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SUMMARY WORK PLAN FOR WESTERN DOG PENS, BACKGROUND, AND OFF-SITE INVESTIGATIONS

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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5500 Shellmound Street
Emeryville, California 94608

September 1997
Rev. 0

DOE Oakland Operations Office Contract DE-AC03-96SF20686

Weiss Associates
Environmental and Geologic Services

LEHR-141

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Approvals Page

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ACRONYMS

bgs	below ground surface
BI	Background Investigation
DPI	Dog Pens Investigation
DQO	Data Quality Objective
EE/CA	Engineering Evaluation/Cost Analysis
USEPA	United States Environmental Protection Agency
LAS	LAS Laboratories
LEHR	Laboratory for Energy-Related Health Research
LFI	Limited Field Investigation
mCi	milliCuries
mg/kg	milligrams per kilogram
MDA	Minimum Detectable Activity
ORI	Off-site Radium-226 Investigation
OU	Operable Unit
pCi/g	PicoCurie(s) per gram
PPE	Personal Protective Equipment
QA/QC	Quality Assurance/Quality Control
QAPP	Quality Assurance Project Plan
RI/FS	Remedial Investigation/Feasibility Study
SCIN	Scintillation detector
RBAG	Risk-Based Action Goal
RPM	Remedial Project Manager
SOP	Standard Operating Procedure
UC Davis	University of California at Davis
USA	Underground Services Alert
USCS	Unified Soil Classification System
USEPA	United States Environmental Protection Agency
WA	Weiss Associates
WRS	Wilcoxon Rank Sum

1. INTRODUCTION

This summary work plan presents the approach and procedures for characterizing contaminants in the Western Dog Pens, for refining background radionuclide and metals levels, and for further assessment of potential off-site, environmental impacts from the Radium Leach System at the Laboratory for Energy-Related Health Research (LEHR), University of California at Davis (UC Davis). The general approach for this investigation was presented to the LEHR Remedial Project Managers (RPMs) in a letter dated July 21, 1997, and was discussed by the RPMs via telephone conference call on August 6, 1997. A detailed workplan including procedures for all fieldwork, quality assurance/quality control (QA/QC), health and safety, data management, waste management, and detailed data quality objectives (DQOs) will be submitted to the LEHR RPMs prior to the start of fieldwork. This plan will conform to the sampling methods, analytes and practices approved by the RPMs for use in both the 1996 Limited Field Investigation (LFI) and 1997 Data Gaps Investigations conducted at LEHR.

The primary objective of the Western Dog Pens Investigation (DPI) is to provide information to guide remedial decisions. The DPI will determine whether or not isolated, predictable, and/or easily removable "hot spots" exist. The primary objective of the Background Investigation (BI) is to refine the background radionuclide and metals levels. Defensible background levels play a key role in setting appropriate risk-based cleanup goals for the LEHR site. The primary goal of the Off-site Radium-226 Investigation (ORI) is to more fully define the lateral and vertical extent of potential environmental impacts from overflow of the Radium-226 leach system and other surface runoff in this area.

A description of the Western Dog Pens, Background Metals/Radionuclide, and ORIs is provided below and their respective operational and environmental investigation histories are detailed in the LFI Work Plan (IT, 1996), Draft Final Site Characterization Report (Weiss Associates (WA), 1997a), and the Remedial Investigation/Feasibility Study (RI/FS) Work Plan (Dames and Moore, 1994).

1.1 Previous Western Dog Pens (OU-3) Investigations

1.1.1 Operational History

OU-3 consists of the Eastern and Western Dog Pens and the North Chemical Dispensing Area. Between 1958 and the mid-1980's, the dog pens were used to house dogs involved in Radium-226 (Ra-226) and Strontium-90 (Sr-90) research activities at the LEHR site. This current DPI will focus only on the Western Dog Pens.

The Western Dog Pens originally contained 320 pens, but in 1975, 64 pens were removed to allow for the construction of the Cellular Biology Lab (Building H-294). It is in the Western Dog Pens that dogs receiving the highest dosages of Sr-90 and Ra-226 were reportedly housed (Dames and Moore, 1994). Excreta from the dogs housed in the outdoor pens contained low levels of radiological constituents (Dames and Moore, 1993). Although solids were cleaned from the pens on a daily basis, urine by contrast, either evaporated and/or infiltrated the gravel fill in the pens. An estimated 2 milliCuries (mCi) of Sr-90 and 0.5 mCi of Ra-226 were potentially excreted in dog urine over the life of the project (DOE, 1988).

From 1960 until the early 1970s, chlordane was used for flea control on dogs kept outdoors. The dogs were routinely sprayed with chlordane or dipped in chlordane, or in a chlordane-kerosene mixture. Annual usage of chlordane is estimated between 25 and 50 gallons (Dames & Moore, 1993). Spent chlordane from the dip tanks was reportedly disposed in trenches and pits and in the outdoor cages where the dogs were dipped.

1.1.2 Existing Data

Soil samples were collected and analyzed from the Dog Pens in 1990, 1994, and 1996 (Figure 1); however, the data do not provide adequate definition of the contaminant distribution for effective remedial decisions. Additionally, the QA/QC procedures followed for these samples generally fall short of those required under CERCLA. The 1994 data (Figure 2), which are considered the highest quality data collected from the Dog Pens Area, will be considered quantitatively in planning the additional investigations, while the 1990 and 1996 data (Figures 3 and 4) will only be considered qualitatively. Field radiation survey data from the dog pen pedestals removed in 1996 and anecdotal information about the dog pen operations will also be considered qualitatively.

Of the 40 samples collected from the Western Dog Pens in 1994 (Figure 1), 30 were analyzed for various radionuclides, organochlorine pesticides, metals, TPH-diesel, TPH-kerosene, nitrate and other general chemical parameters, while the 10 remaining samples were only analyzed for hexavalent chromium. The 30 samples analyzed for the full suite chemical and radiological constituents included: 1) 15 samples from six borings located around the Cellular Biology Lab, with each boring including a surface sample and one or two other samples down to a maximum depth of 6.5 ft below ground surface (bgs) or less; 2) 11 samples from about 6 ft bgs at 11 different locations in the Western Dog Pens; and, 3) four samples, two each from about 11 and 21 ft bgs at two of the 11 locations sampled at 6 ft bgs.

The 1990 investigations included surface and near-surface soil sampling from 17 locations in the Western Dog Pens, as well as soil sampling down to 65 ft bgs from borings for wells UC DAVIS-20 and UC DAVIS-21 (Figure 3). All of these samples were analyzed for selected radionuclides, chlordane and nitrate, and the well boring samples were also analyzed for metals. The 1996 surface soil samples (Figure 4) were collected primarily because of health and safety concerns that arose during the dog pen pedestal removal because field radiation screening indicated gamma and alpha levels significantly above background. Soil samples were collected from immediately below 12

pedestals with significant radiation readings and 12 with background readings. These samples were analyzed for selected radionuclides and chlordane.

1.1.2.1 Western Dog Pens Results above Background

It can be concluded based on the 1994 sample results, with some consideration of the 1990 and 1996 results, that:

1) Chlordane appears to attenuate markedly with depth; no chlordane was detected in samples from 2.5 ft bgs and deeper, although there are only four locations (around the Cellular Biology Lab) where attenuation with depth is substantiated. Other pesticides (DDE and BHC) were detected at low concentrations at a few locations; no other organics were detected.

2) Four of the six surface samples collected around the Cellular Biology Lab in 1994 contained detectable chlordane ranging from 0.077 to 0.49 milligrams per kilogram (mg/kg). All 15 of the surface samples analyzed in 1996 contained detectable chlordane ranging from 0.005 to 15 mg/kg. With the exception of the 15 mg/kg detection, the 1996 chlordane results for surface samples are similar to those for the 1994 surface samples; and based on these data, there is no obvious pattern to the lateral concentration distribution. Chlordane in surface and near surface samples collected in 1990 ranged from not detected at 0.001 mg/kg to 0.48 mg/kg.

3) 1994 strontium-90 data indicate no activities greater than about two times background, and show no obvious trend laterally or with depth. 1996 surface data show significantly higher sr-90 activities than those detected in 1994, and 1990 data generally show lower activities.

4) Only two of the 30 samples analyzed for ra-226 in 1994 showed activities significantly above background (1.82 and 5.11 pCi/g): both from near the center of the Western Dog Pens, one from about 6 ft bgs and one from about 20 ft bgs. The 1996 surface samples showed two samples with ra-226 activities about two times background; both were perimeter pens. None of the 1990 dog pen samples had activities above background.

5) Carbon-14 was detected significantly above background in 14 of the 30 samples collected in 1994, at depths ranging from 0 to 11 ft bgs. A number of other radionuclides, including cesium-137 and tritium, have been detected above background in shallow dog pen samples from the 1990, 1994 and/or 1996 investigations.

6) Nitrate was detected slightly above background in a number of Western Dog Pen samples from 1994 (up to 59 mg/kg) and from 1990 (up to 168 mg/kg). Nitrate was not analyzed in 1996 samples. In general, higher nitrate concentrations were found in those samples collected from the northern half of the Western Dog Pens.

1.1.2.2 Western Dog Pens Results above Risk-Based Action Goals

Comparing all of the analytic results from the Western Dog Pens to the Risk-Based Action Goals (RBAGs) proposed for the LEHR site (WA, 1997b), it appears that chlordane and ra-226 are the primary contaminants of concern in this area. The maximum levels of most constituents detected in the Dog Pens soil are less than the RBAGs for a 10^{-6} excess cancer risk; and only chlordane and ra-226 have been detected at levels greater than two times the 10^{-6} RBAG. Two of the 37 Western Dog Pens surface sampling locations from all previous investigations showed chlordane above the 10^{-6} RBAG, and 10 of these locations showed ra-226 above the 10^{-6} RBAG. Ra-226 was also detected above the 10^{-6} RBAG in 11 of 30 samples collected from depths greater than 2.5 ft bgs, at a maximum depth of 20.75 ft bgs.

