BERKELEY LAB

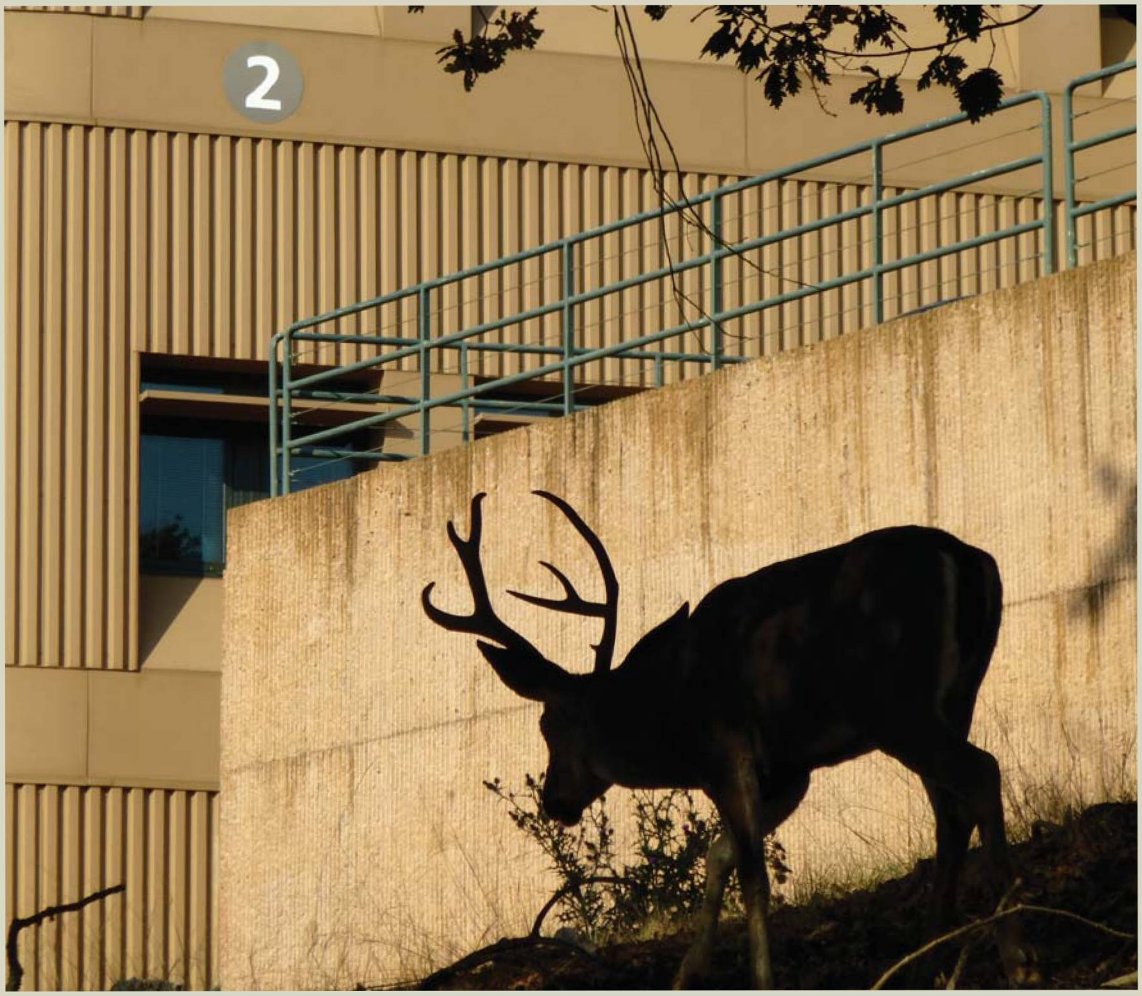
Lawrence Berkeley National Laboratory

LBNL-27170E-2014

Site Environmental Report for 2013

Environment/Health/Safety Division

September 2014



Department of Energy
Office of Science
Berkeley Site Office
Lawrence Berkeley National Laboratory
1 Cyclotron Road, MS 90-1023
Berkeley, California 94720

SEP 3 0 2014

DISTRIBUTION

Subject: 2013 Site Environmental Report (SER) for the Ernest Orlando Lawrence Berkeley National Laboratory (LBNL)

This report, prepared by LBNL for the U.S. Department of Energy, Berkeley Site Office (DOE/BSO), provides a comprehensive summary of the environmental program activities at LBNL for calendar year 2013 SERs are prepared annually for all DOE sites with significant environmental activities, and distributed to relevant external regulatory agencies and other interested organizations or individuals.

To the best of my knowledge, this report accurately summarized the results of the 2013 environmental monitoring, compliance, and restoration programs at LBNL. This assurance can be made based on the reviews conducted by DOE/BSO, Oak Ridge Operations Office, and LBNL, as well as quality assurance protocols applied to monitoring and data analyses at LBNL.

A reader survey form is posted with the SER at the LBNL website to provide comments or suggestions for future versions of the report. Your response is appreciated.

Questions or comments regarding this report may also be made directly to DOE/BSO, by contacting Mr. Kim Abbott of the Berkeley Site Office at (510) 486-7909, or by mail to the address above, or by email kim.abbott@bso.science.doe.gov .

Sincerely,

Signature on file.

Paul Golan
Acting Site Office Manager

Site Environmental Report for 2013

September 2014

Cover photo by Roberto Melgoza-Zermeno, courtesy of Lawrence Berkeley National Laboratory's Photo Club

This work was supported by the Director, Office of Science, U.S. Department of Energy under Contract Number DE- AC02-05CH11231

Table of Contents

Figures

Tables

Preface

Each year the University of California (UC) Lawrence Berkeley National Laboratory (LBNL or Berkeley Lab), prepares a Site Environmental Report (SER) that describes its environmental programs and performance. The SER meets the reporting requirements of United States Department of Energy (DOE) Order 231.1B, *Environment, Safety, and Health Reporting*,[1] and includes the following information:

- Site environmental management performance
- Environmental occurrences and responses
- Environmental compliance
- Significant programs and efforts
- Property clearance activities

The report is organized into an executive summary followed by six chapters that include an overview of LBNL, a discussion of its Environmental Management System (EMS), the status of environmental programs, summarized results from surveillance and monitoring activities, radiologic dose assessment results, and quality assurance measures. The SER is posted online at the Berkeley Lab Environmental Services Group's (ESG) webpage, where many of the documents cited in this report can also be found (see http://www2.lbl.gov/ehs/esg/).

This report was prepared under the direction of ESG environmental manager Ron Pauer. Primary contributors include David Baskin, Ned Borglin, Robert Fox, Zachary Harvey, John Jelinski, Patrick Thorson, Linnea Wahl, Petra Wehle, and Suying Xu. If you have comments or questions, contact Ron Pauer directly at 510-486-7614 or ropauer@lbl.gov, or complete the survey form at ESG's publications page at http://www2.lbl.gov/ehs/esg/Reports/tableforreports.shtml.

Executive Summary

LBNL is a multi-program scientific facility operated by the UC for the DOE. LBNL's research is directed toward the physical, biological, environmental, and computational sciences with the objective of delivering scientific knowledge and discoveries pertinent to DOE's mission. This annual report describes environmental protection activities and potential impacts resulting from LBNL operations conducted in 2013. The format and content of this report satisfy the requirements of DOE Order 231.1B, *Environment, Safety, and Health Reporting*,[1] and the operating contract between UC and DOE.[2]

At Berkeley Lab, activities are planned and conducted with full regard to protecting employees, the public, and the environment, as well as complying with all applicable environmental, safety, and health laws and regulations. Berkeley Lab implements an EMS to support and improve environmental performance and compliance management in such areas as energy, fuel, water use, toxic air emissions, and landfill waste, while improving performance in acquiring more environmentally sustainable and preferable products.

The effectiveness of the EMS and environmental programs are reviewed annually as part of the operating contract's performance evaluation process. For fiscal year (FY) 2013, the EMS was given a performance rating of A- for its management of environmental activities (A+ is the highest grade, F is the lowest). The measures and rating system are developed jointly by Berkeley Lab, UC, and DOE, and the rating is based both on how the EMS successfully implemented elements of the International Organization for Standardization's (ISO) International Standard 14001:2004(E) *Environmental Management Systems—Requirements with Guidance for Use*[3] and on how well Berkeley Lab performed in completing numerous projects that reduced environmental impacts.

The EMS was also graded through the DOE EMS Annual Report Data where elements of the ISO 14001 were rated and the degree of integration between the EMS and Berkeley Lab's sustainable practices was measured. Berkeley Lab received a highest score for FY2013.

An overview of environmental protection and restoration programs is provided including information about compliance activities, operating permits and regulatory agency inspections. The report also includes information on environmental monitoring results and radiation dose assessment for the year. These monitoring activities confirmed that Berkeley Lab operations remained below regulatory limits for the specific environmental media being sampled.

1. Site Overview

1.1 INTRODUCTION

Berkeley Lab is a member of the national laboratory system supported by the DOE through its Office of Science. It is managed by the UC and is charged with conducting unclassified research across a wide range of scientific disciplines, which is accomplished by the nearly 4,200 scientists, engineers, support staff, and students who work at LBNL main site and satellite locations.

1.2 LOCATION

The main site is located about three miles east of San Francisco Bay on land owned by UC. This site is situated on the ridges and in the draws of Blackberry and Strawberry Canyons in the East Bay Hills on approximately 200 acres of land east of the UC Berkeley campus, straddling the border between the cities of Berkeley and Oakland in Alameda County. While LBNL also leases off-site facilities elsewhere in Berkeley, as well as in Emeryville, Oakland, and Walnut Creek, as shown on Figure 1-1, this chapter focuses on LBNL's main site.

Adjacent land use consists of residential, institutional, and recreational areas (see Figure 1-2). The area to the south and east is UC land that is maintained largely in a natural or undeveloped state, and includes UC Berkeley's Strawberry Canyon Recreational Area and Botanical Garden. To the northeast are the UC's Lawrence Hall of Science, Space Sciences Laboratory, and Mathematical Sciences Research Institute. Berkeley Lab is bordered on the north by a residential neighborhood of low-density, single-family homes, and on the west by the UC Berkeley campus, multi-unit dwellings, student residence halls, and private homes; the area to the west is highly urbanized.

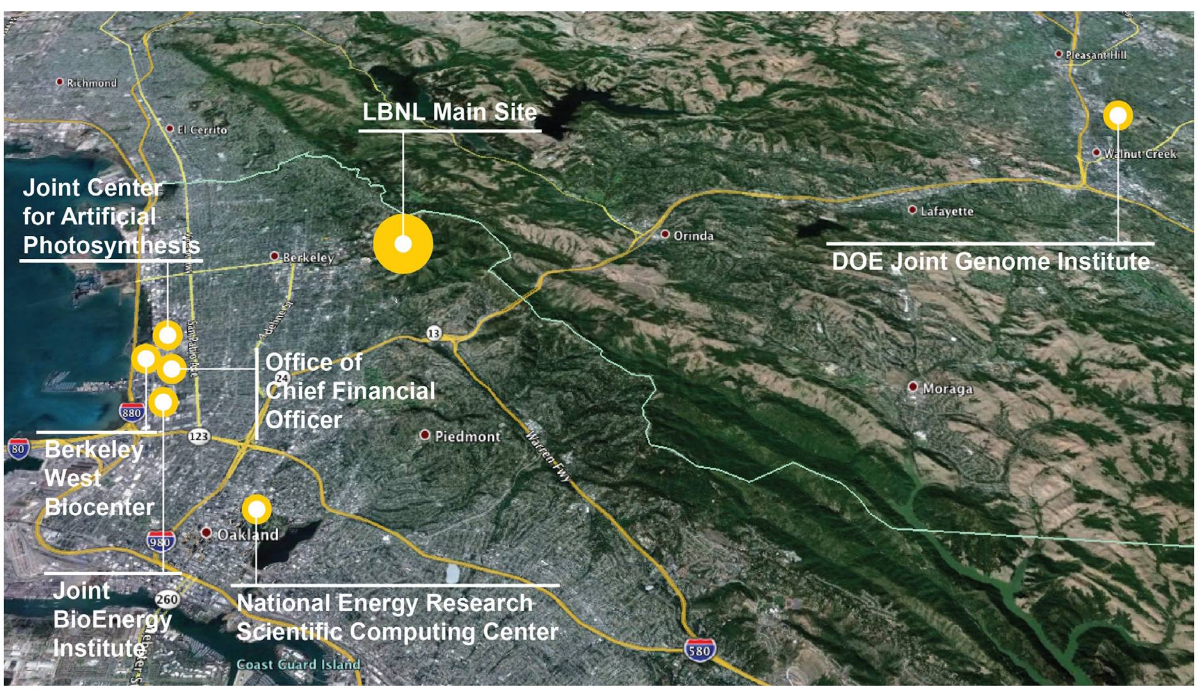


Figure 1-1 LBNL Main Site and Satellite Facilities Location

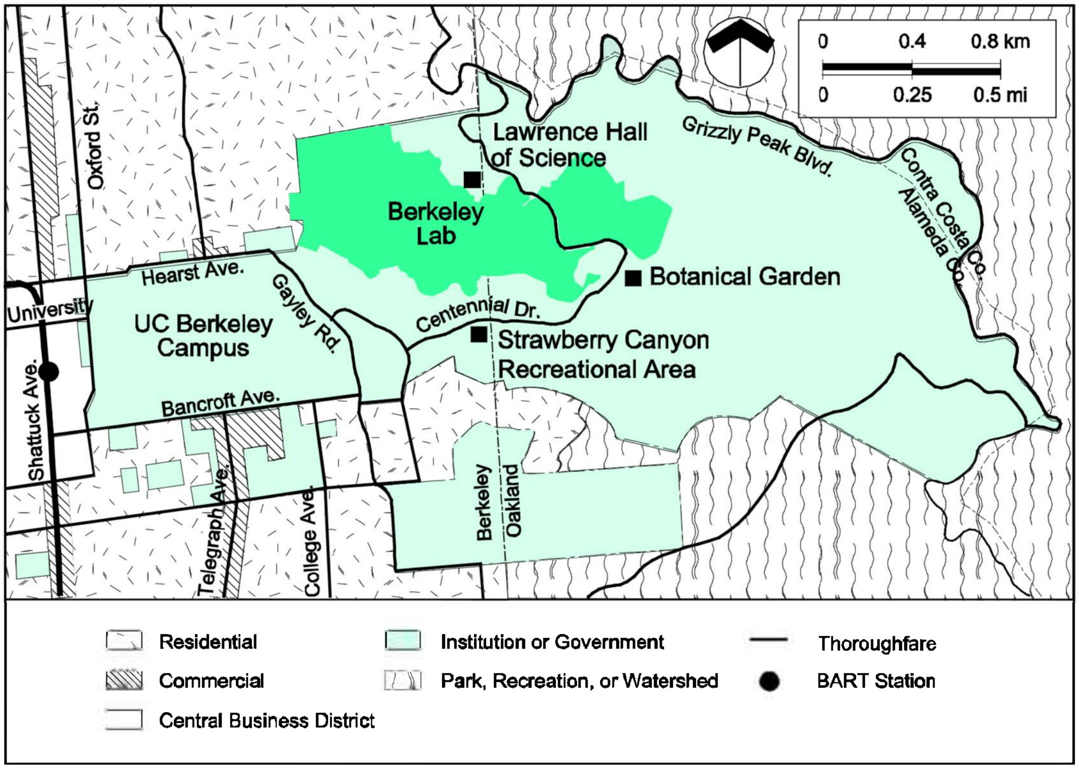


Figure 1-2 Adjacent Land Use

1.3 ENERGY SUPPLY

All electric power for the site is provided by the Western Area Power Administration. Power purchases are arranged through DOE's Northern California Power Purchase Consortium, which serves the electric power needs of DOE facilities in the San Francisco Bay Area, namely Berkeley Lab, Lawrence Livermore National Laboratory, and the SLAC National Accelerator Laboratory. Natural gas is provided by the Defense Logistics Agency and is transported through PG&E's infrastructure.

1.4 WATER SUPPLY

All domestic water for LBNL's main site is supplied by the East Bay Municipal Utility District (EBMUD). The site has no drinking water wells. The domestic water originates in Sierra Nevada watershed lands and is transported to the Bay Area and ultimately to Berkeley Lab through a system of lakes, aqueducts, treatment plants, and pumping stations. EBMUD tests the water for contaminants and treats it to meet disinfection standards required by the Safe Drinking Water Act.[1]

1.5 METEOROLOGY

The climate is temperate, influenced by the moderating effects of nearby San Francisco Bay and the Pacific Ocean to the west, and by the East Bay hills to the east. These physical barriers contribute significantly to the relatively warm, wet winters and cool, dry summers. The average annual temperature at the site is 55° Fahrenheit (F), with temperatures ranging from 41° to 68°F nearly 90% of the year. Only seldom does the maximum temperature exceed 90°F or the minimum temperature drop below 32°F. The average annual precipitation, based on 40 years of on-site measuring records, is almost 30.5 inches. In 2013, due to the extraordinary drought affecting the entire state, the total rainfall amount was 7.35 inches, or approximately 25% of the annual average. Measurable snow does not fall at Berkeley Lab.

On-site wind patterns change little from one year to the next. Figure 1-3 is a graphical summary – or "wind rose" – illustrating the frequency of the year's predominant wind patterns. The most prevalent wind pattern occurs during fair weather, with daytime westerly winds blowing off the bay, followed by lighter nighttime southeasterly drainage winds blowing off the East Bay hills. The other predominant wind pattern is associated with stormy weather in which south-to-southeast winds blow in advance of each system and are followed by a shift to west or northwest winds after its passage.

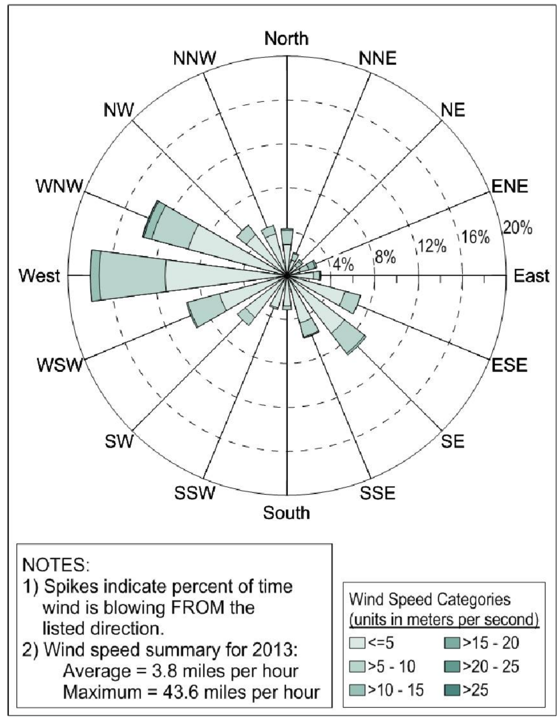


Figure 1-3 Annual Wind Patterns

1.6 VEGETATION

Vegetation on the Berkeley Lab site includes native plants, naturalized exotics, and ornamental species. The region was intensively grazed and farmed for about 150 years before Berkeley Lab development began in the 1930s. Current vegetation is managed in harmony with the local natural succession of native plant communities, and the wooded and savanna character of the areas surrounding buildings and roads is maintained. Ornamental species are generally restricted to courtyards and areas adjacent to buildings. The site has no known rare, threatened, or endangered plant species. Figure 1-4 shows the vegetation types found at the site.

