Lawrence Livermore National Laboratory

Environmental Report 2008

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Lawrence Livermore National Laboratory
Environmental Report 2008

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Preface

The purposes of the *Lawrence Livermore National Laboratory Environmental Report 2008* are to record Lawrence Livermore National Laboratory's (LLNL's) compliance with environmental standards and requirements, describe LLNL's environmental protection and remediation programs, and present the results of environmental monitoring at the two LLNL sites—the Livermore site and Site 300. The report is prepared for the U.S. Department of Energy (DOE) by LLNL's Environmental Protection Department. Submittal of the report satisfies requirements under DOE Order 231.1A, Environmental Safety and Health Reporting, and DOE Order 5400.5, Radiation Protection of the Public and Environment.

The report is distributed electronically and is available at https://saer.lln.gov/, the website for the LLNL annual environmental report. Previous LLNL annual environmental reports beginning in 1994 are also on the website. Some references in the electronic report text are underlined, which indicates that they are clickable links. Clicking on one of these links will open the related document, data workbook, or website that it refers to.

The report begins with an executive summary, which provides the purpose of the report and an overview of LLNL's compliance and monitoring results. The first three chapters provide background information: Chapter 1 is an overview of the location, meteorology, and hydrogeology of the two LLNL sites; Chapter 2 is a summary of LLNL's compliance with environmental regulations; and Chapter 3 is a description of LLNL's environmental programs with an emphasis on the Environmental Management System including pollution prevention.

The majority of the report covers LLNL's environmental monitoring programs and monitoring data for 2008: effluent and ambient air (Chapter 4); waters, including wastewater, storm water runoff, surface water, rain, and groundwater (Chapter 5); and terrestrial, including soil, sediment, vegetation, foodstuff, ambient radiation, and special status wildlife and plants (Chapter 6). Complete monitoring data, which are summarized in the body of the report, are provided in Appendix A.

The remaining three chapters discuss the radiological impact on the public from LLNL operations (Chapter 7), LLNL's groundwater remediation program (Chapter 8), and quality assurance for the environmental monitoring programs (Chapter 9).

The report uses Système International units, consistent with the federal Metric Conversion Act of 1975 and Executive Order 12770, Metric Usage in Federal Government Programs (1991). For ease of comparison to environmental reports issued prior to 1991, dose values and many radiological measurements are given in both metric and U.S. customary units. A conversion table is provided in the glossary.

The report is the responsibility of LLNL's Environmental Protection Department. Monitoring data were obtained through the combined efforts of the Environmental Protection Department;

Environmental Restoration Department; Physical and Life Sciences Environmental Monitoring Radiation Laboratory; and the Hazards Control Department.

Special recognition is given to the technologists who gathered the data—Gary A. Bear, Karl Brunckhorst, Crystal Foster, Steven Hall, Renee Needens, Terrance W. Poole, and Robert Williams; and to the data management personnel—Kimberley A. Swanson, Debbie Stockdale, Suzanne Chamberlain, Nancy Blankenship, Connie Wells, Lisa Graves, Della Burruss, and Susan Lambaren. Special thanks to Loni Hoellworth for helping with distribution.

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Executive Summary

Lawrence Livermore National Laboratory (LLNL) is a premier research laboratory that is part of the National Nuclear Security Administration (NNSA) within the U.S. Department of Energy (DOE). As a national security laboratory, LLNL is responsible for ensuring that the nation's nuclear weapons remain safe, secure, and reliable. The Laboratory also meets other pressing national security needs, including countering the proliferation of weapons of mass destruction and strengthening homeland security, and conducts major research in atmospheric, earth, and energy sciences; bioscience and biotechnology; and engineering, basic science, and advanced technology. The Laboratory serves as a scientific resource to the U.S. government and a partner to industry and academia.

Since its inception in 1952 until October 1, 2007, LLNL was managed by the University of California. In May 2007, DOE selected Lawrence Livermore National Security, LLC (LLNS), to manage the Laboratory under a seven-year contract that began on October 1, 2007.

LLNL operations release a variety of constituents into the environment via atmospheric, surface water, and groundwater pathways. Some of the constituents, such as particles from diesel engines, are common at many types of facilities while others, such as radionuclides, are unique to facilities like LLNL. All releases are highly regulated and carefully monitored.

Safe, secure, and efficient operations that provide a safe, clean environment for employees and neighboring communities are a necessary part of the Laboratory's research and development programs and underpin their success. Experts in environment, safety and health (ES&H) support all Laboratory activities. LLNL's radiological control program ensures that radiological exposures and releases are reduced to as low as reasonably achievable to protect the health and safety of its employees, contractors, the public, and the environment.

LLNL is committed to enhancing its environmental stewardship and reducing any impacts its operations may have on the environment. The Laboratory encourages the public to participate in matters related to the Laboratory's environmental impact on the community by soliciting citizens' input on matters of significant public interest and through various communications. The Laboratory also provides public access to information on its ES&H activities.

LLNL consists of two sites—an urban site in Livermore, California, referred to as the "Livermore site," which occupies 1.3 square miles; and a rural Experimental Test Site, referred to as "Site 300," near Tracy, California, which occupies 10.9 square miles. In 2008 the Laboratory had a staff of approximately 6400.

Purpose and Scope of the Environmental Report

The purposes of the *Environmental Report 2008* are to record LLNL's compliance with environmental standards and requirements, describe LLNL's environmental protection and remediation programs, and present the results of environmental monitoring. Specifically, the report discusses LLNL's Environmental Management System; describes significant accomplishments in pollution prevention; presents the results of air, water, vegetation, and foodstuff monitoring; reports radiological doses from LLNL operations; summarizes LLNL's activities involving special status wildlife, plants, and habitats; and describes the progress LLNL has made in remediating groundwater contamination.

Environmental monitoring at LLNL, including analysis of samples and data, is conducted according to documented standard operation procedures. Duplicate samples are collected and analytical results are reviewed and compared to EPD's acceptance standards.

This report is prepared for DOE by LLNL's Environmental Protection Department. Submittal of the report satisfies requirements under DOE Order 231.1A, Environmental Safety and Health Reporting, and DOE Order 5400.5, Radiation Protection of the Public and Environment. The report is distributed in electronic form and is available to the public at https://saer.llnl.gov/, the website for the LLNL annual environmental report. Previous LLNL annual environmental reports beginning in 1994 are also on the website.

Regulatory Permitting and Compliance

LLNL undertakes substantial activities to comply with many federal, state, and local environmental laws. The major permitting and regulatory activities that LLNL conducts are required by the Clean Air Act; the Clean Water Act and related state programs; the Emergency Planning and Community Right-to-Know Act; the Resource Conservation and Recovery Act and state and local hazardous waste regulations; the National Environmental Policy Act and the California Environmental Quality Act; the Endangered Species Act; the National Historic Preservation Act; the Antiquities Act; and the Comprehensive Environmental Response, Compensation and Liability Act.

Integrated Safety Management System and Environmental Management System

LLNL established its Environmental Management System (EMS) to meet the requirements of the International Organization for Standardization (ISO) 14001:1996 in June 2004. In June 2006, LLNL upgraded its EMS to meet the requirements of ISO 14001:2004. During 2006 and 2007, LLNL developed Environmental Management Plans (EMPs) that address lab-wide and programmatic significant aspects. During 2008, more focus was place on raising lab-wide awareness of EMS and on continued development of EMPs. Moreover, the LLNL Directorates selected aspects to pursue considering those they could reasonably affect, based on budget and mission. In 2008, LLNL had 33 active EMPs on significant aspects, including waste generation, energy use, and cultural and ecological resource disturbance.

Pollution Prevention

A strong Pollution Prevention (P2) Program is an essential element of LLNL's EMS. The P2 program encompasses stewardship and maintenance, waste stream analysis, waste generation reporting, and coordination of institutional P2 programs and activities.

The P2 Team received the California Integrated Waste Management Board's 2008 WRAP award for recycling accomplishments during the 2007 calendar year. The award recognizes California businesses and organizations that have made outstanding efforts to reduce nonhazardous waste by implementing resource-efficient practices, aggressive waste reduction, reuse and recycling activities, and procurement of recycled-content products.

LLNL also conducted activities to promote employee awareness of P2, including participation in the community Earth Day event sponsored by the City of Livermore and the Livermore Area Recreation and Park District, articles in the LLNL newspaper, training for procurement staff, and maintenance of an internal P2 website and telephone hot line.

Air Monitoring

LLNL operations involving radioactive materials had minimal impact on ambient air during 2008. Estimated nonradioactive emissions are small compared to local air district emission criteria.

Releases of radioactivity to the environment from LLNL operations occur through stacks and from diffuse area sources. In 2008, radioactivity released to the atmosphere was monitored at five facilities on the Livermore site and one at Site 300. In 2008, 141 GBq (3.8 Ci) of tritium was released from the Tritium Facility, and 3.2 GBq of tritium (86 mCi) was released from the Decontamination and Waste Treatment Facility. The Contained Firing Facility at Site 300 had 550 Bq (15 nCi) of depleted uranium released in particulate form in 2008. None of the other facilities monitored for gross alpha and gross beta radioactivity had emissions in 2008.

The magnitude of nonradiological releases (e.g., reactive organic gases/precursor organic compounds, nitrogen oxides, carbon monoxide, particulate matter, sulfur oxides) is estimated based on specifications of equipment and hours of operation. Estimated releases in 2008 for the Livermore site and Site 300 were similar to 2007 levels. Nonradiological releases from LLNL continue to be a very small fraction of releases from all sources in the Bay Area or San Joaquin County.

In addition to air effluent monitoring, LLNL samples ambient air for tritium, radioactive particles, and beryllium. Some samplers are situated specifically to monitor areas of known contamination; some monitor potential exposure to the public; and others, distant from the two LLNL sites, monitor the natural background. In 2008, ambient air monitoring data confirmed estimated releases from monitored stacks and were used to determine source terms for resuspended plutonium-contaminated soil and tritium diffusing from area sources at the Livermore site and resuspended uranium-contaminated soil at Site 300. In 2008, radionuclide particulate, tritium, and beryllium concentrations in air at the Livermore site and in the Livermore Valley were well below the levels that would cause concern for the environment or public health.

Water Monitoring

Monitoring of various categories of water is carried out to determine whether any radioactive or nonradioactive constituents released by LLNL might have a negative impact on public health and the environment. Data indicate LLNL has good control of its discharges to the sanitary sewer, and discharges to the surface water and groundwater do not have any apparent environmental impact.

Permits, including one for discharging treated groundwater from the Livermore site Ground Water Project, regulate discharges to the City of Livermore sanitary sewer system. During 2008, no discharges to the sanitary sewer exceeded any effluent limits for either radioactive or nonradioactive materials, and all the values were a fraction of the allowed limits. All discharges to the Site 300 sewage evaporation and percolation ponds were within permitted limits, and groundwater monitoring related to this area showed no measurable impacts.

Storm water is sampled for constituents such as radioactivity, metals, oxygen, dioxins, polychlorinated biphenyls (PCBs), and nitrate both upstream and downstream from both the Livermore site and Site 300. In 2008, no acute or chronic toxicity was seen in runoff, and data showed that the quality of Livermore site storm water effluent was similar to that entering the site (influent). In calendar year 2008, there were no storms at Site 300 that met the criteria for a qualifying event as defined in the General Industrial Storm Water Permit (97-03-DWQ). Storm water visual observations and best management practices inspections indicated that LLNL's storm water program continues to protect water quality.

Extensive monitoring of groundwater occurs at and near the Livermore site and Site 300. Groundwater from wells downgradient from the Livermore site is analyzed for pesticides, herbicides, radioactivity, nitrates, and hexavalent chromium. To detect any off-site contamination quickly, the well water is sampled in the uppermost water-bearing layers. Near Site 300, monitored constituents in off-site groundwater include explosives residue, nitrate, perchlorate, metals, volatile and semivolatile organic compounds, tritium, uranium, and other (gross alpha and beta) radioactivity. With the exception of volatile organic compounds (VOCs) in wells monitored for CERCLA compliance, the constituents of all off-site samples collected at both the Livermore site and Site 300 were below allowable limits for drinking water.

Surface waters and drinking water are analyzed for tritium and gross alpha and gross beta radioactivity. In the Livermore Valley, the maximum tritium activity was less than 1% of the drinking water standard, and the maximum gross alpha and gross beta measurements were less than 60% of their respective drinking water standards. For Lake Haussmann (formerly called the Drainage Retention Basin) on the Livermore site, levels of gross alpha, gross beta, tritium, metals, and pesticides were below discharge limits, and organics and PCBs were below detection limits. Aquatic bioassays for acute and chronic toxicity showed no effects in water discharged from Lake Haussmann. At Site 300, maintenance and the operation of drinking water and cooling systems resulted in permitted discharges without adverse impact on surrounding waters.

Terrestrial Radiological Monitoring

The impact of LLNL operations on surface soil in 2008 was insignificant. Soil is analyzed for plutonium, gamma-emitting radionuclides, tritium, and PCBs as appropriate. Plutonium concentrations at the Livermore Water Reclamation Plant continued to be high relative to other sampled locations, but even this concentration was only 2.6% of the screening level for cleanup recommended by the National Council on Radiation Protection (NCRP). At Site 300, soils are analyzed for gamma-emitting radionuclides and beryllium. In 2008, uranium-238 concentrations in soils at Site 300 were below NCRP-recommended screening levels. Beryllium concentrations were within the ranges reported since sampling began in 1991.

Vegetation and Livermore Valley wine were sampled for tritium. In 2008, the median of concentrations in all off-site vegetation samples were below the lower limit of detection of the analytical method. The highest concentration of tritium in Livermore Valley wines sampled in 2008 was less than 0.3% of the drinking water standard.

LLNL's extensive network of thermoluminescent dosimeters measures the natural terrestrial and cosmogenic background; in 2008, as in recent years, no impact from LLNL operations was detected.

Biota

Through monitoring and compliance activities in 2008, LLNL avoided most impacts to special status species and enhanced some habitats. LLNL studies, preserves, and tries to improve the habitat of five species at Site 300 that are covered by the federal or California Endangered Species Acts—California tiger salamander (*Ambystoma californiense*), California red-legged frog (*Rana aurora draytonii*), Alameda whipsnake (*Masticophus lateralis euryxanthus*), valley elderberry longhorn beetle (*Desmocerus californicus dimorphus*), and the large-flowered fiddleneck (*Amsinckia grandiflora*)—as well as species that are rare and otherwise of special interest. At Site 300, LLNL monitors populations of birds and rare species of plants and also continues restoration activities for the four rare plant species known to occur at Site 300—the large-flowered fiddleneck, the big tarplant (*Blepharizonia plumosa*, also known as *Blepharizonia plumosa* subsp *plumosa*), the diamond-petaled poppy (*Eschscholzia rhombipetala*), and the round-leaved filaree (*Erodium macrophyllum*).

LLNL took several actions to control invasive species in 2008. Measures taken at the Livermore site to control bullfrogs, which are a significant threat to California red-legged frogs, included dispatching adults, removing egg masses, and allowing part of Arroyo Las Positas to dry out in October 2008. As in previous years, Site 300's invasive species control efforts have been focused largely on dispatching feral pigs, animals that threaten red-legged frog habitat.

The 2008 radiological doses calculated for biota at the Livermore site or Site 300 were far below screening limits set by DOE, even though highly conservative assumptions maximized the potential effect of LLNL operations on biota.

Radiological Dose

Annual radiological doses at the Livermore site and Site 300 in 2008 were found to be well below the applicable standards for radiation protection of the public. Dose calculated to the site-wide maximally exposed individual (SW-MEI) for 2008 was 0.013 μSv (0.0013 mrem) for the Livermore site and 4.4×10^{-7} μSv (4.4×10^{-8} mrem) at Site 300. These doses are well below the federal National Emissions Standards for Hazardous Air Pollutants of 100 μSv (10 mrem) and are significantly less than the doses from natural background radiation. There were no unplanned releases of radionuclides to the atmosphere at the Livermore site or at Site 300.

Groundwater Remediation

Groundwater at both the Livermore site and Site 300 is contaminated from historical operations; the contamination, for the most part, is confined to each site. Groundwater at both sites is undergoing cleanup under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA). Remediation activities removed contaminants from groundwater and soil vapor at both sites, and documentation and investigations continue to meet regulatory milestones.

At the Livermore site, contaminants include volatile organic compounds (VOCs), fuel hydrocarbons, metals, and tritium, but only the VOCs in groundwater and saturated and unsaturated soils need remediation. VOCs are the main contaminant found at the nine Site 300 Operable Units (OUs). In addition, nitrate, perchlorate, tritium, high explosives, depleted uranium, organosilicate oil, polychlorinated biphenyls, and metals are found at one or more of the OUs.

During 2008, the Livermore site remediation effort experienced a significant budget reduction that severely impacted operations; remediation pilot tests were put on hold, and facilities were operated until equipment or instrumentation failed. Although funding was ultimately restored, the operations that were curtailed could not immediately be fully resumed. Since funding was restored, an intensive effort has been undertaken to make necessary repairs and restore operations.

In 2008, concentrations continued to decrease in most of the Livermore site VOC plumes due to active remediation and the removal of more than 91.5 kg of VOCs from both groundwater and soil vapor. Although the large budget shortfall resulted in the non-operation of many Livermore site groundwater remediation facilities, hydraulic control was maintained along the boundaries of the site throughout most of 2008. VOC concentrations in boundary plumes remained stable or declined slightly, while concentrations in the source areas remained unchanged due to the cessation of remedial activities there during the year.

In 2008 at Site 300, perchlorate, nitrate, the high explosive RDX, and organosilicate oil were removed from groundwater in addition to about 18 kg of VOCs. Each Site 300 OU has a different profile of contaminants, but overall, groundwater and soil vapor extraction and natural attenuation continue to reduce the mass of contaminants in the subsurface. Cleanup remedies have been fully implemented and are operational at seven of the nine OUs at Site 300; the cleanup remedy for one of the remaining units has been selected, and the Remedial Investigation/Feasibility Study for the other OU was submitted in 2008.

Conclusion

The combination of surveillance and effluent monitoring, source characterization, and dose assessment showed that the radiological dose to the hypothetical, most-exposed member of the public caused by LLNL operations in 2008 was substantially less than the dose from natural background. Potential dose to biota was well below DOE screening limits. LLNL demonstrated good compliance with permit conditions for releases to air and to water. Analytical results and evaluations of air and various waters potentially impacted by LLNL operations showed minimal contributions from LLNL operations. Remediation efforts at both the Livermore site and Site 300 further reduced concentrations of contaminants of concern in groundwater and soil vapor.