In general, there is no clear correlation between the 1996 field radiation levels and the soil radionuclide activities measured under the dog pen pedestals (WA, 1997a). However, the field readings do appear to be good indicators of ra-226 above the RBAG. Nine of the 12 soil samples collected from areas of significant field readings had radium-226 activities above the RBAG, while only one of the 12 samples collected from areas of background field readings had ra-226 activities above the RBAG.

1.2 Previous Background Investigation

In November 1994, 26 background soil samples were collected for analysis from six off-site borings. Locations were located within one-half mile of the LEHR site and were selected based on similar soil types as at the site. Samples from the surface, 4 ft bgs, 19 ft bgs, and 39 ft bgs in each boring were analyzed for selected metals, organochlorine pesticides, radiologic parameters, and general chemical parameters.

While the background data for organochlorine pesticides and general chemical parameters appear to be adequate, the following deficiencies have been noted for the radiological and metals data:

1) several radionuclides that are potential contaminants of concern for the LEHR site were not analyzed, including americium-241, bismuth-212, lead-210, plutonium-241, radium-223, and thorium-234;
2) the background levels for several other radionuclides are of the same order of magnitude as the minimum detectable activity (MDA), and therefore have a large error margin;
3) the background levels for several metals were below the detection limits; and,
4) levels of some metals and radionuclides vary significantly and may vary consistently with soil type and/or depth, although too few data are available to determine this conclusively.

1.3 Off-Site Radium-226 Investigation

As part of the 1996 LFI, four near-surface samples were collected from the storm water ditch along Old Davis Road to assess potential impacts from known overflows of the Radium Leach System immediately to the east (Figure 8). The samples were analyzed for the full suite of potential contaminants at LEHR. The two samples located closest to the Radium Leach System dry wells showed ra-226 levels slightly above background, and several other constituents were detected slightly above background in one or more samples. The lateral and vertical extent of the above-background levels has not been fully determined.

2. FIELD ACTIVITIES

This section describes the proposed field activities for the Western Dog Pens, Background, and ORIs. Fieldwork will be conducted according to the detailed workplan that will be submitted to the RPMs before fieldwork begins. Fieldwork is anticipated to begin in late September or early October 1997. All work will be conducted in accordance with the detailed work plan, the Quality Assurance Project Plan (QAPP; WA, 1997c), and appropriate Standard Operating Procedures (SOPs), which will be included as an appendix to the detailed workplan.

2.1 Western Dog Pens Investigation

As indicated above, the primary purpose of the proposed Western Dog Pens Investigation (DPI) is to provide the information needed to make remedial decisions. The probable alternatives for Dog Pens cleanup include: 1) no action; 2) hot spot removal; 3) capping; 4) hot spot removal followed by capping; and, 5) complete removal. Because of high disposal costs, complete removal may not be a reasonable option. Therefore, the proposed DPI will focus on determining if contaminants are present above the cleanup goals, and if so, what their horizontal and vertical distribution is and whether isolated, easily removable, and predictable hot spots are present.

The following paragraphs describe the proposed approach to the DPI. The proposed DPI is also diagrammatically depicted on the flow chart presented on Figure 5. It is important to emphasize that the Eastern Dog Pens are not included in this investigation. The concrete curbing in the Western Dog Pens is also not included in these investigations because we believe that it will be less costly to dispose of it as low-level waste rather than to attempt to characterize and segregate it. Furthermore, all previous data collected form the Western Dog Pens will be considered in planning the investigations and in conducting data evaluation although the 1994 data will be given more weight than the Phase II and 1996 data for the reasons described in Section 1.1 above.

As shown on Figure 5 and discussed below, we propose a three-phased investigation (Phases A, B, and C) approach for the Western Dog Pens. Phase A is an information review and reconnaissance surface radiation survey. Phase B includes detailed radiation surveying and surface gravel/soil interface sampling of selected pens. Phase C includes additional gravel/soil sampling both at the surface and to depths of 30 ft bgs. Due to the phased nature of this proposed investigation, the information obtained during Phase A will guide the design of Phase B, and results for both Phases A and B will guide the design of Phase C. Therefore, a detailed sampling plan for Phases B and C cannot be developed at this time. However, the overall magnitude of the DPI work scope is presented below, and expected samples and analyses are presented in Table 1.

2.1.1 Dog Pen Investigation - Phase A

Dog Pen Investigation - Phase A work will consist of:

- Records review of Western Dog Pens operations and maintenance, and former Dog Pens employee interviews; and,
- Reconnaissance surface radiation surveying.

Each of these tasks is more fully described below.

2.1.1.1 Records Review and Former Dog Pens Employee Interviews

Information about operation of the Western Dog Pens will be collected by obtaining and reviewing records and interviewing current or former employees involved in the experiments. Operational records researched will be limited and focused, and will build on previous research conducted by Dames & Moore and others to the extent possible. Specific information of interest includes but is not limited to: 1) spatial distribution of dogs receiving varying doses and/or types of radiation; 2) method(s) and spatial distribution of chlordane and other pesticide applications; 3) spatial distribution of female and male dogs; and, 4) pen cleaning/gravel removal procedures.

2.1.1.2 Reconnaissance Surface Radiation Survey

The entire Western Dog Pens area will be surveyed in one day using a stroller-mounted gamma/beta instrument on a roughly 5 ft by 2 ft grid. Prior to conducting the survey, a background activity will be established. Any grid area with readings above background will be marked with a numbered stake and the reading will be recorded. The surface radiation results, operational information, and results from previous investigations will be evaluated and used to design Phase B.

2.1.2 Dog Pen Investigation - Phase B

Dog Pen Investigation - Phase B will involve detailed "inter-pen" surface and near-surface sampling. DPI-Phase B will be conducted on a limited number of individual pens to determine if a predictable pattern of "hot spots" within pens these selected pens exists. DPI - Phase B field activities will consist of:

- Defining "strata" or randomly selecting dog pens;
- Performing a detailed gamma/beta surface survey in the selected pens;
- Sampling and removing the gravel;
- Performing a detailed gamma/beta survey on the native soil; and,
- Sampling and analyzing the first native soil.

Each of these work tasks is described in greater detail below.

2.1.2.1 Defining "Strata" or Random Dog Pen Selection

If possible, the Western Dog Pens will be divided into subsets or "strata" based on the Phase A results, and one or more pens will be selected randomly from each strata following USEPA guidance (Figure 5). If Phase A results show that no "strata" can be defined, then seven to 12 pens will be selected at random. The number of pens proposed for sampling is small because a hot spot pattern must be present in almost all of the pens in a given "strata" if the information is to be useful in designing remedial actions.

2.1.2.2 Detailed Gamma/Beta Radiation Survey and Soil Sampling

A detailed gamma/beta radiation survey using a sodium-iodide detector will be conducted on the gravel surface of the selected pens. Based on all available information, gravel from up to seven locations within each of the selected pens will then be sampled. After the gravel samples are collected, the gravel will be removed from some or all of the selected pens according to the decision flow chart on Figure 6. The removed gravel will be stockpiled and covered within their point of origin in the Western Dog Pen area.

A detailed gamma/beta surface survey will then be conducted on a grid approximately 1 ft by 1 ft over the exposed native soil. Native soil samples will be collected at the exposed interface from all of the selected pens (Figure 6).

We estimate 48 gravel locations and 48 native soil locations will be sampled. Duplicate samples will be collected from 10 locations. These estimated 106 total samples will be analyzed by LAS for the potential contaminants of concern, i.e., chlordane and other organochlorine pesticides, selected radionuclides, mercury, hexavalent chromium, and nitrate, as shown on Table 1a.

2.1.3 Dog Pen Investigation - Phase C

Dog Pen Investigation - Phase C work will consist of:

- Evaluation of Phase A and Phase B Results and Preparation of a Dog Pen – Phase C Addendum;
- Conducting a utility clearance; and,
- Collecting soil samples.

Phase C work tasks are described in greater detail below.

2.1.3.1 Data Evaluation and Phase C Workplan Addendum Preparation

Phase A and B results will be evaluated to select Phase C surface and soil boring locations throughout the Western Dog Pens as described in Figure 5. The Phase C sampling plan will be developed using statistical approaches described in the Draft Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM; USEPA, December, 1996 Draft for Public Comment) and the

Guidance for Data Useability in Risk Assessment (USEPA, 1992), and other USEPA guidance. If Phase B gravel samples show no significant contamination, only soils will be sampled in Phase C. Depending on the Phase A and B results, the approach to first soil/gravel sampling in Phase C will be:

1) *Consistent intrapen pattern and some indication of an interpen pattern:* If elevated contaminants are found in consistent locations in the pens (e.g., near the pedestal location or in the pen corners) and groups of pens appear to have similar contaminant levels (e.g., the perimeter pens or the northeast pens), the sampling plan will be designed to: a) divide the pens into "strata" based on similar contaminant characteristics; and, b) sample enough pens from each strata to confirm the pattern of elevated contaminants within the pens at an acceptable confidence level. In this case, the proposed confidence level may partially depend on a cost/benefits analysis comparing the costs of additional sampling to the costs of limited soil removal.

2) *Consistent intrapen pattern but no observable interpen pattern:* If similarly elevated contaminants are found in consistent locations in all the pens (e.g., near the pedestal location in the pen corners), the sampling plan will be designed to sample enough randomly-selected pens throughout the Western Dog Pens to confirm the pattern of elevated contaminants within the pens at an acceptable confidence level. In this case, the proposed confidence level may partially depend on a cost/benefits analysis comparing the costs of additional sampling to the costs of limited soil removal.