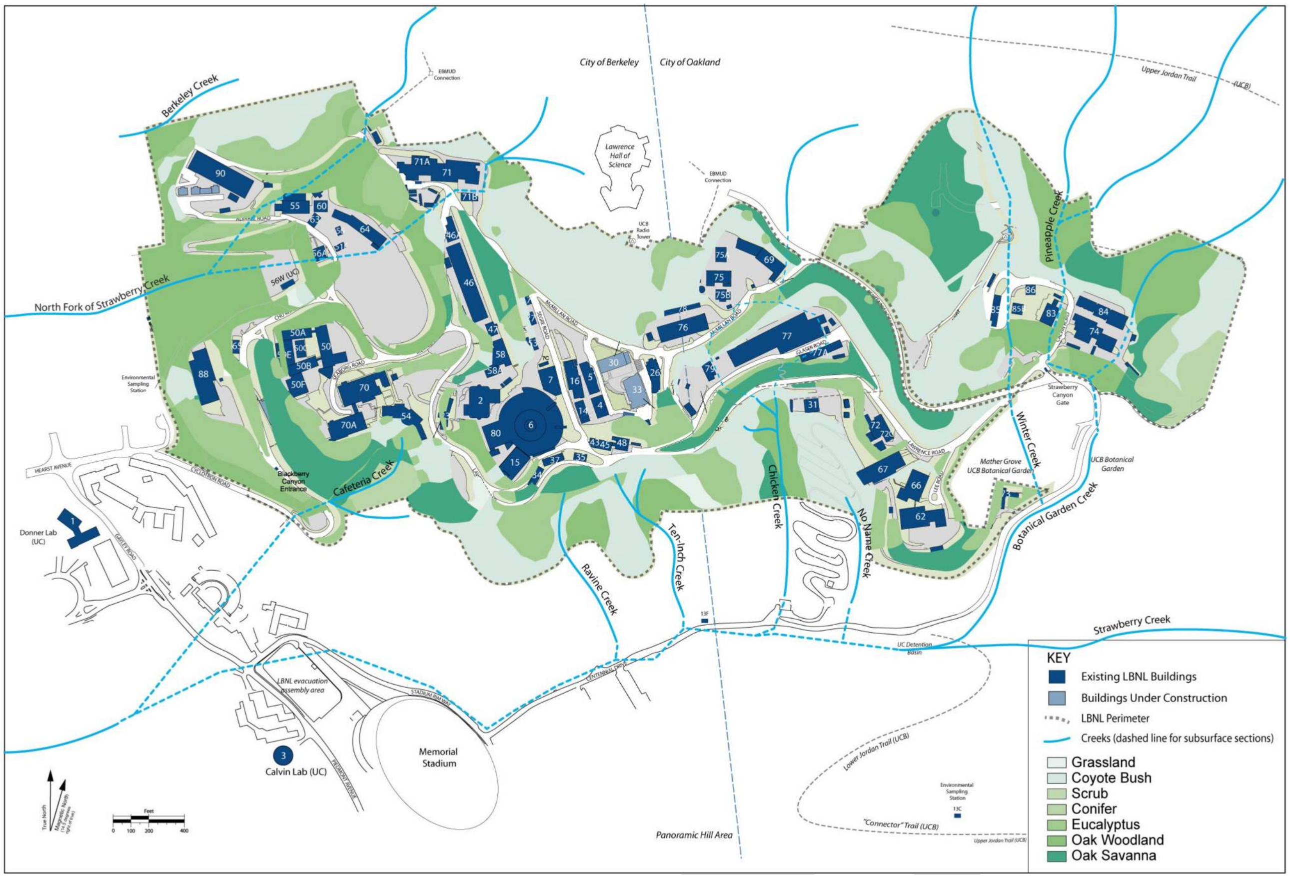


Figure 1-4 Vegetation Types

1.7 WILDLIFE

Wildlife is abundant at Berkeley Lab because the site is adjacent to East Bay Regional Park District and UC open spaces. The wildlife that lives on site or traverses it is typical of that found in disturbed (previously grazed) areas of mid-latitude California with a temperate climate, and is thought to include more than 120 species of birds, mammals, reptiles, and amphibians. The most abundant large mammal is the Columbian black-tailed deer.

Habitat protected by various environmental laws exists on site as follows:

- An area on the south-facing slope of LBNL's Blackberry Canyon has been identified as a site where an arachnid called Lee's Micro-Blind Harvestman (*Microcina leei*) occurs. *Microcina leei* is listed as a "special animal" by the California Department of Fish and Wildlife.
- An approximately five-acre area at the eastern boundary is included in the U.S. Fish and Wildlife Service's designated critical habitat for the Alameda whipsnake. This snake species (*Masticophis lateralis euryxanthus*) is listed as threatened under both federal and state law.

1.8 SOILS

The three principal bedrock units underlying the site are described below:

1. The western and southern parts are underlain by marine siltstones and shales of the Great Valley Group. The permeability of these rocks is relatively low, with groundwater flow controlled through open fractures rather than through pore spaces.
2. Non-marine sedimentary rocks of the Orinda Formation overlie the Great Valley Group and constitute the exposed bedrock over most of the site's developed area. The Orinda Formation consists primarily of sandstones, mudstones, and conglomerates deposited in fluvial and alluvial environments. Groundwater typically moves at a lower rate in this formation than in the underlying Great Valley Group or overlying Moraga Formation, and therefore this formation impedes the horizontal and vertical flow of groundwater.
3. The Moraga Formation consists of volcanic rocks that underlie most of the higher elevations as well as much of the central developed area ("Old Town"). It constitutes the main water-bearing unit at the site, and although the rock's permeability is low, groundwater flows readily through the numerous open fractures.

In addition to the three main units described above, the Claremont Formation (primarily marine chert and shale) and San Pablo Group (primarily marine sandstones) underlie the easternmost area of the site.

Surface materials consist primarily of soil, colluvium (soil accumulated at the foot of a slope), and artificial fill. Soil derived primarily from the bedrock units has accumulated to typical thicknesses of three or more feet across much of the site. Cutting and filling of the hilly terrain has been necessary to provide suitable building sites, resulting in up to tens of feet of engineered cuts and fills at some locations.

1.9 SURFACE WATERS

Berkeley Lab lies within the Blackberry Canyon and Strawberry Canyon subwatersheds of the Strawberry Creek watershed. The two main creeks in these watersheds are the South Fork of Strawberry Creek (in Strawberry Canyon) and the North Fork of Strawberry Creek (in Blackberry Canyon). Both creeks join below Berkeley Lab on the UC Berkeley campus. These two creeks as well as more than a half-dozen of their tributaries are shown on the site maps in this report.

1.10 GROUNDWATER

The groundwater elevation map (Figure 1-5) shows that the water table approximately mirrors surface topography. Groundwater generally flows from higher elevation to lower elevation. Therefore, the groundwater flow in the western portion is generally westwards, and flow in the remainder of the site is generally southwards. The depth to groundwater varies from the ground surface to 100 feet below the surface.

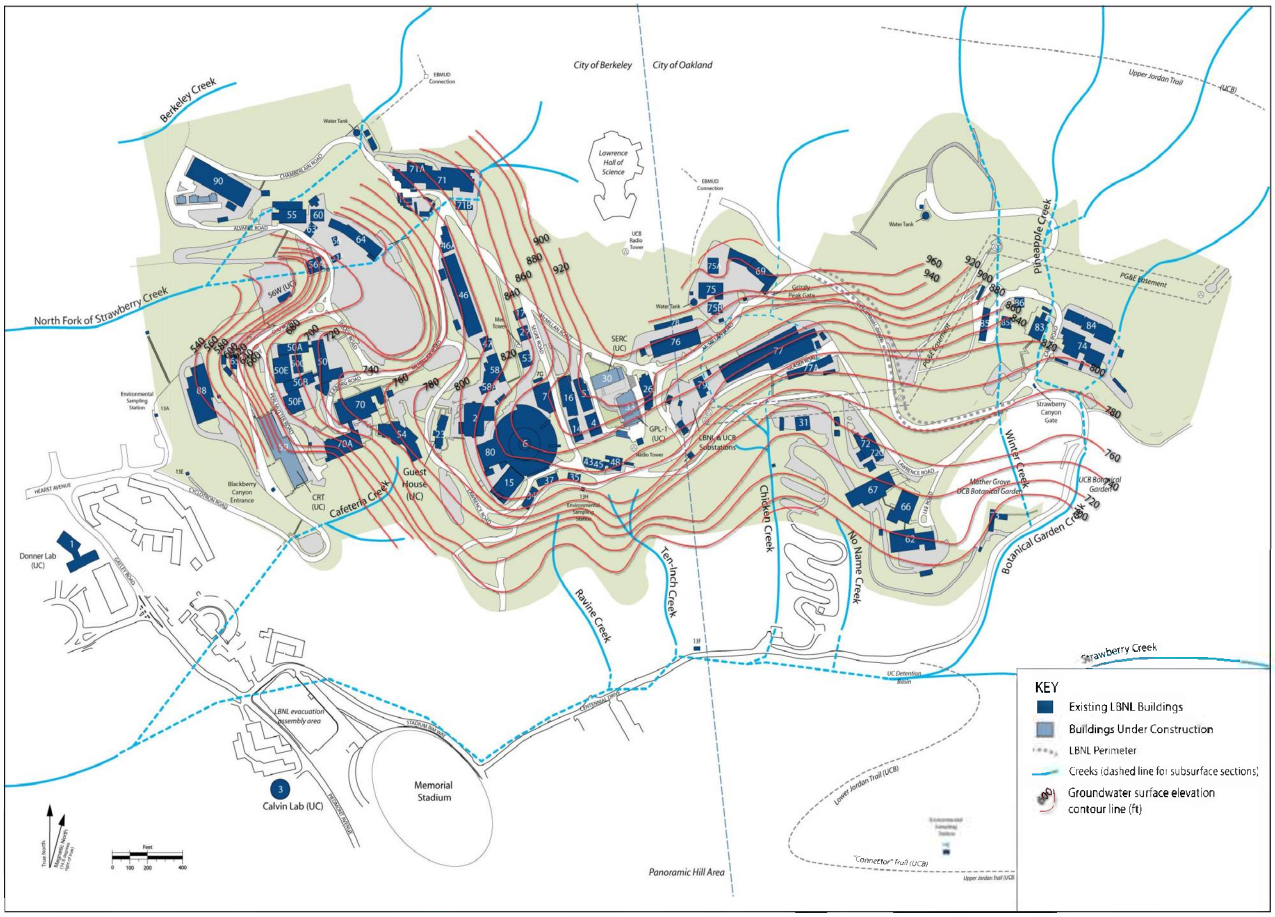


Figure 1-5 Groundwater Elevation Map

2. Environmental Management System

2.1 BACKGROUND

DOE Order 436.1, *Departmental Sustainability*,[1] requires DOE sites like Berkeley Lab develop and maintain an environmental management system that conforms to the ISO 14001:2004(E) standard, *Environmental Management Systems—Requirements with Guidance for Use.*[2]

To continually improve environmental compliance and reduce Berkeley Lab's environmental impacts, an environmental management system has been established that provides a systematic approach to ensure environmental activities are both well-managed and provide business value by addressing regulatory compliance, program performance, and cost-effectiveness of activities. An environmental management system strives for this continual improvement through the familiar four-step "plan-do-check-act" cycle for management systems.

LBNL's EMS-based environmental policy commits to:

- Complying with applicable environmental, public health, and resource conservation laws and regulations
- Preventing pollution, minimizing waste, and conserving natural resources
- Mitigating environmental hazards and cleaning up existing environmental problems
- Continually improving environmental performance while maintaining operational capability
- Sustaining the overall mission

The framework for implementing this policy incorporates the elements of the ISO 14001:2004(E) standard into Berkeley Lab's *Environmental Management System Plan.*[3] This Plan and related documents are available on LBNL's A-Z Index under *Environmental Management System* (see http://www.lbl.gov/a-z-index/).

DOE Order 436.1 also states that a site's sustainability goals must be integrated into the EMS. Berkeley Lab's current sustainability plan, the *FY2014 LBNL Site Sustainability Plan*[4] prepared in December, sets performance goals in the following areas:

- Greenhouse gas reduction and comprehensive greenhouse gas inventory
- Energy use in new and existing buildings
- Fleet management
- Water use efficiency and management
- Pollution prevention and waste reduction
- Sustainable acquisition
- Data center electronic stewardship
- Renewable energy
- Climate change adaptation

The *FY2014 LBNL Site Sustainability Plan* can be found on the "Resources" page of the Sustainable Berkeley Lab website (see http://sbl.lbl.gov/).

2.2 EMS IMPLEMENTATION

While there are eighteen elements to the ISO 14001 standard, the six foundational building blocks for implementing a compliant EMS program are:

- EMS Core Team
- Environmental Aspects
- Environmental Management Programs (EMPs)
- Training
- Appraisals
- Management Review

2.2.1 EMS Core Team

The Core Team is tasked with implementing and maintaining LBNL's EMS, and includes representatives from organizations key to meeting the site's environmental objectives. Key organizations currently include Environment/Health/Safety (EHS), Facilities, Sustainable Berkeley Lab, and Procurement and Property. The team is led by a member of the EHS Division. A representative from the DOE Berkeley Site Office attends the meetings to maintain awareness. Meetings were held in May and November, though Core Team members interact regularly while working toward performance goals. Primary Core Team functions are:

- Identify environmental aspects and determine their significance
- Develop objectives and targets for significant aspects
- Prepare and implement EMPs
- Coordinate internal assessments and external audits of the EMS
- Review performance results
- Prepare recommendations to management to improve the EMS

2.2.2 Environmental Aspects

In preparation for the November EMS Core Team meeting, the team reviewed the list of identified environmental aspects – that is, any activity, product, or service that interacts (adversely or beneficially) with the environment. No new aspects were added during this review. When aspects are reviewed, the following factors are considered:

- Cost
- Duration
- Effect on Berkeley Lab's mission
- Effect on public image
- Potential for improvement
- Potential legal exposure
- Probability of occurrence
- Severity of impacts

2.2.3 Environmental Management Programs

An EMP is a short document that identifies an objective and target for each significant aspect, along with a strategy and set of actions to achieve these goals. An EMP is prepared for each significant aspect and the program document is reviewed and updated periodically. The annual review of aspects identified the following seven significant activities that warranted an EMP, which are summarized in Table 2-1, including the EMP's objective, target, and status:

1. Energy use
2. Greenhouse gas emissions
3. Petroleum use
4. Solid waste diversion
5. Sustainable acquisition
6. Traffic congestion
7. Water use

2.2.4 Training

Training is targeted and graded, and commensurate with EMS roles and responsibilities. In order of increasing rigor, the four levels of training are: general EMS awareness, comprehensive EMS awareness, EMS implementation, and EMS auditor. General EMS awareness training is approximately one hour, is usually tailored to the individual's role, and the general information is integrated into course EHS0010, *Overview of Environment Health and Safety at LBNL*,[5] which is required for all personnel new to LBNL. The intermediate level comprehensive EMS awareness training is intended for EMS Core Team members, and EMS implementation and auditor training are multi-day courses taught by specialized organizations and these courses are intended for EMS professionals.

2.2.5 Appraisals

DOE requires a formal independent audit of the Berkeley Lab EMS every three years. The most recent external audit of the EMS was completed in June 2012. The final corrective action from this review was completed in May 2013.

2.2.6 Management Review

Berkeley Lab's senior management periodically meets with the Core Team leader to review, at minimum, the following topics cited in the ISO standard to determine if adjustments to the EMS are warranted:

- Results of internal audits and evaluations of compliance with legal and other requirements
- Communications from external interested parties
- Berkeley Lab's environmental performance
- The extent to which objectives and targets have been met
- Status of corrective and preventive actions
- Follow-up actions from previous management reviews
- Changing circumstances, including developments in legal and other requirements
- Recommendations for improvement

Table 2-1 Current Environmental Management Programs

Aspect/Activity	Objective(s)	Target(s)	Status at the end of FY13
Energy Use	Implement sustainable practices to achieve energy efficiency	Reduce energy use intensity 30% by end of FY2015, including a minimum cumulative reduction of 24% by end of FY2013 relative to FY2003 baseline year.	Consumption 9.0% above baseline (high risk of not attaining target of a 30% reduction due to expected future projects)
Greenhouse Gas(GHG) Emissions	Track, report, and reduce GHG emissions from LBNL activities	Reduce Scope 1[a] and 2 GHG emissions 28% and selected Scope 3[b] emissions 13% by end of FY2020, relative to FY2008 baseline.	Scope 1 and 2 emissions were 12.9% below baseline (high risk of not attaining target of a 28% reduction due to expected future projects) Scope 3 emissions were 2.5% above baseline (medium risk of not attaining target of a 13% reduction)
Petroleum Use	Reduce vehicle fleet petroleum consumption	Reduce fleet's annual petroleum consumption by 2% annually using FY2005 fleet fuel consumption as a baseline.	Consumption 23.4% below baseline (low risk of not attaining target of 2% annual reduction)
Solid Waste Diversion	Increase solid waste diversion	Divert at least 50% of non-hazardous solid waste, excluding construction and demolition debris, by the end of FY2015. Divert at least 50% of construction and demolition debris by the end of FY2015.	47.0% diversion for non-hazardous solid waste (low risk of not attaining target of 50% diversion) 99.9% diversion for construction and demolition debris (low risk of not attaining target of 50% diversion)
Sustainable Acquisition	Increase procurement opportunities for environmentally sustainable products	Using FY2012 as the baseline year, increase the percentages of priority sustainable products purchased.	Where applicable, 90.1% of subcontracts include sustainable acquisition clauses and specify green products (low risk of not attaining target of increasing percentages)
Traffic Congestion	Reduce commute traffic through transportation demand management; report Scope 3 GHG emissions	Optimize parking; facilitate/promote non-single-occupant vehicle commuting; enhance shuttle bus operations; plan for off-site construction truck trips within the limits of the Long Range Development Plan's Environmental Impact Report.	No metrics in place at present (low risk of not attaining target)
Water Use	Implement sustainable practices to reduce water use intensity	Reduce potable water use consumption intensity 26% by the end of FY2020 from FY2007 base: reduce industrial / agricultural water use 20% by end of FY2020 from FY2010 base. Update and execute annual Water Metering Plan.	Consumption 14.3% below baseline (high risk of not attaining target of 26% reduction for potable water due to expected future projects)

[a]Scope 1 and 2 emissions are direct and indirect GHG emissions from sources owned or controlled by LBNL. Scope 1 can include emissions from fossil fuels burned on site or entity-leased vehicles. Scope 2 can include emissions resulting from the generation of purchased electricity.

[b]Scope 3 emissions include indirect GHG emissions from sources not owned or directly controlled by LBNL, but related to LBNL's activities. The most common activity is GHG emissions associated with employee travel and commuting.