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1. Introduction

Lawrence Livermore National Laboratory (LLNL) is a premier research laboratory that is part of the National Nuclear Security Administration (NNSA) within the U.S. Department of Energy (DOE). LLNL is managed and operated by Lawrence Livermore National Security, LLC (LLNS); the management team includes Bechtel National, University of California, Babcock and Wilcox, Washington Division of URS Corporation, and Battelle. NNSA awarded Contract Number DE-AC52-07NA27344 to LLNS to manage and operate LLNL.

As a national security laboratory, LLNL is responsible for ensuring that the nation's nuclear weapons remain safe, secure, and reliable. The Laboratory also meets other pressing national security needs, including countering the proliferation of weapons of mass destruction and strengthening homeland security, and conducts major research in atmospheric, earth, and energy sciences; bioscience and biotechnology; and engineering, basic science, and advanced technology. The Laboratory, with a staff of approximately 6400, serves as a scientific resource to the U.S. government and a partner to industry and academia.

1.1 Location

LLNL consists of two sites—an urban site in Livermore, California, referred to as the "Livermore site"; and a rural experimental test site, referred to as "Site 300," near Tracy, California. See **Figure 1-1**.

Figure 1-1. Location of the two LLNL sites—the Livermore site and Site 300.

The Livermore site is just east of Livermore, a city of about 80,000 in Alameda County. The site occupies 1.3 mi^2, including the land that serves as a buffer zone around most of the site.

Within a 50-mi radius of the Livermore site are communities such as Tracy and Pleasanton and the more distant (and more densely populated) cities of Oakland, San Jose, and San Francisco. Of the 7.2 million people within 50 mi of the Laboratory, only about 10% are within 20 mi.

Site 300, LLNL's Experimental Test Site, is located in the Altamont Hills of the Diablo Range and straddles the San Joaquin and Alameda county line. The site is 12 mi east of the Livermore site and occupies 10.9 mi^2.

The city of Tracy, with a population of over 80,000, is approximately 6 mi to the northeast (measured from the northeastern border of Site 300 to Sutter Tracy Community Hospital). Of the 6.7 million people who live within 50 mi of Site 300, 95% are more than 20 mi away in distant metropolitan areas such as Oakland, San Jose, and Stockton.

1.2 Meteorology

Meteorological towers at both the Livermore site and Site 300 continuously gather data including wind speed, wind direction, rainfall, humidity, solar radiation, and air temperature. Mild, rainy winters and warm-to-hot, dry summers characterize the climate at both sites. For a detailed review of the climatology for LLNL, see Gouveia and Chapman (1989). A new 52-m meteorological tower was installed at Site 300 in 2007; this new tower and the old 8-m tower in use since 1979 provided simultaneous measurements during 2007 for continuity and to observe any differences between the two tower locations. The old tower was retired in early 2008.

Both wind and rainfall exhibit strong seasonal patterns. Wind patterns at both sites tend to be dominated by the thermal draw of the warm San Joaquin Valley that results in wind blowing from the cool ocean toward the warm valley during the warm season, increasing in intensity as the valley heats up. During the winter, the wind blows from the northeast more frequently as cold, dense air spills out of the San Joaquin Valley. Approximately 55% of the seasonal rain at both sites falls in January, February, and March and approximately 80% falls in the five months from November through March, with very little rain falling during the warmer months. For a detailed review of rainfall at LLNL, see Bowen (2007). The meteorological conditions at Site 300 are modified by higher elevation and more pronounced topological relief. The complex topography of the site strongly influences local wind and temperature patterns.

Temperature, rainfall, and wind speed data for the Livermore site and Site 300 towers during 2008 are summarized in **Table 1-1**. Annual wind data for the Livermore site and Site 300 are shown in **Figure 1-2**.

Table 1-1. Summary of temperature, rainfall, and wind speed data at the Livermore site and Site 300 during 2008.

	Livermore Site		Site 300	
Temperature	**°C**	**°F**	**°C**	**°F**
Mean daily maximum	22.1	71.7	21.4	70.4
Mean daily minimum	8.1	46.5	12.8	55.1
Average	14.4	58.0	16.9	62.5
High	42.6	108.7	42.1	107.7
Low	–3.2	26.2	–0.5	31.2
Rainfall	**cm**	**in.**	**cm**	**in.**
Total for 2008	24.2	9.51	21.5	8.48
Normal	34.6[(a)]	13.62[(a)]	—[(b)]	—[(b)]
Wind	**m/s**	**mph**	**m/s**	**mph**
Average speed	2.4	5.4	5.9	13.1
Peak gust speed	27.5	61.6	33.3	74.4

(a) Based on the mean, 1971–2000

(b) Normal values not available because of brief measurement history at new tower.

1.3 Topography

The Livermore site is located in the southeastern portion of the Livermore Valley, a prominent topographic and structural depression oriented east–west within the Diablo Range. The most prominent valley in the Diablo Range, the Livermore Valley is bounded on the west by Pleasanton Ridge and on the east by the Altamont Hills. The valley is approximately 14 mi long and varies in width generally between 2.5 and 7 mi. The valley floor is at its highest elevation of 720 ft above sea level along the eastern margin near the Altamont Hills and dips gradually to 300 ft at the southwestern corner. The valley floor is covered primarily by alluvial and floodplain deposits consisting of gravels, sands, silts, and clays with an average thickness of about 325 ft. Ephemeral waterways flowing through the Livermore site include Arroyo Seco along the southwestern corner and Arroyo Las Positas along the eastern and northern perimeters.

The topography of Site 300 is much more irregular than that of the Livermore site; a series of steep hills and ridges is oriented along a generally northwest–southeast trend and is separated by intervening ravines. The Altamont Hills, where Site 300 is located, are part of the California Coast Range Province and separate the Livermore Valley to the west from the San Joaquin Valley to the east. The elevation of Site 300 ranges from about 1740 ft above sea level at the northwestern corner of the site to approximately 490 ft in the southeastern portion. Corral Hollow

Creek, an ephemeral stream that drains toward the San Joaquin Basin, runs along the southern and eastern boundaries of Site 300.

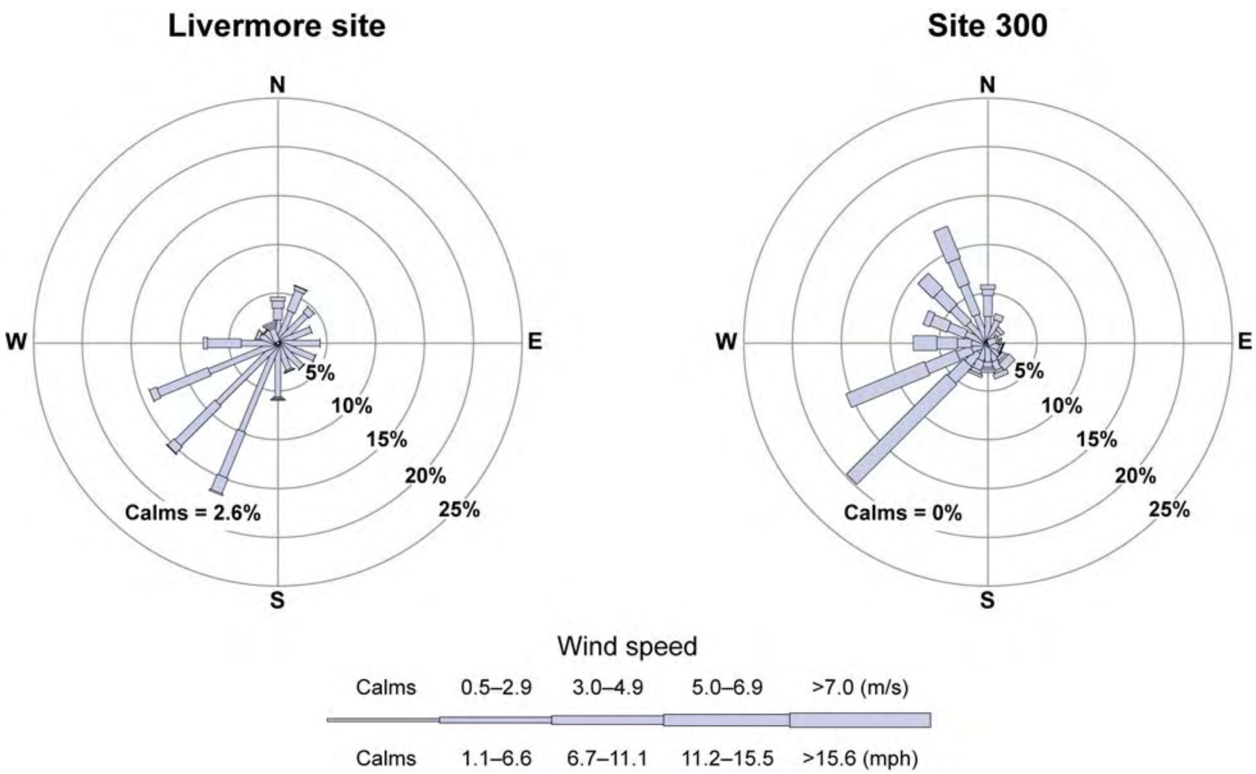

Figure 1-2. Wind roses showing wind direction and speed frequency at the Livermore site and Site 300 during 2008. The length of each spoke is proportional to the frequency at which the wind blows from the indicated direction. Different line widths of each spoke represent wind speed classes.

1.4 Hydrogeology

The Livermore Formation and overlying alluvial deposits contain the primary aquifers of the Livermore Valley groundwater basin. Natural recharge occurs primarily along the basin margins and arroyos during wet winters. In general, groundwater flows toward the central east–west axis of the valley and then westward through the central basin. Groundwater flow in the basin is primarily horizontal, although a significant vertical component probably exists along the basin margins under localized sources of recharge and near heavily used extraction or water production wells. Beneath the Livermore site, the depth to the water table varies from about 30 to 130 ft below the ground surface. See Thorpe et al. (1990) for a detailed discussion of Livermore site hydrogeology.

Site 300 is generally underlain by gently dipping sedimentary bedrock dissected by steep ravines. The bedrock primarily consists of interbedded sandstone, siltstone, and claystone. Groundwater occurs principally in the Neroly Formation upper and lower blue sandstone units and in the underlying Cierbo Formation. Significant groundwater is also locally present in permeable Quaternary alluvium valley fill and underlying decomposed bedrock, especially during wet winters. Minor quantities of groundwater are present within perched aquifers in the unnamed Pliocene nonmarine unit. Perched aquifers contain unconfined groundwater separated from an underlying main body of groundwater by impermeable layers; normally these perched zones are laterally discontinuous. Recharge occurs predominantly in locations where saturated alluvial valley fill is in contact with underlying permeable bedrock or where permeable bedrock strata crop out along the canyon bottom because of structure or topography. The thick Neroly Formation lower blue sandstone, stratigraphically near the base of the formation, generally contains confined groundwater. Wells located in the western part of the Site 300 General Services Area pump water from this aquifer, which is used for drinking and process supply. See Webster-Scholten et al. (1994) and Ferry et al. (2006) for a detailed discussion of Site 300 hydrogeology.

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2. Compliance Summary

LLNL activities comply with federal, state, and local environmental regulations, internal requirements, Executive Orders, and DOE orders as specified in Contract DE-AC52-07NA27344. This chapter provides an overview of LLNL's compliance programs and activities during 2008. **Table 2-1** is a summary of active permits in 2008 at the Livermore site and Site 300. **Table 2-2** lists environmental inspections and findings from them at both LLNL sites in 2008.

2.1 Environmental Restoration and Waste Management

2.1.1 Comprehensive Environmental Response, Compensation and Liability Act

Ongoing remedial investigations and cleanup activities at LLNL fall under the jurisdiction of the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), Title I of the Superfund Amendments and Reauthorization Act (SARA). CERCLA is commonly referred to as the Superfund law.

CERCLA compliance activities for the Livermore site and Site 300 are summarized in **Sections 2.1.1.1** and **2.1.1.2**. Community relations activities conducted by DOE/LLNL are also part of these projects. See **Chapter 8** for more information on the activities and findings of the investigations.

2.1.1.1 Livermore Site Ground Water Project

The Livermore site came under CERCLA in 1987 when it was placed on the National Priorities List. The Livermore Site Ground Water Project (GWP) complies with provisions specified in a Federal Facility Agreement (FFA) entered into by the U.S. Environmental Protection Agency (EPA), DOE, the California EPA's Department of Toxic Substances Control (DTSC), and the San Francisco Bay Regional Water Quality Control Board (SFBRWQCB). As required by the FFA, the GWP addresses compliance issues by investigating potential contamination source areas (e.g., suspected old release sites, solvent-handling areas, leaking underground tank systems), monitoring water quality through an extensive network of wells, and remediating contaminated soil and groundwater. The primary soil and groundwater contaminants (constituents of concern) are common volatile organic compounds (VOCs), primarily trichloroethene (TCE) and perchloroethylene (PCE).

During 2008, the Livermore GWP experienced a significant budget reduction that severely impacted operations. When the final FY 2008 Omnibus Appropriations Bill was passed by Congress, the Livermore GWP received only about 50% of its requested budget. Although funding was ultimately restored in late July 2008, the budget reduction necessitated a dramatic reduction in both staff and cleanup activities at the site. Consequently, enhanced source area remediation pilot tests begun in 2007 were put on hold and existing groundwater and soil vapor treatment operations were significantly curtailed during the year. LLNL continued to operate facilities until equipment or instrumentation failed. See Valett et al. (2009) for the current status of cleanup progress.

Table 2-1. Active permits in 2008 at the Livermore site and Site 300.

Type of permit	Livermore site[a]	Site 300[a]
Hazardous waste	EPA ID No. CA2890012584. Hazardous Waste Facility Permit Number 99-NC-006 (RCRA Part B permit)—to operate hazardous waste management facilities. Registered Hazardous Waste Hauler authorized to transport wastes from Site 300 to the Livermore site. Conditionally Exempt Specified Wastestream Permit to mix resin in Unit CE231-1. Conditional Authorization Permit to operate sludge dewatering unit in Building 322A. PT0305819. RCRA large-quantity hazardous waste generation facility—ACDEH.	EPA ID No. CA2890090002. Hazardous Waste Facility Permit—CSA (Building 883) and EWSF. Hazardous Waste Facility Permit —EWTF. Hazardous Waste Facility Post-Closure Permit—Building 829 High Explosives Open Burn Treatment Facility. PT0010318. Hazardous waste generation facility—SJCEHD.
Medical waste	ACDEH issued a permit that covers medical waste generation and treatment activities for the eight BSL 2 facilities, and the BSL 3 facility at Building 368.	NA
Certified Appliance Recycler (CAR)	DTSC issued CAR certificate No. 0329 to recycle appliances.	DTSC issued CAR certificate No. 0330 to recycle appliances.
Air	BAAQMD issued 165 permits for operation of various types of equipment. BAAQMD issued a SMOP to ensure the Livermore site does not exceed federal Clean Air Act Title V emission limits for regulated pollutants. CARB issued 7 permits for the operation of portable diesel air compressors and generators.	SJVAPCD issued 36 permits for operation of various types of equipment. SJVAPCD approved a Prescribed Burn Plan for the burning of 2042.7 acres of grassland. BAAQMD issued 1 permit for the operation of an emergency diesel generator. BAAQMD approved a Prescribed Burn Plan for the burning of 139.1 acres of grassland.
Storage tanks	Seven operating permits covering 10 underground petroleum product and hazardous waste storage tanks.	One operating permit covering three underground petroleum product tanks assigned individual permit numbers.
Sanitary sewer	Discharge Permit 1250[b] for discharges of wastewater to the sanitary sewer. Permit 1510G for discharges of groundwater from restoration.	WDR No. 96-248 for operation of sewage evaporation and percolation ponds; superseded by WDR R5-2008-0148 in September 2008.

Table 2-1 (cont.). Active permits in 2008 at the Livermore site and Site 300.

Type of permit	Livermore site[a]	Site 300[a]
Water	WDR No. 88-075 for discharges of treated groundwater from Treatment Facility A to recharge basin.[c] NPDES Permit No. CA0030023 for discharges of storm water associated with industrial activities and low-threat nonstorm water discharges to surface waters. NPDES General Permit No. CAS000002, Soil Reuse Project (201C349339), and E-9 Parking Lot (201C349049) for discharges of storm water associated with construction activities affecting 0.4 hectares (1 acre) or more. FFA for groundwater investigation/remediation.	WDR No. 93-100 for post-closure monitoring requirements for two Class I landfills. WDR No. 96-248 for discharges to equipment wastewater percolation pits; superseded by WDR R5-2008-0148 in September 2008. NPDES General Permit No. CAS000001 for discharge of storm water associated with industrial activities. NPDES Regional General Permit No. CAG995001 for large volume discharges from the drinking water system. FFA for groundwater investigation/remediation. 33 registered Class V injection wells.

Note: See the **Acronyms and Glossary** section for acronym definitions.

(a) Numbers of permits are based on actual permitted units or activities maintained and/or renewed by LLNL during 2008.

(b) Permit 1250 includes some wastewater generated at Site 300 and discharged at the Livermore site.

(c) Recharge basin referenced in WDR Order No. 88-075 is located south of East Avenue within Sandia National Laboratories/California boundaries. The discharge no longer occurs; however, the agency has not rescinded the permit.

Table 2-2. Inspections of Livermore site and Site 300 by external agencies in 2008.

Site	Medium	Description	Agency	Date	Finding
Livermore site	Waste	Hazardous waste facilities Compliance Evaluation Inspection (CEI)	DTSC	6/30/08 & 7/8/08–7/11/08	Received one Class I violation for failure to characterize the influent into the oil-water separator at Building 611. Received one Class II violation for assigning the on-duty Fire Chief (an Alameda County employee) as the Emergency Coordinator in the Contingency Plans for the permitted facilities. DTSC issued a final report for the 2008 CEI on 9/25/08. The influent water was analyzed and determined to be nonhazardous. The emergency coordinator function was reassigned to two LEDOs who are LLNL employees. DTSC ultimately decreased the Class I violation to a Class II violation.
	Air	Air emission sources	BAAQMD	2/13/08 4/29/08 5/1/08 5/15/08 7/9/08	No violations
	Sanitary sewer	Annual compliance sampling and categorical sampling/inspection Building 153 and Building 321C.	WRD	9/22/08–9/23/08	No violations
	Storage tanks	Compliance with underground storage tank requirements and operating permits	ACDEH	8/5/08 9/15/08 9/22/08	No violations
	Pesticides	Pest control records inspections	ACCDA	12/11/08	No violations
Site 300	Waste	Permitted hazardous waste operational facilities (EWTF, EWSF, Building 883 CSA), RCRA-closed, post-closure permitted facility Building 829 Open Burn Facility, and a review of hazardous waste-related documentation (CEI).	DTSC	5/21/08–5/22/08	DTSC issued one minor violation for failing to conduct the November 2007 monthly inspection of Building 829. LLNL corrected the violation by immediately conducting the missed inspection on December 3, 2007. Future Building 829 inspections were scheduled at the beginning of the month in order to allow management more time to review the completed inspection checklist. Extra training was also provided to the technician supervisor and technicians responsible for conducting the inspection to ensure this type of violation does not occur in the future. LLNL submitted the corrective action letter to DTSC on October 15, 2008. In the DTSC Inspection Report, compliance would be verified during the next inspection.
		Hazardous waste generator area inspection (WAAs, SAAs and hazardous waste-related related records for hazardous waste generator activities only).	SJCEHD-CUPA	8/18/08	San Joaquin County CUPA issued one violation for failing to determine if a waste is a hazardous waste. The waste was analyzed and determined to be nonhazardous. The analytical data and “Return to Compliance Certification” was submitted to San Joaquin County CUPA on September 15, 2008.
	Air	Air emission sources	SJVAPCD	4/29/08 11/12/08	No violations

Table 2-2 (cont.). Inspections of Livermore site and Site 300 by external agencies in 2008.