3) *No observable intrapen pattern, but some indication of an interpen pattern:* If groups of pens appear to have similar contaminant levels (e.g., the perimeter pens or the northeast pens) but the contaminants do not appear to have a consistent pattern within the pens, the sampling plan will be designed to identify all areas of elevated contamination within the Western Dog Pens. This would be accomplished by determining a minimum expected "hot spot" area (assumed to be the size of at least several dog pens) based on all previous data, and sampling on a grid size small enough to ensure all hot spots of this size or larger are found at an acceptable confidence level.

4) *No observable intrapen or interpen patterns*: If there is no observable pattern to the elevated areas of contamination, the data will be evaluated to determine a minimum "hot spot" size and the grid size necessary to identify all these "hot spots" at an acceptable confidence level. A cost/benefits analysis will be conducted comparing the necessary sampling costs to the costs of soil removal or *in-situ* treatment over the entire Western Dog Pens area. If the necessary sampling is not cost effective, Phase C may be eliminated and an Engineering Evaluation/Cost Analysis (EE/CA) for OU-wide remedial actions will begin.

5) *No measured contamination requiring remediation:* The four scenarios described above assume some Western Dog Pens contamination will be above levels requiring remediation. However, as described above, only ra-226 and chlordane in a few samples exceed the proposed 10^{-6} RBAGs by more than two times, and only chlordane in one of all the previous samples exceeds the proposed 10^{-6} RBAG by an order of magnitude. Therefore, depending on the final cleanup criteria that are established for the site, the goal of sampling may be to establish that these criteria have not been exceeded

throughout the Western Dog Pens. In this case, the sampling plan would be designed to establish this at an acceptable level of confidence using the Wilcoxon Rank Sum (WRS) test or Sign test.

The sampling described above focuses on the surface and near-surface because the nature of past operations and the data collected to date indicate that most contamination in the Western Dog Pens is near the surface. However, because some above-background radionuclide and metals concentrations have been detected at depths up to 21 ft bgs, Phase C also includes sampling at depths up to 30 ft bgs. We assume 10 to 20 locations will be selected for vertical profiling, with samples collected for analysis at depths ranging from 0.5 to 30 ft bgs. Borings will be located primarily where higher surface contamination is indicated, and sampling depths will be selected based on the surface constituents and other data. The boring locations will be cleared for utilities prior to sampling and a direct-push method will be used to collect the samples.

Prior to starting Phase C of the Dog Pen Investigation, WA will submit an addendum to the detailed workplan describing the Phase C sampling plan and its statistically-based rationale. It is anticipated that the "Dog Pens Phase C Addendum" will be issued to the RPM for comment in late November 1997. DPI Phase C sampling and analysis will be performed in accordance with the detailed workplan and addendum, QAPP, and appropriate SOPs.

2.1.3.2 Utility Clearance

Underground utility clearance will be performed prior to direct-push sampling and/or hand augering in the Western Dog Pens. Underground Services Alert (USA) will be contacted at least 48 hours prior to the start of fieldwork and UC Davis Facilities Services will also be alerted to the proposed fieldwork. The UC Davis Facilities Services Department will visit the proposed sampling locations and clear each location of UC Davis utilities. If for any reason the UC Davis Facilities Services Department is uncertain as to the exact location of a utility, an independent line locator may be subcontracted to verify the UC Davis Facilities Service Department's utility clearance prior to the start of any fieldwork. During the fieldwork, the first 5 ft of ground at each proposed soil boring location will be hand-augered as an additional safeguard against unknowingly damaging unmarked utilities.

2.1.3.3 Soil Sample Collection

Shallow soil samples will be collected using a split barrel sampler. Deeper soil samples will be collected using direct-push drilling. Direct-push drilling was successfully used at LEHR during the June 1997 Data Gaps Septic Tank Investigation. This drilling method produces little waste, provides high quality core for visual logging purposes, is rapid, and direst-push rigs can be used in areas of limited access.

Table 1b summarizes the expected number and type of samples that will be collected during Phase C, and the expected analyses to be performed. The exact number of samples and analyses will depend on the Phase A and B results and will be presented in the Dog Pens Phase C Workplan Addendum.

At the conclusion of the shallow soil sampling, boreholes will be backfilled with native soil and tamped to form a small mound. At the conclusion of deep soil sampling, boreholes will be backfilled to grade with grout. Grout will be mixed above ground and will be placed into the core hole using tremie pipe. Unused core will be placed in a shallow trench located immediately adjacent to its point of origin and covered with native soil.

2.2 Background Investigation

Defining defensible background levels is key to establishing cleanup goals for the site. The primary goal of the BI is to fill data gaps as necessary to provide statistically defensible background levels. To arrive at statistically defensible background levels, the BI work will consist of:

- conducting an underground utility clearance;
- exploration drilling and sampling at appropriate locations and depths,
- analyzing the samples for selected radionuclides and metals using sufficiently low detection limits; and,
- statistically analyzing both these new data and the previously-collected background data to establish background levels.

Each of these tasks is described in greater detail below.

2.2.1 Underground Utility Clearance

Underground utility clearance will be performed prior to exploratory drilling in accordance with Section 2.1.3.2, above. UC Davis personnel will locate utilities and mark the ground surface to indicate the type and orientation of utilities at the boring location(s). This procedure will minimize the potential for accidental encounters with underground utilities.

2.2.2 Exploration Drilling and Sampling

We propose collecting additional soil samples from the six locations shown on Figure 7. These locations have the same surface soil type as the LEHR site and do not present significant access difficulties. Based on data from the previous six background soil borings (Figure 7), these borings are expected to show little lateral variation at a given depth, both in terms of soil type and in terms of metals/radionuclide levels. Borings will be drilled using hollow-stem augers and will be continuously cored using a minimum 3.5 in diameter coring system. One-ft intervals of core will be selected for sampling. This large sample volume (at least one liter) is needed to obtain the low detection limits that are required for these background samples.

We assume eight soil samples at depths ranging from 0 to 40 ft bgs will be analyzed from each boring and four duplicate samples will be analyzed. Based on data from the previous background soil samples, some background constituents appear to be bimodally distributed, with the surface and 4 ft bgs samples having similar levels and the 19 and 39 ft bgs samples having similar levels. Therefore, samples from the new borings will be closely spaced between 4 and 19 ft to determine at what depth (or depth range) the concentration change occurs. All soil types encountered will be analyzed and soil logging will be performed using the USCS. In the absence of significant soil-type changes, samples will be collected at 0, 4, 8, 12, 16, 20, 30, and 40 ft bgs.

At the conclusion of the hollow-stem drilling, the augers will be removed from the borehole(s) and the borehole(s) will be backfilled to approximately 3 ft below grade with grout mixed above ground and placed into the borehole using a tremie pipe. The grout will be placed from the bottom of the borehole to about 3 ft below grade as to not interfere with any plowing or other agricultural operations in the future. The borehole from about 3 ft below grade to grade will be backfilled with cuttings collected while drilling. Excess cuttings generated from hollow-stem augering will be drummed, labeled, and transported to the LEHR site for storage and eventual disposal.

2.2.3 Sample Analysis

The approximately 52 samples will be analyzed for the radionuclides and metals shown on Table 2, with the detection limits shown. Most of these analytes are included because the existing background data for them are not sufficient; however, a few (e.g., chromium, mercury, and nickel) are included because they appear to vary predictably with depth. In general, the lower detection limits will be achieved without changing the approved RI/FS Workplan analytical methods (Dames & Moore, 1994). For the metals, a special calibration will be required, and for some radionuclides a larger sample size, longer in-growth time, and/or longer count times will be required. For ra-226, a gamma spectrometry method with 30-day in-growth time and 1,000 minute count time will be used instead of the alpha scintillation cell method used for previous LEHR samples.

2.2.4 Statistical Analysis

After this investigation is completed, both the existing and the new background data will be statistically analyzed to identify any statistically significant differences between the two data sets and/or depth/soil type variations. For analytes with no significant differences between data sets, the previously-established background levels (WA, 1997b) will be refined by combining the two data sets and recalculating the background level. Otherwise, the new data will be used to calculate the background level. As before (WA, 1997b), the background levels will be defined as the 80% lower confidence level on the 95th quantile.

2.3 Off-Site Radium-226 Investigation

Because the lateral and vertical extents of the constituents above background in the vicinity of the Radium Leach System have not been adequately defined, we propose collecting additional samples from surface and near-surface soils in the area.

The ORI work will consist of:

- conducting an underground utility clearance;
- conducting a surface gamma radiation survey;
- collecting soil samples for analysis; and,
- analyzing the samples for selected radionuclides.

Each of these tasks is described in greater detail below.

2.3.1 Surface Gamma Radiation Survey

Prior to sample collection, a surface gamma radiation survey will be conducted over the area shown on Figure 8, which was delineated based on surface water runoff patterns. Any area with readings above the established background will be marked with a numbered stake and the reading will be recorded.

2.3.2 Sample Collection

A total of 14 samples will be collected. Eight surface (immediately below any vegetation/loose soil) samples will be collected from locations within the shaded area on Figure 8, including any areas with above-background radiation survey readings, and six soil samples will be collected by hand-auger at 0.5 ft and 1.5 ft from three locations close to the dry wells and/or with above-background radiation.

2.3.3 Sample Analysis

All 14 samples collected during the ORI will be analyzed for sr-90 and ra-226. In addition, the five surface samples collected closest to the site will be analyzed for the additional constituents listed on Table 3.

3. REFERENCES

Dames and Moore, 1994, Final Draft RI/FS Work Plan, LEHR Environmental Restoration, University of California, Dames and Moore, September 1994.

Dames and Moore, 1993, Phase II Site Characterization Report for the LEHR Environmental Restoration, University of California at Davis, Dames and Moore, February 1993.

