U.S. Department of Energy
Oakland Operations Office, Oakland, California

FINAL
ANNUAL SITE ENVIRONMENTAL REPORT
CALENDAR YEAR 1998

for the

Laboratory for Energy-Related Health Research (LEHR)
University of California at Davis, California

Submitted to:

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

Prepared by:

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Emeryville, California 94608-1827

September 1999
Rev. 0

DOE Oakland Operations Contract DE-AC03-96SF20686

Weiss Associates
Environmental and Geologic Services

U.S. Department of Energy

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memorandum

DATE: AUG 11 1999

REPLY TO ATTN OF: DOE Oakland Operations Office (OEPD)

SUBJECT: 1998 Site Environmental Report (SER) for the Laboratory for Energy-Related Health Research (LEHR)

TO: Distribution:

This report, prepared by Weiss Associates (WA) for the U.S. Department of Energy, Oakland Operations Office (DOE/OAK), provides a comprehensive summary of the environmental protection activities at LEHR for calendar year 1998. SERs are prepared annually for all DOE sites with significant environmental activities, and distributed to relevant external regulatory agencies and other interested organizations or individuals.

To the best of my knowledge, this report accurately summarizes the results of the 1998 environmental monitoring and restoration program at LEHR. This assurance can be made based on DOE/OAK and WA review of the SER, and quality assurance protocols applied to monitoring and data analysis at LEHR.

A reader survey form is provided with the SER to provide comments or suggestions for future versions of the report. Your response is appreciated. Questions or comments regarding this report may also be made directly to DOE/OAK, by contacting Susan Fields of the Oakland Environmental Programs Division at (510) 637-1608.

James T. Davis
Assistant Manager
for Environment and
National Security

Attachment

CERTIFICATION OF ACCURACY FOR:

ANNUAL SITE ENVIRONMENTAL REPORT, 1998, FOR LEHR

I certify that the information submitted herein is true, accurate, and complete, based on my familiarity with the information and my inquiry of those individuals immediately responsible for obtaining the information.

Signature: Robert O. Devany Date: 9/14/99
Robert O. Devany, Project Manager

ENVIRONMENTAL REPORT READER SURVEY

To Our Readers:

Each annual Environmental Report publishes the results of environmental monitoring at the Former Laboratory for Energy-Related Health Research (LEHR) and documents our compliance with environmental regulations. In providing this information, our goal is to give our readership — whether they be regulators, scientists, or the public — a clear accounting of the range of environmental activities we undertake, the methods we employ, and the degree of accuracy of our results.

It is important that the information we provide is easily understood, is of interest, and communicates the Department of Energy's effort to protect human health and the environment. We would like to know from you, our readers, whether we are successful in these goals. Your comments are welcome.

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ACRONYMS AND ABBREVIATIONS

AEC	Atomic Energy Commission
ASER	Annual Site Environmental Report
BHC	Hexachlorocyclohexane
CEQA	California Environmental Quality Act
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CFR	Code of Federal Regulations
Ci	Curie
COC	Constituent-of-Concern
CRDL	Contract Required Detection Limit
CVRWQCB	Central Valley Regional Water Quality Control Board
CY	Cubic Yard
DCG	Derived Concentration Guide
D&D	Decontamination and Decommissioning
DHS	California Department of Health Services
DOE	U.S. Department of Energy
DTSC	California Department of Toxic Substances Control
EDE	Effective Dose Equivalent
EE/CA	Engineering Evaluation/Cost Analysis
EHS	Extremely Hazardous Substances
EPA	U.S. Environmental Protection Agency
ER/WM	Environmental Restoration
ESA	Endangered Species Act
FIFRA	Federal Insecticide, Fungicide, and Rodenticide Act
Ft bgs	feet below ground surface
g	Gram
GEL	General Engineering Laboratories
HSU	Hydrostratigraphic Unit
ITEH	Institute for Toxicology and Environmental Health (UC Davis)

l	Liter
LEHR	Laboratory for Energy-Related Health Research
LTRAS	Long Term Research Acquisition Site
m^3	Cubic Meter
MCL	Maximum Contaminant Level
MDA	Minimum Detectable Activity
MEI	Maximally Exposed Individual
mg	milligram
MOA	Memorandum of Agreement
mR	milliRoentgen
mrem	millirem
MSDS	Material Safety Data Sheets
mSv	milliSievert
MWSF	Mixed Waste Storage Facility
NEPA	National Environmental Policy Act
NESHAP	National Emission Standard for Hazardous Air Pollutants
NHPA	National Historic Preservation Act
NPDES	National Pollutant Discharge Elimination System
NRC	Nuclear Regulatory Commission
NQA	National Quality Assurance
NTU	Nephlometric Turbidity Unit
OAK	Oakland Operations Office
OSHA	Occupational Safety and Health Administration
PCB	Polychlorinated Biphenyl
PCD	Putah Creek Downstream
pCi/m^3	picoCurie per cubic meter
PCU	Putah Creek Upstream
pH	potential of Hydrogen
PM-10	Respirable Particulate Matter
PNA	Polynuclear Aromatic Compound
PNNL	Pacific Northwest National Laboratory
PRG	Preliminary Remediation Goal

QA	Quality Assurance
QAPP	Quality Assurance Project Plan
QC	Quality Control
RA	Removal Action
RAO	Removal Action Objectives
RBAS	Risk Based Action Standard
RCRA	Resource Conservation and Recovery Act
rem	Roentgen Equivalent Man
RI/FS	Remedial Investigation/Feasibility Study
RME	Reasonable Maximum Exposure
RPM	Remedial Project Manager
RWQCB	Regional Water Quality Control Board
SC	Screening Criteria
SOP	Standard Operating Procedures
STPO	Wastewater (Sewage) Treatment Plant Outfall
SVOC	Semivolatile Organic Compound
SWT	Southwest Trenches
TLD	Thermoluminescent Dosimeter
TRI	Toxic Release Inventory
TSCA	Toxic Substances Control Act
UC Davis	University of California at Davis
µCi	microcurie
µg/l	micrograms per liter
VOC	Volatile Organic Compound
WA	Weiss Associates
WDR	Waste Discharge Requirement
YSAQMD	Yolo-Solano Air Quality Management District

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SUMMARY

This Annual Site Environmental Report (ASER) for the Laboratory for Energy-Related Health Research (LEHR) Site (the Site) includes 1998 environmental monitoring data for Site air, soil, ground water, surface water, storm water and ambient radiation. The U.S. Department of Energy (DOE) operation of LEHR as a functioning research location ceased in 1989, after the completion of three decades of research on the health effects of low-level radiation exposure (primarily strontium-90 and radium-226), using beagles to simulate effects on human health. During 1998, the U.S. DOE continued activities at the Site in support of Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) environmental remediation.

Progress of Site Environmental Restoration and Overview of 1998 Monitoring Results

Site restoration activities are conducted by DOE and the University of California at Davis (UC Davis) in coordination with the U.S. Environmental Protection Agency (EPA), and state agencies including the Department of Toxic Substance Control (DTSC), the Central Valley Regional Water Quality Control Board (CVRWQCB), and the Department of Health Services (DHS). In 1997 DOE and UC Davis finalized a Memorandum of Agreement (MOA) dividing responsibility for Site operable units (DOE, 1997).

DOE activities at the Site in 1998 primarily focused on the Southwest Trenches Removal Action (RA), and additional soil characterization. Significant progress was made during the year toward the characterization of Site air, soil, and water to meet the remaining data requirements and for evaluation of removal action options.

- ***Southwest Trenches RA:*** Approximately 873 cubic yards (CY) of buried waste, and nearly 900 CY of overburden and chlordane-impacted soil were removed from the Southwest Trenches Area. The excess cumulative cancer risk from buried waste in the Area was reduced to less than 10^{-5}. The Non-Cancer Hazard Quotient and the risk to ground water and the ecology have been reduced, although additional work may be necessary to determine whether the levels targeted in the removal action objectives have been achieved. Characterization and offsite disposal of the excavated waste will continue through 1999.
- ***Off-Site Cesium-137 Investigation:*** Surface soil sampling and a radiation survey were conducted along a drainage ditch adjacent to Old Davis Road. The purpose of this investigation was to verify a 1997 study, which identified potential elevated cesium-137 within the drainage ditch immediately west of the Site. The results indicate that cesium-137 activities in soil in the drainage ditch are consistent with shallow soil background. Based on these findings it is concluded that the Site is not a source of cesium-137 in the off-site ditch area.

- ***Western Dog Pens Phase C Investigation:*** Soil samples were collected from 0 to 25 ft bgs in 20 pens. Grab ground water samples were collected from 6 of the borings. This investigation indicated that constituents of concern (COCs) are not present in the pens above the Risk Based Action Level (RBAS), and that COCs detected in ground water beneath the pens are present at approximately the same levels as detected in upgradient wells.

The 1998 water monitoring continued the extensive program applied in previous years. The results of the water monitoring program are similar to previous years, and are summarized below.

- ***Ground Water:*** Eleven radionuclides, including tritium, were detected above the minimum detectable activity (MDA) but below the maximum contaminant level (MCL) in Site wells. Tritium was detected below the MCL at up to 17,600 pCi/l in well UCD1-13. Chloroform was detected above the 100 µg/l total trihalomethane MCL in many onsite wells with a maximum of 6,870 µg/l in UCD1-012. 1,1-dichloroethane, 1,1-dichloroethene and 1,2-dichloroethane were detected in at least one well above the MCL. One semi-volatile organic compound, bis(2-ethylhexyl)phthalate, was detected in one well. One pesticide, dieldrin, was detected above the contract required detection limit (CRDL). No PCBs were detected. Fourteen metals, were detected in Site ground water, but only one, chromium, exceeded the MCL. Total dissolved solids and nitrate concentrations are above the secondary MCL in many wells. Secondary MCLs are based on adverse taste, appearance, and/or odor, rather than heath effects.
- ***Surface Water:*** Gross beta and radium-226 were detected above the MDA, but below the MCL in surface water. Six VOCs and two pesticides were detected in surface water samples below the MCL. Metals were detected in all samples below the MCL.
- ***Storm Water:*** Four radionuclides were detected above the MDA, but below the MCL in storm water samples. Four VOCs and one pesticide were detected below their MCLs. Metals were detected in all samples below the MCL.

The 1998 sampling results confirm previous findings that elevated levels of chloroform, tritium, chromium and nitrate are present in Site ground water. Chromium and nitrate occur in regional ground water, and do not appear to be solely attributable to Site activities.

A reduced air monitoring program was implemented in January 1997 to monitor radionuclides present in Site ambient air. The results of the radionuclide air monitoring program are similar to previous years, and are summarized below:

- ***Radionuclides in Air:*** Total alpha and beta activities detected at the Site were similar to offsite background levels. All gamma-emitting radionuclides detected were well below the DOE Derived Concentration Guides (DCGs). The average radon activity detected on-site was lower than the average detectable off-site radon activity and below the DOE DCG of 3.0 pCi/l.

Assessment of Radiological Impact of LEHR Environmental Restoration Project

The Southwest Trenches RA was the primary focus of environmental activity at the Site in 1998. The removal of waste from this area will reduce the long-term risk of radiological exposure at the Site. The radiological air and ambient data all indicate that the low radionuclide activities detectable at the Site in 1998 are near or below natural background levels, and do not pose a risk to Site workers or the general public.

1. INTRODUCTION

This Annual Site Environmental Report (ASER) describes calendar year 1998 DOE Environmental Restoration/Waste Management (ER/WM) activities at the Laboratory for Energy-Related Health Research (LEHR) site (the Site) at UC Davis California (Figure 1-1). This report was prepared in accordance with the requirements of DOE Order 5400.1 General Environmental Protection Program, and DOE Order 231.1 Environmental Safety and Health Reporting. The purpose of this report is to present summary environmental data, confirm compliance with environmental standards and requirements, and to highlight significant programs and efforts. This report describes activities conducted by DOE during 1998 in support of the Site environmental restoration efforts, and information about the impact of these activities on the public and the environment. The ground water monitoring program, which is performed by UC Davis and includes information important to the overall environmental restoration of the Site, is also discussed briefly.

1.1 Site History

The Atomic Energy Commission (AEC) first sponsored radiological studies on laboratory animals at UC Davis in the early 1950s. Initially situated on the main campus, LEHR was established in 1958 at its present location (Figure 1-1) by the AEC. Research at LEHR through the mid-1980s focused on the health effects from chronic exposures to radionuclides, primarily strontium-90 and radium-226, using beagles to simulate radiation effects on humans. Other related research was conducted at the Site concurrent with these long-term studies. In the early 1970s, a cobalt-60 (Co-60) irradiator facility was constructed at the Site to study the effects on beagles of chronic exposure to gamma radiation.

A campus landfill with two waste burial units, used from the 1940s until the mid-1960s, are located at the Site. Several low-level radioactive waste burial areas are also present at the Site. Campus and LEHR research waste were buried in these areas until 1974, in accordance with regulations in effect at the time.

In 1988, pursuant to a Memorandum of Agreement (MOA) between DOE and the University of California, DOE's Office of Energy Research initiated activities to close out the research program at LEHR. In 1997 a second MOA divided the responsibility for environmental restoration between DOE and UC Davis.

1.1.1 Environmental Restoration

The U.S. Department of Energy Oakland Operations Office (DOE-OAK) manages the environmental restoration of the DOE-impacted areas of the Site. From October 1989 through February 1990, an interim contract with UC Davis was implemented to begin Site restoration. From

1990 to 1996 Battelle Environmental Management Operations managed the LEHR ER/WM project. In 1996 ER/WM project implementation was transferred to Weiss Associates (WA) of Emeryville, California.

In May 1994, the U.S. Environmental Protection Agency (EPA) added the Site to the National Priorities List. A Site Remedial Investigation and Feasibility Study (RI/FS) work plan was developed to ensure that investigation and remediation are conducted in accordance with regulatory requirements. Remedial Project Manager (RPM) meetings are held monthly to evaluate the progress of remediation and identify actions needed to facilitate the process. A draft Federal Facility Agreement has been prepared and is being discussed with the U.S. EPA and state agencies.

Primary DOE restoration/remediation activities which have been or will be performed at the LEHR Site include: soil and ground water characterization, building assessment, Decontamination and Decommissioning (D&D) of above-ground structures, waste management, chemical and radiological risk assessment, and remediation of contaminated trenches, soil, and underground tanks. Project management, health and safety, and quality assurance are components of all actions undertaken on behalf of DOE.

1.2 Site Description

The Site is a 15-acre parcel owned by the Regents of the University of California. It is 1.5 miles south of the main UC Davis campus in a rural agricultural area (Figure 1-1), and is presently occupied by the UC Davis Institute of Toxicology and Environmental Health (ITEH). Research at ITEH is directed towards toxicology, epidemiology, radiation biology, and radiochemistry.

The Site consists of 15 buildings, including a main administration and office building, two animal hospitals, and a laboratory and support buildings. Historical use of specific facilities and/or areas at the Site has impacted the environment, which is being investigated and remediated. Former facilities include: radioactive waste water treatment systems, an indoor/outdoor Co-60 beam irradiator, a radioactive waste burial area, animal hospitals, and outdoor dog pens. Potential environmental impacts from the inactive campus landfill units and numerous inactive campus low-level radioactive disposal sites (trenches and holes) used by UC Davis and DOE to dispose waste are also being evaluated for remediation by UC Davis. Figure 1-2 shows areas that have potentially impacted the environment at the Site.

1.3 Population Data

1.3.1 Site Population

Currently, the Site is used by UC Davis and DOE to support ongoing research and remediation. UC Davis' ITEH consists of several research facilities on the Site involving approximately 200 university researchers and support staff. ITEH researchers and student assistants have varying schedules and are not all present at the Site at the same time.

The DOE LEHR ER/WM Project is currently managed and staffed by WA and its subcontractors. Total LEHR ER/WM Project on-site personnel currently include up to six full-time workers. This number changes as on-site remediation and waste management projects progress.

1.3.2 Local Population

The Site is located in a rural area in northeast Solano County just outside of Davis, California. UC Davis has a student population of approximately 22,000 and employs approximately 15,000 full-time faculty and staff. The estimated 1998 population of Davis is approximately 55,000 and the estimated total population of Yolo County is about 150,000. The more densely populated and metropolitan Sacramento area is approximately 12 miles east of the Site. The current population of Sacramento County is about 1,160,000, and approximately 393,000 people live in the city of Sacramento.

1.4 Environmental Setting

The Site is located on a flat plain bordered on the south by the south fork of Putah Creek. The Site property is very gently sloping and mostly open, with a few trees and bushes. The Site lies outside the FEMA-designated 100-year floodplain.