Site	Medium	Description	Agency	Date	Finding
Site 300 (cont.)	Water	Permitted operations	CVRWQCB	3/20/08 11/6/08	No violations
	Storage tanks	Compliance with underground storage tank requirements and operating permits	SJCEHD	9/8/08 9/19/08	During the September 8, 2008, inspection of the underground storage tanks at Building 879, four violations were issued for 1) deficient Monitoring Plan, 2) unavailable maintenance records, 3) spill bucket did not pass leak test, and 4) work done without a permit. All deficiencies were corrected and the corrective action letter was submitted to SJCEHD on October 8, 2008.

Note: See the **Acronyms and Glossary** section for acronym definitions.

In 2008, the Livermore GWP met all regulatory and DOE milestones on schedule including restarting the TF406 and TFA East groundwater extraction and treatment facilities.

Treatment Facilities. During 2008, the Livermore GWP maintained 29 groundwater and 9 soil vapor treatment facilities as funds allowed. The groundwater extraction wells and dual phase extraction wells extracted about 670 million L of groundwater during 2008. The dual phase extraction wells and soil vapor extraction wells together removed 570 thousand m^3 of soil vapor.

In 2008, the Livermore GWP treatment facilities removed about 91 kg of VOCs. Since remediation efforts began in 1989, more than 13.6 billion L of groundwater and approximately 9.5 million m^3 of soil vapor have been treated, removing about 2709 kg of VOCs.

Community Relations. Livermore site community relations activities in 2008 included communication and meetings with neighbors and local, regional, and national interest groups and other community organizations; public presentations; maintenance of information repositories and an administrative record; tours of site environmental activities; and responses to public and news media inquiries. In addition, DOE/LLNL met with members of Tri-Valley Communities Against a Radioactive Environment (Tri-Valley CAREs) and the organization's scientific advisor as part of the activities funded by an EPA Technical Assistance Grant (TAG). Community questions were also addressed via electronic mail, and project documents, letters, and public notices were posted on a public website: http://www-envirinfo.llnl.gov.

2.1.1.2 Site 300 Environmental Restoration Project

Remedial activities are ongoing at Site 300, which became a CERCLA site in 1990 when it was placed on the National Priorities List. Remedial activities are overseen by the EPA, the Central Valley Regional Water Quality Control Board (CVRWQCB), and DTSC, under the authority of an FFA for the site. Contaminants of concern at Site 300 include VOCs (primarily TCE), high explosive compounds, tritium, depleted uranium, silicone-based oils, nitrate, perchlorate, polychlorinated biphenyls, dioxins, furans, and metals. The contaminants present in environmental media vary within the different environmental restoration operable units (OUs) at the site. See Webster-Scholten (1994), and Ferry et al. (1999) for background information on LLNL environmental characterization and restoration activities at Site 300. See Dibley et al. (2009) for the current status of cleanup progress. In 2008, the Site 300 Environmental Restoration Project (ERP) met all regulatory and DOE milestones on schedule including finalizing the Building 850 PCB-contaminated Soil Engineering Evaluation/Cost Analysis, the Pit 7 Complex Interim Remedial Design report, the Building 850 PCB-contaminated Soil Action Memo, and the Building 854 Final 5-Year Review. In addition, the Site-Wide Record of Decision for Site 300 establishing final cleanup actions and standards was completed in 2008.

Treatment Facilities. During 2008, the Site 300 ERP operated 15 groundwater and 5 soil vapor treatment facilities at Site 300. The groundwater extraction wells and dual phase extraction wells extracted about 38 million L of groundwater during 2008. The dual phase extraction wells and soil vapor extraction wells together removed 2.3 million m^3 of soil vapor.

In 2008, the Site 300 treatment facilities removed about 18 kg of VOCs, 0.13 kg of perchlorate, 1300 kg of nitrate, 0.21 kg of the high explosive compound RDX, and 0.0068 kg of silicone-based oil. Since remediation efforts began in 1990, more than 1389 million L of groundwater and approximately 11 million m^3 of soil vapor have been treated, removing about 520 kg of VOCs, 0.79 kg of perchlorate, 6600 kg of nitrate, 1.1 kg of RDX, and 9.5 kg of silicone-based oil.

Community Relations. The Site 300 CERCLA Project maintains continuing communications with the community of Tracy and nearby neighbors. Community relations activities in 2008 included maintenance of information repositories and an administrative record; participation in community meetings and workshops; tours of site environmental activities; offsite, private, well-sampling activities; mailings to stakeholders; and providing responses to public and news media inquiries. LLNL hosted TAG meetings with Tri-Valley CAREs to provide a forum for focused discussions on CERCLA activities at Site 300. A public workshop was held in Tracy for the Building 850 Removal Action for PCB-contaminated soil on March 6, 2008.

2.1.2 Emergency Planning and Community Right-to-Know Act and Toxics Release Inventory Report

Title III of SARA, known as the Emergency Planning and Community Right-to-Know Act (EPCRA), requires owners and operators of facilities who handle certain hazardous chemicals on site to provide information on the release, storage, and use of these chemicals to organizations responsible for emergency response planning. Executive Order 13423, Strengthening Federal Environmental, Energy, and Transportation Management, directs all federal agencies to comply with the requirements of the EPCRA, including SARA, Section 313, the Toxic Release Inventory (TRI) Program. EPCRA requirements and LLNL compliance are summarized in **Table 2-3.**

Table 2-3. Compliance with EPCRA.

EPCRA section	Brief description of requirement	LLNL action
302	Notify SERC of presence of extremely hazardous substances.	Originally submitted 5/87.
303	Designate a facility representative to serve as emergency response coordinator.	Update submitted 1/22/08 to San Joaquin County for Site 300 and 3/1/08 to Alameda County for Livermore site.
304	Report releases of certain hazardous substances to SERC and LEPC.	No EPCRA-listed extremely hazardous substances were released above reportable quantities in 2008.
311	Submit MSDSs or chemical list to SERC, LEPC, and Fire Department.	Update submitted 3/18/08.
312	Submit hazardous chemical inventory to local administering agency (county).	Submitted to San Joaquin and Alameda counties on 1/22/08 and 3/1/08, respectively.
313	Submit Form R to U.S. EPA and California EPA for toxic chemicals released above threshold levels.	Form R for lead for Site 300 and mercury for Livermore site submitted to DOE 6/10/08; DOE forwarded it to U.S. EPA and California EPA 6/26/08.

On June 10, 2008, LLNL submitted to DOE/NNSA the TRI Form R for mercury for the Livermore site detailing environmental release estimates for calendar year (TRI reporting year) 2007. Form R is used for reporting TRI chemical releases and includes information about waste management and waste minimization activities. This is the first year LLNL exceeded reporting thresholds for mercury; therefore, no year-to-year trending information is currently available.

LLNL has reported lead release data for Site 300 since 2002. Over 99 percent of lead releases are associated with activities at the Site 300 Small Firearms Training Facility (SFTF). Data for the 2007 TRI Form R for lead at Site 300 was submitted to DOE/NNSA on June 10, 2008. Site 300 SFTF lead releases were calculated based on information from the ammunition material safety data sheets (MSDSs), which was confirmed by the manufacturer, and subsequently reported based on best available information. In April 2009, LLNL became aware that manufacturer-provided data for a certain caliber ammunition was not just for the bullet, but for the entire round. The lower lead composition of the entire round caused LLNL to underreport lead releases for calendar years 2002–2007 (TRI reporting years 2002–2007). LLNL has since obtained revised composition data from the manufacturer and opted to submit revised TRI reports for reporting years 2002–2007 to DOE/NNSA in May 2009. Although the revised release estimates range from 1 to 8 times higher than originally reported, the revised data still indicate a trend of decreasing lead releases over this time period as a result of pollution prevention efforts, such as increasing the use of frangible bullets. A summary of the original and revised estimates of the total lead releases at Site 300 is shown in **Table 2-4**. Although the release values in **Table 2-4** include both land and air releases, the releases from the SFTF are, by far, the largest contributor to the total values. LLNL subsequently issued a Lessons Learned, "Relying on MSDSs to Estimate Environmental Releases Can Cause Errors," (LLNL 2009b), so other DOE sites can learn from LLNL's experience.

Table 2-4. Original and revised total on-site disposal or other releases of lead at Site 300, 2002–2007.

Reporting Year	Original Total On-site Disposal or Other Releases (pounds)	Revised Total On-site Disposal or Other Releases (pounds)
2002	3898.9	4889.9
2003	1129.8	6198.6
2004	605.3	4882.2
2005	471.9	4065.9
2006	447.5	2910.3
2007	372.2	2679.0

2.1.3 California Accidental Release Prevention (CalARP) Program

The California Accidental Release Prevention (CalARP) Program is the combined federal and state program for the prevention of accidental release of regulated toxic and flammable substances. The goal of the combined program is to eliminate the need for two separate and distinct chemical risk management programs.

In June 2000, LLNL Site 300 submitted a risk management plan (RMP) to the San Joaquin County, Office of Emergency Services (SJCOES). The RMP described the systems in place to prevent or mitigate the hazards associated with chlorine used in the LLNL Site 300 water treatment system. In accordance with the Final CalARP Program Regulations in the California Code of Regulations (Title 19, Division 2, Chapter 4.5), the LLNL Site 300 RMP was updated in August 2005. It has been determined that the Site 300 water treatment system falls under CalARP Program Level 2. This plan is updated at least every five years.

In August 2008, LLNL submitted a CalARP Program Level 1 RMP for both lithium hydride and nitric acid present at the Livermore site in quantities above the state thresholds.

2.1.4 Resource Conservation and Recovery Act and Related State Laws

The Resource Conservation and Recovery Act (RCRA) provides the framework at the federal level for regulating solid wastes, including wastes designated as hazardous. The California Hazardous Waste Control Law (HWCL) and California Code of Regulations (CCR) Title 22 set requirements for managing hazardous wastes and implementing RCRA in California. LLNL works with DTSC to comply with these regulations and obtain hazardous waste permits.

The hazardous waste management facilities at the Livermore site consist of permitted units in Area 612 and Buildings 693, 695, and 696 of the Decontamination and Waste Treatment Facility (DWTF). Permitted waste management units include container storage, tank storage, and various treatment processes (e.g., wastewater filtration, blending, and size reduction). Final closure was granted by the DTSC for Area 514, and closure approval for the Building 233 container storage unit (CSU) is expected once LLNL submits the Closure Report to the DTSC. LLNL also expects to receive DTSC's approval of the Building 419 Closure Plan during fiscal year 2009. During 2007/2008, LLNL submitted several permit modification requests to DTSC that have all been approved and implemented.

The hazardous waste management facilities at Site 300 consist of three operational RCRA-permitted facilities. The Explosives Waste Storage Facility (EWSF) and the Explosives Waste Treatment Facility (EWTF) are permitted to store and treat explosives waste, respectively. The Building 883 container storage area (CSA) is permitted to store routine facility-generated waste such as spent acids, bases, contaminated oil, and spent solvents. Site 300 has one post-closure permit for the RCRA-closed Building 829 High Explosives Burn Pits. LLNL is currently in the process of renewing the hazardous waste facility permit for EWSF, EWTF, and Building 883 CSA. The Building 829 permit will not expire until April 2, 2013. Transportation of hazardous or mixed waste over public roads occurs by DTSC-registered transporters. DTSC issued hazardous waste transporter registration #1351 to LLNS on November 24, 2008.

2.1.5 California Medical Waste Management Act

All LLNL medical waste management operations are conducted in accordance with the California Medical Waste Management Act (CMWMA). The program is administered by the California Department of Health Services (DHS) and is enforced by the Alameda County Department of Environmental Health (ACDEH). LLNL's medical waste permit is renewed on an annual basis and covers medical waste generation and treatment activities for the eight Biosafety Level (BSL) 2 facilities, and the BSL 3 facility at Building 368.

2.1.6 Radioactive Waste and Mixed Waste Management

LLNL manages radioactive waste and mixed waste in compliance with applicable sections of DOE Order 435.1, and the LLNL-developed *Radioactive Waste Management Basis for the Lawrence Livermore National Laboratory* (LLNL 2008), which summarizes radioactive waste management controls relating to waste generators and treatment and storage facilities. LLNL does not release to the public any property with residual radioactivity above the limits specified in DOE Order 5400.5. Excess property of this type is either transferred to other DOE facilities for reuse or transferred to LLNL's Radioactive and Hazardous Waste Management Division for disposal.

2.1.7 Federal Facility Compliance Act

LLNL is continuing to work with DOE to maintain compliance with the Federal Facilities Compliance Act (FFCA) Site Treatment Plan (STP) for LLNL, which was signed in February 1997. LLNL completed 20 milestones during 2008, and of those, 13 had due dates beyond 2008 (ranging from 2009 to 2011).

LLNL requested, and was granted, extensions for two additional milestones to allow LLNL time to pursue alternative treatment options for 1.7 m^3 of waste.

LLNL removed approximately 51 m^3 of mixed waste from the STP in 2008. An additional 22 m^3 of newly generated mixed waste was added to the STP, reflecting an overall reduction of 29 m^3 of mixed waste being stored by LLNL.

Reports and certification letters were submitted to DOE as required. LLNL continued the use of available commercial treatment and disposal facilities that are permitted to accept LLNL mixed waste. These facilities provide LLNL greater flexibility in pursuing the goals and milestones set forth in the STP.

2.1.8 Toxic Substances Control Act

The Federal Toxic Substances Control Act (TSCA) and implementing regulations found in Title 40 of the Code of Federal Regulation, Parts 700–789 (40 CFR 700-789) govern the uses of newly developed chemical substances and TSCA-governed waste. All TSCA-regulated waste was disposed of in accordance with TSCA, state, and local disposal requirements with one exception. Radioactive polychlorinated biphenyl (PCB) waste is currently stored at one of

LLNL's hazardous waste storage facilities until an approved facility accepts this waste for final disposal.

2.2 Air Quality and Protection

2.2.1 Clean Air Act

All activities at LLNL are evaluated to determine the need for air permits. Air permits are obtained from the Bay Area Air Quality Management District (BAAQMD) for the Livermore site and from the San Joaquin Valley Air Pollution Control District (SJVAPCD) and/or BAAQMD for Site 300. Both agencies are overseen by the California Air Resources Board (CARB), which also oversees statewide permitting for portable diesel fuel-driven equipment such as portable generators and portable air compressors.

In 2008, LLNL operated 172 permitted air emission sources at the Livermore site and 37 permitted air emission sources at Site 300. In addition, the Livermore site continues to maintain a Synthetic Minor Operating Permit (SMOP), which was issued by the BAAQMD in 2002, to ensure the Livermore site does not emit regulated air pollutants in excess of federal Clean Air Act (CAA) Title V limits. Therefore, LLNL is able to demonstrate that it does not have any major sources of air pollutant emissions per 40 CFR 70.2.

LLNL eliminated an adhesive application operation as well as a solvent wipe cleaning operation that, together, had the potential of emitting 0.95 MT of volatile organic compounds (VOCs), annually. In addition, LLNL eliminated six diesel-powered generators and installed exhaust filters with a verified 85% particulate capture capability on five diesel-powered generators. The elimination or modification of the eleven generators significantly reduced the combustion pollutants emitted from the Livermore site by the diesel powered generator fleet. LLNL also consolidated semiconductor fabrication research and development operations into one facility, thus reducing the potential to emit 0.2 MT of precursor organic compounds (POCs) annually.

2.2.2 National Emission Standards for Hazardous Air Pollutants, Radionuclides

To demonstrate compliance with 40 CFR Part 61, Subpart H (National Emission Standards for Hazardous Air Pollutants [NESHAPs] for radiological emissions from DOE facilities), LLNL monitors certain air release points and evaluates the maximum possible dose to the public. The *LLNL NESHAPs 2008 Annual Report* (Bertoldo et al. 2009), submitted to EPA, reported that the estimated maximum radiological doses that could have been received by a member of the public in 2008 were 0.013 µSv (0.0013mrem) for the Livermore site and 0.00000044 µSv (0.000000044 mrem) for Site 300. The totals are well below the 100 µSv/y (10 mrem/y) dose limits defined by the NESHAPs regulations.

2.3 Water Quality and Protection

LLNL complies with requirements of the federal Clean Water Act (CWA) and Safe Drinking Water Act (SDWA); the California Aboveground Petroleum Storage Act, Water Code, and Health and Safety Code; and City of Livermore ordinances, by complying with regulations and obtaining permits issued by several agencies whose mission is to protect water quality.

LLNL complies with the requirements of National Pollutant Discharge Elimination System (NPDES) and Waste Discharge Requirement (WDR) permits, and Water Quality Certifications issued by Regional Water Quality Control Boards (RWQCBs) and the State Water Resources Control Board (SWRCB) for discharges to waters of the U.S. and waters of the State. Discharges to the City of Livermore's sanitary sewer system are governed by permits issued by the Water Resources Division (WRD). The SDWA requires that LLNL register Class V injection wells with EPA, and LLNL obtains permits from the Army Corps of Engineers (ACOE) for work in wetlands and waters of the U.S.

The CWA and California Aboveground Petroleum Storage Act require LLNL to have and implement Spill Prevention Control and Countermeasure (SPCC) plans for aboveground, oil-containing containers. The ACDEH and the San Joaquin County Environmental Health Department (SJCEHD) also issue permits for operating underground storage tanks containing hazardous materials or hazardous waste (see **Table 2-1**). LLNL's permitted underground storage tanks, for which permits are required, contain diesel fuel, gasoline, and used oil; aboveground storage tanks, for which permits are not required, contain fuel, insulating oil, and process wastewater.