United States Department of Energy (DOE), 1988, Radioactive Waste Management, DOE Order 5820.2A, DOE, Washington, D.C.

IT, 1996, Limited Field Investigation Work Plan, Laboratory for Energy-Related Health Research (LEHR), University of California at Davis, IT Corporation, July, 1996.

United States Environmental Protection Agency (USEPA), 1996, Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM) – Draft for Public Comment, USEPA, December, 1996.

USEPA, 1992, Guidance for Data Useability in Risk Assessment (Part A), USEPA, April, 1992.

Weiss Associates (WA), 1997a, Draft Final Site Characterization Summary Report for the U.S. Department of Energy Areas at LEHR, UC Davis, California, WA, January, 1997.

WA, 1997b, Final Determination of Risk-Based Action Levels for DOE Areas at LEHR, UC Davis, California, WA, August, 1997.

WA, 1997c, Final Quality Assurance Project Plan for Environmental Restoration/Waste Management, LEHR, UC Davis, California, WA, February, 1997.

FIGURES

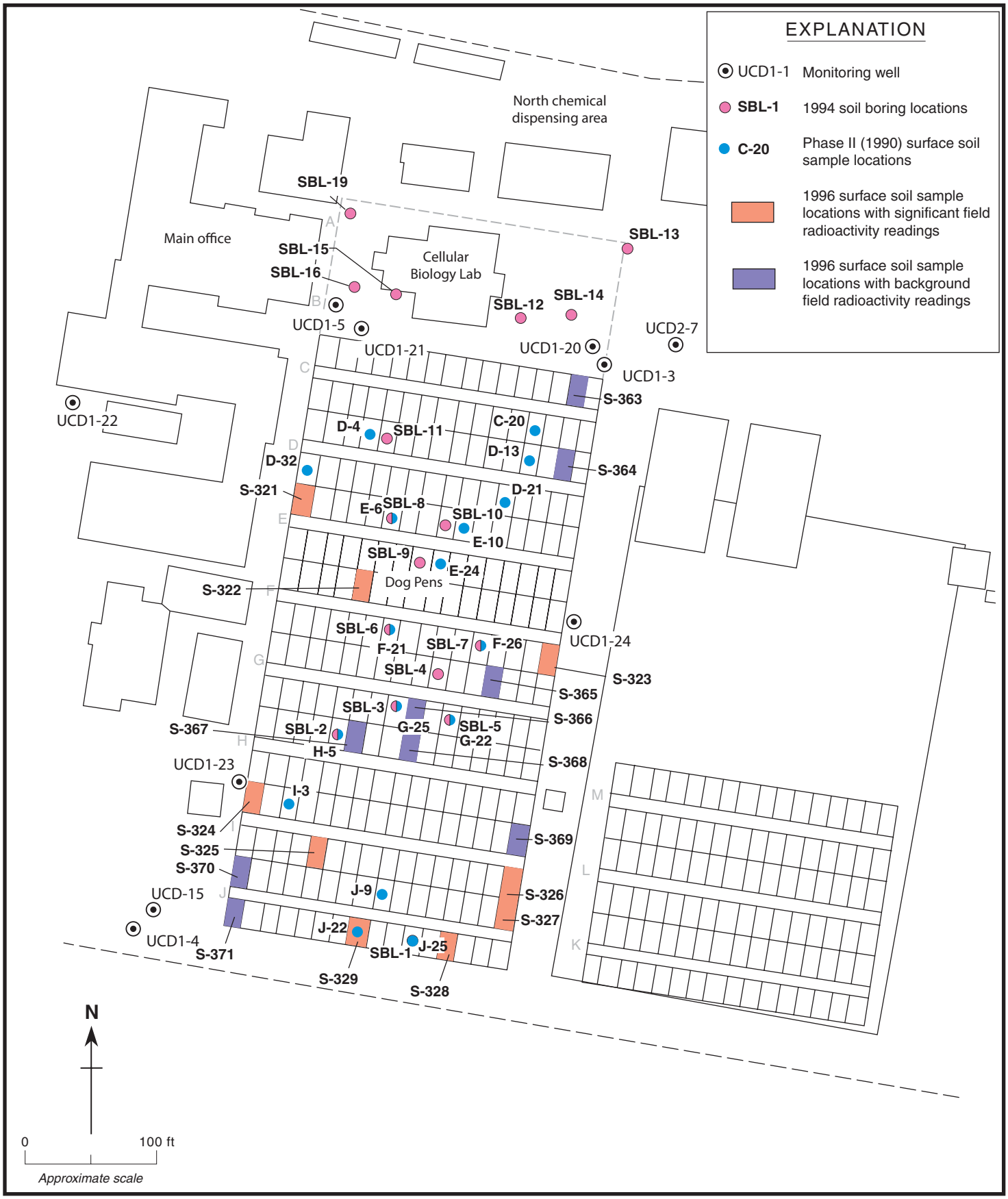

Figure 2. Pre–1997 Sample Locations in the Western Dog Pens Area, LEHR Site, UC Davis, California

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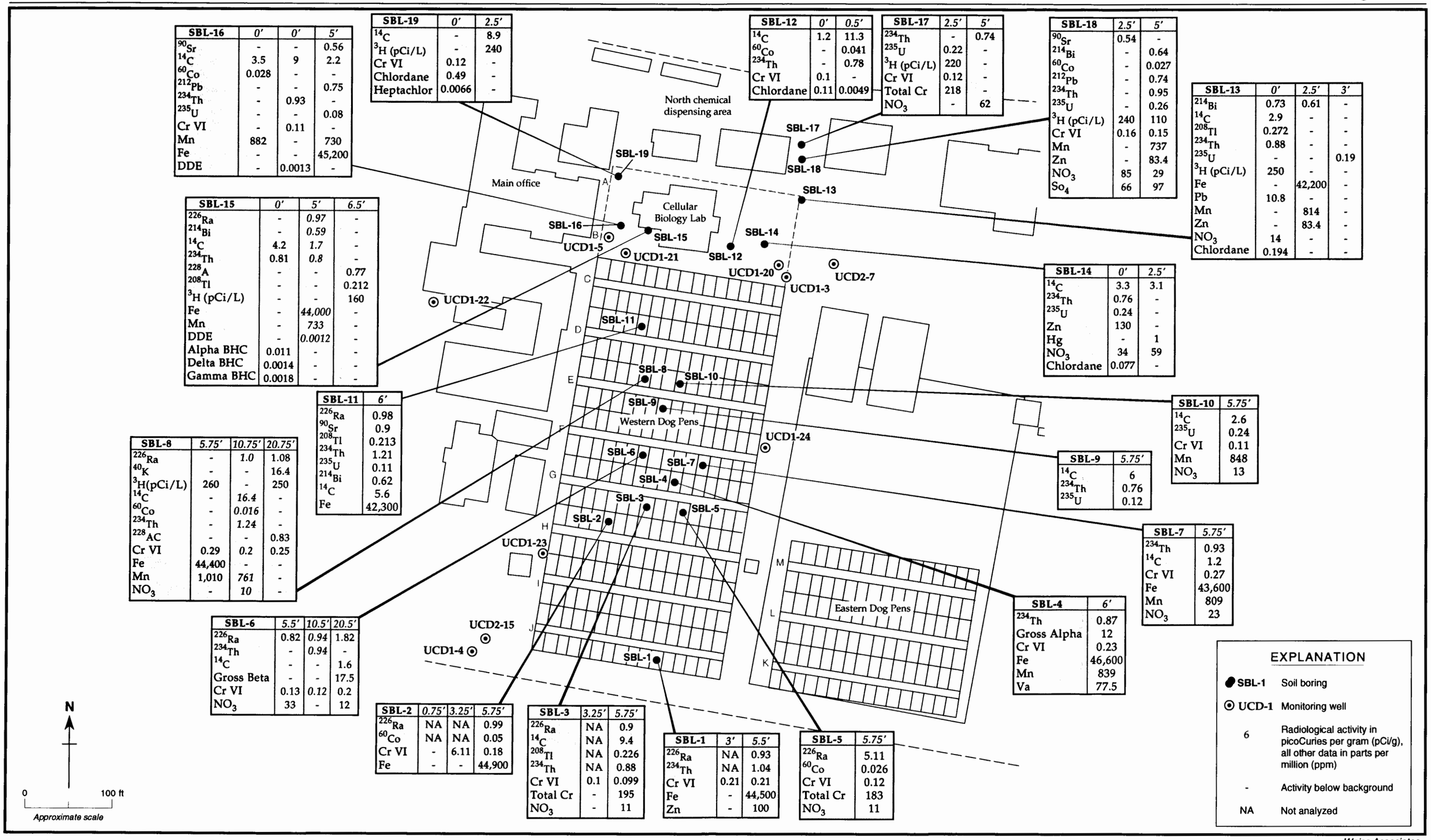

SBL-16	0′	0′	5′
^{90}Sr	-	-	0.56
^{14}C	3.5	9	2.2
^{60}Co	0.028	-	-
^{212}Pb	-	-	0.75
^{234}Th	-	0.93	-
^{235}U	-	-	0.08
Cr VI	-	0.11	-
Mn	882	-	730
Fe	-	-	45,200
DDE	-	0.0013	-

SBL-19	0′	2.5′
^{14}C	-	8.9
^{3}H (pCi/L)	-	240
Cr VI	0.12	-
Chlordane	0.49	-
Heptachlor	0.0066	-

SBL-12	0′	0.5′
^{14}C	1.2	11.3
^{60}Co	-	0.041
^{234}Th	-	0.78
Cr VI	0.1	-
Chlordane	0.11	0.0049

SBL-17	2.5′	5′
^{234}Th	-	0.74
^{235}U	0.22	-
^{3}H (pCi/L)	220	-
Cr VI	0.12	-
Total Cr	218	-
NO_3	-	62

