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Lawrence Berkeley National Laboratory

Site Environmental Report for 2014

Environment/Health/Safety Division

September 2015

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Subject: 2014 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 2014. 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 2014 environmental monitoring, compliance, and restoration programs at LBNL. This assurance can be made based on the reviews conducted by DOE/BSO, 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@science.doe.gov .

Sincerely,

[redacted]

Signature on file

Paul Golan
Site Office Manager

Site Environmental Report for 2014

September 2015

Cover photo: Building 74 is the first LEED Platinum Certified Renovation Project for both Berkeley Lab and the U.S. Department of Energy. Courtesy of RMW architecture & interiors; photo by Michael O'Callahan.

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Table of Contents

Preface ..... P-I

Executive Summary ..... ES-I

1. Site Overview 1-1

2. Environmental Management System 2-1

3. Environmental Program Summary 3-1

4. Environmental Monitoring 4-1

5. Radiological Dose Assessment 5-1

6. Quality Assurance 6-1

Acronyms and Abbreviations AA-1

Glossary G-1

References R-1

Figures

Figure 1-1 LBNL Main Site and Satellite Facilities Locations in the East Bay 1-1
Figure 1-2 Adjacent Land Use 1-2
Figure 1-3 Annual Wind Patterns 1-3
Figure 1-4 Vegetation Types 1-4
Figure 1-5 Surface Water and Groundwater Elevation Map 1-6
Figure 3-1 Storage Tank Locations (Above and Underground) 3-10
Figure 4-1 Building Exhaust Sampling and Monitoring Locations 4-3
Figure 4-2 Stormwater Sampling Locations 4-4
Figure 4-3 Sanitary Sewer System (Main Lines) 4-6
Figure 4-4 Downgradient Monitoring Wells Nearest the Site Boundary 4-9
Figure 4-5 Locations of Groundwater Contamination (September 2014) 4-11
Figure 4-6 Soil and Sediment Sampling Sites 4-12
Figure 4-7 Environmental Penetrating Radiation Primary Sources and Monitoring Stations 4-14
Figure 5-1 2014 Comparative Radiological Doses 5-3

Tables

Table 2-1 Current Environmental Management Programs 2-4
Table 3-1 Environmental Permits 3-1
Table 3-2 Summary of Environmental Audits, Inspections, and Appraisals 3-2
Table 3-4 Trends in Highest Quantities of Chemicals Subject to EPCRA Toxic Release Inventory Reporting 3-5
Table 3-6 Fixed Treatment Unit Operations Summary 3-7
Table 3-7 Underground Storage Tanks Requiring Operating Permits 3-9
Table 4-1 U.S. EPA-Approved Radionuclide Emissions Measurement Approach 4-2
Table 6-1 Summary of Quality Control Testing Performed by Analytical Laboratories 6-3

Preface

Each year the University of California (UC) Lawrence Berkeley National Laboratory (LBNL, Berkeley Lab) prepares a Site Environmental Report that describes its environmental programs and performance. This report meets the reporting requirements of United States Department of Energy (DOE) Order 231.1B Admin Chg 1, *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, the status of environmental programs, summarized results from surveillance and monitoring activities, radiologic dose assessment results, and quality assurance measures. The Site Environmental Report is posted on the Berkeley Lab Environmental Services Group's (ESG's) 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's environmental manager Ron Pauer. Primary contributors include David Baskin, Ned Borglin, Robert Fox, Zachary Harvey, John Jelinski, Brendan Mulholland, Patrick Thorson, Petra Wehle, and Suying Xu. If you have comments or questions, contact Ron Pauer by email at ropauer@lbl.gov or by phone at 510-486-7614. You can also provide feedback on the report by completing a survey form available on ESG's publications page: 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 2014. The format and content of this report satisfy the requirements of DOE Order 231.1B Admin Chg 1, *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 environmental management system (EMS) to oversee these compliance activities and improve comprehensive environmental performance while maintaining operational capability and sustaining the overall mission.

The effectiveness of the EMS and environmental programs is reviewed annually as part of the operating contract's performance evaluation process. For fiscal year (FY) 2014, 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 is 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 federal Office of Management and Budget's EMS Annual Report Data, in which elements of the ISO 14001 standard were rated and the degree of integration between the EMS and Berkeley Lab's sustainable practices was measured. Overall scores fall into one of three ranges: green (highest), yellow (middle), or red (lowest). For FY2014, Berkeley Lab received a yellow score, but in previous years Berkeley Lab had maintained a green score. The factors contributing to the lower score in FY2014 are described in Chapter 2.

An overview of environmental protection and restoration programs is provided, including information about compliance activities, operating permits, and regulatory agency inspections. This report also includes information on environmental monitoring results and radiation dose assessments performed in 2014. These monitoring activities confirmed that environmental releases from Berkeley Lab operations meet compliance standards and that environmental restoration actions continue to show improving conditions.

1. Site Overview

1.1 INTRODUCTION

Berkeley Lab is a member of the national laboratory system supported by DOE through its Office of Science. It is managed by UC with a mission of conducting unclassified research across a wide range of scientific disciplines. This research is accomplished at the main site and satellite locations by the nearly 4,100 scientists, engineers, support staff, students, and several thousand national facility user and visiting researchers Berkeley Lab hosts each year.

1.2 LOCATION

Figure 1-1 shows the location of LBNL's main site and nearby satellite facilities in the East Bay of the San Francisco Bay area. The main site is located about three miles east of San Francisco Bay on land owned by UC. It 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. Satellite facilities in Berkeley, Emeryville, Oakland, and Walnut Creek consist of leased buildings in developed urban areas. This chapter provides an overview of the physical features of the 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 state, and includes UC Berkeley's Strawberry Canyon Recreational Area and Botanical Garden. To the northeast are UC's Lawrence Hall of Science and Space Sciences Laboratory, as well as the independent nonprofit Mathematical Sciences Research Institute. The north is bordered by a residential neighborhood of low-density, single-family homes. The area to the west is highly urbanized and includes the UC Berkeley campus, multi-unit dwellings, student residence halls, and private homes.

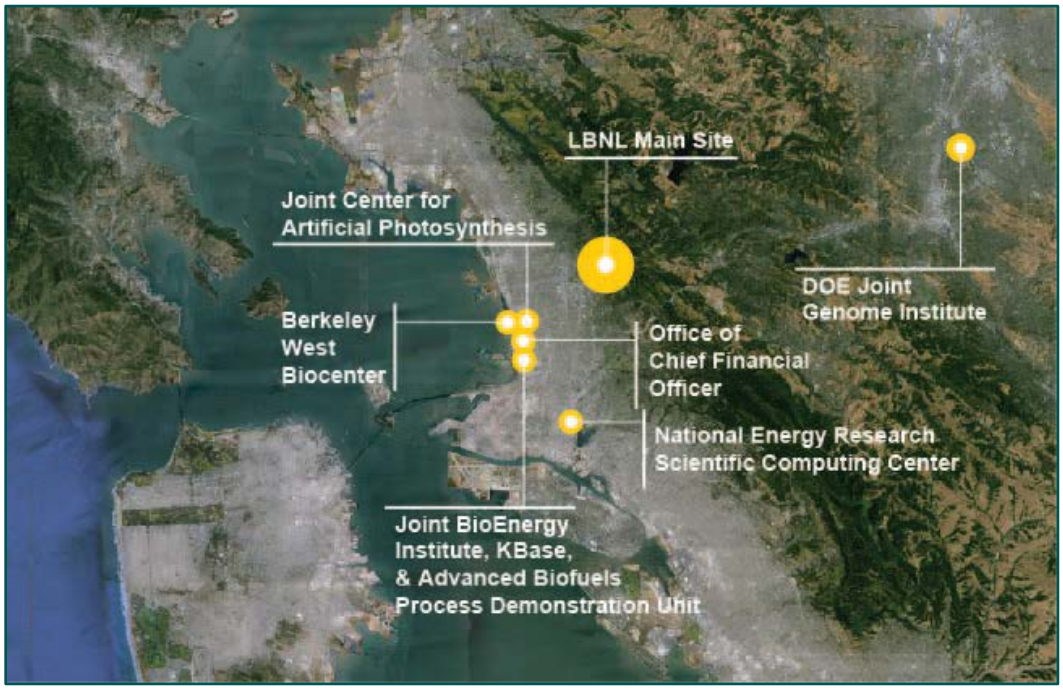

Figure 1-1 LBNL Main Site and Satellite Facilities Locations in the East Bay

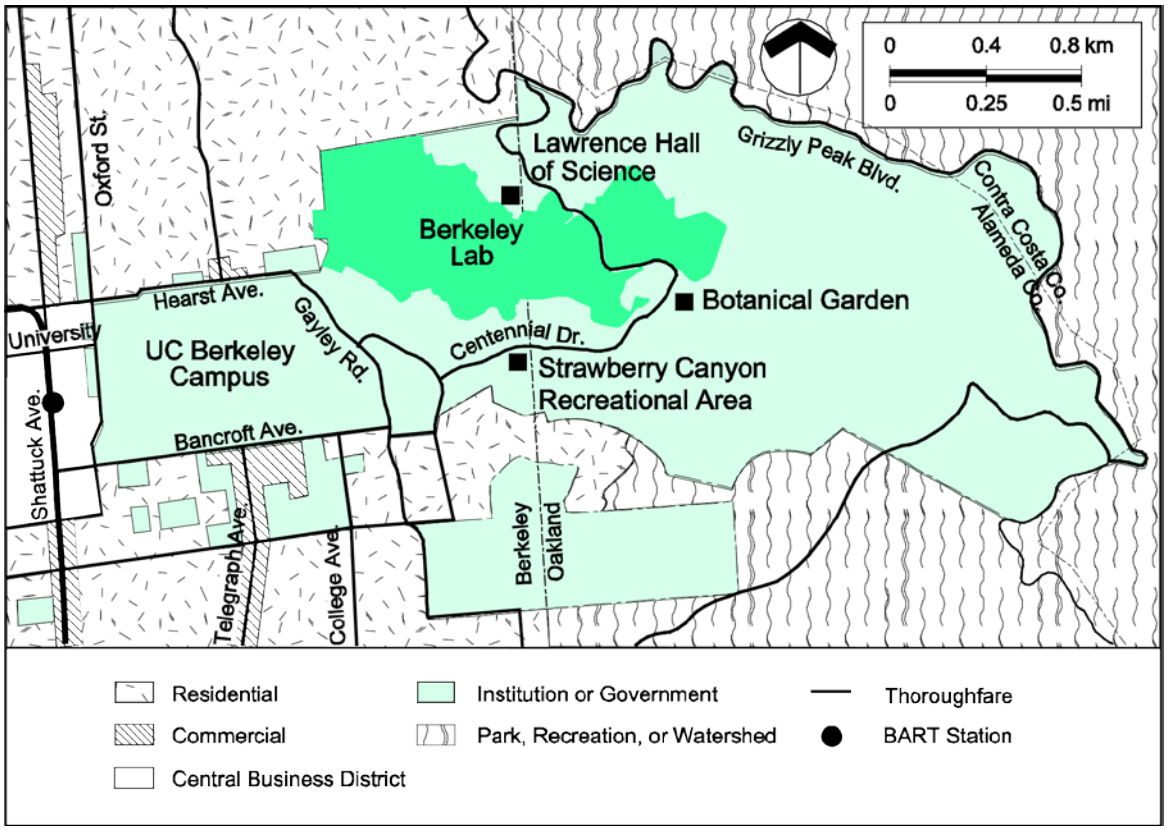

Figure 1-2 Adjacent Land Use

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

The East Bay Municipal Utility District (EBMUD) supplies water, which originates in Sierra Nevada watershed lands and is conveyed to the Bay Area and ultimately to Berkeley Lab through a system of rivers, lakes, aqueducts, treatment plants, supply lines, and pumping stations. EBMUD tests the water for contaminants and treats it to meet disinfection standards required by the Safe Drinking Water Act.[1] Three large tanks store water for emergencies. There are no drinking water wells onsite.

1.5 METEOROLOGY

The temperate climate – cool, dry summers and relatively warm, wet winters – is heavily influenced by the moderating effects of nearby San Francisco Bay and the Pacific Ocean to the west, and the East Bay hills to the east. The annual average temperature at the site is 55 degrees Fahrenheit (°F), with temperatures in the range of 41°F 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.

Based on more than 40 years of on-site measurements, the average precipitation total for a "water year" is 30.0 inches of rain (with no record of measurable snow). The term water year is used by hydrologists and climatologists to represent rainfall occurring between October 1st of one year and September 30th of the next year. Reporting water year rainfall better characterizes California's seasonal rainfall cycle, as data for 2014 shows. The precipitation total for the calendar year – at just over 34 inches – indicates above normal rainfall. However, the totals for the last two water years were 18.9 and 22.7 inches, respectively, consistent with the extraordinary drought conditions affecting California and much of the western states for a fourth consecutive year.

During calendar year 2014 nearly 80% of the total fell during the months of February (2013-14 water year) and December (2014-15 water year). Precipitation for the remaining months of calendar year 2014, and both of these water years, was considerably below normal.