2.2.7 Environmental Management Performance and Highlights

In the *FY2013 Performance Evaluation Annual Report,*[6] prepared by the DOE Berkeley Site Office to summarize the *FY13 Performance Evaluation and Measurement Plan*[7] required by the operating contract between DOE and UC, Berkeley Lab's EMS program earned the highest score – "green" – based on the most recent reporting year's performance. This score was, in part, based on achieving a green rating within DOE's eight EMS scorecard metrics for:

- Environmental aspects
- Sustainable practices (*e.g.,* use of renewable energy, electronics stewardship, sustainable acquisition)
- Objectives, targets, and programs
- Environmental training
- Operational controls
- Contracts and concessionaire agreements
- Evaluation of compliance with regulatory requirements
- Management review

The DOE EMS Annual Report Data (*i.e.*, scorecard) also requested more qualitative information to reflect the degree of integration between the EMS and Berkeley Lab's sustainable practices in such areas as energy use, greenhouse gas emissions, water use, and solid waste generation.

Other notable environmental management accomplishments include:

- Replacing sulfur hexafluoride with nitrous oxide as the tracer gas for testing fume hoods to an ASHRAE standard
- Adopting a first-ever Berkeley Lab policy on *Sustainability Standards for New Construction*
- Certifying the Building 74 renovation to the Leadership in Energy & Environmental Design's top certification level, making it the first renovation within the DOE complex to receive the platinum certification
- Establishing LBNL's first contract with a recycler certified to the Responsible Recycler standard to ensure that electronic waste is properly recycled
- Completing a waste diversion pilot at Building 74 for its new occupants, successfully improving the diversion rate to nearly 75%, up significantly from the 45 - 50% range typical for the entire site. This program was expanded to other main site buildings later in the year.
- Collecting paper towels from restrooms across the entire main site for composting
- Partnering with Lawrence Livermore National Laboratory on a 10-acre solar project in the Livermore area
- Starting an on-site electric vehicle charging program, allowing more staff to commute with their personal electric vehicle, reducing greenhouse gas emissions
- Converting LBNL's Earth Day Fair from a one-day format to a week-long Earth Week series with a specific focus each day, resulting in more attention to each topic

Also notable is that LBNL received a bronze award in June from DOE for achieving excellence in sustainable acquisition. The criteria for bronze were meeting the goals for a minimum of three products in at least two product categories. For the award, LBNL demonstrated that it met or surpassed the goals in the categories of cafeteria and construction.

For the cafeteria category, purchases of cutlery and food exceeded federally established goals.

- The goal for cutlery was for at least 75% of containers, cutlery, and dishware to be manufactured with a specified minimum of bio-based content. Through its cafeteria vendor, LBNL exceeded this goal by purchasing only items that meet the bio-based content requirement (100%), and which in addition contained a much higher bio-based content than stated in the goal. The purchased items are 100% compostable.
- The goal for food was to purchase at least 50% of the food is grown within a 100-mile radius of the site or that 50% of the food meets the United States Department of Agriculture “organic” designation. Through its cafeteria vendor, LBNL exceeded the goal by purchasing food that met both criteria 60% of the time.

For the construction category, LBNL purchases met or exceeded established goals for fluorescent lighting and commercial boilers.

- The goal for fluorescent lighting was to purchase a specific type of lamp (Super - T8) for retrofit projects 95% of the time, which is the rate LBNL achieved in FY2013. LBNL was also acknowledged for using LED lighting for its outdoor lighting needs.
- The purchasing goal for commercial boilers was 95%. LBNL achieved a 100% score by purchasing only boilers that were Federal Energy Management Program Designated and Energy Star rated.

3. Environmental Program Summary

3.1 INTRODUCTION

The status of environmental compliance programs is discussed including general regulatory requirements, permits held from regulatory agencies, and audits and inspections conducted during the year.

3.2 ENVIRONMENTAL PERMITS

Certain activities require operating permits from regulatory agencies. Table 3-1 summarizes, by area of environmental activity, the 50 active permits held by LBNL at the end of 2013.

Table 3-1 Environmental Permits

Permit Type	Issuing Agency	Description (Section with Details)	Location
Air quality	BAAQMD[a]	Various activities with emissions to atmosphere (3.5.1)	Main Site
		Emergency generators (3.5.1)	Joint Genome Institute
Certified Unified Program Agency	ACEH[b]	Hazardous Materials Business Plan and hazardous waste generator areas (3.5.2)	Joint BioEnergy Institute
Permit and registration	CCHS[c]	Aboveground storage tanks (3.5.4.3) Hazardous Materials Business Plan and hazardous waste generator areas (3.5.2)	Joint Genome Institute
	COB[d]	Aboveground storage tank (3.5.4.3) Fixed treatment units (3.5.3.1) Hazardous Materials Business Plan and hazardous waste generator areas (3.5.2) Underground storage tanks (3.5.3.3)	Main Site
		Hazardous Materials Business Plan and hazardous waste generator areas (3.5.2)	Berkeley West Biocenter
		Hazardous Materials Business Plan and hazardous waste generator areas (3.5.2)	Joint Center for Artificial Photosynthesis
Hazardous waste	DTSC[e]	Hazardous Waste Handling Facility operations and hazardous waste generator areas (3.5.3.1)	Main Site
Stormwater	SWRCB[f]	Sitewide and construction stormwater discharges (3.5.4.2)	Main Site
Wastewater	CCCSD[g]	Wastewater discharges to sanitary sewer (3.5.4.1)	Joint Genome Institute
	EBMUD[h]	Sitewide and operation-specific wastewater discharges to sanitary sewer (3.5.4.1)	Main Site

[a]Bay Area Air Quality Management District
[b]Alameda County Environmental Health
[c]Contra Costa Health Services
[d]City of Berkeley
[e]Department of Toxic Substances Control
[f]State Water Resources Control Board
[g]Central Contra Costa Sanitary District
[h]East Bay Municipal Utility District

3.3 AUDITS AND INSPECTIONS

The regulatory agencies that enforce the environmental requirements at Berkeley Lab periodically conduct inspections. A summary of such inspections conducted in 2013 is shown in Table 3-2. Also included are self-monitoring inspections conducted by Berkeley Lab that are required by EBMUD wastewater discharge permits, since the results of these self-monitoring activities expose LBNL to potential regulatory actions. A total of 13 inspections were conducted during 2013, resulting in two minor violation notices, which are discussed in Section 3.5.3.1.

Table 3-2 Summary of Environmental Audits, Inspections, and Appraisals

Organization	Inspection Title	Start Date	Violations
BAAQMD[a]	Air quality	Mar 11	0
COB[b]	SAA and WAA inspection	June 17	1
	Tiered permitting units	June 25	0
	Underground storage tanks	April 16 Oct 30	0 0
EBMUD[c]	Wastewater monitoring inspection at Hearst and Strawberry outfalls	Jan 16 June 11	0 0
LBNL	EBMUD self-monitoring inspections at groundwater treatment units	Feb 12 May 14	0 0
	EBMUD self-monitoring inspections at B77 Fixed Treatment Unit	Sept 10	0
	EBMUD self-monitoring inspections at Hearst and Strawberry outfalls	Sept 17	0
U.S. EPA[d] (with COB and DTSC[e] participation)	Hazardous waste generator and accumulation (SAA, WAA) areas	April 30	1
	Hazardous Waste Handling Facility	April 30	0

[a] Bay Area Air Quality Management District
[b] City of Berkeley
[c] East Bay Municipal Utility District
[d] United States Environmental Protection Agency
[e] California Department of Toxic Substances Control

SAA – Satellite Accumulation Area
WAA – Waste Accumulation Area

3.4 DOE-REPORTABLE ENVIRONMENTAL INCIDENTS

Two environmental incidents occurred during the year that resulted in submittal of reports under the DOE occurrence-reporting program used to track incidents across the DOE complex, as follows:

1. An accidental release of fire suppression aqueous foam entered a storm drain
2. Sewage overflowed into a storm drain

Both releases were promptly reported to appropriate state and local agencies. Minimal impact on the environment occurred. Further information about these events can be obtained at the DOE occurrence reporting website: http://energy.gov/ehss/policy-guidance-reports/dashboards.

3.5 COMPLIANCE PROGRAMS

The primary federal laws impacting Berkeley Lab operations are the Clean Air Act, Emergency Planning and Community Right-to-Know Act, Resource Conservation and Recovery Act, and Clean Water Act. The National Environmental Policy Act of 1969 (NEPA) and California Environmental Quality Act of 1970 (CEQA) are federal and state laws that impact Berkeley Lab's environmental planning for future activities. The following sections provide brief descriptions of these primary environmental laws and their associated regulations, and how Berkeley Lab activities are impacted.

3.5.1 Clean Air Act

The Clean Air Act[1] is the key statutory reference for federal, state, and local air pollution control programs. It classifies air pollutants into these main categories:

- Hazardous air pollutants (*e.g.,* radionuclides, air toxics)
- Criteria air pollutants (*e.g.,* carbon monoxide, nitrogen oxides, particulate matter)Ozone-depleting substances (*e.g.,* chlorofluorocarbons or Freons)

3.5.1.1 Radiological

Radionuclides released to the atmosphere from LBNL research activities must adhere to *National Emission Standards for Emissions of Radionuclides Other Than Radon from Department of Energy Facilities* regulations,[2] as well as sections of DOE Order 458.1, *Radiation Protection of the Public and the Environment.*[3] U.S. EPA administers the National Emission Standards for Hazardous Air Pollutants (NESHAP) regulations (40 Code of Federal Regulations [CFR] Part 61), which limit the dose to the public from a facility's airborne radionuclide emissions to 10 millirem per year. Berkeley Lab documents its NESHAP review and compliance in its annual *Radionuclide Air Emission Report.*[4] Doses from Berkeley Lab activities were well below applicable limits. Reports from recent years are available on ESG's publications website: http://www2.lbl.gov/ehs/esg/Reports/tableforreports.shtml.

DOE Order 458.1 also has requirements on release and clearance of property with the potential to contain residual radioactive material. Berkeley Lab developed and received approval from the DOE Berkeley Site Office in early 2013 on an implementation plan and schedule to address these requirements. The Site Environmental Report for 2014 is expected to include Berkeley Lab's initial reporting on property clearance activities.

3.5.1.2 Non-radiological

The State of California's air pollution control program[5] created air districts to regulate sources of air emissions. The Bay Area Air Quality Management District (BAAQMD) implements federal and state air quality requirements for most non-radiological air emission activities. The California Air Resources Board administers regulations on mobile sources such as vehicles as well as regulations on certain toxic chemicals. At the end of 2013, Berkeley Lab held 31 operating permits issued by the BAAQMD,[6] as listed in Table 3-3. Twenty-nine of these operating permits cover activities at the main site, and two cover standby emergency generators at the DOE Joint Genome Institute (JGI) in Walnut Creek. One new standby diesel generator was permitted and installed this year for the new General Purpose Laboratory (Building 33).

Table 3-3 BAAQMD Permitted Air Emission Source

BAAQMD Category	Description (No. of permitted sources)	Building	Abatement Type
Combustion equipment	Standby emergency generators (4)	64, 66, 67, 70	Catalytic converter
	Standby emergency generators (3)	48, 50A, 72	Diesel particulate filter
	Standby emergency generators (17)	Various[a]	None
	Standby emergency generators (2)	JGI	None
Gasoline dispensing	Fueling stations: unleaded and E85	76	Vapor recovery
Surface coating and painting	Paint spray booth (1)	77	Dry filter
Surface preparation and cleaning	Sandblast booth (1)	77	Baghouse
	Wipe-cleaning (1)	Sitewide	None
Miscellaneous	Soil-vapor extraction systems (1)	58	Activated carbon

[a]Individual generators are located at Buildings 2, 33, 37 (2), 50B, 55, 62, 64, 70A, 74, 75, 77, 84B, and 85, plus three portable units.

Operating permits are renewed annually, at which time the BAAQMD also requests information required by the state's *Air Toxics "Hot Spots" Information and Assessment Act of 1987*.[7] Renewing these permits requires usage information on most sources. At the same time, Berkeley Lab also submits its site-wide adhesive and sealant usage under the BAAQMD-approved alternative recordkeeping agreement for compliance with Regulation 8, Rule 51: *Adhesive and Sealant Products*. BAAQMD conducted an inspection of permitted sources on March 11. No violations were issued.

California Air Resources Board regulations governing the use and release of the potent greenhouse gas sulfur hexafluoride (SF_6) took effect in 2012. The new regulation targets SF_6 because its global warming potential is 23,900, which is the highest global warming potential value for any substance currently identified. Beginning with calendar year 2013, these regulations prohibited the use of SF_6 as a tracer gas except under specified exemptions, such as military operations. LBNL requested – and was granted – a one-year exemption to the regulation for 2013 for ongoing research at Berkeley Lab's Environmental Energy Technologies Division. Researchers in this division use SF_6 in very small quantities as a tracer gas for occupied building ventilation and air movement studies. Berkeley Lab must reapply for this exemption annually, as necessary.

Also this year Berkeley Lab substituted nitrous oxide (N_20) for SF_6 as a tracer gas while performing ASHRAE fume hood testing. This represents a significant reduction in environmental impact with no change in fume hood testing performance. When SF_6 was used for this testing, an average of 1.9 million pounds of carbon dioxide equivalent greenhouse gas emissions would be released annually. With N_2O's much lower global warming potential value of 300, using this tracer gas reduced the average annual release from fume hood testing to 48,000 pounds of carbon dioxide equivalent greenhouse gas emissions, or a reduction of over 97%.

A federal mandate established in 2005 requires that Berkeley Lab decrease the use of petroleum fuel each year through such strategies as reducing fleet size, increasing the fleet's fuel efficiency, and switching to alternative fuels. These actions both reduce dependence on petroleum and lower greenhouse gas emissions. Berkeley Lab achieves the goal of using less petroleum fuel by operating an E85 fuel (85% ethanol and 15% unleaded gasoline) dispensing facility that now serves over 90 vehicles in Berkeley Lab's fleet. This number of vehicles represents an increase of approximately 30% over the previous year.

Beginning in FY2010, Executive Order 13514 has required Berkeley Lab to report its annual greenhouse gas emissions to DOE at the end of each fiscal year. Berkeley Lab facilities do not emit greenhouse gases in quantities that exceed any of the U.S. EPA or California reporting levels cited in other regulations, namely U.S. EPA's *Greenhouse Gas Reporting Program* and California's *Assembly Bill 32*, *California Global Warming Solutions Act of 2006*.

3.5.2 Emergency Planning and Community Right-to-Know Act

The *Emergency Planning and Community Right-to-Know Act* (EPCRA)[8] was passed in 1986 as Title III of the *Superfund Amendments and Reauthorization Act* (SARA). The Act establishes requirements for emergency planning, notification, and reporting. In California, the requirements of SARA Title III are incorporated into the state's *Hazardous Materials Release Response Plans and Inventory Law*.[9] Berkeley Lab activities addressing these requirements are summarized below.

As a federal facility, LBNL is subject to EPCRA Toxic Release Inventory reporting requirements. If threshold usage quantities are exceeded, preparation of a U.S. EPA Form R would be required. LBNL determined that in 2013 no chemical usage exceeded the Toxic Release Inventory criterion of 10,000 pounds (lb) for a listed substance and that DOE was therefore not required to submit a Form R on behalf of LBNL. Table 3-4 shows the highest usage quantities of the chemicals from LBNL's assessments over recent years.

Table 3-4 Trends in Highest Quantities of Chemicals Subject to EPCRA Toxic Release Inventory Reporting

Substance	Quantity (pounds)							
	2006	2007	2008	2009	2010	2011	2012	2013
Chlorofluorocarbons	271	1140	209	172	150	319	202	70
Methanol	363	139	152	180	147	88	103	172
Nitric acid	887	198	667	614	592	634	631	633
1,1,1-trichloroethane	<2.2	<2.2	<2.2	<2.2	<2.2	0	0	0

The City of Berkeley, Alameda County, and Contra Costa County are the local administering agencies for certain hazardous materials regulations that fall under federal EPCRA and corresponding state law. Berkeley Lab complies with applicable federal hazardous materials reporting requirements and each year voluntarily submits Hazardous Materials Business Plans (HMBP) meeting state requirements, even though as a federal facility LBNL is not subject to state hazardous materials regulations.

LBNL's HMBPs include a list of all hazardous materials present in amounts exceeding the state's aggregate threshold quantities per building (*i.e.*, 55 gallons for liquids, 500 pounds for solids, and 200 cubic feet for compressed gases). Also included is a site map and information regarding emergency plans, procedures, and training. In 2013, five HMBPs[10] were submitted electronically to the California Environmental Reporting System for these facilities:

- Main Site
- Joint Center for Artificial Photosynthesis
- Berkeley West Biocenter

- Joint BioEnergy Institute
- Joint Genome Institute

They are also available on ESG's publications website (http://www2.lbl.gov/ehs/esg/Reports/tableforreports.shtml).

3.5.3 Resource Conservation and Recovery Act

The *Resource Conservation and Recovery Act* (RCRA)[11] is an amendment to the earlier Solid Waste Disposal Act of 1965 that was enacted to create a management system that would regulate waste from "cradle to grave." In 1984, the Hazardous and Solid Wastes Amendments were added to the Solid Waste Disposal Act to reduce or eliminate the generation and disposal of hazardous wastes, and between 1984 and 1988 RCRA was further expanded to regulate underground storage tanks (USTs) and leaking waste storage facilities. The primary goals of RCRA are to: protect the public from harm caused by waste disposal; encourage reuse, reduction, and recycling; and clean up spilled or improperly stored wastes. RCRA applies to Berkeley Lab operations in these three primary areas:

1. Treatment and storage of hazardous waste (including the hazardous portion of mixed waste)
2. Cleanup of historical releases of hazardous chemicals to the environment
3. UST operation

3.5.3.1 Hazardous Waste

In California, DTSC administers the RCRA hazardous waste program. The California program incorporates the provisions of both the federal and state hazardous waste laws.[12] The state program includes both permitting and enforcement elements.

The state's permitting program for hazardous waste treatment and storage facilities consists of five tiers, shown below in decreasing order of regulatory complexity:

1. Full permit
2. Standardized permit
3. Permit-by-rule
4. Conditional authorization
5. Conditional exemption

The state oversees the "full permit" and the "standardized permit" tiers; at Berkeley Lab, the other three tiers have been delegated to the City of Berkeley (COB) for oversight under California's Certified Unified Program Agency (CUPA) program.

Berkeley Lab's Hazardous Waste Handling Facility (HWHF) operates under the "full permit" tier of the state's program. The permit, issued by DTSC, authorizes storage and treatment of certain hazardous and mixed wastes at the HWHF. Berkeley Lab has a second hazardous waste permit, issued by the COB, to operate four fixed treatment units (FTUs).[13]

The permit for the FTUs is renewed annually as part of the HMBP submission for the main site, due March 1. The type, location, and wastewater volume treated for each unit are listed in Table 3-5, as well as the permit tier under which each is authorized to operate as determined by regulations.