SBL-18	2.5′	5′
^{90}Sr	0.54	-
^{214}Bi	-	0.64
^{60}Co	-	0.027
^{212}Pb	-	0.74
^{234}Th	-	0.95
^{235}U	-	0.26
^{3}H (pCi/L)	240	110
Cr VI	0.16	0.15
Mn	-	737
Zn	-	83.4
NO_3	85	29
So_4	66	97

SBL-13	0′	2.5′	3′
^{214}Bi	0.73	0.61	-
^{14}C	2.9	-	-
^{208}Tl	0.272	-	-
^{234}Th	0.88	-	-
^{235}U	-	-	0.19
^{3}H (pCi/L)	250	-	-
Fe	-	42,200	-
Pb	10.8	-	-
Mn	-	814	-
Zn	-	83.4	-
NO_3	14	-	-
Chlordane	0.194	-	-

SBL-15	0′	5′	6.5′
^{226}Ra	-	0.97	-
^{214}Bi	-	0.59	-
^{14}C	4.2	1.7	-
^{234}Th	0.81	0.8	-
^{228}A	-	-	0.77
^{208}Tl	-	-	0.212
^{3}H (pCi/L)	-	-	160
Fe	-	44,000	-
Mn	-	733	-
DDE	-	0.0012	-
Alpha BHC	0.011	-	-
Delta BHC	0.0014	-	-
Gamma BHC	0.0018	-	-

SBL-14	0′	2.5′
^{14}C	3.3	3.1
^{234}Th	0.76	-
^{235}U	0.24	-
Zn	130	-
Hg	-	1
NO_3	34	59
Chlordane	0.077	-

SBL-11	6′
^{226}Ra	0.98
^{90}Sr	0.9
^{208}Tl	0.213
^{234}Th	1.21
^{235}U	0.11
^{214}Bi	0.62
^{14}C	5.6
Fe	42,300

SBL-10	5.75′
^{14}C	2.6
^{235}U	0.24
Cr VI	0.11
Mn	848
NO_3	13

SBL-8	5.75′	10.75′	20.75′
^{226}Ra	-	1.0	1.08
^{40}K	-	-	16.4
^{3}H(pCi/L)	260	-	250
^{14}C	-	16.4	-
^{60}Co	-	0.016	-
^{234}Th	-	1.24	-
^{228}AC	-	-	0.83
Cr VI	0.29	0.2	0.25
Fe	44,400	-	-
Mn	1,010	761	-
NO_3	-	10	-

SBL-9	5.75′
^{14}C	6
^{234}Th	0.76
^{235}U	0.12

SBL-7	5.75′
^{234}Th	0.93
^{14}C	1.2
Cr VI	0.27
Fe	43,600
Mn	809
NO_3	23

SBL-4	6′
^{234}Th	0.87
Gross Alpha	12
Cr VI	0.23
Fe	46,600
Mn	839
Va	77.5

SBL-6	5.5′	10.5′	20.5′
^{226}Ra	0.82	0.94	1.82
^{234}Th	-	0.94	-
^{14}C	-	-	1.6
Gross Beta	-	-	17.5
Cr VI	0.13	0.12	0.2
NO_3	33	-	12

SBL-2	0.75′	3.25′	5.75′
^{226}Ra	NA	NA	0.99
^{60}Co	NA	NA	0.05
Cr VI	-	6.11	0.18
Fe	-	-	44,900

SBL-3	3.25′	5.75′
^{226}Ra	NA	0.9
^{14}C	NA	9.4
^{208}Tl	NA	0.226
^{234}Th	NA	0.88
Cr VI	0.1	0.099
Total Cr	-	195
NO_3	-	11

SBL-1	3′	5.5′
^{226}Ra	NA	0.93
^{234}Th	NA	1.04
Cr VI	0.21	0.21
Fe	-	44,500
Zn	-	100

SBL-5	5.75′
^{226}Ra	5.11
^{60}Co	0.026
Cr VI	0.12
Total Cr	183
NO_3	11

Figure 2. Analytic Results above Background from December 1994 Investigation in the Western Dog Pen and North Chemical Dispensing Area - LEHR Site, Davis, California

Weiss Associates
09/02/97

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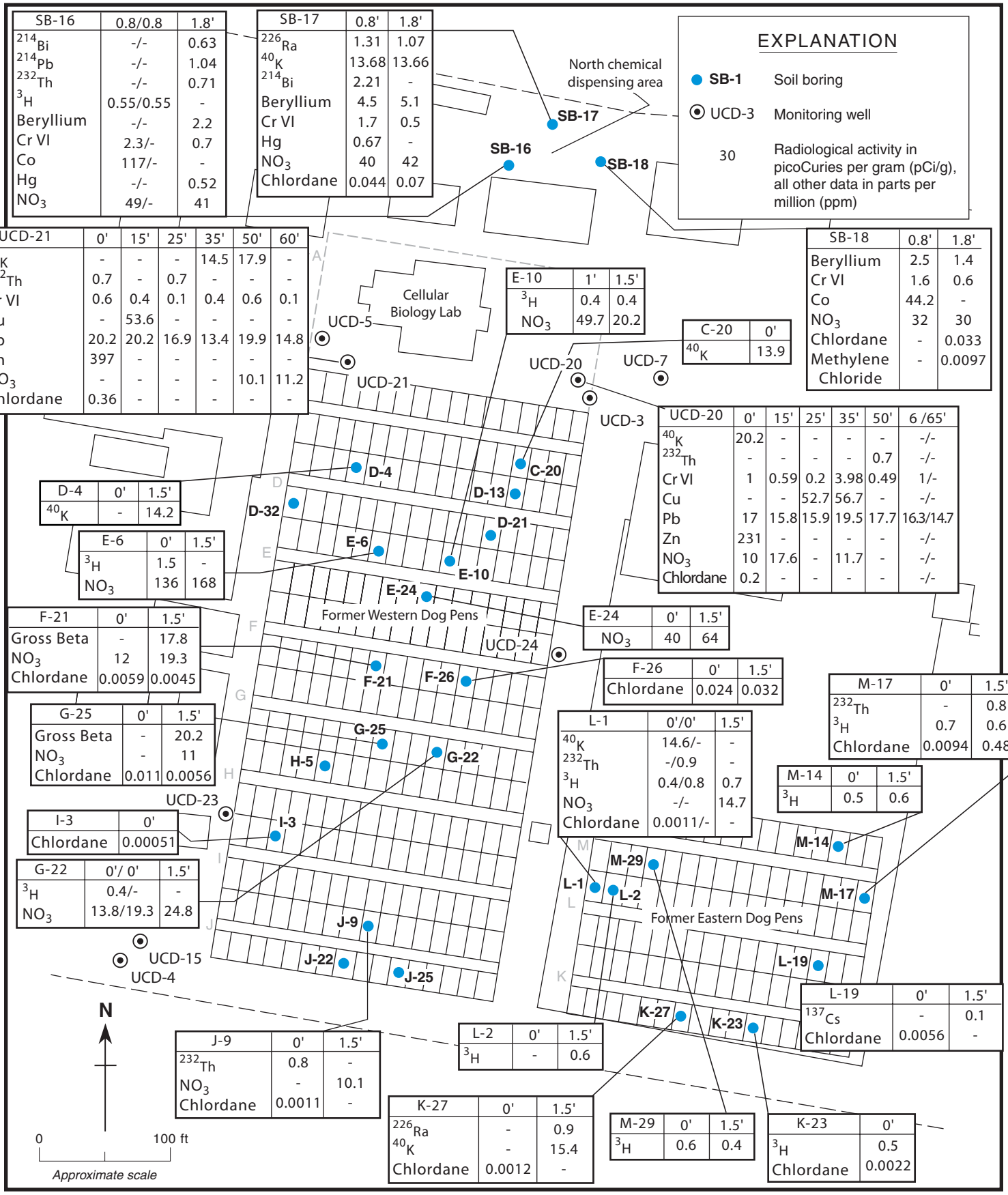

SB-16	0.8/0.8	1.8'
^{214}Bi	-/-	0.63
^{214}Pb	-/-	1.04
^{232}Th	-/-	0.71
^{3}H	0.55/0.55	-
Beryllium	-/-	2.2
Cr VI	2.3/-	0.7
Co	117/-	-
Hg	-/-	0.52
NO_3	49/-	41

SB-17	0.8'	1.8'
^{226}Ra	1.31	1.07
^{40}K	13.68	13.66
^{214}Bi	2.21	-
Beryllium	4.5	5.1
Cr VI	1.7	0.5
Hg	0.67	-
NO_3	40	42
Chlordane	0.044	0.07

UCD-21	0'	15'	25'	35'	50'	60'
^{40}K	-	-	-	14.5	17.9	-
^{232}Th	0.7	-	0.7	-	-	-
Cr VI	0.6	0.4	0.1	0.4	0.6	0.1
Cu	-	53.6	-	-	-	-
Pb	20.2	20.2	16.9	13.4	19.9	14.8
Zn	397	-	-	-	-	-
NO_3	-	-	-	-	10.1	11.2
Chlordane	0.36	-	-	-	-	-

E-10	1'	1.5'
^{3}H	0.4	0.4
NO_3	49.7	20.2

C-20	0'
^{40}K	13.9

SB-18	0.8'	1.8'
Beryllium	2.5	1.4
Cr VI	1.6	0.6
Co	44.2	-
NO_3	32	30
Chlordane	-	0.033
Methylene Chloride	-	0.0097

UCD-20	0'	15'	25'	35'	50'	6 /65'
^{40}K	20.2	-	-	-	-	-/-
^{232}Th	-	-	-	-	0.7	-/-
Cr VI	1	0.59	0.2	3.98	0.49	1/-
Cu	-	-	52.7	56.7	-	-/-
Pb	17	15.8	15.9	19.5	17.7	16.3/14.7
Zn	231	-	-	-	-	-/-
NO_3	10	17.6	-	11.7	-	-/-
Chlordane	0.2	-	-	-	-	-/-