1.4.1 Land Use

The land within a one-mile radius of the Site is owned both privately and by UC Davis. It is used for animal research, agriculture, and recreation (fishing and swimming). Privately owned lands to the south and east of the Site are used to produce wheat, tomatoes, corn, barley, and oats and include permanent residences. Private property to the south is separated from the Site by the South Fork of Putah Creek, and private property to the east is adjacent to non-LEHR, UC Davis-owned research facilities. The property immediately west, north and south of the Site (Putah Creek Reserve) is owned by UC Davis and is currently used for various types of animal, agricultural, and health research.

1.4.2 Hydrogeology

The hydrogeology of the Sacramento Valley is characterized by both unconfined and confined aquifers in the near flat-lying or gently sloping sedimentary deposits in the upper 3,000 feet beneath the valley.

The major ground water sources for public and private water supplies in the Sacramento Valley are unconsolidated deposits of Pliocene and Pleistocene age, and older alluvium (Dames & Moore, 1993).

The first regional aquifer beneath the Site has been divided into two hydrogeologic units, based on differences in composition. The uppermost unit, extending from ground surface to a depth of about 80 feet, has been identified as hydrostratigraphic unit one (HSU-1). It consists predominantly of fine-grained alluvial-fan sediments composed of clayey silt, sandy silt, and silty fine sand with thin beds or lenses of sand and/or gravel.

The deeper part of the first aquifer, ranging from about 80 feet below ground surface to 125 feet, is known as hydrostratigraphic unit two (HSU-2). This unit consists of relatively coarse-grained alluvial fan sediments, including sand, gravel and cobble-sized sediments. This unit is laterally continuous on a regional scale and represents the first major aquifer underlying the Davis area. This lateral continuity is an important distinction between the first and the second HSUs. Within HSU-1, the ground water gradient is primarily vertical and its recharge is largely dependent upon HSU-2 (DOE, 1996).

1.4.3 Water Supply and Quality

Ground water in the vicinity of the Site is used for agricultural and domestic supply. Regional ground water quality has been impacted by nitrates, probably from agricultural sources, and by hexavalent chromium, probably from natural sources.

Local ground water is recharged by streams and rivers, and direct infiltration from precipitation and irrigation. At the Site, recharge rates are highest immediately after precipitation events. Within a day after a heavy precipitation event, continuous water level measuring equipment located in monitoring wells near the creek show a significant increase (DOE, 1996).

1.4.4 Sanitary Sewer Systems

The Site discharges its sanitary wastewater to the UC Davis Wastewater Treatment Plant. UC Davis operates the plant under the conditions specified in its National Pollutant Discharge Elimination System (NPDES) permit, granted by the EPA in conjunction with the Central Valley Regional Water Quality Control Board (CVRWQCB).

1.4.5 Storm Drainage System

Storm water runoff at the Site is collected in an underground drainage system. Storm water from the paved area in the west part of the Site and around the southern buildings in the western area is collected in a storm water drainage system. The drainage system flows to the Site storm water lift station (LS-1 on Figure 1-3) and then to an outfall along the west side of the Old Davis Road, where it is discharged to Putah Creek. Storm water in the northwestern area of the Site drains into a ditch along Old Davis Road. Storm water in the eastern and non-paved southern portions of the Site percolates into the soil, except for a section of the former Co-60 field where dog pens were once located, and where drainage is connected to the sanitary sewer. Water collects in shallow ponds during heavy rains in some areas of the Site.

1.4.6 Biological Resources

A number of sensitive biological resources were identified in an Ecological Scoping Assessment (Weiss Associates, 1997c), as potentially occurring in the vicinity of the project Site. These species include the Giant Garter Snake, the Northern Harrier, the Coopers Hawk, the California Horned Lark, the Great Egret, the Burrowing Owl, and the Valley Elderberry Longhorn Beetle, which lives in elderberry bushes. Although elderberry bushes are present at the site, a focussed biosurvey (IT, 1998) found no sensitive species actually present on-site and concluded that the on-site elderberry bushes are not currently hosting the Valley Elderberry Longhorn Beetle.

2. COMPLIANCE SUMMARY

This section summarizes primary environmental regulatory compliance status for 1998 LEHR activities. DOE-funded work at the Site centered on environmental restoration LEHR and waste management.

2.1 Comprehensive Environmental Response, Compensation and Liability Act (CERCLA)

In 1995 a streamlined CERCLA process was initiated at the Site that encourages an interactive remedial decision-making framework, wherein data are evaluated and clean-up actions are implemented in an ongoing process. A Removal Action and continued characterization of Site soil and air were the primary focus of DOE 1998 CERCLA compliance actions. Characterization efforts have been planned and implemented to develop sufficient information for health risk evaluation as well as to support expeditious completion of required remedial actions. No CERCLA, Resource Conservation and Recovery Act (RCRA) or other violations, fines, or penalties were issued for the Site in 1998.

2.2 Resource Conservation and Recovery Act (RCRA)

2.2.1 Site Treatment Plan for RCRA-regulated/Mixed Waste

The Federal Facilities Compliance Act of 1992 waives sovereign immunity for federal facilities for fines and penalties under the provisions of RCRA's hazardous and solid waste management requirements. It requires that a Site Treatment Plan for the Site be prepared for each DOE Site that generates or stores mixed waste. After completion of the California Environmental Quality Act (CEQA) Initial Study and public comment, a final Site Treatment Plan was approved and issued in October 1995.

2.2.2 Mixed Waste Storage Facility

In 1989, UC Davis as operator and DOE as owner, submitted a Part A permit application to EPA for the on-site storage of mixed waste generated during D&D activities. The waste was stored in a mixed waste storage facility (MWSF) located in the eastern part of the Site. The MWSF consisted of a pre-fabricated steel chemical storage building with three separate lockers that were used to store mixed waste between 1989 and 1996.

All stored waste has been properly characterized, packaged and shipped to off-site locations for treatment or disposal, and the MWSF is now empty. A closure plan was submitted by DTSC for public comment on April 27, 1999, and the MWSF is targeted for closure in 1999.

2.3 National Environmental Policy Act (NEPA)

An Engineering Evaluation/Cost Analysis (EE/CA) for the southwest trenches, radium-226/strontium-90 treatment systems, and domestic septic system areas was completed in early 1998 (Weiss Associates, 1998b). The EE/CA reviews environmental impacts in a manner that is consistent with NEPA and with DOE environmental compliance guidelines, as required under NEPA.

2.4 California Environmental Quality Act (CEQA)

No CEQA documentation was processed or required in 1998.

2.5 Clean Air Act

The Site is subject to Yolo-Solano Air Quality Management District (YSAQMD) regulations. There are no sources at the Site currently subject to permit requirements by YSAQMD.

Verification of Site compliance with clean air regulations is accomplished through computer modeling to estimate potential fugitive wind-blown dust emissions from diffuse sources, and localized air monitoring during excavation or remediation of buildings. Site ambient air monitoring was conducted from 1995 through 1998 as part of a baseline air sampling investigation. This investigation is expected to determine whether normal Site activities and waste burial locations contribute to local airborne effluent.

As various environmental restoration activities progress at the Site, the need for additional air monitoring is evaluated during restoration activities. The potential exists for some of the contamination in burial areas to become exposed during tests and excavation. Prior to the start of each phase of the project, an analysis is performed to determine required controls to reduce potential emissions and to evaluate air monitoring requirements. Monitoring data are collected during the activity to verify that controls are maintained and requirements are met. Conclusions will be discussed in the LEHR Air Monitoring Report Summary (Weiss Associates, 1999d).

2.5.1 National Emission Standards for Hazardous Air Pollutants

The Site complies with 40 CFR Part 61 Subpart H – *National Emissions Standards for Hazardous Air Pollutants (NESHAP) for Emissions of Radionuclides from DOE Facilities.* The NESHAP regulations require that radionuclide emissions not exceed levels that would result in an effective dose equivalent (EDE) of 10 millirem per year (mrem/yr). To demonstrate compliance, an EDE may be calculated for the facility by applying models to estimate radionuclide air activities, or

measured radionuclide air activities at critical receptor locations may be used as an alternative to air dispersion calculations. The EPA prefers the application of approved dispersion models that account for multi-pathway ingestion routes of radionuclides in ambient air resulting from facility emissions. The use of radionuclide air monitoring data at critical receptor locations for use as an alternative to air dispersion calculations requires prior approval from the EPA.

There are currently no point sources of radionuclide emissions at the Site. The NESHAP requirements primarily target point source/stack emissions. However a Memorandum of Understanding between the DOE and the EPA (DOE, 1995) applies the same criteria to potential diffuse area sources that are required of point sources.

Calculations were performed to determine estimated dose from Site sources to the public. These calculations were based on Site residual surface soil contamination (diffuse sources). The potential radionuclide diffuse area sources at the Site are further discussed in Section 4. The potential sources of emissions at the Site during 1998 were re-entrainment and dispersion of surface soil dust containing potentially elevated concentrations of radionuclides as well as disturbances from excavation activities which took place in the summer of 1998 at the Southwest Trenches Area. Estimated contributions to the annual Site EDE from nonpoint source emissions (surface soils) are well below the NESHAP limit, as shown in Table 4-2.

An analysis of potential diffuse airborne radiological effluent sources at the Site was prepared for the 1998 Calendar Year Radionuclide Air Emission Annual Report (under Subpart H of 40 CFR Part 61) (Weiss Associates, 1999c). No changes to site conditions occurred during 1998 except the RA at the Southwest Trenches Area. Otherwise, the estimated emissions are similar to those assumed in the 1997 calendar year LEHR facility NESHAP report. Source conditions at the Southwest Trenches changed as a result of extensive excavation of contaminated soil and buried waste. Thus, modeling assumptions were modified for the Southwest Trenches Area. The results of the potential diffuse airborne radiological effluent source dose assessment are presented in the 1998 calendar year Radionuclide Air Emission Annual Report (Weiss Associates, 1999c) and are summarized in Section 4 of this report. The modeling was completed using an EPA approved DOE computer code, CAP88-PC, Version 1, based on estimated wind blown re-suspension of residual material contamination measured during Phase II Site Characterization and the Limited Field Investigation. Site areas included in the fugitive emissions modeling were the Southwest Trenches Area, the Ra/Sr Treatment Systems Area, and the Western and Eastern Dog Pens Area. Fugitive emissions modeling indicated that the maximum annual credible dose equivalent to a member of the public from residual contamination on the Site is 0.086 mrem, far below the 10 mrem/yr NESHAP EDE.

2.6 National Pollutant Discharge Elimination System (NPDES)

Some surface water from the Site is directed to the UC Davis Wastewater Treatment Plant. Wastewater from this plant is discharged to the south fork of Putah Creek. This discharge is conducted by UC Davis under NPDES Permit #CA0077895 (EPA) and Waste Discharge Requirements (WDR) Order No. 92-040 (CVRWQCB).

2.7 Clean Water Act

The Site discharges its sanitary waste to the UC Davis Wastewater Treatment Plant which is subject to the conditions in NPDES permit CA0077895 and WDR Order No. 92-040, granted by the CVRWQCB. DOE operations at the Site do not include any underground or above ground tanks that are subject to any county, state, or federal permit requirements.

Storm water samples are usually collected twice a year: once at the beginning of the rainy season after the first significant storm of the season, and once near the end of the season. Grab samples were collected from three locations at the Site in 1998. Storm water sample locations are shown on Figure 1-3. Although the Site does not fall under the industrial categories subject to the State General Storm Water Permit requirements, the storm water sampling program meets the State General Permit requirements, and is performed in accordance with the Field Sampling Plan. Best management practices are also in use at the Site to mitigate contamination in storm water runoff.

2.8 Safe Drinking Water Act/California Porter-Cologne Water Quality Control Act/California Safe Drinking Water and Toxics Enforcement Act (Proposition 65)

Current DOE activities at LEHR do not contribute to hazardous discharges. The facilities at LEHR that historically released liquid effluent to the environment, the Imhoff treatment facility, the domestic septic tanks and the radium-226 septic system, have ceased operation and are included in planned remedial actions. DOE research operations at the Site were discontinued in 1989.

Quarterly ground water and surface water monitoring has been conducted since November 1990 and focuses primarily on environmental surveillance activities and monitoring the performance of the UC Davis Interim Remedial Action (IRA). Ground water and surface water monitoring in 1998 were conducted under the Revised Field Sampling Plan (Dames and Moore, 1998d).

2.9 Emergency Planning and Community Right to Know Act (EPCRA)

The Site has a Contingency Plan and General Emergency Response Procedures (Weiss Associates, 1998g) as required under 40 CFR Part 265. These have been distributed to the campus fire department, local medical centers and hospitals, and are required reading for all on-site workers, including employees of ITEH. To comply with EPCRA, UC Davis Environmental Health and Safety has also prepared the required emergency and hazardous chemical inventory for all hazardous substances present on University property that require Material Safety Data Sheets (MSDSs). This also meets the hazardous material inventory requirements under California Health and Safety Code Section 25509. Compliance with reporting requirements of this regulation is summarized for the Site in Table 2-1.

Table 2-1. Compliance with Hazardous Material Reporting Under EPCRA

EPCRA 302-303: Planning Notification	[ ] Yes	[ ] No	[x] Not Required
EPCRA 304: EHS Release Notification	[ ] Yes	[ ] No	[x] Not Required
EPCRA 311-312: MSDS/Chemical Inventory	[x] Yes	[ ] No	[ ] Not Required
EPCRA 313: TRI Reporting	[ ] Yes	[ ] No	[x] Not Required

2.10 Toxic Substances Control Act: 40 CFR 763 (TSCA); and Demolition/Renovation Involving Asbestos: NESHAP Subpart M, 40 CFR 61.14

No asbestos removal was conducted in 1998.

2.11 Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA)

Herbicides were used at the Site in 1998 by UC Davis Agricultural Services Department personnel to control weeds. Pesticides were applied following applicable campus, local and federal regulations.

2.12 Endangered Species Act

The Ecological Scoping Assessment (Weiss Associates, 1997c) identified special status species that have a high potential to exist in or near Putah Creek, including two plant species, five invertebrates, nineteen birds, two reptiles, one amphibian, and four mammals. These species and other potential receptors of concern are discussed in more detail in the Ecological Scoping Assessment. Habitat for the Valley Elderberry Longhorn Beetle has been identified at the Site, as discussed in Section 1.4.6 of this report.

These resources are considered during planning of remedial activities to minimize their disturbance during remedial activities. Prior to the Southwest Trenches Area (SWT) RA a biological survey of the area was conducted, and protection/mitigation measures were coordinated with the state fish and wildlife.

2.13 National Historic Preservation Act (NHPA)

All areas affected by current remediation activities involve existing structures located on previously graded and developed land. An archeological evaluation was conducted during the Phase II Soil and Ground Water Characterization of the Site (DOE, 1992a). No evidence of cultural resources, or historical or agriculturally sensitive areas was encountered.

2.14 Executive Order 11988, "Floodplain Management" and Executive Order 11990, "Protection of Wetlands"

The Site is not on a floodplain, nor is any portion of it designated as a wetland.

2.15 Other Major Environmental Issues and Actions

2.15.1 Southwest Trenches Removal Action

A non-time-critical Removal Action (RA) was conducted at the Site in 1998. The RA was implemented in accordance with the RA Work Plan (Weiss Associates, 1998c), the RA Engineering Evaluation/Cost Analysis (EE/CA), (Weiss Associates, 1998b), and the national Contingency Plan, 40 Code of Federal Regulations (CFR) Part 300.415. The RA is summarized below, and discussed in detail in the Southwest Trenches Area Removal Action Confirmation Report (Weiss Associates, 1999e).

The SWT Area is located in the southwest corner of the Site (Figure 2-2). The SWT Area is flat, unpaved, and occupies approximately one-half of an acre. From the late 1950s to the early 1970s, low-level radioactive waste, fecal material, gravel from the onsite dog pens, and laboratory waste generated by LEHR Site activities were disposed of in shallow pits and trenches (disposal cells) in the SWT Area. These disposal practices complied with regulations in effect at the time. The primary COCs associated with the disposal cells were mercury, hexavalent chromium, nitrate, radium-226 and strontium-90. In addition to the waste disposal cells, the SWT Area had been impacted by chlordane used for flea control on the laboratory dogs.

The Removal Action Objectives (RAOs) for the SWT RA as defined in the EE/CA and include:

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

Excavation and off-site disposal was selected as the best remedial alternative to achieve these objectives. RA field activities began in May 1998 and concluded in November 1998. Final data interpretation and analysis will be completed in 1999, and presented in the Southwest Trenches Area Fiscal Year 1998 Confirmation Report (Weiss Associates, 1999e).

