Environment,
Health & Safety
BERKELEY LAB

Soil Management Plan for Lawrence Berkeley National Laboratory

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Abbreviations

AOC	Area of Concern
Berkeley Lab	Lawrence Berkeley National Laboratory
BioEPIC	Biological and Environmental Program Integration Center
BioGEM	Biological Genome Engineering and Manufacturing Facility
BMP	best management practice
CAP	Corrective Action Program
CCR	California Code of Regulations
CDF	Control Density Fill
CMI	Corrective Measures Implementation
CMS	Corrective Measures Study
COC	contaminant of concern
COPC	chemical of potential concern
CY	cubic yard(s)
DCA	dichloroethane
DCE	dichloroethene
DOE	U.S. Department of Energy
DQO	data quality objective
DTSC	Department of Toxic Substances Control
DTSC-SL	DTSC-recommended screening level
EHS	Environment, Health & Safety (Division)
EIR	Environmental Impact Report
ELAP	Environmental Laboratory Accreditation Program
EPA	U.S. Environmental Protection Agency
ESG	LBNL Environmental Services Group
ESL	Environmental Screening Level
HHRA	Human Health Risk Assessment
IFB	indistinguishable from LBNL background
IFP	Import Fill Plan
IGB	Integrated Genomics Building

LBNL	Lawrence Berkeley National Laboratory
LRDP	Long Range Development Plan
NOA	Naturally Occurring Asbestos
PAH	polynuclear aromatic hydrocarbon
PCB	polychlorinated biphenyl
PCE	tetrachloroethene
PDF	portable document format (Adobe Acrobat)
PIMD	Projects and Infrastructure Modernization Division
PRG	Preliminary Remediation Goal
QAPP	Quality Assurance Program Plan
RCRA	Resource Conservation and Recovery Act
RFA	RCRA Facility Assessment
RFI	RCRA Facility Investigation
RSL	Regional Screening Level
RWQCB	Regional Water Quality Control Board
SAP	Sampling and Analysis Plan
SMP	Soil Management Plan
SVOC	semi-volatile organic compound
SWMU	Solid Waste Management Unit
SWPPP	Stormwater Pollution Prevention Plan
TCA	trichloroethane
TCE	trichloroethene
TCLP	Toxicity Characteristic Leaching Procedure
TPH	total petroleum hydrocarbon
TSCA	Toxic Substances Control Act
UC	University of California
UCL	upper confidence limit
VOC	volatile organic compound
WET	Waste Extraction Test

1 Introduction

1.1 Purpose

The Soil Management Plan (SMP) establishes policies and procedures to ensure that soil excavated at Lawrence Berkeley National Laboratory (LBNL, Berkeley Lab) does not adversely impact human health or the environment and is handled, stored, reused, or replaced on-site, or disposed of off-site in accordance with applicable laws and regulations. The plan provides clear and consistent criteria for determining the requirements for the soil management process. This document is a revision of the SMP that was approved by the California Environmental Protection Agency's Department of Toxic Substances Control (DTSC) in 2018 (LBNL, 2017). The primary revisions from the previous version are as follows:

- The soil replacement category was revised to allow soil removed from trenches excavated for utility assessment, repair, or replacement ("sidecast soil") and potholing to determine utility locations to be placed back into the same utility trench or pothole from which it was removed without sampling, provided there is no indication of contamination. This revision is consistent with regulations and with soil management practices allowed by regulatory agencies for use on utility and redevelopment projects throughout California.
- The use of estimated indoor air concentrations calculated using soil concentrations and the soil/soil vapor partitioning equation (DTSC, 2011) was eliminated as a requirement to screen soil for replacement in the same excavation from which it was removed. The rationale for this change was that many of the calculated soil screening values were below laboratory detection limits, replacement does not increase the risk, and replacement is consistent with "green remediation" objectives. In addition, "soil matrix data are less than ideal for evaluating vapor intrusion risk because of the uncertainty associated with using partitioning equations and the potential loss of volatile chemicals during sample collection" (DTSC, 2011).
- The use of Regional Water Quality Control Board (RWQCB) Environmental Screening Levels (ESLs) for construction workers was eliminated as a requirement to screen soil for replacement in the same excavation from which it was removed. The rationale for this change was that Berkeley Lab has an institutional management system in place to protect the health and safety of workers conducting below-grade work.
- Regulatory agency screening levels were updated.
- The soil vapor to indoor air attenuation factor (α) was revised to 0.03, the attenuation factor currently recommended by DTSC for the initial evaluation of the potential for vapors to enter a building (DTSC & RWQCB, 2023).
- Section 6.6, Control of Fugitive Emissions and Section 6.7, Control of Imported Fill Material were added in response to DTSC's request to address soil management measures to control fugitive emissions and control imported soil materials (DTSC, 2022a).

- Section 6.8, Dewatering was added in response to DTSC's request to address potential dewatering requirements (DTSC, 2024). Additionally, requirements were added should Berkeley Lab import soil from a source other than a virgin quarry and for the staging, storing, or reuse of Berkeley Lab soil at an off-site location.

1.2 Scope

This document discusses soil management activities for potentially contaminated soil that may fall under the regulatory oversight of DTSC, the U.S. Environmental Protection Agency (EPA), and/or the RWQCB. The following topics relevant to soil management at Berkeley Lab are described:

- The general distribution of known soil contaminants
- Institutional controls that reduce potential impacts to human health and the environment from exposure to soil contaminants
- Requirements for the on-site management[1] of soils generated during demolition, construction, maintenance, and other activities that disturb soil
- Sampling and analysis requirements and criteria for the on-site reuse, on-site replacement, or off-site disposal of soils generated during activities that disturb soil

Requirements for the management of radiologically contaminated soil at Berkeley Lab are under the jurisdiction of the U.S. Department of Energy (DOE). Requirements specific to radiological contamination are therefore not governed by this document but are provided in the *Soil Management Plan – Radiological Sampling and Analysis Plan* (LBNL, 2024), which complies with DOE requirements.

Management of soil excavated from an area undergoing a cleanup action under regulatory oversight may be subject to the requirements of a project-specific SMP or other governing document that must be approved by DTSC or other regulatory agencies. The requirements of such project-specific SMPs would supersede those described in this document.

[1] If it becomes necessary to stage or store Berkeley Lab soil at an offsite location, DTSC approval would be required and the soil would need to be managed in accordance with requirements of this SMP.

2 Background

2.1 Site Description

Berkeley Lab is a scientific research campus operated by the University of California (UC) for DOE. Beginning with a focus on nuclear physics research in the 1940s, Berkeley Lab has grown into a multidisciplinary scientific research facility that supports research in the physical, energy, life, environmental, and biological sciences and high-performance computing. It is located on a 202-acre parcel of UC Regents' land in the East Bay Hills in Alameda County, California, straddling the border between the cities of Berkeley and Oakland. A map showing the locations of site buildings, creeks, and surface topography is provided as Figure 1. The site physiography, geology, and hydrogeology are described in the RCRA Facility Investigation Report (LBNL, 2000).

2.2 RCRA Corrective Action Program

Berkeley Lab's Hazardous Waste Handling Facility operates under a Resource Conservation and Recovery Act (RCRA) Part B Hazardous Waste Facility Permit issued by DTSC. The permit issued in 1993 required Berkeley Lab to investigate and address releases of hazardous waste and hazardous constituents in accordance with RCRA Corrective Action Program (CAP) requirements.

The RCRA CAP has four primary components, each of which is discussed briefly in this section as it pertains to Berkeley Lab:

- RCRA Facility Assessment (RFA)
- RCRA Facility Investigation (RFI)
- Corrective Measures Study (CMS)
- Corrective Measures Implementation (CMI)

The areas of soil contamination that were addressed in the RFA, RFI, CMS, and CMI, including Solid Waste Management Units (SWMUs) and Areas of Concern (AOCs), are listed in Table 1, along with their status. The table also lists soil contamination areas that were discovered after the DTSC-approved corrective measures for soil were completed. The SWMUs, AOCs, and other areas of soil contamination are collectively referred to in this SMP as "units." Table 1 provides the following information about these units:

- Page numbers of the reports that reference the units (LBNL, 1992, 1994, 1995b, 2000, 2003, 2005)
- Whether the unit was determined to be acceptable for unrestricted use or whether it should be restricted to institutional land use
- The specific soil contaminants detected

The locations of the units are shown on Figure 2.

2.2.1 RCRA Facility Assessment

The RFA was completed in 1992. Its purpose was to identify SWMUs and AOCs at Berkeley Lab that were the source of known releases of hazardous waste and hazardous constituents or had the potential for past or future releases. The RFA found that hazardous waste or hazardous constituents had been released to soil and groundwater at a number of units.

2.2.2 RCRA Facility Investigation

The RFI was conducted between October 1992 and September 2000. It identified the source and nature of contaminants that had been released to the environment at identified units, and it characterized the magnitude and extent of those releases. The RFI was divided into three phases, each documented in a report, as follows:

- RCRA Facility Investigation Phase I Progress Report (LBNL, 1994)
- RCRA Facility Investigation Phase II Progress Report (LBNL, 1995b)
- RCRA Facility Investigation Report (LBNL, 2000)

As described in the RFI reports, the principal chemical contaminants detected at Berkeley Lab were chlorinated volatile organic compounds (VOCs) in the soil and groundwater and polychlorinated biphenyls (PCBs) in the soil. The chlorinated VOCs included tetrachloroethene (PCE); trichloroethene (TCE); carbon tetrachloride; 1,1,1-trichloroethane (TCA); and associated degradation products. Other contaminants detected in soil include petroleum hydrocarbons and metals and, to a much lesser extent, semi-volatile organic compounds (SVOCs) and polynuclear aromatic hydrocarbons (PAHs).

The RFI used a screening process to determine which units required further action. The screening involved comparing the maximum concentration of each chemical detected in soil at each unit to California-modified Preliminary Remediation Goals (PRGs) and EPA Region 9 PRGs for residential soil. Concentrations of naturally occurring inorganic elements were also compared to LBNL background levels for soil (LBNL, 1995a). Units that failed the screening process were assessed in the *Human Health Risk Assessment for the Lawrence Berkeley National Laboratory, Environmental Restoration Program* ("HHRA") (LBNL, 2003).

2.2.3 Corrective Measures Study and Implementation

The initial phase of the CMS consisted of preparing the HHRA and an ecological risk assessment for chemicals (LBNL, 2002). The HHRA estimated the risk to human health for each unit that failed the screening process and for four units that passed the screening process but that were added because either additional samples that were collected after the RFI exceeded PRGs or PRG values for some chemicals had been revised. The HHRA risk estimates were based on an industrial/institutional use scenario for Berkeley Lab that is considered to represent both the current use and the reasonable and likely future use for the facility. The units evaluated in the HHRA are noted in Table 1.

The HHRA concluded that the following four areas of soil contamination posed a potential risk to the health of institutional workers:

- Building 88 Hydraulic Gate Unit (AOC 6-3)
- Building 75 Former Hazardous Waste Handling and Storage Facility (SWMU 3-6)
- Building 7 Sump (AOC 2-5)
- Building 51L Groundwater Solvent Plume Source Area (not designated)

The *RCRA Corrective Measures Study Report for the Lawrence Berkeley National Laboratory, Environmental Restoration Program* ("CMS Report") (LBNL, 2005) recommended that contaminated soils in these four areas be excavated and disposed of at a permitted off-site disposal facility. Cleanups of the Building 88 Hydraulic Gate Unit and Building 75 former Hazardous Waste Handling and Storage Facility were completed as Interim Corrective Measures in 2004. Cleanups of the Building 7 Sump and the Building 51L Groundwater Solvent Plume Source Area were completed as DTSC-approved corrective measures in 2006 (LBNL, 2007b).

2.2.4 Activities Conducted Since Corrective Measures Implementation

Since the corrective measures approved by DTSC were implemented, additional soil and soil vapor contamination has been detected in two Berkeley Lab areas at concentrations exceeding regulatory screening levels. The areas include the Old Town Demolition Project area and the Bayview area. The results of investigations and cleanup activities conducted in these areas have been reported to the regulatory oversight agencies. The general locations of the areas are shown on Figure 2 and are briefly discussed below.

From 2014 to the present, Berkeley Lab investigated potential subsurface contamination as part of the Old Town Demolition Project. During the investigations, PCBs and a minor amount of metals and petroleum hydrocarbons (but no VOCs or SVOCs commonly associated with petroleum hydrocarbons) were detected in soil and/or soil vapor at concentrations that exceeded screening levels. The PCB-contaminated soil is being excavated to the industrial land use level and disposed of off-site in compliance with Toxic Substances Control Act (TSCA) requirements under EPA Region 9 oversight. Depending on the level of cleanup achieved, institutional controls may be required for the PCB-contaminated areas. DTSC has been kept informed on the progress of this work.

The Bevatron was a particle accelerator that operated between 1954 and 1993. Demolition of the Bevatron and the buildings that housed it (Building 51 and Building 51A) was completed in 2012. Between 2010 and 2015, Berkeley Lab investigated potential subsurface contamination in and around the former Bevatron area. The purpose of the investigations was to assess the area for potential future redevelopment. During those investigations, VOCs were detected in the soil and soil vapor at concentrations exceeding screening levels protective of human health in the following three areas:

- Former Building 51A area (location number 91 on Figure 2)
- Former Building 51 Vacuum Pump Room/Cooling Tower area (location number 92 on Figure 2)
- The former Building 51 Motor Generator Room Yard area (location number 59 on Figure 2).

Although the contamination poses no unacceptable risks to current site workers, soil vapor sampling results indicated that there would be a potential for health risks to future indoor workers through the vapor intrusion pathway (soil vapor migrating into indoor air) should a building be constructed over those areas.

Berkeley Lab is currently in the process of redeveloping the former Bevatron area and the area to the north, collectively referred to as the Bayview area. Redevelopment includes the completed construction of the Integrated Genomics Building (IGB) on the former Bevatron site, construction of the Biological and Environmental Program Integration Center (BioEPIC) (in progress) north of the IGB, and construction of additional research facilities to the north of BioEPIC, including the Biological Genome Engineering and Manufacturing Facility (BioGEM), currently in the planning process. Berkeley Lab has investigated potential subsurface contamination in preparation for construction of these new buildings, with the most recent investigations conducted in September 2022. During these more recent investigations, VOCs were detected above screening levels in soil vapor samples collected in the following three additional areas:

- Former Building 51L area (location number 81 on Figure 2)
- Near the southeastern end of Building 64
- Building 56 area (location number 87 on Figure 2)

New buildings or other facilities intended for human occupancy cannot be constructed in these areas until at least one of the following conditions is met and approved by DTSC:

- A risk assessment is completed or lines of evidence developed that indicate that there would be no unacceptable health risks to future building occupants.
- Mitigation methods are implemented to ensure that risks to future building occupants are within acceptable levels. Mitigation methods might include engineering controls such as installation of subslab organic-vapor barriers, lateral routing of utilities to avoid vapor barrier penetration, sealing of utility penetrations, and installation of subslab ventilation systems.
- Additional data are collected to document that risks to human health would be within acceptable levels.

To comply with the above noted requirements, the footprint of the IGB was adjusted so there would be no unacceptable health risks to future building occupants and BioEPIC is being constructed with a vapor intrusion mitigation system to eliminate potential vapor intrusion risk.

2.2.5 Release Reporting Requirements

If sampling results show contamination that poses an immediate or potential threat to human health and/or the environment, a previously unreported historical release of hazardous waste and/or hazardous constituents, or a newly identified SWMU, Berkeley Lab will notify DTSC, as required by the corrective action section of LBNL's Hazardous Waste Facility Permit. The LBNL Environmental Services Group (ESG) is responsible for assessing analytical results and determining if DTSC notification is required.

3 Discussion of Key Terms

3.1 General Definitions

Area of Concern (AOC). A unit or area that does not meet the definition of a SWMU but that merits further investigation to determine the presence or absence of releases.

Historical Environmental Review. A review of historical information, process knowledge, and existing soil characterization data to evaluate environmental conditions, assess the potential for contamination, identify contaminants of concern (COCs), and determine whether the soil has been adequately characterized. For very small, well-understood sites, this review is commonly conducted as part of the penetration permit process. For larger or more complex projects, a more comprehensive review is conducted, which may include extensive historical research, interviews, etc.

Hot Spot. A localized area of contamination where concentrations are higher than those in adjacent areas.

LBNL Metals Background Concentrations. Background metals concentrations are presented in the *Analysis of Background Distributions of Metals in the Soil at Lawrence Berkeley National Laboratory* (LBNL, 2009) and are based on the use of 99th percentiles as the upper estimates of background.

Metals. The 17 metals listed in the California Code of Regulations (CCR), Title 22, Section 66261.24.

Off-Site Disposal. The disposal of excavated soil at an off-site facility (typically a landfill) that possesses a current permit to accept the specific type of waste soil generated.

Regulatory Screening Levels. DTSC-recommended screening levels (DTSC-SLs) (DTSC, 2022b), EPA Regional Screening Levels (RSLs) (U.S. EPA, 2022), and RWQCB ESLs (RWQCB, 2019). EPA RSLs, if available, are used for contaminants for which a DTSC-SL is not available.

Solid Waste Management Unit (SWMU). Any unit at a hazardous waste facility from which hazardous constituents might migrate, irrespective of whether the units were intended for the management of wastes. Examples include containers, tanks, and waste piles.

3.2 Soil Classification Definitions

For the purpose of this SMP, the following criteria are used to classify soil to determine reuse, replacement, or disposal options:

Clean Soil. Soil containing no metal at concentrations above the upper estimate of LBNL background (LBNL, 2009) and no other detectable chemical contaminants, and having radionuclide levels that are indistinguishable from LBNL background (IFB) (LBNL, 2021).