D-4	0'	1.5'
^{40}K	-	14.2

E-6	0'	1.5'
^{3}H	1.5	-
NO_3	136	168

F-21	0'	1.5'
Gross Beta	-	17.8
NO_3	12	19.3
Chlordane	0.0059	0.0045

E-24	0'	1.5'
NO_3	40	64

F-26	0'	1.5'
Chlordane	0.024	0.032

M-17	0'	1.5'
^{232}Th	-	0.8
^{3}H	0.7	0.6
Chlordane	0.0094	0.48

G-25	0'	1.5'
Gross Beta	-	20.2
NO_3	-	11
Chlordane	0.011	0.0056

L-1	0'/0'	1.5'
^{40}K	14.6/-	-
^{232}Th	-/0.9	-
^{3}H	0.4/0.8	0.7
NO_3	-/-	14.7
Chlordane	0.0011/-	-

M-14	0'	1.5'
^{3}H	0.5	0.6

I-3	0'
Chlordane	0.00051

G-22	0'/ 0'	1.5'
^{3}H	0.4/-	-
NO_3	13.8/19.3	24.8

L-19	0'	1.5'
^{137}Cs	-	0.1
Chlordane	0.0056	-

J-9	0'	1.5'
^{232}Th	0.8	-
NO_3	-	10.1
Chlordane	0.0011	-

L-2	0'	1.5'
^{3}H	-	0.6

K-27	0'	1.5'
^{226}Ra	-	0.9
^{40}K	-	15.4
Chlordane	0.0012	-

M-29	0'	1.5'
^{3}H	0.6	0.4

K-23	0'
^{3}H	0.5
Chlordane	0.0022

Figure 3. Analytic Results above Background from Phase II Investigation in the Dog Pens and North Chemical Dispensing Area - LEHR Site, Davis, California

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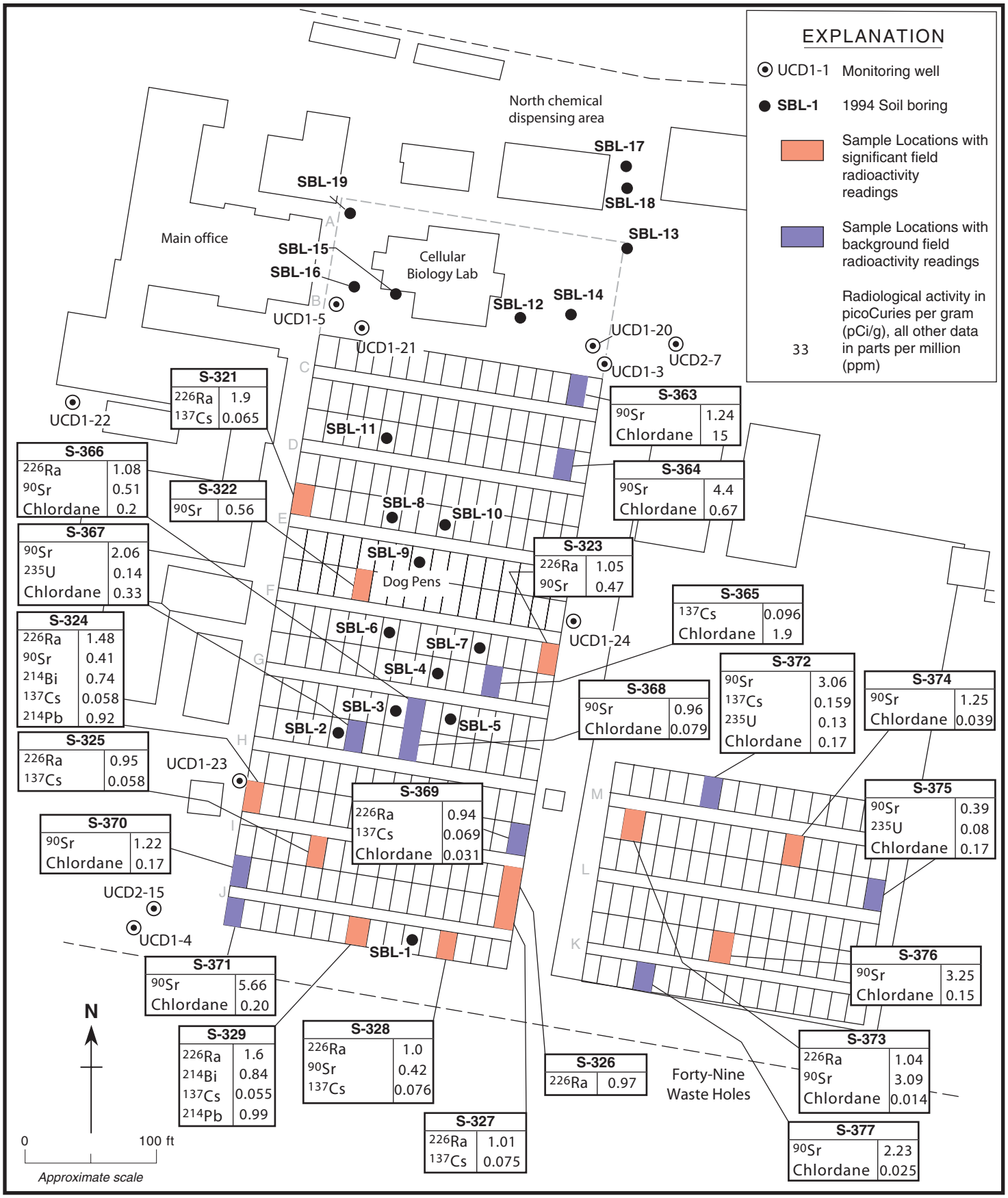

Figure 4. Surface Sample Locations and Results above Background from Summer 1996 Investigation in the Dog Pens Area - LEHR Site, Davis, California

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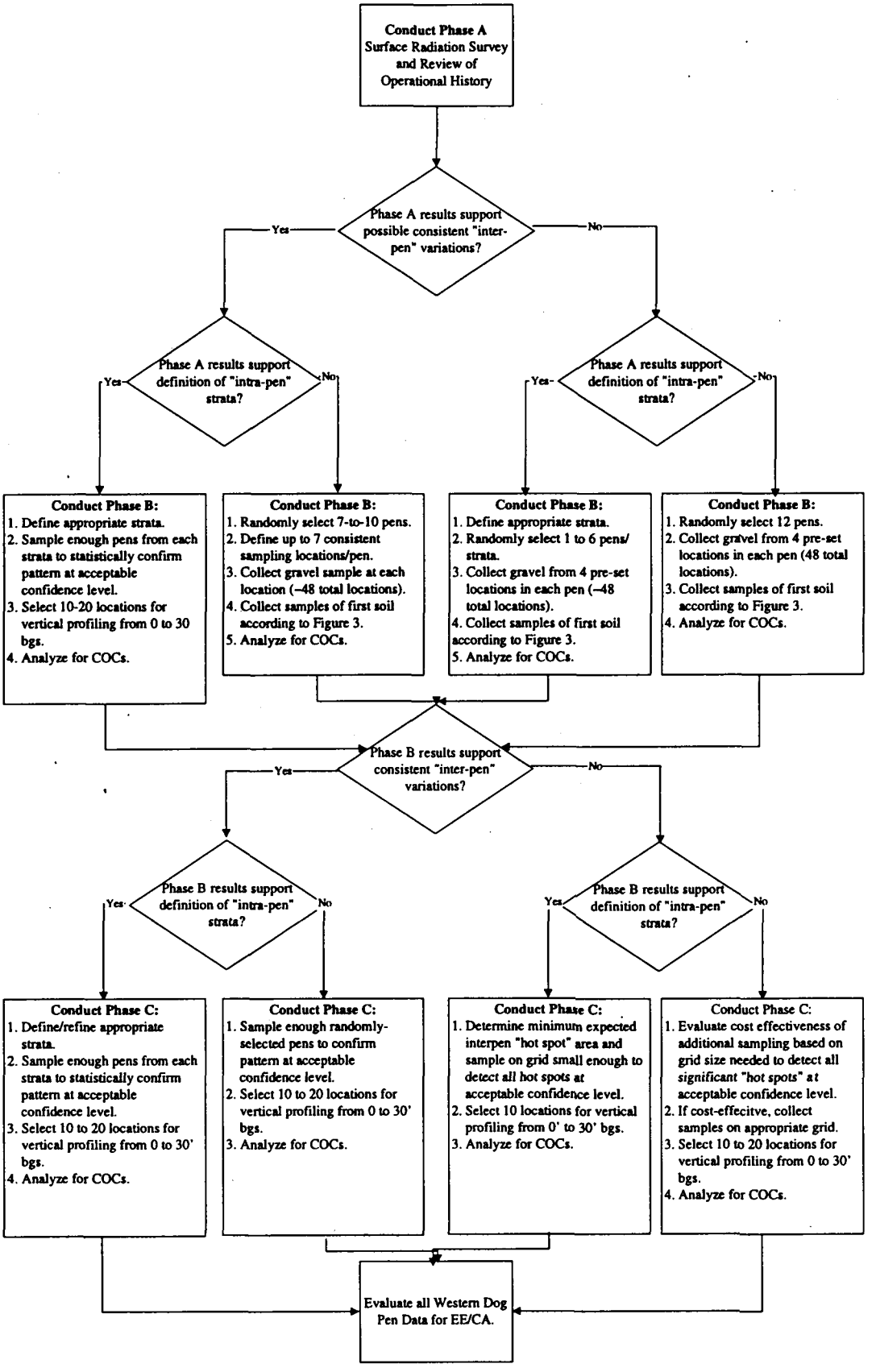