Table 3-5 Fixed Treatment Unit Summary

FTU	Building	Treatment Description	California's Tiered Permitting Program Permit Tier	Wastewater Volume Treated (Gallons/Year)
004	70A/70F	Acid neutralization	Conditional authorization	575,689 (376,540 recycled)
005	2	Acid neutralization	Conditional authorization	76,240
006	77	Metals precipitation and acid neutralization	Permit-by-rule	26,183
007	67	Acid and alkaline neutralization	Permit-by-rule	30,478

In 2011, Berkeley Lab installed a system that recycles treated wastewater from the FTU at Building 70A to the building's cooling tower. In 2013, this system recycled 376,540 gallons of wastewater – or about 65% of the water used by the FTU – and effectively fulfilled most cooling tower water needs for the year. By the end of 2013, the total water volume recycled by this system since installation was approximately 1,270,000 gallons.

Berkeley Lab's waste management program also sends hazardous, universal, mixed, medical, and radioactive waste generated at LBNL to permitted off-site facilities for disposal. Disposal of medical waste is managed in accordance with the state's *Medical Waste Management Act.*[14] Low-level radioactive waste is managed in accordance with DOE orders. Mixed waste is managed in accordance with the *Mixed Waste Site Treatment Plan*[15] and is subject to both California regulations and DOE orders.

In late April, the HWHF was inspected by U.S. EPA, with participation by DTSC and COB. No violations were issued during this inspection. On this same date, U.S. EPA and COB also inspected waste management programs at generator areas in Building 67, including satellite accumulation areas and waste accumulation areas. One minor violation was identified at a waste accumulation area due to the lack of immediate access to equipment that would warn staff and responsible parties of an emergency situation. A local alarm was installed and inspecting agencies were notified of the corrective action. In June, the COB inspected generator areas in thirteen additional buildings. One minor violation was issued for a hazardous waste labeling error, which was corrected on the spot. The COB inspected the four fixed treatment units in June. No violations were issued.

3.5.3.2 Corrective Action Program

Berkeley Lab is currently in the Corrective Measures Implementation phase of the RCRA Corrective Action Program, which consists of operating, maintaining, and monitoring the corrective measures (cleanup activities) approved by DTSC in the *Corrective Measures Study Report*.[16] These measures are intended to reduce or eliminate the potentially adverse effects to human health or the environment caused by past releases of chemicals to soil and groundwater at Berkeley Lab.

The corrective measures currently operating to clean up contaminated groundwater consist of *in situ* soil flushing, groundwater capture and treatment, subsurface injection of Hydrogen Release Compound (HRC®), and monitored natural attenuation (MNA), as described below:

- *In situ* soil flushing consists of extracting contaminated groundwater from the subsurface, cleaning the water on site using granular activated carbon (GAC), and then recirculating the treated groundwater by injecting it into the subsurface.
- Groundwater capture and treatment consists of extracting groundwater in the down gradient portions of groundwater contaminant plumes to minimize further migration, cleaning the extracted groundwater on site using GAC, and then either injecting the treated water into the subsurface if needed for soil flushing or discharging the treated water to the sanitary sewer system.
- HRC® — an environmentally safe polylactate ester formulate used to enhance the natural biodegradation of volatile organic compounds (VOCs) — has been injected at regular intervals into certain contaminant plume source areas.
- MNA refers to the reliance on natural processes within the context of a controlled and monitored site cleanup approach to achieve site-specific remediation objectives.

As part of the Corrective Measures Implementation phase, LBNL prepared a *Soil Management Plan*[17] and a *Groundwater Monitoring and Management Plan*.[18] These plans describe the nature and extent of the contamination and the controls that are used to reduce potential risk from exposure to the contaminants. Additionally, the *Groundwater Monitoring and Management Plan* provides the requirements for ongoing groundwater and surface water monitoring. These documents, as well as other RCRA Corrective Action Program documents prepared by Berkeley Lab, are available to the public at the main branch of the Berkeley Public Library and on ESG's publications page (see http://www2.lbl.gov/ehs/erp/html/documents.shtml).

3.5.3.3 Underground Storage Tanks

In the early 1980s, California addressed groundwater contamination from leaking USTs through a rigorous regulatory and remediation program.[19] The state program for USTs containing hazardous materials addresses permitting, construction, design, monitoring, record-keeping, inspection, accidental releases, financial responsibility, and tank closure, and it also satisfies the provisions of the federal RCRA requirements.[20] The COB is the local administering agency for UST regulations that apply to Berkeley Lab. At the end of 2013, six permitted USTs containing either diesel or unleaded gasoline were in operation at Berkeley Lab, as shown in Table 3-6 and Figure 3-1. LBNL has removed and properly closed nine USTs since 1993.

Table 3-6 Underground Storage Tanks Requiring Operating Permits

Registration ID	Location (Building)	Contents	Capacity (Gallons)	Year Installed
Fiberglass tanks, double-walled				
TK-3-2	2	Diesel	4,000	1988
TK-4-2	2	Diesel	1,000	1988
TK-1-85	85	Diesel	2,500	1995
Glasteel tanks, double-walled, with fiberglass-reinforced plastic corrosion protection				
TK-1-55	55	Diesel	1,000	1986
TK-5-76	76	Unleaded gasoline	10,000	1990
TK-6-76	76	Diesel	10,000	1990

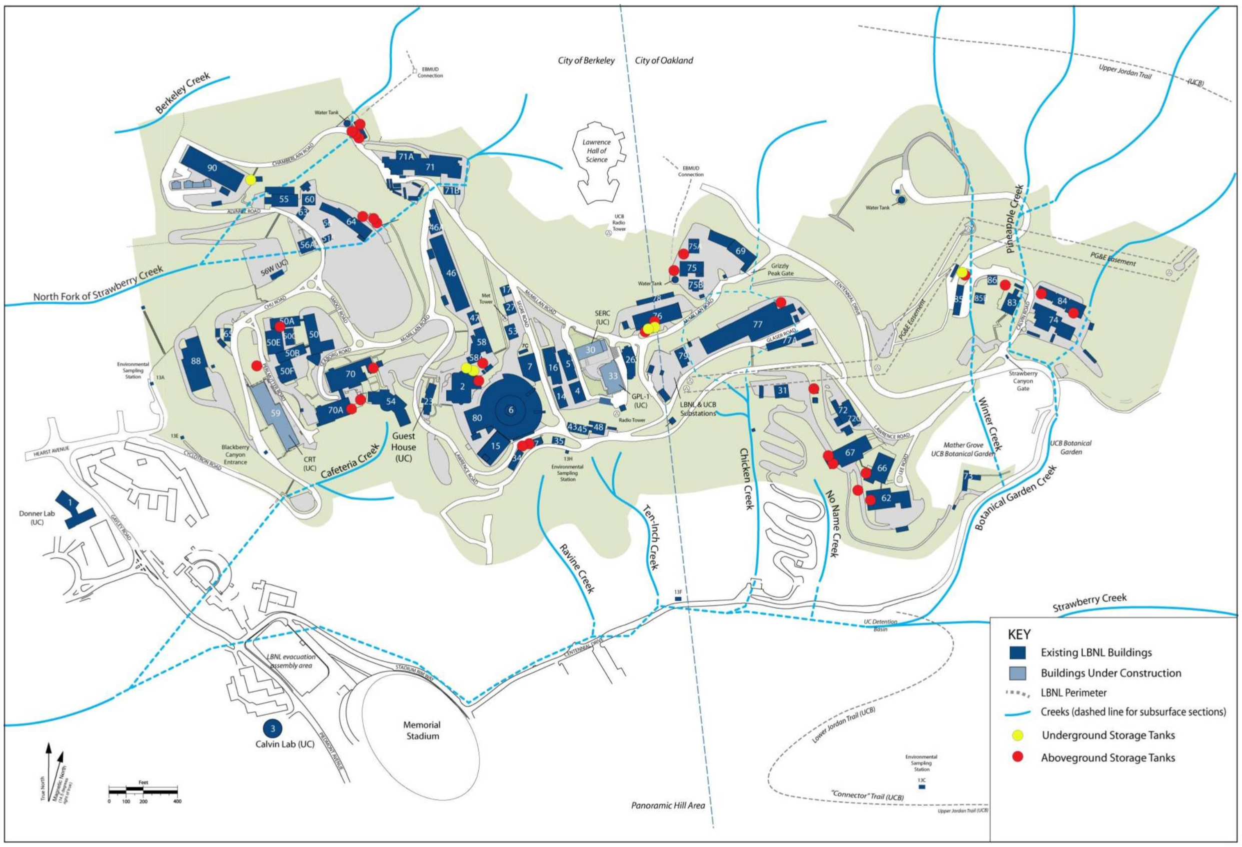


Figure 3-1 Storage Tank Locations (Above and Underground)

During annual testing on October 30, leak-detection monitors were tested and recertified for all UST systems and on the same date all product piping for the UST systems passed pressure tests. At the time of this annual testing a COB Hazardous Materials Specialist conducted annual UST inspections and all USTs were found to be compliant with regulations. In mid-April a volumetric tank tightness test was performed on the UST at Building 85 (TK-1-85) and witnessed by a City of Berkeley Hazardous Materials Specialist. Testing confirmed that the primary and secondary containment walls were leak tight.

3.5.4 Clean Water Act

The *Clean Water Act*[21] regulates the discharge of pollutants from both point and nonpoint sources to the waters of the United States using such means as development of pollutant discharge standards and limitations as well as a permit and licensing system to enforce the standards. California is authorized by the U.S. EPA to administer the principal components of the federal water quality management program.

The *California Porter-Cologne Water Quality Control Act*[22] established a comprehensive statewide system for regulating water use. This 1969 act provides for a three-tiered system of regulatory oversight and enforcement: 1) the State Water Resources Control Board (SWRCB); 2) nine Regional Water Quality Control Boards (RWQCBs); and 3) local governments. For the Berkeley Lab main site, the regional regulatory agency is the San Francisco Bay RWQCB and the local agencies are the cities of Berkeley and Oakland for stormwater and EBMUD for drinking water supply and wastewater discharges. For JGI, which is located in Walnut Creek, the Central Contra Costa Sanitary District is responsible for regulatory oversight of both wastewater and stormwater discharges.

3.5.4.1 Wastewater

EBMUD is the local Publicly Owned Treatment Works that regulates all industrial and sanitary discharges to its treatment facilities. Berkeley Lab holds wastewater discharge permits issued by EBMUD[23] for the following activities at the main site:

- General sitewide wastewater discharge (expires in 2017)
- FTU discharge of rinse water from the metal finishing operations in Building 77 (expires in 2017)
- Treatment system discharge of groundwater from hydraugers and groundwater monitoring wells (no expiration)
- Special permits for construction and demolition activities (see below for detail)

In 2013 EBMUD approved the permit for the groundwater treatment systems in March and the sitewide permit in May. The permits incorporate standard terms and conditions, individual discharge limits and provisions, as well as monitoring and reporting requirements. Berkeley Lab submits periodic self-monitoring reports as specified under each permit. No wastewater discharge limits were exceeded in 2013. For more information regarding LBNL's annual wastewater self-monitoring program results, see Chapter 4.

EBMUD inspects the site's sanitary sewer discharge without giving prior notice to Berkeley Lab. Inspections include the collection and analysis of wastewater samples. The agency conducted inspections on two occasions in 2013, as listed in Table 3-2. The EBMUD sample collection results for all permits showed no violations.

The EBMUD wastewater discharge permit for Building 77 requires that the facility incorporate a *Toxic Organics Management Plan* and a *Slug Discharge Plan* into the facility's activity hazard document (AHD) for operations. The AHD outlines facility management practices designed to eliminate the accidental release of toxic organics or any other pollutant to the sanitary sewers or external environment by emphasizing secondary containment and other appropriate spill prevention practices. The AHD for the metal finishing area at Building 77 also includes emergency response procedures.

Three special wastewater discharge permits from EBMUD were for the following activities:

- The Solar Energy Research Center construction project for treated rainwater and groundwater discharged to the sanitary sewer, which was terminated in June.
- The Computational Research and Theory facility construction project for treated rainwater. This permit was renewed in April.
- The Fault Line Research Study for discharging groundwater, which was terminated in December.

Berkeley Lab also holds a *Class III Industrial User Permit*[24] re-issued by Central Contra Costa Sanitary District on January 1, 2012 that will remain in effect until December 2014 for general wastewater discharged at the JGI facility in Walnut Creek. The permit contains requirements for inspecting and reporting on operations, but no monitoring requirements.

3.5.4.2 Stormwater

Berkeley Lab's stormwater releases are permitted under the California-wide *General Permit for Storm Water Associated with Industrial Activity* (or Industrial General Permit, IGP).[25] The IGP is issued by the SWRCB, but is administered and enforced by the RWQCB. Under this permit, Berkeley Lab has implemented a *Storm Water Pollution Prevention Plan* (SWPPP)[26] and an *Alternative Storm Water Monitoring Program* (ASWMP).[27] The purpose of the SWPPP is to identify sources of pollution that could affect the quality of stormwater discharges, and to describe and ensure the implementation of practices to reduce pollutants in these discharges. The ASWMP describes the rationale for sampling, sampling locations, and analytical parameters (both radiological and non-radiological). Together, these documents represent LBNL's plan and procedures for identifying, monitoring, and reducing pollutants in its stormwater discharges.

The IGP requires submittal of an annual report to the RWQCB on stormwater activities by July 1 of each year. Berkeley Lab met this requirement by submitting its report[28] by the end of June as posted, along with other recent annual reports, on ESG's publication web page at: http://www2.lbl.gov/ehs/esg/Reports/tableforreports.shtml. No regulatory concerns were raised by the agency regarding the 2012-2013 annual report. According to the IGP, its water quality benchmarks are guideline values, not effluent permit limits; for a summary of sampling locations and stormwater monitoring results, see Chapter 4.

Stormwater releases from construction activity disturbing one or more acres of soil are regulated under the California-wide *General Permit for Stormwater Discharges Associated with Construction Activities* (or Construction General Permit, CGP).[29] During 2013, three construction projects at Berkeley Lab required separate stormwater construction permits because they each disturbed more than one acre of soil, as follows:

- Computational Research and Theory
- Solar Energy Research Center
- FLEXLAB (Facility for Low-Energy eXperiments in buildings LABoratory)

3.5.4.3 Aboveground Storage Tanks

Aboveground storage tanks (ASTs) also fall under the authority of the Clean Water Act which, together with the state's *Aboveground Petroleum Storage Act*[30] outlines the regulatory requirements for ASTs. ASTs containing chemicals or hazardous materials consist of FTU tanks, storage drums at Waste Accumulation Areas (WAAs), and storage drums at product distribution areas. FTU operators inspect FTU tanks each operating day. EHS staff inspects WAAs weekly.

Under the authority of the Clean Water Act, a *Spill Prevention, Control, and Countermeasure* (SPCC) *Plan*[31] is required for petroleum-containing tanks, both aboveground and underground. Berkeley Lab maintains an SPCC Plan for the main site with the goal of preventing and, if needed, mitigating spills or leaks from petroleum-containing tanks. These ASTs are provided with secondary containment or spill kits to capture any potential leaks, and their location is shown in Figure 3-1. A 4,000-gallon AST at the JGI facility supports two standby emergency generators. The JGI maintains a separate SPCC Plan[32] for this AST.

3.5.5 National Environmental Policy Act and California Environmental Quality Act

The *National Environmental Policy Act of 1969*[33] and the *California Environmental Quality Act of 1970*)[34] require that potential environmental impacts of proposed actions are one of the considerations in the decision making process. At Berkeley Lab, LBNL environmental staff provides information and technical support to assist DOE and UC in complying with NEPA and CEQA requirements.

In 2013, seven proposed federally-funded activities met the criteria for a categorical exclusion. Review documents for each are posted at the following DOE website: http://science.energy.gov/bso/esh/. Also, DOE determined that none of these projects had the potential to affect historic properties, satisfying evaluation requirements in the National Historic Preservation Act for federally-funded projects.

4. Environmental Monitoring

4.1 INTRODUCTION

Berkeley Lab's environmental monitoring programs assess the impact of LBNL's emissions on public health and the environment. They are important for environmental stewardship and for demonstrating compliance with requirements imposed by federal, state, and local agencies. The program also confirms adherence to DOE environmental protection policies and supports environmental management decisions.

This chapter presents summaries of the 2013 monitoring results for the following categories:

- Stack air
- Surface water and wastewater
- Groundwater
- Soil and sediment
- Vegetation and foodstuffs
- Penetrating radiation

A comprehensive *Environmental Monitoring Plan*[1] prepared by Berkeley Lab was updated in June and provides the basis and current scope for each monitoring program.

4.2 AIR QUALITY

Berkeley Lab's air monitoring program is designed to measure the impacts from radiological air emissions. The program meets the following U.S. EPA and DOE requirements:

- 40 CFR Part 61, Subpart H – *National Emission Standards for Emissions of Radionuclides Other Than Radon from Department of Energy Facilities*[2]
- DOE Order 458.1 – *Radiation Protection of the Public and the Environment*[3]

This program consists of emissions sampling and monitoring to measure contaminants in building exhaust systems.

Berkeley Lab uses various radionuclides in its radiochemical and biomedical research programs. Charged particle accelerators also generate radioactive materials. These operations may result in small amounts of airborne radionuclides, which are typically emitted through building exhaust systems.

Berkeley Lab is required to evaluate the potential for radionuclide emissions from laboratories where radionuclides are used or generated. If the potential emissions exceed the U.S. EPA-approved threshold, LBNL must measure emissions by sampling or monitoring stacks through which emissions are released. *Sampling* is defined as the collection of radionuclides on a filter and subsequent analysis of the filters at an analytical laboratory. *Monitoring* is defined as the continuous measurement of radionuclides in real time.

LBNL measures stack emissions in accordance with U.S. EPA regulations. EPA-approved emission categories and their respective measurement requirements are identified in Table 4-1.

Table 4-1 U.S. EPA-Approved Radionuclide Emissions Measurement Approach

Category	AEDE (millirem/year)	Requirements
Noncompliant	AEDE[a] ≥ 10	Reduction or relocation of the source and reevaluation before authorization
1	10 > AEDE ≥ 1	Continuous sampling with weekly collection and real-time monitoring for short-lived radionuclides
2	1 > AEDE ≥ 0.1	Continuous sampling with monthly collection or real-time monitoring for short-lived radionuclides
3	0.1 > AEDE ≥ 0.01	Periodic sampling 25% of the year
4	0.01 > AEDE	Potential dose evaluation before project starts and when project changes; no sampling or monitoring required

[a]AEDE = Annual Effective Dose Equivalent

When all sites were evaluated for their potential to emit in 2013, all potential doses were found to be <0.1 millirem per year, and therefore are Category 3 or 4 sources. Berkeley Lab was not found to have any Category 1 or 2 sources. While this lessens the measurement requirements that must be met at each site, Berkeley Lab may conservatively choose to implement real-time monitoring (to better characterize emissions), or sample and monitor more frequently than is required. In 2013, sixteen stacks were sampled and four stacks implemented real-time monitoring. Sampling and monitoring locations are shown in Figure 4-1.