On-site wind patterns change little from year to year as shown by the "wind rose" comparison in Figure 1-3. The illustration on the left shows the distribution of wind patterns for 2014, while the illustration on the right summarizes the wind patterns at the site since 1994. The most common wind pattern occurs during fair weather, with westerly winds blowing off the bay. The other predominant wind pattern is associated with stormy weather when south-to-southeast winds blow in advance of each system, followed by a shift to west or northwest winds after its passage.

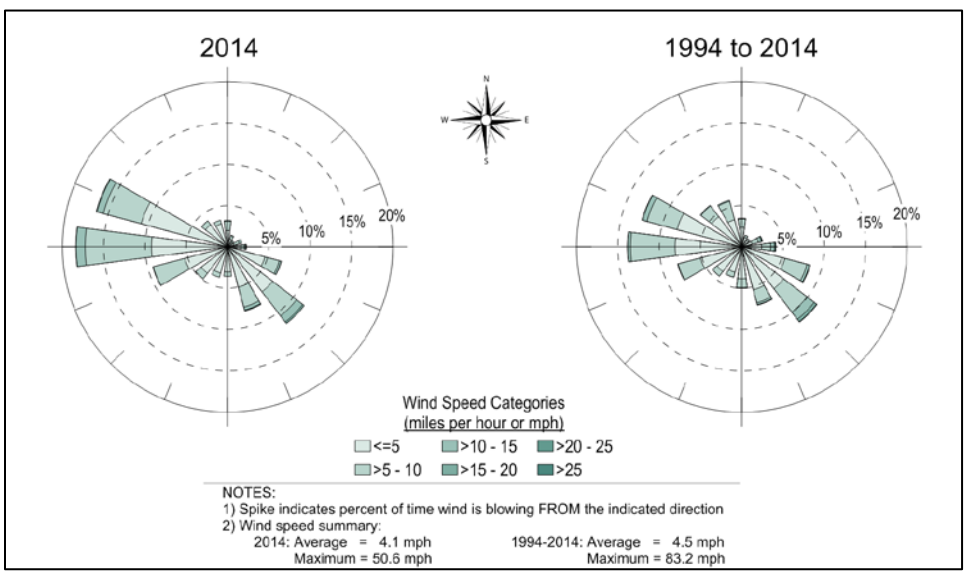

Figure 1-3 Annual Wind Patterns

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.

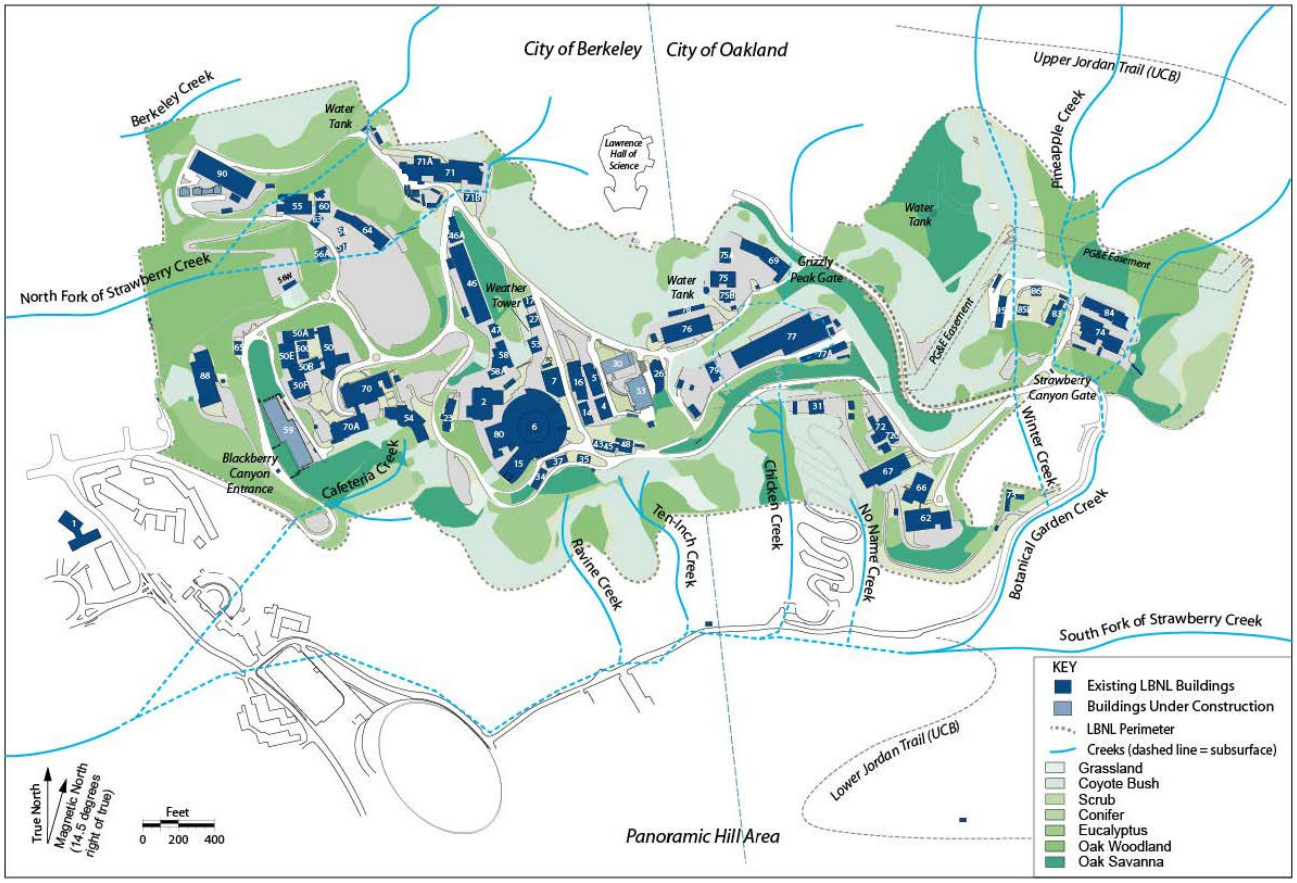

Figure 1-4 Vegetation Types

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 GEOLOGY

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, also referred to as "Old Town". The Moraga Formation 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 Strawberry Creek watershed. The two main creeks in this watershed receiving storm water discharges from the Berkeley Lab site 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, along with their tributaries on or near the site, are shown on Figure 1-5.

1.10 GROUNDWATER

The groundwater elevations are also shown on Figure 1-5. The water table approximately mirrors surface topography, flowing from higher to lower elevation. 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.

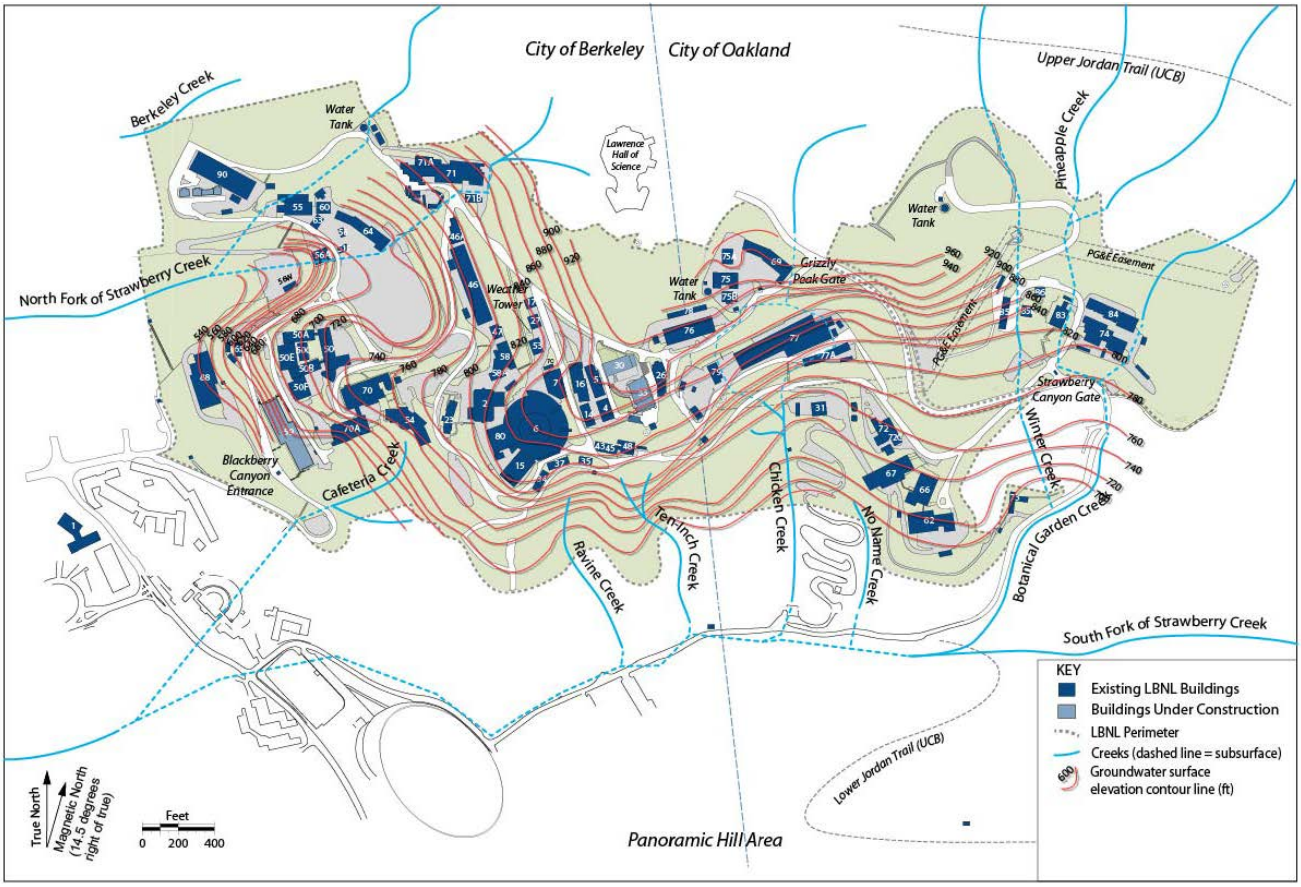

Figure 1-5 Surface Water and Groundwater Elevation Map

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 EMS has been established that provides a systematic approach to ensure environmental activities are well-managed, reduce environmental impacts, and provide business value. The EMS addresses regulatory compliance, program performance, and cost-effectiveness of activities, and also strives for continual improvement through the 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 at https://commons.lbl.gov/display/SBL/Environmental+Management+System.

DOE Order 436.1 also states that a site's sustainability goals must be integrated into the EMS. Berkeley Lab's *Site Sustainability Plan for FY2015*[4] sets performance goals in the following areas:

- Greenhouse gas reduction
- Sustainable buildings
- Fleet management
- Water use efficiency and management
- Pollution prevention and waste reduction
- Sustainable acquisition
- Electronic stewardship and data centers
- Renewable energy
- Climate change resilience
- Energy performance contracts

Berkeley Lab's sustainability plan is updated each year. The current and previous plans are available at https://commons.lbl.gov/display/SBL/Reports.

2.2 EMS IMPLEMENTATION

The ISO 14001 standard contains eighteen elements. Berkeley Lab has developed six procedures for implementing an EMS program to comply with the most important aspects of these elements. The procedures cover the following topics:

- 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. It includes representatives from organizations key to meeting the site's environmental objectives, namely Environment, Health, and Safety (EHS), Facilities, Sustainable Berkeley Lab, and Procurement and Property Management. An EHS representative leads the team, and a DOE Berkeley Site Office representative attends scheduled meetings to maintain awareness. A meeting was held in June, though team members interact regularly while working toward performance goals. Primary Core Team functions include:

- Identifying environmental aspects and determine their significance
- Developing objectives and targets for significant aspects
- Preparing and implement EMPs
- Coordinating internal assessments and external audits of the EMS
- Reviewing performance results
- Preparing recommendations to management to improve the EMS

2.2.2 Environmental Aspects

In preparation for the Core Team's June meeting, the list of identified environmental aspects –any activity, product, or service that interacts (adversely or beneficially) with the environment – was reviewed. No new aspects were added as a result of this review. Each aspect was scored according to a methodology that considers the following eight factors:

- 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

For each aspect determined as significant from the scoring methodology, an EMP document is developed to define the objective, target, strategy, and actions. Each document is periodically reviewed and updated. The 2014 annual review identified no change from the previous year to the seven significant aspects warranting an EMP document. Current significant aspects are listed below, with the target, objective, and status of each summarized in Table 2-1:

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 external audit of the Berkeley Lab EMS once every three years that must be performed by a qualified independent party. An audit of this type was conducted in May 2015 in advance of the end of June deadline, allowing Berkeley Lab to develop a corrective action plan for all audit findings. As a result, DOE Berkeley Site Office declared the EMS in conformance with the ISO 14001 standard. The standard also requires one or more independent internal audits conducted between two consecutive external audits.

