an agreed upon project schedule for the completion of this RI/FS. This schedule is being developed and will be incorporated into the Federal Facility Agreement (FFA). ~~However, to assist in the management of the overall environmental restoration program at LEHR, a preliminary RI/FS schedule has been proposed.~~ Figure 14.1 presents a preliminary ~~the anticipated~~ schedule for the completion of the tasks presented in this Work Plan. It is anticipated that tasks described in this Work Plan will be completed approximately 36~~0~~ months after final acceptance of this Work Plan. The major project deliverables include a RI Report, a FS Report, and a Baseline Risk Assessment. A brief discussion of the project schedule and deliverables is presented below.

~~**Note: Revised schedule in progress. This section and the schedule will be revised prior to distribution of the Final Draft, based on discussions and review of schedule by DOE/PNL.~~

14.1 PROJECT SCHEDULE

During the RI, the investigation of each area of interest is planned to be staged utilizing less intrusive data collection methods first. Because of the current unknown chemical and radiological conditions in the DOE and UC Davis disposal trenches and UC Davis landfill units, screening tasks including literature review, geophysical and soil vapor surveys will be obtained prior to intrusive sampling that uses backhoe or drilling methods. Additionally, the CPT/Hydropunch™ task will be conducted prior to initiating the groundwater monitoring well installation task.

The RI/FS investigation will utilize a phased approach. Preliminary investigation information will be used to refine the scope of subsequent phases of work. Screening results will assist in identifying locations for the more intrusive investigative methods such as backhoe excavation and drilling. Soil borings will be conducted in two stages in most areas of investigation. Analytical results from first stage soil sampling will be used to evaluate the need for ~~guide~~ second stage soil sampling locations and modify the analytical requests.