Contaminated Soil. Soil that does not meet the definition of clean soil listed above is considered to be contaminated soil. The following categories of contaminated soil are used to determine reuse and replacement options in this SMP:

- **Nonhazardous Contaminated Soil.** Soil containing metals at concentrations above the upper estimate of LBNL background and below State of California or federal hazardous waste levels, and/or soil containing detectable concentrations of organic contaminants below State of California or federal hazardous waste levels and radionuclides at concentrations that are IFB (LBNL, 2021).
- **Residential Soil.** Nonhazardous contaminated soil in which concentrations of the COCs are less than or equal to the more conservative of regulatory screening levels for residents, construction workers, or the groundwater leaching pathway. Metals concentrations can exceed screening levels and still be classified as "residential" if they are below LBNL background concentrations (LBNL, 2009).
- **Industrial Soil.** Nonhazardous contaminated soil in which concentrations of the COCs are less than or equal to the more conservative of regulatory screening levels for commercial/industrial workers or the groundwater leaching pathway and that contain radionuclides at concentrations that are IFB (LBNL, 2021). Metals concentrations can exceed screening levels and still be classified as "industrial" if they are below LBNL background concentrations (LBNL, 2009).
- **Radiologically Contaminated Soil.** Soil containing radionuclides above LBNL background levels (LBNL, 2021).

The following definitions are used to classify soil solely for on-site disposition purposes:

Soil Replacement. The use of excavated industrial soil as backfill in the same excavation area from which it was removed.

Soil Reuse. The use of excavated soil as backfill at a location within the LBNL facility. Soil reuse is either restricted or unrestricted, as defined below:

- **Restricted Reuse.** The use of residential soil as backfill at a location within the developed areas of the LBNL facility.
- **Unrestricted Reuse.** The use of clean soil as backfill at a location anywhere within the LBNL facility.

The following definitions are used to classify soil solely for disposal purposes:

Designated Waste. Hazardous waste granted a variance under Health and Safety Code Section 25143, or nonhazardous waste that consists of or contains pollutants that under ambient environmental conditions could be released in concentrations exceeding applicable water quality objectives or could reasonably be expected to affect beneficial uses of the waters of the state.

Hazardous Waste. Waste containing chemical contaminants above State of California ("California hazardous") or federal ("RCRA hazardous") waste standards.

Inert Waste. A subset of solid waste that does not contain hazardous waste or soluble pollutants at concentrations in excess of applicable water quality objectives, nor does it contain significant quantities of decomposable waste.

4 Land Use and Land Use Restrictions

4.1 Land Use

Both the HHRA (LBNL, 2003) and the CMS Report (LBNL, 2005) were developed based on the assumption that Berkeley Lab would continue to operate as a research laboratory for the foreseeable future, a scenario that is consistent with the current and reasonably anticipated future land use at Berkeley Lab. The ecological risk assessment (LBNL, 2002) is based on the assumption that the central developed area at the site does not provide suitable habitat or resources for wildlife and that ecological receptors will therefore not be exposed to the contaminants detected in the soil within the central developed area. These assumptions, which were used to assess human health and ecological risk, have been incorporated into the soil management requirements specified in this plan.

The central developed area and the open areas of the site are shown on Figure 3. The open areas are based on "rustic zones" where, as noted in Berkeley Lab's *Long Range Development Plan* [LRDP] *Environmental Impact Report* [EIR] (LBNL, 2007a), "in general most Lab activities would not occur ..." The rustic zones are shown on Figure 5, which is the Landscape Framework Plan of the EIR. Note that the open areas shown on Figure 3 have been modified from those shown in the EIR to include both areas that have been subsequently developed (construction of buildings, parking lots, construction staging areas, etc.) and to include small areas classified as rustic zones that separate the developed areas. Only clean soil may be reused in the open areas of the site. Contaminated soil may not be reused in the open areas unless, as indicated by the LRDP, those areas become subject to future development. If such development occurs, the developed areas will be considered to have been incorporated into the central developed area where restricted soil reuse is allowed.

4.2 Land Use Restrictions

In April 2007, Berkeley Lab submitted its CMI Report to DTSC (LBNL, 2007b). The report provided a summary of the DTSC-approved corrective measures that were implemented. All corrective measures that were required for contaminated soil were completed by the end of 2006, with all known locations of soil contamination acceptable for industrial land use. Concentrations of contaminants in the soil at 18 units, however, were at levels that posed potential health risks to hypothetical future residential receptors, based on the conservative evaluation of risk provided in the HHRA. In addition, concentrations of contaminants exceeded PRGs for residential soil at two LBNL construction sites (Building 56 and Building 58) and the Building 71B lobe source area, which were not evaluated in the HHRA. These 21 units are indicated in Table 1 as units restricted to industrial land use. The locations of the 21 units are shown on Figure 4.

Until a site is cleaned up to unrestricted land use standards, DTSC generally imposes specific land use restrictions where groundwater contamination exists above drinking water standards, or where residual soil contamination is above residential risk levels. UC has indicated that it is willing to voluntarily restrict

use of the affected portions of designated parcels to institutional use through a land use covenant with DTSC (UC, 2004). In July 2007, at the request of the City of Berkeley, DTSC agreed to delay imposition of land use restrictions at Berkeley Lab (DTSC, 2007). In its letter, DTSC acknowledged that Berkeley Lab operates within secured property boundaries and has internal procedures that control on-site subsurface activities.

5 Classifying Soil for Replacement, Reuse, and Disposal

This section describes the requirements and process needed to classify soil in order to determine its disposition. Clean soil may be reused at any location at Berkeley Lab. Three options are available for disposition of contaminated soil at Berkeley Lab, based on regulatory requirements governing waste disposal and protection of human health and the environment:

- Replacement in the area where it was excavated
- Restricted reuse in the developed area of the Berkeley Lab site
- Disposal off site

5.1 Soil Disposition

For this SMP, the disposition of excavated soil at Berkeley Lab falls into one or more of the following five categories based on the volume and/or concentrations of contaminants. All soil is subject to the soil management requirements given in Section 6. Note that these categories do not apply to radiologically contaminated soil, which is subject to additional requirements (LBNL, 2024).

- **De Minimis** – An excavation project in which the in situ soil excavation volume is 20 cubic yards (CY) or less in areas where there is no evidence of contamination based on historical site information and visual and olfactory indications during excavation, and the soil will be replaced in the original excavation area. Sampling is not required for de minimis excavation projects. The intent of the de minimis classification is to avoid unnecessary sampling and administrative costs for small excavations that have already been reviewed for issues related to soil contamination.
- **Unrestricted Soil Reuse** – Clean soil that does not contain radionuclides or metals above LBNL background levels or detectable levels of other chemical contaminants may be reused without restriction anywhere at Berkeley Lab. All unrestricted-reuse soil must be managed and placed in accordance with the procedures detailed in Sections 6.4 and 6.5.
- **Restricted Soil Reuse** – Residential soil (i.e., nonhazardous contaminated soil that has chemical concentrations below regulatory screening levels for residents, construction workers, and leaching to groundwater or LBNL background levels) can be reused anywhere within the central developed area of Berkeley Lab (Figure 3). All restricted-reuse soil must be managed and placed in accordance with the procedures detailed in Sections 6.4 and 6.5.
- **Soil Replacement** – Industrial soil (i.e., nonhazardous soil that has chemical concentrations below regulatory screening levels for industrial workers and leaching to groundwater or LBNL background levels) can be placed back into the same general excavation area (e.g., the same building foundation excavation) from which it was removed. Sidecast soil from trenches excavated

for utility assessment, repair, or replacement and potholing to determine utility locations can be placed back into the same utility trench or pothole from which it was removed without sampling if there is no indication of contamination. All replaced soil must be managed and placed in accordance with the procedures detailed in Sections 6.4 and 6.5.

- **Soil Disposal** – Soil that is not reused or replaced must be transported off-site for disposal at a facility that possesses a current permit to accept the specific type of waste soil generated. Permitted landfills are listed in the RWQCB Land Disposal Program's online database at https://www.waterboards.ca.gov/water_issues/programs/land_disposal/walist.html.

5.2 Data Quality Objectives Process

This SMP describes the requirements for sampling and analysis of soil that will generate sufficient data to determine whether the soil is acceptable for on-site unrestricted reuse, restricted reuse, or replacement, or whether it must be disposed of off-site. The determination must be compliant with RCRA, the California Hazardous Waste Control Law (27 CCR), TSCA, Berkeley Lab's internal procedures, and the receiving facility's waste acceptance criteria.

EPA's data quality objectives (DQOs) process (U.S. EPA, 2006) is used to establish performance or acceptance criteria, which serve as the basis for collecting data of sufficient quality and quantity to support the goals of a study. The following subsections describe the first six of the seven steps of the DQO process applicable to t this SMP. The *Plan for Obtaining the Data*, the seventh step in the process, is provided in Sections 5.3 and 5.4 below.

5.2.1 Problem Statement

Define the problem that necessitates the study; identify the planning team; and examine budget and schedule.

- **Describe the Problem** – Berkeley Lab regularly conducts demolition and construction of new facilities, excavates trenches for installation of new utilities, and conducts other activities that generate excavated soil. Characterization of contaminants in excavated soil is required to determine the acceptable disposal, reuse, and/or replacement options for these materials.
- **Establish Planning Team** – Following is a brief description of the team that plans and implements the requirements of this SMP. A more detailed discussion of roles and responsibilities is provided in Section 6.2.

  Both the Berkeley Lab Facilities Division and the Projects and Infrastructure Modernization Division (PIMD) implement projects that result in excavation of soil. Both divisions are responsible for the following tasks associated with their respective projects:

  - Managing soil during most soil-generating activities, including excavating, storing, sampling, transporting, reusing or replacing, and disposing of soil off site.

- Implementing and maintaining best management practices (BMPs) in compliance with the sitewide Stormwater Pollution Prevention Plan (SWPPP) and any construction-related SWPPPs.

In addition to the above, Berkeley Lab's Facilities Division is responsible for the following task:

- Issuing Penetration Permits and inspecting sites for compliance with Penetration Permit requirements.

Berkeley Lab's Environment, Health & Safety (EHS) Division is responsible for providing overall environmental project support and oversight for activities such as the following:

- Conducting historical environmental reviews as part of the penetration permit process.
- Assisting with soil testing and management strategies.
- Evaluating analytical results for comparison with on-site unrestricted reuse, on-site restricted reuse, on-site replacement, and off-site disposal criteria.
- Entering analytical results in the EQuIS data management system.
- Maintaining summary tables of analytical results and records discussed in Section 6.9.

The LBNL Facilities Division Director and PIMD Director are responsible for the overall implementation of SMP requirements for those projects that their divisions manage. The EHS Division Director is responsible for oversight of SMP compliance.

- **Identify Available Resources, Constraints, and Deadlines** – Berkeley Lab requests, obtains, and allocates funds to complete the characterization needed. Funds are obtained from project or overhead budgets associated with soil-generating activities, or from DOE directly. Constraints and deadlines are specific to each soil-generating activity.

5.2.2 Soil Management Plan Goals

State how environmental data will be used in meeting objectives and solving the problem; identify principal study questions; and define alternative outcomes.

The sample analytical results will be used to determine whether excavated soil is suitable for unrestricted reuse, restricted reuse, or replacement, or is required to be disposed of off-site as nonhazardous waste, hazardous waste, designated waste, or PCB remediation waste, based on responses to the following questions:

1. *Are sampling results at or below background levels for metals and radionuclides, and non-detect for other chemical contaminants so that the soil can be considered "clean"?*

   If not, proceed to Question 2 below. If so, then the soil may be reused without restriction anywhere on-site or disposed of off-site at a facility that possesses a current permit to accept the specific type of waste soil generated.

2. *Are sampling results at or below residential levels?*

   If not, proceed to Question 3 below. If so, then the soil is considered inert waste and may be designated for restricted reuse anywhere within the developed areas of the LBNL site with certain restrictions (described in detail in Sections 6.4 and 6.5) to protect groundwater and surface water, or it may disposed of off-site at a facility that possesses a current permit to accept the specific type of waste soil generated.

3. *Are sampling results at or below industrial levels?*

   If not, proceed to Question 4 below. If so, then the soil may be either replaced in the excavation area from which it originated or disposed of off-site at a facility that possesses a current permit to accept the specific type of waste soil generated.

4. *Are sampling results at or above hazardous waste or PCB remediation waste criteria?*

   If so, then the soil must be managed as hazardous waste or PCB remediation waste and disposed of off-site at a facility that possesses a current permit to accept the specific type of waste soil generated.

5.2.3 Required Information

Identify data and information needed to answer the principal questions.

The following data and information are required:

- Historical information and environmental investigation data previously collected in the areas where soil is to be excavated
- Background concentrations in site soil of constituents being evaluated
- Hazardous waste threshold values
- DTSC, RWQCB, and EPA screening levels for soil, soil vapor, and indoor air
- Analytical results of samples collected
- Data gathered while in the field (notes, photos, etc.)

5.2.4 Study Boundaries

Specify the target population and characteristics of interest; define spatial and temporal limits and scale of inference.

The target population is the group of receptors that might be exposed to contaminants within the developed areas of Berkeley Lab. The physical study area is limited to in situ soil and stockpiles of soil generated by excavation and drilling activities conducted at Berkeley Lab. Generally, soil will be sampled on a grid, so the area of inference is the volume of soil in the grid section in which the samples are collected.

5.2.5 Analytical Approach

Define the parameter of interest, specify the type of inference, and develop the logic for drawing conclusions from findings.

The parameters of interest are the concentrations of potential contaminants, including primarily metals, PCBs, petroleum hydrocarbons in the diesel and motor oil ranges, and VOCs that may be present in media (soil and soil vapor) to be excavated.

The sample results will be used to classify the soil for either unrestricted reuse, restricted reuse, replacement, or disposal by comparing chemical constituent concentrations to the following levels/limits:

- LBNL background levels
- Reuse/replacement levels derived from DTSC, RWQCB, and EPA screening levels for potential receptors relevant to the LBNL site
- Hazardous waste limits (federal and California)

A detailed discussion of the derivation of these reuse/replacement levels is provided in Section 5.3. A description of the overall soil screening process is provided in Section 5.4.

5.2.6 Performance Criteria

Develop performance criteria for new data being collected, or acceptance criteria for existing data being considered for use.

All data collected as part of these procedures must be compliant with the *Quality Assurance Program Plan for the Lawrence Berkeley National Laboratory Environmental Restoration Program* ("QAPP") (LBNL, 2022b). If modifications to the collection or analysis requirements described in this plan are necessary, these changes will be evaluated for their impact on the usability of the resulting data.

5.3 Method for Selecting Soil Classification Levels

As noted above, soil will be classified as follows:

- As clean soil suitable for unrestricted reuse – if analytical results for metals and radionuclides do not exceed background levels and the soil contains no other chemical contaminants
- As residential soil suitable for restricted reuse – if the analytical results do not exceed residential screening levels and radionuclides do not exceed background levels
- As industrial soil suitable for replacement – if the analytical results do not exceed industrial screening levels and radionuclides do not exceed background levels

The specific background, residential, and industrial concentration levels selected are derived from comparison of the LBNL background criteria, regulatory screening criteria, and California and federal hazardous waste criteria shown in Table 2. These criteria are discussed below, along with how they are applied to developing the unrestricted soil reuse, restricted soil reuse, and soil replacement levels; the

levels are listed in Table 3. All risk-based regulatory screening levels used to develop the reuse/replacement levels were derived from the more conservative of either a theoretical incremental lifetime cancer risk of 10^{-6} or a non-cancer hazard index of 1.0.

The residential concentration levels are equivalent to a residential risk scenario and are therefore protective of hypothetical future residents, construction workers, and groundwater quality. The industrial concentration levels are equivalent to an industrial risk scenario and are protective of LBNL employees, commercial workers, maintenance workers, on-site visitors, and groundwater quality. Construction worker screening levels are not included as industrial concentration levels because Berkeley Lab has an institutional management system in place that protects the health and safety of workers conducting below-grade work. As shown in Table 2, criteria protective of some of these receptors apply to both industrial and residential risk scenarios.

- **Soil criteria for petroleum hydrocarbons, metals, SVOCs, PAHs, pesticides, and PCBs** – The restricted-reuse screening levels for petroleum hydrocarbons, metals, SVOCs, PAHs, pesticides, and PCBs in soil are the most stringent of the DTSC-SLs (DTSC, 2022b) for residents or commercial/industrial workers, the RWQCB ESLs (RWQCB, 2019) for the construction worker and groundwater leaching pathway, and hazardous waste thresholds (22 CCR, Section 66261.24; and Code of Federal Regulations, Title 40, Section 261.24). For constituents with no DTSC-SL, the EPA RSLs (U.S. EPA, 2022), if available, are used instead of DTSC-SLs. The replacement screening levels are the same as the restricted-reuse criteria, except that RWQCB ESLs for the construction worker are excluded.

  LBNL upper estimates of background metals concentrations (LBNL, 2009) are used as the restricted-reuse/replacement levels if they are higher than the aforementioned criteria for metals. However, arsenic in soil derived from rocks of the Great Valley Group has a distinctly higher upper estimate of background (42 mg/kg) than soil from the Berkeley Lab site as a whole (28 mg/kg). Therefore, the screening level for arsenic in soil that is excavated from and reused/replaced in the area of Berkeley Lab underlain by the Great Valley Group (shown on Figure 6) is 42 mg/kg. Great Valley Group soil exceeding 28 mg/kg arsenic cannot be reused outside the Great Valley Group area unless approved otherwise by the appropriate agency with environmental regulatory oversight. Soil with arsenic levels that do not exceed 28 mg/kg can be reused at any location within the Berkeley Lab site.