2.2.6 Management Review

Senior management of organizations involved in implementing the EMS periodically meet with the EMS Program Manager to review, at minimum, the following topics cited in the ISO standard to determine any adjustments that may be 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 FY14
Energy Use	Implement sustainable practices to achieve energy efficiency	Reduce energy use intensity 30% by end of FY2015, including a minimum cumulative reduction of 27% by end of FY2014 relative to FY2003 baseline year	Consumption 4% 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 by 28% and selected Scope 3[b] emissions 13% by end of FY2020 (baseline: FY2008)	Scope 1 and 2 emissions were 7% below baseline (high risk of not attaining target of a 28% reduction due to expected future projects) Scope 3 emissions were 2% below 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 (baseline: FY2005 fleet fuel consumption).	Consumption 72% below baseline (low risk of not attaining target of 2% annual reduction)
Solid Waste Diversion	Increase solid waste diversion	Divert at least 75% of non-hazardous solid waste, excluding construction and demolition debris, by the end of FY2015. Divert at least 75% of construction and demolition debris by the end of FY2015.	54% diversion for non-hazardous solid waste (low risk of not attaining target of 50% diversion) 84% diversion for construction and demolition debris (low risk of not attaining target of 50% diversion)
Sustainable Acquisition	Increase procurement opportunities for environmentally sustainable products	Increase the percentage of priority sustainable products purchased (baseline: FY2012).	Where applicable, 98% 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 (baseline: FY2007); Reduce industrial / agricultural water use 20% by end of FY2020 (baseline: FY2010); Update and execute annual Water Metering Plan.	Consumption 27% below baseline (medium 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

2.2.7.1 DOE's EMS Performance Evaluation

In DOE Berkeley Site Office's *FY2014 Performance Evaluation Annual Report*[6] Berkeley Lab received an "A-" score for providing an effective and efficient EMS. The DOE report summarizes the *FY14 Performance Evaluation and Measurement Plan,*[7] as required by the operating contract between DOE and UC. It cites the following accomplishments as contributing to the A- grade:

- Successfully characterizing the building and subsurface hazardous and radiological contamination for the "Old Town" Demolition Project and working effectively with both DOE Office of Environmental Management and Berkeley Site Office to implement related requirements into the project's subcontract. Relatedly, LBNL proactively engaged the U.S. Environmental Protection Agency (U.S. EPA) and the Department of Toxic Substances Control (DTSC) to find a strategy for dealing with polychlorinated biphenyl (PCB) soil contamination and a source of PCB discharges to the sanitary sewer at the project site.
- Commissioning a comprehensive third-party assessment of the Environmental Radiological Protection Program that identified only one finding, which has since been resolved.
- Meeting submission deadlines for over 100 environmental protection and restoration documents, including compliance reports and operating permit applications and renewals.
- Completing waste shipments that significantly decreased legacy waste and inventory in storage.

2.2.7.2 Federal Office of Management and Budget EMS Reporting Scorecard

A second component of EMS reporting originated from the 2007 Executive Order 13423, *Strengthening Federal Environmental, Energy, and Transportation Management*.[8] To measure performance against goals established in this Executive Order, the federal Office of Management and Budget has set up an online reporting scorecard that collects annual performance information in the following eight categories from sites associated with each federal agency:

- 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

For FY2014, Berkeley Lab's EMS program earned the score of "yellow" (green is best) based on collective ratings in the eight categories. The program gained enough "D" grades (best) without receiving any "A" grades (worst) toward achieving a green score, but only one "B" grade is allowed and LBNL's program received two B grades as follows:

1. For the "Environmental Training" category, new Core Team members who joined in June had not received training prior to the end of the fiscal year, September 30.
2. For the "Management Review" category, a review was not held during FY2014 because the priority was on implementing a new lab-wide Work Planning and Control system that drew resources away from EMS activities. The new Work Planning and Control system was developed in response to a 2009 DOE audit finding that identified the approach to authorizing work activities did not meet the requirements of DOE Order 450.2, *Integrated Safety Management*.

3. Environmental Program Summary

3.1 INTRODUCTION

This chapter summarizes the status of environmental compliance programs and includes general regulatory requirements, permits issued by regulatory agencies, and audits and inspections conducted during the year.

3.2 ENVIRONMENTAL PERMITS

Certain activities require operating permits issued by government agencies. Table 3-1 summarizes, by area of environmental activity, the 61 active permits held by LBNL at the end of 2014.

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
CUPA[b] (permit and registration)	ACEH[c]	Hazardous Materials Business Plan and hazardous waste generator areas (3.5.2)	Joint BioEnergy Institute
	CCHS[d]	Aboveground storage tanks (3.5.4.3) Hazardous Materials Business Plan and hazardous waste generator areas (3.5.2)	Joint Genome Institute
	COB[e]	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[f]	Hazardous Waste Handling Facility operations and hazardous waste generator areas (3.5.3.1)	Main Site
Stormwater	SWRCB[g]	Sitewide and construction stormwater discharges (3.5.4.2)	Main Site
Surface water and sediment	EBRPD[h]	Surface water and sediment sampling (4.3.1, 4.6.2)	Tilden Park
Wastewater	CCCSD[i]	Wastewater discharges to sanitary sewer (3.5.4.1)	Joint Genome Institute
	EBMUD[j]	Sitewide and operation-specific wastewater discharges to sanitary sewer (3.5.4.1)	Main Site

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

3.3 AUDITS AND INSPECTIONS

The regulatory agencies that enforce environmental requirements periodically conduct on-site inspections. A summary of inspections conducted in 2014 is provided in Table 3-2. This table includes the self-monitoring inspections conducted by Berkeley Lab as required by EBMUD wastewater discharge permits, since the self-monitoring results expose LBNL to potential regulatory actions. A total of 15 inspections were conducted during 2014, resulting in four minor violation notices, which are discussed in Section 3.5.3.1.

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

Organization	Inspection Type	Start Date	Violations
BAAQMD[a]	Air quality	Mar 11	0
COB[b]	Hazardous Waste Satellite Accumulation Areas	June 17 to 19	3
	Tiered permitting units (i.e., fixed wastewater treatment units)	June 25	0
	Underground storage tanks	July 24 Oct 30	0 0
EBMUD[c]	Wastewater monitoring inspection at Hearst and Strawberry sanitary sewer outfalls	Jan 14 & 15 July 2	0 0
	Wastewater monitoring inspection at Building 77 Fixed Treatment Unit	July 1	0
LBNL	EBMUD self-monitoring inspections at groundwater treatment units	Feb 19 July 22	0 0
	EBMUD self-monitoring inspections at B77 Fixed Treatment Unit	Sept 17	0
	EBMUD self-monitoring inspections at Hearst and Strawberry sanitary sewer outfalls	March 19 Sept 3	0 0
RWQCB[d]	Inspection of Computational Research and Theory construction site	Sept 9	0
U.S. EPA[e] (participation from COB and DTSC[f])	Hazardous Waste Handling Facility, hazardous waste generator and accumulation (SAA[g], WAA[h]) areas	July 31 & Aug 1	1

[a] Bay Area Air Quality Management District
[b] City of Berkeley
[c] East Bay Municipal Utility District
[d] (San Francisco Bay) Regional Water Quality Control Board
[e] United States Environmental Protection Agency
[f] California Department of Toxic Substances Control
[g] SAA – Satellite Accumulation Area
[h] WAA – Waste Accumulation Area

3.4 DOE-REPORTABLE ENVIRONMENTAL INCIDENTS

Three environmental incidents occurred during the year that resulted in submittal of reports under the DOE's occurrence reporting program, which tracks incidents across the DOE complex. The three incidents were:

1. On February 12, an estimated 50 gallons of sewage overflowed onto Lawrence Road from a sanitary sewer manhole east of the Firehouse (Building 48) and south of Building 61 due to a blockage in the line. An estimated 30 gallons of the sewage entered a storm drain. (Occurrence Report #SC--BSO-LBL-OPERATIONS-2014-0003)

2. On February 15, in the same general area as the spill three days earlier, an estimated 225 gallons of sewage overflowed the sanitary sewer system and entered a storm drain.
   It was later discovered that the blockage was caused by a misaligned or broken section of pipe. (Occurrence Report #SC--BSO-LBL-OPERATIONS-2014-0004)
3. On June 19, a notice of violation was issued by the City of Berkeley during an inspection for minor noncompliance issues with satellite accumulation areas in Buildings 64, 70, and 71. (Occurrence Report #SC--BSO-LBL-EHS-2014-0003)

Both sewage releases were reported promptly to the appropriate state and local agencies, and minimal impact on the environment occurred. Further information about these events is available through the DOE's occurrence reporting website: http://energy.gov/ehss/policy-guidance-reports/dashboards.

3.5 COMPLIANCE PROGRAMS

The primary federal laws driving Berkeley Lab compliance programs for federal, state, and local environmental regulations 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 the following regulations: *National Emission Standards for Emissions of Radionuclides Other Than Radon from Department of Energy Facilities*[2] and 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 (mrem/yr). Doses from Berkeley Lab activities in 2014 were about 0.25% of these limits.

Berkeley Lab documents its NESHAP review and compliance in its annual *Radionuclide Air Emission Report*,[4] which is available on ESG's publications website: http://www2.lbl.gov/ehs/esg/Reports/tableforreports.shtml.

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 (CARB) administers regulations on mobile sources such as vehicles as well as regulations on certain toxic chemicals. At the end of 2014, Berkeley Lab held 32 operating permits issued by the BAAQMD,[6] as listed in Table 3-3. Thirty 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 at the recently commissioned Solar Energy Research Center (Building 30).

Operating permits are renewed annually, at which time 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, as well as submittal of Berkeley Lab's site-wide adhesive and sealant usage under a 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.

Table 3-3 BAAQMD Permitted Air Emission Sources

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 (4)	30, 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.

CARB regulations governing the use and release of the potent greenhouse gas sulfur hexafluoride (SF_6) took effect in 2012. This regulation targets SF_6 because its global warming potential is 23,900, making it the highest global warming potential value for any substance currently identified. Beginning in 2013, CARB 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 for 2014 for ongoing research performed by Berkeley Lab's Environmental Energy Technologies Division, where researchers use very small quantities of SF_6 as a tracer gas for building ventilation and air movement studies. Berkeley Lab must report SF_6 usage and show progress in finding a substitute tracer gas as CARB moves toward phasing out research exemptions. Additionally, CARB regulates SF_6 emissions from gas insulated switchgear by requiring an annual usage report. This affects 15 switches and breakers at Berkeley Lab.

CARB's Refrigerant Management Program regulates stationary non-residential refrigeration systems that use more than 50 pounds of a refrigerant with high global warming potential by requiring use reporting and fee payment. Berkeley Lab's 66 refrigeration systems affected by this program are on the main site and at the Oakland Scientific Facility, which houses the National Energy Research Scientific Computing Center.

A federal mandate established in 2005 requires that Berkeley Lab decrease the use of petroleum fuel 2% each year through such strategies as switching to alternative fuels, increasing the fleet's fuel efficiency, and reducing fleet size. These actions reduce both dependence on petroleum and greenhouse gas emissions and are incorporated into LBNL's EMS aspect "Petroleum Use" listed in Table 2-1. Berkeley Lab is achieving this goal by operating an E85 fuel (85% ethanol, 15% unleaded gasoline) dispensing facility that now serves over 100 fleet vehicles. The fleet includes 16 hybrid vehicles, bringing the percentage of LBNL's alternative fueled fleet vehicles to 72%. An additional 73 electric carts contribute to achieving the 2% per year goal by reducing the size of the petroleum consuming fleet. (However, since the U.S. Department of Transportation categorizes electric carts as a "neighborhood electric vehicle," they are not counted as alternative-fueled vehicles in the LBNL fleet.)

Beginning in FY2010, Executive Order 13514, *Federal Leadership in Environmental, Energy, and Economic Performance*, 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 reporting thresholds Reporting requirements under other regulations such as the 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] which was passed in 1986 as Title III of the *Superfund Amendments and Reauthorization Act* (SARA), 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 addresses these requirements as summarized below.

As a federal facility, LBNL is subject to EPCRA Toxic Release Inventory reporting requirements. If threshold usage quantities are exceeded, a U.S. EPA Form R must be submitted. LBNL determined in 2014, as in recent years, that no chemical usage exceeded the chemical-specific Toxic Release Inventory criterion for a listed substance, and that DOE was therefore not required to submit a Form R on behalf of LBNL. Table 3-4 summarizes LBNL's assessments of highest chemical usage quantities since 2007.