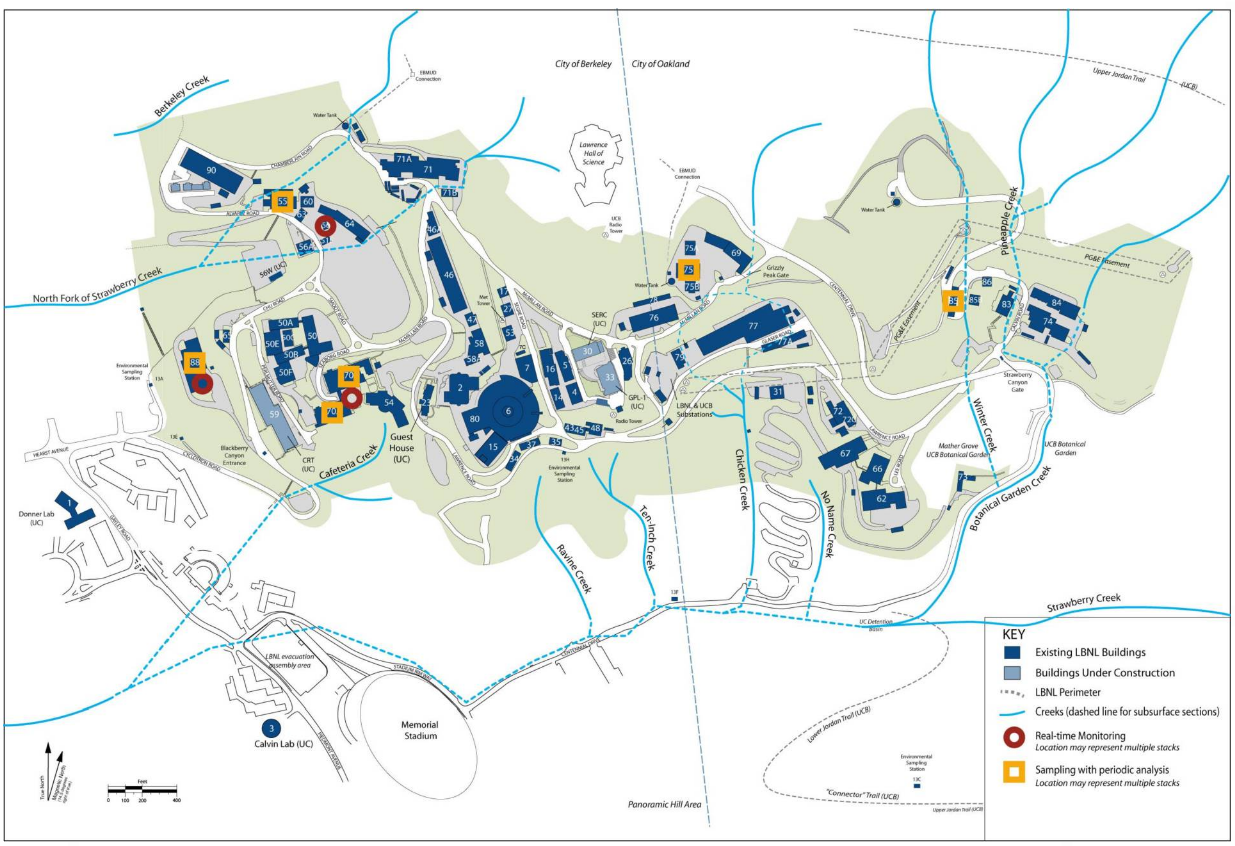


Figure 4-1 Building Exhaust Sampling and Monitoring Locations

Stack exhaust samples were analyzed for five radiological parameters: gross alpha, gross beta, carbon-14, iodine-125, and tritium. Real-time stack monitoring systems measured alpha emitters and positron emitters. The positron emitter fluorine-18 (half-life of 1.8 hours) was the predominant radionuclide emitted in 2013, accounting for about 99% of the emitted activity. The Building 56 accelerator was the main source of fluorine-18 emissions at 2.01 curies (Ci). Additional details on stack emissions are available in LBNL's annual *Radionuclide Air Emission Report*,[4] which is submitted to the U.S. EPA. For information on the projected dose from radionuclide emissions, see Chapter 5.

4.3 SURFACE WATER

This section summarizes monitoring results of surface waters, which consists of sampling creeks and stormwater.

4.3.1 Creek Sampling

Flow volume in many of Strawberry Creek's watershed creeks varies throughout the year. To track any seasonal variation in water quality, a set of creek samples is collected semi-annually from the following creeks that flow through or originate within the Berkeley Lab site: North Fork Strawberry Creek, Chicken Creek, Botanical Garden Creek, Cafeteria Creek, No-Name Creek, Ravine Creek, and Winter Creek (two locations). Also sampled is Wildcat Creek, which is located approximately 1.6 miles north-northwest of the site in Tilden Regional Park and is not impacted by Berkeley Lab activities.

Creeks are sampled for gross alpha, gross beta, and tritium in accordance with DOE Order 458.1, which prescribes monitoring requirements for radionuclides. Samples measuring radionuclide concentrations were collected semi-annually from Chicken Creek, the North Fork of Strawberry Creek, Wildcat Creek, Winter Creek, and the Winter Creek influent. Although LBNL surface waters are ultimately not used as a supply for public drinking water, Berkeley Lab evaluates creek water results against conservative Maximum Contaminant Level (MCL) drinking water standards, as well as water quality objectives as stated in the *Water Quality Control Plan for the San Francisco Bay Basin (Basin Plan)*.[5] The federal and state MCL for alpha in drinking water is 15 picocuries/liter (pCi/L), beta is 50 pCi/L, and tritium is 20,000 picocuries/liter (pCi/L).[6,7] Of the samples collected, two samples from the North Fork of Strawberry Creek detected gross alpha at 9.3% and 10% of the MCL, five samples detected gross beta at less than 8% of the MCL, and one sample from Chicken Creek detected tritium at 2% of the MCL for drinking water.

All samples were also analyzed for VOCs and metals. No VOCs were detected except for the August sample from Chicken Creek, in which a questionable trace concentration of tetrachloroethene (1.5 micrograms/liter [µg/L]) was detected. This questionable detection was not confirmed by the result of a duplicate sample and follow-up sample collected from Chicken Creek at both the same location and a short distance upstream on October 18, 2013. Metals detected in the creek samples were aluminum, antimony, arsenic, barium, copper, iron, lead, magnesium, selenium, vanadium, and zinc. Their concentrations were within historical levels for LBNL, well below the water quality objectives listed in the *Basin Plan*, and well below the drinking water standard.

In addition, a total of 47 samples were analyzed for the following general indicator parameters: chemical oxygen demand (COD), pH, specific conductance, total suspended solids (TSS), and nitrate plus nitrite. Results indicate that concentrations in all samples analyzed for these indicator parameters were within historical levels for the site.

4.3.2 Stormwater Sampling

Stormwater monitoring is required by the state-wide Industrial General Permit. Under the terms of California's IGP, sampling must take place during rain events at least twice each wet season (*i.e.*, October 1 through May 30) under specific conditions. Berkeley Lab's ASWMP[8] describes the rationale for sampling, sampling locations, and analytical parameters for each specific industrial activity. The IGP also requires visual observation of the surface water runoff from one storm each month and visual observation of authorized and unauthorized non-stormwater discharges once each quarter.

As required by the IGP, sampling and observation results are included in the Stormwater Annual Reports. Sampling results show that Berkeley Lab's best management practices provide adequate control for stormwater discharges at most locations. At other locations where results exceed regional benchmark levels, improvements to best management practices were made, as noted in each annual report. Recent reports are available on ESG's publications page at: http://www2.lbl.gov/ehs/esg/Reports/tableforreports.shtml.

4.4 WASTEWATER

4.4.1 Wastewater Monitoring Locations

As discussed in Section 3.5.4.1, Berkeley Lab holds wastewater discharge permits issued by EBMUD for: general sitewide activities; metal finishing operations in Building 77; treated groundwater operations at seven locations; as well as special permits for wastewater discharges associated with construction, demolition, or research activities. Each permit specifies EBMUD's periodic monitoring and reporting requirements.

Berkeley Lab's sanitary sewer system, shown in Figure 4-2, includes a monitoring station located near the outfall of each of the two main sewer system branches:

- Hearst Station, located at the head of Hearst Avenue below the western edge of Berkeley Lab, monitors discharges from LBNL's western and northern areas. The monitoring site (outfall) is located immediately before the connection to the COB's sewer main.
- Strawberry Station, located next to Centennial Drive in Strawberry Canyon, monitors discharges from LBNL's eastern and southern areas. Downstream from the monitoring station the discharge system first ties into UC-owned piping and then into the COB system. This station also receives effluent from several UC Berkeley campus facilities located above LBNL, namely, the Lawrence Hall of Science, Space Sciences Laboratory, Mathematical Sciences Research Institute, Animal Research Facility, and Botanical Garden.

In addition to the self-monitoring of wastewater discharges at the sanitary sewer stations, wastewater sampling is conducted to monitor specific activities at hydraugers and extraction wells, the Building 77 Ultra-High Vacuum Cleaning Facility, and the various treated groundwater sites. EBMUD also conducts unannounced wastewater discharge monitoring. For this reporting year all monitoring results were below EBMUD discharge limits.

4.4.2 Hearst and Strawberry Sewer Outfalls

Non-radiological monitoring of sitewide samples collected at the outfalls near the Hearst and Strawberry monitoring stations includes analyses for pH, total identifiable chlorinated hydrocarbons, TSS, and COD, and specified metals.

Total flow is also measured and recorded. In 2013, Berkeley Lab discharged approximately 13.0 million gallons through the Hearst branch of the sewer system and 18.6 million gallons through the Strawberry branch.

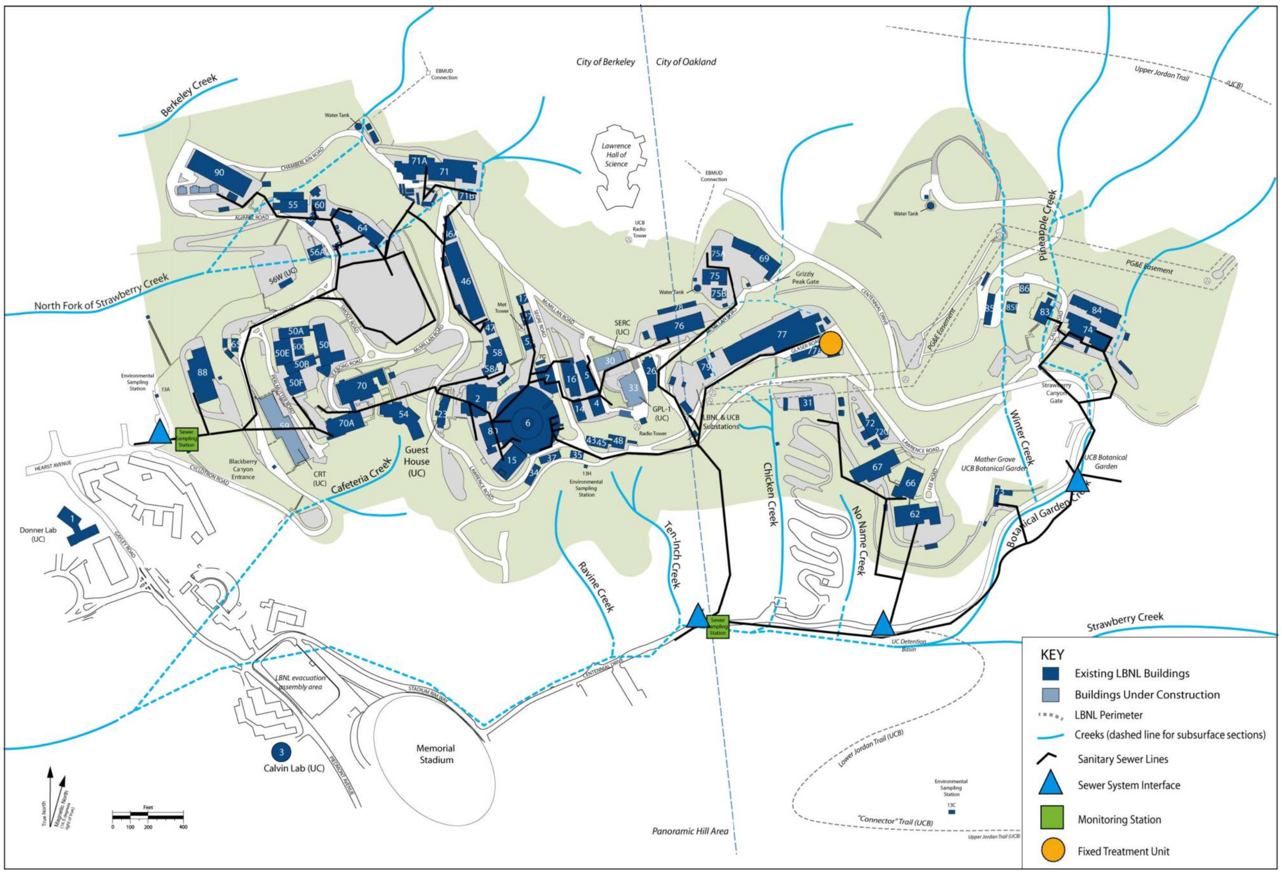


Figure 4-2 Sanitary Sewer System (Main Lines)

Radiological monitoring is required by DOE Order 458.1[9] and guidance,[10] and verifies compliance with radiological limits under the Nuclear Regulatory Commission (NRC) or other governmental agency empowered to regulate the use of radioactive materials.

Analyses are performed by a state-certified external laboratory. Results are compared against the discharge limits for each parameter specified in the EBMUD permits. Self-monitoring reports are submitted to EBMUD in compliance with permit requirements, and Berkeley Lab annually submits a certification to EBMUD that its discharges are in compliance with NRC, DOE, state, and local regulations for discharges of radioactive materials.

4.4.2.1 Non-radiological Monitoring

Berkeley Lab collected one non-radiological set of samples from both the Hearst and Strawberry outfalls as part of EBMUD-required self-monitoring performed during the year. The EBMUD permit specifies the collection dates for this sampling. EBMUD also conducted two independent sampling events.

All metals and chlorinated hydrocarbon results were below EBMUD permit limits or not detected. All pH results were well above 5.5, as required by the permit. TSS and COD do not have discharge limits and are measured to determine wastewater strength, which forms the basis for EBMUD's wastewater treatment charges.

4.4.2.2 Radiological Monitoring

Composite samples are collected once every four weeks at both the Hearst and Strawberry sewer outfalls by sampling the wastewater every half hour for a 24-hour period using an automated sampler. The composite samples are analyzed by a state-certified laboratory for gross alpha radiation, gross beta radiation, iodine-125, tritium, and carbon-14.

Positive results for gross beta were consistently detected throughout the year at Hearst and Strawberry sewer outfalls, which are likely due to naturally occurring radioactive material such as potassium-40. The highest monthly gross beta concentration was 22 pCi/L, well below the federal and state drinking water MCL for drinking water of 50 pCi/L. No samples taken at the Hearst or Strawberry sanitary sewer outfalls in 2013 contained levels of gross alpha, carbon-14, iodine-125, or tritium above the Minimum Detectable Activity (MDA).

Annual discharges are estimated by multiplying the activity found in the sample result by the volume discharged during the monitoring period. Since gross alpha, carbon-14, iodine-125 and tritium were below MDA levels, they are considered to be estimated values. The federal and state regulatory limits for radioisotopes in wastewater are based on total amounts released per year. Tritium values were totaled to give an estimated annual discharge of 3.77×10^{-3} Ci, or 0.076% of the tritium discharge limit of 5 Ci. Carbon-14 values were totaled to give an estimated annual discharge of 6.86×10^{-4} Ci, or 0.069% of the carbon-14 discharge limit of 1 Ci. The estimated annual discharge for all other radioisotopes (gross alpha, gross beta, and iodine-125) was 1.31×10^{-3} Ci, or 0.131% of the combined discharge limit of 1 Ci.

DOE Order 458.1 requires facilities to control discharges into sanitary sewers if average monthly activity at the point of discharge is greater than five times Derived Concentration Standard (DCS) values for ingested water located in Derived Concentration Technical Standard DOE-STD-1196-2011.[11] Compliance is demonstrated when the fraction of each DCS value is calculated, based upon consecutive 12 month average concentrations, and totaled together. Using conservative assumptions on the radionuclides responsible for the gross alpha (thorium-232) and beta (strontium-90) activity, the calculated discharges were 0.008 and 0.019 of the fractional DCS values in the Strawberry and Hearst sanitary sewer systems, respectively.

4.4.3 Treated Hydrauger and Extraction Well Discharge

Since 1993 EBMUD has permitted Berkeley Lab to discharge treated groundwater to the sanitary sewer at seven locations. The EBMUD permit allows for discharge of treated groundwater from certain hydraugers (subsurface drains) and extraction wells, and also from well sampling and development activities.

The treatment process consists of passing the contaminated groundwater through a two-stage carbon-drum adsorption system. Samples of the treated water are collected and analyzed for VOCs using U.S. EPA-approved methods to document that discharge limits have not been exceeded. All sampling results have been below EBMUD discharge thresholds.

4.4.4 Building 77 Ultra-High Vacuum Cleaning Facility Wastewater

The cleaning activities at the Ultra-High Vacuum Cleaning Facility at Building 77 include passivating, acid and alkaline cleaning, and ultrasonic cleaning of various types of metal parts used in research and support activities at Berkeley Lab. Acid and alkaline rinse waters that contain metals from this facility's operations are routed to a fixed treatment unit with a capacity of approximately 60 gallons per minute.

LBNL submits a *Total Toxic Organics Compliance Report* twice per year certifying that Building 77 is not discharging chlorinated hydrocarbons or other toxic organic compounds to the fixed treatment unit or to the sanitary sewer. In addition, a confirmatory sample taken by Berkeley Lab showed results were well within permitted limits.

4.5 GROUNDWATER

This section reviews Berkeley Lab's groundwater monitoring program and provides a brief summary of site groundwater contaminant plumes and the corrective measures applied to each. More detailed information is provided in the Environmental Restoration Program's progress reports, which contain all site groundwater monitoring data, site maps showing monitoring well locations and contaminant concentrations, and graphs showing decreasing contaminant concentrations over time. These reports are available at the main branch of the Berkeley Public Library and on the program's web page at http://www2.lbl.gov/ehs/erp/html/documents.shtml.

4.5.1 Groundwater Monitoring Overview

The objectives of groundwater monitoring are to: (1) evaluate the continued effectiveness of the corrective measures that have been implemented for cleanup of contaminated groundwater; (2) document that site groundwater plumes continue to be stable or attenuating and are not migrating offsite; and (3) monitor progress toward attaining the long-term goal of restoring all groundwater at the site to drinking water standards, if practicable. Although attaining drinking water standards is the long-term goal, it should be understood that groundwater at Berkeley Lab is not used for domestic, irrigation, or industrial purposes.

The groundwater monitoring network at Berkeley Lab consists of more than 230 wells, which are sampled for VOCs, metals, and/or tritium in accordance with schedules approved by the DOE, DTSC, and/or the RWQCB. Selected wells are also monitored for other potential contaminants. Seventeen of the wells are used to monitor for potential migration of contaminated groundwater beyond the developed areas of the site (see Figure 4-3). The monitoring data continue to indicate that the corrective measures are effective in reducing contaminant concentrations in the groundwater, the groundwater plumes are stable or are attenuating, and contaminants are not migrating offsite in the groundwater.