2.15.1.1 Chlordane-Impacted Soil

Chlordane was used at the Site to control fleas. Prior to excavating the disposal cells surficial soil samples were collected from the SWT Area, and analyzed for chlordane. Four areas with elevated chlordane were identified. Additional sampling was performed to define the horizontal and vertical extent of the elevated concentrations, and 450 cubic yards (CYs) of chlordane-impacted soil were excavated and stockpiled in the Western Dog Pens.

2.15.1.2 Waste Disposal Cells

Location and Excavation: Following removal of the chlordane-impacted soil, the waste disposal cells were located by direct push sampling and grid trenching. Using these data the approximate location of the buried waste was identified. Approximately 873 CYs of buried waste and 435 CY of overburden soil were removed from the SWT Area. The waste material included gravel, syringes, glass jars, animal bones and other lab-related waste.

Screening/Confirmation Sampling: During waste removal soil samples collected from the sidewalls and base of the excavation were analyzed to help guide removal activities, and to determine whether the screening criteria for the driver COCs were attained. Over 200 screening and confirmation samples were collected between 2 and 13 ft bgs. These results are summarized briefly in Sections 4 and 5 of this report, and are discussed in detail in the Southwest Trenches Area Year 1998 Confirmation Report (Weiss Associates, 1999e).

Backfill and Compaction: When the excavations were complete, the RPMs and DOE reviewed analytical results and determined that the RAOs were achieved for the five driver COCs except nitrate and mercury, and that the Area should be backfilled and restored. However, analytic results also indicated that the overburden soil removed from the Area may contain mercury above current Site background levels, and was not acceptable for use as backfill. The excavations were therefore backfilled using approximately 1,700 CYs of clean imported soil.

Data Evaluation: After the confirmation data were validated, risk and designated level analyses were performed to determine whether the residual COC concentrations achieved the RAOs. Statistical analysis was used to calculate Reasonable Maximum Exposure (RME) concentrations for each COC. RME concentrations were compared to the Risk-Based Action Standards (RBAS) developed in the Draft Final Determination of Risk-Based Action Standards Report (Weiss Associates 1997b), and to USEPA Preliminary Remediation Goals (PRGs). Designated Levels for the protection of drinking water were calculated based on chemical fate and transport properties and site-specific characteristics.

None of the COCs detected in post-RA confirmation samples exceeded the carcinogenic RBAS values derived for the Southwest Trenches for the 10^{-4}, 10^{-5} or 10^{-6} levels. Only one COC, mercury, exceeded the non-carcinogenic RBAS value. Five COCs; cesium-137, hexavalent chromium, cobalt-60, lead-210, and thorium-234 marginally exceeded the PRGs.

Designated Level calculations were performed for 171 analytes including the five driver COCs. These calculations identified five COCs which may require further evaluation before achievement of RAO No. 3 – Ground Water Impacts can be confirmed; mercury, nitrate, carbon-14, cesium-137, and tritium. Nitrate and mercury are driver COCs.

Waste Handling and Disposal: The overburden soil was transported to the Western Dog Pens and stockpiled prior to characterization. Preliminary analytic results indicate that up to 100 CY of the soil may require disposal at a Class I hazardous waste facility. The remaining soil is non-hazardous and may be re-used on-site.

The soil and gravel waste material removed from the disposal cells was sampled, then placed in B-25 storage box containers in the Western Dog Pens pending disposal. The disposal process for these boxes will be finished in 1999. Waste items such as vials, glass jars and bottles that were intact and contained residual liquid or solid matter were manually segregated from the soil/debris, and were placed in poly-bucket. The poly buckets are stored in a secure are in the Geriatrics I building onsite. This waste will be characterized under a Waste Characterization Workplan, and disposed of at an approved waste disposal facility.

2.15.1.3 Achievement of RAOs

Progress made to date towards achieving the RA objectives is summarized below.

RAO No. 1 - Cancer Risk, and RAO No. 5 - University Research have been achieved. Removal of the waste reduced the calculated excess cumulative cancer risk to less than 10^{-5} to 10^{-6}, and the RA did not significantly impact UC Davis research.

Achievement of RAO No. 2 - Non-Cancer Hazard Quotient, RAO No. 3 - Ground Water Impact, and RAO No. 4 - Ecological Risk have not yet been fully assessed. Additional sampling and risk analysis may be required to confirm attainment of these RAOs.

2.15.2 Off-Site Cesium-137 Investigation

In July, 1998 surface soil sampling and a radiation survey were conducted along a drainage ditch adjacent to Old Davis Road (Figure 4-4). The purpose of this investigation was to determine if cesium-137 was present above background levels within the drainage ditch, and to identify potential onsite sources of any elevated levels. This results of this investigation are discussed in detail in the Technical Memorandum: Results of Off-Site Cesium-137 Investigation (Weiss Associates, 1999b), and are summarized in Section 4.

2.15.3 Dog Pens Phase C Investigation

A three-phase investigation of the Western Dog Pens was initiated in 1997 and completed in 1998. Phases A and B were completed in 1997 and are summarized in the 1997 Annual Site Environmental Report. Phase C, which commenced in February 1998 is summarized briefly in Sections 4 and 5 of this report. All phases of the Western Dog Pens Investigation and all data related to the investigation are presented in detail in the Final Technical Report: Results of the Western Dog Pens, Background and Off-Site Investigations (Weiss Associates, 1998f).

2.15.4 Mixed Waste Storage Facility

In May and June, 1998, radiological and chemical analyses were performed on the MWSF structure and underlying surfacial soil. A surface radiological survey was performed, and samples were collected from the wood floors, secondary containment trays, and surface soil beneath the facility. The results of these investigations are discussed in detail in the Mixed-Waste Storage Facility Summary Data Report (Weiss Associates, 1999a), and are summarized in Sections 4 and 5 of this report.

On September 30, 1997 a Closure Plan for Mixed Waste Storage Facility (EMS, 1997) was submitted to DTSC. On April 27, 1999 DTSC issued a letter accepting the Closure Plan pending a public notice period.

2.16 Summary of Permits

There were no permit violations involving Site operations in 1998. The following permits are related to operations at LEHR:

1. ***NPDES Permit #CA0077895 (EPA) and WDR Order No. 92-040 (California RWQCB, Central Valley Region):*** UC Davis permits for discharge of wastewater from the UC Davis Wastewater Treatment Plant to the south fork of Putah Creek.
2. ***EPA RCRA Permit #CAD982469702:*** Part A Permit application for storage of mixed waste (interim status).
3. ***Drilling permits***: Obtained as necessary from the Solano County Department of Environmental Health for the specific purpose of drilling new borings or monitoring wells.

3. ENVIRONMENTAL PROGRAM INFORMATION

Each year DOE monitors the environment at the Site via air, water and soil sampling. This section describes the environmental monitoring program, and summarizes 1998 environmental monitoring activities. The results of this monitoring program are discussed in Sections 4, 5 and 6.

3.1 Summary of Environmental Protection Program

The environmental protection program at LEHR consists of ongoing programs that include compliance monitoring and any other relevant environmental protection requirements. Overall program requirements are defined in DOE Order 5400.1, as well as in applicable federal, state, and local environmental regulations. This program consists of, but is not limited to, those actions needed for compliance in the following areas:

- Remedial actions involving cleanup of past actions under CERCLA;
- Ground water, surface water, soil, sediment, air, and biota monitoring defined by the Water Monitoring Plan (Dames and Moore, 1994), and the Revised Field Sampling Plan (Dames and Moore, 1998d);
- Documentation under NEPA;
- Reports to DOE, including this ASER and other reports required by DOE Orders;
- Hazardous waste management, including waste minimization, storage, segregation, characterization, designation, and disposal;
- Hazardous materials inventory and usage and other reports and information as requested or required by regulatory agencies; and,
- EPA permit requirements for storage of mixed waste if it is found during remediation.

3.2 Notification of Environmental Occurrences and Reporting

Requirements for notification and reporting of environmental occurrences are defined in DOE Orders and/or in the regulations governing release of hazardous materials. Environmental monitoring personnel have been instructed to notify appropriate management personnel if monitoring data indicate that hazardous material has been released above reportable quantities.

The DOE LEHR Project Manager is responsible for reporting environmental occurrences under DOE Orders 5484.1 and 232.1-1. The reports are transmitted to the DOE System Safety and Development Center and DOE Headquarters. The Occurrence Reporting and Processing System is utilized in this process. No reports were filed in 1998.

3.3 General Planning and Reporting

In addition to this ASER, general planning and reporting for the Site environmental management program is facilitated through documentation prepared by the DOE prime contractor, Weiss Associates. This ensures comprehensiveness of the environmental monitoring program at LEHR.

3.4 Environmental Monitoring Programs

The LEHR ER/WM Project performs environmental monitoring in accordance with permit and regulatory requirements to establish background information and to monitor operations related to Site restoration activities. The Weiss Associates Project Manager has responsibility for the oversight of these programs, and assures that plans are reviewed and updated as required by DOE orders.

3.5 Summary of 1998 Environmental Monitoring

3.5.1 Environmental Monitoring and Surveillance Plan

The environmental monitoring program for the LEHR ER/WM Project is described in the Environmental Monitoring and Surveillance Plans (DOE, 1992b and Weiss Associates, 1997a) developed in accordance with DOE Order 5400.1. These plans provide guidelines for the measurement and documentation of environmental releases, should they occur. Data are evaluated to determine the effects of DOE operations at LEHR on the environment, both on-site and off-site. The program supports environmental compliance requirements and promotes goals of the Site environmental management policy. Because remedial action at the Site is being conducted under CERCLA, water, soil, and biota are being investigated within the streamlined CERCLA process as discussed in the following sections.

3.5.2 Effluent Monitoring

Storm water runoff and airborne emissions during D&D and RA activities are the only effluent streams monitored by the Site Environmental Monitoring and Surveillance Program. Active liquid effluent discharges to the environment were curtailed in the 1980s at the end of the LEHR research activities. There are now no active radiological or hazardous liquid effluent discharges to the environment from DOE-sponsored activities at the Site. An analysis of potential airborne effluent sources (leach field, chemical dispensing areas, dog pen soils, Imhoff D&D, etc.) determined that non-point sources at the Site would generate an effective dose equivalent below 4.2×10^{-3} mrem (Weiss Associates, 1999c), well below the 10 mrem/yr NESHAP standard.

3.5.3 Ambient Radiation Monitoring

Passive thermoluminescent dosimeters (TLDs) are used to monitor gamma radiation at LEHR. Twenty-six TLDs are placed near perimeter fence lines, radioactive waste storage areas, and various work areas around the Site. The TLDs are collected quarterly, and an annual gamma radiation dose is calculated for each location. The laboratory data are normalized for each quarter by subtracting Site background activity from each location. The results of the ambient radiation monitoring program are discussed in Section 4.

3.5.4 Surface and Ground Water Monitoring

The Field Sampling Plan (Dames and Moore, 1998d) has been developed in accordance with CERCLA as well as applicable state and federal regulations. Water monitoring is conducted as part of the Site environmental restoration program.

Monitoring points have been identified to evaluate water quality and lateral and vertical extent of environmental impact at the Site. The program is guided by data needs for risk analysis and evaluation of Site remediation alternatives. The scope of the program is modified when required to meet objectives (as approved by regulatory oversight agencies) as the CERCLA process and environmental restoration activities progress. This also provides flexibility necessary to obtain temporal and spatial information regarding chemical and radiological constituents.

In 1998 UC Davis performed all ground water and surface water monitoring, and monitored storm water runoff from the UC Davis areas of the Site. DOE monitored storm water runoff from the DOE areas only.

3.5.5 Air Monitoring

Pacific Northwest National Laboratories (PNNL) conducted a CERCLA one-year baseline air monitoring program at the LEHR Site in August of 1995. Data collected from the Site included both radiologic and nonradiologic parameters for substances previously detected in soil, ground water, and surface water at the Site. Air monitoring locations were based on historical records of Site activities, planned investigation activities, and soil and water monitoring data.

On January 1, 1997, WA assumed responsibility for the air monitoring activity at the Site. The baseline air monitoring program was extended through the summer of 1998 to include the Southwest Trenches RA.

3.6 Site Environmental Training

Site-specific environmental training has been conducted to instruct environmental restoration project personnel on pollution prevention, waste minimization, and procedures to ensure environmental controls are adequately maintained during remediation activities. This training is conducted as part of the Site orientation training, and prior to any new activity with the potential of impacting the environment. Daily safety meetings reinforce this training and specify steps needed to assure adequate environmental protection during that day's activities.

Before an employee is allowed to begin hazardous Site work, he or she must complete the 40-hour Occupational Safety and Health Administration (OSHA) "Hazardous Waste Operations Training." In addition, prior to working on-site, pollution prevention information is provided within the Site-specific "Hazard Communication Training." This training assures that the worker is aware of proper handling, usage, and disposal of chemicals used on the job. It also covers spill prevention and control as well as proper storage and chemical disposal methods. Workers are also trained in radiological control methods to prevent the spread of radioactivity to the environment,

3.7 Waste Minimization

The Site Waste Management Plan (Weiss Associates, 1998a) reflects DOE's commitment to reduce the quantity and toxicity of waste generated at the Site during restoration activities. The plan is designed to satisfy the requirements of the Solid Waste Disposal Act, as amended by RCRA, Hazardous and Solid Waste Amendments of 1984, and the Pollution Prevention Act of 1990. It also complies with the intent of NEPA to develop waste management and minimization methodologies to reduce the impact of these wastes on natural resources and the environment.

The plan requires that waste assessments be made for all project activities prior to initiation. Economically practical waste reduction and minimization techniques, including waste abatement, recycling, good housekeeping, and treatment are discussed. Methods to promote awareness and recognition of the waste minimization effort are also included. The plan is designed to eliminate or minimize pollutant releases to all environmental media.

4. ENVIRONMENTAL RADIOLOGICAL PROGRAM INFORMATION

DOE activities at the Site in 1998 primarily consisted of the Southwest Trenches RA, gathering additional off-site and background data, further investigation of the Western Dog Pens area, and Site air and ambient radiation monitoring. Storm water monitoring was performed by both DOE and UC Davis for their respective areas; surface water and ground water monitoring and off-site neighbor well sampling were performed by UC Davis.

Data collection and Site monitoring programs for DOE areas are conducted under the guidance of the Site Environmental Monitoring and Surveillance Plan, and comply with CERCLA requirements.

4.1 Reporting Format for Radiological Results

Radiological results for 1998 air, soil and water samples are summarized in this report. The majority of radionuclide results in Site samples are close to or below the Minimum Detectable Activity (MDA) for the laboratory analysis methods. Many of the results are therefore reported either as negative numbers (measured sample activity below laboratory background) or with a high uncertainty associated with the result. It is helpful to understand the following information concerning the reporting format since this format it is unique to radiological analyses.

Radionuclide results show the calculated activity of the sample and the counting error. The counting error represents the total statistical uncertainty resulting from measuring all random processes involved in the analytical procedures used. Individual errors associated with these processes are used to estimate the total uncertainty. The uncertainty value is reported as a two-sigma (two standard deviations) error for each sample analysis result. This uncertainty, therefore, approximates a 95% confidence interval about the reported value. The significance of the radionuclide results can be evaluated by comparing the reported value with the reported uncertainty. It should be noted that despite being statistically detectable on the basis of total uncertainty, a given sample result may not be significant in terms of health risk, presence of Site contamination, or regional background concentrations.

Uranium-238 and thorium-232 are naturally occurring radionuclides found in most soil, including soil at the Site. Uranium-238 decays into daughter products (progeny) such as thorium-234, radium-226, radon-222, bismuth-214, and lead-210. Thorium-232 progeny include radium-228, radon-220, lead-212, bismuth-212 and lead-208. Because these parent radionuclides naturally occur in soil and ground water, their progeny are also commonly found in soil and ground water analytical results. The ratio of parent to progeny can be used to estimate if a given radionuclide activity is due to decay of a parent product, or indicates a separate source of the daughter product. For example, radium-226 is present in soil as a natural daughter product of uranium-238. However, some radium-226 activities detected at the Site are higher than would be expected if the only source were decay of

uranium-238. These data and historical records can be used to evaluate release of radium-226 into Site soil.

4.2 Radiological Air Monitoring

4.2.1 Site Baseline Air Sampling

Atmospheric releases of pollutants from the Site are a potential source of human exposure. Therefore, radioactive and nonradioactive materials in air have been monitored at a number of locations on and around the Site since August 1995. The locations of the air monitoring stations are shown in Figures 4-1 and 4-2.