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

Substance	Quantity (pounds)							
	2007	2008	2009	2010	2011	2012	2013	2014
Chlorofluorocarbons	1140	209	172	150	319	202	70	193
Methanol	139	152	180	147	88	103	172	127
Nitric acid	198	667	614	592	634	631	633	556
1,1,1-trichloroethane	<2.2	<2.2	<2.2	<2.2	0	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: 1) 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); 2) emergency plans; 3) procedures; 4) training; and 5) a facility map. The HMBP for each facility listed below is updated each year and submitted electronically to the California Environmental Reporting System. These plans are also available on ESG's publications web page at http://www2.lbl.gov/ehs/esg/Reports/tableforreports.shtml. The facilities for which an HMBP is prepared are:

- Berkeley Lab Main Site
- Joint Center for Artificial Photosynthesis
- Berkeley West Biocenter
- Joint BioEnergy Institute and the Advance Biofuels Process Demonstration Unit
- Joint Genome Institute

3.5.3 Resource Conservation and Recovery Act

The *Resource Conservation and Recovery Act* (RCRA)[10] 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. RCRA's primary goals 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 primarily impacts Berkeley Lab operations in these three areas:

1. Treatment and storage of hazardous waste (including the hazardous portion of mixed waste)
2. Investigation and cleanup of historical releases of hazardous chemicals to the environment
3. Storage of petroleum products in underground storage tanks

3.5.3.1 Hazardous Waste

In California, DTSC administers the hazardous waste program. The state's program incorporates the provisions of both the federal and state hazardous waste laws,[11] and includes permitting and enforcement elements.

The state's permitting program for hazardous waste treatment and storage facilities consists of five tiers, as listed in Table 3-5 in order of decreasing regulatory complexity. Berkeley Lab's Hazardous Waste Handling Facility operates under a full permit issued by DTSC, which authorizes storage and treatment of certain hazardous and mixed wastes at the facility. Berkeley Lab's hazardous wastewater treatment permit for four fixed treatment units (FTUs)[12] is issued by the City of Berkeley. Oversight over the three lowest tiers is delegated to the City of Berkeley under California's Certified Unified Program Agency program. The FTU permit is renewed annually as part of the HMBP submission process for the main site.

Table 3-5 California's Tiered Permitting Program Overview

Program Tier	Regulatory Agency Oversight	LBNL Facilities under each Program Tier
Full permit	DTSC	Hazardous Waste Handling Facility
Standardized permit	DTSC	—
Permit-by-rule	City of Berkeley	FTU 006, FTU 007
Conditional authorization	City of Berkeley	FTU 004, FTU 005
Conditional exemption	City of Berkeley	—

FTU treatment types and operational throughput is summarized in Table 3-6. Also shown is the amount of wastewater recycled in 2014 by the FTU serving Buildings 70A and 70F. By doing so, nearly 95% of the water processed by this FTU was diverted to supply a nearby cooling tower with nearly all the water it consumes. Since the recycling system was installed in 2011, the total volume recycled has now reached 1.7 million gallons.

Table 3-6 Fixed Treatment Unit Operations Summary

FTU	Building No.	Treatment Types	Gallons of Wastewater Treated in 2014
004	70A/70F	Acid neutralization	464,195 (441,430 recycled)
005	2	Acid neutralization	61,844
006	77	Metals precipitation and acid neutralization	18,573
007	67	Acid and alkaline neutralization	34,630

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.*[13] Low-level radioactive waste is managed in accordance with DOE orders. Mixed waste is managed in accordance with the *Mixed Waste Site Treatment Plan*[14] and is subject to both California regulations and DOE orders.

In June, the City of Berkeley conducted separate inspections of FTUs and satellite accumulation areas around the main site. No violations were issued as a result of the FTU inspection, but three minor violations related to labeling were issued at the satellite accumulation areas, as follows:

- A 5-gallon metal container in Building 64 was labeled as "unknown substance"
- A container of acetic acid in Building 70 did not include a hazardous waste label
- Wire containing solder in Building 71 was not labeled as hazardous waste

Berkeley Lab's immediate response included sending a sample of the material in Building 64 for analysis and attaching proper hazardous waste labels to the items in Buildings 70 and 71. The analytical results on the unknown substance allowed for proper characterizing and processing for disposal as hazardous waste.

On July 31 and August 1, an unannounced inspection by U.S. EPA, DTSC, and the City of Berkeley representatives was conducted of the Hazardous Waste Handling Facility and selected waste generator areas and permitted storage and treatment areas. Waste records were also reviewed. Initially, four violations at the Building 77 FTU were issued as described below (2 through 4 were later contested by LBNL and dismissed by U.S. EPA):

1. An open waste accumulation container was not labeled
2. The contents of an open five-gallon container were not known: the lead FTU operator was absent at the time of the inspection due to a family emergency. It was the understanding of the backup operator that the only liquid in the container was water. That was confirmed by the lead operator upon his return. Analytical testing further confirmed the absence of any hazardous components in the container or residual solids.
3. Used filter pads were not containerized and also were not labeled: the violations were based on an assumption that the waste treated in the FTU was part of an electroplating operation and therefore would carry a U.S. EPA F006 hazardous waste code. The treated waste does not include waste generated from an electroplating operation, and therefore not an F006 listed waste.
4. Used gloves contaminated with listed hazardous waste from the FTU were not containerized: see item number 3, above.

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 (environmental restoration activities) approved by DTSC in the *Corrective Measures Study Report*.[15] 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 performed to clean up contaminated groundwater consist of the following:

- *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.
- Hydrogen Release Compound is an environmentally-safe polylactate ester formulate used to enhance the natural biodegradation of volatile organic compounds (VOCs) that has been injected at regular intervals into certain contaminant plume source areas.
- Monitored natural attenuation 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*[16] and a *Groundwater Monitoring and Management Plan*.[17] 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 web page (see http://www2.lbl.gov/ehs/erp/html/documents.shtml).

3.5.3.3 Underground Storage Tanks

In the early 1980s California began addressing groundwater contamination from leaking USTs through a rigorous regulatory and remediation program.[18] 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.[19] The City of Berkeley is the local administering agency for UST regulations that apply to Berkeley Lab. There are six permitted USTs onsite containing either diesel or unleaded gasoline, as shown in Table 3-7 and Figure 3-1. LBNL has removed and properly closed nine USTs since 1993.

On July 24, tri-annual secondary containment testing was performed on all UST systems. All UST systems passed. The City of Berkeley witnessed the tests and also found all USTs to be in compliance with secondary containment requirements. On October 30, the annual testing and recertification of leak-detection monitors for all UST systems was conducted. On the same day all product piping for the UST systems passed pressure tests, and an annual inspection by the City of Berkeley was conducted. All USTs were found to be compliant with regulations.

Table 3-7 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

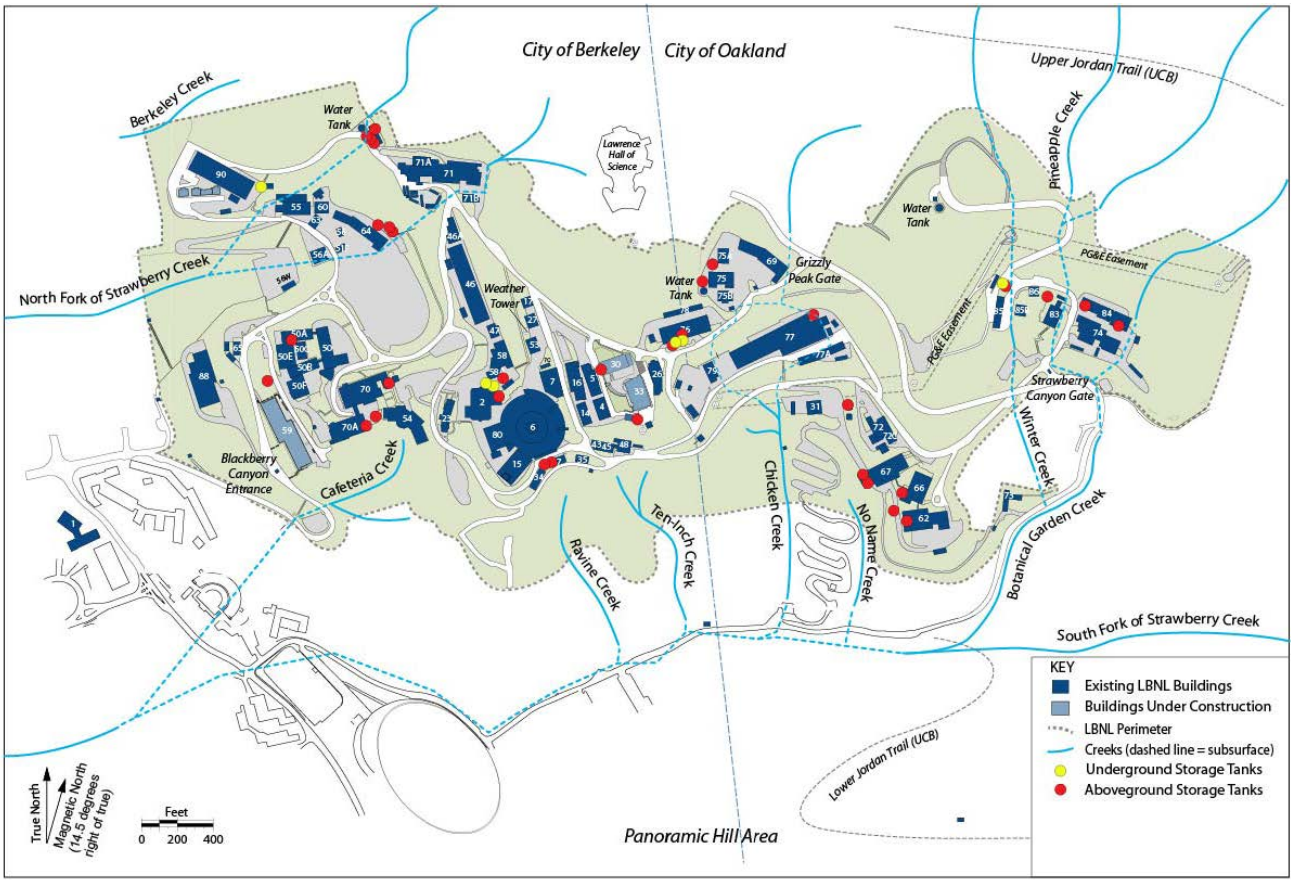

Figure 3-1 Storage Tank Locations (Above and Underground)

3.5.4 Clean Water Act

The *Clean Water Act*[20] 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*[21] 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 responsible agencies for regulatory oversight are the San Francisco Bay RWQCB for stormwater discharges 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 EBMUD[22] wastewater discharge permits for the following activities at the main site:

- General sitewide wastewater discharges
- Treatment systems discharge of groundwater from hydraugers and groundwater monitoring wells
- FTU discharge of rinse water from the metal finishing operations in the Ultra-High Vacuum Cleaning Facility at Building 77
- Special permit for construction and demolition discharges

The sitewide and groundwater treatment system permits approved in 2013 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 2014. For more information regarding LBNL's annual wastewater self-monitoring program results, see Chapter 4.

EBMUD periodically inspects the site's sanitary sewer discharge without prior notice, and in 2014 this occurred on three occasions, as listed in Table 3-2. The 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 for metal finishing operations in the Ultra-High Vacuum Cleaning Facility. This document 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. This document also includes emergency response procedures.

EBMUD issued a special wastewater discharge permit for treated rainwater from the Computational Research and Theory facility (Building 59) construction project. EBMUD renewed this permit in April 2013. Berkeley Lab's last discharge to the sanitary sewer occurred in May 2014.

Berkeley Lab also holds a *Class III Industrial User Permit*[23] for general wastewater discharged at the JGI facility in Walnut Creek, re-issued by Central Contra Costa Sanitary District in December. This permit specifies requirements for inspecting and reporting on operations. There are 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).[24] 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)[25] and an *Alternative Stormwater Monitoring Plan* (ASMP).[26]

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 ASWP describes the rationale for sampling, sampling locations, and analytical parameters. Together, these documents represent LBNL's plan and procedures for identifying, monitoring, and reducing pollutants in its stormwater discharges.

As required by the IGP, Berkeley Lab submitted the annual report on stormwater activities to the RWQCB by July 1. This report[27], along with other recent annual reports, is posted on ESG's publication web page at: http://www2.lbl.gov/ehs/esg/Reports/tableforreports.shtml.

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.[28] During 2014, 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
- Facility for Low-Energy eXperiments in buildings LABoratory (FLEXLAB)

A Notice of Termination for the FLEXLAB construction permit was approved by the SWRCB on July 1. The permits for the other two construction projects remained active at the end of 2014, although a separate Notice of Termination for the Solar Energy Research Center and Computational Research and Theory construction permits will be submitted in 2015.

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*[29] outlines the regulatory requirements for ASTs. ASTs containing chemicals or hazardous materials consist of FTU tanks, storage drums at waste accumulation areas, and storage drums at product distribution areas. FTU operators inspect FTU tanks each operating day. EHS staff inspects waste accumulation areas weekly. Under the authority of the Clean Water Act, a *Spill Prevention, Control, and Countermeasure* (SPCC) *Plan*[30] is required for petroleum-containing aboveground tanks. 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. Their locations are shown in Figure 3-1.

In 2014, two new ASTs were installed at two newly constructed buildings: 1) a 660-gallon belly tank to an engine generator serving the General Purpose Laboratory (Building 33), and 2) a 640-gallon belly tank to an engine generator serving the Solar Energy Research Center (Building 30).

A 4,000-gallon AST at the JGI facility supports two standby emergency generators. The JGI maintains a separate SPCC Plan[31] for this AST.