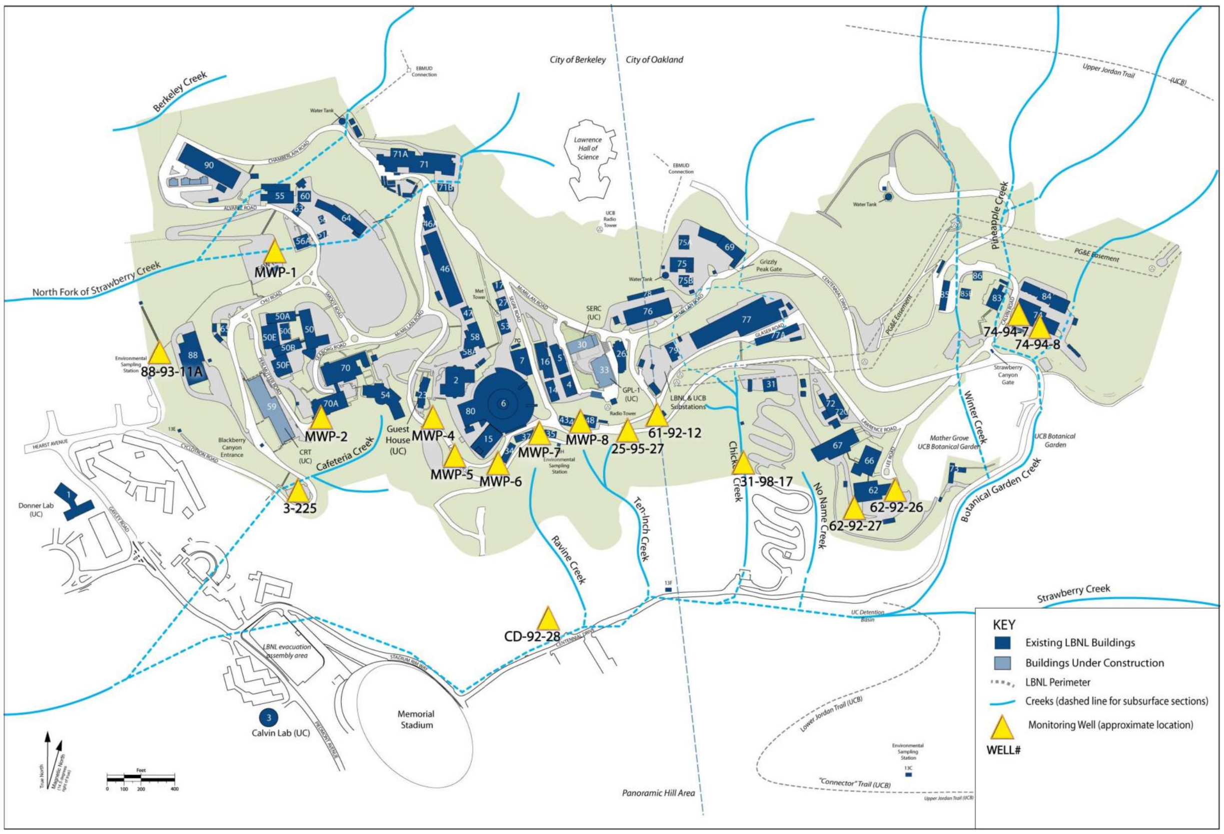


Figure 4-3 Monitoring Wells Nearest the Site Boundary

4.5.2 Groundwater Sampling

Metals: Concentrations of metals detected in 2013 were consistent with previous results. The only metal detected at a concentration above both the drinking water standard and the statistically-estimated Berkeley Lab background level[12] was arsenic in three wells. In addition, molybdenum, which has no drinking water standard, was detected above the upper estimate of background in five wells. The elevated arsenic concentrations detected are attributed to the relatively high natural concentration of arsenic in certain rock types at Berkeley Lab.

VOCs: Four principal plumes of VOC-contaminated groundwater have been identified at Berkeley Lab – Old Town, Building 51/64, Building 51L, and Building 71B. The geometry and distribution of chemicals in the Old Town plume indicate that it consists of three coalescing lobes (Building 7, Building 25A, and Building 52 lobes) that were originally discrete plumes derived from distinct sources. In addition, six other localized areas of VOC-contaminated groundwater have been identified, as follows: former Building 51A, former Building 51 Vacuum Pump Room, Building 69A, Building 75/75A, Building 76, and Building 77.

The primary VOCs detected in the groundwater have been tetrachloroethylene, trichloroethylene (TCE), 1,1-dichloroethane, and carbon tetrachloride and their associated degradation products such as 1,1-dichloroethylene (DCE), cis-1,2-DCE, 1,1,1-trichloroethane (TCA), and vinyl chloride. Concentrations of VOCs in most areas have shown significant declines primarily as a result of the corrective measures that have been implemented.

However, VOC concentrations remain above the drinking water standard, except for the Building 77 area and the Building 52 lobe of the Old Town plume.

Tritium: A plume of tritium-contaminated groundwater extends southward from the Building 75 area. The source of the plume was the former National Tritium Labeling Facility (NTLF), which ceased operation in December 2001. Since closure of the NTLF, concentrations of tritium in the groundwater have been steadily declining, with concentrations below the drinking water standard of 20,000 pCi/L[13, 14] in all wells since February 2005. Low concentrations of tritium – well below the drinking water standard – have also been detected in groundwater samples collected in the Building 71B area and beneath the central area of the former Bevatron site.

Petroleum Hydrocarbon: Two petroleum hydrocarbon plumes associated with former USTs are present; one is located at Building 74 (Building 74 diesel plume) and the other near Building 6 (Building 7 diesel plume). While not considered a plume, petroleum hydrocarbons have also been detected in the groundwater at a former UST site south of Building 76. No aromatic VOCs, including BTEX components (*i.e.,* benzene, toluene, ethylbenzene, xylenes), have been detected in the groundwater at any of these UST sites since 2003.

The locations where the groundwater at Berkeley Lab is contaminated and the extent of groundwater with contaminant concentrations exceeding the drinking water standard are shown on Figure 4-4.

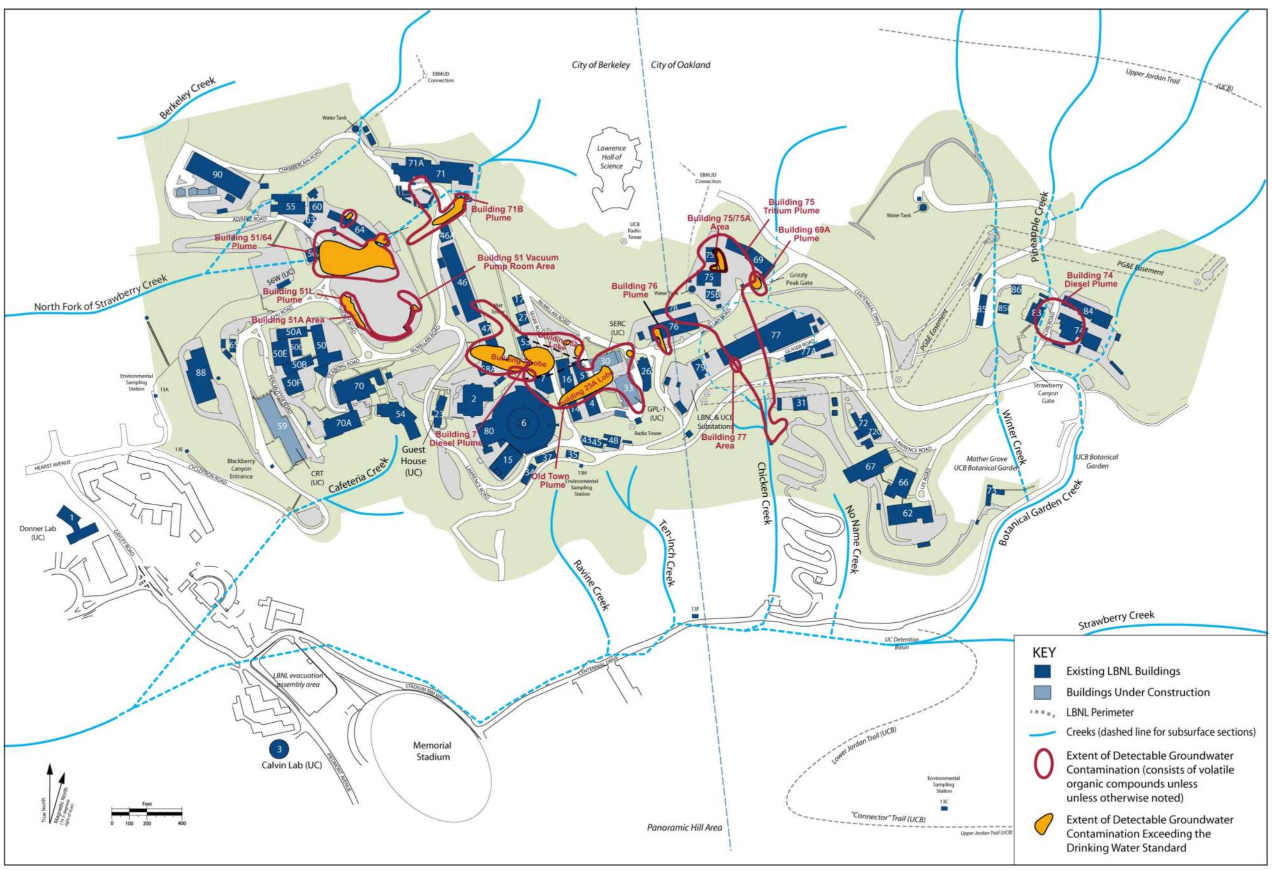


Figure 4-4 Locations of Groundwater Contamination (September 2013)

4.5.3 Treatment Systems

Berkeley Lab is using collection trenches, groundwater extraction wells, and subdrains to control the migration of groundwater plumes and to clean up contaminated groundwater. Eleven GAC treatment systems were operated in 2013 to treat the extracted groundwater. The treated water is primarily re-injected into the subsurface for *in situ* soil-flushing purposes. Excess water is also released to the sanitary sewer in accordance with Berkeley Lab's treated groundwater discharge permit from EBMUD.[15] The total volume of contaminated groundwater treated by these systems during the year was approximately 11.3 million gallons. From 1991 through the end of 2013, more than 155 million gallons of contaminated groundwater have been extracted, treated, and – in large part – re-injected as clean water into the subsurface for *in situ* soil-flushing purposes.

4.6 SOIL AND SEDIMENT

This section summarizes routine monitoring results for soil and sediment samples required by DOE Order 458.1 and guidance.[16] Non-routine sampling conducted to investigate contamination at specific sites is reported in the Environmental Restoration Program's semiannual progress reports, which are available for public view on the program's web page at http://www2.lbl.gov/ehs/erp/html/documents.shtml and in hardcopy at the main branch of the Berkeley Public Library.

4.6.1 Soil Sampling

Soil samples obtained from the top one to two inches of surface soils were collected from three locations on the LBNL site and one off-site environmental monitoring station (see Figure 4-5). Samples were analyzed for gross alpha and gross beta radiation, gamma emitters, tritium, moisture content, pH, and 15 metals. For radioisotope analysis, the alpha, beta, and gamma emitter results were similar to background levels of naturally occurring radioisotopes commonly found in soils. Tritium measurements at each of the sampling locations were below detection limits. For non-radioisotope analysis involving metals, the results were within established Berkeley Lab soil background levels[17] or levels commonly found in California soils.

4.6.2 Sediment Sampling

Sediment samples were collected in the creek beds of the North Fork of Strawberry Creek and Chicken Creek on the LBNL site and at one off-site location at Wildcat Creek in Tilden Regional Park in Berkeley (see Figure 4-5).

Due to limited sediment availability, several grab samples from the general sampling area of each location were composited and analyzed. Samples were analyzed for gross alpha, gross beta, and gamma emitters, tritium, 15 metals, pH, and petroleum hydrocarbons (diesel and oil/grease).

For radioisotope analysis, the levels of alpha, beta, and gamma emitters were within background levels of naturally occurring radioisotopes commonly found in sediments. With the exception of Chicken Creek, tritium measurements at each of the sampling locations were below detection limits. At Chicken Creek, tritium was detected above the practical quantitation limit; however, it was below LBNL's reporting limit of 0.200 pCi/gram.

For non-radioisotope analysis, the pH measurement at each of the sampling locations was within the historical range. Petroleum hydrocarbons (diesel and oil/grease) were within the range of historical values found at the site and below any applicable environmental screening levels set by the RWQCB. The metals results were within either the established Berkeley Lab soil background levels or levels commonly found in California soils.

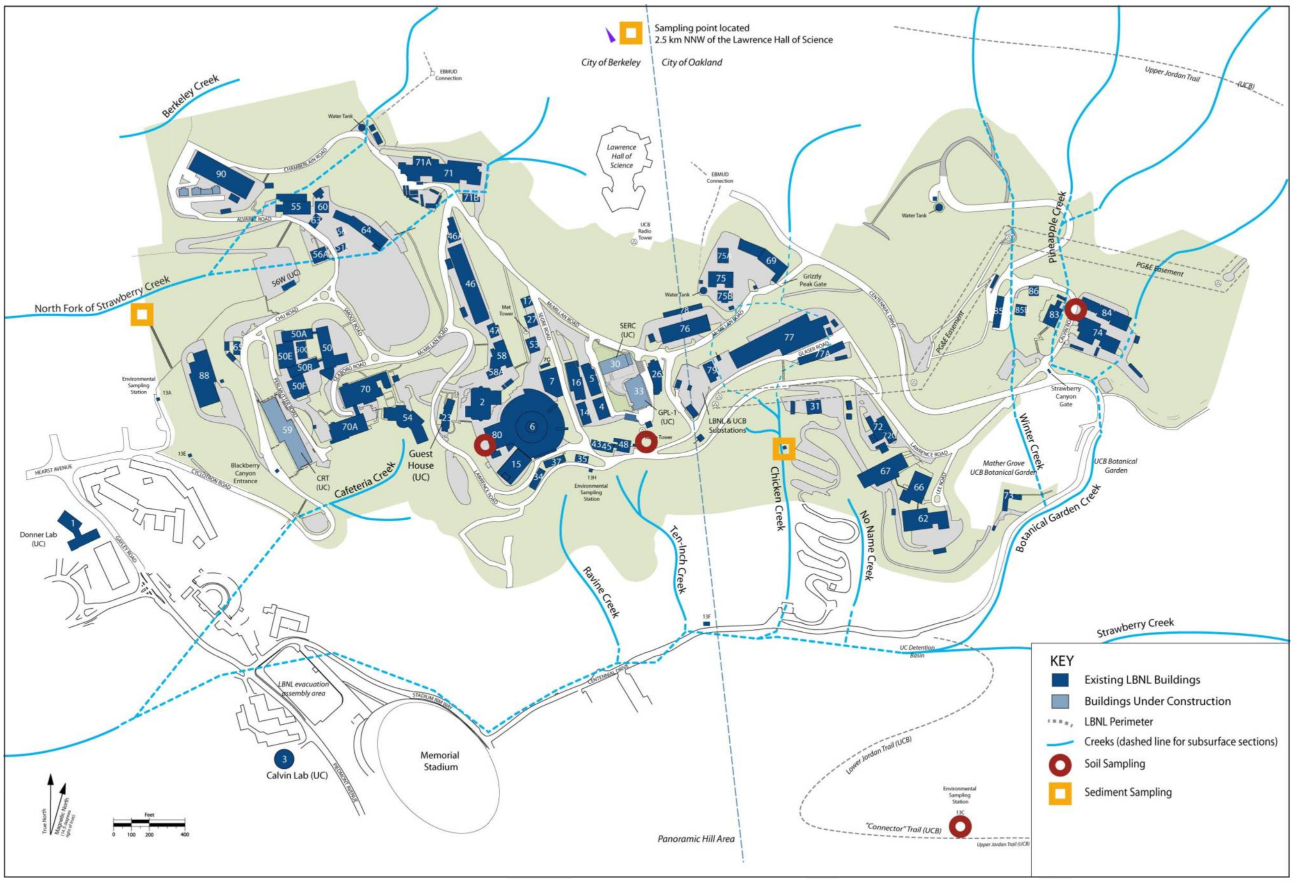


Figure 4-5 Soil and Sediment Sampling Sites

4.7 VEGETATION AND FOODSTUFFS

Sampling and analysis of vegetation and foodstuffs can provide information regarding the presence, transport, and distribution of radioactive emissions in the environment. This information can be used to detect and evaluate changes in environmental radioactivity resulting from Berkeley Lab activities and to calculate potential human doses that would occur from consuming vegetation and foodstuffs.

Due to historical air emissions from the former NTLF Hillside Stack, vegetation near that site contains measurable concentrations of tritium. Tritium in vegetation occurs in two chemical forms – organically bound tritium and tissue-free water tritium. Berkeley Lab analyzes vegetation for both forms. Since the closure of the NTLF in December 2001, tritium emissions from Berkeley Lab have decreased sharply and tritium concentrations in vegetation have decreased as well, albeit more slowly. To document changes in the concentrations of tritium in the local vegetation, Berkeley Lab routinely samples this vegetation every five years. In 2013, no samples were collected for this purpose. The next sampling is scheduled for 2015.

4.8 PENETRATING RADIATION MONITORING

Radiation-producing machines (*e.g.,* accelerators, x-ray machines, irradiators) and various radionuclides are used at Berkeley Lab for high-energy particle studies and biomedical research. Accelerator operations at the site are the primary contributors of penetrating radiation. Smaller radiation-producing machines at LBNL do not measurably increase the dose to the public as these devices are both small sources of radioactivity and they are well shielded. When operating, accelerators may produce both gamma radiation and neutrons, and such devices include the Advanced Light Source (Building 6), Biomedical Isotope Facility (Building 56), and 88-Inch Cyclotron (Building 88). The Laser Optics and Acceleration System Integrated Studies Project (Building 71), however, is an experimental laser-driven accelerator that does not produce measurable gamma or neutron radiation outside the building.

Berkeley Lab uses two methods to determine the environmental radiological impact from accelerator operations:

- Real-time monitors that continuously detect and record gamma radiation and neutron doses
- Passive detectors called "optically stimulated luminescence dosimeters," which by laboratory analysis provide an average dose over time from gamma radiation

The real-time monitors are used to satisfy criteria in DOE Order 458.1. Passive detectors supplement the real-time monitors and confirm that the dose from Berkeley Lab operations is negligible and approximately that of background radiation. The locations of real-time monitors and dosimeters are shown in Figure 4-6. Results of both measurement methods are given in terms of dose and are provided in Section 5.2.