Figure 5. Decision Flow Chart for Western Dog Pens Investigations

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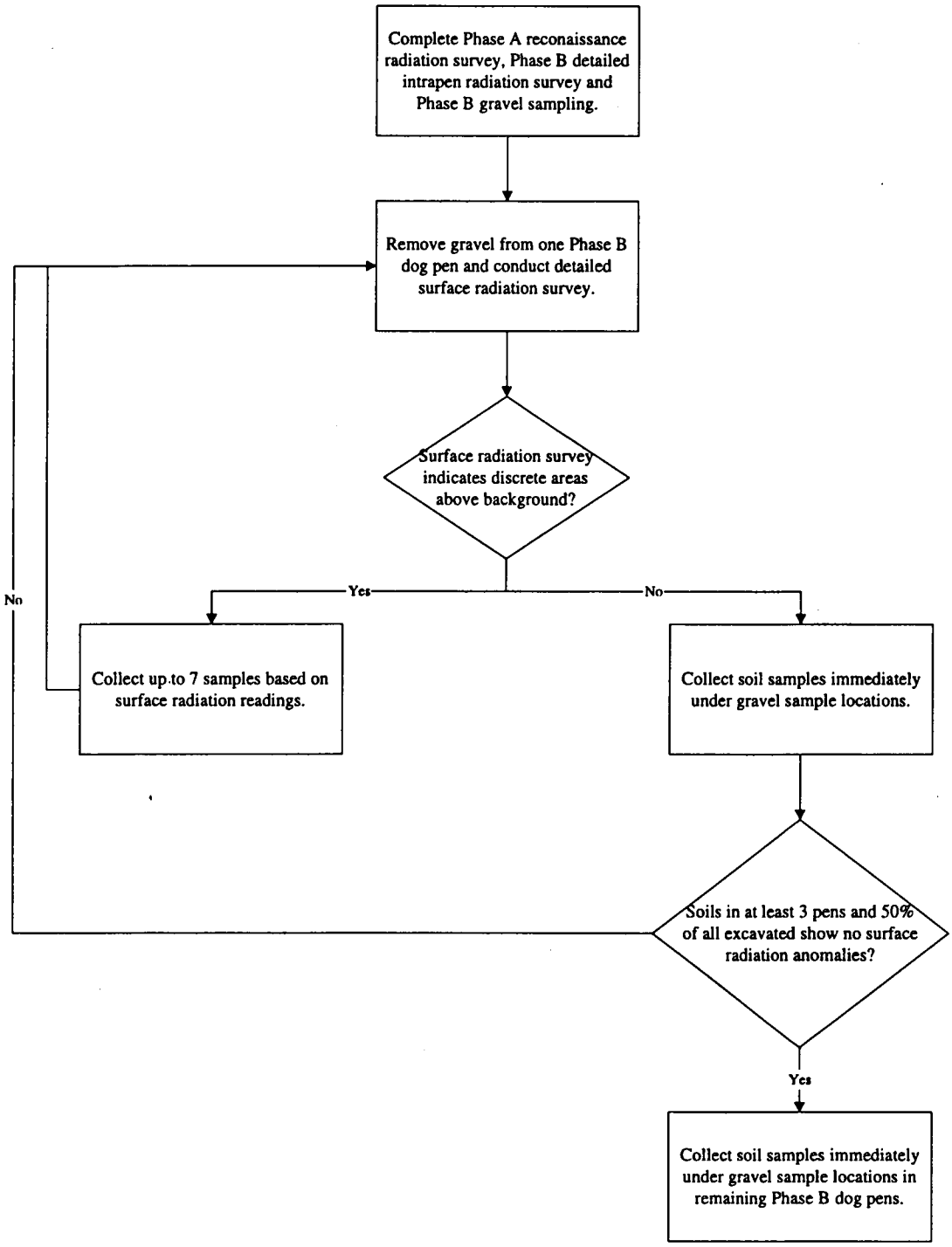

Figure 6. Decision Flow Chart for Phase B Surface Soil Sampling in Western Dog Pens J:\DOE\4000\A1D\DRAWINGS\FIG_3.VSD

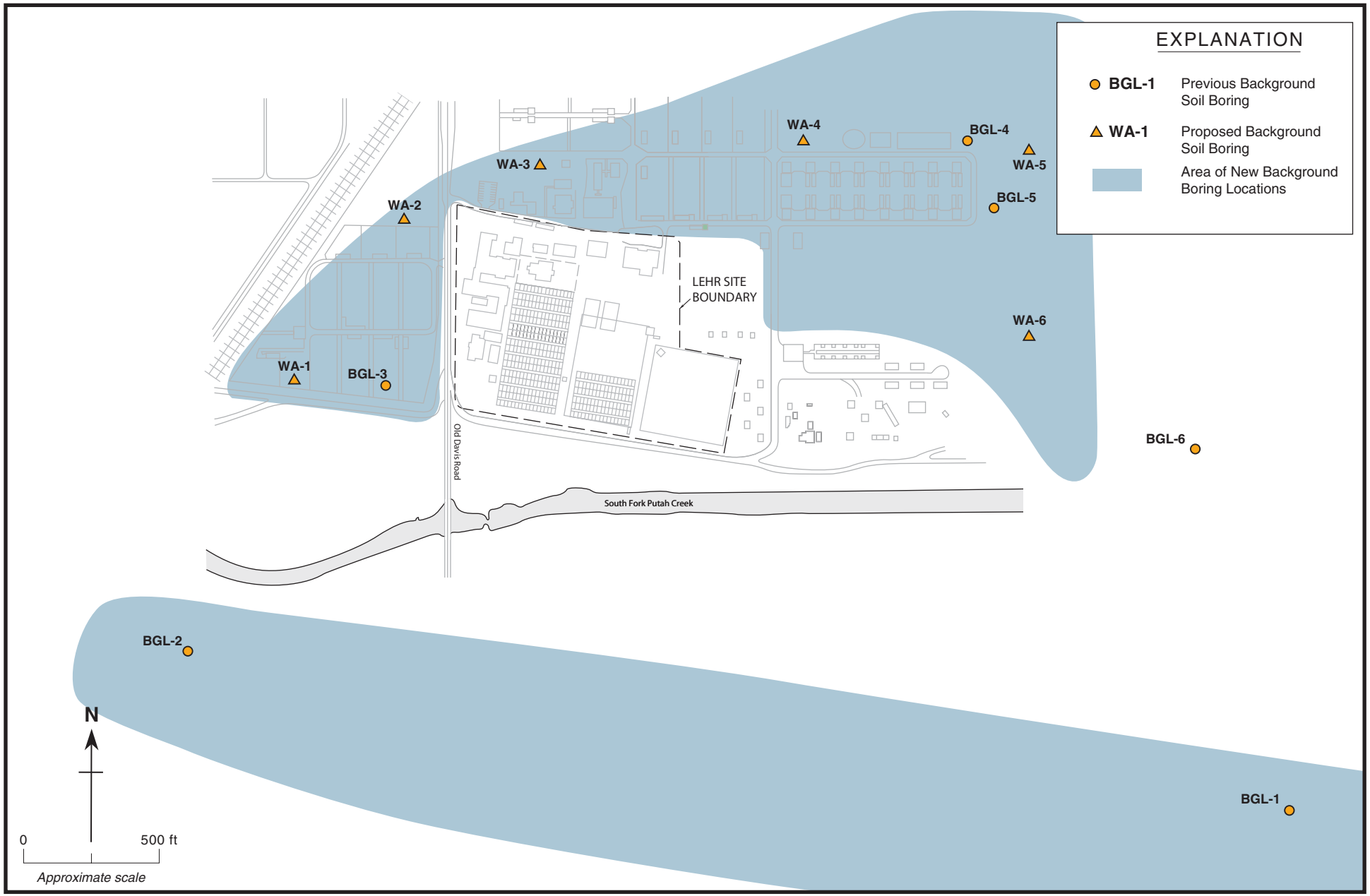

Figure 7. 1995 Background and Proposed New Background Soil Boring Locations, LEHR Site, Davis, California