3.5.5 Toxic Substances Control Act

The objective of the *Toxic Substances Control Act* (TSCA)[32] is to minimize the exposure of humans and the environment to chemicals used in manufacturing, processing, commercial distribution, and disposal activities. TSCA establishes a protocol for evaluating chemicals before they are introduced into the marketplace and controlling their use once they are approved for manufacturing. TSCA regulations are administered by the U.S. EPA.

Polychlorinated biphenyls (PCBs) are the principal substances at Berkeley Lab currently subject to the TSCA regulations. The only remaining equipment containing TSCA-regulated PCBs consists of four large low-voltage capacitors in Building 88. These capacitors remain in use and contain an estimated 170 kilograms (375 pounds) of regulated PCB dielectric fluid, which is below annual reporting thresholds to the U.S. EPA.

PCBs were detected in soil samples collected during a preliminary environmental hazard assessment of the Old Town area in preparation for demolition of Buildings 5 and 16. Concentrations were above the TSCA self-implementing cleanup level of 1 milligram per kilogram for soil in high-occupancy areas. Efforts to fully characterize the contamination are ongoing with regulatory oversight for cleanup of the PCB-contaminated soil conducted by the U.S. EPA. Characterization and cleanup activities have been and will continue to be described in the Environmental Restoration Program's progress reports 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.

3.5.6 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 considered in the decision making process by the designated Lead Agency. At Berkeley Lab, LBNL environmental staff provide information and technical support to assist DOE and UC in complying with NEPA and CEQA requirements.

In 2014, five 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/nepa-documents/. No Environmental Assessments or Environmental Impact Statements were prepared for Berkeley Lab activities.

4. Environmental Monitoring

4.1 INTRODUCTION

Berkeley Lab's environmental monitoring programs assess the impact of its emissions on public health and the environment, which are important for demonstrating compliance with requirements imposed by federal, state, and local agencies and for measuring environmental stewardship performance. These monitoring programs also confirm adherence to DOE environmental protection policies and support environmental management decisions.

A comprehensive *Environmental Monitoring Plan*[1] provides the basis and current scope for each monitoring program. This chapter presents summaries of 2014 sampling and monitoring results for the following programs:

- Stack air
- Surface water
- Wastewater
- Groundwater
- Soil and sediment
- Vegetation and foodstuffs
- Penetrating radiation
- Radiological clearance of property

4.2 AIR QUALITY

Berkeley Lab's air monitoring program, which consists of emissions sampling and monitoring to measure contaminants in building exhaust systems, 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]

Berkeley Lab uses various radionuclides in its radiochemical and biomedical research programs. Particle accelerators also generate radioactive materials. These operations may result in very small amounts of airborne radionuclides, which are typically emitted through building exhaust systems. Berkeley Lab is required to evaluate the potential for radionuclide emissions where radionuclides are used or generated. If the dose from potential emissions exceeds U.S. EPA Region 9-approved thresholds listed in Table 4-1, LBNL must measure emissions by sampling or monitoring stacks through which emissions are released following U.S. EPA-approved methods. Specifically:

- *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.

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

Category	AEDE[a] (millirem/year)	Requirements
Noncompliant	AEDE ≥ 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

All sites were evaluated in 2014 for their potential to emit radionuclides. All potential doses were found to be less than 0.1 mrem/yr, indicating that the applicable requirements are Category 3 – which requires periodic sampling – or Category 4 – which requires dose evaluation but no sampling or monitoring. In practice, Berkeley Lab follows a more conservative approach that may include real-time monitoring to better characterize emissions, or more frequent sampling and monitoring than required. In 2014, 16 stacks were sampled and real-time monitoring was performed on four stacks. Sampling and monitoring locations are shown in Figure 4-1.

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 2014, accounting for nearly 99% of the emitted activity. The Building 56 accelerator was the main source of fluorine-18 emissions at 6.65 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 and also published on ESG's publications web page at: http://www2.lbl.gov/ehs/esg/Reports/tableforreports.shtml.

For information on the projected dose from radionuclide emissions, see Chapter 5.

4.3 SURFACE WATER

4.3.1 Creek Sampling

Surface water is monitored by sampling creeks within the Strawberry Creek watershed. The creeks sampled either flow through or originate within the Berkeley Lab site and are shown on Figure 4-2. They include the North Fork of Strawberry Creek, Chicken Creek, Botanical Garden Creek, Cafeteria Creek, No-Name Creek, Ravine Creek, Ten-Inch Creek, and Winter Creek (inflow and outflow points). Because seasonal changes affect the flow volume and water quality in many of the creeks, samples are collected semi-annually – once during the wet season and once during the dry season. In 2014, sampling was conducted in March and August. To establish baseline water quality values, samples were also collected semi-annually from Wildcat Creek, which is located in Tilden Regional Park approximately 1.4 miles north-northwest of the UC's Lawrence Hall of Science. Results show that Wildcat Creek is not impacted by Berkeley Lab operations.

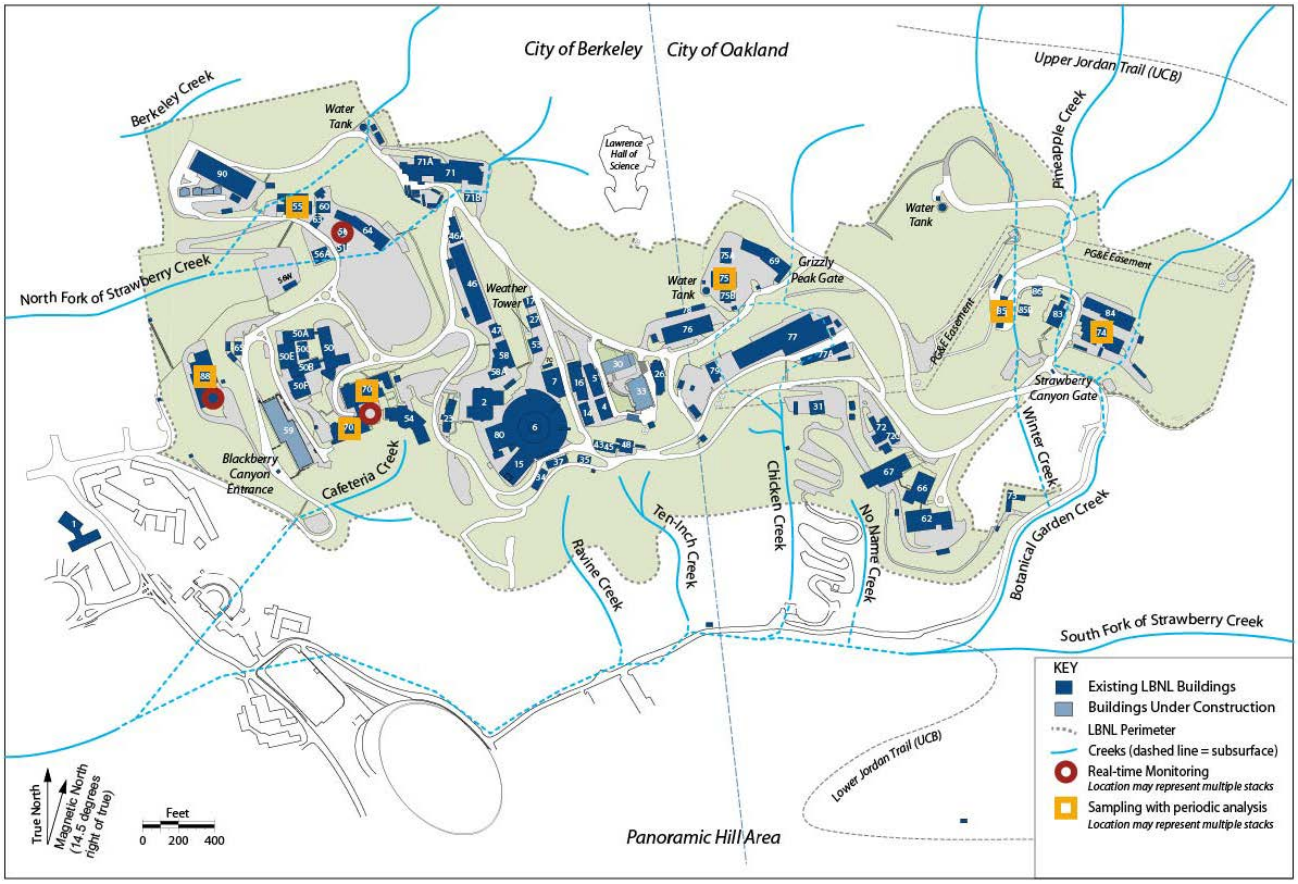

Figure 4-1 Building Exhaust Sampling and Monitoring Locations

Samples from the following subset of creeks were analyzed for gross alpha, gross beta, and tritium in accordance with DOE Order 458.1 requirements: Chicken Creek, the North Fork of Strawberry Creek, Wildcat Creek, and the same two locations on Winter Creek. Although LBNL surface waters are 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 values for drinking water are as follows: alpha is 15 picocuries/liter (pCi/L); beta is 50 pCi/L; and tritium is 20,000 pCi/L.[6,7]

Of the semi-annual samples collected, the only ones showing detectable analytical results were collected from Chicken Creek, and the activity values were very low; (1) both samples detected gross alpha, both at 15.3% of the MCL, (2) one sample detected gross beta at just over 6% of the MCL, and (3) one sample detected tritium at 1% of the MCL for drinking water.

Samples were also analyzed for VOCs and metals. VOCs were not detected in any creek. Metals detected in the creek samples were aluminum, antimony, barium, copper, iron, magnesium, selenium, 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, the March samples from Chicken Creek, the North Fork Strawberry Creek, and Wildcat Creek were analyzed for the following general indicator parameters: chemical oxygen demand (COD), 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

Under the terms of the state-wide IGP, stormwater sampling must take place during rain events at least twice each wet season (October 1 through May 30) under permit-specific conditions. Berkeley Lab's ASMP[8] describes the rationale for sampling, locations for sampling (see Figure 4-2), 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 results and visual observation summaries are included in the annual stormwater report. 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, best management practices were improved, as noted in each annual report. The current and recent reports are available on ESG's publications page at: http://www2.lbl.gov/ehs/esg/Reports/tableforreports.shtml.

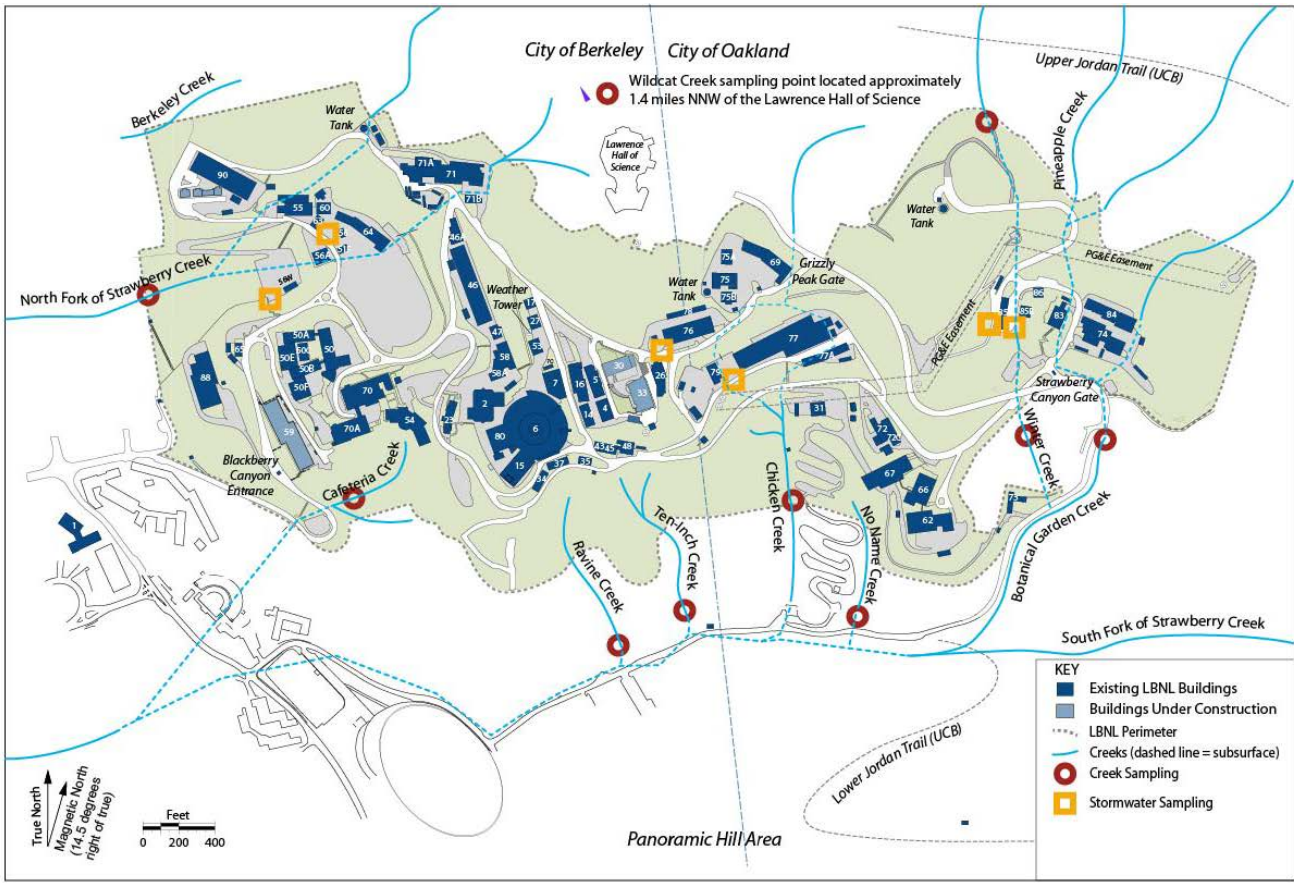

Figure 4-2 Stormwater Sampling Locations

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 the Ultra-High Vacuum Cleaning Facility at Building 77; treated groundwater operations at seven locations; and one special permit for wastewater discharges associated with construction at the Computational Research and Theory building. Each permit specifies EBMUD's periodic monitoring and reporting requirements.