2.4 Other Environmental Statutes

2.4.1 National Environmental Policy Act and Floodplains and Wetland Assessments

The National Environmental Policy Act (NEPA) is the U.S. government's basic environmental charter. When considering a proposed project or action at LLNL, DOE/NNSA must (1) consider how the action would affect the environment and (2) make certain that environmental information is available to public officials and citizens before decisions are made and actions are taken. The results of the evaluations and notice requirements are met through publication of "NEPA documents", such as environmental impact statements (EISs) and environmental assessments (EAs) under DOE regulations in 10 CFR 1021. In 2005 DOE completed the *Final Site-Wide Environmental Impact Statement for Continued Operation of Lawrence Livermore National Laboratory and Supplemental Stockpile Stewardship and Management Programmatic Environmental Impact Statement* (U.S. DOE/NNSA 2005). There were no proposed actions at LLNL that required separate DOE floodplain or wetlands assessments under DOE regulations in 10 CFR Part 1022.

2.4.2 National Historic Preservation Act

The National Historic Preservation Act (NHPA) provides for the protection and preservation of historic properties that are significant in the nation's history. LLNL resources subject to NHPA consideration range from prehistoric archeological sites to remnants of LLNL's own history of scientific and technological endeavors. The responsibility to comply with the provisions of NHPA rests with DOE/NNSA as the lead federal agency in this undertaking. LLNL supports the agency's NHPA responsibilities with direction from DOE/NNSA.

In consultation with the State Historic Preservation Officer (SHPO), DOE/NNSA formally determined that five archaeological resources, five buildings, two historic districts, and selected objects in one building at LLNL are eligible for listing in the National Register of Historic Places (NRHP). To assist DOE and SHPO in developing an agreement as to how to manage the NRHP-eligible properties, LLNL prepared a draft Programmatic Agreement (PA), which includes a draft archaeological resources treatment plan and a draft historic buildings treatment plan as appendices. These plans describe specific resource management and treatment strategies that DOE/NNSA, in cooperation with LLNL, could implement to ensure that significant historic properties are managed in a manner that considers their historic value. As of the end of 2008, SHPO was still reviewing the draft PA and treatment plans.

2.4.3 Antiquities Act of 1906

Provisions of the Antiquities Act provide for protection of items of antiquities (i.e., paleontological remains). No remains subject to the provisions of the Antiquities Act were identified in 2008.

2.4.4 Endangered Species Act and Sensitive Natural Resources

LLNL meets the requirements of the federal and state Endangered Species Act (ESA), the Eagle Protection Act, the Migratory Bird Treaty Act, and other applicable regulations as they pertain to endangered species, threatened species, and other special-status species (including their habitats) and designated critical habitats that exist at the LLNL sites. The following list highlights 2008 compliance activities.

- In September 2008, LLNL biologists monitored the removal of boulders from Arroyo Mocho as required by the amendment to the *Biological Opinion for the Arroyo Mocho Road Improvement and Anadromous Fish Passage Project* for the Arroyo Mocho Boulder Removal Project.
- On July 29, 2008, LLNL submitted a Biological Assessment to the U.S. Fish and Wildlife Service (USFWS) for the Arroyo Mocho Erosion Control Maintenance Project**.** LLNL received an amendment to the *Biological Opinion for the Arroyo Mocho Road Improvement and Anadromous Fish Passage Project* for this project on May 21, 2009.
- LLNL biologists monitored the removal of sediment and vegetation from the drainage channel located immediately east of the A-8W parking lot as required by the amended

Biological Opinion for the Arroyo Maintenance Project on Arroyo Las Positas at Lawrence Livermore National Laboratory.

- On November 17, 2008, LLNL submitted a Biological Assessment to the USFWS for the Building 850 Polychlorinated Biphenyls-Bearing Soil Removal Project. An amendment to the 2002 Biological Opinion for the *Formal Consultation on the Routine Maintenance and Operations Project at LLNL, Site 300 Experimental Test Site* for this project was received on April 9, 2009.

2.4.5 Federal Insecticide, Fungicide, and Rodenticide Act

LLNL complies with the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA), which provides federal control of the distribution, sale, and use of pesticides, and requires that commercial users of pesticides are certified pesticide applicators. The California Department of Pesticide Regulation (DPR) has enforcement responsibility for FIFRA in California; DPR has in turn given enforcement responsibility to county departments of agriculture. All pesticides at LLNL are applied, stored, and used in compliance with FIFRA and other California, Alameda County, and San Joaquin County regulations governing the use of pesticides. The staff of the Landscape and Pest Management Shop at the Livermore site and the Laborer/Gardener Shop at Site 300 includes certified pesticide applicators. These shops ensure that all storage and use of pesticides at LLNL is in accordance with applicable regulations. LLNL also reviews pesticide applications to ensure they do not result in impacts to water quality or special status species.

2.5 Environmental Occurrences

Notification of environmental occurrences is required under a number of environmental laws and regulations as well as DOE Order 231.1A and DOE Manual 231.1-2. In 2008, eight environmental incidents, summarized in **Table 2-5**, were reportable under DOE Order 232.1A.

Contributing Authors

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Table 2-5. Environmental Occurrences reported under the Occurrence Reporting System in 2008.

Date[(a)]	Occurrence category/group	Description
4/17/08	Significance Category SC2 Occurrence under Group 5A(1) OR 2008-0014	Legacy mercury contamination was discovered in soil at Building 212 during facility decontamination and demolition activities.
6/3/08	Significance Category SC3 Occurrence under Group 10(2) OR 2008-0018	An LLNL contractor sent metal with detectable levels of tritium below DOE release limits to a landfill for disposal as instructed by LLNL. The landfill subsequently released the metal to a third party for recycling.
8/19/08	Significance Category SC4 Occurrence under Group 9(2) OR 2008-0033	LLNL received a Notice to Comply from the SJCEHD during the CUPA inspection of Site 300 for failure to properly characterize a waste container.
9/8/08	Significance Category SC4 Occurrence under Group 9(2) OR 2008-0037	LLNL received a notice of violation (NOV) from the SJCEHD during the annual inspection of the Site 300 Building 879 fuel station. The NOV identified violations in the monitoring program, records maintenance, spill containment, and repair permits for underground storage tanks.
9/23/08	Significance Category SC4 Occurrence under Group 9(2) OR 2008-0041	LLNL received a report for the DTSC for the Site 300 CEI performed on May 21–22, 2008. The report noted that LLNL failed to conduct the November 2007 monthly inspection for the Post-Closure Unit Building 829.
10/3/08	Significance Category SC4 Occurrence under Group 9(2) OR 2008-0044	LLNL received a final audit report from the DTSC for the 2008 CEI performed between June 30 and July 11, 2008. The report identified two violations: 1) failure to determine if water entering the oil/water separator at Building 611 is hazardous and 2) having an Emergency Coordinator (on-duty Fire Chief) who is not an LLNL employee.
10/9/08	Significance Category SC4 Occurrence under Group 9(2) OR 2008-0045	LLNL received an NOV from the State of Utah, Department of Environmental Quality, following an audit of LLNL waste shipped to EnergySolutions of Utah. The violation pertained to inadequate bracing of the containers within the trailer.
12/23/08	Significance Category SC2 Occurrence under Group 2B(2) OR 2008-0069	During small-scale treatment activities involving radioactive waste inside a glove box, a rapid pressure pulse event occurred resulting in the loss of less than 4 mCi of material. The material was contained in the facility and no release to the environment occurred.

(a) Date the occurrence was categorized, not discovered.

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3. Environmental Program Information

Jennifer Doman

LLNL is committed to enhancing its environmental stewardship and to reducing any impacts its operations may have on the environment. This chapter describes the lead organizations that support the LLNL's environmental stewardship and describes LLNL's Environmental Management System (EMS) and Pollution Prevention (P2) program.

3.1 Environmental Protection Program

Three organizations lead the environmental protection program and provide environmental expertise to the Laboratory: Environmental Protection Department (EPD), Radioactive and Hazardous Waste Management (RHWM) Division and Environmental Restoration Department (ERD). Spill response and energy, water and fleet management are also key components of environmental protection and sustainability.

3.1.1 Environmental Protection Department

EPD is responsible for environmental monitoring and environmental regulatory interpretation and implementation guidance in support of LLNL's programs. EPD prepares and maintains environmental plans, reports, and permits; maintains the environmental portions of the *Environment, Safety, and Health* (*ES&H) Manual*; informs management about pending changes in environmental regulations pertinent to LLNL; represents LLNL in day-to-day interactions with regulatory agencies and the public; develops and provides institutional environmental training; and assesses the effectiveness of pollution control programs. A principal part of EPD's mission is to work with LLNL programs to ensure that operations are conducted in a manner that limits environmental impact and that is in compliance with regulatory requirements. The EPD Department Head also serves as the LLNL EMS Coordinator and leads the EMS task force.

3.1.2 Radioactive and Hazardous Waste Management Division

RHWM manages all hazardous, radioactive, and mixed wastes generated at LLNL facilities in accordance with local, state, and federal requirements. RHWM processes, stores, packages, treats, and prepares waste for shipment and disposal, recycling, or discharge to the sanitary sewer. As part of its waste management activities, RHWM tracks and documents the movement of hazardous, mixed, and radioactive wastes from waste accumulation areas (WAAs), which are typically located near the waste generator, to final disposition; develops and implements approved standard operating procedures; decontaminates LLNL equipment; ensures that containers for shipment of waste meet the specifications of the U.S. Department of Transportation (DOT) and other regulatory agencies; responds to emergencies; and participates in the cleanup of potential hazardous and radioactive spills at LLNL facilities. RHWM prepares numerous reports in support of its mission including those required by regulation and various guidance and management plans.

RHWM meets regulations for the treatment of LLNL's mixed waste in accordance with the requirements of the FFCA. The schedule for this treatment is negotiated with California and involves developing new on-site treatment options as well as finding off-site alternatives.

3.1.3 Environmental Restoration Department

ERD evaluates and remediates soil and groundwater contaminated by past hazardous materials handling and disposal practices and from leaks and spills that have occurred at the Livermore site and Site 300 prior to and during LLNL operations. ERD conducts field investigations at both sites to characterize the existence, extent, and impact of contamination. ERD evaluates and develops various remediation technologies, makes recommendations, and implements actions for site restoration. ERD is responsible for managing remedial activities, such as soil removal and groundwater and soil vapor extraction and treatment, and for decontamination, decommissioning, and demolition of closed facilities in a manner that prevents environmental contamination and completes the facility life cycle. As part of its responsibility for CERCLA compliance issues, ERD plans, directs, and conducts assessments to determine both the impact of past releases on the environment and the restoration activities needed to reduce contaminant concentrations to protect human health and the environment.

3.1.4 Response to Spills and Other Environmental Emergencies

LLNL has an active spill response program to investigate and evaluate all spills and leaks (releases) at LLNL that are potentially hazardous to the environment. During working hours incidents can be reported to the EPD environmental analysts supporting program areas, or the LLNL Fire Dispatch for investigation and response. Off-hour incidents are reported to Fire Dispatch who notifies the Environmental Duty Officer (EDO) and the on-site Fire Department if required. The EDO, who is available 24 hours a day, seven days a week, maximizes efficient and effective emergency environmental response. The EDO and environmental analysts also notify and consult with LLNL management and have seven-day-a-week, 24-hour-a-day access to the Office of Laboratory Counsel for questions concerning regulatory reporting requirements.

3.1.5 Energy, Water and Fleet Management

The Facilities and Infrastructure Directorate implements Laboratory-wide programs for energy and water conservation, fleet management, high performance sustainable building, and renewable energy. These programs are designed to meet the requirements of DOE Order 430.2B, Departmental Energy, Renewable Energy and Transportation Management. The programs contribute to environmental protection through implementation of lab-wide reduction initiatives (see **Table 3-2**).

3.2 Environmental Management System

LLNL established its EMS to meet the requirements of International Organization for Standardization (ISO) 14001:1996 in June 2004. In 2006, LLNL upgraded its EMS to meet the requirements of ISO 14001:2004, and developed a number of Environmental Management Plans (EMPs) that address lab-wide significant aspects. During FY07, the EMS expanded to incorporate

EMPs at the programmatic level. During FY08, more focus was placed on raising lab-wide awareness of the EMS, and on continued development of EMPs at both the institutional and programmatic levels.

3.2.1 Environmental Management Plans

EMS representatives from each program area continue to develop EMPs and associated objectives and targets, based on program-specific aspects. During FY08, directorates completed a reorganization into five Principal Directorates, plus the Director's Office. Existing active environmental plans were adopted by the new organizations, and additional EMPs were developed.

Directorates selected aspects to pursue considering which ones they could reasonably affect, based on budget and mission. During 2008, the directorate EMPs listed in **Table 3-1** were active. In addition, a number of EMPs and initiatives have been implemented to address Lab-wide environmental aspects (see **Table 3-2**).

Table 3-1. LLNL Directorate Environmental Management Plans active in 2008

Principal Directorate	Aspect(s) addressed	Environmental Management Plan(s) and Program(s)
Operations & Business	• Mixed waste generation	• Development of Authorized Limits for ERD GAC Filters (closed in 2008)
	• Municipal waste generation	• Municipal Waste Generation
	• Municipal waste generation	• Recycling of Beverage Containers
	• Municipal waste generation • Nonhazardous materials use	• Office Paper Use Reduction and Recycling
	• Nonhazardous materials use	• Nonhazardous Materials Use
	• Electrical energy use • Fossil fuel consumption	• IMF (Institutionally Managed Facilities) Energy Conservation
Weapons & Complex Integration	• Cultural resource disturbance	• Archaeological Resources
	• Ecological resource disturbance	• Ecological Resources
	• Electrical energy use	• Electrical Energy Use
	• Fossil fuel consumption	• Fossil Fuel Consumption
	• Hazardous materials use	• Hazardous Materials Use
	• Municipal waste generation	• Municipal Waste Generation
	• Nonhazardous materials use	• Nonhazardous Materials Use
	• Radioactive materials use	• Radioactive Materials Use
	• Renewable energy use	• Renewable Energy Use
Science & Technology	• Municipal waste generation • Nonhazardous materials use	• Computer Packaging Material Recycling Plan
	• Nonhazardous materials use	• Minimizing Outdoor Equipment Storage

Table 3-1 (cont.). LLNL Directorate Environmental Management Plans active in 2008

Principal Directorate	Aspect(s) addressed	Environmental Management Plan(s) and Program(s)
Science & Technology (cont.)	• Hazardous materials use • Waste reduction	• Preventing the Formation of Lead Oxide by Sealing Lead Shielding
	• All environmental aspects	• EMS Integration into Work Control Process
	• Electrical energy use	• Server Energy Efficiency Opportunities
	• Radioactive materials use	• Minimizing Radioactive Sealed Sources and Reducing Exposure Hazards
	• Municipal waste generation	• Office Paper Use Reduction and Recycling
	• Municipal waste generation	• Evaluation of Beverage Container Recycling Opportunities in the S&T PAD
	• Electrical energy use	• B453 Electrical Energy Conservation
	• Hazardous waste generation • Industrial waste generation	• Engineering Shop Consolidation
Global Security	• Municipal waste generation • Nonhazardous materials use	• Office Paper Use Reduction and Recycling (completed in 2008)
Director's Office	• Municipal waste generation • Nonhazardous materials use	• Office Paper Use Reduction and Recycling
	•	•
	• Waste reduction	• Pharmaceutical Inventory Reduction Review (completed in 2008)
	•	•
	• Hazardous air pollutants emissions • Hazardous waste generation • Industrial waste generation • Hazardous materials use	• Modified Procedure for the Analysis of Plutonium in Urine Samples (completed in 2008)
	• Hazardous materials use	• Hazardous Materials Use Reduction
NIF & Photon Science	• Hazardous waste generation • Municipal waste generation	• Legacy Waste Management
	• Hazardous waste management	• Online Service Request Button

Table 3-2. LLNL Environmental Management Plans and Initiatives for Lab-wide aspects active in 2008

Environmental aspect	Objective summary	Status
Ecological resource disturbance	• Establish an LLNL policy prohibiting the introduction of exotic species • Educate LLNL employees about the consequences of exotic species introduction • Control exotic species, e.g., feral pig, largemouth bass	Ongoing.
Electrical energy use[(a)]	• Meet the energy use intensity goals outlined in DOE Order 430.2B, Departmental Energy, Renewable Energy and Transportation Management	Energy use intensity was reduced by 5.39% over the FY03 baseline, exceeding the 3% fixed target for FY08.
Fossil fuel consumption/ renewable energy use[(a)]	• Meet the Vehicle Fleet Management objectives outlined in DOE Order 430.2B, Departmental Energy, Renewable Energy and Transportation Management	The E85 fuel station continued operation in 2008. LLNL has 267 E85 compatible alternative fuel vehicles (AFV) on-site and 65 electric vehicles (GEMS). Fleet Management continues to replace conventional fuel vehicles with AFVs per the General Services Administration (GSA) replacement schedule. LLNL's fleet size was reduced by 24% during FY08, resulting in a net reduction in total fuel consumption of 29,601 gallons.
Hazardous materials use	• Identify priority chemicals for reduction, assess current hazardous materials usage, and provide information to programs for reduction evaluation.	Revised in late 2008, and republished as "Promotion of Safe Alternatives to Toxic Chemical Use".
Mixed waste generation	• Reduce the amount of mixed and California combined solid waste generated from routine LLNL programmatic operations when economically and technologically feasible	Evaluation report prepared and EMP updated. (completed in 2008)
Nonhazardous materials use	• Incorporate affirmative procurement site-wide • Increase site-wide use of products with recycled content	Remaining training sessions scheduled for Q2FY08. (completed Q2FY08)
Water use[(a)]	• Meet the water conservation goals outlined in DOE Order 430.2B, Departmental Energy, Renewable Energy and Transportation Management	LLNL decreased potable water use in FY08 by 3.43% over the FY07 baseline, exceeding the 2% fixed target for FY08.
Construction and building maintenance[(a)]	• Achieve Leadership in Energy & Environmental Design for Existing Buildings (LEED-EB) certification for 15% of site's existing building square footage by FY2015	Submitted one office building for U.S. Green Building Council (USGBC) LEED-EB operations and maintenance certification review.
Renewable energy use[(a)]	• Meet the renewable energy goals outlined in DOE Order 430.2B, Departmental Energy, Renewable Energy and Transportation Management	A renewable energy analysis was conducted in April 2008. The assessment included an analysis of potential opportunities for renewable energy technologies, including solar photovoltaics, solar thermal, wind turbines and biomass energy projects.

(a) Aspect is addressed as part of the DOE Order 430.2B Executable Plan.

3.2.2 Senior Management Review of EMS

No management review of the EMS was performed during FY 2008.