- **Soil vapor criteria for VOCs** – As described in Section 5.4.3 below, using soil vapor sampling data is a more accurate method for assessing potential indoor air risk from VOCs than using an estimate derived from soil sampling data. The residential restricted-reuse and industrial replacement soil vapor levels in Table 2 are based on DTSC-SLs and EPA RSLs for VOC concentrations in industrial or residential indoor air (DTSC, 2022b). To obtain the concentration levels, the indoor air DTSC-SL for each chemical is divided by the DTSC-recommended attenuation factor (α) of 0.03 for the initial evaluation of the potential for vapors to enter a building (DTSC and RWQCB, 2023). If soil vapor data is not available for determining acceptable restricted-reuse/replacement soil options, the following soil criteria for VOCs are to be used.

- **Soil criteria for VOCs** – The restricted-reuse/replacement concentration levels for VOC-contaminated soil are obtained using a methodology similar to that described above for metals, SVOCs, PAHs, pesticides, and PCBs (i.e., regulatory screening levels). However, for VOCs, the pathway of concern for residents and industrial workers is primarily based on the vapor intrusion pathway for which no soil screening levels exist.
    - For the residential soil (i.e., restricted-reuse) pathway, vapor intrusion screening levels were estimated by calculating the steady-state soil concentrations that would be in equilibrium with the residential soil vapor screening levels. Those levels, which are listed in Table 2, were calculated using the soil/soil vapor partitioning equation from DTSC's vapor intrusion guidance (DTSC, 2011) (see Appendix A).
    - For the industrial soil (i.e., replacement) pathway, the steady-state soil concentrations were not used as screening levels because many of the calculated values were below laboratory detection limits and replacement would not increase the risk. Therefore, the screening levels in Table 2 are based on DTSC-SLs for industrial soil and EPA RSLs, if available, for those constituents with no DTSC-SLs.

Current LBNL background criteria, regulatory screening criteria, and California and federal hazardous waste criteria for the most frequently detected chemicals at Berkeley Lab are presented in Table 2, and the reuse/replacement levels derived from them are presented in Table 3. These levels will be compared to current regulatory sources and updated to the most recent levels, if necessary, before each new project begins.

5.4 Soil Screening Process

Three steps are used to determine sampling requirements for excavated soil, as described below and summarized on the flowchart shown on Figure 7. A fourth step is used to determine the appropriate disposition of excavated soil based on the sampling results, as described below and summarized on the flowchart shown on Figure 8.

- **Step 1:** Complete a historical environmental review for the excavation site to assess the potential presence of chemicals of potential concern (COPCs).
- **Step 2:** Determine whether the project is classified as de minimis or whether sampling is required.
- **Step 3:** Prepare a project-specific sampling and analysis plan (SAP), if required, and collect and analyze samples.
- **Step 4:** Compare the chemical analytical results with clean soil, residential, and industrial reuse/replacement levels to determine whether the soil can be replaced or reused, or whether it requires off-site disposal.

These steps are discussed in more detail in the following subsections.

5.4.1 Step 1 – Historical Environmental Review

The review will involve examining historical information, process knowledge, and existing soil characterization data, and will contain the following tasks:

1. Completing a historical environmental review to assess the potential for contamination
2. Identifying COPCs
3. Determining whether the soil has been adequately characterized

For small, well-understood sites, this review is commonly conducted as part of the penetration permit process. For larger or more complex projects, a more comprehensive review will be conducted that may consist of extensive historical research, interviews, and the like. At a minimum, the initial review will involve examining the latest versions of Figures 9 through 12, which show the known locations of the following contaminants in soil at Berkeley Lab:

- VOCs (Figure 9)
- PCBs (Figure 10)
- Petroleum hydrocarbons (Figure 11)
- PAHs, SVOCs, metal/cyanide, and pesticides (Figure 12)

The location numbers on the figures are cross-referenced to Table 1, which provides sources of information for the identified units. Reference sources include the various RFI reports (LBNL, 1994, 1995b, 2000), the HHRA (LBNL, 2003), and the CMS Report (LBNL, 2005). Additional supporting information can be found in the RFA (LBNL, 1992). The information on Figures 9 through 12 and Table 1 will be updated periodically and published in the annual Environmental Restoration Program Progress Report, which is submitted each year to the DTSC Project Manager at the end of February.

5.4.2 Step 2 – De Minimis Project Determination

The intent of classifying projects as de minimis is to avoid expending unnecessary sampling and administrative costs for small, low-risk projects or emergency repairs requiring rapid response. Projects that will disturb 20 CY or less of soil or that involve emergency repairs (e.g., landslides, failed retaining walls) requiring rapid response may be classified as de minimis under the following circumstances:

- The historical environmental review indicates that the excavation area is not located in an area with known or suspected levels of contamination above industrial soil levels.
- There is no visual or olfactory evidence of contamination during excavation.
- The soil will be replaced in the same general excavation area from which it originated.

Typical de minimis projects, which do not require sampling of soil before replacement, include the following:

- Minor sidewalk or utility repairs
- Landscaping activities such as tree, shrub, or weed removal
- Installation of fence posts or signage

- Roadway asphalt pothole repair
- Installation of geotechnical soil boreholes outside of areas with known contamination

5.4.3 Step 3 – Characterize Soil

Soil is characterized to determine acceptable reuse, replacement, and disposal options. All soil characterization must be conducted under direct oversight of a California-licensed Professional Geologist (or Professional Engineer – Civil, with training and experience in environmental investigation). Characterization must be conducted in accordance with the LBNL QAPP (LBNL, 2022b) and generally following the methodology described in the *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods* (U.S. EPA, 2015).

Samples collected from within the soil mass (stockpile or in situ) should be either randomly located and uniformly spaced or biased toward hot spot areas if potential hot spots have been identified, based on professional judgment and available field screening indications. The volume of individual stockpiles from a discrete excavation can be combined when calculating the number of composite samples needed to characterize the excavated soil. Soil stockpiles do not need to be physically combined.

The following analytical methods will be used for soil characterization:

- VOCs using EPA Method 5035 + 8260
- PCBs using EPA Method 8082
- Total petroleum hydrocarbons (TPH) (diesel and motor oil ranges) using EPA Method 8015
- California Title 22 metals using EPA Method 6000 and 7000 series

Additional analyses (e.g., for PAHs, pesticides) may be required for specific areas where historical information indicates that those chemicals may be present. All results must be on a dry weight basis to allow comparisons to human health screening levels.

The minimum number of soil samples to be collected for characterization is given in Table 4. Sampling design is discussed in the following subsections.

Sampling Design for Stockpiles with a Soil Volume of 100 CY or Less

For projects with a total soil volume stockpile of 100 CY or less, sampling and analytical requirements will be consistent with the LBNL QAPP, and a project-specific SAP may not need to be prepared. Samples will be analyzed for the recommended analytes based on the history of the area (refer to Step 1 – Historical Environmental Review).

Sampling Design for in Situ Soil Characterization or Stockpiles with a Soil Volume of More Than 100 CY

A project-specific SAP must be prepared when excavating more than 100 CY of soil or when soil characterization is conducted in situ. Information gathered during the historical environmental review will be used to develop a project-specific SAP; the minimum requirements for preparing a SAP, as well as sampling and analytical requirements, are specified in the LBNL QAPP.

General Sampling Process

Stockpile samples should be collected using a methodology similar to that described in the U.S. EPA guidance manual *Petitions to Delist Hazardous Waste* (U.S. EPA, 1993). The stockpile will be divided into approximately equal volumes, as many as the number of samples required. For each volume, a random location and depth of each component subsample should be selected for the composite sample representing that volume. The component subsamples should be collected from a full vertical core, if possible, and then combined to form a representative sample of each volume.

Special Considerations for Volatile Organic Compounds

For VOCs, the primary risk for both residential and industrial receptors is inhalation of indoor air via the vapor intrusion pathway. The ability to obtain representative soil samples from stockpiles to assess the vapor intrusion pathway is limited due to aeration of soil during excavation. Soil sample data have been determined to be unreliable indicators of vapor intrusion potential, and regulatory soil screening levels are not available for this pathway. Instead, regulatory agencies generally require that soil vapor sampling data be used to assess potential indoor air risk. Two approaches may be used to screen soil with known or suspected VOC contamination if the soil is being considered for on-site reuse:

- **Option 1.** The preferred approach is to collect in situ soil vapor samples (or use previously collected soil vapor data) in the proposed excavation area and compare the results to the residential vapor intrusion screening levels (discussed under Step 4 below). Soil from beneath areas with soil vapor concentrations less than the screening levels is the only acceptable soil for restricted-reuse (residential screening levels) projects. In addition to soil vapor sampling to address the vapor intrusion pathway, soil sampling would be conducted to address construction worker, direct contact, and groundwater protection pathways.
- **Option 2.** Valid soil vapor samples cannot be collected from disturbed (i.e., stockpiled) soil. Therefore, an alternative approach for assessing the vapor intrusion pathway may be used for situations where it is impractical to collect in situ soil vapor samples. The method is based on DTSC vapor intrusion guidance (DTSC, 2011), which provides soil/soil vapor partitioning equations to estimate soil vapor concentrations from soil data where soil vapor data are unobtainable.

5.4.4 Step 4 – Compare to Reuse/Replacement Levels

To determine acceptable options for the disposition of excavated soil, analytical data generated during Step 3 will be compared with reuse/replacement levels listed in Table 3, which were derived from the applicable regulatory agency screening levels, hazardous waste classification levels, and LBNL background levels that are listed in Table 2. Analytical results and the reuse/replacement levels listed in Table 3 may be compared by using either maximum detected concentrations or 95% upper confidence limits (UCLs) (if a sufficient number of samples is collected). UCLs may not be used if hot spots (localized areas with elevated concentrations compared to adjacent areas) are present. Subsets of the data may be used (e.g., if several different soil areas are sampled for one project and only one volume is contaminated) as long as the minimum number of samples listed in Table 4 is collected from each subset.

The methodology to select the reuse/replacement levels used for determining soil disposition is illustrated as a flowchart on Figure 8 and described below. An acceptable alternative for all soil is disposal at an off-site facility that possesses an active permit to accept the specific type of waste soil generated.

- Clean soil may be reused anywhere on the LBNL site. (*Unrestricted reuse*)
- Nonhazardous contaminated soil meeting residential screening levels (Table 2) is considered inert waste and may be reused in the developed areas of Berkeley Lab (Figure 3) as long as the reuse location meets certain requirements protective of surface water and groundwater. (*Restricted reuse in the central developed area*)
- Nonhazardous contaminated soil meeting industrial screening levels (Table 2) may be replaced in the same excavation area from which it was removed. (*Soil replacement in same excavation area*)
- Nonhazardous soil exceeding industrial screening levels must be disposed of off-site at a facility that is permitted to accept the specific type of waste soil generated. (*Soil disposal off-site*)
- Soil exceeding hazardous waste levels will be managed as hazardous waste per all applicable regulations, policies, and procedures. Depending on total concentrations detected, solubility testing using the California Waste Extraction Test (WET) and/or Toxicity Characteristic Leaching Procedure (TCLP) may be required. The results would then be compared to the hazardous waste criteria in Table 2. (*Hazardous waste management*)

Other restrictions or options may be available for the disposition of excavated soil but may require regulatory approval, as follows:

- Soil from LBNL areas where cleanup actions are being conducted under regulatory oversight is prohibited from reuse anywhere on-site unless specifically allowed by the appropriate agency with environmental regulatory oversight.
- Soil containing any chemicals or radionuclides above background levels is prohibited from reuse in the undeveloped areas of the LBNL site (Figure 3) unless specifically allowed by the appropriate agency with environmental regulatory oversight or where a previously undeveloped area is being developed (i.e., construction of buildings and other infrastructure).
- Contaminated soil meeting industrial reuse criteria might also be acceptable for transport for use at another industrial site; however, the soil must meet the acceptance criteria of the receiving facility, and the approval of the appropriate agency with environmental regulatory oversight would be required. *Any such reuse would require DTSC approval of Berkeley Lab's request for an exemption to SMP requirements. The exemption will provide the controls and procedures for managing the soil.*

6 Soil Management Requirements

6.1 Excavation and Construction Activities

The following typical types of projects at Berkeley Lab may generate soil:

- Demolishing building foundations and pavement
- Repairing, replacing, removing, and/or installing underground utilities
- Constructing new buildings, including site grading and installing foundations and underground utilities
- Excavating small areas or potholes for activities such as sign or traffic bollard installation
- Drilling borings for environmental or geotechnical purposes
- Excavating soil for environmental cleanups
- Repairing landslides
- Landscaping and gardening

6.2 Roles and Responsibilities

Both the Berkeley Lab Facilities Division and PIMD implement projects that result in excavation of soil. Both divisions are responsible for the following tasks associated with their respective projects:

- Carrying out demolition, construction, redevelopment, and maintenance projects
- Soil management activities including excavating, segregating, stockpiling, and sampling soil
- Installing and maintaining BMPs in compliance with the sitewide SWPPP
- Ensuring that work is completed in accordance with the requirements of this SMP and any project-specific SMP

In addition to the above, Berkeley Lab's Facilities Division is also responsible for the following:

- Issuing penetration permits and inspecting sites for compliance with penetration permit requirements

Berkeley Lab's EHS Division is responsible for implementing or overseeing the following activities:

- Providing overall environmental project support and oversight
- Submitting samples either to a State Water Resources Control Board Environmental Laboratory Accreditation Program (ELAP) certified laboratory or to a DOE Consolidated Audit Program qualified laboratory for radiological sampling
- Evaluating soil analytical results for acceptability for on-site reuse or replacement, or for waste profiling purposes for off-site disposal
- Maintaining a tracking spreadsheet with a summary of the soil analytical results

- Maintaining portable document format (PDF) copies, electronic data deliverables, and a database of all analytical records

The LBNL PIMD Director and the Facilities Division Director are responsible for the overall implementation of the SMP for those projects that their divisions manage. The EHS Division Director is responsible for oversight of SMP compliance.

6.3 Preconstruction Evaluation of Soils

Before any penetration action of ground or existing surfaces can start at Berkeley Lab, LBNL policy requires that a Permit to Penetrate Ground or Existing Surfaces of LBNL Property be obtained. After it is determined that soil will be disturbed at a project site, the proposed project location will be evaluated for the nature and extent of any contamination known or suspected to be present in the soil. ESG will perform the preliminary evaluation during the penetration permit process and the project may require a more thorough evaluation should it be deemed necessary. In addition, worker protection or training requirements will need to be assessed.

6.4 Management of Excavated Soil

The following controls will be implemented for the management of all excavated soil:

- Observe soils as they are excavated for signs of potential contamination. Stop work if indications of potential contamination are observed or suspected. Signs of contamination include the following:
  - Positive readings of the soil on air monitoring instruments
  - Soils that smell of oil, gasoline, solvents, or other chemicals
  - Soils that contain unexpected buried debris
  - Soils that appear to have changed color through staining by oils or chemicals
  - Soils that contain any visible non-soil materials (sheens, powders, chemicals, unknown solid wastes, and non-aqueous liquids such as beads of mercury)
  - Unknown piping, broken process piping/sanitary sewer lines, or signs of leaking from process piping/sanitary sewer or drain lines into surrounding soil
- If apparent contamination is observed or suspected, screen and segregate the soil. Direct-reading instruments should be used if applicable to the suspected contaminants. Typical direct-reading instruments used for VOC- and mercury-contaminated soil are, respectively, a photoionization detector and a mercury vapor analyzer.
- Sample the soil for potential contaminants in accordance with requirements specified in Section 5.4.3 of this plan and manage the soil in accordance with the requirements specified in Section 5.4.4 and Section 6.5 of this plan.
- Follow the SWPPP BMPs, including requirements to prevent sediment from discharging into the storm drain system. If there is any potential for rain, soil stockpiles must be surrounded by straw

wattles, silt screens, or similar material (in addition to being covered by plastic sheeting). Refer to the sitewide or project-specific SWPPP for additional requirements.

- Ensure that waste types are not mixed and that debris is segregated from excavated soil. Maintain discrete stockpiles and/or soil bins to facilitate sampling for reuse, replacement, or disposal characterization. Do not mix soils from areas that are potentially radiologically contaminated with soils from other areas potentially contaminated with chemicals. Do not add, remove, or mix soils in stockpiles or bins from different areas after they have been sampled.
- Maintain records of the source location or area of each stockpile or bin, and label each stockpile or bin with sufficient information to maintain control. At a minimum, the label should provide the responsible person's name and phone number, the date of generation, the location where the soil was generated, the date of sampling, and the bin number.
- Maintain detailed records, such as maps, photographs, and other documentation (see Section 6.9).

6.5 Management of Soil Reuse and Soil Replacement Areas

The following controls will be implemented for the management of all soil being reused or replaced on-site:

- For reuse of potentially contaminated soil outside the original excavation area, ensure that the planned reuse area lies within the central developed area of the site and that exposed soil is located at a 50-foot minimum lateral distance from any open creeks (see Figure 3) or storm drain openings. In addition, ensure that the soil meets residential use criteria and that the base of the backfilled soil is at least 5 feet above the groundwater highstand.
- When replacing soil in excavations, except for sidecast soil from trenches excavated for utility assessment, repair, or replacement and potholing, ensure that the soil meets industrial use criteria.
- Ensure that any backfilled soil containing detectable contamination is covered with either hardscape (paving, foundation materials) or at least 6 inches of clean soil and that sitewide or project-specific SWPPP requirements are met. Implement dust control measures to ensure that no visible dust leaves the excavation or reuse/replacement area.
- Maintain detailed records (see Section 6.9).

6.6 Control of Fugitive Emissions

The potential for fugitive dust and vapor emissions will be minimized by implementing the following controls

- Place covers on bins or other containers when not in active use. Completely cover with, and securely anchor, heavy-duty plastic sheeting over storage piles when not in active use and at the

end of each workday. The covering must be in good condition and securely anchored to minimize potential dust and vapor emissions to the atmosphere.