Berkeley Lab's sanitary sewer system, shown in Figure 4-3, includes a monitoring station located near the outfall of each of the two main sewer system branches:

- Hearst Monitoring 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 is located immediately before the connection to the City of Berkeley's sewer main.
- Strawberry Monitoring Station, located next to Centennial Drive in lower Strawberry Canyon, monitors discharges from LBNL's eastern and southern areas, as well as several upstream UC Berkeley campus facilities. Downstream from the monitoring station the discharge system first ties into UC-owned piping and then into the City of Berkeley system.

As required by the permits, Berkeley Lab self-monitors wastewater discharges at these monitoring stations. Wastewater sampling is also conducted to monitor specific activities at hydraugers, extraction wells, and treated groundwater sites, as well as the Building 77 Ultra-High Vacuum Cleaning Facility. In addition, EBMUD 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 samples collected in the Hearst and Strawberry monitoring stations from their respective outfalls are analyzed for pH, total identifiable chlorinated hydrocarbons, TSS, COD, and specified metals. Total volumetric flow is also measured. In 2014, Berkeley Lab discharged approximately 19.7 million gallons through the Hearst branch of the sewer system and 21.5 million gallons through the Strawberry branch.

Radiological monitoring is required by DOE Order 458.1[9] and guidance,[10] and verifies compliance with radiological limits under the Nuclear Regulatory Commission 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 and the required self-monitoring reports are submitted to EBMUD. Based on sampling results, Berkeley Lab also submits an annual certification to EBMUD that its discharges are in compliance with Nuclear Regulatory Commission, DOE, state, and local regulations for discharges of radioactive materials.

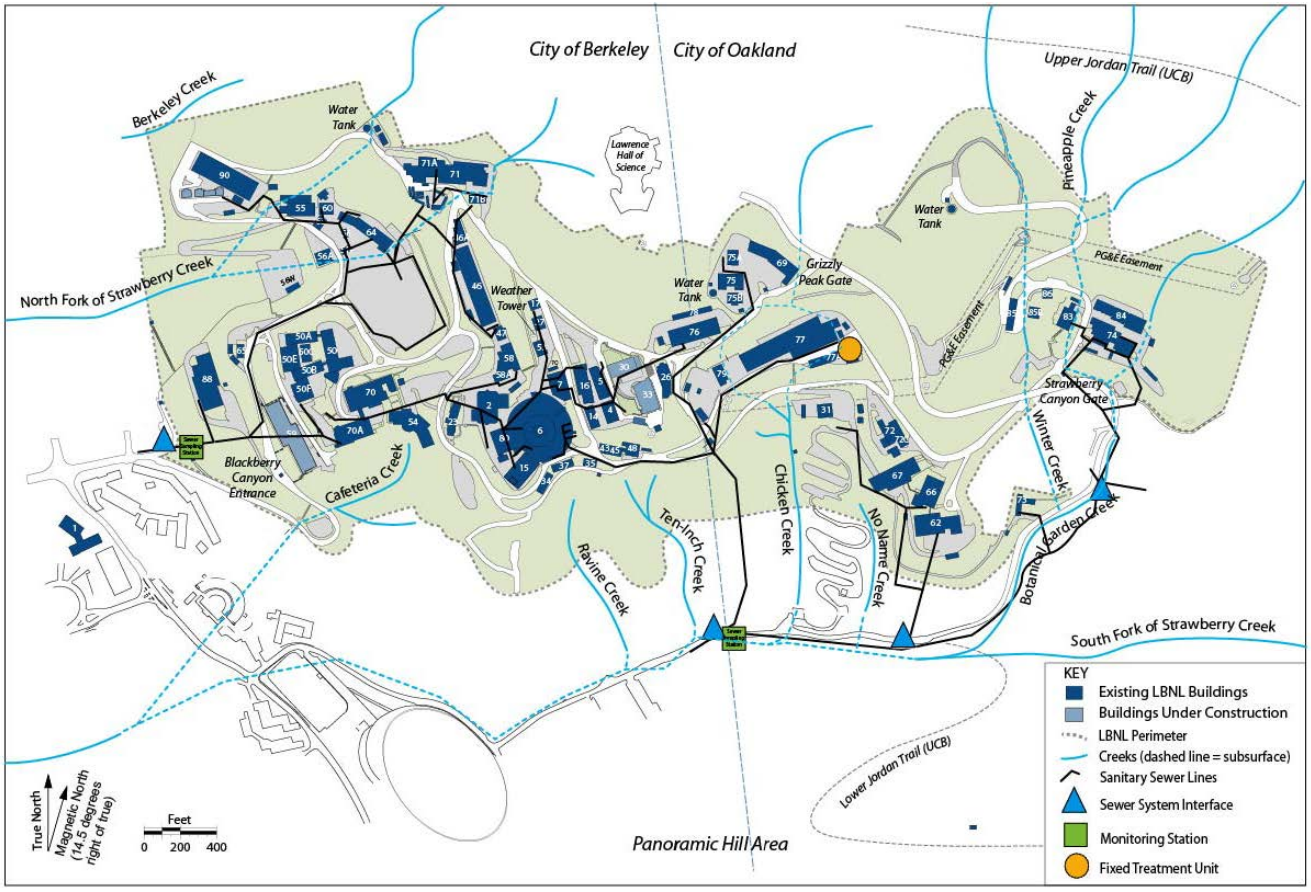

Figure 4-3 Sanitary Sewer System (Main Lines)

4.4.2.1 Non-radiological Monitoring

Berkeley Lab collected two non-radiological sets of samples from both the Hearst and Strawberry outfalls in March and September in accordance with the EBMUD-specified sample collection dates as part of required self-monitoring. Two further sampling events were carried out by EBMUD; one in January and one in July. 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

For radiological monitoring, time interval (every hour) composite samples are collected every month at the Hearst and Strawberry outfalls. The composite samples are analyzed by a state-certified laboratory for gross alpha, gross beta, 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 22.5 pCi/L, which is below the federal and state MCL for drinking water of 50 pCi/L.

The highest monthly gross alpha concentration was 6.04 pCi/L, which is also below the federal and state MCL for drinking water of 15 pCi/L. All samples taken at the Hearst or Strawberry sanitary sewer outfalls in 2014 were below the minimum detectable activity levels for carbon-14, iodine-125, and tritium.

Following DOE guidance, annual discharges are estimated by multiplying the activity found in the sample result by the volume discharged during the monitoring period, even when the activity level is below the minimum detectable limits. Since carbon-14, iodine-125 and tritium were below minimum detectable activity 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. The annual discharge estimated from tritium values totaled 3.30×10^{-3} Ci, or 0.07 % of the tritium discharge limit of 5 Ci. The annual discharge estimated from carbon-14 values totaled 2.68×10^{-3} Ci, or 0.27% 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 2.07×10^{-3} Ci, or 0.21 % 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 on consecutive 12-month average concentrations, and totaled together. Applying conservative assumptions to the radionuclides responsible for the gross alpha (thorium-232) and beta (strontium-90) activity, the calculated discharges were 0.009 and 0.027 of the allowable 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 collected since this program began 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 FTU 006, which can treat approximately 60 gallons per minute. EBMUD sampled the FTU effluent in July and Berkeley Lab conducted its annual FTU effluent sampling in September. Results for both sampling events showed that pH and metals were within the EBMUD permit limits.

LBNL submits a *Total Toxic Organics Compliance Report* once per year in December certifying that Building 77 is not discharging chlorinated hydrocarbons or other toxic organic compounds to the FTU or to the sanitary sewer. A sample taken by Berkeley Lab confirmed that results were well within permitted limits.

4.4.5 Sewer System Management Plan

Berkeley Lab's *Sewer System Management Plan*[12] addresses the SWRCB's requirements for maintaining LBNL's sanitary sewer systems, and preventing and reporting overflows. SWRCB regulations require that any public agency owning or operating a wastewater collection system with more than one mile of pipe in length prepare a written sewer system management plan to address the proper operation, maintenance, and funding of the system. Berkeley Lab must review its plan every 5 years (most recent update completed in early 2015) to ensure that current information is available regarding management, operation, and maintenance programs and objectives.

SWRCB's Sanitary Sewer Order[13] (WQ 2013-0058-EXEC, *Amending Monitoring and Reporting Program for Statewide General Waste Discharge Requirements for Sanitary Sewer Systems*) requires reporting of all spill activity, including monthly reporting for each month during which no sanitary sewer overflow occurred. Sanitary sewer overflow reporting is accomplished through the California Integrated Water Quality System, an online computer system used by the State and Regional Water Quality Control Boards to track water quality related information. In 2014, three sanitary sewer overflows requiring sampling and reporting occurred at Berkeley Lab. Four monthly "No-Spill" certifications were also submitted to the online system.

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 on RCRA Corrective Action Program activities 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 three 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
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, 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 that are sampled for one or more of the following analyses: VOCs, metals, or tritium. 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 4-4).

The monitoring data continue to indicate that the corrective measures are effective in reducing groundwater contaminant concentrations, groundwater plumes are stable or are attenuating, and contaminants are not migrating offsite in the groundwater.

4.5.2 Groundwater Sampling

Metals: Concentrations of metals detected in 2014 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[14] was arsenic in two wells. In addition, molybdenum, which has no drinking water standard, was detected above the upper estimate of background in four 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, Berkeley Lab monitors VOC-contaminated groundwater in six other localized areas as follows: former Building 51A, former Building 51 Vacuum Pump Room, Building 69A, Building 75/75A, Building 76, and Building 77.

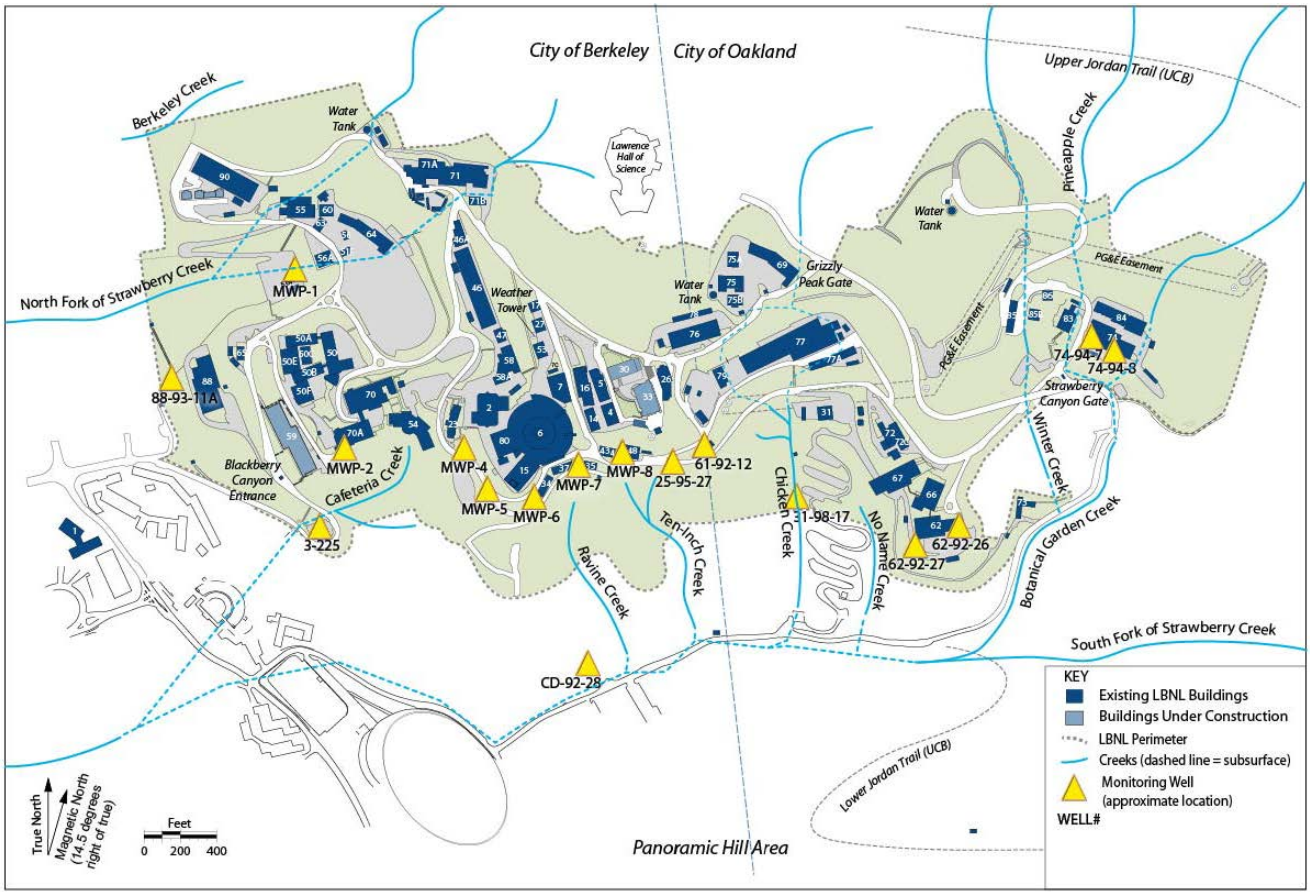

Figure 4-4 Downgradient Monitoring Wells Nearest the Site Boundary

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.