3.3 Pollution Prevention Program

LLNL's P2 Program operates within the framework of the Integrated Safety Management System (ISMS) and EMS and in accordance with applicable laws, regulations, and DOE orders as required by contract. It encompasses stewardship and maintenance, waste stream analysis, reporting of waste generation and P2 accomplishments, and fostering of P2 awareness through presentations, articles, and events. The P2 Program supports institutional and directorate P2 activities via environmental teams, including implementation and facilitation of source reduction and/or reclamation, recycling, and reuse programs for hazardous and nonhazardous waste; facilitation of environmentally preferable procurement; and preparation of P2 opportunity assessments. LLNL's P2 Program is described in the *ES&H Manual*, Document 30.1.

The P2 Program at LLNL strives to systematically reduce all types of waste generated, and to eliminate or minimize pollutant releases to all environmental media from all aspects of the operations at the Livermore site and Site 300. These efforts help protect public health and the environment by reducing or eliminating waste, improving resource usage, and reducing inventories and releases of hazardous chemicals. These efforts also benefit LLNL by reducing compliance costs and minimizing the potential for civil and criminal liabilities under environmental laws. In accordance with EPA guidelines and DOE policy, the P2 Program uses a hierarchical approach to waste reduction (i.e., source elimination or reduction, material substitution, reuse and recycling, and treatment and disposal), which is applied, where feasible, to all types of waste. Waste generation is tracked using RHWM's HazTrack database. By reviewing the information in this database, program managers and P2 Program staff can monitor and analyze waste streams to determine cost-effective improvements to LLNL operations.

LLNL continues its efforts to phase-out Class I ozone depleting substances (ODSs). These efforts include recovery and recycling activities, refrigerant and coolant substitutions, preventative maintenance, leak detection programs, and equipment replacement. LLNL uses minimal quantities of ODSs for mission-critical laboratory research, under the "laboratory exemption" provided for in 40 CFR Part 82, Subpart A, Appendix G.

3.3.1 Routine Hazardous, Transuranic, and Radioactive Waste

Routine waste listed in **Table 3-3** includes waste from ongoing operations produced by any type of production, analysis, and research and development taking place at LLNL. Residues resulting from the treatment of routine waste are not included to avoid double counting. There was an increase in hazardous waste volume in FY 2008, including a large volume of waste oil resulting from decommissioned equipment, site consolidation, and maintenance activities.

Table 3-3. Routine hazardous, transuranic, and radioactive waste at LLNL, FY 2005–2008.

Waste category	FY 2005	FY 2006	FY 2007	FY 2008
Routine hazardous waste generated	127 MT	153 MT	138 MT	248 MT
Routine low-level waste generated	54 m^3	66 m^3	197 m^3	77 m^3
Routine mixed waste generated	16 m^3	18 m^3	30 m^3	17 m^3
Routine TRU / mixed TRU waste generated	1 m^3	1 m^3	3 m^3	4 m^3

3.3.2 Diverted Waste

LLNL maintains an active waste diversion program, encouraging recycling and reuse of both routine and nonroutine waste.

3.3.2.1 Routine Waste

Together, the Livermore site and Site 300 generated 3506 MT of routine nonhazardous solid waste in FY 2008. This volume includes diverted waste (e.g., material diverted through recycling and reuse programs) and landfill waste.

Both sites combined diverted a total 2242 MT of routine nonhazardous waste in FY 2008, which represents a diversion rate of 64%. The diverted routine nonhazardous waste includes waste recycled by RHWM and materials diverted through the surplus sales program. The portion of routine nonhazardous waste sent to landfill was 1264 MT. See **Table 3-4**.

In 2008, LLNL transferred or donated for reuse 1 MT of electronics and recycled 69 MT of electronics, which were managed as universal waste.

Table 3-4. Routine nonhazardous waste in FY 2008, Livermore site and Site 300 combined.

Destination	Waste description	Amount in FY 2008 (MT)
Diverted	Batteries, small[a]	7
	Batteries, lead-acid[a]	30
	Beverage containers	3
	Cardboard	131
	Cooking grease	2
	Engine oils	8
	Fluorescent lights[a]	5
	Magazines, newspapers, phone books	20
	Metals	1171
	Paper	220
	Tires and scrap	22

Table 3-4 (cont.). Routine nonhazardous waste in FY 2008, Livermore site and Site 300 combined.

Destination	Waste description	Amount in FY 2008 (MT)
Diverted (cont.)	Toner cartridges	7
	Wood (chips, compost)	616
	TOTAL diverted	**2242**
Landfill	Compacted (landfill)	1264
	TOTAL landfill	**1264**
TOTAL routine nonhazardous waste		**3506**

(a) Batteries and fluorescent lights are managed as universal waste.

3.3.2.2 Nonroutine Waste

Nonroutine nonhazardous solid wastes include excavated soils, wastes and metals from construction, and decontamination and demolition activities. The Livermore site and Site 300 generated a total of 6889 MT of nonroutine nonhazardous solid waste in FY 2008.

In FY 2008, the two sites combined diverted 6342 MT of nonroutine nonhazardous solid waste through reuse or recycling, which represents a diversion rate of 92%. Diverted nonroutine nonhazardous solid waste includes soil reused either on site for other projects or as cover soil at Class II landfills, and metals recycled through the metals recycling programs. See **Table 3-5**.

Table 3-5. Nonroutine nonhazardous waste in FY 2008, Livermore site and Site 300 combined.

Destination	Waste description	Amount in FY 2008 (MT)
Diverted	Class II cover soil (reused at landfill)	3622
	Class II concrete (reused at landfill)	2467
	Nonroutine metals	253
	TOTAL diverted	**6342**
Landfill	Construction demolition (noncompacted landfill)	425
	Industrial (HazTrack[a])	122
	TOTAL landfill	**547**
TOTAL nonroutine nonhazardous waste		**6889**

(a) RHWM Waste Data Management System

3.3.3 Environmentally Preferable Purchasing

LLNL has a comprehensive Environmentally Preferable Purchasing (EPP) program that includes preferential purchasing of recycled content and biobased products. During FY08 LLNL implemented additional tracking for recycled content, biobased, and Energy Star products to facilitate tracking and improvements in EPP.

In 2008, the EPP program continued to include a preference for Electronic Product Environmental Assessment Tool (EPEAT) registered products. 95% of all desktop electronics purchases in FY 2008 were EPEAT Silver or EPEAT Gold, indicating that the products meet or exceed the Institute of Electrical and Electronics Engineers (IEEE) 1680-2006 environmental performance standard for electronic products.

3.3.4 Pollution Prevention Activities

3.3.4.1 Environmental Stewardship Accomplishments and Awards

The P2 Team nominated LLNL's Space Action Team (SAT) for the 2008 EPA Region 9 Environmental Award, for their "Assets for Value" accomplishments during the 2007 calendar year. The "Assets for Value" process gives contractors the opportunity to include the reuse/salvage value of equipment and recyclable materials from a decontamination and demolition area as an offset in their bid. This process, in place since 2002, reduces the cost of the decontamination and decommissioning (D&D) contracts and maximizes reuse and recycling. SAT D&D activities are critical to the ongoing ability of LLNL to support its mission because for each facility constructed, LLNL must tear down an equivalent amount of legacy facility space.

The P2 Team received the California Integrated Waste Management Board's 2008 WRAP award for recycling accomplishments during the 2007 calendar year. The award recognizes California businesses and organizations that have made outstanding efforts to reduce nonhazardous waste by implementing resource-efficient practices, aggressive waste reduction, reuse and recycling activities, and procurement of recycled-content products.

3.3.4.2 High Performance Sustainable Buildings

The Facilities and Infrastructure Directorate manages the implementation of DOE Order 430.2B objectives related to sustainable building materials and practices. In FY08, a Green Cleaning Policy was developed that meets the U. S. Green Building Council's (USGBC) Leadership in Energy and Environmental Design (LEED) requirements. The purpose and goal of the Policy is to reduce the usage of potentially hazardous cleaning chemicals and their adverse impact on indoor air quality, occupant health, and the environment. Also in FY08, one office building at the Livermore site was submitted for USGBC LEED-EB Operations and Maintenance certification review. This submission is the initial LEED certification effort at LLNL.

3.3.4.3 Energy Conservation

During FY08, LLNL achieved an energy use intensity reduction of 9.94% from FY03 baseline levels, exceeding the cumulative three year 9.0% goal. A number of energy conservation initiatives were implemented or active during FY08, including a formalized Laboratory-wide energy contest, “Every Watt Counts”. The contest encouraged friendly competition between the Principal Directorates as a way to promote energy conservation measures. Employee awareness of energy conservation was promoted through a series of energy savings articles published in *NewsOnline* (the LLNL electronic newsletter).

3.3.5 Pollution Prevention Employee Training and Awareness Programs

In 2008, LLNL conducted a number of activities to promote employee awareness of pollution prevention. LLNL participated in a community Earth Day event, held April 19, 2008. The event was sponsored by the City of Livermore and the Livermore Area Recreation and Park District, and included a creek cleanup and a festival. Over 400 attendees and 25 organizations participated. The P2 Team and volunteers from the LLNL Environmental Protection Department staffed a table at the festival, which included a poster display of LLNL waste diversion activities. Information on LLNL and pollution prevention was distributed to festival attendees.

The P2 Team conducted other awareness activities during the year. Articles on pollution prevention appeared in *Newsline* (the LLNL newspaper) and *NewsOnLine*. The P2 Team conducted training for purchasing staff on EPA requirements for affirmative procurement.

The P2 Team maintains an internal P2 website for LLNL employees. The website is a resource for employees regarding pollution prevention, energy efficiency, reuse and recycling of materials, green building, and other environmental topics. Employees can also use the site to suggest P2 ideas, ask questions about P2 planning and implementation, and find out about P2 current events. The P2 Team also operates the Earth Hotline for employees to call with questions, suggestions, or ideas regarding LLNL’s pollution prevention and waste diversion endeavors.

4. Air Monitoring Programs

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Lawrence Livermore National Laboratory performs continuous air sampling to evaluate its compliance with local, state, and federal laws and regulations and to ensure that human health and the environment are protected. Federal environmental air quality laws and U.S. DOE regulations include 40 CFR 61, Subpart H—the NESHAPs section of the Clean Air Act; applicable portions of DOE Order 5400.5; and ANSI standards. The *Environmental Regulatory Guide for Radiological Effluent Monitoring and Environmental Surveillance* (U.S. DOE 1991) provides the guidance for implementing DOE Order 5400.5.

The EPA Region IX has enforcement authority for LLNL compliance with radiological air emission regulations. Enforcement authority for the Clean Air Act regulations pertaining to nonradiological air emissions belongs to two local air districts: the BAAQMD and the SJVAPCD.

4.1 Air Effluent Monitoring

Air effluent monitoring of atmospheric discharge points is in place for compliance with 40 CFR 61, Subpart H and is used to determine the actual radionuclide releases from individual facilities during routine and nonroutine operations and to confirm the operation of facility emission control systems. Subpart H requires continuous monitoring of facility radiological air effluents if the potential off-site (fence-line) dose equivalent is greater than 1 µSv/y (0.1 mrem/y), as calculated using the EPA-mandated air dispersion dose model, CAP88-PC, without credit for emission control devices. The results of monitoring air discharge points provide the actual emission source information for modeling, which is used to ensure that the NESHAPs standard of 100 µSv/y (10 mrem/y) total site effective dose equivalent from the airborne pathway is not exceeded. See **Chapter 7** for further information on radiological dose assessment.

Currently, the air effluent sampling program measures only radiological emissions. For LLNL operations with nonradiological discharges, LLNL obtains permits from local air districts (i.e., BAAQMD and SJVAPCD) for stationary emission sources, and from the CARB for portable emission sources such as diesel air compressors and generators. Current permits do not require monitoring of air effluent but do require monitoring of equipment usage, material usage, and record keeping during operations. Based on air toxics emissions inventory and risk assessment required by the California Air Toxics “Hot Spots” Information and Assessment Act of 1987, BAAQMD and SJVAPCD have ranked LLNL as a low-risk facility for nonradiological air emissions.

4.1.1 Air Effluent Radiological Monitoring Results and Impact on the Environment

In 2008, LLNL measured releases of radioactivity from air exhausts at five facilities at the Livermore site and at one facility at Site 300. Air effluent monitoring locations at the Livermore site and Site 300 are shown in **Figures 4-1** and **4-2**, respectively.

In 2008, a total of 137 GBq (3.7 Ci) of measured tritium was released from the Tritium Facility. Of this, approximately 93 GBq (2.5 Ci) of tritium was released as vapor (HTO). The remaining tritium released, 44 GBq (1.2 Ci), was gaseous tritium (HT).

During a DOE/NNSA Livermore Site Office walkthrough in May 2008, it was observed that the glycol bubbler from Stack 2 was not correctly assembled. It is believed that a construction project in February 2008 was the cause. There were no activities with tritium during the time frame the bubbler was offline and any tritium emissions to the environment from Stack 2 would be at outgassing levels. A conservative estimate of 3.7 GBq (0.1 Ci) of tritium in the vapor state is being applied. The estimate is based on an average of previous known outgassing results from Stack 2. The total tritium stack emissions from the facility for 2008 (measured plus estimate) were 141 GBq (3.8 Ci).

In 2008, a total of 3.2 GBq (8.6×10^{-2} Ci) of measured tritium was released from the DWTF as HTO. Tritium in the gaseous state (HT) was not detected from the stack effluent in 2008. The emissions were a result of planned activities with tritium

The Contained Firing Facility (CFF) at Site 300 had measured depleted uranium emissions in 2008. A total of 6.7×10^{-8} GBq (1.8×10^{-9} Ci) of uranium-234, 5.9×10^{-9} GBq (1.6×10^{-10} Ci) of uranium-235, and 4.8×10^{-7} GBq (1.3×10^{-8} Ci) of uranium-238 was released in particulate form. The emissions were a result of planned activities with depleted uranium.

None of the other facilities monitored for radionuclides had reportable emissions in 2008. The data tables in **Appendix A, <u>Section A.1</u>** provide summary results of all air effluent monitored facilities and include upwind locations (control stations) for gross alpha and gross beta background comparison to stack effluent gross alpha and gross beta results.

The dose to the hypothetical, site-wide maximally exposed individual (SW-MEI) member of the public caused by the measured air emissions from the Tritium Facility (modeling HT emissions as HTO as required by EPA) was 3.3×10^{-3} µSv/y (3.3×10^{-4} mrem/y); the dose from the DWTF (modeling HT emissions as HTO) was 3.3×10^{-5} µSv/y (3.3×10^{-6} mrem/y); and the dose from the CFF was 4.4×10^{-7} µSv/y (4.4×10^{-8} mrem/y).

All of the reported SW-MEI doses at the Livermore site and Site 300 are less than one-tenth of one percent of the annual NESHAPs standard, which is 100 µSv/y (10 mrem/y) total site effective dose equivalent. As shown in **Chapter 7**, the estimated radiological dose caused by measured air emissions from LLNL operations was minimal. See also the *LLNL NESHAPs 2008 Annual Report* (<u>Bertoldo et al. 2009</u>) for a complete description of air effluent monitoring.

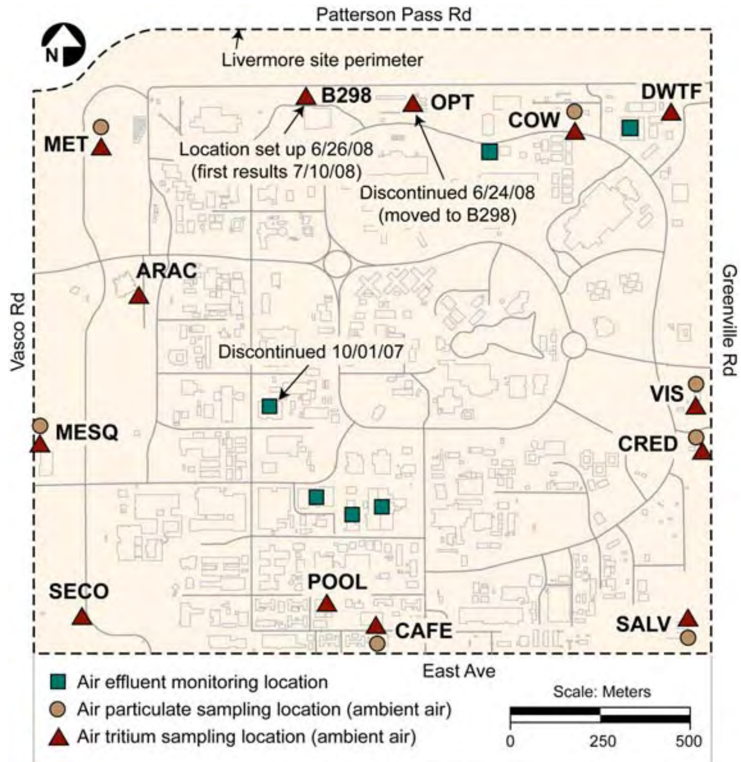

Figure 4-1. Air effluent and ambient air monitoring locations at the Livermore site, 2008.

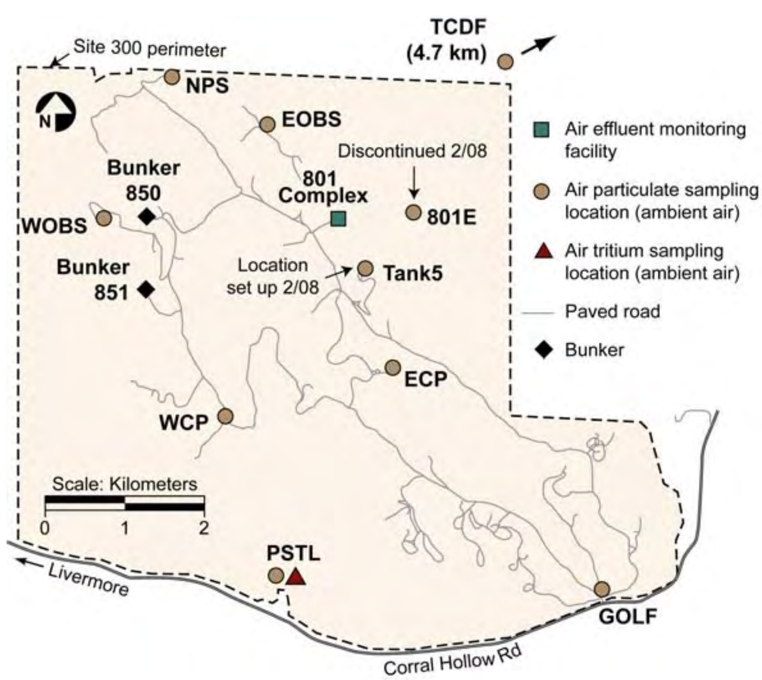

Figure 4-2. Air effluent and ambient air monitoring locations at Site 300, 2008.