The influence of LEHR emissions on local pollutant concentrations is evaluated by comparing air concentrations measured at a distant location within the region to concentrations measured at the Site perimeter.

Between August 1995 and August 1996, a one-year baseline air sampling investigation was conducted. The analytical results of the one-year baseline air sampling investigation were presented in PNNL's Baseline Air Monitoring Report (Patton, 1996). Weiss Associates continued several elements of the monitoring program through 1998 to provide additional baseline radiological data. The 1998 air monitoring program is summarized here and is discussed in more detail in the LEHR Air Monitoring Report Summary 1995-1998 (Weiss Associates, 1999d).

Based on the results of the air sampling investigation and the requirements to conduct environmental surveillance under DOE Orders 5400.1 and 5400.5 and DOE/EH-0173T – Environmental Regulatory Guide for Radiological Effluent Monitoring and Environmental Surveillance (DOE, 1991a), Weiss Associates implemented a reduced air monitoring program in January 1997, which includes:

1) Continuous monitoring at four on-site stations, AM-2, AM-3, AM-5, and AM-7 (Figure 4-1) and the background station AM-6 (Figure 4-2) for alpha and beta activities;
2) Quarterly radon sampling of the four on-site stations and the background station; and,
3) Continued collection of meteorological data at the on-site meteorological station.

The revised air monitoring program reduced sampling for tritium and non-radiological compounds (chlordane, respirable particulate matter [PM-10], metals, VOCs).

The approach for radionuclide monitoring in air includes continuous air monitoring for particle-associated radionuclides and for radon. Radionuclides to be analyzed in air samples were selected on the basis of: (1) their detection in Site soil or ground water in typical above-background

activities; (2) past Site history and use; and (3) their relative importance in terms of potential dose to man and the environment.

Radon is sampled at four locations using passive alpha-track air sampling cartridges. The air sampling cartridges are identical to those used for sampling residential radon activities. The cartridges are exchanged quarterly.

During the 1998 RA at the SWT Area, additional air sampling was implemented at the Site to determine potential elevated releases of radionuclides, VOCs, SVOCs, and metals into ambient air. Gross alpha and beta air samples were collected continuously on a biweekly basis with one composite (gamma) analysis during the RA. Samples for tritium, radon, metals, VOCs, and SVOCs analysis were collected monthly.

4.2.2 Radiological Results for the Air Monitoring Program

The analytical results of the 1998 reduced air monitoring program are summarized below and will be discussed in more detail in the LEHR Air Monitoring Report Summary 1995-1998 (Weiss Associates, 1999d).

No increased activities were detected during the southwest trenches RA. The activity level of all COCs detected at AM-7 (at the SWT Area) were statistically indistinguishable from levels detected at AM-6 (offsite).

Both the average and maximum activities of total alpha radiation collected during 1998 were similar for Site perimeter locations and the distant location, indicating that the observed levels were from natural sources and worldwide fallout. The 1998 average air activity for the Site location was 2.2×10^{-3} pCi/m^3, which was not statistically different from the average activity at the distant location (2.6×10^{-3} pCi/m^3). The highest 1998 gross alpha air activity for a Site location was at AM-6 (1.4×10^{-2} pCi/m^3). Total beta radiation activities in ambient air collected during 1998 were below the laboratory detection limit for both Site perimeter stations and the distant station.

Three biennial composite air samples collected during 1998 were analyzed for gamma-emitting radionuclides. Fifteen radionuclides were detected in at least one onsite composite sample. All gamma-emitting radionuclides were well below the DOE Derived Concentration Guides (DCGs) specified in DOE Order 5400.5, "Radiation Protection of the Public and the Environment." The DCG values represent the activity of a radionuclide in air that an individual could continuously inhale at average annual rates without receiving an effective dose equivalent of greater than 100 mrem/yr.

Four quarterly radon composite samples were collected at four on-site and one remote air monitoring station. The average total radon activity detected on-site during 1998 was 0.4 pCi per liter (pCi/l), with a maximum activity of 0.6 pCi/l. The average detectable off-site radon activity was 0.6 pCi/l, with a maximum activity of 0.9 pCi/l. All measured radon air activities and detection limits were below the DOE DCG of 3.0 pCi/l, although the highest on-site and off-site activities exceeded the NESHAP limit of 0.3 pCi/l. Since radon activity is higher off-site, radon in the vicinity of the Site is probably associated with background sources.

4.3 Soil Radiological Measurements

The following section summarizes 1998 field activities and important soil analytical results for radiological compounds for the DOE areas at the Site. Results for non-radiological compounds are discussed in Section 5.

Soil sampling in support of the on-going CERCLA remediation was performed in several areas in 1998. Soil samples are shipped to a contract laboratory for the requested suite of analyses. Full descriptions of the soil sampling methods, procedures for sample preparation and shipment, requested analyses and minimum detectable activity limits, along with the associated quality assurance/control requirements, are contained in the relevant workplans and reports.

Soil sampling was conducted in support of the Southwest Trenches RA, to guide the excavation, to characterize the waste, and to determine whether RAOs had been achieved. Site characterization soil sampling was conducted in the Western Dog Pens, and along Old Davis Road. The results of these investigations are summarized briefly here, and are presented in detail in the Southwest Trenches Area Removal Action Confirmation Report (Weiss Associates, 1999e), the Technical Memorandum: Results of the Off-Site Cesium-137 Investigation (Weiss Associates, 1999b) and the Final Technical Report: Results of the Western Dog Pens, Background, and Off-Site Investigations (Weiss Associates, 1998f).

4.3.1 Southwest Trenches RA

As discussed in Section 2, a non-time-critical RA was conducted at the Site in 1998. Extensive soil sampling and analysis were conducted prior to and during excavation activities. Soil sampling was performed in conjunction with exploratory trenching to delineate the extent of contamination, during excavation activities to guide the removal action, and after the excavation was complete to confirm that RAOs had been achieved. A detailed discussion and data summary are included in the Southwest Trenches Area Fiscal Year 1998 Confirmation Report (Weiss Associates, 1999e), and Figure 4-3 shows the Southwest Trenches Area.

Screening Sampling: Over 130 screening samples collected from the sidewalls and bottoms of the excavations were analyzed for the driver radionuclide COCs radium-226 and strontium-90. Twenty-six soil samples were analyzed for tritium in an area where tritium was detected in a swipe sample from a glass bottle. Radium-226 was not detected above the 0.75 pCi/g screening criteria, and tritium was not detected above the MDA. Strontium-90 was detected above the 10 pCi/g screening criteria in one sample, and additional soil in the vicinity of the sample was excavated. Secondary confirmation sampling determined that the elevated concentration had been removed.

Confirmation Sampling: Over 60 confirmation samples collected from the excavations were analyzed for Site radionuclides. Fifteen radionuclides were detected above the MDA, and 14 were detected above Site background. A detailed evaluation of the data indicated that RAO No. 1, reducing excess cancer risk from the Site, has been attained, and additional excavation does not appear to be necessary.

4.3.2 Off Site Cesium-137 Investigation

In July, 1998 surface soil sampling was conducted along a drainage ditch adjacent to Old Davis Road (Figure 4-4). The purpose of this investigation was to determine if cesium-137 was present above background levels within the drainage ditch, and to identify potential sources of any elevated levels. This investigation is summarized briefly here, and is discussed in detail in the Technical Memorandum: Results of Off-Site Cesium-137 Investigation (Weiss Associates, 1999b).

A surface gamma radiation survey was conducted in the drainage ditch using a hand-held detector. Gamma readings from this survey ranged from 370 counts per minute (cpm) to 617 cpm, with no apparent distribution pattern.

Thirty-five surface soil samples were collected from depths of 0 to 6 inches from the drainage ditch along old Davis road adjacent to the Site and from a similar storm water runoff ditch located approximately one-half mile from the Site.

The results of this investigation indicated that:

- Cesium-137 was detected in all samples at activities from 0.0229 to 0.2394 pCi/g.
- There was no significant difference between the cesium-137 activities detected in the drainage ditch near the Site, and activities detected in the ditch located one-half mile from the Site.
- Cesium-137 activities in these areas are within the range reported by others for activities associated with global fallout from atmospheric nuclear testing in the vicinity of the Site.
- Potential human health risks associated with cesium-137 in the ditches appear to fall within the NCP-defined Acceptable Exposure Levels (i.e. 10^{-4} to 10^{-6} excess upper bound lifetime risk to an individual).

Based on these findings, it appears that the Site is not a source of significant environmental releases of cesium-137 in the off-site ditch area, and no further action is warranted.

4.3.3 Dog Pens Phase C Investigation

A three-phase investigation of the Western Dog Pens was initiated in 1997 and completed in 1998. Phases A and B were completed in 1997 and are summarized in the 1997 Annual Site Environmental Report. Phase C, which commenced in February 1998, is summarized briefly in this report. All phases of the Western Dog Pens Investigation and all data related to the investigation are presented in detail in the Final Technical Report: Results of the Western Dog Pens, Background and Off-Site Investigations (Weiss Associates, 1998f).

The Dog Pens Investigation Phase C (DPI Phase C) was designed to better define the vertical extent of radionuclide, pesticide and metals concentrations that are significantly above background, and to identify any COCs present at depth, but not identified in widespread surface samples.

DPI Phase C consisted of: 1) collecting 5 samples each (and 6 duplicates) from 20 soil borings located in 20 different dog pens; 2) collecting 6 grab ground water samples (and one duplicate) from 6 of the 20 boreholes; 3) analyzing all soil samples for selected radionuclides, organochlorine pesticides, mercury, nitrate, and hexavalent chromium; 4) analyzing selected soil samples for ammonia, organic nitrogen, total organic carbon (TOC), and total chromium; and, 5) analyzing all ground water samples for strontium-90, radium-226, gross alpha, gross beta, mercury, nitrate, ammonia, organic nitrogen, TOC, total chromium, and hexavalent chromium. Sampling locations are shown in Figure 4-5.

DPI Phase C radiological soil data indicate that:

- Radium-226 was below background (0.75 pCi/g) in all 106 Phase C soil samples.
- Radionuclides detected above background include srontium-90, cesium-137, carbon-14, thorium-234, uranium-235, uranium-238, and lead-210. None of these radionuclide activities exceed their respective 10^{-6} RBAS, and there was no apparent pattern in the distribution.

DPI Phase C radiological ground water data indicate that:

- Strontium-90 was not detected in any of the seven grab ground water samples.
- Radium-226 was detected at a maximum concentration of 0.97 pCi/L, which is well below the 5 pCi/L MCL and similar to levels recently detected in upgradient wells UCD1-4 and UCD1-18.
- There is no apparent correlation between constituent concentrations in ground water and concentrations in the immediately overlying soil.

The results of the Phase C investigation, when integrated with information gathered during phases A and B and all previous investigations, comprise a large body of data regarding the nature and extent of contamination in this area. These data are considered sufficient to support remedial decisions for the Western Dog Pens, and no additional investigations are planned.

4.3.4 Mixed Waste Storage Facility

In May and June 1998, radiological survey and analyses were performed on the MWSF structure and underlying surface soil. The results of these investigations are discussed in detail in the Mixed-Waste Storage Facility Summary Data Report (Weiss Associates, 1999a), and are summarized briefly here.

The results of the MWSF investigations indicated that:

- The radiological survey detected no radionuclides above the guideline value of 1000 dpm/100 cm^2.
- Three radionuclides (Bisthmuth-212, potassium-40 and cesium-137) were detected in wood samples at a maximum activity of 3.11 pCi/g; and

- Five radionuclides (bismuth-212, cesium-137, lead-210, thorium-234 and uranium-238) were detected in soil slightly above background.

On September 30, 1997 a Closure Plan for the Mixed Waste Storage Facility (EMS, 1997) was submitted to DTSC. On April 27, 1999 DTSC issued a letter accepting the Closure Plan pending a public notice period.

4.4 Surface and Storm Water Monitoring for Radiological Constituents

Quarterly ground water and surface water sampling has been conducted at the Site since 1990 for an extensive list of analytes. In 1997, in accordance with the MOA, responsibility for surface water and ground water sampling was transferred to UC Davis. DOE retained responsibility for storm water runoff sampling in the DOE areas of the Site. Results of the surface water and storm water sampling are summarized here, and discussed in detail in the Quarterly Water Sampling Reports (Dames and Moore, 1998a, 1998b, 1998c) and the Annual Water Monitoring Report (Dames and Moore, 1999). The ground water monitoring results are discussed in Section 6 of this report.

4.4.1 Surface Water Monitoring

In 1998 surface water samples were collected quarterly from three locations, Putah Creek Upstream (PCU), Putah Creek Downstream (PCD) and Wastewater (Sewage) Treatment Plant Outfall (STPO) (Figure 1-3). Gross beta and radium-226 were detected slightly above the MDA in surface water samples, but did not exceed the MCL. No other radionuclides were detected above the MDA.

4.4.2 Storm Water Monitoring

Storm water samples are usually collected twice a year; once at the beginning of the rainy season after the first storm of the season, and once near the end of the season. In accordance with the MOA between DOE and UC Davis (DOE, 1997a), DOE collected storm water from the lift station located on the western border of the site (LS-1 in Figure 1-3) and UC Davis collected samples from the UC Davis areas of the site (LF-1 and LF-3).

Storm water samples were collected in February 1998. Lead-212, tritium, uranium-238 and gross beta were detected above their MDAs. None of the activities for these compounds exceeded their MCL.

4.5 NESHAP Dose Estimation Calculations

Calculations were performed to determine estimated dose from Site sources to the public. These calculations were based on Site residual surface soil contamination (diffuse sources) and maximum waste activities generated from the RA in 1998. Remedial action in the summer of 1998

did not cause any elevated fugitive dust emissions. The other potential sources of emissions at the Site during 1998 were re-entrainment and subsequent dispersion of surface soil dust containing potentially elevated concentrations of radionuclides. Estimated contributions to the annual Site EDE from nonpoint source emissions (surface soil) are shown in Table 4-1, and are well below the NESHAP limit.

Table 4-1. Estimated Annual Maximum Effective Dose Equivalent

Maximum Individual Dose[1]	EPA and DOE Standard
8.6×10^{-2} mrem/year (8.6×10^{-4} mSv/year)	10 mrem/year (0.1 mSv/year)

Notes:
1 = Maximum effective dose equivalent from 1998 Radionuclide Air Emission Annual Report. Data are calculated, not measured; therefore, they represent potential or estimated rather than actual doses.
[1 Sievert (Sv) = 100 Roentgen equivalent man (rem)]

The Site non-point or diffuse sources (areas with known or potential radionuclide contamination resulting from past DOE activities at the Site) include the Ra/Sr Treatment Systems Area, the Southwest Trenches Area, the Eastern and Western Dog Pens Area, inactive landfill units and the storm water runoff system. Of these non-point sources, four have been determined to have radioactive material in near-surface soil (0 to 3 ft below ground surface) that could potentially lead to airborne radioactive material emissions. Those sources are the Ra/Sr Treatment Systems Area, the Southwest Trenches Area, and the Eastern and Western Dog Pens Area. Emission estimates from these sources are discussed below.

4.5.1 Nonpoint/Diffuse Source Emission

As noted above, there are no remaining point sources of radionuclide emissions at the LEHR facility. Compliance with the NESHAP requirements for diffuse, non-point source emissions was assessed using the EPA approved DOE atmospheric dispersion/radiation dose calculation computer code, CAP88-PC version 1.0. Conservative radionuclide emission rates were estimated using maximum soil activities measured above background for the Ra/Sr Treatment Systems Area and the Western and Eastern Dog Pens Areas as fugitive area sources. The emission rates for the Southwest Trenches were calculated by using the maximum radionuclide activities from the excavated wastes and assumed the wastes were exposed to the atmosphere for up to several weeks during the RA. Otherwise, modeling assumptions are identical to those assumed in the 1997 calendar year LEHR facility NESHAP report. These dust emissions rates were used to calculate the total estimated contribution to the EDE. The total contribution was estimated to be 8.6×10^{-2} mrem/year (Table 4-2). The CAP88-PC computer code was then used to calculate the EDE to individual receptors at various distances and from each of the four potential LEHR facility radionuclide emission sources. The estimated EDE to a Maximally Exposed Individual (MEI) at the LEHR facility was determined by summing the contributions from all four potential LEHR facility radionuclide emission sources. Based upon the combined source exposures, the MEI assumed for the LEHR facility would be

located on-site in the Reproductive Biology Laboratory. The results of the assessment are shown in Table 4-2.