- Cover the soils loaded into trucks for off-site disposal with heavy-duty plastic sheeting or other covering to minimize potential emissions to the atmosphere. The covering must be in good condition and securely anchored.
- During excavation and backfilling activities, keep exposed soil surfaces visibly moist by water spray when necessary to prevent fugitive dust emissions

6.7 Control of Imported Fill Material

Berkeley Lab prepared an Import Fill Plan (IFP) (LBNL, 2022a) to support LBNL projects that may require the use of imported fill. The IFP provides the requirements and specifies the process for assessing the environmental quality and acceptability of fill imported from an off-site location to be used at Berkeley Lab. The primary requirements of the IFP are summarized below.

The following are prohibited as sources of fill import:

- Unknown sources
- Former industrial sites
- Sites that may have handled, used, or stored hazardous materials/waste
- Sites with a known history of radiological contamination
- Sites undergoing or having completed a cleanup action
- Unpaved parking areas

The following material is prohibited for import as fill:

- Recycled aggregate

The following material is exempt from IFP requirements:

- Control Density Fill (CDF)
- Landscape material from a commercial vendor

The following material is partially exempt from IFP requirements:

- Material from a commercial vendor for a de minimis project (less than 10 CY) and coarse sand, rock, or gravel used as a base layer under paved areas or immediately under building foundations (engineered fill) are exempt unless the material originates from an ultramafic rock area.

Partially exempt fill material from an ultramafic rock area will be sampled for the following analytes:

- California Title 22 Metals
- Asbestos

Fill material from a virgin quarry will be sampled for the following analytes:

- California Title 22 Metals
- Asbestos if the source is an ultramafic rock area

Fill material from all other sources will be sampled for the following:

- California Title 22 Metals
- TPH in the diesel and oil range
- VOCs
- PCBs
- Asbestos (if the source is an ultramafic rock area)

Samples of fill material from the specific fill source areas shown in the following table will also be analyzed for the additional listed analytes:

Fill Source Area	Additional Analytes
Land near a current or former freeway or major roadway	PAHs
Agricultural land	Pesticides Herbicides
Residential/acceptable commercial land	SVOCs Pesticides Herbicides

In addition to the analytes listed above, samples of proposed fill material will be analyzed for radionuclides in accordance with requirements of the *Soil Management Plan – Radiological Sampling and Analysis Plan* (LBNL, 2024).

For native quarries, a minimum of two 4-point composite samples representative of the material to be imported are required. For other source areas, the minimum sampling frequency must comply with requirements of the DTSC *Information Advisory Clean Imported Fill Material Fact Sheet* (DTSC, 2001). Should the import of fill from any other source be considered, an SAP will be prepared and the SAP and corresponding analytical data will be provided to DTSC prior to the import of the material to LBNL.

Analytical results will be compared to the following screening criteria to determine the acceptability of fill material for import:

- DTSC-SLs for residential soil (DTSC, 2022b)
- RWQCB ESLs for construction workers and groundwater protection (RWQCB, 2019)
- Hazardous waste criteria
- LBNL background levels (LBNL, 2009)
- Analytical laboratory reporting limits
- DTSC screening level for naturally occurring asbestos (NOA) at school sites (DTSC, 2004)

The specific criteria used to assess the acceptability of fill for import are dependent on the class of the detected chemical (e.g., metal, VOC, SVOC). However, in no case is soil exceeding screening levels for residential receptors acceptable for import, with the exception of metals at concentrations below the LBNL background level. In addition, soil containing any chemical above the background level is prohibited from reuse in the undeveloped areas of the LBNL site.

6.8 Dewatering

If dewatering is required, subcontractors must prepare a Dewatering Plan in accordance with the following text excerpted from Section 2.6 of Berkeley Lab Master Specifications – Section 013543.20:

10. Dewatering Plan for the Construction General Permit
    a. The Dewatering Plan addresses construction-dewatering requirements at the project site, including requirements for controlling contaminated groundwater as well as rainwater potentially mixed with water used for dust control.

    b. The Plan will include the following items as applicable, at a minimum:
        1) Proposed discharge methodology, including a copy of the application form for an EBMUD Special Discharge Permit;
        2) Basis of design and rationale for treatment;
        3) Required storage;
        4) Water monitoring and testing requirements;
        5) Water treatment requirements for discharge to the sewer; and
        6) Surface water containment.

6.9 Record Keeping

Record keeping is required for all soil excavation projects, which include de minimis and non–de minimis projects, restricted-reuse and replacement projects, and projects for which soil is disposed of off-site.

For de minimis projects (i.e., those projects where 20 CY or less of soil will be disturbed, historical environmental review indicates no evidence of contamination that might exceed industrial levels, and soil is to be replaced in the same general excavation area from which it was removed), the following records should be maintained:

- Email communications between the project manager and EHS requesting review of the project and providing the name(s) of staff responsible for overseeing the work, a description of the location and scope, and the proposed plan for use of excavation spoils
- Email communications between EHS and the Facilities Division indicating that the penetration permit request has been reviewed and describing any known or potential contamination or worker safety issues

For non–de minimis projects involving soil excavation, a summary table of the soil analytical results is maintained that includes a comparison of the results to the unrestricted soil reuse, restricted soil reuse and replacement screening levels, and hazardous waste criteria.

For restricted-reuse and replacement projects, the following records should be maintained:

- Maps, tables, and text describing the sample locations and depths, and extent of excavation(s)
- PDF copies and electronic data deliverables of all analytical records

- Maps and survey coordinates in the UC grid system showing soil reuse areas
- Photo documentation (photographs and dates) of soil reuse activities clearly showing the geometry and location of soil reuse areas in relation to identifiable permanent landmarks
- Any additional records that may be required for projects requiring approval from an appropriate agency with environmental regulatory oversight

For projects for which soil is disposed of off-site, the following records should be maintained (and copies provided to the Waste Management Group [EHS Procedure 873, *Management of Non-HWHF Waste*]):

- Approved waste profile documentation
- Hazardous and nonhazardous waste manifests (including Bills of Lading, 540/541, etc.)
- Land Disposal Restriction forms
- Certificates of Disposal
- Tracking spreadsheet with a summary of the soil analytical results
- PDF copies and electronic data deliverables of all analytical records

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Table 1. Summary of Soil Units

Area with Soil Contamination	Location Ref. No.	LBNL Unit No.	Included in RFA (LBNL, 1992)	Ref. Page in an RFI Report*	Ref. Page in HHRA (LBNL, 2003a)	Ref. Page in CMS Report (LBNL, 2005)	Acceptable for Unrestricted Land Use	Restricted to Institutional Land Use (LBNL, 2003a)	Contaminant(s)
Solid Waste Management Units									
B7 Former Plating Shop	1	SWMU 2-1	●	Final: B-13	4-95			●	metals, VOCs, PCBs
B52B Abandoned Liquid Waste AST and Sump	2	SWMU 2-2	●	Final: B-18	4-103			●	PAHs, PCBs
B17 Former Scrap Yard and Drum Storage Area	3	SWMU 2-3	●	Final: B-23	4-111			●	PCBs, TPH
Building 69A Former Hazmat Storage and Delivery Area	4	SWMU 3-1	●	not included	4-187		●(b)		PCBs, pesticides, SVOCs
B69 Former (Present) Waste Oil UST	5	SWMU 3-3	●	Phase 1: 5-61			●(a)		TPH, O&G
B69/75A Former Scrap Yard and Drum Storage Area	6	SWMU 3-4	●	Phase 2: 5-35			●(a)		VOCs, SVOCs
B69A Storage Area Sump	7	SWMU 3-5	●	Phase 1: 5-61	4-193			●	VOCs, PCBs, pesticides
B75 Former Haz Waste Handling and Storage Facility	8	SWMU 3-6	●	Final: C-10	4-201	200	●(c)		PCBs, VOCs, SVOCs
B76 Oil/Water Separator, Basin, and Sumps	9	SWMU 4-2	●	Phase 1: 5-62			●(a)		VOCs, TPH
B76 Motor Pool and Collection Trenches (and sump)	10	SWMU 4-3	●	Final: C-15	4-213			●	VOCs, TPH
B76 Present and Former Waste Accumulation Area #3	11	SWMU 4-6	●	Phase 1: 5-63	4-221			●	VOCs
B42 Scrap Yard	12	SWMU 5-1	●	Phase 1: 5-63			●(a)		VOCs
B77 Plating Shop Floor and Sump	13	SWMU 5-4	●	Final: C-18	4-227			●	VOCs, metals
B77 Waste Accumulation Area	14	SWMU 5-6	●	Phase 2: 5-37			●(a)		TPH-D, methylene chloride
B77G Waste Accumulation Area	15	SWMU 5-7	●	not included (unit design eval. only)			●(a)		none
B77 Sand Blasting Room	16	SWMU 5-9	●	Phase 1: 5-65			●(a)		none
B77 Present and Former Yard Decontamination Areas	17	SWMU 5-10	●	Phase 2: 5-37	4-234			●	VOCs, cyanide, TPH
B88 Waste Accumulation Area	18	SWMU 6-2	●	Phase 2: 5-38			●(a)		none
B58 Inactive Underground Rinsate Tank	19	SWMU 7-1	●	Phase 1: 5-69			●(a)		TPH
B58 Sumps	20	SWMU 7-5		Final: B-26			●(a)		VOCs, TPH
B70A Former Waste Water Holding Tanks	21	SWMU 8-1	●	Phase 2: 5-41			●(a)		none
B51 Vacuum Pump Room Waste Oil Tank	22	SWMU 9-1	●	Final: A-10			●(a)		none
B51 Vacuum Pump Room Sump and Collection Basins	23	SWMU 9-4	●	Final: A-11	4-49			●	benzene
B51 Motor Generator Room Sump	24	SWMU 9-6	●	Final: A-13	4-55			●	VOCs, PCBs
B16 Former Waste Accumulation Area	25	SWMU 10-4	●	Final: B-28	4-119			●	PCBs, VOCs, TPH, metals
B16 Present Waste Accumulation Area	26	SWMU 10-5	●	Phase 2: 5-44			●(a)		VOCs, TPH
B25 Plating Shop Floor Drains	27	SWMU 10-10		Final: B-31	4-127		●(b)		metals
B50 Former Residual Photographic Solution UST	28	SWMU 12-1	●	Phase 2: 5-50	4-242		●(b)		cyanide
B62 Waste Accumulation Area	29	SWMU 13-2	●	Final: D-16			●(a)		VOCs

Table 1 (continued)

Area with Soil Contamination	Location Ref. No.	LBNL Unit No.	Included in RFA (LBNL, 1992)	Ref. Page in an RFI Report*	Ref. Page in HHRA (LBNL, 2003a)	Ref. Page in CMS Report (LBNL, 2005)	Acceptable for Unrestricted Land Use	Restricted to Institutional Land Use (LBNL, 2003a)	Contaminant(s)
Areas of Concern									
B46A Former Motor Pool Gasoline UST	30	AOC 1-1	●	Final: A-17			●(a)		none
B71 Linear Accelerator Cooling Unit	31	AOC 1-3	●	Final: A-18			●(a)		VOCs
B71 Former Hazardous Materials Storage Area	32	AOC 1-5	●	Phase 1: 6-2			●(a)		none
B71 Transformers	33	AOC 1-6	●	Final: A-20			●(a)		O&G
B71 Mercury Contamination	34	AOC 1-10		Final: A-22			●(a)		none
B7E Former UST	35	AOC 2-1	●	Final: B-33	4-133			●	TPH, aromatic hydrocarbons
B7 Former Hazardous Materials Storage Area	36	AOC 2-2	●	Phase 2: 5-33	4-140		●(b)		VOCs
B7 Sump	37	AOC 2-5		Final: B-39	4-146	116		●	VOCs
B69/B75 Fire Drill Area	38	AOC 3-2	●	Phase 2: 5-36			●(a)		TPH
B76 Former Gasoline UST	39	AOC 4-1	●	Final: C-20			●(a)		TPH-D, VOCs, PAHs
B76 Former Diesel UST	40	AOC 4-2	●	Final: C-20			●(a)		TPH-G, VOCs, PAHs
B79 Hazardous Materials Storage Area #2	41	AOC 5-3	●	Phase 2: 5-37			●(a)		none
B77 Sanitary Sewer System	42	AOC 5-4		Final: C-23			●(a)		VOCs
B77 Generator Pad	43	AOC 5-5		Phase 2: 5-38			●(a)		TPH-D
B88 Abandoned Diesel UST	44	AOC 6-1	●	Phase 2: 5-38			●(a)		none
B88 Transformers	45	AOC 6-2	●	Phase 2: 5-38			●(a)		none
B88 Hydraulic Gate Unit	46	AOC 6-3	●	Phase 2: 5-39	4-247	198	●(c)		PCBs, O&G
B88 Hazardous Materials Storage Area	47	AOC 6-4	●	Phase 2: 5-40			●(a)		none
B46 Former Scrap Yard	48	AOC 7-1	●	Final: B-44			●(a)		TPH
B46 Hazardous Materials Storage Area	49	AOC 7-3	●	Phase 2: 5-40	4-154		●(b)		VOCs
B58 Former Hazardous Materials Storage Area	50	AOC 7-6	●	Final: B-46	4-160		●(b)		VOCs
B70A Diesel UST	51	AOC 8-1	●	Final: D-19			●(a)		TPH-D, VOCs, SVOCs
B70 Diesel UST	52	AOC 8-2	●	Final: D-21			●(a)		TPH-D
B70A Transformer	53	AOC 8-3	●	Phase 1: 5-71			●(a)		none
B70 Transformer	54	AOC 8-4	●	Phase 1: 5-72			●(a)		none
B70 Hazardous Materials Storage Area	55	AOC 8-5	●	Phase 2: 5-42			●(a)		SVOC, VOCs
B58/B70 Sanitary Sewer	56	AOC 8-6		Phase 2: 5-42	4-253			●	VOCs
B70A Sanitary Sewer	57	AOC 8-7		Final: D-23			●(a)		none
B51 Diesel UST	58	AOC 9-2	●	Final: A-23			●(a)		TPH, PAHs
B51 Former Hazardous Materials Storage Area	59	AOC 9-7		Final: A-26			●(a)		VOCs

Table 1 (continued)

Area with Soil Contamination	Location Ref. No.	LBNL Unit No.	Included in RFA (LBNL, 1992)	Ref. Page in an RFI Report*	Ref. Page in HHRA (LBNL, 2003a)	Ref. Page in CMS Report (LBNL, 2005)	Acceptable for Unrestricted Land Use	Restricted to Institutional Land Use (LBNL, 2003a)	Contaminant(s)
Sanitary Sewer Lines West of Buildings 51 and 51B	60	AOC 9-8		Final: A-27			●(a)		none
B51 Sanitary Sewer and Drainage System	61	AOC 9-9		Final: A-29	4-62			●	PCBs, VOCs, PAHs, TPH
B64 Catch Basin	62	AOC 9-10		Phase 2: 5-43					none
Former Cooling Towers Southeast of Building 51	63	AOC 9-11		Final: A-39			●(a)		none
B51/64 Former Temporary Equipment Storage Area	64	AOC 9-12		Final: A-42	4-75			●	VOCs,
B52 Former Hazardous Materials Storage Area	65	AOC 10-2	●	Final: B-49	4-167			●	VOCs, PCBs, TPH
B25A Sanitary Sewer	66	AOC 10-3		Final: B-52			●(a)		none
B25 Sanitary Sewer	67	AOC 10-4		Phase 2: 5-47			●(a)		none
B74 (Former) Diesel UST	68	AOC 11-1	●	Final: D-25			●(a)		TPH-D, aromatic VOCs
B83 Diesel AST	69	AOC 11-2	●	Phase 2: 5-48			●(a)		TPH-D
B83/83A Sanitary Sewers	70	AOC 11-3		Final: D-29			●(a)		none
B50 Sanitary Sewer Dislocations	71	AOC 12-4		Final: D-32			●(a)		aromatic VOCs
B62 Hazardous Materials Storage Area	72	AOC 13-1	●	Final: D-34	4-259		●(d)		VOCs
B62 Former Diesel UST	73	AOC 13-2	●	Final: D-35			●(a)		TPH
Building 62 Transformer	74	AOC 13-3	●	Phase 2: 5-50			●(a)		PCBs, TPH
B62 Possible Solvent Spills East of B62	75	AOC 13-4	●	Final: D-38			●(a)		none
B62 Acid Sewer Lines West of B62	76	AOC 13-8		Phase 2: 5-50			●(a)		VOCs, TPH
B62 Sanitary Sewers South of B62	77	AOC 13-9		Phase 2: 5-50			●(a)		TPH-D
B10 and B80 Sanitary Sewers	78	AOC 14-6		Final: B-56			●(a)		none
B37 Proposed Electrical Substation	79	AOC 14-7		Phase 1: 5-79	4-173		●(b)		TPH
Other Areas of Soil Contamination (Not Designated as a SWMU or AOC)									
Slope West of Building 53	80			Final: B-59	4-177		●(b)		VOCs, metals
Building 51L Groundwater Plume Source Area	81			not included	4-83	94		●	VOCs
Building 52A Lobe Source Area	82			Final: B-57		153	●(a)		VOCs
Building 71B Lobe Source Area	83			Final: A-44		106		●	VOCs
Chicken Creek Poultry Research Station	84			Final: C-26			●(a)		pesticides
Grizzly Substation	85			Final: C-27			●(e)		PCBs, TPH
Building 71 Utility Trench	86			Phase 2: 5-31			●(a,e)		PCBs, VOCs, TPH
Building 56 Construction Site	87			Phase 1: 5-73				●	VOCs
Building 2 Diesel USTs	88	AOC 14-1		Phase 1: 5-77			●(e)		TPH, PCBs
Building 58 Electrical Substation Construction	89			Phase 1: 5-71				●	TPH, metals, PAHs

Table 1 (continued)

Area with Soil Contamination	Location Ref. No.	LBNL Unit No.	Included in RFA (LBNL, 1992)	Ref. Page in an RFI Report*	Ref. Page in HHRA (LBNL, 2003a)	Ref. Page in CMS Report (LBNL, 2005)	Acceptable for Unrestricted Land Use	Restricted to Institutional Land Use (LBNL, 2003a)	Contaminant(s)
Building 71 PCB Spill (2004-2005)	90			not included		Report to EPA (Jan. 2005)	●(e)		PCBs
Former Building 51A Area	91			not included				(f)	VOCs
Former Building 51 Vacuum Pump Room Area	92			not included				(f)	VOCs
TPH under former Building 16	93			not included				(f)	TPH
Old Town PCB Contamination	94			not included				(g)	PCBs

● indicates yes

* Phase 1 (LBNL, 1994); Phase 2 (LBNL, 1995); Final (LBNL, 2000) showing module number (A, B, C, or D).