4.1.2 Nonradiological Air Releases and Impact on the Environment

In 2008, the Livermore site emitted approximately 133 kg/d of regulated air pollutants as defined by the Clean Air Act, including nitrous oxides (NOx), sulphur oxides (SOx), particulate matter (PM-10), carbon monoxide (CO), and reactive organic gases/precursor organic compounds (ROGs/POCs) (see **Table 4-1**). The stationary emission sources that released the greatest amount of regulated pollutants at the Livermore site were natural gas fired boilers, internal combustion engines (such as diesel generators), solvent cleaning, and surface coating operations (such as painting). Pollutant emission information was primarily derived from monthly material and equipment usage records.

Table 4-1. Nonradioactive air emissions, Livermore site and Site 300, 2008.

	Estimated releases (kg/d)	
Pollutant	**Livermore site**	**Site 300**
ROGs/POCs	13.3	0.42
Nitrogen oxides	63.0	2.32
Carbon monoxide	49.0	0.51
Particulates (PM-10)	5.8	0.49
Sulfur oxides	1.7	0.21
Total	132.8	3.95

Livermore site air pollutant emissions were very low in 2008 compared to the daily releases of air pollutants from all sources in the entire Bay Area. For example, the average daily emission of NOx in the Bay Area was approximately 4.32×10^5 kg/d, compared to the estimated daily release from the Livermore site of 63.0 kg/d, which is 0.015% of total Bay Area source emissions for NOx. The 2008 BAAQMD estimate for ROGs/POCs daily emissions throughout the Bay Area was 3.21×10^5 kg/d, while the daily emission estimate for 2008 from the Livermore site was 13.3 kg/d, or 0.004% of the total Bay Area source emissions for ROGs/POCs.

Certain operations at Site 300 require permits from the SJVAPCD. The estimated daily air pollutant emissions during 2008 from operations (permitted and exempt stationary sources) at Site 300 are listed in **Table 4-1**. The stationary emission sources that release the greatest amounts of regulated air pollutants at Site 300 include internal combustion engines (such as diesel generators), a gasoline-dispensing facility, and general machine shop operations. Combustion pollutant emissions, such as NOx, CO, SOx, and PM-10, increased at Site 300 in 2008 primarily from the required, periodic preventative maintenance of emergency stand-by diesel generators and generator operation during emergency power outages.

4.2 Ambient Air Monitoring

LLNL conducts ambient air monitoring at on- and off-site locations to determine whether airborne radionuclides or beryllium are being released to the environs in measurable quantities by LLNL operations. Ambient air monitoring also serves to verify the air concentrations predicted by air dispersion modeling and to determine compliance with NESHAPs regulations.

The derived concentration guides (DCGs) in DOE Order 5400.5 specify the concentrations of a radionuclide that can be inhaled continuously 365 days a year without exceeding the DOE primary radiation protection standard for the public, which is 1 mSv/y (100 mrem/y) effective dose equivalent.

Beryllium is the only nonradiological emission from LLNL that is monitored in ambient air. LLNL requested and was granted a waiver by the BAAQMD for source-specific monitoring and record keeping for beryllium operations, provided that LLNL can demonstrate that monthly average beryllium concentrations in air are well below regulatory limits of 10,000 pg/m^3. LLNL meets this requirement by sampling for beryllium at perimeter locations.

Based on air dispersion modeling using site-specific meteorological data, the ambient air samplers, particularly those on the site perimeters, have been placed to monitor locations where elevated air concentrations due to LLNL operations may occur. Sampling locations for each monitoring network are shown in **Figures 4-1**, **4-2**, and **4-3**.

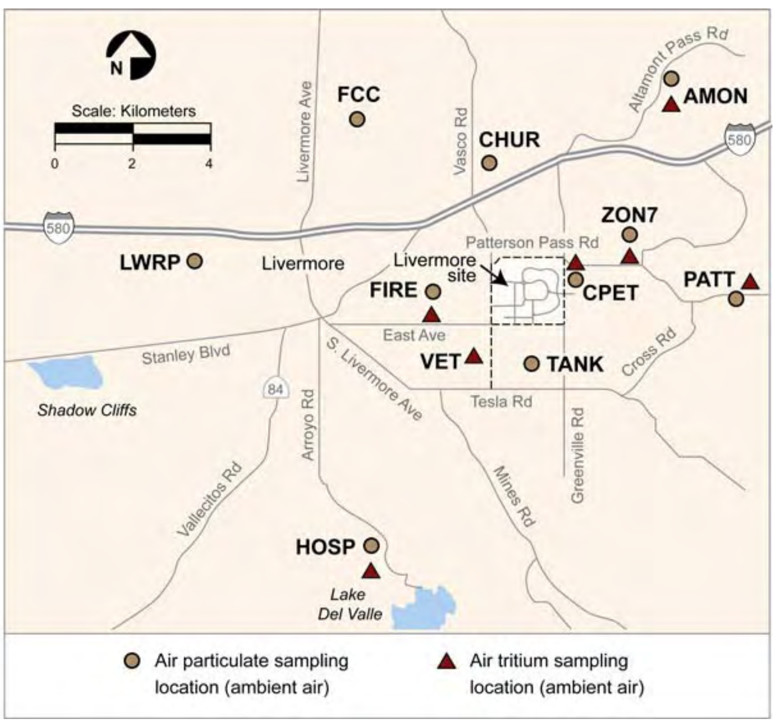

Figure 4-3. Air particulate and tritium monitoring locations in the Livermore Valley, 2008.

4.2.1 Ambient Air Radioactive Particulates

By analyzing air samples for gamma-emitting radionuclides, LLNL verifies that there is no evidence of release of the small inventories of mixed-fission products and radiochemical tracers used by LLNL. Composite samples for the Livermore site and Site 300 were analyzed for an environmental suite of gamma-emitting radionuclide concentrations in air that include fission products, activation products, actinides, and naturally occurring products. The isotopes detected at both sites in 2008 were beryllium-7 (cosmogenic), lead-210, radium-226, and potassium-40, all of which are naturally occurring in the environment.

Plutonium-239+240 was detected in 21 out of 216 samples taken in 2008. The highest values and percentage of the DCG were as follows:

- Livermore site perimeter: 17 nBq/m^3 (0.46 aCi/m^3); 0.0023% of the DCG
- Livermore off-site locations: 56 nBq/m^3 (1.5 aCi/m^3); 0.0076% of the DCG
- Site 300 composite: 6.3 nBq/m^3 (0.17 aCi/m^3); 0.00085% of the DCG

The plutonium-239+240 detection at Site 300 is calculated to be from resuspended fallout from historic aboveground nuclear testing. Site 300 does not use or store plutonium on-site.

Uranium-235 and uranium-238 were detected at all sample locations. Uranium ratios are used to determine the type of uranium present in the environment. Natural uranium has a mathematical uranium-235/uranium-238 ratio of 0.00725, and depleted uranium has a uranium-235/uranium-238 ratio of 0.002. Uranium isotopes are naturally occurring. The annual median uranium-235/uranium-238 isotopic ratios for 2008 were as follows:

- Livermore site perimeter composite: 0.0073
- Site 300 sample locations: 0.0073
- Site 300 off-site location: 0.0073

The annual uranium-235/uranium-238 isotopic ratio medians are consistent with naturally occurring uranium. All of the individual uranium-235 and uranium-238 results were less than one-tenth of one percent of the DCG as shown in **Appendix A**, **Section A.2**.

Gross alpha and gross beta were sampled for at all locations. The primary sources of alpha and beta activities are naturally occurring radioisotopes. Routine isotopic gamma results indicate the activities are the result of naturally occurring isotopes (uranium, thorium, potassium, and lead), which are also routinely found in local soils. See **Appendix A, Section A.2**.

4.2.2 Ambient Air Tritium Concentrations

The biweekly air tritium data that are provided in **Appendix A**, **Section A.2** are summarized in **Table 4.2**. Area (diffuse) sources include stored containers of tritium waste or tritium-contaminated equipment from which HTO diffuses into the atmosphere.

Due to the very low HTO air concentrations observed at the Livermore site sample locations, where concentrations are expected to be greater than those at remote locations at greater distances, the remote sample locations are readily predicted to be below the minimum detectable concentration (MDC). However, some samples from these remote locations yielded results greater than the MDC. These results are attributed to the inability to discriminate between a true signal and a background signal in the observed data.

Table 4-2. Air tritium sampling summary for 2008.

Sampling locations	Detection frequency	Concentration (mBq/m^3)				Median % DCG[a]	Dose (nSv)
		Mean	Median	IQR	Maximum		
Livermore site perimeter	176 of 307	31.9	18.1	25.4	1050	0.00049%	6.72
Livermore Valley	46 of 181	7.2	7.25	17.2	48.5	0.0002%	1.52
Site 300	7 of 24	3.31	1.32	17.2	31.9	0.000036%	0.697

(a) DCG = derived concentration guide of 3.7×10^6 mBq/m^3 for tritium in air.

For a location at which the mean concentration is at or below the MDC, inhalation dose from tritium is assumed to be less than 5 nSv/y (0.5 μrem/y) (i.e., the annual dose from inhaling air with a concentration at the MDC of about 25 mBq/m^3 [0.675 pCi/m^3]).

4.2.3 Ambient Air Beryllium Concentrations

LLNL measures the monthly concentrations of airborne beryllium at the Livermore site, Site 300, and at the off-site sampler northeast of Site 300. The highest value recorded at the Livermore site perimeter in 2008 for airborne beryllium was 69 pg/m^3. This value is only 0.69% of the BAAQMD ambient concentration limit for beryllium (10,000 pg/m^3). There is no regulatory requirement to monitor beryllium in San Joaquin County; however, LLNL analyzes samples from three Site 300 perimeter locations as a best management practice. The highest value recorded at the Site 300 perimeter in 2008 was 81 pg/m^3 and the highest value at the off-site location was 120 pg/m^3. These data are similar to data collected from previous years.

4.2.4 Impact of Ambient Air Releases on the Environment

LLNL operations involving radioactive materials had minimal impact on ambient air during 2008. The measured radionuclide particulate and tritium concentrations in air at the Livermore site and Site 300 were all less than one-tenth of one percent of the DOE primary radiation protection standard for the public (DCG).

Beryllium is naturally occurring and has a soil concentration of approximately 1 part per million. The sampled results are believed to be from naturally occurring beryllium that was resuspended from the soil and collected by the sampler. Even if the concentrations of beryllium detected were from LLNL activities, the amount is still less than one percent of the BAAQMD ambient air concentration limit.

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5. Water Monitoring Programs

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Lawrence Livermore National Laboratory monitors a multifaceted system of waters that includes wastewaters, storm water, and groundwater, as well as rainfall and local surface waters. Water systems at the two LLNL sites (the Livermore site and Site 300) operate differently. For example, the Livermore site is serviced by publicly owned treatment works but Site 300 is not, resulting in different methods of treating and disposing of sanitary wastewater at the two sites. Many drivers determine the appropriate methods and locations of the various water monitoring programs, as described below.

In general, water samples are collected according to written, standardized procedures appropriate for the medium (Gallegos 2009). Sampling plans are prepared by the LLNL network analysts who are responsible for developing and implementing monitoring programs or networks. Network analysts decide which analytes are sampled (see **Appendix B**) and at what frequency, incorporating any permit-specified requirements. Except for analyses of certain sanitary sewer and retention tank analytes, analyses are usually performed by off-site, California-certified contract analytical laboratories.

5.1 Sanitary Sewer Effluent Monitoring

In 2008, the Livermore site discharged an average of 0.96 million L/d (252,783 gal/d) of wastewater to the City of Livermore sewer system, or 4% of the total flow into the City's system. This volume includes wastewater generated by Sandia/California and a very small quantity from Site 300. In 2008, Sandia/California generated approximately 8.5% of the total effluent discharged from the Livermore outfall. Wastewater from Sandia/California and Site 300 is discharged to the LLNL collection system and combined with LLNL sewage before it is released at a single point to the municipal collection system.

LLNL's wastewater contains both sanitary sewage and process wastewater and is discharged in accordance with permit requirements and the City of Livermore Municipal Code, as discussed below. Most of the process wastewater generated at the Livermore site is collected in various retention tanks and discharged to LLNL's collection system under prior approval from LLNL's Permits and Regulatory Affairs Division (PRAD) Waste Discharge Authorization Requirement (WDAR) approval process.

5.1.1 Livermore Site Sanitary Sewer Monitoring Complex

LLNL's sanitary sewer discharge permit (Permit 1250, 2007/2008 and 2008/2009) requires continuous monitoring of the effluent flow rate and pH. Samplers at the Sewer Monitoring Station (SMS) collect flow-proportional composite samples and instantaneous grab samples that are analyzed for metals, radioactivity, total toxic organics, and other water-quality parameters.

5.1.1.1 Radiological Monitoring Results

DOE orders and federal regulations establish the standards of operation at LLNL (see **Chapter 2**), including the standards for sanitary sewer discharges. Primarily the standards for radioactive material releases are contained in complementary (rather than overlapping) sections of the DOE Order 5400.5 and 10 CFR Part 20.

For sanitary sewer discharges, DOE Order 5400.5 provides the criteria DOE has established for the application of best available technology to protect public health and minimize degradation of the environment. These criteria (the DCGs) limit the concentration of each radionuclide discharged to publicly owned treatment works. If the measured monthly average concentration of a radioisotope exceeds its concentration limit, LLNL is required to improve discharge control measures until concentrations are again below the DOE limits.

The 10 CFR Part 20 sanitary sewer discharge numerical limits include the following annual discharge limits for radioactivity: tritium, 185 GBq (5 Ci); carbon-14, 37 GBq (1 Ci); and all other radionuclides combined, 37 GBq (1 Ci). The 10 CFR Part 20 limit on total tritium activity dischargeable during a single year (185 GBq [5 Ci]) takes precedence over the DOE Order 5400.5 concentration-based limit for tritium for facilities that generate wastewater in large volumes, such as LLNL. In addition to complying with the 10 CFR Part 20 annual mass-based discharge limit for tritium and the DOE monthly concentration-based discharge limit for tritium, LLNL also complies with the daily effluent concentration-based discharge limit for tritium established by WRD for LLNL. The WRD limit is smaller by a factor of 30 than the DOE monthly limit so the limits are therefore essentially equivalent; however, the WRD limit is more stringent in the sense that it is daily rather than monthly. The radioisotopes with the potential to be found in sanitary sewer effluent at LLNL and their discharge limits are discussed below. All analytical results are provided in **Appendix A**, **Section A.3**.

LLNL determines the total radioactivity contributed by tritium, gross alpha emitters, and gross beta emitters from the measured radioactivity in the monthly effluent samples. As shown in **Table 5-1**, the 2008 combined release of alpha and beta sources was 0.22 GBq (0.006 Ci), which is 0.6% of the corresponding 10 CFR Part 20 limit (37 GBq [1.0 Ci]). The tritium total was 0.83 GBq (0.02 Ci), which is 0.4 % of the 10 CFR Part 20 limit (185 GBq [5 Ci]).

Table 5-1. Estimated total radioactivity in LLNL sanitary sewer effluent, 2008.

Radioactivity	Estimate based on effluent activity (GBq)	Limit of sensitivity (GBq)
Tritium	0.83	0.86
Gross alpha	0.02	0.04
Gross beta	0.20	0.08

Discharge limits and a summary of the measurements of tritium in the sanitary sewer effluent from LLNL and LWRP are reported in LLNL monthly reports. The maximum daily concentration for tritium of 0.12 Bq/mL (3.3 pCi/mL) was far below the permit discharge limit of 12 Bq/mL (333 pCi/mL).

Measured concentrations of cesium-137 and plutonium-239 in the sanitary sewer effluent from LLNL, the LWRP, and in LWRP sludge are reported in the LLNL February 2009 Report (Jones 2009). Cesium and plutonium results are from monthly composite samples of LLNL and LWRP effluent and from quarterly composites of LWRP sludge. For 2008, the annual total discharges of cesium-137 and plutonium-239 were far below the DOE DCGs. Plutonium discharged in LLNL effluent is ultimately concentrated in LWRP sludge. The highest plutonium concentration observed in 2008 sludge is 0.15 mBq/g (0.004 pCi/g), which is many times lower than the National Council on Radiation Protection and Measurements (NCRP) recommended screening limit of 470 mBq/g (12.7 pCi/g) for commercial or industrial property.

The historical levels for plutonium-239 observed in effluent since 1998 averaged approximately 1 µBq/mL (3×10^{-5} pCi/mL). The historical levels are generally 0.0003% of the DOE DCG for plutonium-239. The highest plutonium and cesium concentrations are well below DOE DCGs.

LLNL also compares annual discharges with historical values to evaluate the effectiveness of ongoing discharge control programs. **Table 5-2** summarizes the radioactivity in sanitary sewer effluent over the past 10 years. During 2008, a total of 0.83 GBq (0.08 Ci) of tritium was discharged to the sanitary sewer, an amount that is well within environmental protection standards and is comparable to the amounts discharged during the past 20 years.

Table 5-2. Historical radioactive liquid effluent releases from the Livermore site, 1998–2008.(a)

Year	Tritium (GBq)	Plutonium-239 (GBq)
1998	10	0.77×10^{-4}
1999	7.1	0.68×10^{-4}
2000	5.0	0.96×10^{-4}
2001	4.9	1.1×10^{-4}
2002	0.74	0.42×10^{-4}
2003	1.11	0.51×10^{-4}
2004	1.34	1.16×10^{-5}
2005	3.12	9.64×10^{-6}
2006	19.9	7.56×10^{-6}
2007	2.83	6.24×10^{-6}
2008	0.83	5.52×10^{-6}

(a) Starting in 2002, following DOE guidance, actual analytical values instead of limit of sensitivity values were used to calculate total.

5.1.1.2 Nonradiological Monitoring Results

LLNL monitors sanitary sewer effluent for chemical and physical parameters at different frequencies depending on the intended use of the result. For example, LLNL's wastewater discharge permit requires LLNL to collect monthly grab samples and 24-hour composites, weekly composites, and daily composites. Once a month, a 24-hour, flow-proportional composite is collected and analyzed; this is referred to as the monthly 24-hour composite in the discussion below. The weekly composite refers to the flow-proportional samples collected over a 7-day period continuously throughout the year. The daily composite refers to the flow-proportional sample collected over a 24-hour period, also collected continuously throughout the year. LLNL's wastewater discharge permit specifies that the effluent pollutant limit (EPL) is equal to the maximum pollutant concentration allowed per 24-hour composite sample. Only when a weekly composite sample concentration is at or above 50% of its EPL are the daily samples that were collected during the corresponding period analyzed to determine whether any of the concentrations are above the EPL.