Table 4-2. Estimated Dose Equivalent to On-Site Maximally Exposed Individual from Site Nonpoint/Diffuse Sources

Nonpoint Source	Dose Equivalent[1]	Percent of NESHAP Standard
Ra/Sr treatment system	6.3×10^{-5} mrem/yr	0.001
Southwest trenches area	8.5×10^{-2} mrem/yr	0.85
Western dog pen area	1.1×10^{-3} mrem/yr	0.01
Eastern dog pen area	8.3×10^{-6} mrem/yr	0.0001
Total Combined Contribution	8.6×10^{-2} mrem/yr	0.86

Notes:
[1] = Maximum EDE from 1998 NESHAP report (Weiss Associates 1999c). Data are calculated, not measured. Therefore, they represent potential or estimated rather than actual doses.
[1 Sievert (Sv) = 100 rem]

This calculated exposure for the MEI is very conservative due to the close proximity of the Southwest Trenches, and the assumption that maximum waste activities of all radionuclides are distributed across the entire Southwest Trenches. Despite the conservative assumptions, however, the resulting EDE from all sources to the MEI is 8.6×10^{-2} mrem/yr, significantly below the 10 mrem/yr NESHAP standard.

The CAP88-PC computer code was also used to calculate the collective population dose, as required by DOE order 5400.5. The collective population dose is calculated as the average radiation dose to an individual in a specified area, multiplied by the number of individuals in that area. The calculation included receptors at a distance of up to 10 km, rather than 80 km as specified in DOE Guidance, to avoid including the large number of receptors in the Sacramento area whose exposure to radionuclides resulting from the LEHR facility are negligible, but whose population numbers would have a large effect on population run results. This approach is appropriate for calculating the collective population dose for the primarily rural LEHR facility surroundings. The maximum off-site receptor exposure is estimated to be 4.1×10^{-4} mrem/yr; significantly below the 10 mrem/yr NESHAP standard (Table 4-3).

Table 4-3. Summary of Estimated Off-site Collective Population Dose Resulting from Radionuclide Emissions from Each Fugitive Dust Emission Source

Location	Off-Site Maximally Exposed Individual (mrem/yr)[1]	Distance[2]	Collective Population Dose (person-rem/yr)
Ra/Sr treatment systems area	2.8×10^{-6}	250 m North	7.9×10^{-6}
Southwest trenches area	3.8×10^{-4}	250 m North	1.1×10^{-3}
Western dog pens area	1.8×10^{-5}	250 m North	5.0×10^{-5}
Eastern dog pens area	2.3×10^{-6}	250 m North	6.5×10^{-6}
Total Site	**4.1×10^{-4}**		**1.2×10^{-3}**

Notes:
[1] = Maximum off-site EDE from 1998 Draft Final NESHAP report. Data are calculated, not measured. Therefore, they represent potential or estimated rather than actual doses.
[2] = Distance and direction from source area center to MEI receptor location.
[1 Sievert (Sv) = 100 rem]

4.6 Passive Thermoluminescent Dosimeter (TLD) Monitoring Program

The LEHR ambient radiation monitoring program uses TLDs to monitor gamma radiation throughout the Site. The TLDs are placed near perimeter fence lines, radioactive waste storage areas, and various work areas around the Site (Figure 4-6). The TLDs are collected quarterly, and an annual gamma radiation dose is calculated for each location. In 1998, TLD detectors and analyses were provided by Radiation Detection Company, which is certified by the National Voluntary Laboratory Accreditation Program. The laboratory data are normalized for each quarter by subtracting Site background activity from each location. TLD 35, located at the equine to the north of the Site is used to monitor background.

The annual background dose near the LEHR Site (measured by TLD 35) is 96 milliroentgen (mR)/yr which is consistent with previous years. The annual dose at the Site did not exceed the background at any location. The DOE public dose limit for exposure of members of the public as a consequence of routine DOE activities is 100 mrem/yr above background. These results show that ambient radiation detected at the Site is not elevated with respect to offsite background, and is well below the DOE dose limit for the general public.

5. ENVIRONMENTAL NON-RADIOLOGICAL PROGRAM INFORMATION

DOE activities at the Site in 1998 primarily consisted of the Southwest Trenches RA and additional soil characterization. This section provides a brief overview of significant results and trends in non-radiological Site air, soil and water monitoring identified in 1998. More detailed discussions of investigations and findings are presented in the reports referenced in each section.

5.1 Non-radiological Air Monitoring

Details of non-radiological air compound monitoring are presented in the LEHR Air Monitoring Report Summary 1995-1998 (Weiss Associates, 1999d). During the RA in 1998, air monitoring for non-radiological compounds was performed to monitor for potential elevated releases of non-radiological compounds into ambient air. In general the majority of air contaminants identified during the 1998 RA were below the laboratory detection limits. The results of air monitoring during the 1998 RA are included in the RA Confirmation Report (Weiss Associates, 1999e).

5.2 Non-radiological Soil Monitoring

The following sections summarize 1998 field activities and important analytical results for non-radiological compounds from the DOE areas at the Site.

5.2.1 Southwest Trenches RA

As discussed in Section 2, a non-time-critical RA was conducted at the Site in 1998. Extensive soil sampling and analysis were conducted prior to, and during excavation activities. Soil sampling was performed in conjunction with exploratory trenching to delineate the extent of contamination, during excavation activities to guide the removal action, and after the excavation was complete to evaluate whether RAOs had been achieved. A detailed discussion of these data and a data summary are included in the RA Confirmation Report (Weiss Associates, 1999e).

Delineation Sampling: Prior to excavation, the SWT Area was sampled to estimate the horizontal and vertical extent of chlordane and selected radionuclides. One hundred sixty-three samples were analyzed for chlordane, and an additional 24 locations were sampled for radium-226, cesium-137 and strontium-90. The results of this sampling were used to help determine the locations of the excavations.

Screening Sampling: Over 130 screening samples collected from the sidewalls and bottoms of the excavations were analyzed for the driver COCs chlordane, mercury, hexavalent chromium and nitrate. Hexavalent chromium was not detected above the 3.8 mg/kg screening criterion. Chlordane was detected in a few samples above the 800 µg/kg screening criterion, and additional excavation was performed to remove elevated concentrations. Mercury and nitrate were detected in many samples above their respective screening criteria (0.63 mg/kg and 36 mg/kg).

Confirmation Sampling: Over 60 confirmation samples collected from the excavations were analyzed for pesticides/PCBs, metals, VOCs, SVOCs and nitrate. The following compounds were detected:

- Pesticides; 4,4'-DDD, 4,4'-DDE, 4,4'-DDT, alpha and gamma chlordane, delta-BHC, dieldrin, heptachlor and PCB-1260 arochlor.
- VOCs; acetone, 2-butanone, ethylbenzene, styrene, toluene, total xylenes.
- Metals above background; antimony, barium, chromium, hexavalent chromium, lead, manganese, mercury, selenium, silver and zinc.
- Nitrate was detected above background in 40 samples.

Additional Nitrate Sampling: Based on the results of the confirmation sampling, over 300 additional samples were collected from the SWT Area from depths of 3 to 30 ft bgs. The samples were collected using a direct push drilling system. This sampling indicated that nitrate is present above background to 30 ft bgs, but that the horizontal extent of the elevated nitrate is limited to the area of investigation.

Based on these results additional investigation of nitrate and mercury may be required before it can be determined whether all the RAOs have been achieved.

5.2.2 Dog Pens Phase C Investigation

As discussed in Section 4, the Dog Pens Investigation Phase C was designed to better define the vertical extent of radionuclide, metals and pesticide concentrations that are significantly above background, and to identify any COCs present at depth, but not identified in widespread surface samples.

DPI Phase C non-radiological soil data indicate that:

- Alpha- and gamma-chlordane were detected in all but two of the surface soil samples at concentrations ranging from less than 0.001 mg/kg to 0.81 mg/kg. One sample exceeded the lowest 10^{-6} RBAS.
- Chlordane concentrations attenuated markedly with depth, and chlordane was below the detection limit in all of the soil samples collected from greater than 2 ft bgs.

- Other pesticides detected in trace concentrations (0.02 mg/kg or less) include 4,4'-DDE, 4,4'-DDT, and heptachlor epoxide. These trace concentrations were detected primarily in samples from the surface and 2 ft bgs.
- Hexavalent chromium was detected in concentrations exceeding two times background in 17 of the pens. Total chromium was slightly above background in five shallow or surface samples.
- Mercury was detected in concentrations exceeding two times background in samples from 10 of the pens. For mercury, the 10^{-6} RBAS is defined as background.
- All nitrate concentrations were below background.

DPI Phase C non-radionuclide ground water data indicate that:

- Ammonia and mercury were not detected in any of the seven grab ground water samples.
- Total chromium and hexavalent chromium, total organic nitrogen and TOC were detected at levels similar to those recently detected in upgradient wells UCD1-4 and UCD1-18, and are below the 0.050 mg/l MCL for hexavalent chromium.
- Nitrate was detected in all samples in concentrations ranging from 2.54 mg/l to 78.6 mg/l. The MCL for nitrate is 10 mg/l.
- There is no apparent correlation between constituent concentrations in ground water and concentrations in the immediately overlying soil.

The results of the Phase C investigation, when integrated with information gathered during phases A and B and all previous investigations, comprise a large body of data regarding the nature and extent of contamination in this area. These data are considered sufficient to support remedial decisions for the Western Dog Pens, and no additional investigations are planned.

5.2.3 Mixed Waste Storage Facility

In May and June, 1998, chemical analyses were performed on the MWSF structure and underlying surfacial soil: The results of these investigations are discussed in detail in the Mixed-Waste Storage Facility Summary Data Report (Weiss Associates, 1999a), and are summarized briefly here.

The results of these MWSF investigations indicate that:

- Eight VOCs and one SVOC were detected at up to 43.3 mg/kg in three samples collected from the wood floor. Formaldehyde was detected at up to 424 mg/kg.
- Five VOCs were detected at up to 2.2 mg/100cm^2 in three wipe samples collected from the secondary containment trays. Formaldehyde was detected at concentrations less than the field blank.

- Nine VOCs were detected at less than 1 mg/kg and formaldehyde was detected at up to 1.31 mg/kg in five surface soil samples collected beneath the structure.
- Additional soil sampling was conducted in October 1998 to determine whether the detected VOCs were present below the surface. No VOCs were detected except a trace concentration of chloroform at 18-24 ft bgs.

Based on the sampling results, it was determined that the MWSF had no significant environmental impact on the underlying soil, and the Facility Closure Plan (EMS, 1997) was accepted by DTSC.

5.3 Non-radiological Surface and Storm Water Monitoring

In 1998 ground water and surface water sampling were conducted and reported by UC Davis. DOE sampled only storm water runoff from the Site. Surface water and storm water monitoring results are summarized briefly here, and will be presented in detail in the UC Davis's Annual Water Monitoring (Dames and Moore, in progress). Ground water monitoring is discussed in Section 6 of this report.

5.3.1 Surface Water Monitoring

Surface water samples were collected quarterly during 1998 from locations PCU, PCD and STPO (Figure 1-3). 1998 surface water analytic results were very similar to previous years. Six VOCs were detected; acetone, bromodichloromethane, bromoform, chloroform, dibromochloromethane, and toluene. One or more of the trihalomethane group (chloroform, bromodichloromethane, dibromochloromethane, and bromoform) were detected at STPO and downstream at PCD well below the total trihalomethane MCL of 100 µg/l. The use of chlorine disinfectants in the UC Davis wastewater treatment plant is the apparent source of these constituents. Toluene was detected at all locations at up to 0.44 µg/l, well below the 150 µg/l MCL. No VOCs were found in surface water samples in concentrations exceeding their MCL in 1998.

Beta-BHC and heptachlor were the only pesticides detected. Both compounds were detected at STPO in the fall sample at up to 0.025 µg/l. Each quarterly surface water sample was analyzed for 19 metals and hexavalent chromium. None of the metals detected in 1998 exceeded the MCL.

Nitrate concentrations in surface water samples were below the 10 mg/l MCL (for nitrate as nitrogen) in all 1998 samples. Reported concentrations of nitrate in STPO were higher than in the upstream or downstream samples. This trend has been observed since 1994.

5.3.2 Storm Water Monitoring

Storm water samples are usually collected twice a year; once at the beginning of the rainy season after the first storm of the season, and once near the end of the season. However, in 1998, fall samples were not collected due to unfavorable weather conditions.

1,3-dichlorobenzene, 2-butanone, tetrachloroethene, and trichloroethene were detected in storm water samples in concentrations less than the MCLs. Gamma-chlordane was detected at LS-1 at less than 0.014 µg/l, well below the 0.1µg/l MCL. No other pesticides were detected.

Metals were detected in all samples, but none were detected above the MCL. This result is consistent with previous years.

5.3.3 National Pollutant Discharge Elimination System (NPDES) Data

The Site discharges its sanitary waste to the UC Davis Wastewater Treatment Plant, which is permitted according to NPDES requirements. Current DOE activities do not contribute to hazardous discharges.

6. GROUND WATER PROTECTION PROGRAM

Ground water monitoring has been conducted quarterly for the LEHR ER/WM Project since November 1990. The quarterly monitoring program began as a component of the Phase II Site Characterization (Dames & Moore 1993). In 1993, the program evolved to include the development of a Site Water Monitoring Plan, designed to meet the requirements of DOE's General Environmental Protection Program in DOE Order 5400.1.

Water monitoring is conducted in conjunction with the CERCLA process as part of the DOE-sponsored environmental restoration program underway at the Site. Since LEHR has not been an operational site since 1989, the current water monitoring program focuses primarily on environmental surveillance activities for non-operational facilities. Figure 1-3 shows the location of ground water monitoring wells for the Site.

The objectives of the ground water monitoring program are to characterize baseline ground water conditions at the Site by: 1) further evaluating impacts of previous LEHR facility operations on ground water in the area; 2) providing data to support future Site activities (risk assessment and remedial actions); and 3) compliance with applicable federal, state and local regulations.

In 1998 all ground water and surface water monitoring at the Site was performed and reported by UC Davis except for storm water sampling from DOE areas. The results of the water monitoring are discussed briefly here, and are discussed in detail in the Dames and Moore Quarterly and Annual Water Monitoring Reports.

6.1 Hydrology

The hydrogeology of the Sacramento Valley is comprised of both unconfined and confined aquifers in the flat or gently sloping sedimentary deposits in the upper 3,000 feet beneath the valley. No regionally identified confining units are known to exist in the Sacramento Valley. Ground water is recharged through leakage from streams and rivers, as well as from direct precipitation and irrigation (DOE, 1992b).

Ground water is encountered beneath the Site at depths ranging seasonally from about 20 to 70 feet below ground surface. The water levels are usually highest in early spring and lowest in summer. Based on analysis of subsurface stratigraphy, the uppermost aquifer has been divided into two hydrostratigraphic units (HSUs). A hydraulic connection exists between these two layers, as evidenced by comparison of hydrographs. Water levels in both HSUs show a characteristic rise during fall and winter, and a decline during spring and summer. However, the two HSUs are distinctly different water-bearing zones with different characteristics.

Hydraulic testing performed on well EW2-1 indicates that the hydraulic conductivity of HSU-2 is approximately 750-1,200 ft/day, transmissivity is approximately 33,000-52,000 ft^2/day, and storativity is estimated at 0.0005 to 0.0067 (Dames and Moore, 1997).

The direction of ground water flow in HSU-1 is generally toward the northeast, although local temporary changes in flow direction and gradient occasionally occur. In HSU-2, ground water flow is predominantly toward the east/northeast. Generally, gradients are lower in winter and fall, and higher in spring and summer.

6.2 Uses of Ground Water in Vicinity

Local ground water is utilized for both drinking and agricultural purposes. The major ground water sources for both public and private water supplies in the Sacramento Valley are unconsolidated deposits of Pliocene and Pleistocene age, and older alluvium (DOE, 1992b). The first HSU is not used for drinking or irrigating purposes. In the general area near the Site, a number of domestic and irrigation wells produce water from HSU-2.

HSU-2 is underlain by HSU-3, a clayey silty aquitard, and HSU-4, a sand and gravel aquifer extending to approximately 280 feet below ground surface.

6.3 Potential Sources of Ground Water Pollution

A number of locations on-site are considered "waste management areas," where a variety of potential wastes were handled and/or buried during former Site operations. Impact from these areas has been evaluated during previous investigations and may be further evaluated during future investigations and/or remedial actions. Most impacts to ground water that have been identified are localized on the Site near waste burial locations and are within the first HSU, which is not used for drinking water. The primary waste management areas include: the Imhoff treatment system, the radium-226 treatment system, domestic septic tanks (some of which may have received project effluent), chemical dispensing areas, waste burial trenches, landfill units, dog pen areas, and dry wells for storm water (storm water may have carried wastes from other management areas). Some of the waste burial trenches were excavated and removed by DOE in 1999.