(a) Maximum detected concentrations less than Preliminary Remediation Goals (PRGs) for residential soil and/or background levels.

(b) Human Health Risk Assessment (HHRA) result for residential land use: Cancer Risk $<10^{-6}$ and Hazard Index (HI) <1.

(c) Soil was cleaned up under Interim Corrective Measures to the Toxic Substances Control Act (TSCA) self-implementing cleanup level of 1 mg/kg for soil in high-occupancy areas.

(d) Additional samples were collected in 2003 to show that the risk driver, 1,2,3-trichloropropane, detected in a single sample in 1992 was no longer present.

(e) Concentration below TSCA self-implementing cleanup level of 1 mg/kg for soil in high-occupancy areas.

(f) Required restrictions for these areas have not been determined. Soil and/or soil vapor concentrations exceed industrial use screening levels (LBNL, 2015a and 2015b).

(g) Area is being cleaned up to industrial use levels under EPA oversight (LBNL, 2016).

Table 2. Screening Levels for Common Contaminants for Classification of Soil as Clean, for Soil Reuse, for Soil Replacement, or as Hazardous Waste

Classification	Unrestricted Soil Reuse (Clean Soil)	Restricted Soil Reuse (Residential Levels)					Restricted Soil Reuse and Soil Replacement (levels apply to both residential and industrial risk scenarios)		Soil Replacement (Industrial Levels)			Offsite Disposal Required Hazardous Waste Criteria	
Receptors	All	Resident	Construction Worker	Resident			Groundwater Protection		Industrial Worker(e)			All	
Media	Soil	Soil		Soil	Soil Vapor	Indoor Air	Soil	*Water (SPLP Soil Leachate)*	Soil	Soil Vapor	Indoor Air	Soil (TTLC)	Leachate(d) (STLC/TCLP)
Screening Level Source	LBNL Background Levels (mg/kg)	Residential DTSC-SL/EPA RSLs (mg/kg)	Construction Worker ESL (mg/kg)	Soil Partitioning[(a)] from DTSC-SL/EPA RSLs for soil vapor (mg/kg)	Derived From DTSC--SL/EPA RSLs using α=0.03 (µg/m^3)	DTSC-Modified RSL (µg/m^3)	Water Board ESL (mg/kg)	*Water Board ESL (µg/L)*	Commercial/ Industrial DTSC-SL/EPA RSLs (mg/kg)	Derived From DTSC--SL/EPA RSLs using 0.03 α (µg/m^3)	DTSC-Modified RSL (µg/m^3)	(mg/kg)	*(mg/L)*
Risk Pathway	None	Human Health - Outdoor Exposure	Human Health - Outdoor Exposure	Human Health - Vapor Intrusion			Groundwater Protection		Human Health - Outdoor Exposure			NA	NA
Risk or Regulatory Limit	None	ILCR: 1E-6 HI: 1.0	ILCR: 1E-6 HI: 1.0	ILCR: 1E-6 HI: 1.0	ILCR: 1E-6 HI: 1.0	ILCR: 1E-6 HI: 1.0	Leaching (j)	*MCLs*	ILCR: 1E-6 HI: 1.0	ILCR: 1E-6 HI: 1.0	ILCR: 1E-6 HI: 1.0	NA	NA
Volatile Organic Compounds													
Tetrachloroethene (PCE)	0.005(g)	0.59	33	0.005(f)	15	0.46	0.08	*5.0*	2.7	67	2.0		*--/0.7*
Trichloroethene (TCE)	0.005(g)	0.94	18	0.005(f)	16	0.48	0.085	*5.0*	6.0	6,000	3.0	2040	*204/0.5*
cis-1,2-Dichloroethene (c12DCE)	0.005(g)	18	78	0.005(f)	277	8.3	0.19	*6.0*	84	70,000	35		
Vinyl chloride	0.01(g)	0.0082	3.4	0.01(f)	0.32	0.0095	0.01(f)	*0.5*	0.15	320	0.16	10	*--/0.2*
trans-1,2-Dichloroethene (t12DCE)	0.005(g)	130	570	ND(f)	2,767	83	0.65	*10*	600	700,000	350		
1,1-Dichloroethene (11DCE)	0.005(g)	83	350	ND(f)	2,433	73	0.54	*6*	350	620,000	310		*--/0.7*
1,1,1-Trichloroethane (111TCA)	0.005(g)	1,700	7,200	0.01	33,333	1,000	7	*200*	7200	8,800,000	4,400		
1,1-Dichloroethane (11DCA)	0.005(g)	3.6	370	0.005(f)	60	1.8	0.20	*5.0*	16	15,400	7.7		
1,2-Dichloroethane (12DCA)	0.005(g)	0.46	45	0.005(f)	3.67	0.11	0.007	*0.5*	2.0	940	0.47		*--/0.5*
Chloroform	0.005(g)	0.32	34	0.005(f)	4.0	0.12	0.023	*80*	1.4	1,060	0.53		*--/6.0*
Methylene chloride	0.01(g)	2.2	490	0.01(f)	33	1.0	0.12	*5.0*	26	24,000	12		
Carbon tetrachloride	0.005(g)	0.65	10	0.005(f)	16	0.47	0.076	*0.5*	2.9	4,000	**2**		*--/0.5*
Freon 11 (trichlorofluoromethane)	0.005(g)	1,200		0.01	43,333	1300		*150*	5,400	10,600,000	5,300		
Benzene	0.005(g)	0.33	33	0.005(f)	3.23	0.097	0.025	*1*	1.4	840	0.42		*--/0.5*
Toluene	0.005(g)	1,100	4700	0.02	10,333	310	3.2	*40*	5,300	2,600,000	1300		
Xylenes	0.01(g)	580	2,400	0.01	3,333	100	2.1	*20*	2,500	880,000	440		
Acetone	0.1(g)	70,000	270,000	28	1,066,667	32000	0.92	*14000(k)*	1,100,000	280,000,000	140,000		
Petroleum													
Petroleum hydrocarbons (diesel)	10(g)	97	1,100				1,100	*100(c)*	500				
Petroleum hydrocarbons (oil)	50(g)	2,400	54,000				5,100	*100(c)*	18,000				
PCBs													
PCBs (various Aroclors)	0.2(g)	0.23(i)	5.5				330	*0.5*	0.58(i)			50	*5.0/--*
Metals													
Antimony	<6	31	50					*6*	470			500	*15/--*
Arsenic	28(h)	0.11	0.98					*56(b)*	0.36			500	*5.0/5.0*
Barium	410	15,000	3000					*1,000*	220,000			10,000	*100/100*
Beryllium	1.0	16	27					*4*	230			75	*0.75/--*
Cadmium	5.6	7.1	51					*5*	79			100	*1.0/1.0*
Chromium	120	120,000	530,000					*50*	1,800,000			2,500	*5.0/5.0*
Cobalt	25	23	28					*9.3(b)*	350			8,000	*80/--*
Copper	63	3,100	14,000					*1300(l)*	47,000			2,500	*25/--*
Lead	43	80	160					*15(l)*	500			1,000	*5.0/5.0*
Mercury	0.42	1.0	44					*2*	4.4			20	*0.2/0.2*
Molybdenum	4.8	390	1,800					*156(b)*	5,800			3,500	*350/--*
Nickel	272	820	86					*100*	11,000			2,000	*20/--*
Selenium	4.9	390	1,700					*50*	5,800			100	*1.0/1.0*
Silver	2.9	390	1,800					*100*	5,800			500	*5.0/5.0*
Thallium	10	0.78	3.5					*2*	12			700	*7.0/--*
Vanadium	90	390	470					*62(b)*	5,800			2,400	*24/--*
Zinc	140	23,000	110,000	(l)				*5,000*	350,000			5,000	*250/--*

α = soil vapor to indoor air attenuation factor
ESL = Environmental Screening Level (from RWQCB, 2019)
RSL = Regional Screening Level (from U.S. EPA, 2022)
DTSC = Department of Toxic Substances Control (California EPA)
DTSC-SL = DTSC Recommended Screening Level (from DTSC, 2022)
ILCR = incremental lifetime cancer risk
HI = non-cancer hazard index
MCL = maximum contaminant level for drinking water
STLC = soluble threshold limit concentration (threshold used with California Waste Extraction Test [WET])
TTLC = total threshold limit concentration (depending on concentrations, solubility testing using WET or TCLP methods may also be required for disposal).
TCLP = toxicity characteristic leaching procedure
SPLP = synthetic precipitation leaching procedure

Soil replacement maximum concentrations (Industrial soil)
Restricted soil reuse maximum concentrations (residential soil)
Unrestricted reuse maximum concentrations (clean soil)
Offsite disposal required (Hazardous waste thresholds)

Italics indicate aqueous samples
Underline indicates soil vapor samples. Soil vapor data supersede soil data.
Double underline indicates calculated values

(a) Partitioning equation is derived from Feenstra et al. (1991) as specified in DTSC's 2011 Vapor Intrusion Guidance
Note that partitioning equation units for soil gas (g/cm3) and soil matrix (g/g) concentrations in DTSC vapor intrusion differ from those in Feenstra et al. (1991), which are µg/cm3 and µg/g, respectively.
(b) LBNL upper estimate of background concentration (LBNL, 2009) used for metals where background exceeds screening levels.
(c) nuisance ESL
(d) Any analyte with total concentrations in mg/kg exceeding 10x the STLC value expressed as mg/kg must be tested using the California Waste Extraction Test and results compared to STLC value.
(e) Industrial worker is equivalent to the EPA composite worker receptor, which includes both indoor and outdoor industrial workers but excludes construction workers.
(f) Laboratory detection limit substituted where calculated soil value is below laboratory limit.
(g) Laboratory detection limit
(h) The upper estimate of background for arsenic for all soil at Berkeley Lab ["Arsenic (all) as referenced in LBNL, 2009] is 28 mg/kg. However, for soil in the area underlain by the Great Valley Group shown on Figure 6, the value of 42 mg/kg ["Arsenic (Great Valley Group)" value as referenced in LBNL, 2009] may be used as long as soil exceeding 28 mg/kg arsenic is not reused outside that area.
(i) Tottal PCBs
(j) Leaching to drinking water source
(k) Tapwater risk
(l) Action level

Note 1: Additional requirements presented in the *Soil Management Plan – Radiological Assessment* (LBNL, 2017b) apply to potentially radiologically contaminated soil.
Note 2: Published screening levels shown and used to derive values on the table are periodically updated and, therefore, subject to change. Refer to Section 5.3 regarding use of these tables.

Table revision date: 10/21/22

Table 3. Clean Soil, Soil Reuse, and Soil Replacement Levels for Common Contaminants

	Clean Soil Level (Unrestricted Soil Reuse)	Source of Clean Soil Screening Level	Residential Soil Level (Restricted Soil Reuse)		Source of Residential Soil Screening Level	Industrial Soil Level (Soil Replacement)		Source of Industrial Soil Screening Level
	Soil (mg/kg)		Soil (mg/kg)	Soil Vapor ($\mu g/m^3$)		Soil (mg/kg)	Soil Vapor ($\mu g/m^3$)	
Volatile Organic Compounds								
Tetrachloroethene (PCE)	0.005(g)	LBNL Background Level	0.005(f)	15	Derived based on the DTSC/SL air screening level	0.08	67	RWQCB groundwater protection ESL
Trichloroethene (TCE)	0.005(g)	LBNL Background Level	0.005(f)	16	Derived based on the EPA/RSL air screening level	0.085	6,000	RWQCB groundwater protection ESL
cis-1,2-Dichloroethene (c12DCE)	0.005(g)	LBNL Background Level	0.005(f)	277	Derived based on the DTSC/SL air screening level	0.19	70,000	RWQCB groundwater protection ESL
Vinyl chloride	0.01(g)	LBNL Background Level	0.01(f)	0.32	Derived based on the DTSC/SL air screening level	0.01	320	RWQCB groundwater protection ESL
trans-1,2-Dichloroethene (t12DCE)	0.005(g)	LBNL Background Level	ND(f)	2,767	Derived based on the DTSC/SL air screening level	0.65	700,000	RWQCB groundwater protection ESL
1,1-dichloroethene (11DCE)	0.005(g)	LBNL Background Level	ND(f)	2,433	Derived based on the DTSC/SL air screening level	0.54	620,000	RWQCB groundwater protection ESL
1,1,1-Trichloroethane (111TCA)	0.005(g)	LBNL Background Level	0.01	33,333	Derived based on the DTSC/SL air screening level	7	8,800,000	RWQCB groundwater protection ESL
1,1-Dichloroethane (11DCA)	0.005(g)	LBNL Background Level	0.005(f)	60	Derived based on the DTSC/SL air screening level	0.20	15,400	RWQCB groundwater protection ESL
1,2-dichloroethane (12DCA)	0.005(g)	LBNL Background Level	0.005(f)	3.67	Derived based on the EPA/RSL air screening level	0.007	940	RWQCB groundwater protection ESL
Chloroform	0.005(g)	LBNL Background Level	0.005(f)	4.00	Derived based on the EPA/RSL air screening level	0.023	1,060	RWQCB groundwater protection ESL
Methylene chloride	0.01(g)	LBNL Background Level	0.01(f)	33	Derived based on the DTSC/SL air screening level	0.12	24,000	RWQCB groundwater protection ESL
Carbon tetrachloride	0.005(g)	LBNL Background Level	0.005(f)	16	Derived based on the DTSC/SL air screening level	0.076	4,000	RWQCB groundwater protection ESL
Freon 11 (trichlorofluoromethane)	0.005(g)	LBNL Background Level	0.01	43,333	Derived based on the DTSC/SL air screening level	5,400.0	10,600,000	DTSC industrial SL
Benzene	0.005(g)	LBNL Background Level	0.005(f)	3.23	Derived based on the DTSC/SL air screening level	0.025	840	RWQCB groundwater protection ESL
Toluene	0.005(g)	LBNL Background Level	0.02	10,333	Derived based on the DTSC/SL air screening level	3.2	2,600,000	RWQCB groundwater protection ESL
Xylenes	0.01(g)	LBNL Background Level	0.01	3,333	Derived based on the EPA/RSL air screening level	2.1	880,000	RWQCB groundwater protection ESL
Acetone	0.1(g)	LBNL Background Level	0.92	1,066,667	Groundwater protection ESL	0.92	280,000,000	RWQCB groundwater protection ESL
Petroleum								
Petroleum hydrocarbons (diesel)	10(g)	LBNL Background Level	97		DTSC residential SL (C9-C16 aromatic medium)	500		DTSC industrial SL (C9-C16 aromatic medium)
Petroleum hydrocarbons (oil)	50(g)	LBNL Background Level	2400		DTSC residential SL (C17-C32 aromatic high)	18,000		DTSC industrial SL (C17-C32 aromatic high)
PCBs								
PCBs (various Aroclors)	0.2(g)	LBNL Background Level	0.23		DTSC residential SL	0.58		DTSC industrial SL
Metals								
Antimony	<6	LBNL Background Level	31		EPA residential RSL	470		EPA industrial RSL
Arsenic	28(h)	LBNL Background Level	28(h)		LBNL background Level	28(h)		LBNL background level
Barium	410	LBNL Background Level	3,000		RWQCB construction worker ESL	10,000		Hazardous waste criteria
Beryllium	1.0	LBNL Background Level	16		DTSC residential SL	75		Hazardous waste criteria
Cadmium	5.6	LBNL Background Level	7.1		DTSC residential SL	79		DTSC residential SL
Chromium	120	LBNL Background Level	2500		Hazardous waste criteria	2,500		Hazardous waste criteria
Cobalt	25	LBNL Background Level	25		LBNL background Level	350		EPA industrial RSL
Copper	63	LBNL Background Level	2,500		Hazardous waste criteria	2,500		Hazardous waste criteria
Lead	43	LBNL Background Level	80		DTSC residential SL	500		DTSC industrial SL
Mercury	0.42	LBNL Background Level	1.0		DTSC residential SL	4.4		DTSC industrial SL
Molybdenum	4.8	LBNL Background Level	390		DTSC residential SL	3,500		Hazardous waste criteria
Nickel	272	LBNL Background Level	272		LBNL background level	272		LBNL background level
Selenium	4.9	LBNL Background Level	100		Hazardous waste criteria	100		Hazardous waste criteria
Silver	2.9	LBNL Background Level	390		EPA residential RSL	500		Hazardous waste criteria
Thallium	10	LBNL Background Level	10		LBNL background Level	10		LBNL background level
Vanadium	90	LBNL Background Level	390		EPA residential RSL	2400		Hazardous waste criteria
Zinc	140	LBNL Background Level	5,000		Hazardous waste criteria	5,000		Hazardous waste criteria

DTSC = Department of Toxic Substances Control (California EPA)
ESL = Environmental Screening Level
SL - DTSC Recommended Soil Screening Level
RWQCB = Regional Water Quality Control Board
(f) Laboratory detection limit substituted where calculated soil value is below laboratory limit.
(g) Laboratory quantitation limit.

mg/kg = milligrams per kilogram
$\mu g/m^3$ = micrograms per cubic meter
Underline indicates soil vapor samples. Soil vapor data supersede soil data.
Double underline indicates calculated values

Table revision date: 10/28/22

(h) The upper estimate of background for arsenic for all soil at Berkeley Lab ["Arsenic (all) as referenced in LBNL, 2009] is 28 mg/kg. However, for soil in the area underlain by the Great Valley Group shown on Figure 6, the value of 42 mg/kg ["Arsenic (Great Valley Group)" as referenced in LBNL, 2009] may be used as long as soil exceeding 28 mg/kg arsenic is not reused outside that area.