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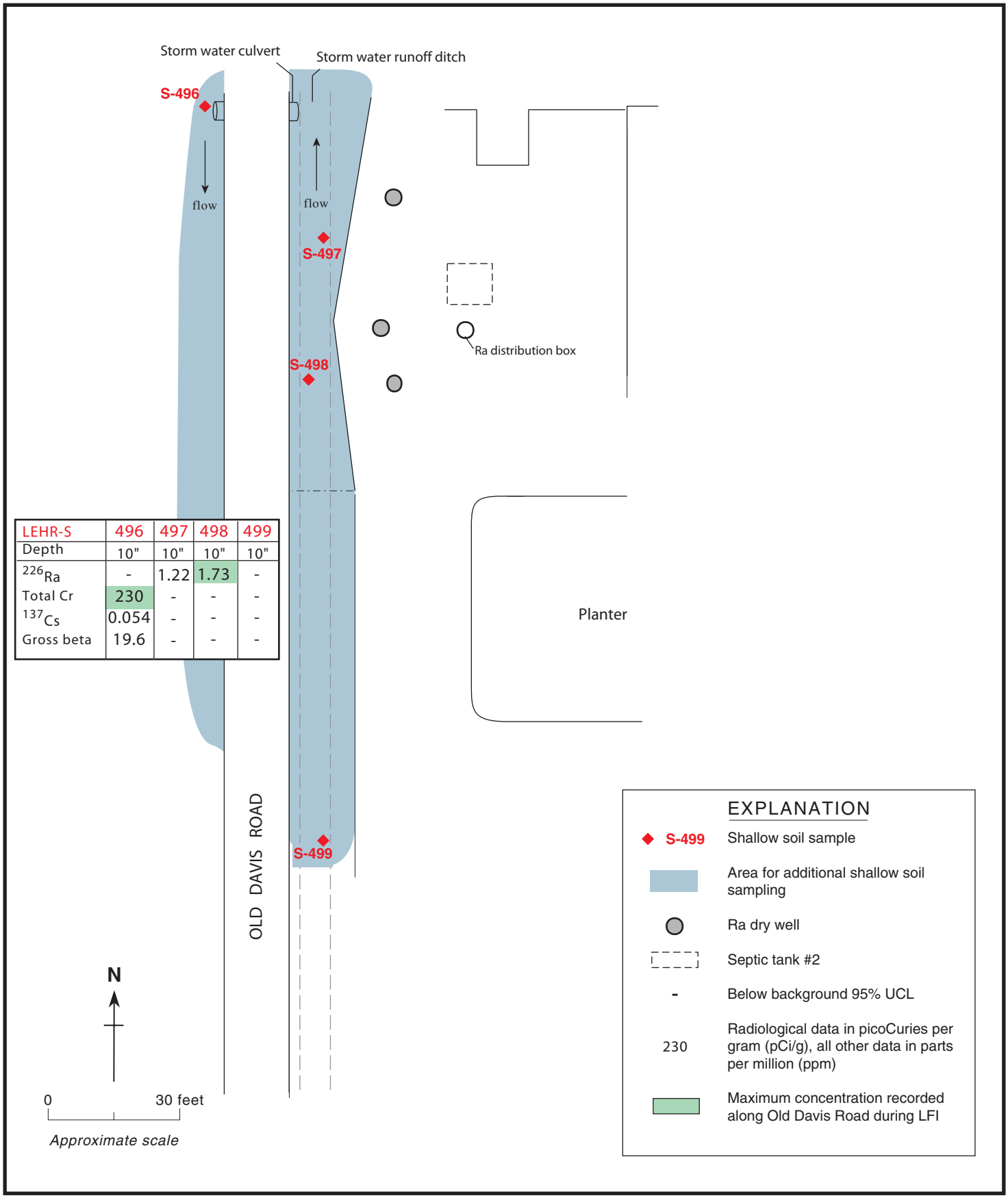

LEHR-S	496	497	498	499
Depth	10"	10"	10"	10"
^{226}Ra	-	1.22	1.73	-
Total Cr	230	-	-	-
^{137}Cs	0.054	-	-	-
Gross beta	19.6	-	-	-

Figure 8. Previous Soil Sampling Locations and Analytic Results and Area for Additional Soil Sampling, Old Davis Road - LEHR Site, Davis, California

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TABLES

Table 1a. Sampling and Analysis Summary for Western Dog Pens Investigation, Phase B

Parameter	Analytical Method	Detection Limit (pCi/g for radionuclides, mg/kg for metals)	Estimated Number of Samples (Soil/Gravel)[1]	Field Duplicate Samples
Organochlorine Pesticides	CLP SOW OLM 01.8[2]	Page C-8 of SOW OLM 01.8	96	10
Radium-226	903.1	0.5	96	10
Gross Alpha	9310	5.0	96	10
Gross Beta	9310	5.0	96	10
Carbon-14	LSC	2.0	96	10
Strontium-90	905.0	1.0	96	10
Gamma Emitters	901.1	(see below)	96	10
Hexavalent Chromium	7196	1.0	96	10
Mercury	CLP SOW ILM 02.1[(2)]	0.1	96	10
Nitrate	300.0	0.2	96	10

Abbreviations:
LSC = Liquid Scintillation Counter
pCi/g = picocuries per gram
mg/kg = milligrams per kilogram

Notes:
1 = 48 gravel samples and 48 gravel/native soil interface samples
2 = More recent revisions can be used

Gamma Spectral Analysis

Analyte	Detection Limits, pCi/g
Th-234	5
Pb-214	0.2
Bi-214	0.2
Pb-210	10
U-235	0.5
U-238	0.5
Ac-228	0.5
Pb-212	0.1
Bi-212	1
Tl-208	0.2
K-40	2
Co-60	0.1
Cs-137	0.1

Table 1b. Sampling and Analysis Summary for Western Dog Pens Investigation, Phase C

Parameter	Analytical Method	Detection Limit (pCi/g for radionuclides, mg/kg for metals)	Estimated Number of Samples (Soil/Gravel)	Field Duplicate Samples
Organochlorine Pesticides	CLP SOW OLM 01.8[1]	Page C-8 of SOW OLM 01.8	110	10
Radium-226	903.1	0.5	110	10
Gross Alpha	9310	5.0	110	10
Gross Beta	9310	5.0	110	10
Carbon-14	LSC	2.0	110	10
Strontium-90	905.0	1.0	110	10
Gamma Emitters	901.1	(see below)	110	10
Hexavalent Chromium	7196	0.5	110	10
Mercury	CLP SOW ILM 02.1[(1)]	0.1	110	10
Nitrate	300.0	0.2	110	10

Abbreviations:
LSC = Liquid Scintillation Counter
pCi/g = picocuries per gram
mg/kg = milligrams per kilogram

Notes:
1 = More recent revisions can be used

Gamma Spectral Analysis

Analyte	Detection Limits, pCi/g
Th-234	5
Pb-214	0.2
Bi-214	0.2
Pb-210	10
U-235	0.5
U-238	0.5
Ac-228	0.5
Pb-212	0.1
Bi-212	1
Tl-208	0.2
K-40	2
Co-60	0.1
Cs-137	0.1

Table 2. Sampling and Analysis Summary for Background Soil Investigation

Parameter	Analytical Method	Contract Required Detection Limit (pCi/g for radionuclides, mg/kg for metals)	Estimated Number of Samples (Soil)[1]	Field Duplicate Samples
Radionuclides				
Americium-241	Lab SOP	0.01	48	4
Carbon-14	Lab SOP	0.1	48	4
Gamma Emitters	901.1		48	4
Actinium-228		0.1		
Bismuth-212		0.1		
Bismuth-214		0.1		
Cesium-137		0.01		
Cobalt-60		0.005		
Lead-210		0.5		
Lead-212		0.1		
Lead-214		0.1		
Potassium-40		1		
Radium-228		0.1		
Radium-226		0.1		
Thallium-208		0.05		
Thorium-234		0.5		
Gross Alpha	9310	1	48	4
Gross Beta	9310	1	48	4
Plutonium-241	Lab SOP	0.5	48	4
Strontium-90	905.0	0.05	48	4
Tritium	906.0	1	48	4
Uranium-235	Lab SOP	0.01	48	4
Metals/Other Inorganics				
Antimony	CLP SOW ILM 02.1[2]	0.1	48	4
Cadmium	CLP SOW ILM 02.1	0.05	48	4
Chromium (total)	CLP SOW ILM 02.1	1	48	4
Chromium (+6)	7196	0.05	48	4
Lead	CLP SOW ILM 02.1	0.3	48	4
Mercury	CLP SOW ILM 02.1	0.1	48	4
Molybdenum	CLP SOW ILM 02.1	0.1	48	4
Nickel	CLP SOW ILM 02.1	1	48	4
Silver	CLP SOW ILM 02.1	0.1	48	4
Thallium	CLP SOW ILM 02.1	0.1	48	4
Nitrate	300.0	1	48	4

Abbreviations:
SOP = Standard Operating Procedure

Notes:
1 = Eight samples at depth 0-40 ft bgs from each of six borings
2 = More recent revisions can be used

Table 3. Sampling and Analysis Summary for Off-site Ra-226 Investigation

Parameter	Analytical Method	Detection Limit (pCi/g for radionuclides)	Estimated Number of Samples (Soil)[1]	Field Duplicate Samples
Gross Alpha	EPA 9310	5.0	5	0
Gross Beta	EPA 9310	5.0	5	0
Tritium	EPA 906.0	2.5	5	0
Carbon-14	LSC	2.0	5	0
Radium-226	EPA 903.1 (M)	0.5	5	0
Strontium-90	EPA 905.0	1.0	5	0
Americium-241	LAS 0108*	0.1	5	0
Plutonium-241	LAS 0108*	2	5	0
Gamma Emitters	EPA 901.1	(see below)	5	0
Volatile Organic Compounds	CLP SOW OLM 01.8[2]	Compound specific	5	0
Semi-Volatile Organic Compounds	CLP SOW OLM 01.8[2]	Compound specific	5	0
Organochlorine Pesticides (and PCBs)	CLP SOW OLM 01.8[2]	Page C-8 of SOW OLM 01.8	5	0
Nitrate	EPA 300.0	0.2	5	0
Total Chromium	CLP SOW ILM 02.1[2]	1.0	5	0
Hexavalent Chromium	EPA 7196	1.0	5	0
Antimony	CLP SOW ILM 02.1[2]	0.5	5	0
Arsenic	CLP SOW ILM 02.1[2]	1.0	5	0
Barium	CLP SOW ILM 02.1[2]	1.0	5	0
Beryllium	CLP SOW ILM 02.1[2]	0.1	5	0
Cadmium	CLP SOW ILM 02.1[2]	0.1	5	0
Mercury	CLP SOW ILM 02.1[2]	0.1	5	0

Abbreviations:
LSC = Liquid Scintillation Counter
pCi/g = picocuries per gram

Notes:
1 = 11 surface (immediately below any vegetation/loose soil) samples and nine soil samples at 0.5 ft, 1.5 ft, and 3 ft from three locations.
2 = More recent revisions can be used
* = Laboratory Standard Operating Procedure

Gamma Spectral Analysis

Analyte	Detection Limits, pCi/g
Th-234	5
Pb-214	0.2
Bi-214	0.2
Pb-210	10
U-235	0.5
U-238	0.5
Ac-228	0.5
Pb-212	0.1
Bi-212	1
Tl-208	0.2
K-40	2
Co-60	0.1
Cs-137	0.1