6.4 Ground Water Monitoring

In 1997, in accordance with the MOA between DOE and UC Davis, responsibility for surface water and ground water sampling was transferred to UC Davis. The ground water monitoring program discussed in this section is under the jurisdiction of, and is performed by, UC Davis. The ground water monitoring program is summarized here and discussed in more detail in UC Davis's Annual Water Monitoring Report (Dames and Moore, in progress). Quarterly ground water samples were collected in February, May, August and November, 1998. The sampling frequency and requested analytes followed the specifications of the Water Monitoring Plan. All well locations are shown in Figure 1-3.

6.4.1 Radionuclides

Results of the radiological analyses indicated that americium-241, bismuth-212, bismuth-214, carbon-14, gross alpha and gross beta, lead-214, plutonium-241, radium-226 and thallium-208 were detected in Site wells in activities slightly above the MDAs. Tritium was detected above its MDA but below the 20,000 piC/l MCL in Site wells during 1998. The maximum tritium concentration of 17,600 piC/l was detected in well UCD1-13. These results are consistent with previous years, and no new trends were identified.

6.4.2 Volatile Organic Compounds

VOCs were detected mostly in HSU-2 and the downgradient HSU-4 wells, with the exception of UCD1-12. Observed trends in 1998 analytical results were not significantly different from previous years for the majority of wells.

Chloroform was the most frequently detected VOC with a maximum concentration of 6,870 µg/l detected in UCD1-12. These results are consistent with previous years and exceed the 100 µg/l MCL for total trihalomethanes. 1,1-dichloroethane, 1,1-dichloroethene, and 1,2-dichloroethane were detected in at least one well at concentrations exceeding their respective MCL. The maximum concentration for all of these compounds was detected in UCD1-12, which is consistent with previous years. Acetone, bromoform, bromomethane, bromodichloromethane, chloromethane, 1,2-dichloropropane, methylene chloride, tetrachloroethene and 1,1,2-trichloroethane were detected in concentrations above the contract required detection limit (CRDL) limit, but not exceeding their MCL.

6.4.3 Semivolatile Organic Compounds

One SVOC, bis(2-ethylhexyl)phthalate was detected at 88.3 µg/l in well UCD2-017. SVOCs have historically been sporadically detected in LEHR area ground water and no definite trends are evident. No SVOCs were detected above the MCL.

6.4.4 Pesticides and PCBs

Eight pesticide compounds were reported in 1998 ground water samples; 4,4'-DDD, alpha chlordane, dieldrin, endrin, endrin keytone, gamma-BHC (lindane), gamma-chlordane and heptachlor. Of these, only dieldrin was detected above the CRDL at 0.03 µg/l in UCD1-13. No PCB compounds were reported in 1998 ground water samples.

6.4.5 Metals

Arsenic, barium, calcium, cobalt, iron, magnesium, manganese, nickel, selenium, sodium, vanadium and zinc were detected in Site wells above the CRDL. None of these compounds exceeded their respective MCL.

Total and hexevalent chromium are detected consistently in most site wells, and exceeded the 50 µg/l MCL in most HSU-1 wells, one HSU-2 well, and no HSU-4 wells. No definite pattern of contamination related to site burial areas is discernable for chromium, although results from each well are very consistent over time.

6.4.6 General Chemicals

Alkalinity, ammonia as nitrogen, chemical oxygen demand, chloride, phosphorus, and sulfate were monitored in site wells in 1998, and were generally detected at or below background. TDS exceeded its 500 mg/l secondary MCL in many wells. These results are consistent with previous years.

Nitrate as nitrogen was detected above the 10 mg/l MCL in many HSU-1 wells but only two HSU-2 wells. The highest concentrations were detected in UCD1-24 (94.6 mg/l), which has shown increasing levels for several years. Concentrations also appear to be increasing in UCD1-10. Concentrations in all other wells have been relatively consistent over time.

6.5 Off-Site Neighbor Well Sampling

Sampling of private wells to the south, north, and east of the Site has been conducted since 1989. Because the wells are not uniform in dimension or construction, limited comparisons can be made between these wells and Site ground water data. The off-site neighbor well sampling program has provided information about the quality of water in private domestic and irrigation wells regarding the primary Site COCs: VOCs, tritium, hexavalent chromium, nitrate as nitrogen, gross alpha and gross beta. Monitoring of radiological constituents was ceased in 1996 because no radiological contamination that could be attributed to the LEHR site was found in any neighbor well. Private wells sampled in 1998 are shown in Figure 6-1.

In 1998, UC Davis sampled selected irrigation and domestic wells to the east of the Site four times. Hexavalent chromium and nitrate as nitrogen were detected in many of the wells. These compounds are present in regional ground water, and no direct link to the Site has been established.

Chloroform was detected in concentrations of less than 1 µg/l in three off-site wells: 22A, 22P2 and 22K. Bromomethane was detected at an estimated value of 2.9 µg/l in well 15K3, however no bromomethane was detected in a duplicate sample collected on the same date.

7. QUALITY ASSURANCE

Quality assurance (QA) is a key element of the environmental protection program for the Site. A Quality Assurance Project Plan (QAPP) that describes the requirements for all quality-related work on the LEHR project has been prepared (Weiss Associates, 1998e). In the planning for each phase of the LEHR ER/WM Project (site characterization, investigation, D&D, etc.) this QAPP and other quality-assuring documents, such as Standard Quality Procedures (SQPs), Standard Operating Procedures (SOPs) and task-specific workplans are followed. The purpose of the QAPP and these other documents is to identify the specifications and methods employed to establish technical accuracy and precision, validity of measurements and statistics, and to provide a sound basis for management decisions that will be based on environmental information collected for the Site. The QAPP for the LEHR ER/WM Project was prepared in accordance with EPA QA/R-5 and National Quality Assurance (NQA)-1 specifications. It also incorporates guidance from DOE Order 5700.6C and the General Environmental Protection Program as defined in DOE Order 5400.1, to ensure that DOE quality and environmental goals are met.

Environmental samples collected by DOE discussed in this report were collected, analyzed and reviewed according to the QAPP and other relevant SOPs and/or task-specific workplans. To assure quality, quality control (QC) is integrated into all aspects of environmental sampling. Included in the QAPP and related documents are sections identifying QC for sample collection requirements and specific quality assurance objectives for the measurement data. QC samples are run with each sample batch at the laboratory to validate the method of analysis and the proficiency of the analyst. Because holding times are an important factor in the sample quality, these are carefully controlled. To ensure the comparability of analytical data, all samples are analyzed by EPA-approved methods when available. When analytic results are received, they are reviewed by the contractor according to the defined data quality objectives and data review procedures.

Most of the 1998 environmental sample data for Site air, soil and water were collected under the strict quality assurance requirements of the CERCLA process. Most of these data have been carefully reviewed and validated as required by the QAPP. Most of the 1998 Site air, soil and water monitoring data have been, or will be, presented in separate reports. The individual review and validation process for each data set is presented in these reports, and will not be discussed in detail here.

7.1 Field Quality Assurance

Quality assurance for field sampling is accomplished by using field replicates, decontamination rinseates, trip blanks and field blanks, as appropriate for the type of sample collected. For each round of sampling, duplicate samples are collected from a selected sample point at the same time as the original sample to check for consistency in the sampling process. The duplicate sample serves as a check on the precision of the sampling and analytical procedures.

Decontamination rinseates are analyzed whenever the potential exists for cross-contamination from sampling equipment. Trip blanks are sent with each shipment of water samples requiring analysis for volatiles. Field blanks are collected to check for contamination during the water sampling process. Calibration records for each field instrument are maintained in the contractor QA files.

7.2 Laboratory Quality Assurance

Contracted laboratories providing analytical services for the LEHR ER/WM Project are evaluated by UC Davis and/or Weiss Associates to assure compliance with the QA program requirements. Laboratory quality assurance is analyzed externally by submitting split samples, spiked samples, and blanks to the laboratories analyzing environmental samples. Laboratories must submit their analytical procedure for review if it differs from standard procedures. Each contract laboratory is required to maintain participation, as applicable, in DOE, State of California, and/or EPA approved inter-laboratory QA programs such as DOE's' Environmental Measurement Laboratory inter-laboratory comparison program, or EPA's Water Pollution/Water Supply Program.

7.3 Compliance Audits

Periodic audits of aspects of the LEHR program are conducted to assure compliance with project standards. Several Health and Safety audits, a QA field audit, and an audit of General Engineering Laboratory were performed in 1998. All findings and observations identified during the audits were addressed in a timely manner, and these audits are considered closed.

7.4 Summary of Quality Control Data Validation

The overall quality assurance objective is to collect and analyze environmental samples from the Site in a manner that ensures technical data are accurate and representative, are able to withstand scientific and legal scrutiny, and are useful for evaluating Site conditions and remedial actions. The criteria used to specify QA goals are precision, accuracy, representativeness, completeness, and comparability (PARCC) for evaluation of QC data. The PARCC parameters are evaluated through data validation. Table 7-1 summarizes the components that are used to monitor and evaluate the quality of LEHR environmental data.

Table 7-1. Components of the LEHR QC Program in Support of Data Quality Objectives

Data Quality Objective	QC Component	Evaluation Criteria
Precision	• Field duplicate • Matrix spike • Matrix spike duplicate	Relative percent difference
Accuracy	• Matrix spike • Matrix spike duplicate • Surrogate spikes	Percent recovery
Representativeness	• Trip blanks • Field duplicate • Method blanks	Qualitative degree of confidence
Completeness	• Holding time • Valid data points	Percent valid data
Comparability	• Analytical methods • Field duplicates	Qualitative degree of confidence

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9. ACKNOWLEDGMENTS

The following LEHR Project personnel worked on the 1998 ASER:

Name and Position	Responsibility
Michael Dresen LEHR Program Manager, Weiss Associates	Senior guidance and review, and quality assurance
Robert Devany LEHR Project Manager, Weiss Associates	Project management, guidance and review.
Salem Attiga Principal, EMS	Senior review
Mary Stallard LEHR Quality Assurance, Weiss Associates	Technical guidance and review, and quality assurance
Alison Watts Project Geologist, Weiss Associates	Project coordination, report writing
Craig Adams Graphics, Weiss Associates	Graphics
Nerissa de Jesus Project Administrator, Weiss Associates	Word processing and report coordination
Ted Trammel Production Personnel, Weiss Associates	Graphics and report production

FIGURES

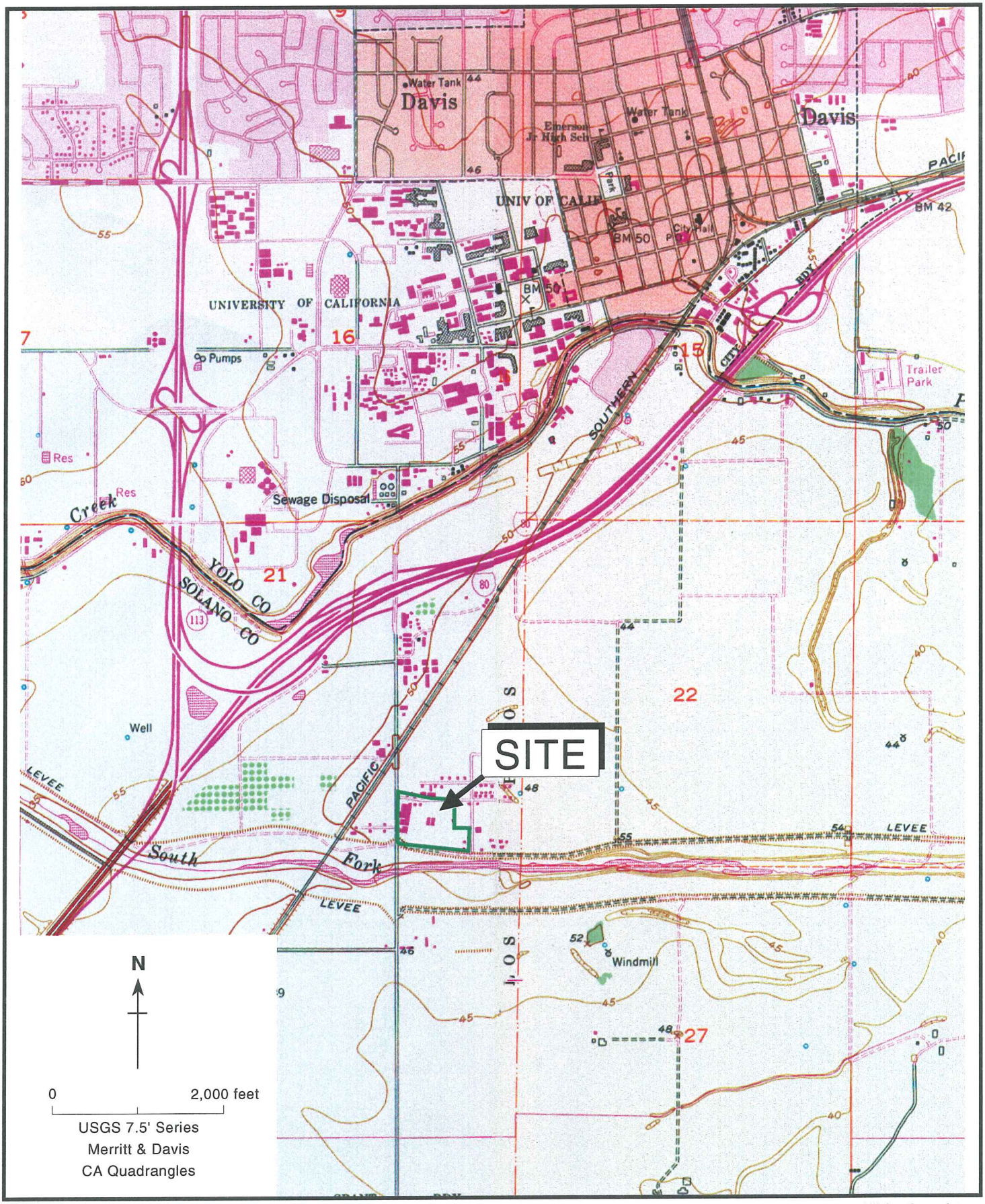

Figure 1–1. Location of the LEHR Site, UC Davis, California

Weiss Associates

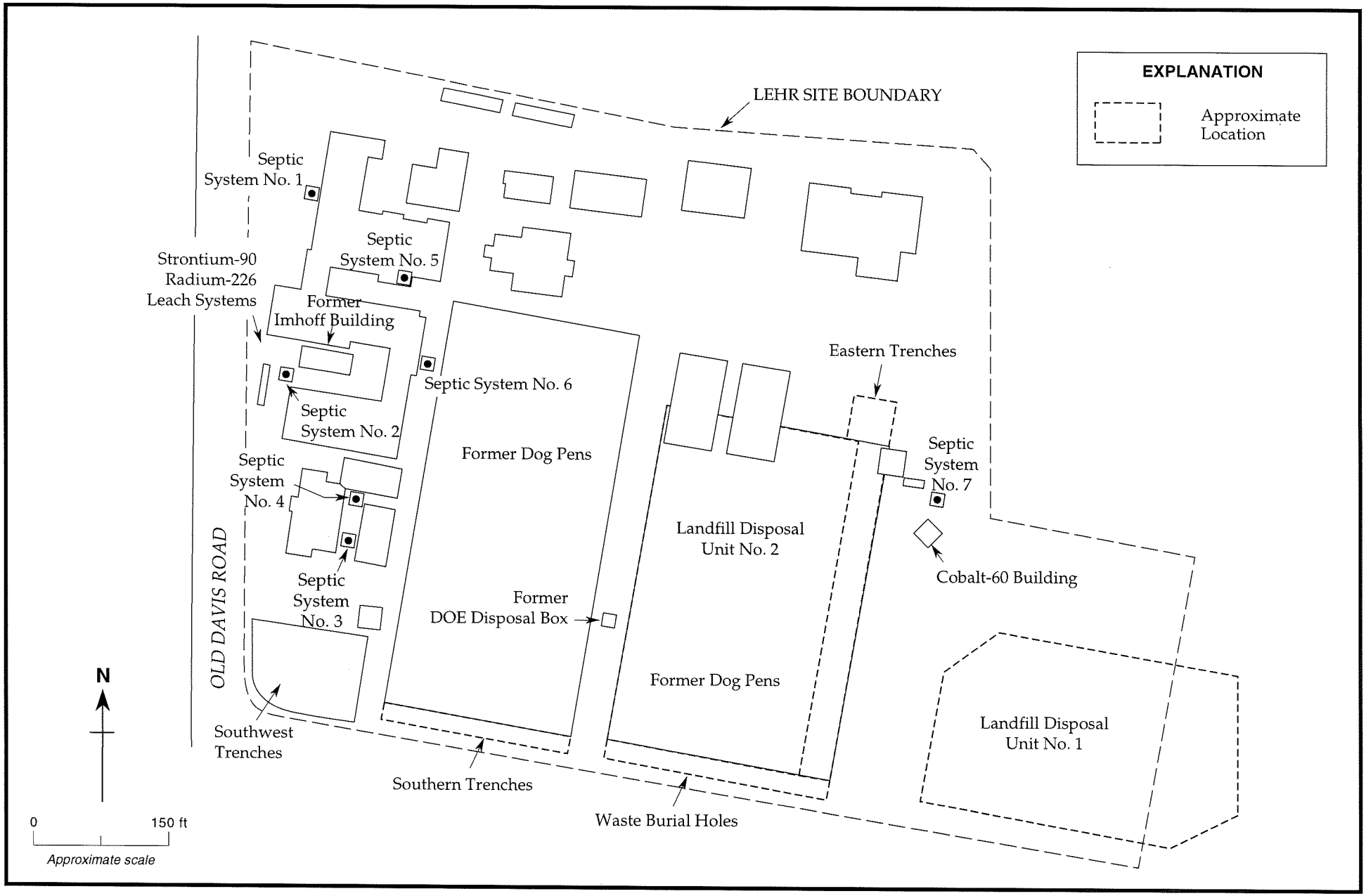

Figure 1-2. Site Features that May have Impacted the Environment, LEHR Site, UC Davis, California