Note 1: Leachate testing may be required to determine whether the soil is hazardous. See Table 2 for criteria.
Note 2: Additional requirements presented in the *Soil Management Plan – Radiological Assessment* (LBNL, 2017b) apply to potentially radiologically contaminated soil.
Note 3: Published screening levels shown and used to derive values on the table are periodically updated and, therefore, subject to change. Refer to Section 5.3 regarding use of these tables.

	Soil replacement maximum concentrations (Industrial soil)
	Restricted soil reuse maximum concentrations (residential soil)
	Unrestricted reuse maximum concentrations (clean soil)

Table 4. Minimum Number of Soil Samples Required for Soil Classification

Ex Situ Volume of Soil	Number of Samples (VOCs)*	Number of Composite Samples (Non-VOCs)	Sample Type
≤0.3 CY (55 gallons)	1 sample	1 sample	• 4-point composite for non-VOC chemical analysis • individual VOC sample
>0.3 CY and ≤200 CY	2 samples plus 1 additional sample if the volume is greater than 100 CY	2 samples	• 4-point composite for non-VOC chemical analysis • individual VOC samples
>200 and ≤1,000 CY	4 samples for first 200 CY plus 1 sample for each additional 250 CY	2 samples for first 200 CY plus 1 sample for each additional 250 CY	• 4-point composite for non-VOCs • individual VOC samples
>1,000 CY	8 samples for first 1,000 CY plus 1 sample for each additional 500 CY	4 samples for first 1,000 CY plus 1 sample for each additional 500 CY	

* See Section 5.4.3 for discussion of the limitations of obtaining representative soil samples from stockpiles.

CY: Cubic Yard
VOCs: Volatile Organic Compounds

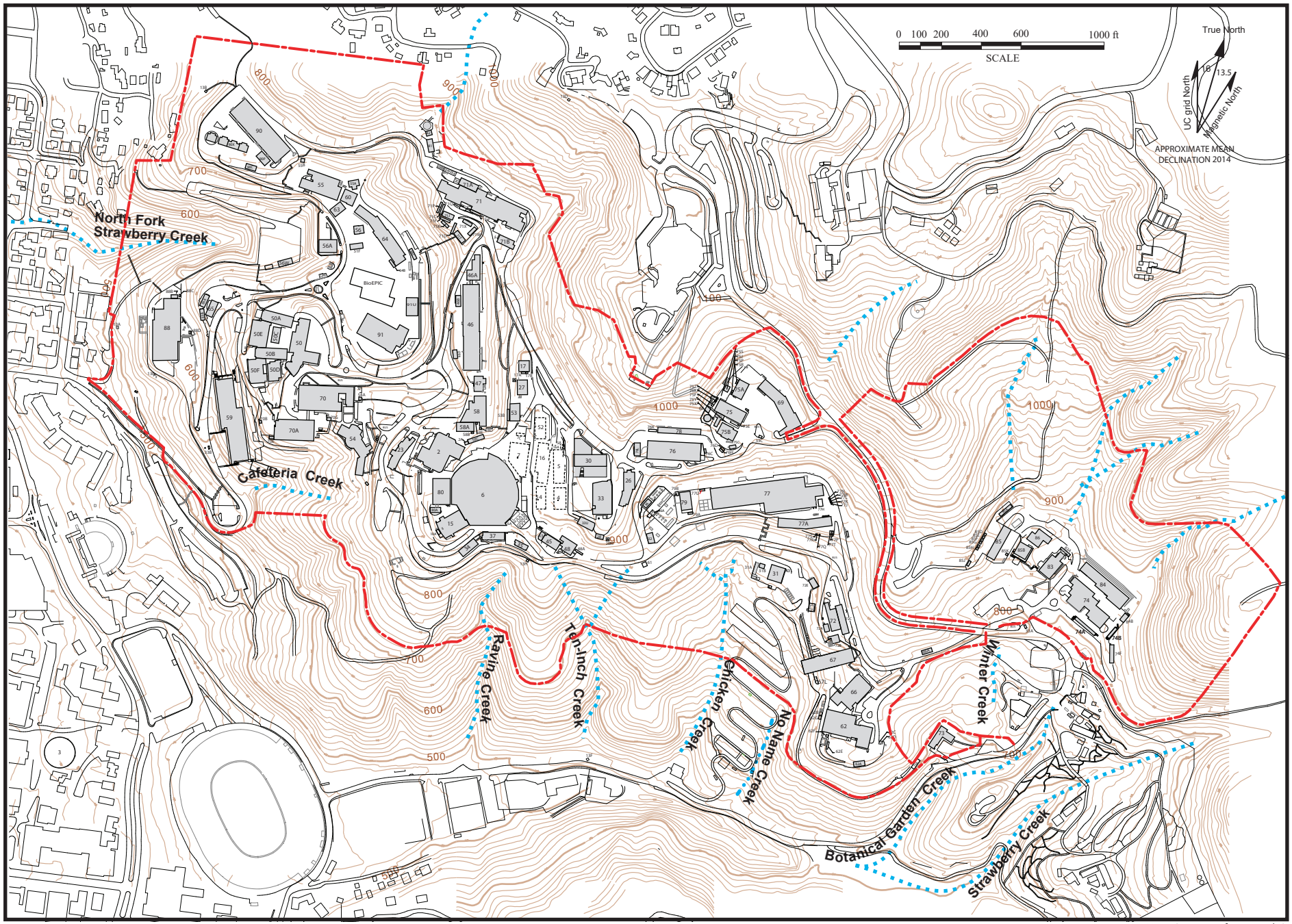

Figure 1. Site Map and Topography, Lawrence Berkeley National Laboratory

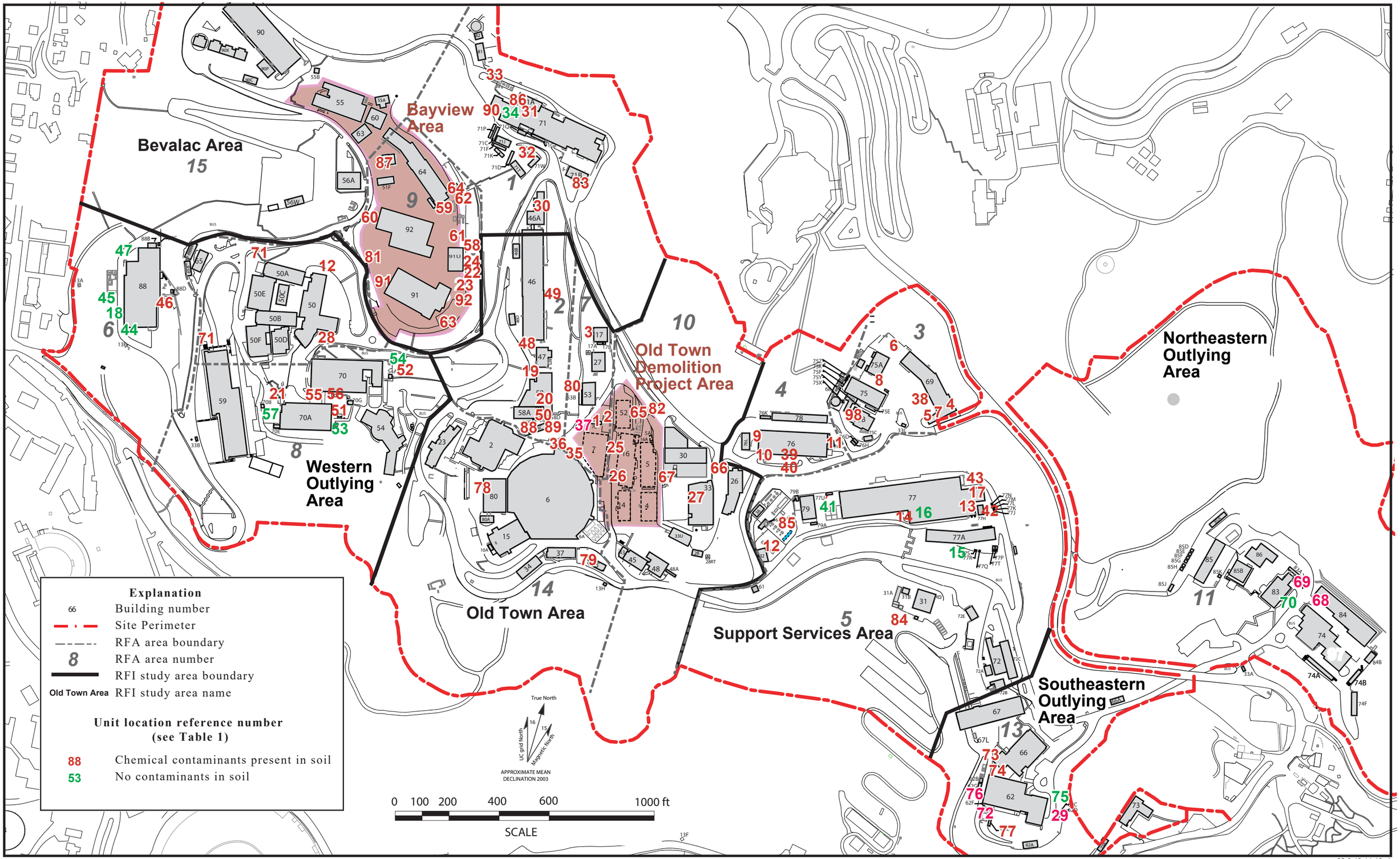

Figure 2. Locations of Chemical Soil Units, Lawrence Berkeley National Laboratory.

02-9-10-11-12.ai
1o/22

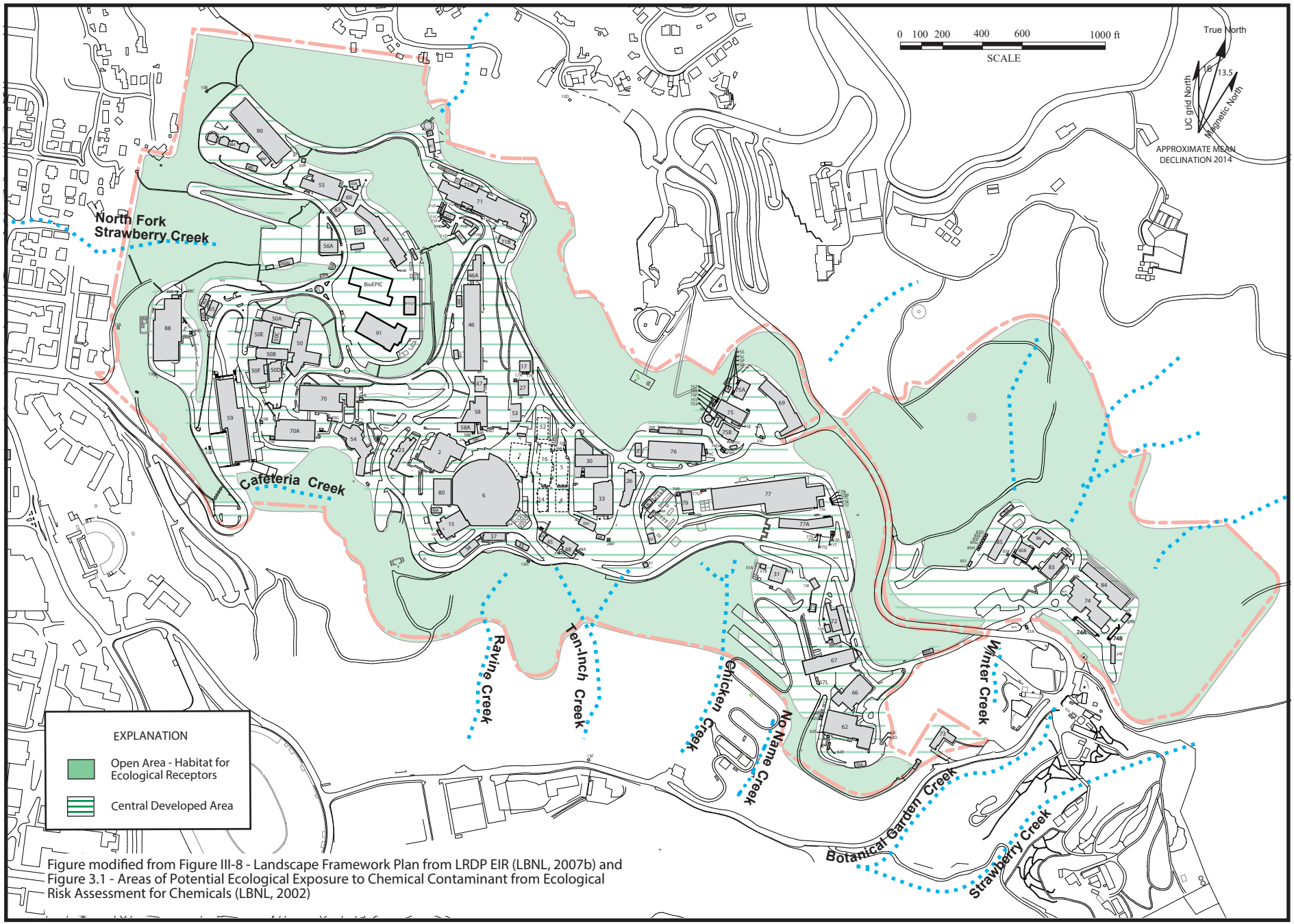

Figure 3. Location of Central Developed Area, Lawrence Berkeley National Laboratory.

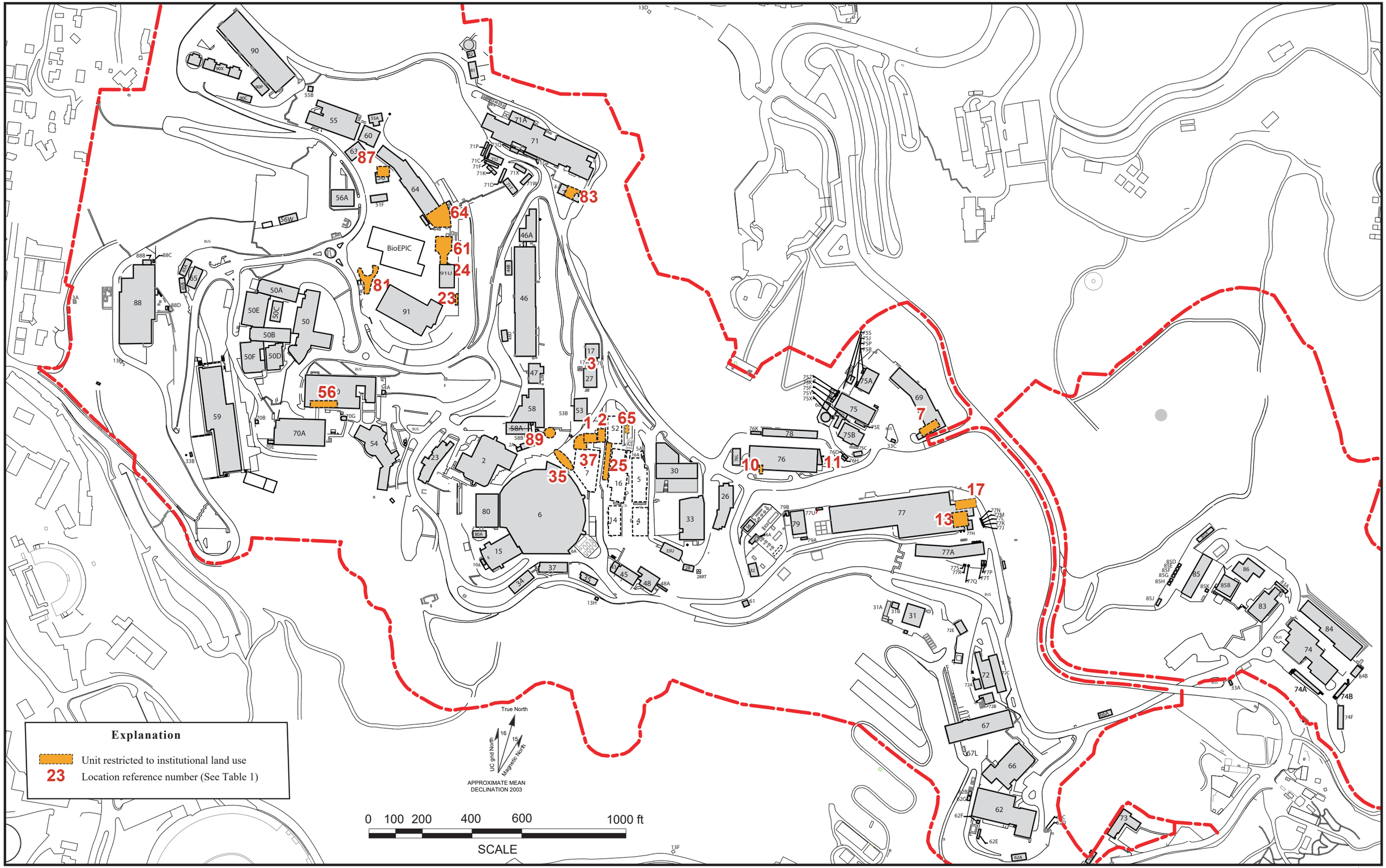

Figure 4. Locations of Units Restricted to Institutional Land Use.