A summary of the analytical results from the permit-specified monthly and weekly composite sampling programs is presented in **Table 5-3**. The permit also requires that grab samples of effluent be collected on a monthly and semiannual basis, and analyzed for total toxic organic (TTO) compounds and cyanide, respectively. (Complete results from LLNL's 2008 sanitary sewer effluent monitoring program are provided in **Appendix A**, **Section A.3**.)

During 2008, concentrations of the regulated metals show generally good agreement between the monthly composite samples and the corresponding weekly composite samples, and these results closely resemble the 2007 results. In **Table 5-3**, the 2008 maximum concentration for each metal is shown and compared with the EPL. These maximum values did not exceed 10% of their respective EPLs for eight of the nine regulated metals. Only arsenic, with maximum values of 17% and 27% of its EPL (monthly and weekly composite concentrations, respectively), had a maximum concentration above 10% of its EPL; comparable to 2007 results. All of the monthly 24-hour composite and weekly composite samples were in compliance with LLNL's wastewater discharge permit limits.

Figure 5-1 presents historical trends for the monthly 24-hour composite sample results from 2001 through 2008 for eight of the nine regulated metals; cadmium is not presented because this metal was not detected above the practical quantitation limit (PQL) in any of the 2001 through 2008 monthly sampling events. (Typical PQLs for the regulated metals in LLNL sanitary effluent are shown in **Table 5-3**.) The 2008 results routinely show concentrations of arsenic, copper, lead, and zinc at levels above their respective PQLs; nickel showed only one detection above its PQL. These observations are generally consistent with the 2001 through 2004 data; however, with the exception of arsenic, the concentrations of those metals detected in 2005 through 2008 have shown an overall downward trend. The range of monthly 24-hour composite concentrations reported for arsenic in 2008, although never exceeding 17% of its EPL, has not shown a similar downward trend.

Table 5-3. Summary of analytical results for permit-specified composite sampling of the LLNL sanitary sewer effluent, 2008.

Sample	Parameter	Detection frequency[(a)]	PQL[(b)]	EPL[(c)]	Minimum	Maximum	Median	Maximum % of EPL
Monthly 24-hour Composite	**Oxygen demand (mg/L)**							
	Biochemical oxygen demand	12 of 12	2	None Specified	73	100	84	N/A
	Solids (mg/L)							
	Total dissolved solids	12 of 12	1	None Specified	220	580	235	N/A
	Total suspended solids	12 of 12	1	None Specified	51	75	63	N/A
	Total metals (mg/L)							
	Silver	0 of 12	0.010	0.20	<0.01	<0.01	<0.01	<5.0
	Arsenic	11 of 12	0.0020	0.06	<0.002	0.010	0.0046	17
	Cadmium	0 of 12	0.0050	0.14	<0.005	<0.005	<0.005	<3.6
	Chromium	0 of 12	0.010	0.62	<0.01	<0.01	<0.01	<1.6
	Copper	12 of 12	0.010	1.0	0.028	0.068	0.048	6.8
	Mercury	0 of 12	0.00020	0.01	<0.0002	<0.0002	<0.0002	<2.0
	Nickel	1 of 12	0.0050	0.61	<0.005	0.0051	<0.005	0.84
	Lead	7 of 12	0.0020	0.20	<0.002	0.0043	.0023	2.2
	Zinc	12 of 12	0.050	3.00	0.074	0.12	0.096	4.0
Weekly Composite	**Total metals (mg/L)**							
	Silver	0 of 53	0.010	0.20	<0.01	<0.01	<0.01	<5.0
	Arsenic	48 of 53	0.0020	0.06	<0.002	0.016	0.0033	27
	Cadmium	0 of 53	0.0050	0.14	<0.005	<0.005	<0.005	<3.6
	Chromium	0 of 53	0.010	0.62	<0.01	<0.01	<0.01	<1.6
	Copper	53 of 53	0.010	1.0	0.015	0.062	0.028	6.2
	Mercury	1 of 53	0.00020	0.01	<0.0002	0.00022	<0.0002	2.2
	Nickel	1 of 53	0.0050	0.61	<0.005	0.0054	<0.005	0.89
	Lead	11 of 53	0.0020	0.20	<0.002	0.008	<0.002	4.1
	Zinc	39 of 53	0.050	3.00	<0.05	0.085	0.057	2.8

(a) The number of times an analyte was positively identified, followed by the number of samples that were analyzed.

(b) PQL = Practical quantitation limit (these limits are typical values for sanitary sewer effluent samples).

(c) EPL = Effluent pollutant limit (LLNL Wastewater Discharge Permit 1250, 2007/2008 and 2008/2009).

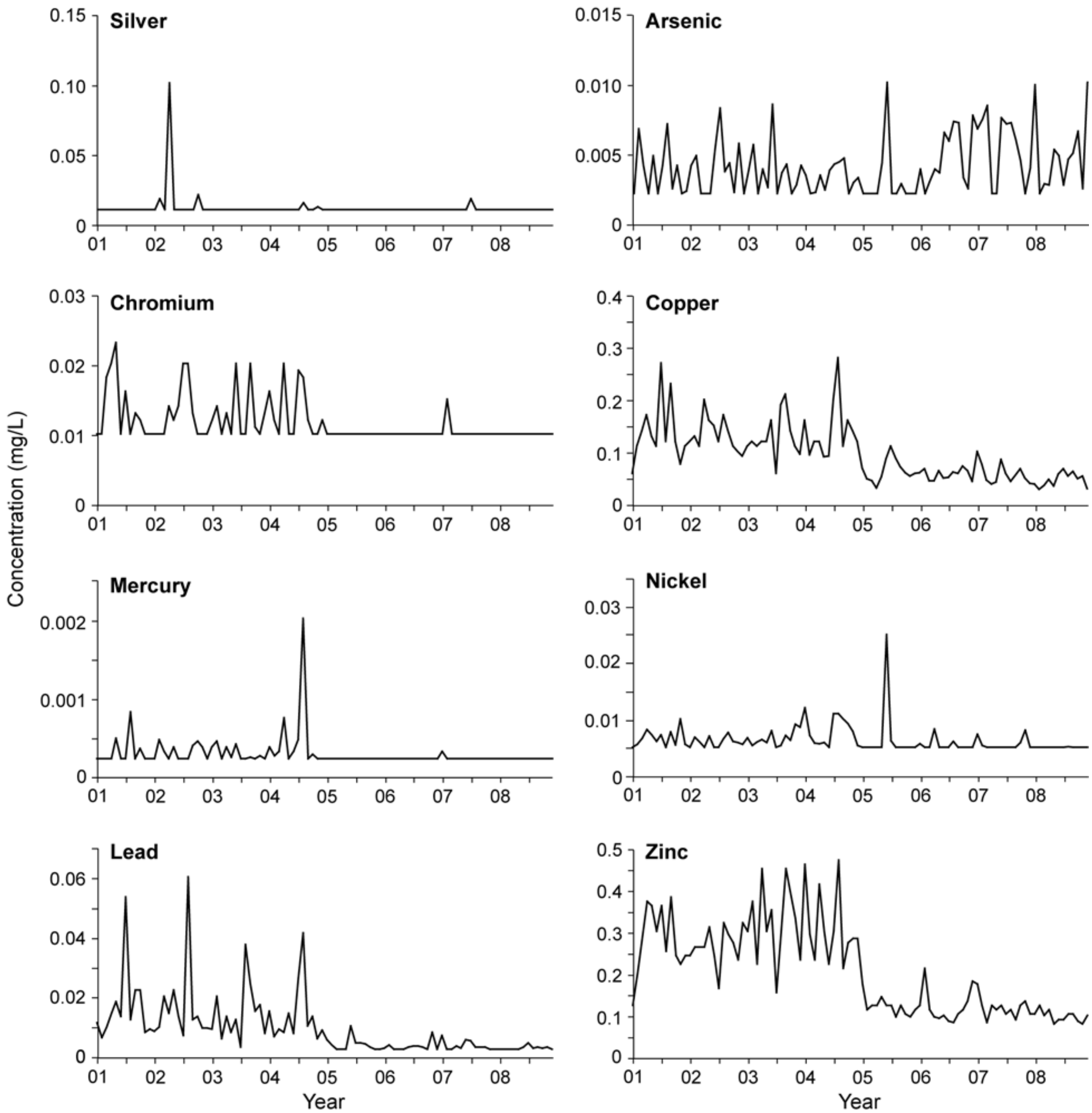

Figure 5-1. Monthly 24-hour composite sample concentrations for eight of the nine regulated metals in LLNL sanitary sewer effluent showing historical trends

As previously noted, grab samples of LLNL's sanitary sewer effluent are collected monthly for TTO analysis (permit limit = 1.0 mg/L) and semiannually for cyanide analysis (permit limit = 0.04 mg/L). In 2008, LLNL did not exceed either of these discharge limits. Results from the monthly TTO analyses for 2008 show that no priority pollutants, listed by the EPA as toxic organics, were identified in LLNL effluent above the 10 µg/L permit-specified reporting limit. As shown in **Appendix A**, **Section A.3**, one non-regulated organic compound, acetone, was identified in monthly grab samples at concentrations above the 10 µg/L permit-specified reporting limit. Cyanide was below the analytical detection limit in April (<0.02 mg/L) and November (<0.03 mg/L).

5.1.2 Categorical Processes

The EPA has established pretreatment standards for categories of industrial processes that EPA has determined are major contributors to point-source water pollution. These federal standards include prescribed sampling, self-monitoring, reporting, and numerical limits for the discharge of category-specific pollutants. At LLNL, the categorical pretreatment standards are incorporated into the wastewater discharge permit (Permit 1250, 2007/2008 and 2008/2009), which is administered by the WRD.

The processes at LLNL that are defined as categorical change as programmatic requirements dictate. During 2008, the WRD identified 14 wastewater-generating processes at LLNL that are defined under either 40 CFR Part 469 or 40 CFR Part 433.

Only processes that discharge to the sanitary sewer require semiannual sampling, inspection, and reporting. Two of the 14 processes discharge wastewater to the sanitary sewer: semiconductor processes located in the Building 153 microfabrication facility, and the abrasive jet machining located in Building 321C. In 2008, LLNL analyzed compliance samples for all regulated parameters from both processes and demonstrated compliance with all federal categorical discharge limits. As a further environmental safeguard, LLNL sampled the wastewater in each categorical wastewater tank prior to each discharge to the sanitary sewer. These monitoring data were reported to the WRD in July 2008 and January 2009 semiannual wastewater reports (Grayson et al. 2008, 2009).

The remaining 12 processes, which do not discharge wastewater to the sanitary sewer, are regulated under 40 CFR Part 433. Wastewater from these processes is either recycled or contained for eventual removal and appropriate disposal by RHWM. Because the processes do not discharge directly or indirectly to the sanitary sewer, they are not subject to the monitoring and reporting requirements contained in the applicable standard. (See Grayson et al. 2008, 2009).

As required in LLNL's wastewater discharge permit, LLNL demonstrated compliance with permit requirements by semiannual sampling and reporting in 2008. In addition, WRD source control staff performed their required annual inspection and sampling of the two discharging categorical processes in September 2008. The compliance samples were analyzed for all regulated parameters, and the results demonstrated compliance with all federal and local pretreatment limits.

5.1.3 Discharges of Treated Groundwater

LLNL's groundwater discharge permit (1510G, 2006–2008) allows treated groundwater from the Livermore site GWP to be discharged in the City of Livermore sanitary sewer system (see **Chapter 8** for more information on the GWP). During 2008, a total of 2.5 million L (664,000 gal) of treated groundwater were discharged to the sanitary sewer. This entire volume was associated with GWP treatment operations at well W-404. LLNL did not discharge groundwater from any other location to the sanitary sewer during 2008. All discharges were in compliance with self-monitoring permit provisions and discharge limits of the permit. Complete monitoring data are presented in Revelli (2009a).

5.1.4 Environmental Impact of Sanitary Sewer Effluent

During 2008, no discharges exceeded any discharge limits for either radioactive or nonradioactive materials to the sanitary sewer. The data are comparable to the lowest historical LLNL values. All the values reported for radiological releases are a fraction of their corresponding limits. For nonradiological releases, LLNL achieved excellent compliance with all the provisions of its wastewater discharge permit.

The data demonstrate that LLNL continues to have excellent control of both radiological and nonradiological discharges to the sanitary sewer. Monitoring results for 2008 reflect an effective year for LLNL's wastewater discharge control program and indicate no adverse impact to the LWRP or the environment from LLNL sanitary sewer discharges.

5.2 Site 300 Sewage Ponds and Site 300 Waste Discharge Requirements

Wastewater samples collected from the influent to the sewage evaporation pond, within the sewage evaporation pond, and flow to the sewage percolation pond were obtained in accordance with the written, standardized procedures summarized in Gallegos (2009).

5.2.1 Sewage Evaporation and Percolation Ponds

Sewage (nonhazardous wastewater) generated at buildings in the General Services Area at Site 300 is disposed of through a lined evaporation pond. However, during winter rains, treated wastewater may discharge into an unlined percolation pond where it enters the ground and the shallow groundwater.

Before September 2008, the environmental monitoring requirements for the sewage evaporation and percolation ponds (hereafter collectively referred to as sewage ponds) were specified in the Monitoring and Reporting Program (MRP) for Waste Discharge Requirement (WDR) 96-248. The monitoring requirements included both wastewater monitoring and groundwater monitoring to detect potential impacts of the sewage on groundwater quality. The sewage ponds were monitored and reported under this permit for the first three quarters of 2008. All wastewater parameters for the sewage evaporation and percolation ponds complied with permit provisions and specifications during those three quarters. The monitoring results are reported in the required quarterly monitoring reports (Blake 2008a,b,c).

In September 2008, WDR 96-248 was replaced by a new permit issued by the Central Valley Regional Water Quality Control Board (CVRWQCB) for WDR at Site 300. The replacement permit is Order No. R5-2008-0148 and puts in place new monitoring requirements for additional WDR systems at Site 300.

Under the terms of WDR R5-2008-0148, LLNL submits semiannual and annual monitoring reports regarding not only discharges of domestic and wastewater effluent to the sewage evaporation and percolation ponds in the General Services Area, but also septic system groundwater monitoring at Buildings 812, 834, 850, and 899; cooling tower blow down to a septic system at Building 825; cooling tower blow down to percolation pits at Buildings 801, 809, 812, 817A, and 851; and septic systems and mechanical equipment discharges at Buildings 806, 827A, 827C, 827D, and 827E.

The new reporting requirement contains the elements required by WDR R5-2008-0148. Starting during the fourth quarter 2008, the report presented monitoring data for the fourth quarter and annual report elements required by WDR 96-248. This was the first annual report prepared under WDR R5-2008-0148.

The monitoring data collected for the 2008 fourth quarter/annual report documents compliance with all MRP and permit conditions and limits. All networks were in compliance with the new permit requirements. Compliance certification accompanied this report, as required by federal and state regulations.

5.2.2 Environmental Impact of Sewage Ponds

All discharges from the Site 300 sewage evaporation pond to the percolation pond were in compliance with discharge limits. Groundwater monitoring related to this area indicated there were no measurable impacts to the groundwater from the sewage pond operations (Blake 2008c).

5.3 Storm Water Compliance and Surveillance Monitoring

LLNL monitors storm water at the Livermore site in accordance with Permit WDR 95-174 (SFBRWQCB 1995) and at Site 300 in accordance with the California NPDES General Permit for Storm Water Discharges Associated with Industrial Activities (WDR 97-03-DWQ) (SWRCB 1997). Site 300 storm water monitoring also meets the requirements of the *Post-Closure Plan for the Pit 6 Landfill Operable Unit* (Ferry et al. 1998). For construction projects that disturb 1 acre of land or more, LLNL also meets storm water compliance monitoring requirements of the California NPDES General Permit for Storm Water Discharges Associated with Construction Activity (WDR 99-08-DWQ) (SWRCB 1999). Storm water monitoring at both sites also follows the requirements in the *Environmental Regulatory Guide for Radiological Effluent Monitoring and Environmental Surveillance* (U.S. DOE 1991) and meets the applicable requirements of DOE Order 5400.5. **Appendix B** includes the current list of analyses conducted on storm water, including analytical methods and typical reporting limits.

At all monitoring locations grab samples are collected by submerging sample bottles directly into the storm water discharge. If a sample location is not directly accessible, an automatic water sampler is used to pump water into the appropriate containers. LLNL permits require sample collection and analysis at the sample locations specified in the permit two times per rainy season. Influent (upstream) sampling is also required at the Livermore site. In addition, LLNL is required to visually inspect the storm drainage system during one storm event per month in the wet season (defined as October through April for the Livermore site and October through May for Site 300) to observe runoff quality and twice during the dry season to identify any dry weather flows. Annual facility inspections are also required to ensure that the best management practices for controlling storm water pollution are implemented and adequate.

5.3.1 LLNL Site-Specific Storm Water

Various chemical analyses are performed on the storm water samples collected. There are no numeric concentration limits for storm water effluent; moreover, the EPA's benchmark concentration values for storm water are not intended to be interpreted as limits (U.S. EPA 2000). To evaluate the program, LLNL has established site-specific thresholds for selected parameters (Campbell and Mathews 2006). A value exceeds a parameter's threshold when it is greater than the 95% confidence limit for the historical mean value for that parameter (see **Table 5-4**). The thresholds are used to identify out-of-the-ordinary data that merit further investigation to determine whether concentrations of that parameter are increasing in the storm water runoff.

Table 5-4. Site-specific thresholds for selected water quality parameters for storm water runoff.(a)

Parameter	Livermore site	Site 300
Total suspended solids (TSS)	750 mg/L(b)	1,700 mg/L(b)
Chemical oxygen demand (COD)	200 mg/L(b)	200 mg/L(b)
pH	<6.0, >8.5(b)	<6.0, >9.0(c)
Nitrate (as NO_3)	10 mg/L(b)	Not monitored
Orthophosphate	2.5 mg/L(b)	Not monitored
Beryllium	1.6 µg/L(b)	1.6 µg/L(b)
Chromium(VI)	15 µg/L(b)	Not monitored
Copper	36 µg/L(b)	Not monitored
Lead	15 µg/L(d)	30 µg/L(b)
Zinc	350 µg/L(b)	Not monitored
Mercury	above RL(e)	1 µg/L(b)
Diuron	14 µg/L(b)	Not monitored
Oil and grease	9 mg/L(b)	9 mg/L(b)
Tritium	36 Bq/L(b)	3.17 Bq/L(b)
Gross alpha radioactivity	0.34 Bq/L(b)	0.90 Bq/L(b)
Gross beta radioactivity	0.48 Bq/L(b)	1.73 Bq/L(b)

(a) If data exceed the threshold comparison criteria, an investigation is initiated to assess if those data are indicative of a water quality problem.