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[15,16] 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 former UST sites since 2003.

Polychlorinated Biphenyls: PCBs were detected in early 2014 in soil samples collected as part of the characterization of the Old Town Demolition Project area. To assess whether the contaminated soil impacted groundwater, samples were collected during in early 2015 from 15 wells located both in the areas where PCBs in soil had been detected and downgradient from those areas. No PCBs were detected in groundwater.

The locations where groundwater at Berkeley Lab is contaminated and the extent of groundwater with contaminant concentrations exceeding the drinking water standard are shown on Figure 4-5.

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 2014 to treat the extracted groundwater. The total volume of contaminated groundwater treated by these systems during the year was approximately 9.6 million gallons. From 1991 through the end of 2014, more than 164 million gallons of contaminated groundwater were extracted and treated. The treated water is primarily re-injected into the subsurface for *in situ* soil-flushing purposes. Treated water not needed for soil flushing is released to the sanitary sewer in accordance with an EBMUD permit for this type of discharge.[17]

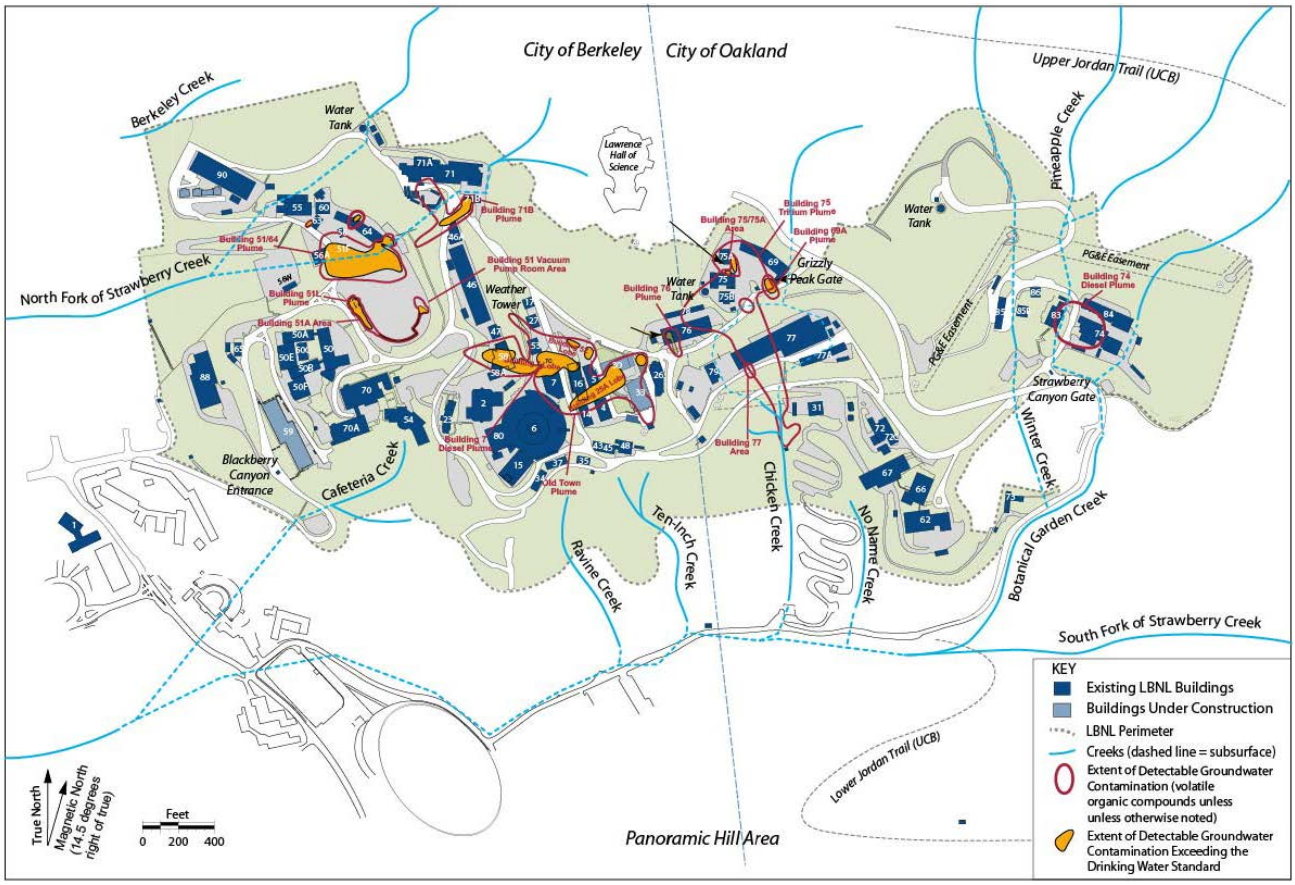

Figure 4-5 Locations of Groundwater Contamination (September 2014)

4.6 SOIL AND SEDIMENT

This section summarizes routine monitoring results for soil and sediment samples required by DOE Order 458.1 and guidance[18]. Of note for both soil and sediment, the alpha, beta, and gamma emitter results were consistent with background levels of naturally-occurring radioisotopes commonly found in these materials.[19,20]

Non-routine sampling conducted to investigate contamination at specific sites, such as the Old Town demolition project area, 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 4-6). Samples were analyzed for gross alpha and gross beta, gamma emitters, tritium, moisture content, pH, and 15 metals. For radioisotope analysis, besides alpha, beta, and gamma emitter results being consistent with background levels of naturally-occurring radioisotopes, tritium measurements at each sampling location were below detection limits with the exception of

the sampling location near Building 69. At this site, the detected tritium was slightly above the practical quantitation limit but below LBNL's reporting limit of 0.200 pCi/g. For non-radioisotope analysis involving metals, the results were within established Berkeley Lab background levels[21] or levels commonly found in California soils.

4.6.2 Sediment Sampling

Sediment samples were collected from the creek beds of Chicken Creek and the North Fork of Strawberry Creek on the LBNL site and at one off-site location at Wildcat Creek in Tilden Regional Park, as shown on Figure 4-6.

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

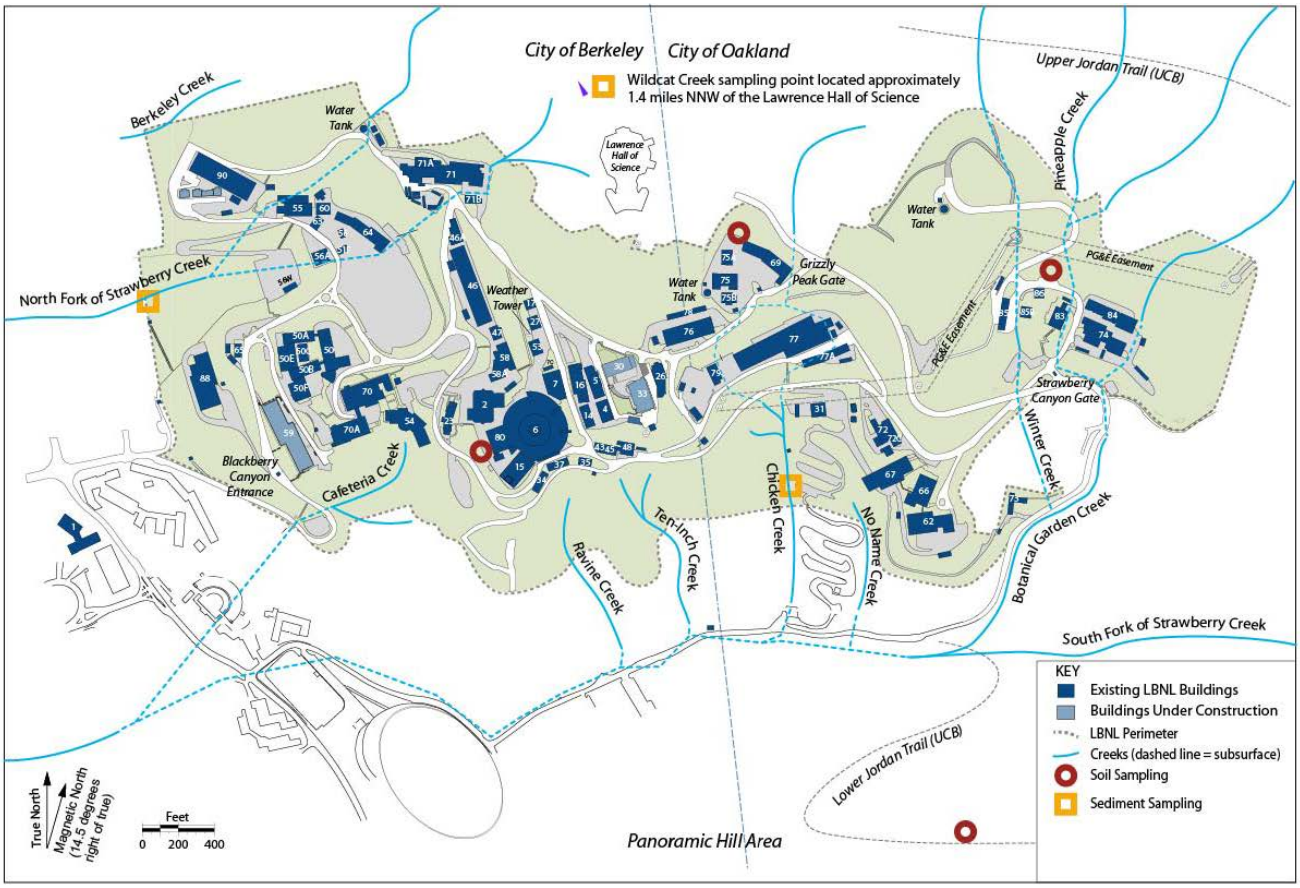

Figure 4-6 Soil and Sediment Sampling Sites

Similar to soil sampling results, the radioisotope analysis showed that levels of alpha, beta, and gamma emitters were consistent with background levels of naturally-occurring radioisotopes commonly found in sediment and that tritium measurements were below detection limits at all sampling locations.

The non-radioisotope analysis showed pH measurements at each of the sampling locations were within the historical range, as were the values for petroleum hydrocarbons (diesel and oil/grease), with all values 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.

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 past air emissions from the former NTLF Hillside Stack from when the NTLF was operational, 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 samples this vegetation every five years. The next sampling is scheduled for 2015.

4.8 PENETRATING RADIATION MONITORING

Radiation-producing machines (*e.g.,* accelerators, x-ray machines, and irradiators) and various radionuclides are used at Berkeley Lab for high-energy particle studies and biomedical research. Accelerator operations are the primary contributors of penetrating radiation, and when operating, accelerators may produce gamma and neutron radiation. The accelerators include the Advanced Light Source (Building 6), Biomedical Isotope Facility (Building 56), 88-Inch Cyclotron (Building 88), and the Laser Optics and Acceleration System Integrated Studies Project (Building 71). The system in Building 71 is an experimental laser-driven accelerator that does not emit measurable gamma or neutron radiation into the environment. Smaller radiation-producing machines (x-ray machines and irradiators) at LBNL do not measurably increase the dose to the public.

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 provide an integrated 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 comparable to the measured background location. The locations of real-time monitors and dosimeters are shown in Figure 4-7. Results of both measurement methods are given in terms of dose and are provided in Section 5.2.

4.9 RADIOLOGICAL CLEARANCE

DOE Order 458.1 sets requirements on the release and clearance of property with the potential to contain residual radioactive material. Berkeley Lab meets these release requirements by demonstrating that property only contains levels of radioactive material indistinguishable from background. LBNL's as low as reasonably achievable (ALARA) process requires that property not be cleared for unrestricted release from radiological control under 10 CFR 835 and DOE Order 458.1 if it contains residual radioactivity that is distinguishable from background, even if the amount of radioactivity is known to be below the applicable release limit.

Any excess property that does not meet indistinguishable from background criteria is either transferred to another DOE radiological facility for reuse or to a licensed radioactive waste facility for disposal.