3-institutional use.ai
10/22

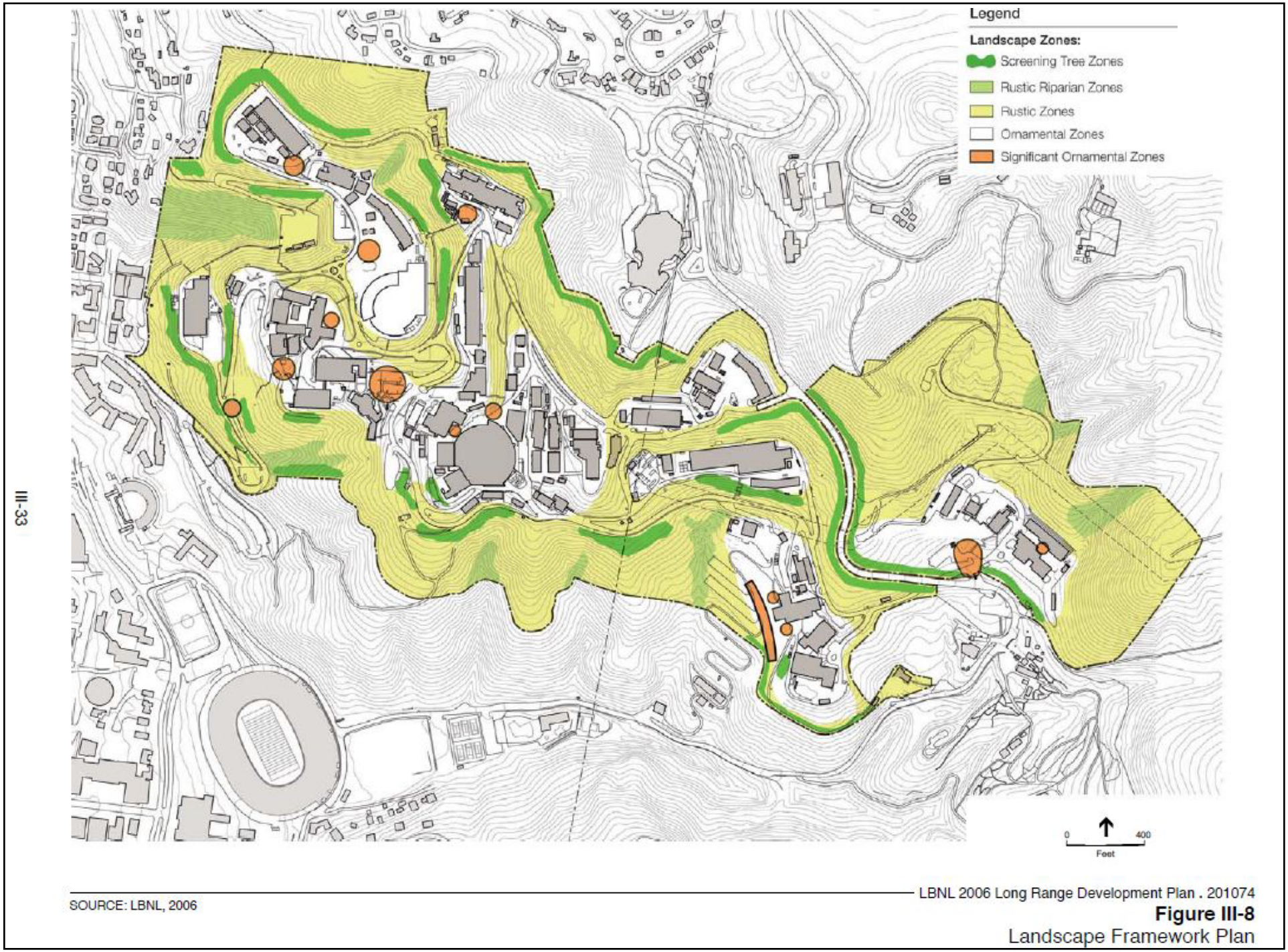

Figure 5. Landscape Framework Plan
(Reproduced from University of California Berkeley Lab LRDP 2006 Long Range Development Plan Environmental Impact Report) .

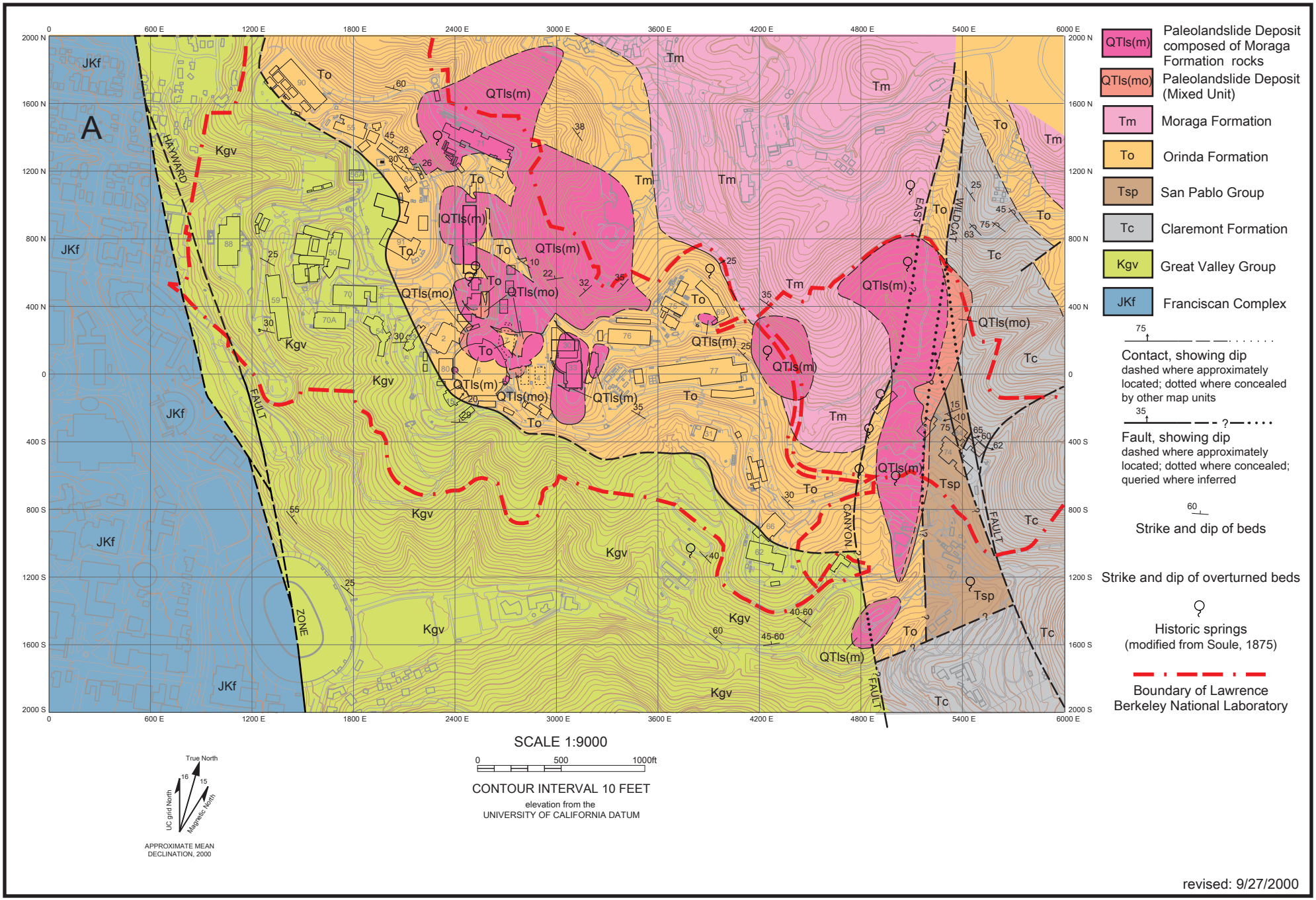

Figure 6. Bedrock Geologic Map, Lawrence Berkeley National Laboratory.

3A site br map.ai
09/00

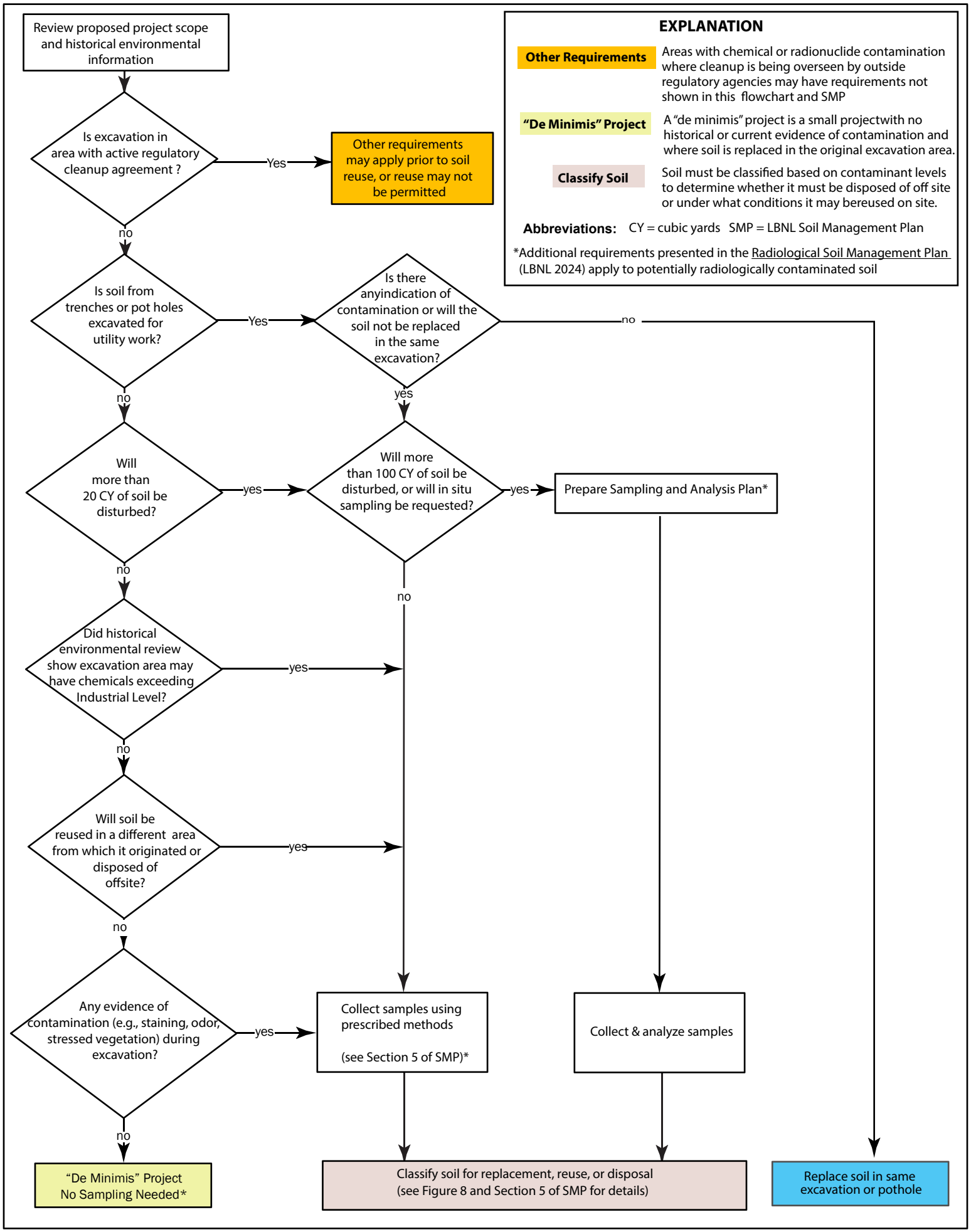

Figure 7. Flowchart for Characterizing Soil for Reuse, Replacement, or Disposal

Soil Reuse Process Flowchart r4.ai
7/19/24

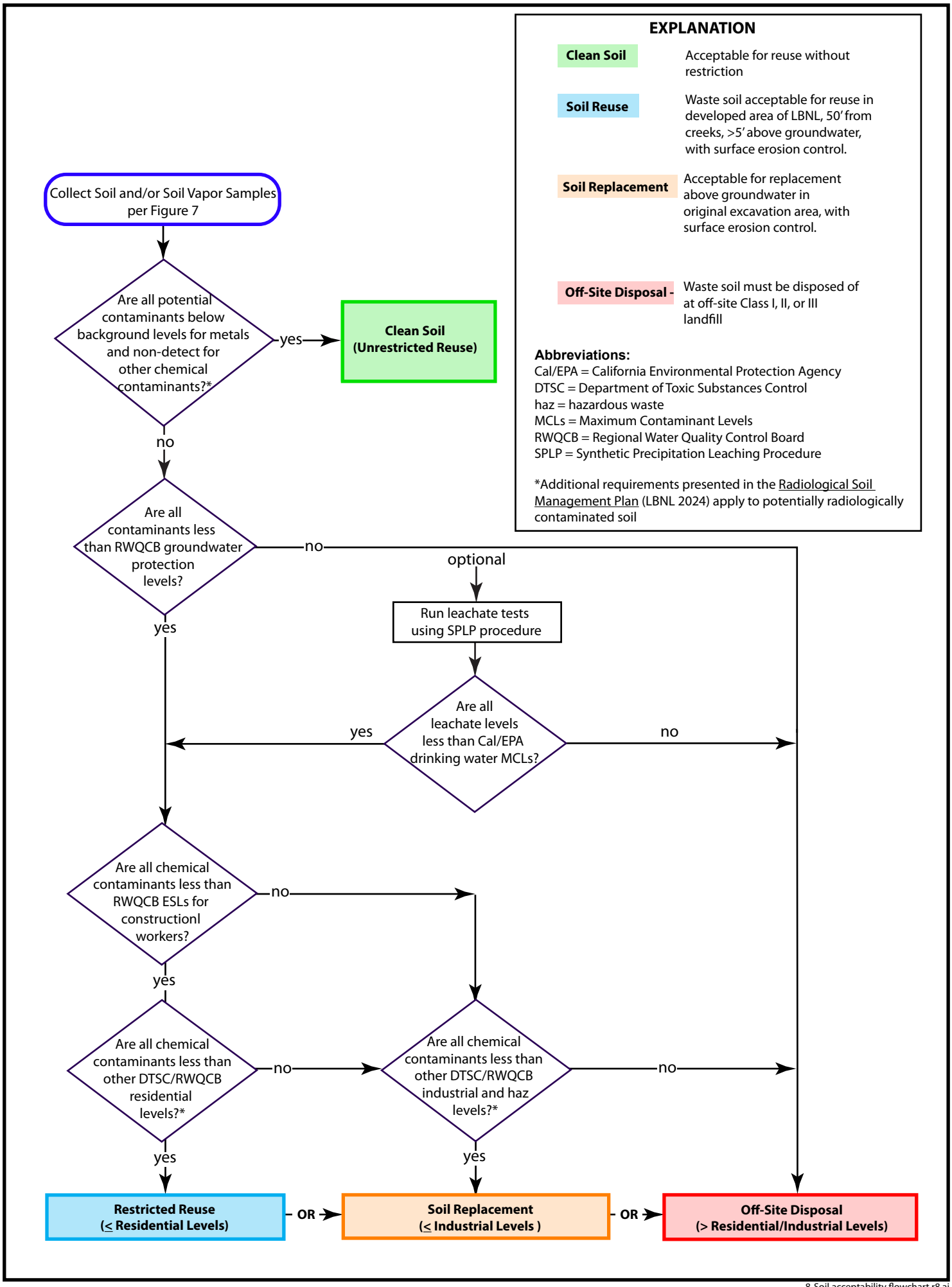

Figure 8. Flowchart for Classifying Soil Based on Sampling Data

8-Soil acceptability flowchart r8.ai
07/19/24

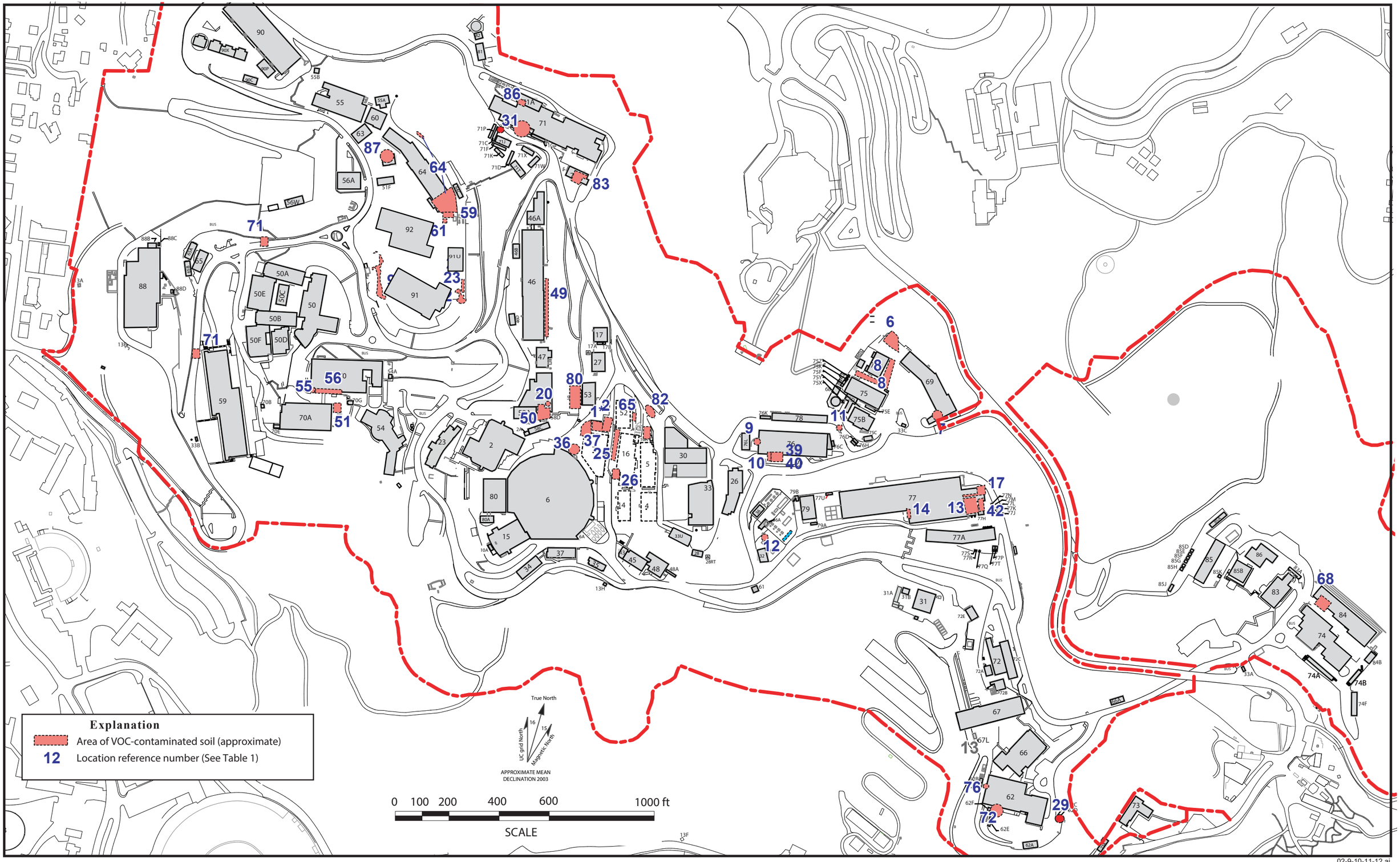

Figure 9. Locations of Volatile Organic Compounds in the Soil.