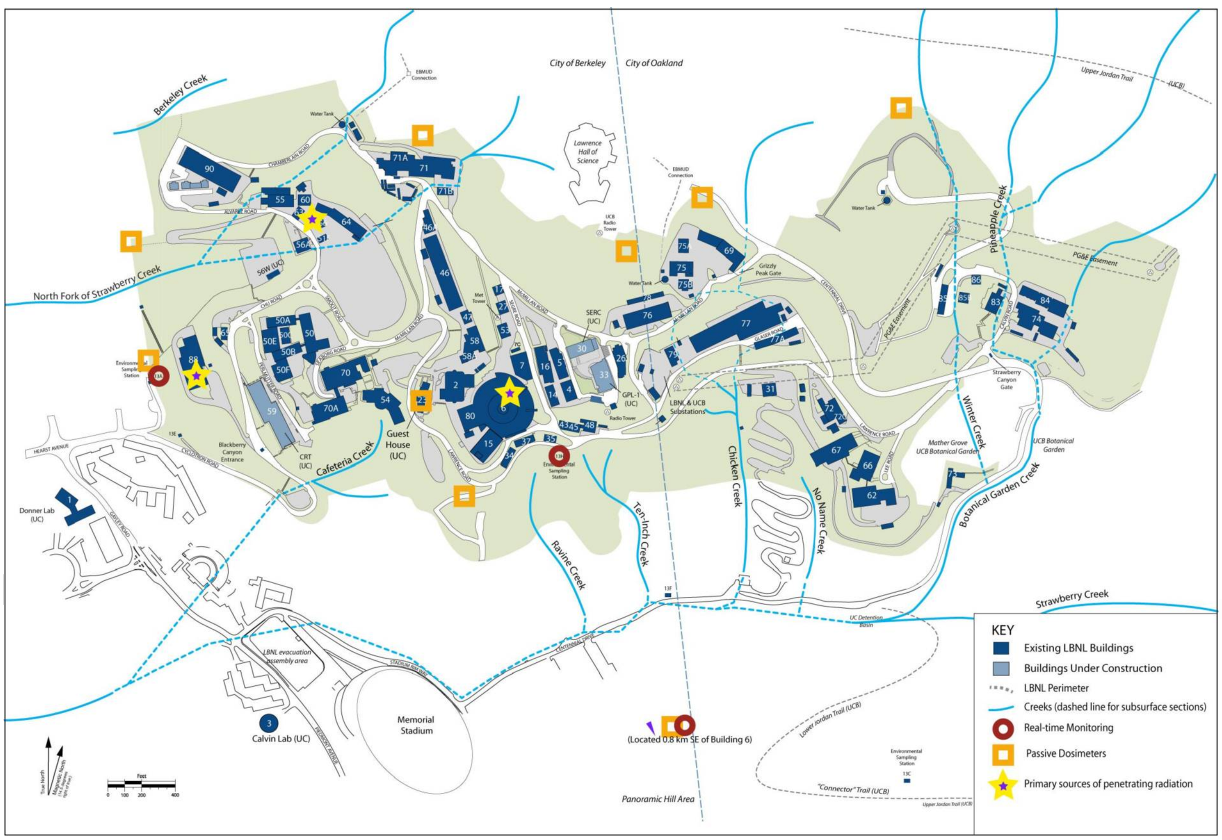


Figure 4-6 Environmental Penetrating Radiation Primary Sources and Monitoring Stations

5. Radiological Dose Assessment

5.1 BACKGROUND

An exposure to concentrations of a radioactive substance over a period of time is referred to as "dose." Because doses are calculated rather than measured, they represent potential or estimated, instead of actual, doses. This chapter presents the estimated dose results from Berkeley Lab's penetrating radiation and airborne radionuclide monitoring programs. Doses to nearby individual members of the public are calculated, as well as population doses to people in the surrounding region extending 50 miles from the site. Within this area, the daytime population is about 7,253,000.[1] The doses projected from each monitoring program are presented separately before they are cumulatively evaluated to summarize the overall impact of LBNL's radiological activities on members of the public. Additionally, the radiological impact of Berkeley Lab's operations on local animals and plants is discussed.

Radiation doses to the public and the environment from Berkeley Lab's operations are very low, and health effects from very low doses are either too small to be observed or are nonexistent.[2] To ensure that radiological impacts to the environment and the public remain very low, Berkeley Lab manages its activities so that radioactive emissions and external exposures are as low as reasonably achievable (ALARA). LBNL's Environmental ALARA Program ensures that a screening (qualitative) review is performed on activities that could result in a dose to the public or the environment.[3] Potential doses from activities that may generate airborne radionuclides are estimated through the NESHAP[4] process, as discussed in Section 4.2. If the potential for a public dose is greater than 1 millirem (mrem) to an individual or 10 person-rem to a population, an in-depth quantitative review is required. No quantitative reviews were required or performed in 2013.

5.2 DOSE FROM PENETRATING RADIATION

As discussed in Section 4.8, penetrating radiation from Berkeley Lab operations is measured by real-time monitors and passive dosimeters. Results of real-time penetrating radiation measurements, which are used to comply with DOE Order 458.1, indicate that the maximum annual dose from gamma and neutron radiation (which is from the 88-inch Cyclotron) to a person at the nearest residence (about 360 feet away) was 3.3×10^{-1} mrem, and the annual population dose to people in the surrounding region that extends 50 miles from the site was 3.4×10^{-1} person-rem. A network of passive optically stimulated luminescence dosimeters located around the perimeter of the site validate the real-time penetrating radiation measurements and confirm that the dose from Berkeley Lab activities is negligible.

5.3 DOSE FROM DISPERSIBLE AIRBORNE RADIONUCLIDES

Dose due to dispersible contaminants represents the time-weighted exposure to a concentration of a substance, whether the contaminant is inhaled in air, ingested in drink or food, or absorbed through skin contact with soil or other environmental media. Very small quantities of dispersible radionuclides originate as emissions from building exhaust points generally located on rooftops, as discussed in Section 4.2. Once emitted, these small quantities of radionuclides may affect any of several environmental media: air, water, soil, plants, and animals. Each of these media represents a possible pathway of exposure affecting human dose.

Dose to an individual and the population is determined using computer dispersion models. The NESHAP regulation[5] requires that any facility that releases airborne radionuclides assess the impact of such releases using a computer program approved by the U.S. EPA. Berkeley Lab satisfies this requirement with the use of the U.S. EPA-approved programs CAP88-PC and COMPLY. Details of dose calculations from dispersible airborne radionuclides are included in LBNL's annual NESHAP report.[6]

The maximally exposed individual to airborne emissions from the main LBNL site was determined to be a hypothetical person residing at the Lawrence Hall of Science as prescribed by the NESHAP regulation. (The maximum possible dose at this location is hypothetical because the exposure calculation assumes the person is present at the location the entire year.) For 2013, the calculated annual dose from airborne radionuclides was approximately 8.7×10^{-3} mrem. This value is approximately 0.09% of the DOE and U.S. EPA annual limit for airborne radionuclides (10 mrem/year)[7,8]

As with penetrating radiation, the population dose from airborne radionuclides to the surrounding population is estimated for a region that extends from the site for 50 miles. The estimated annual population dose from all airborne emissions from the LBNL main site for the year was 1.5×10^{-1} person-rem.

5.4 TOTAL DOSE TO THE PUBLIC

The total radiological impact to the public from penetrating radiation and airborne radionuclides is well below applicable standards and local background radiation levels. As presented in Figure 5-1, the maximum effective dose equivalent from penetrating radiation and airborne radionuclides from Berkeley Lab operations to an individual residing near LBNL in 2013 was about 3.4×10^{-1} mrem/year, primarily from gamma and neutron radiation from the LBNL accelerators. This value is approximately 0.1% of the average United States natural background radiation dose[9] (310 mrem/year) and about 0.3% of the DOE annual limit from all sources (100 mrem/year).[10]

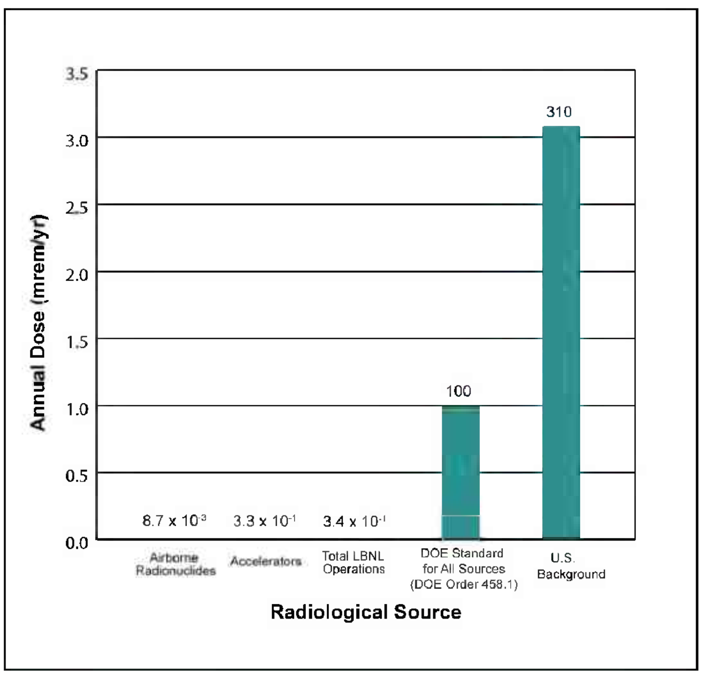


Figure 5-1 2013 Comparison of Radiological Dose Impacts

The total estimated annual dose to the population within 50 miles of Berkeley Lab from penetrating radiation and airborne radionuclides emitted by LBNL operations was 4.9×10^{-1} person-rem for the same period. From natural background airborne radionuclides alone, this same population receives an estimated dose of 1,200,000 person-rem each year.[11] The dose to the population from Berkeley Lab is about 0.00004% of the background level, or about two million times less than background level.

5.5 DOSE TO ANIMALS AND PLANTS

Liquid and airborne emissions may also affect animals and plants. DOE requires that aquatic animals and terrestrial plants be protected by limiting their radiation doses to 1 rad/day and doses to riparian and terrestrial animals must be limited to less than 0.1 rad/day.[12] To determine dose to animals and plants, several sources of exposure were considered, including:

- Animal ingestion of vegetation, water, and soil
- Animal inhalation of dusty soil
- Plant uptake of water
- External exposure of animals and plants to radionuclides in water, soil, and sediment

Creek water, soil, and sediment samples were collected and analyzed for several radionuclides, including tritium and gamma-emitting radionuclides. These radionuclides were measured at levels similar to natural background levels, or well below standards. Sample results were evaluated using the DOE-endorsed computer model RESRAD-BIOTA. Both terrestrial and aquatic systems passed the “general screening process” described in a DOE-approved technical standard,[13] which demonstrates that doses calculated are less than biota dose limits. This confirms that Berkeley Lab is in compliance with DOE requirements to limit radiation doses to aquatic organisms and terrestrial plants to 1 rad/day and to limit radiation doses to riparian and terrestrial animals to 0.1 rad/day.

6. Quality Assurance

6.1 OVERVIEW

Berkeley Lab's Quality Assurance (QA) policy is documented in the *Operating and Quality Management Plan* (OQMP).[1] The OQMP consists of a set of operating principles used to support internal organizations in achieving consistent, safe, and high-quality performance in their work activities. OQMP principles are applied to individual programs through a graded approach, with consideration given to factors such as environmental, health, and safety consequences.

In addition to the OQMP, the monitoring and sampling activities and results presented in this report were conducted in accordance with Berkeley Lab's *Environmental Monitoring Plan*[2] and applicable DOE[3] and U.S. EPA[4] guidance. A Quality Assurance Project Plan is developed and implemented when special QA and Quality Control (QC) requirements are necessary for such environmental monitoring as the NESHAP stack monitoring program.[5]

In 2013 LBNL contracted with eight analytical laboratories, one on-site and seven external. (One external laboratory providing radiochemical analyses closed operations in late 2013.) All laboratories are certified through California's Environmental Laboratory Accreditation Program (ELAP)[6] by having demonstrated the capability to analyze samples for environmental monitoring using approved testing methods. These laboratories must meet demanding QA and QC specifications and certifications[7] that were established to define, monitor, and document laboratory performance, and their QA and QC data is incorporated into Berkeley Lab's processes performed to assess data quality.

Each data set (batch) received from the analytical laboratory is systematically evaluated and compared to established data-quality objectives before the results can be authenticated and accepted into the environmental monitoring database. Categories of data quality objectives include accuracy, precision, representativeness, comparability, and completeness. When possible, quantitative criteria are used to define and assess data quality.

In addition to the ELAP certification, the DOE Consolidated Audit Program (DOECAP) annually audits external analytical laboratories supporting DOE facilities, including those working with Berkeley Lab. In general, DOECAP audits are two to three days in length, with five or more auditors participating in the audit. A member of DOE or a DOE contractor representative who is trained as a Nuclear Quality Assurance lead auditor heads the DOECAP audit team. Other team members come from across the DOE complex and add a wealth of experience. Typically, Berkeley Lab sends two representatives to participate in DOECAP audits of external analytical laboratories that provide services to LBNL. The team audits each of the following six areas that pertain to the services provided by the particular external analytical laboratory:

- QA management systems and general laboratory practices
- Organic analyses
- Inorganic and wet chemistry analyses
- Radiochemical analyses
- Laboratory information management systems and electronic deliverables
- Hazardous and radioactive materials management

The DOECAP laboratory audits also include a review of the external analytical laboratory's performance in proficiency testing required by the California ELAP. In 2013, none of the external laboratories were found to have a major deficiency during an audit, and any identified minor deficiencies were followed by corrective action plans and were tracked to closure.

In addition, external oversight of Berkeley Lab programs is performed through the DOE *Operational Awareness Program*.[8] Operational awareness activities are ongoing and include field orientation, meetings, audits, workshops, document and information system reviews, and day-to-day communications. DOE criteria for performance evaluation include (1) federal, state, and local regulations with general applicability to DOE facilities and (2) applicable DOE requirements. This program enables DOE to directly oversee Berkeley Lab programs and assess performance.

6.2 PROFILE OF ENVIRONMENTAL MONITORING SAMPLES AND RESULTS

Berkeley Lab's environmental monitoring program collected 1,705 individual samples to support air, sediment, soil, and water programs throughout the year; the samples generated 69,470 analytical results. The numbers are approximately 5.2% lower than the previous year due to the scaling back of some monitoring programs.

Samples collected by these programs were obtained from 336 different locations on or surrounding the Berkeley Lab site. Detailed discussion of sampling conducted by the Environmental Restoration Program can be found at the program's website (http://www2.lbl.gov/ehs/erp/html/documents.shtml) and at the main branch of the Berkeley Public Library.

6.3 SPLIT AND DUPLICATE SAMPLING FROM ENVIRONMENTAL MONITORING

An essential activity undertaken to measure the quality of environmental monitoring results is the regular collection and analysis of split and duplicate samples collected in the field. In 2013, a total of 13 split and 83 duplicate samples from all programs were collected for either radiological or non-radiological (or both) analyses, leading to 362 and 2,407 analytical results, respectively. Additionally, 137 blank samples were submitted for QA purposes. Blank samples are useful because they can identify contamination occurring outside the sampling period.

Berkeley Lab uses the metrics of relative percent difference and relative error ratio to determine whether paired results, such as split or duplicate samples, are within control limits. Relative percent difference is defined as the absolute value of the difference between two results divided by the mean of the two results. Relative error ratio is defined as the absolute value of the difference between two results divided by the sum of the analytical error of the two results. Relative percent difference is determined in all cases; relative error ratio is applicable only to radiological analyses where analytical error is determined.

When the primary sample and the split or duplicate sample results are below analytical detection limits, results from these tests are not meaningful. When QA pair results are outside of control limits, an investigation is performed to determine the cause of the discrepancy.

6.4 QUALITY CONTROL ACTIVITIES FROM ANALYTICAL LABORATORIES

Analytical laboratories routinely perform QC tests to assess the quality and validity of their sample results. These tests are run with each batch of environmental samples submitted by Berkeley Lab. The same relative percent difference and relative error ratio metrics are used to evaluate these control sample results, with the relative error ratio test applicable only to radiological analyses.

During the year, the eight analytical laboratories performed 1,691 radiological and non-radiological QC analyses to validate the environmental samples submitted by Berkeley Lab. These QC analyses include various types of blank, replicate (also referred to as duplicate), matrix spike, and laboratory control samples. Table 6-1 shows the breadth and diversity of this program.

Table 6-1 Summary of Quality Control Testing Performed by Analytical Laboratories

Program	No. of Sample Batches	No. of QC Analysis	No. of Laboratories Involved	Radiological[a]	Non-radiological[b]
Stack Air	42	145	2	X	--
Stormwater and Creeks	77	217	5	X	X
Wastewater	82	372	7	X	X
Groundwater	116	863	6	X	X
Soil Water	2	10	2	X	X
Sediment	16	48	4	X	X
Soil	13	36	4	X	X

[a]An "X" in this column indicates that the program tests for radiological substances.

[b]An "X" in this column indicates that the program tests for non-radiological substances.

In addition to the relative percent difference and relative error ratio tests, lower and upper control limits are established for each analyte and for each type of QC test. As with split and duplicate QA, when QC results are outside of established criteria, an investigation is performed to determine the cause of the discrepancy.

Acronyms and Abbreviations

AEDE	annual effective dose equivalent
AHD	Activity Hazard Document
ALARA	as low as reasonably achievable
AST	aboveground storage tank
ASWMP	Alternative Stormwater Monitoring Plan
BAAQMD	Bay Area Air Quality Management District
Basin Plan	Water Quality Control Plan for the San Francisco Bay Basin
Berkeley Lab	Lawrence Berkeley National Laboratory
CCCSD	Central Contra Costa Sanitary District
CCR	California Code of Regulations
CEQA	California Environmental Quality Act
CFR	Code of Federal Regulations
CGP	Construction General Permit
Ci	curie
COB	City of Berkeley
COD	chemical oxygen demand
CUPA	Certified Unified Program Agency
DCE	dichloroethylene
DOE	United States Department of Energy
DOECAP	Department of Energy Consolidated Audit Program
DTSC	Department of Toxic Substances Control
E85	85% ethanol fuel
EBMUD	East Bay Municipal Utility District
EHS	Environment / Health / Safety Division at Berkeley Lab
ELAP	Environmental Laboratory Accreditation Program
EMP	Environmental Management Program
EMS	Environmental Management System
EPCRA	Emergency Planning and Community Right-to-Know Act
ESG	Environmental Services Group
F	Fahrenheit
FLEXLAB	Facility for Low-Energy eXperiments in buildings LABoratory
FTU	fixed treatment unit

FY	fiscal year (October 1 – September 30)
GAC	granular activated carbon
gal	gallon(s)
GHG	greenhouse gas
HMBP	Hazardous Materials Business Plan
HRC®	Hydrogen Release Compound
HWHF	Hazardous Waste Handling Facility
IGP	Industrial General Permit (for stormwater discharges associated with industrial activity)
ISO	International Organization for Standardization
JGI	Joint Genome Institute
kg	kilogram
L	liter
lb	pound
LBNL	Lawrence Berkeley National Laboratory
MDA	minimum detectable activity
µg	microgram
mg/kg	milligrams per kilogram
MNA	monitored natural attenuation
mrem	millirem
NEPA	National Environmental Policy Act
NESHAP	National Emission Standards for Hazardous Air Pollutants
NTLF	National Tritium Labeling Facility
OQMP	Operating and Quality Management Plan
pCi	picocurie (one trillionth of a curie)
QA	quality assurance
QC	quality control
RCRA	Resource Conservation and Recovery Act
rem	roentgen equivalent man (mrem = 1×10^{-3} rem)
RWQCB	Regional Water Quality Control Board (for the San Francisco Bay Region)
SAA	Satellite Accumulation Area
SARA	Superfund Amendments and Reauthorization Act
SER	Site Environmental Report
SF_6	sulfur hexafluoride
SPCC	Spill Prevention, Control, and Countermeasure (Plan)
SWPPP	Storm Water Pollution Prevention Plan

SWRCB	State Water Resources Control Board
TCE	trichloroethylene
TPH	total petroleum hydrocarbons
TSS	total suspended solids
UC	University of California
U.S. EPA	United States Environmental Protection Agency
UST	underground storage tank
VOC	volatile organic compound
WAA	Waste Accumulation Area

Glossary

accuracy

The degree of agreement between a measurement and the true value of the quantity measured.