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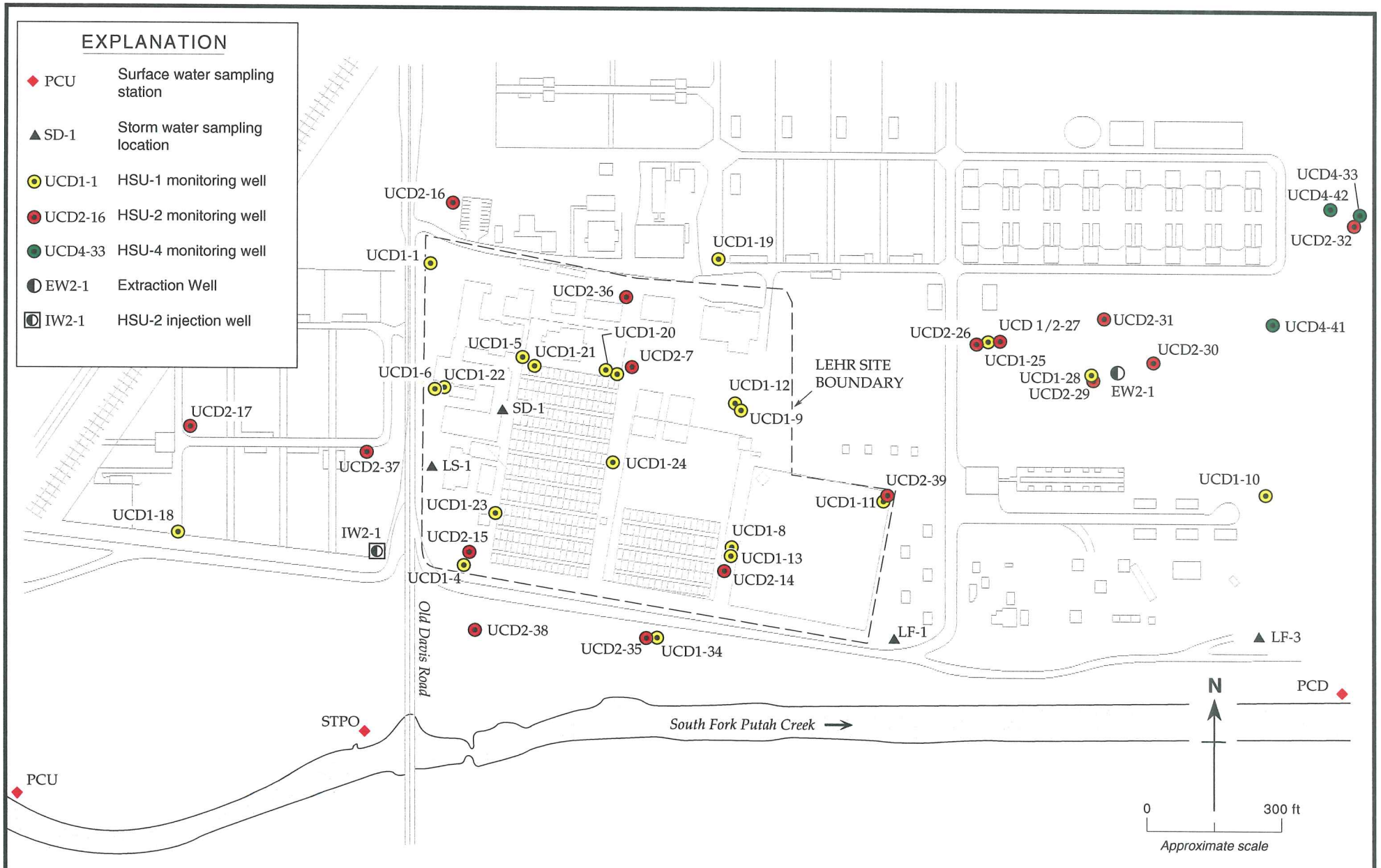

Figure 1-3. Monitoring Well, Storm Water and Surface Water Monitoring Locations, LEHR Site, UC Davis, California

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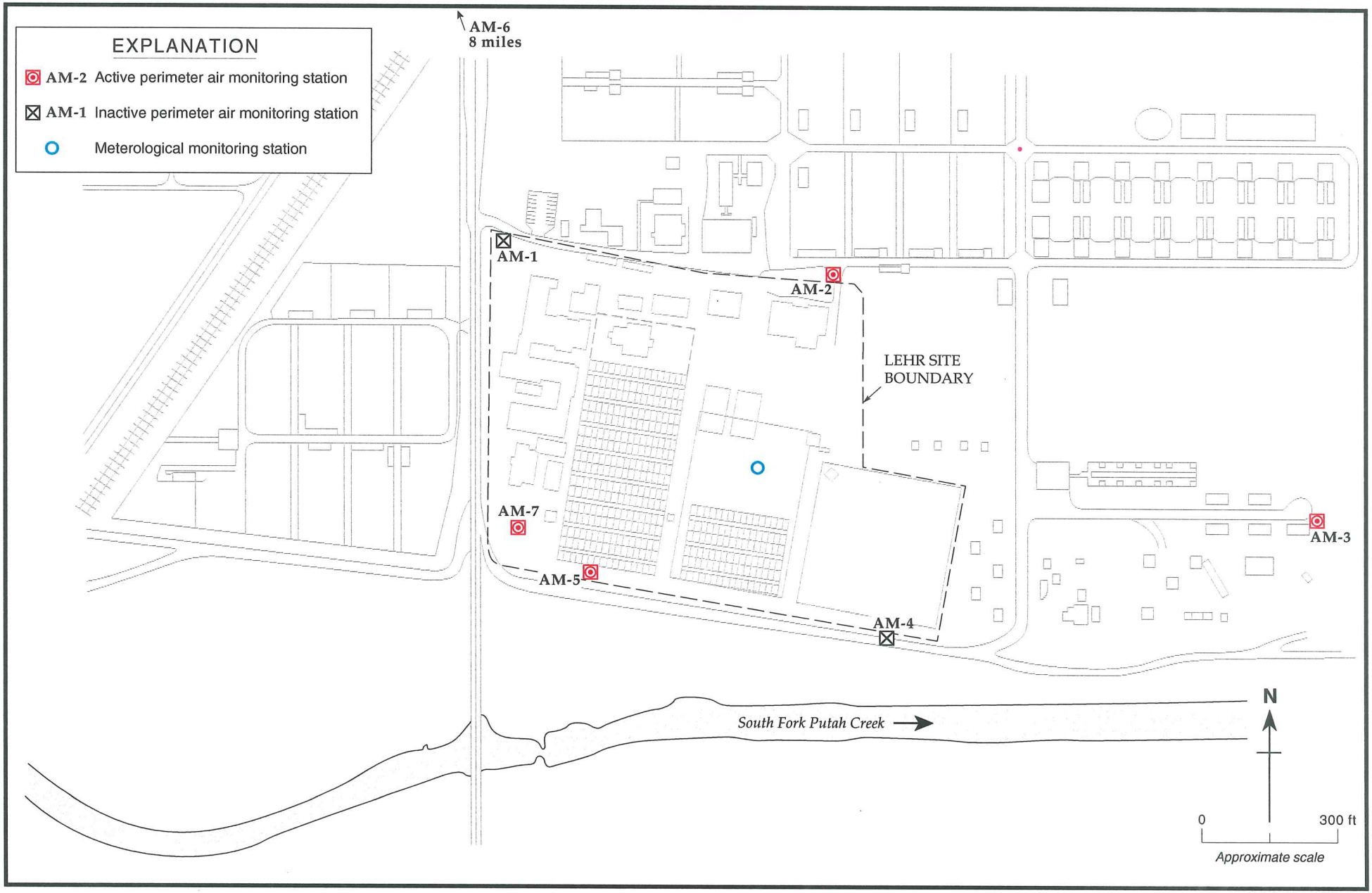

Figure 4-1. On-Site Air Monitoring Station Locations, LEHR Site, UC Davis, California

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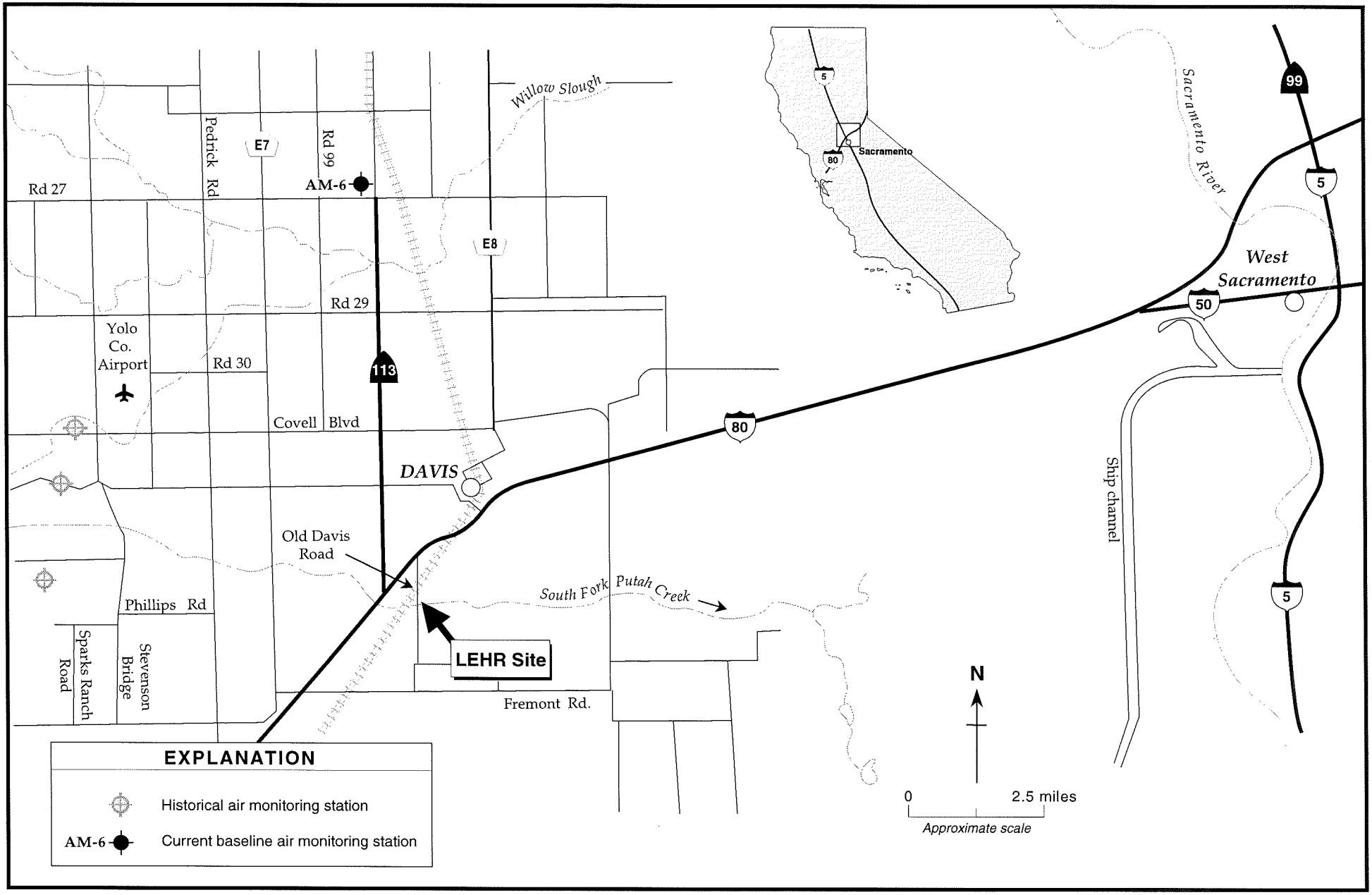

Figure 4-2. Off-Site Air Monitoring Station Locations, LEHR Site, UC Davis, California