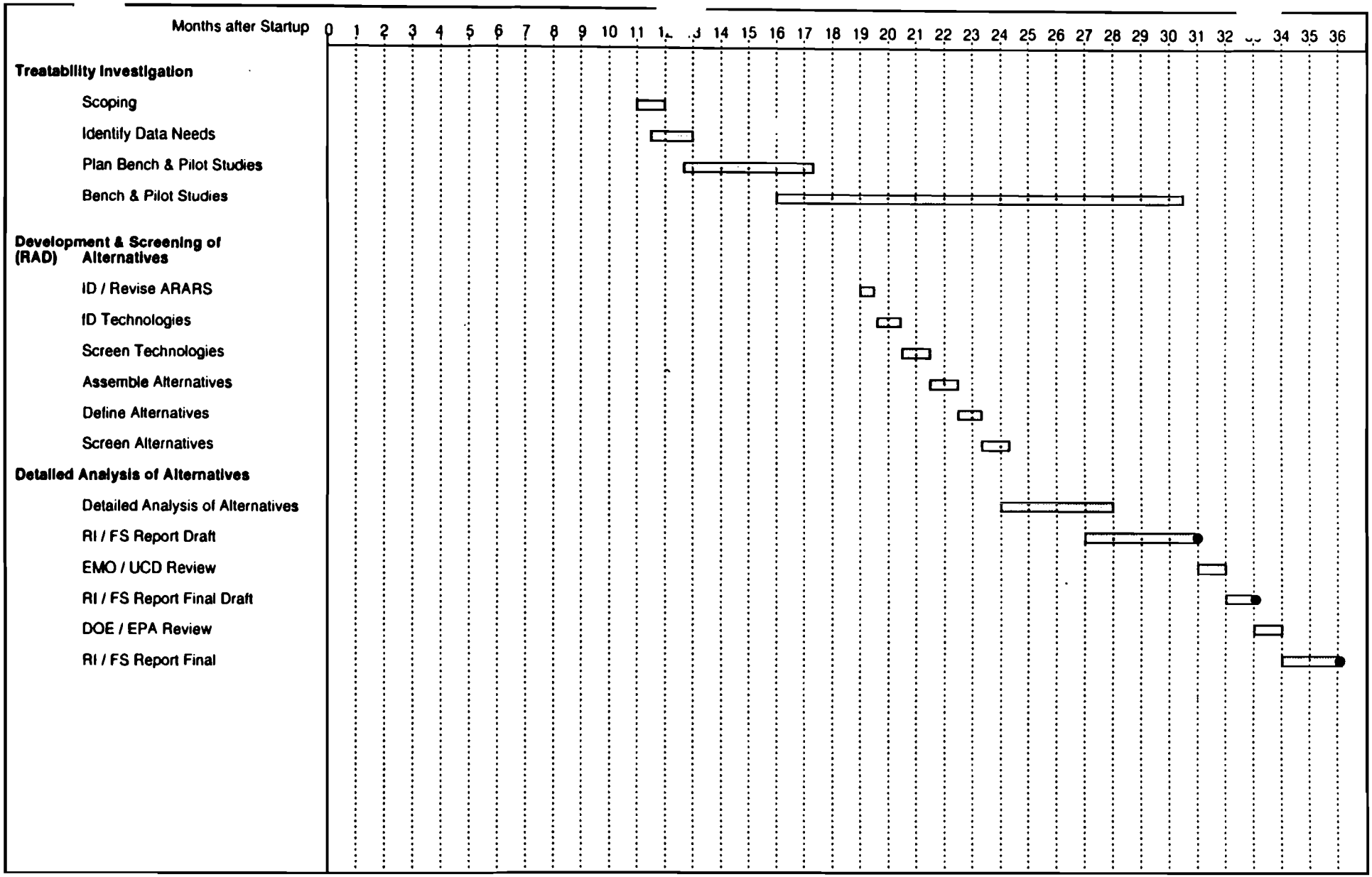


EXPLANATION ● Client Deliverable

* Schedule Preliminary

PRELIMINARY PROJECT SCHEDULE

RI/FS Work Plan
LEHR Environmental Restoration
Davis, California



EXPLANATION ● Client Deliverable

* Schedule Preliminary

PRELIMINARY PROJECT SCHEDULE

RI/FS Work Plan
LEHR Environmental Restoration
Davis, California

10805-720-044 sjr 5705A 2/17/94

FIGURE 14.1 (cont.)

The schedule is dependent on timely receipt of analytical data. Turn around time for analysis results are specified in the QAPjP and will be coordinated closely with the analytical laboratory.

Additional reasonable factors that may influence the schedule which are beyond control include:

- review of interim documents (such as the technical memoranda);
- severe weather conditions;
- quality assurance issues;
- laboratory results;
- unanticipated subsurface conditions;
- unforeseen health and safety issues; and
- identification of additional source areas.

Non-investigative tasks including the risk assessment and feasibility study will be initiated as data are received from RI activities. Figure 14.1 identifies relationships between data acquisition and data evaluation tasks. It is possible that the risk assessment or feasibility study may identify a need for additional physical or chemical analytical data. This potential need will be ~~has been~~ considered during the development of the proposed schedule.

The project team members will be kept informed of schedule progress or difficulties through weekly progress updates and monthly status reports. Progress of each task will be tracked separately so that scheduling difficulties may be identified early and corrective measures implemented.

14.2 DELIVERABLES

The key deliverables for this project include the RI Report, two technical memoranda, the FS Report and the Baseline Risk Assessment. Applicable aspects of the NEPA/CEQA analysis will be included in each of these reports. Other deliverables such as periodic progress updates, interim findings, and quarterly monitoring reports, may be generated for DOE; however, these interim deliverables have not been addressed in this Work Plan.

The RI Report presents the results of the investigations of soil, water and air in order to refine the site model and also to describe the nature and extent of site constituents for risk

assessment and evaluation of remedial action options. The RI report format will follow the CERCLA guidance documentation (EPA, 1988) that includes:

- introduction;
- physical site features;
- investigative methods;
- soils investigations results;
- hydrogeologic investigations results;
- surface water investigations results;
- air monitoring results;
- public participation; and
- references.

Two technical memoranda will be prepared as part of the FS process. Technical Memorandum No. 1 will identify the ARARs, RAOs, and potential remedial technologies considered. Technical Memorandum No. 2 will present the results of the remedial alternative development and screening process. Details of each memorandum are presented in Chapter 11.0.

The FS Report will consider the site conditions in evaluating remedial actions for a number of considerations including waste characteristics, treatment effectiveness, implementability, and impacts on the community. The FS Report will also follow EPA guidance under CERCLA (EPA, 1988), and will include:

- introduction;
- identification and screening of remedial technologies;
- development and screening of remedial alternatives;
- detailed analysis of remedial alternatives;
- final evaluation of alternatives; and
- summary.

The Baseline Risk Assessment will consider the exposure pathways, constituent distribution, and toxicity, background conditions and an evaluation of receptors. The format

of the Baseline Risk Assessment will follow the Risk Assessment Guidance for Superfund (EPA, 1989) which includes:

- introduction;
- site setting;
- data evaluation;
- exposure assessment;
- toxicity assessment; and
- risk characterization.

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