Property is cleared only if it has been demonstrated through process knowledge and/or radiological survey that it does not contain residual radioactive material, or residual radioactivity has been characterized sufficiently to demonstrate that it is indistinguishable from background. In September, Berkeley Lab received concurrence from the DOE Berkeley Site Office that Buildings 16 and 16A, which are slated for demolition in 2015, met the indistinguishable from background criteria and therefore were released from radiological control under 10 CFR 835 and DOE Order 458.1.

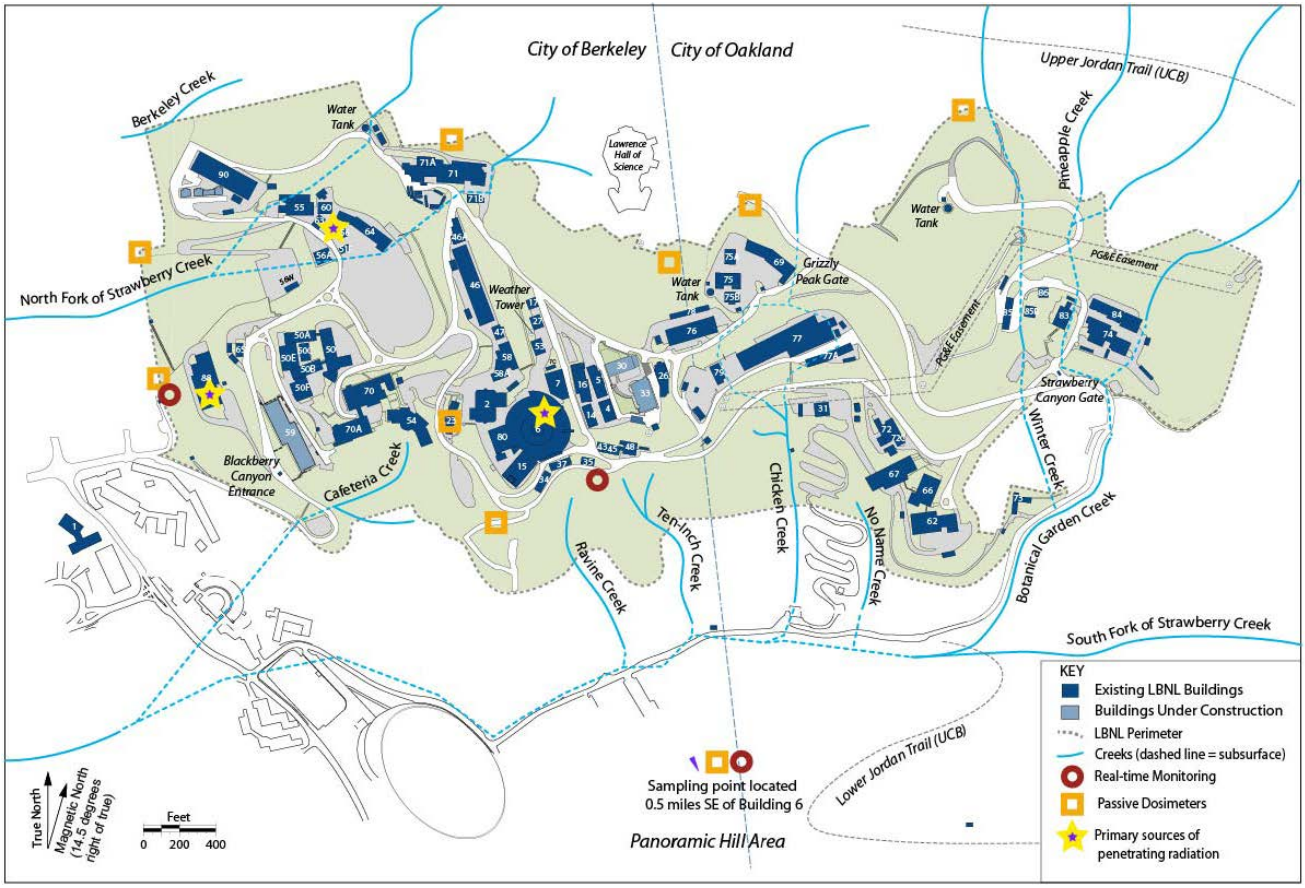

Figure 4-7 Environmental Penetrating Radiation Primary Sources and Monitoring Stations

5. Radiological Dose Assessment

5.1 BACKGROUND

Exposure to radioactive material by external irradiation, inhalation, or ingestion results in energy being deposited in tissue mass; hereafter referred to as "dose." Radiation doses to the public and the environment from Berkeley Lab's operations are very low, with health effects from very low doses either too small to be observed or are nonexistent.[1]

This chapter presents the estimated dose results from Berkeley Lab's penetrating radiation and airborne radionuclide monitoring programs. This includes doses to nearby individual members of the public and doses to the general population in the region extending 50 miles from the site. Within this area, the daytime population is about 7,253,000.[2] The doses projected from each monitoring program are presented separately, before being 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.

To ensure that radiological impacts to the public and the environment remain very low, Berkeley Lab manages its activities so that radioactive emissions and external exposures are as low as reasonably achievable. 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] required regulatory process, as discussed in Section 4.2. If the potential for a public dose is greater than 1 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 2014.

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 determine compliance with DOE Order 458.1, indicate that the maximum annual dose from gamma and neutron radiation to a person outside the western boundary of the site was 4.6×10^{-2} mrem, with the primary contributing source being the 88-inch Cyclotron and the location of this maximum dose being the nearest residence about 360 feet away from the source. The annual population dose to people in the surrounding region that extends 50 miles from the site was 2.21×10^{-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. The dose from penetrating radiation is independent of wind conditions.

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 interact with any of several environmental media: air, water, soil, plants, and animals. Each of these media represents a potential pathway of exposure affecting human dose.

Doses to an individual and the population are determined using computer software programs that estimate dispersion of emissions factoring in wind speed and direction, atmospheric stability, and precipitation. The NESHAP regulation[5] requires DOE facilities that potentially release airborne radionuclides assess the impact of such releases using an U.S. EPA-approved computer program. Berkeley Lab satisfies this criteria by using two such programs, CAP88-PC and COMPLY. Details of dose calculations from dispersible airborne radionuclide emissions are included in LBNL's annual NESHAP report.[6]

Following NESHAP requirements for determining the maximally exposed individual to airborne emissions from the main LBNL site, this individual was determined to be a hypothetical person residing at the Lawrence Hall of Science on the northern side of the site and downwind of the primary source, fluorine-18 emissions from building 55, 56, and 64, contributing to this dose. 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 2014, the calculated annual dose from airborne radionuclides was approximately 2.7×10^{-2} mrem. This value is approximately 0.27% of the DOE and U.S. EPA annual limit for airborne radionuclides of 10 mrem/year.[7,8]

As with penetrating radiation, the collective dose from airborne radionuclides to the population within a radius of 50 miles of the site is estimated. The estimated population dose from all airborne emissions from the LBNL main site for the year was 3.2×10^{-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 several orders of magnitude less than local background radiation levels. As shown 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 2014 was approximately 7.3×10^{-2} mrem/yr. Penetrating radiation (i.e., gamma and neutron radiation) from accelerators at LBNL and radionuclides from airborne radionuclide emissions contributed to this total dose, which is a conservatively high estimate since the location of the maximum dose for penetrating and airborne radiation differ slightly, as described in previous sections. Yet this value is still only approximately 0.02% of the average United States natural background radiation dose[9] (310 mrem/yr) and about 0.07% of the DOE annual limit from all sources (100 mrem/yr).[10]

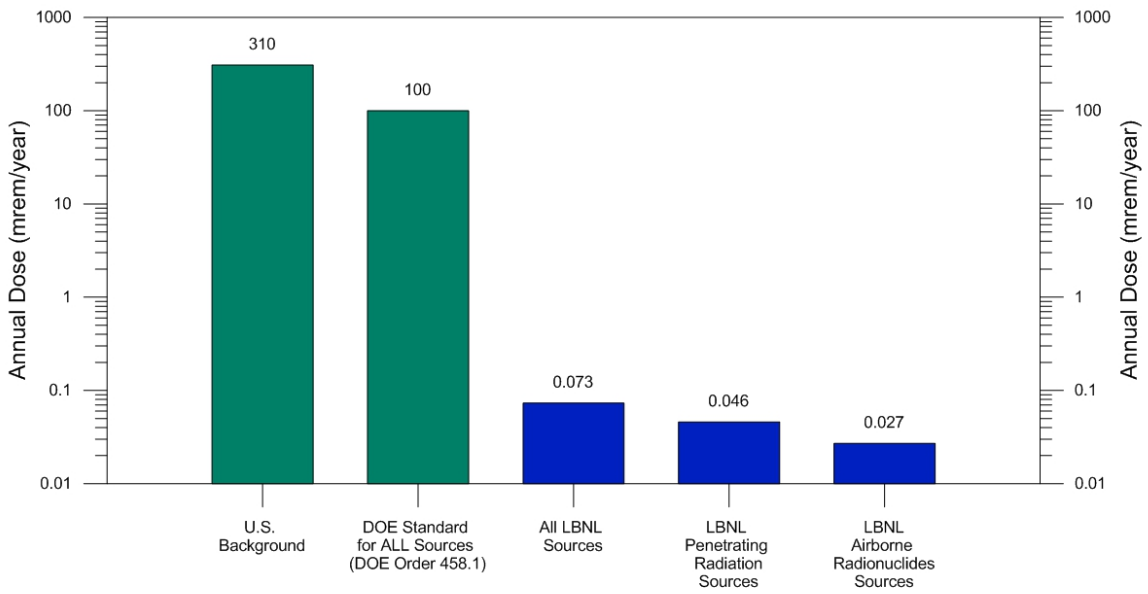

Figure 5-1 2014 Comparative Radiological Doses

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.[11] 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 applicable 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,[12] which demonstrates that doses calculated are less than biota dose limits. This confirms that Berkeley Lab is in compliance with DOE requirements to 1) limit radiation doses to aquatic organisms and terrestrial plants to 1 rad/day and to 2) 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 environmental programs such as the NESHAP stack monitoring program.[5]

For 2014, LBNL had contracts with five commercial analytical laboratories for specific analytical services. 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 last two to three days and include five or more experienced auditors from across the DOE complex. When the audit involves an analytical laboratory providing service to Berkeley Lab, typically two representatives from LBNL participate.

A DOECAP audit also includes a review of the analytical laboratory's performance in proficiency testing required by the California ELAP. In 2014, none of the audited 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 ENVIRONMENTAL MONITORING SAMPLES AND RESULTS PROFILE

In 2014, Berkeley Lab's environmental monitoring programs collected approximately 2,500 individual samples throughout the year to support air, sediment, soil, and water programs, generating 78,286 analytical results. This activity represents a nearly 13% increase from the previous year and was due to the large number of samples collected in preparation for the Old Town Demolition Project.

Samples were obtained from nearly 600 different locations on or surrounding the Berkeley Lab site. Figures in Chapter 4 show many of these locations for the different programs. For a 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. In 2014, a total of 37 split and 48 duplicate samples, involving all monitoring programs, were collected for either radiological or non-radiological (or both) analyses, leading to 389 and 1,135 analytical results, respectively. Additionally, 140 blank samples were submitted for QA purposes. The primary purpose of a blank sample is to identify artificially introduced contamination.

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 by the program leader 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 five analytical laboratories performed almost 2,600 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	Number of Sample Batches	Number of QC Analysis	Number of Laboratories Involved	Radiological[a]	Non-radiological[b]
Stack Air	34	103	2	X	--
Stormwater and Creeks	78	219	4	X	X
Wastewater	126	542	5	X	X
Groundwater	162	1002	5	X	X
Soil Investigation	178	631	5	X	X
Sediment	16	50	4	X	X
Soil	18	50	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
ALARA	as low as reasonably achievable
AST	aboveground storage tank
ASMP	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
CARB	California Air Resources Board
CCCSD	Central Contra Costa Sanitary District
CCR	California Code of Regulations
CEQA	California Environmental Quality Act
CFR	Code of Federal Regulations
Ci	curie
COD	chemical oxygen demand
CUPA	Certified Unified Program Agency (California)
DCE	dichloroethylene
DOE	United States Department of Energy
DOECAP	Department of Energy Consolidated Audit Program
DTSC	Department of Toxic Substances Control
E85	85% ethanol/15% unleaded fuel blend
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
IGP	Industrial General Permit (for stormwater discharges associated with industrial activity)
ISO	International Organization for Standardization
JGI	Joint Genome Institute
kg	kilogram
L	liter
LBNL	Lawrence Berkeley National Laboratory
µg	microgram
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)
SARA	Superfund Amendments and Reauthorization Act
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

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.

fiscal year

The 12-month period for which an organization plans the use of its funds. For the United States federal government and its contractors, this is the period from October 1 to September 30 of the following year.

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 RCRA-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.

water year

The term water year is used by hydrologists and climatologists to represent rainfall occurring between October 1st of one year and September 30th of the next year.

wind rose

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

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