Advanced Light Source

An accelerator that is a third-generation synchrotron light source, one of the world's brightest sources of ultraviolet and soft x-ray beams.

alpha particle

A charged particle comprising two protons and two neutrons, which is emitted during decay of certain radioactive atoms. Alpha particles are stopped by several centimeters of air or a sheet of paper.

analyte

The subject of a sample analysis.

annual effective dose equivalent

The largest amount of ionizing radiation a person may receive in a given year. It combines both internal and external dose. The AEDE limit is prescribed for various organs as well as whole body and for various working conditions. The AEDE limit is 5000 millirem per year.

background radiation

Ionizing radiation from sources other than LBNL. Background radiation may include cosmic radiation; external penetrating radiation from naturally occurring radioactivity in the earth (terrestrial radiation), air, and water; and internal radiation from naturally occurring radioactive elements in the human body.

beta particle

A charged particle identical to the electron that is emitted during decay of certain radioactive atoms. Most beta particles are stopped by less than 0.2 inches of aluminum.

contaminant

Any hazardous or radioactive material present in an environmental medium such as air, water, or vegetation. See also pollutant.

cosmic radiation

High-energy particulate and electromagnetic radiation that originates outside the earth's atmosphere. Cosmic radiation is part of natural background radiation.

curie

Unit of radioactive decay equal to 2.22×10^{12} disintegrations per minute.

detection limit

The lowest concentration of an analyte that can reliably be distinguished from a zero concentration.[1]

discharge

The release of a liquid or pollutant to the environment or to a system (usually of pipes) for disposal.

dose

The quantity of radiation energy absorbed by a human, animal, or vegetation. Dose to humans is also called effective dose equivalent (measured in units of rem), which takes into account the type of radiation and the parts of the body exposed. Dose to animals and vegetation is also called absorbed dose (measured in units of rad), which is the energy deposited per unit of mass.

dose, population

The sum of the radiation doses to individuals of a population. It is expressed in units of person-rem. For example, if 1,000 people each received a radiation dose of one rem, their population dose would be 1,000 person-rem.

dosimeter

A portable detection device for measuring the total accumulated dose from ionizing radiation. See also optically stimulated luminescence dosimeter.

duplicate sample

A sample that is equivalent to a routine sample and is analyzed to evaluate sampling or analytical precision.

effective dose equivalent

Abbreviated EDE, it is the sum of the products of the dose equivalent received by specified tissues of the body and a tissue-specific weighting factor. This sum is a risk-equivalent value and can be used to estimate the health risk of the exposed individual. The tissue-specific weighting factor represents the fraction of the total health risk resulting from uniform whole-body irradiation that would be contributed by that particular tissue. The EDE includes the committed EDE from internal deposition of radionuclides and the EDE due to penetrating radiation from sources external to the body. EDE is expressed in units of rem. See dose.

effluent

A liquid waste discharged to the environment.

effluent monitoring

The collection and analysis of samples or measurements of liquid discharges for the purpose of characterizing and quantifying contaminants, assessing exposures of members of the public, and demonstrating compliance with applicable standards and permit requirements. Effluent is usually monitored at or near the point of discharge.

emission

A release of air to the environment that contains gaseous or particulate matter having one or more contaminants.

environmental monitoring

The collection and analysis of samples or direct measurements of environmental media for possible contaminants. Environmental monitoring consists of two major activities: effluent monitoring and environmental surveillance.

environmental surveillance

The collection and analysis of samples, or direct measurements, of air, water, soil, foodstuff, biota, and other media from LBNL facilities and their environs for possible contaminants with the purpose of determining compliance with applicable standards and permit requirements, assessing radiation exposures of members of the public, and assessing the effects, if any, on the local environment.

gamma radiation

Short-wavelength electromagnetic radiation of nuclear origin that has no mass or charge. Because of its short wavelength (high energy), gamma radiation can cause ionization. Other electromagnetic radiation, such as microwaves, visible light, and radio waves, has longer wavelengths (lower energy) and cannot cause ionization.

greenhouse gas

Any of the atmospheric gases – such as carbon dioxide, water vapor, and methane - that contribute to the greenhouse effect. The greenhouse effect is the trapping and build-up of heat in the upper atmosphere by gases that absorb infrared radiation. These gases then reradiate some of this heat back towards the Earth's surface.

groundwater

Water below the earth’s surface in a zone of saturation.

half-life, radioactive

The time required for the activity of a radioactive substance to decrease to half its value by inherent radioactive decay. After two half-lives, one-fourth of the original activity remains (1/2 × 1/2); after three half-lives, one-eighth of the original activity remains (1/2 × 1/2 × 1/2); and so on.

hazardous waste

Waste exhibiting any of the following characteristics: ignitability, corrosivity, reactivity, or extraction procedure-toxicity (yielding toxic constituents in a leaching test). Because of its concentration, quantity, or physical or chemical characteristics, it may (1) cause or significantly contribute to an increase in mortality rates or cases of serious irreversible illness or (2) pose a substantial present or potential threat to human health or the environment when improperly treated, stored, transported, disposed of, or handled.

hydrauger

A subhorizontal drain used to extract groundwater for slope stability purposes.

low-level radioactive waste

Waste containing radioactivity that is not classified as high-level waste, transuranic (TRU) waste, spent nuclear fuel, by-product material (as defined in Section 1 1e(2) of the Atomic Energy Act of 1954, as amended), or naturally occurring radioactive material.

millirem

A common unit for reporting human radiation dose. One millirem is one thousandth (10^{-3}) of a rem. *See also rem*.

mixed waste

Any radioactive waste that is also a U.S. EPA-regulated hazardous waste.

nuclide

A species of atom characterized by what constitutes the nucleus, which is specified by the number of protons, number of neutrons, and energy content; or, alternatively, by the atomic number, mass number, and atomic mass. To be regarded as a distinct nuclide, the atom must be able to exist for a measurable length of time.

optically stimulated luminescence dosimeter

A type of dosimeter. After being exposed to radiation, the material in the dosimeter luminesces on being stimulated by laser light. The amount of light that the material emits is proportional to the amount of radiation absorbed (dose). See also dosimeter.

organic compound

A chemical whose primary constituents are carbon and hydrogen.

person-rem

See dose, population.

pH

A measure of hydrogen ion concentration in an aqueous solution. Acidic solutions have a pH less than 7; basic solutions have a pH greater than 7; and neutral solutions have a pH of 7.

plume

A volume of a substance that moves from its source to places farther away from the source. Plumes can be described by the volume of air or water they occupy and the direction they move. For example, a plume can be a column of smoke from a chimney or a substance moving with groundwater.[2]

pollutant

Any hazardous or radioactive material present in an environmental medium such as air, water, or vegetation. *See also contaminant.*

positron

A particle that is equal in mass to the electron but opposite in charge. A positively charged beta particle.[3]

precision

The degree of agreement between measurements of the same quantity.

rad

The conventional unit of absorbed dose from ionizing radiation, commonly used for dose to animals and vegetation.

radiation protection standard

Limits on radiation exposure regarded as necessary for protection of public health. These standards are based on acceptable levels of risk to individuals.

radiation

Electromagnetic energy in the form of waves or particles.

radioactivity

The property or characteristic of a nucleus of an atom to spontaneously disintegrate, accompanied by the emission of energy in the form of radiation.

radiological

Arising from radiation or radioactive materials.

radionuclide

An unstable nuclide. *See nuclide and radioactivity.*

rem

Acronym for "roentgen equivalent man." A unit of ionizing radiation, equal to the amount of radiation needed to produce the same biological effect to humans as one rad of high-voltage x-rays. It is the product of the absorbed dose, quality factor, distribution factor, and other necessary modifying factors. It describes the effectiveness of various types of radiation in producing biological effects.

remediation

The process of improving a contaminated area to an uncontaminated or safe condition.

source

Any operation or equipment that produces, discharges, and/or emits pollutants (e.g., pipe, ditch, well, or stack), or the location where a pollutant was released to the environment.

split sample

A single well-mixed sample that is divided into parts for analysis and comparison of results.

terrestrial

Pertaining to or deriving from the earth.

terrestrial radiation

Radiation emitted by naturally occurring radionuclides, such as potassium-40; the natural decay chains of uranium-235, uranium-238, thorium-232, or cosmic ray-induced radionuclides in the soil.

tritium

A radionuclide of hydrogen with a half-life of 12.3 years, which decays by emitting a low-energy beta particle.

wind rose

Meteorological diagram that depicts the distribution of wind direction over a period of time.

References

Preface

1. DOE, Order 231.1B, *Environment, Safety, and Health Reporting* (2011, as amended).

Executive Summary

1. *ibid.*
2. DOE, *Contract between the United States of America and the Regents of the University of California*, DE-AC02-05CH11231 (2005, as amended).
3. ISO 14001:2004(E), *Environmental Management Systems—Requirements with Guidance for Use* (November 2004).

Chapter 1

1. *Safe Drinking Water Act*, 42 United States Code (USC) §300f *et seq.* (1974, as amended).

Chapter 2

1. DOE Order 436.1, *Departmental Sustainability* (May 2, 2011).
2. ISO 14001:2004(E), *Environmental Management Systems—Requirements with Guidance for Use* (November 2004).
3. LBNL, *Environmental Management System Plan*, LBNL-PUB-3180 (May 2012).
4. LBNL, *FY2014 LBNL Site Sustainability Plan* (December 6, 2013).
5. Berkeley Lab Training
6. LBNL DOE Berkeley Site Office, *FY2013 Performance Evaluation Annual Report* (December, 2013).
7. University of California Office of the President, *FUC-DOE Prime Contract (No. DE-AC02-05CH11231), Section J, Appendix B, Performance Evaluation and Measurement Plan* (Modification No. 869).

Chapter 3

1. *Clean Air Act,* 42 USC §7401 *et seq.* (1967, as amended).
2. U.S. EPA, *National Emission Standards for Emissions of Radionuclides Other Than Radon from Department of Energy Facilities*, Title 40 CFR Part 61, Subpart H (1989, as amended).

3. DOE Order 458.1, *Radiation Protection of the Public and the Environment* (2011).

4. LBNL, *Radionuclide Air Emission Report for 2013*, Environmental Services Group Publications (May 2014).

5. *Air Resources,* California Health and Safety Code §39000 *et seq*. (1967, as amended).

6. BAAQMD, Permit to Operate for Lawrence Berkeley National Laboratory (Plant No. 723 and GDF No. 6134) and BAAQMD Permit to Operate for Joint Genome Institute in Walnut Creek, (Plant No. 14549).

7. *Air Toxics "Hot Spots" Information and Assessment Act of 1987,* California Health and Safety Code §44300 *et seq*. (1987, as amended).

8. *Emergency Planning and Community Right-to-Know Act of 1986*, 42 USC §11001 *et seq*. (1986, as amended).

9. *Hazardous Materials Release Response Plans and Inventory Law*, California Health and Safety Code §25500 *et seq*. (1985, as amended).

10. LBNL, *Hazardous Materials Business Plans,* Environmental Services Group Publications (March 2014).

11. *Resource Conservation and Recovery Act of 1976*, 42 USC §6901 *et seq*. (1976, as amended).

12. *Hazardous Waste Control Law,* California Health and Safety Code §25100 *et seq*. (1972, as amended).

13. City of Berkeley, Certified Unified Program Agency Consolidated Permit and Registration.

14. *Medical Waste Management Act*, California Health and Safety Code §117600–118360 (1991, as amended).

15. DOE, *Mixed Waste Site Treatment Plan for the Lawrence Berkeley National Laboratory* (October 1995).

16. LBNL, *Corrective Measures Study Report,* Environmental Restoration Program Documents (February 2005).

17. LBNL, *Soil Management Plan,* Environmental Restoration Program Documents (September 2006).

18. LBNL, *Groundwater Monitoring and Management Plan,* Environmental Restoration Program Documents (September 2006).

19. *Underground Storage of Hazardous Substances*, California Health and Safety Code §25280 *et seq*. (1983, as amended).

20. *Resource Conservation and Recovery Act of 1976,* Subchapter IX, Regulation of Underground Storage Tanks, 42 USC §6991 (1988, as amended).

21. *Clean Water Act,* 33 USC §1251 *et seq*. (1977, as amended).

22. *California Porter-Cologne Water Quality Control Act*, California Water Code §13000 *et seq*. (1969, as amended).

23. East Bay Municipal Utility District *Wastewater Discharge Permits.*

24. Contra Costa Health Services, *Permit to Operate for Joint Genome Institute.*

25. California State Water Resources Control Board, *General Permit for Storm Water Discharges Associated With Industrial Activity (No. 201I002421)*, Water Quality Order 97-03-DWQ, NPDES General Permit No. CAS 000001 (1997).

26. LBNL, *Storm Water Pollution Prevention Plan*, Environmental Services Group Publications (February 2013).

27. LBNL, *Alternative Storm Water Monitoring Program,* Environmental Services Group Publications (September 2009).

28. *LBNL, Stormwater Annual Report 2012-2013,* Environmental Services Group Publications (June 2013).

29. California State Water Resources Control Board, *General Permit for Stormwater Discharges Associated with Construction and Land Disturbance Activities*, Order No. 2009-0009-DWQ, NPDES No. CAS000002 (September 2, 2009, as amended).

30. Aboveground Petroleum Storage Act, California Health and Safety Code, §25270 et seq. (1989, as amended).

31. LBNL, *Spill Prevention, Control, and Countermeasure Plan*, Environmental Services Group Publications (December 2012).

32. LBNL JGI, Production Sequencing Facility, *Spill Prevention, Control, and Countermeasure Plan*, Environmental Services Group Publications, (February 2014).

33. *National Environmental Policy Act of 1969*, 42 USC §4321 *et seq.* (1970, as amended).

34. *California Environmental Quality Act of 1970*, Public Resources Code §21000 et seq. (1970, as amended).

Chapter 4: Environmental Monitoring

1. LBNL, *Environmental Monitoring Plan,* Environmental Services Group Publications (June 2013).

2. U.S. EPA, *National Emission Standards for Emissions of Radionuclides Other Than Radon from Department of Energy Facilities*, Title 40 CFR Part 61, Subpart H (1989, as amended).

3. DOE, Order 458.1, *Radiation Protection of the Public and the Environment* (2011).

4. LBNL, *Radionuclide Air Emission Report for 2013*, Environmental Services Group Publications.

5. California RWQCB, *San Francisco Bay Basin Plan*, Chapter 3 (current version).

6. U.S. EPA, *National Primary Drinking Water Standards*, 40 CFR 141, Subpart B (1976, as amended).

7. California Department of Public Health, *Domestic Water Quality and Monitoring Regulations*, 22 CCR §64443 (1984, as amended).

8. LBNL, *Alternative Storm Water Monitoring Program,* Environmental Services Group Publications, (September 2009).

9. DOE Order 458.1, *Radiation Protection of the Public and the Environment* (2011).

10. DOE, *Environmental Regulatory Guide for Radiological Effluent Monitoring and Environmental Surveillance*, DOE/EH-0173T (January 1991).

11 DOE-STD-1196-2011, *Derived Concentration Technical Standard* (2011)

12. LBNL, *Analysis of Background Distributions of Inorganic Elements in the Groundwater at Lawrence Berkeley National Laboratory*, Environmental Restoration Program Documents (July 2002).

13. U.S. EPA, *National Primary Drinking Water Standards*, 40 CFR 141, Subpart B (1976, as amended).

14. California Department of Public Health, *Domestic Water Quality and Monitoring Regulations*, 22 CCR §64443 (1984, as amended)

15. East Bay Municipal Utility District *Wastewater Discharge Permits.*

16. DOE, *Environmental Regulatory Guide for Radiological Effluent Monitoring and Environmental Surveillance*, DOE/EH-0173T (January 1991).

17. LBNL, *Analysis of Background Distributions of Metals in the Soil at Lawrence Berkeley National Laboratory*, Environmental Restoration Program Documents (Revised April 2009).

Chapter 5: Radiological Dose Assessment

1. Bright, E.A., P.R. Coleman, A.N. Rose, and M.L. Urban, LandScan 2010, (accessed April 14, 2014).

2. Health Physics Society, Position Statement of the Health Physics Society, *Radiation Risk in Perspective* (2010).

3 LBNL, *Environmental ALARA Program Plan*, Revision 6, Environmental Services Group Publications (March 2013).

4. U.S. EPA, *National Emission Standards for Emissions of Radionuclides Other Than Radon from Department of Energy Facilities*, Title 40 CFR Part 61, Subpart H (1989, as amended).

5. *Ibid.*

6. LBNL, *Radionuclide Air Emission Annual Reports,* Environmental Services Group Publications.

7. DOE Order 458.1, *Radiation Protection of the Public and the Environment* (2011).

8. U.S. EPA, *National Emission Standards for Emissions of Radionuclides Other Than Radon from Department of Energy Facilities,* Title 40 CFR Part 61, Subpart H (1989, as amended).

9. National Council on Radiation Protection and Measurements, *Ionizing Radiation Exposure of the Population of the United States,* NCRP Report No. 160 (2009).

10. DOE Order 458.1, *Radiation Protection of the Public and the Environment* (2011).

11. Mauro, J., and N.M. Briggs, Assessment of Variations in Radiation Exposure in the United States, U.S. Environmental Protection Agency (2005).

12. DOE, *A Graded Approach for Evaluating Radiation Dose to Aquatic and Terrestrial Biota*, DOE-STD-1153-2002 (July 2002).

13. *Ibid.*

Chapter 6: Quality Assurance

1. LBNL, *Operating and Quality Management Plan*, LBNL-PUB-3111, Revision 11 (December 2013).

2. LBNL, *Environmental Monitoring Plan,* Environmental Services Group Publications (June 2013).

3. DOE Order 458.1, *Radiation Protection of the Public and the Environment* (2011).

4. California DPH, *Standards for Protecting Against Radiation,* 17 CCR §30253 (1994, as amended).

5. LBNL, Quality Assurance Program Plan for NESHAP Compliance (2012)

6. California DPH, *Certıfication and Amendment Process*, 22 CCR §64803 (1994, as amended).

7. Lawrence Livermore National Laboratory/LBNL, *Quality Assurance and Quality Control Plan for Analytical Services* (February 2004).

8. DOE, *ES&H Operational Awareness Guide*, Berkeley Site Office (January 1998).

Glossary

1. Agency for Toxic Substances and Disease Registry, *ATSDR Glossary of Terms,* (June 21, 2004).

2. *Ibid.*

3. Shlein, Bernard, Lester A. Slaback, Jr., and Brian Kent Birdy, editors, *Handbook of Health Physics and Radiological Health,* Lippincott Williams and Wilkins (1998).

This work was supported by the Director, Office of Science, U.S. Department of Energy under Contract Number DE-AC02-05CH11231

CSO_27289