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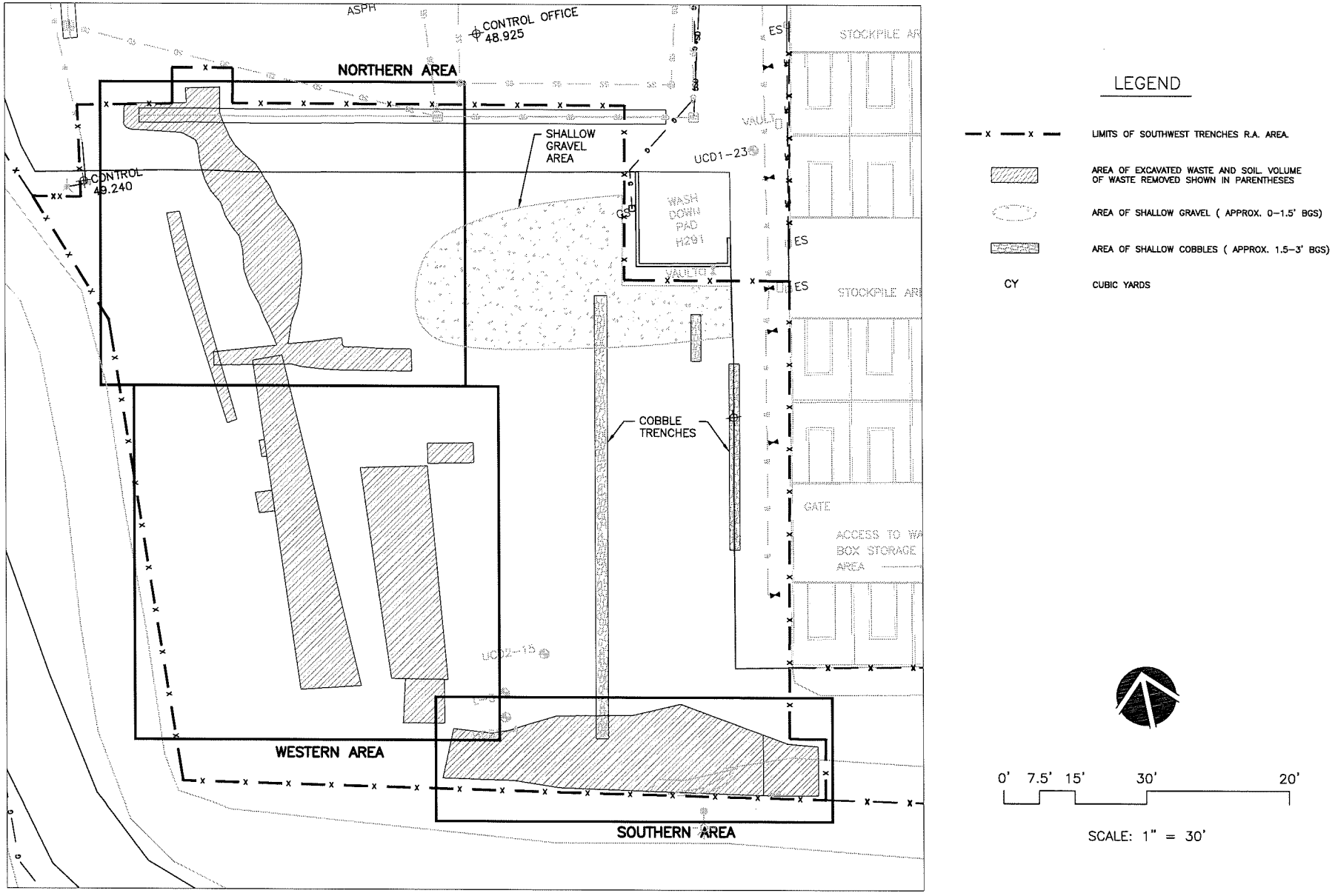
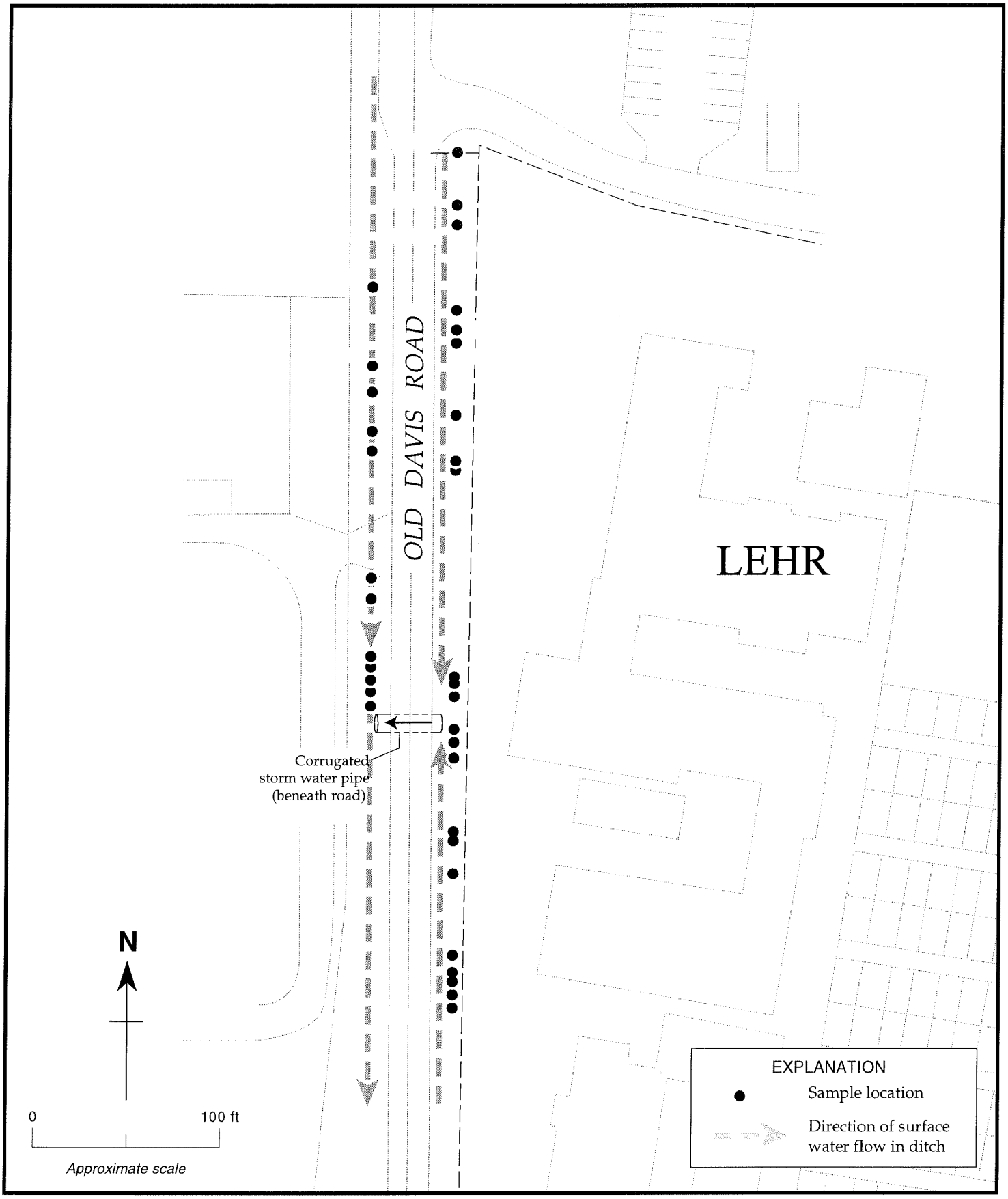


FIGURE 4-3. SOUTHWEST TRENCHES LOCATION MAP, LEHR SITE, UC DAVIS, CALIFORNIA



Weiss Associates

Figure 4-4. Off-Site Cesium-137 Investigation Sampling Locations, LEHR Site, UC Davis, California

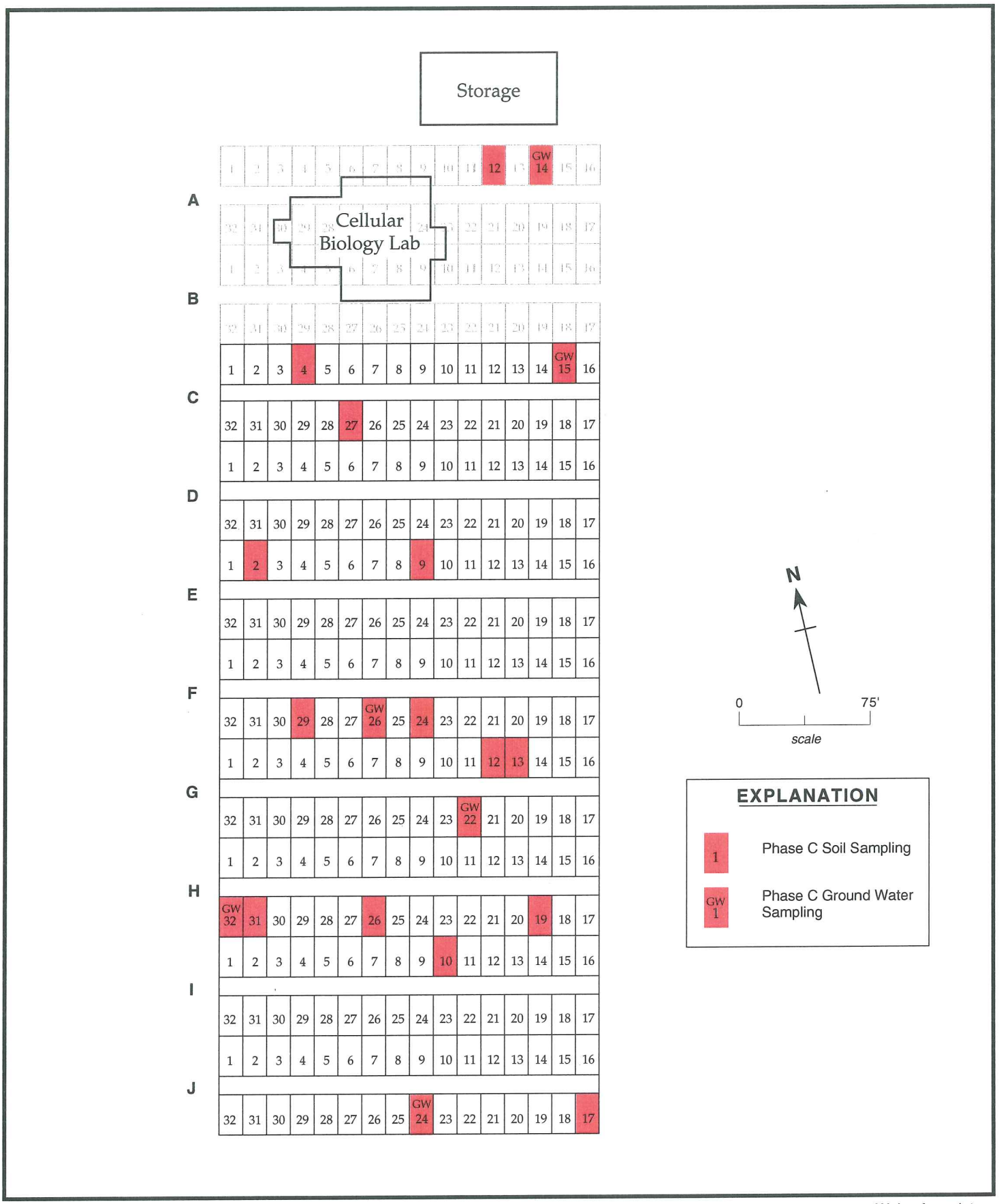


Figure 4-5. Dog Pens Phase C Sample Locations, LEHR Site, UC Davis, California

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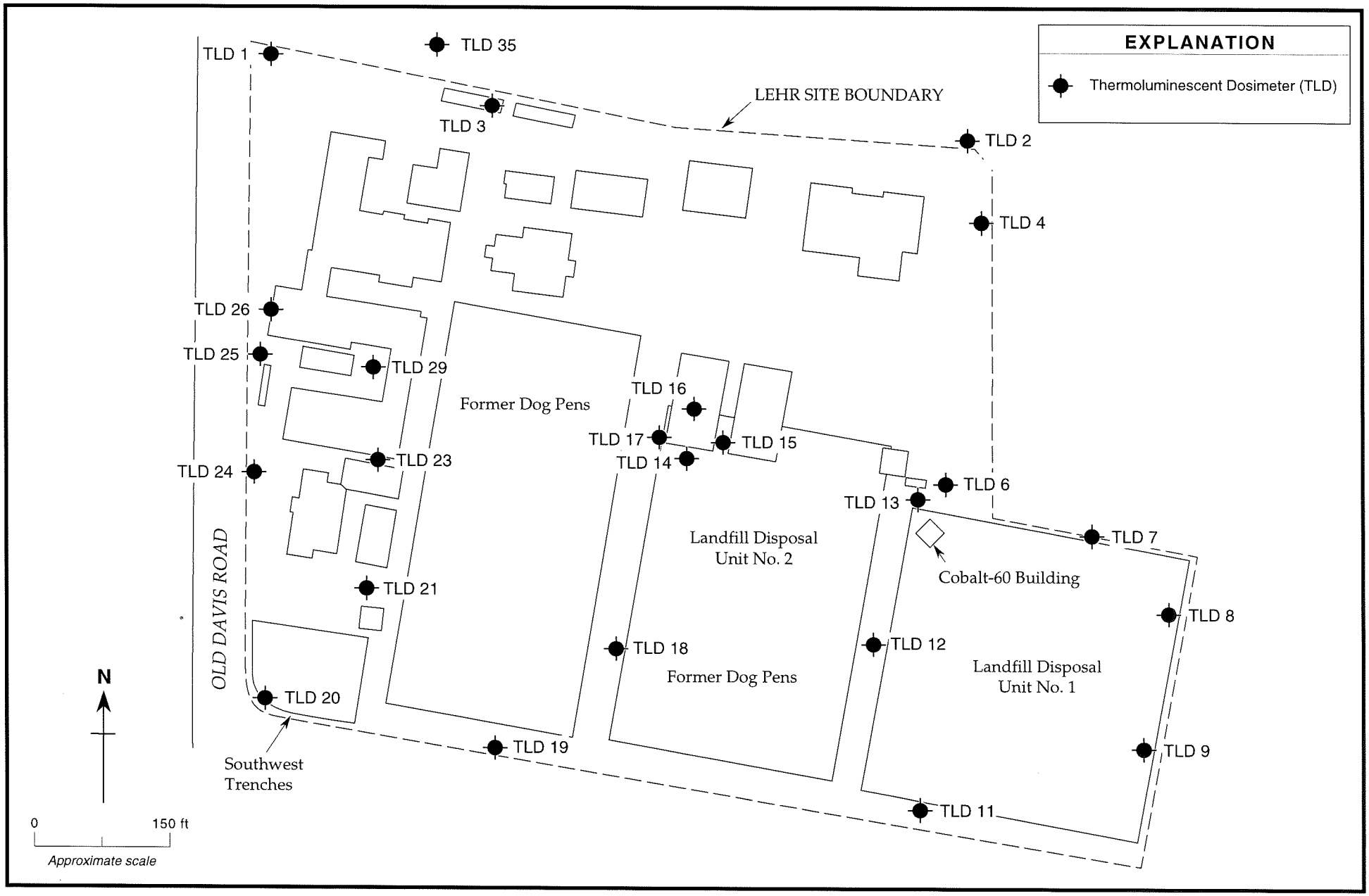

Figure 4-6. TLD Location Map, LEHR Site, UC Davis, California

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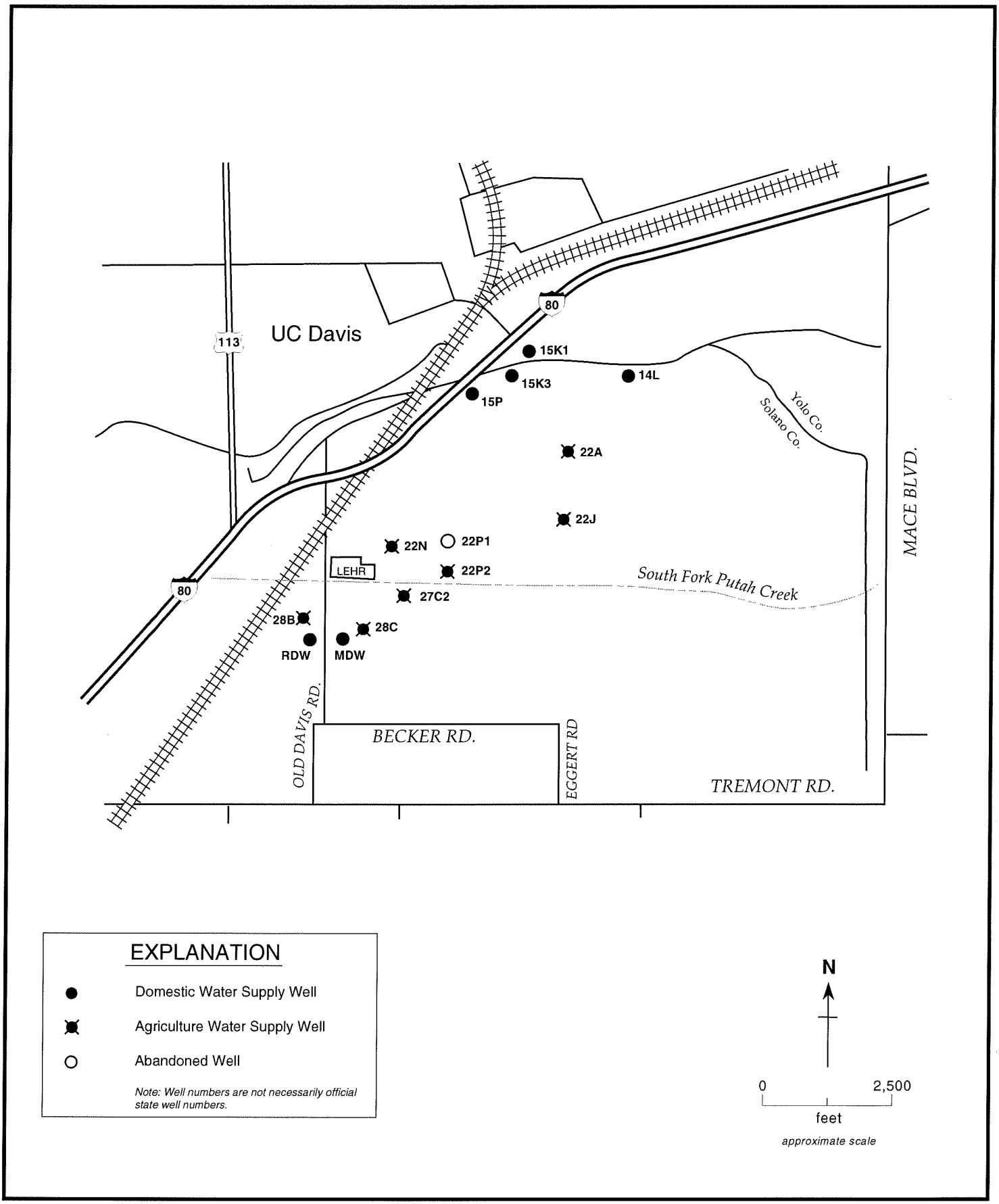

Figure 6-1. Neighbor Well Sampling Program Locations Near the LEHR Site, UC Davis, California

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