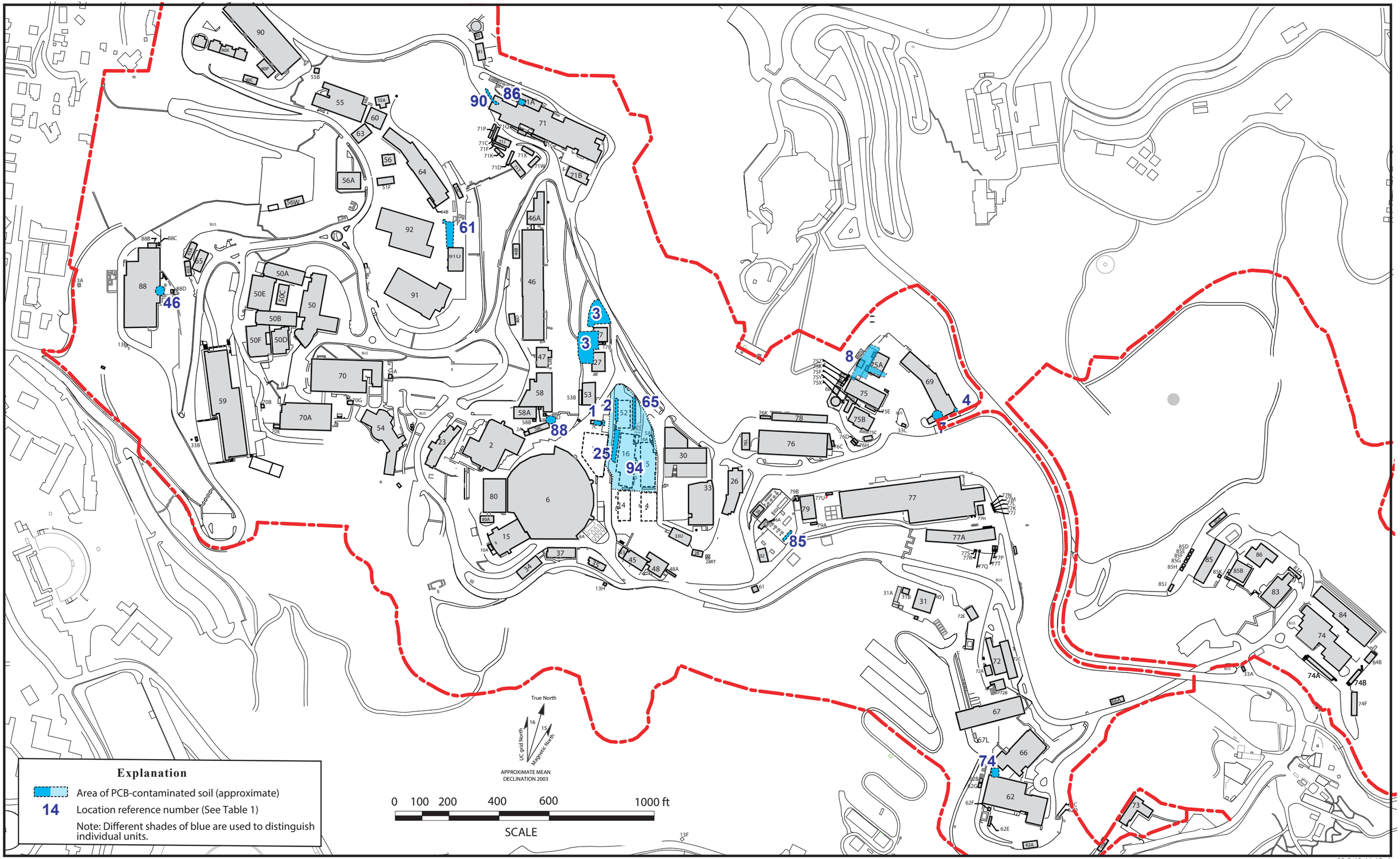

Figure 10. Locations of Polychlorinated Biphenyls (PCBs) in the Soil.

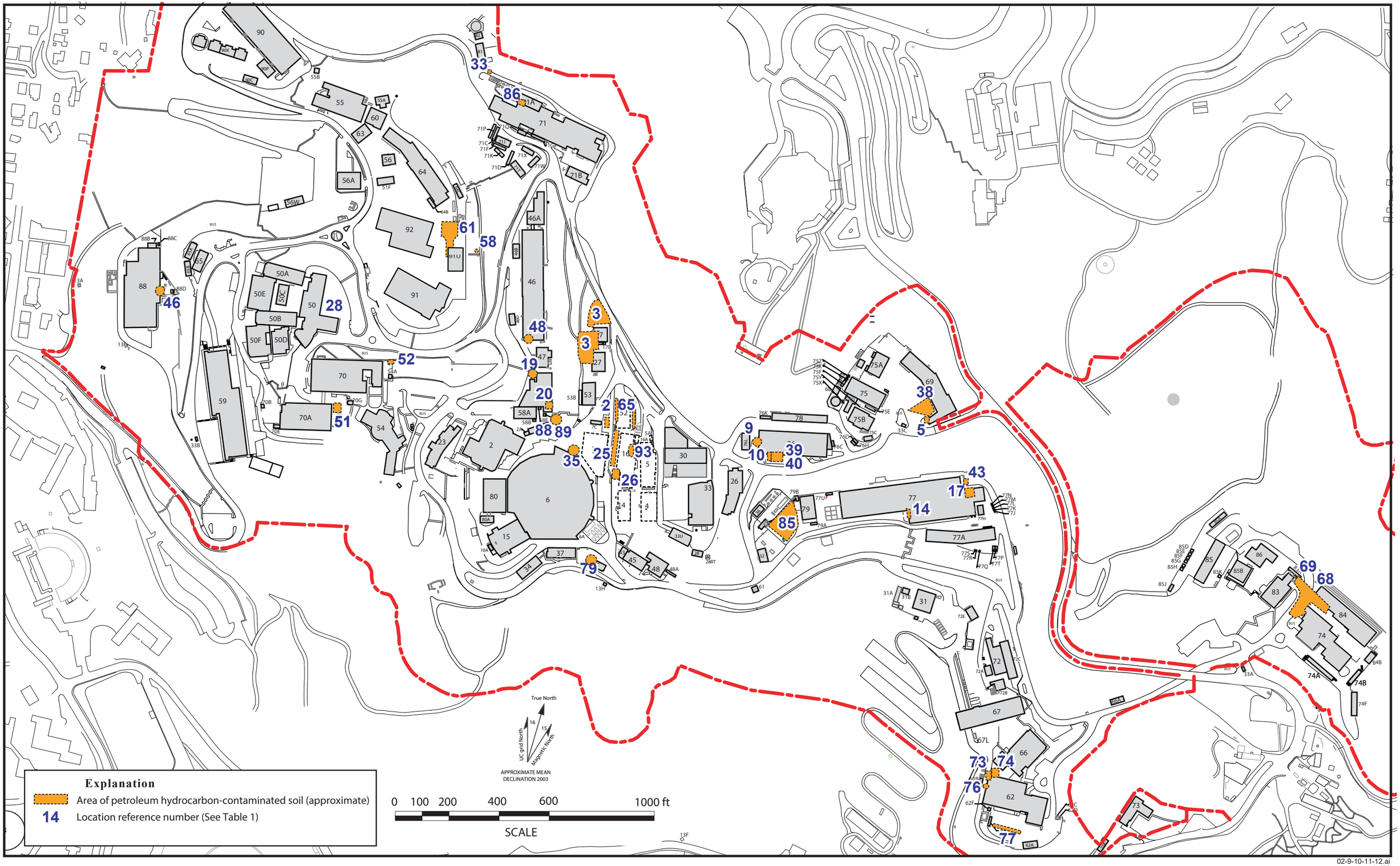

Figure 11. Locations of Petroleum Hydrocarbons (TPH) in the Soil.

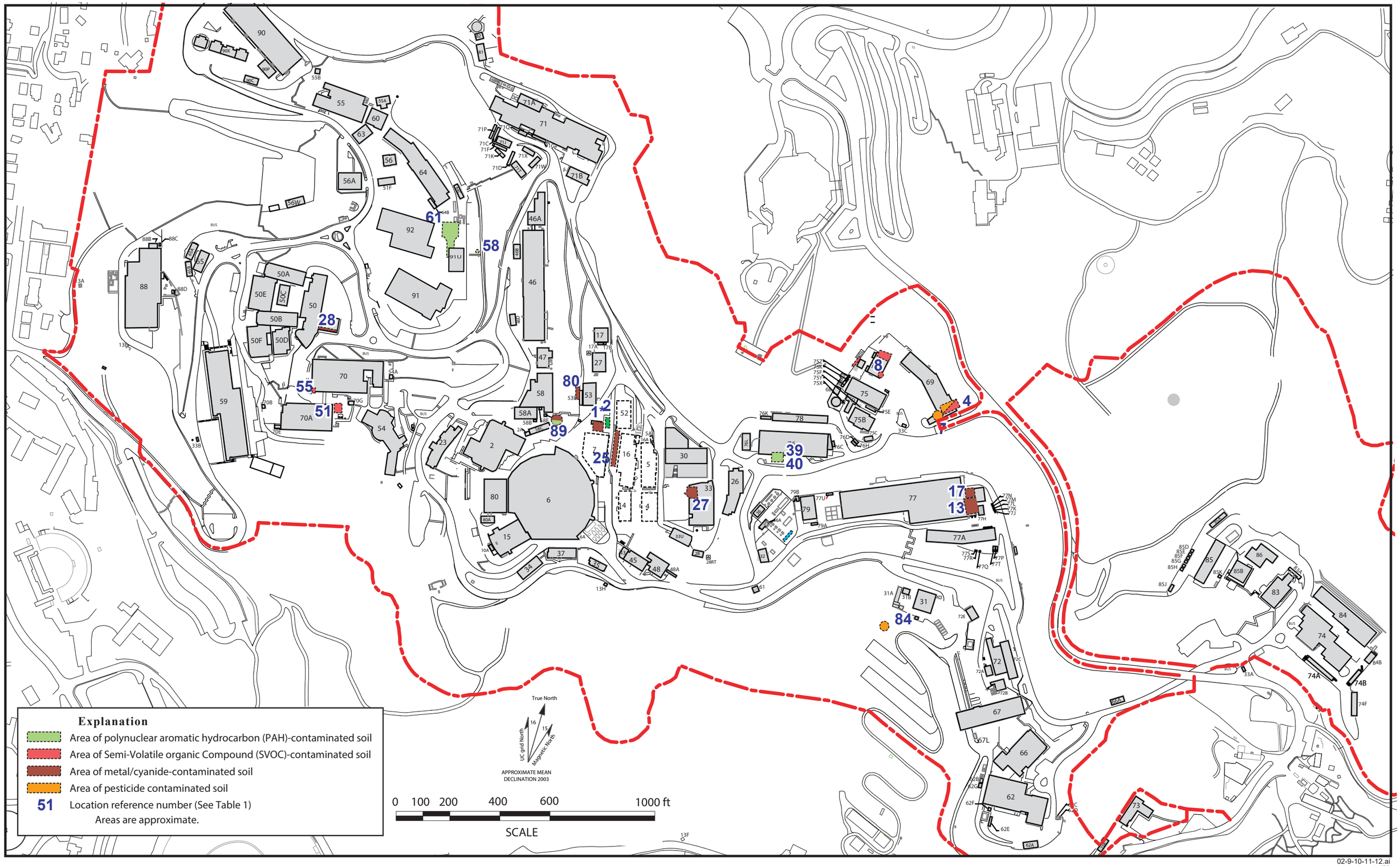

Figure 12. Locations of Other Contaminants in the Soil.

Appendix A Method for Estimating Soil Concentrations Based on Partitioning from Soil Vapor

For situations where it is impractical to collect in situ soil vapor samples, the vapor intrusion pathway can be assessed by using the method presented in Appendix E of the DTSC vapor intrusion guidance (DTSC, 2011). This method uses soil/soil vapor partitioning equations to estimate soil vapor concentrations from soil data where soil vapor data are unobtainable. A copy of the DTSC appendix is presented on the following page.

The soil screening levels given for VOCs in Table 2 of the SMP were calculated by inverting the equation given in DTSC Appendix E to calculate the soil concentrations that would be equivalent to the soil gas screening value (the DTSC-modified RSL) presented in Table 2. The inverted equation is written as follows:

$$C_{soil} = \frac{C_{gas}(\theta w + K_{oc} f_{oc} \rho_s + H\theta_a)}{H_c \rho_s}$$

Table 2 lists soil vapor screening values for the vapor intrusion pathway derived from DTSC-modified RSLs for indoor air. Those screening values were substituted for C_{gas} in the equation above, and the resultant calculated C_{soil} values were used as the soil screening values for the soil inhalation pathway that are shown in Table 2. The chemical-specific H_c and K_{oc} values were obtained from the EPA's RSL tables (U.S. EPA, 2016) and are listed below.

Volatile Organic Compounds	H_c (unit less)	K_{oc} (cm^3/g or L/kg)
Tetrachloroethene (PCE)	0.7236304	94.94
Trichloroethene (TCE)	0.4026983	60.7
cis-1,2-dichloroethene (C12DCE)	0.1668029	39.6
Vinyl chloride	1.1365495	21.73
trans-1,2-Dichloroethene (T12DCE)	0.1668029	39.6
1,1-Dichloroethene (11DCE)	1.0670482	31.82
1,1,1-Trichloroethane (111TCA)	0.7031889	43.89
1,1-Dichloroethane (11DCA)	0.2297629	31.82
1,2-Dichloroethane (12DCA)	0.048242	39.6
Chloroform	0.1500409	31.82
Methylene chloride	0.13287	21.73
Carbon tetrachloride	1.1283729	43.89
Freon 11 (trichlorofluoromethane)	3.9656582	43.89
Benzene	0.2269011	145.8
Toluene	0.2714636	233.9
Xylenes	0.2117743	382.9
Acetone	0.0014309	2.364

APPENDIX E - SOIL GAS CONCENTRATIONS FROM SOIL MATRIX ANALYTICAL RESULTS

Soil matrix sampling, in some instances, can be used as an additional line of evidence for evaluating vapor intrusion. Samples should be collected pursuant to USEPA Method 5035A (DTSC, 2004). The associated soil gas concentration from the soil matrix data should be determined using the following partitioning calculation (Feenstra et al., 1991) and associated default parameters.

$$C_{gas} = \frac{H_c \, C_{soil} \, \rho_s}{(\theta_w + k_{oc} f_{oc} \rho_s + H \theta_a)}$$

where,

Input Parameter		Units	Default Value	Basis for Default Value
C_{gas}	Soil gas concentration	g/cm^3	Calculated	-
C_{soil}	Soil matrix concentration	g/g	Measured at site	-
θ_w	Soil volumetric water content	cm^3/cm^3	0.054	Cal/EPA (2005)
θ_a	Soil volumetric air content	cm^3/cm^3	0.321	
ρ_s	Soil bulk density	g/cm^3	1.66	
f_{oc}	Soil fraction organic carbon	g/g	0.002	
H_c	Henry's law constant	unitless	Chemical specific	-
k_{oc}	Carbon-water sorption coefficient	cm^3/g	Chemical specific	-

g = grams
cm^3 = cubic centimeters

The above equation assumes equilibrium conditions exist in the subsurface that allow for complete partitioning of contaminants into their respective phases. Hence, the above equation should only be used with a full understanding of these potential limitations.

REFERENCES

California Environmental Protection Agency. 2005. Human-Exposure-Based Screening Numbers Developed to Aid Estimation of Cleanup Costs for Contaminated Soil. Office of Environmental Health Hazard Assessment, Integrated Risk Assessment Section. January 2005 (Original November 2004).

Department of Toxic Substances Control. 2004. Guidance Document for the Implementation of United States Environmental Protection Agency Method 5035: Methodologies for Collection, Preservation, Storage, and Preparation of Soils to be Analyzed for Volatile Organic Compounds. California Environmental Protection Agency. November 2004.

Feenstra, S., D. M. Mackay, and J. A. Cherry. 1991. A Method for Assessing Residual NAPL Based on Organic Chemical Concentrations in Soil Samples. Ground Water Monitoring and Remediation, v. 11, no. 2, p. 128-136.

Note that partitioning equation units for soil gas (g/cm^3) and soil matrix (g/g) in the DTSC vapor intrusion guidance Appendix E shown above differ from the original source (Feenstra et al., 1991), which used $\mu g/cm^3$ and µg/g, respectively. Unit conversions are required to match typical units for soil and soil gas concentrations.