(b) Site-specific value calculated from historical data and studies. These values are lower than the MCLs and EPA benchmarks except for copper, COD, TSS, and zinc

(c) EPA benchmark

(d) California and EPA drinking water action level

(e) RL (reporting limit) = 0.0002 mg/L for mercury

5.3.2 Storm Water Inspections

Each directorate at LLNL conducts an annual inspection of its facilities to verify implementation of the Storm Water Pollution Prevention Plans (SWPPPs) and to ensure that measures to reduce pollutant discharges to storm water runoff are adequate. LLNL's associate directors certified in 2008 that their facilities complied with the provisions of LLNL's SWPPPs. LLNL submits annual storm water monitoring reports to the SFBRWQCB (Revelli and Brunckhorst 2008) and to the CVRWQCB (Folks 2008) with the results of sampling, observations, and inspections.

For each construction project permitted by WDR 99-08-DWQ, LLNL conducts visual monitoring of construction sites before, during, and after storms to assess the effectiveness of the best management practices. Annual compliance certifications summarize the inspections.

5.3.3 Livermore Site

The Livermore site storm water runoff monitoring network consists of nine sampling locations (see **Figure 5-2**). LLNL collected samples at all nine locations on January 4, 2008. Only one complete set of storm water samples was collected at the Livermore site during calendar year 2008 because the first major storm of the 2007–2008 water year occurred on December 18, 2007, and there were no major storms during the last quarter of 2008 that would have been sampled for the 2008–2009 water year. Fish toxicity tests (both acute and chronic) are typically performed using the runoff samples from the first storm of the water year; however, the contract laboratory failed to run the chronic fish toxicity test using samples from the December 18, 2007 storm and did not notify LLNL until after the January 4, 2008 storm. As a result, LLNL collected samples from the next major storm (February 21, 2008) for chronic fish toxicity testing. No issues were identified in either the acute or chronic toxicity analysis.

5.3.3.1 Radiological Monitoring Results

Storm water tritium, gross alpha, and gross beta results are summarized in **Table 5-5**. (Complete analytical results are provided in **Appendix A**, **Section A.4**.) Tritium activities at the site effluent sampling locations were less than 1% of the maximum contaminant level (MCL). Gross alpha and gross beta radioactivity in the storm water samples collected during 2008 were also generally low, less than 49% and 23% of their MCLs, respectively. These tritium, gross alpha, and gross beta activities were all below their respective LLNL site-specific thresholds listed in **Table 5-4**.

LLNL began analyzing for plutonium in storm water in 1998. Current storm water sampling locations for plutonium are the Arroyo Seco and the Arroyo Las Positas effluent locations (ASW and WPDC, respectively). In 2008, there were no plutonium results above the detection limit of 0.0037 Bq/L (0.10 pCi/L).

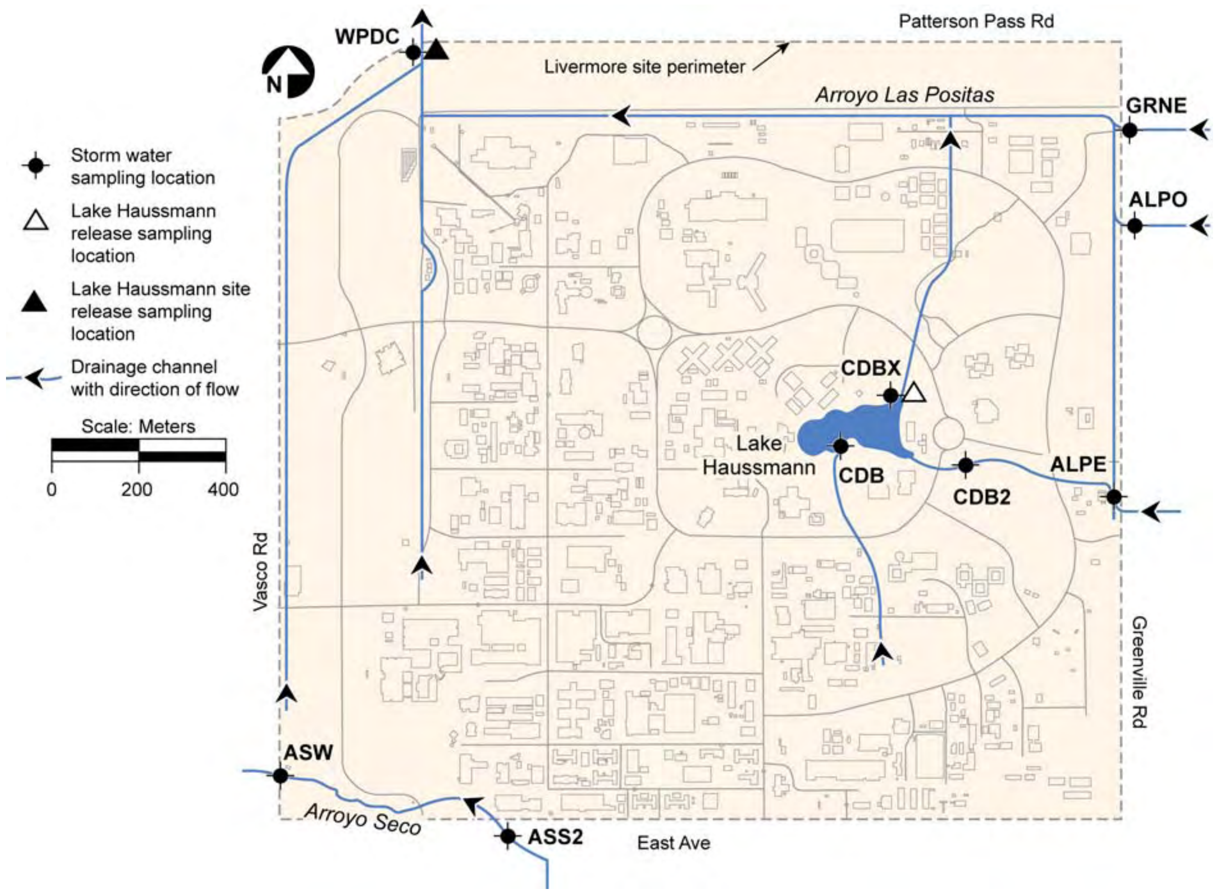

Figure 5-2. Storm water runoff and Lake Haussmann sampling locations, Livermore site, 2008.

Table 5-5. Radioactivity in storm water from the Livermore site, 2008.[a]

Parameter	Tritium (Bq/L)	Gross Alpha (Bq/L)	Gross Beta (Bq/L)
MCL	740	0.555	1.85
Influent			
Minimum	–1.0	0.020	0.140
Maximum	1.7	0.270	0.410
Median	1.1	0.090	0.185
Effluent			
Minimum	0.8	0.039	0.150
Maximum	3.3	0.100	0.230
Median	N/A[a]	N/A[a]	N/A[a]

(a) Median value not available. See **Chapter 9** for an explanation of calculating summary statistics.

5.3.3.2 Nonradiological Monitoring Results

Nonradiological results were compared to the site-specific thresholds listed in **Table 5-4**. Of interest were the constituents that exceeded the thresholds at effluent points and whose concentrations were lower in influent than in effluent water samples. If influent concentrations are higher than effluent concentrations, the source is generally assumed to be unrelated to LLNL operations and LLNL conducts no further investigation. (Complete analytical results are provided in **Appendix A**, **Section A.4**.)

Constituents that exceeded site-specific thresholds for effluent and/or influent locations are listed in **Table 5-6**. All of the values above the site-specific thresholds for the Livermore site during 2008 were found at influent tributaries at similar or higher concentrations than at effluent locations. The presence of diuron (an herbicide used for roadside vegetation management) in runoff flowing onto the LLNL site has been documented by Campbell et al. (2004). These results suggest that current operations at the Livermore site during 2008 did not impact the quality of storm water runoff.

Table 5-6. Water quality parameters in storm water runoff above LLNL site-specific thresholds, Livermore site in 2008.

Parameter	Date	Location	Influent / Effluent	Result	LLNL threshold
Diuron (µg/L)	1/4	ALPE	Influent	59	14
	1/4	ALPO	Influent	72	14
	1/4	WPDC	Effluent	18	14
Nitrate (NO_3) (mg/L)	1/4	GRNE	Influent	20	10

5.3.4 Site 300

In the calendar year 2008, there were no storms at Site 300 that met the criteria for a qualifying event as defined in the General Industrial Storm Water Permit (97-03-DWQ). Consequently, no samples were collected or analytical data produced. LLNL will continue to monitor the five sampling locations (NLIN, NPT7, N833, NPT6, and N829) that characterize runoff from on-site industrial activities, an upstream off-site location (CARW2), and a downstream off-site location (GEOCRK) on the Corral Hollow Creek when there are permit-qualifying storms that generate sufficient runoff to collect samples.

5.3.5 Environmental Impact of Storm Water

Storm water runoff from the Livermore site did not have any apparent environmental impact in 2008. Tritium activities in storm water runoff effluent were <1% of the drinking water MCL. Gross alpha and gross beta activities in effluent samples at the Livermore site were both less than their respective MCLs.

Storm water runoff at Site 300 was minimal in calendar year 2008, and no samples were collected. However, storm water visual observations and best management practices inspections indicated that LLNL's storm water program continues to protect water quality.

5.4 Groundwater

LLNL conducts surveillance monitoring of groundwater in the Livermore Valley and at Site 300 through networks of wells and springs that include off-site private wells and on-site DOE CERCLA wells. To maintain a comprehensive, cost-effective monitoring program, LLNL determines the number and locations of surveillance wells, the analytes to be monitored, the frequency of sampling, and the analytical methods to be used. A wide range of analytes is monitored to assess the impact, if any, of current LLNL operations on local groundwater resources. Because surveillance monitoring is geared to detecting substances at very low concentrations in groundwater, contamination can be detected before it significantly impacts groundwater resources. Groundwater monitoring wells at the Livermore site, in the Livermore Valley, and at Site 300 are included in LLNL's *Environmental Monitoring Plan* (Gallegos 2009)**.**

Beginning in January 2003, LLNL implemented a new CERCLA comprehensive compliance monitoring plan at Site 300 (Ferry et al. 2002) that adequately covers the DOE requirements for on-site groundwater surveillance. In addition, LLNL continues two additional surveillance networks to supplement the CERCLA compliance monitoring plan and provide additional data to characterize potential impacts of LLNL operations. LLNL monitoring related to CERCLA activities is described in **Chapter 8**. Additional monitoring programs at Site 300 comply with numerous federal and state controls such as state-issued permits associated with closed landfills containing solid wastes and with continuing discharges of liquid waste to sewage ponds and percolation pits; the latter are discussed in **Section 5.2.1**. Compliance monitoring is specified in WDRs issued by the CVRWQCB and in landfill closure and post-closure monitoring plans. (See **Chapter 2**, **Table 2-1** for a summary of LLNL permits.)

The WDRs and post-closure plans specify wells and effluents to be monitored, constituents of concern (COCs) and parameters, frequency of measurement, inspections, and the frequency and form of required reports. These monitoring programs include quarterly, semiannual, and annual monitoring of groundwater, monitoring of various influent waste streams, and visual inspections. LLNL performs the maintenance necessary to ensure the physical integrity of closed facilities, such as those that have undergone CERCLA or RCRA closure, and their monitoring networks.

During 2008, representative samples of groundwater were obtained from monitoring wells in accordance with the *LLNL Livermore Site and Site 300 Environmental Restoration Project Standard Operating Procedures* (Goodrich and Wimborough 2006). The procedures cover sampling techniques and information concerning the chemicals that are routinely analyzed for in groundwater. Different sampling techniques were applied to different wells depending on whether they were fitted with submersible pumps or had to be bailed. All of the chemical and radioactivity analyses of groundwater samples were performed by California-certified analytical laboratories. For comparison purposes only, some of the results were compared with drinking water limits

(MCLs). This MCL comparison is used as one way to evaluate groundwater quality, not as a way to determine compliance with Safe Drinking Water Act requirements.

5.4.1 Livermore Site and Environs

5.4.1.1 Livermore Valley

LLNL has monitored tritium in water hydrologically downgradient of the Livermore site since 1988. HTO is potentially the most mobile groundwater contaminant from LLNL operations. Groundwater samples were obtained during 2008 from 16 of 18 water wells in the Livermore Valley (see **Figure 5-3**) and measured for tritium activity. Two wells could not be sampled during 2008.

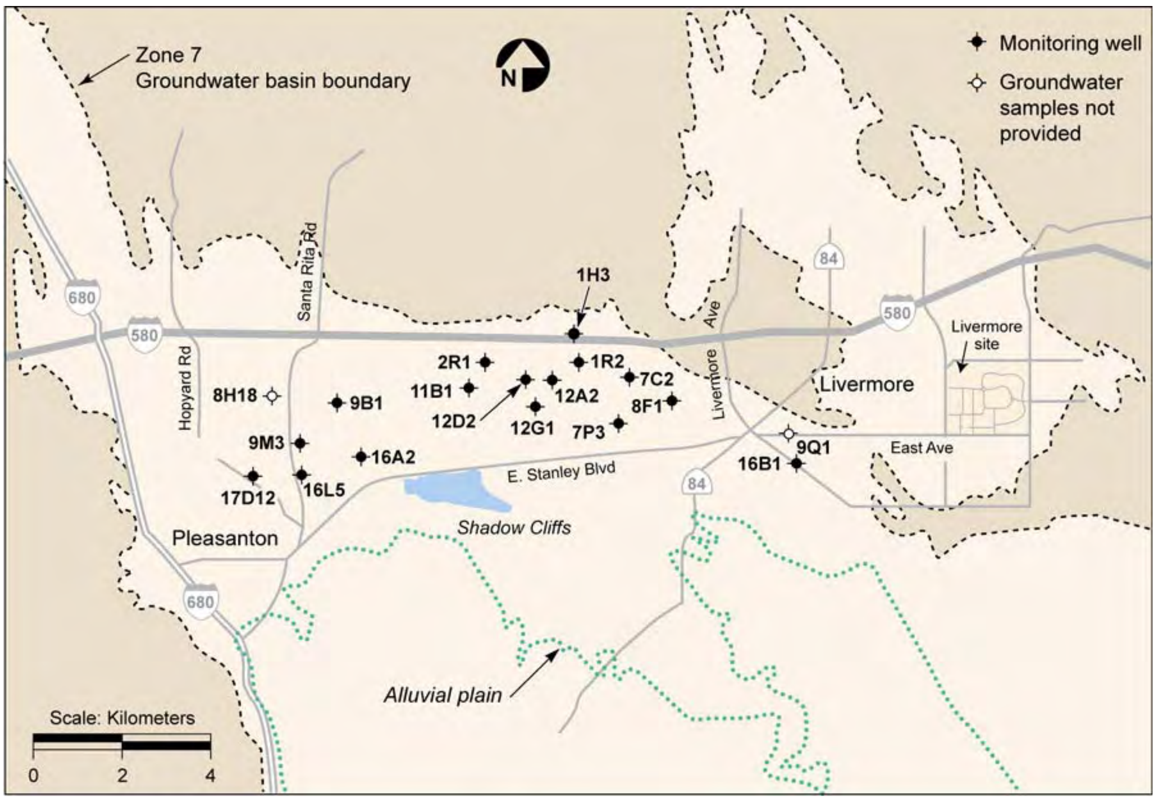

Figure 5-3. Off-site tritium monitoring wells in the Livermore Valley, 2008.

Tritium measurements of Livermore Valley groundwaters are provided in **Appendix A**, **Section A.5**. The measurements continue to show very low and decreasing activities compared with the 740 Bq/L (20,000 pCi/L) MCL established for drinking water in California. The maximum tritium activity measured off site was in the groundwater at well 9M3, located about 16 km (10 mi) west of LLNL (see **Figure 5-3**). The measured activity there was 3.2 Bq/L (86.4 pCi/L) in 2008, less than 0.5% of the MCL.

5.4.1.2 Livermore Site Perimeter

LLNL's groundwater surveillance monitoring program was designed to complement the Livermore Site GWP (see **Chapter 8**). The intent of the program is to monitor for potential groundwater contamination from LLNL operations. The perimeter portion of the surveillance groundwater monitoring network uses three upgradient (background) monitoring wells (wells W-008, W-221, and W-017) near the eastern boundary of the site and seven downgradient monitoring wells located near the western boundary (wells 14B1, W‑121, W-151, W-1012, W‑571, W-556, and W-373) (see **Figure 5-4**). As discussed in **Chapter 8**, the alluvial sediments have been divided into nine hydrostratigraphic units (HSUs) dipping gently westward. Screened intervals (depth range from which groundwater is drawn) for these monitoring wells range from the shallow HSU-1B to the deeper HSU-5. Two of the background wells, W-008 and W-221, are screened partially in HSU-3A; well W‑017 is considered a background well for the deeper HSU-5. To detect contaminants as quickly as possible, the seven western downgradient wells (except well 14B1, screened over a depth range that includes HSU-2, HSU-3A, and HSU‑3B) were screened in shallower HSU-1B and HSU-2, the uppermost water-bearing HSUs at the western perimeter. These perimeter wells were sampled and analyzed at least once during 2008 for general minerals (including nitrate) and for certain radioactive constituents. Analytical results for the Livermore site perimeter wells are provided in **Appendix A**, **Section A.5**. Although there have been variations in these concentrations since regular surveillance monitoring began in 1996, the concentrations detected in the 2008 groundwater samples from the upgradient wells represent current background values.

Historically, chromium(VI) had been detected above the MCL (50 µg/L) in groundwater samples from western perimeter well W-373. However, the 2008 sample from this location showed a chromium(VI) concentration of 10 µg/L, continuing the overall downward trend that first dropped below the MCL in 2002. Groundwater samples collected in 2008 from the nearby wells W-556 and W-1012, also along the western perimeter of the LLNL site, showed chromium(VI) concentrations of 17 mg/L and 16 mg/L, respectively.

From 1996 through 2004, concentrations of nitrate detected in groundwater samples from downgradient well W-1012 were greater than the MCL of 45 mg/L. The nitrate concentrations detected in samples from this well during 2008 (31 and 30 mg/L) were again, as in the past three years, below the MCL. During 2008, concentrations of nitrate in on-site shallow background wells W-008 and W-221 ranged from 26 mg/L to 30 mg/L. Detected concentrations of nitrate in western perimeter wells ranged from 10 mg/L (in well W-373) to 41 mg/L (in well W‑151).

During 2008, gross alpha, gross beta, radium-226, and tritium were detected occasionally in LLNL's site perimeter wells, at levels consistent with the results from recent years; however, the concentrations again remain below drinking water MCLs.

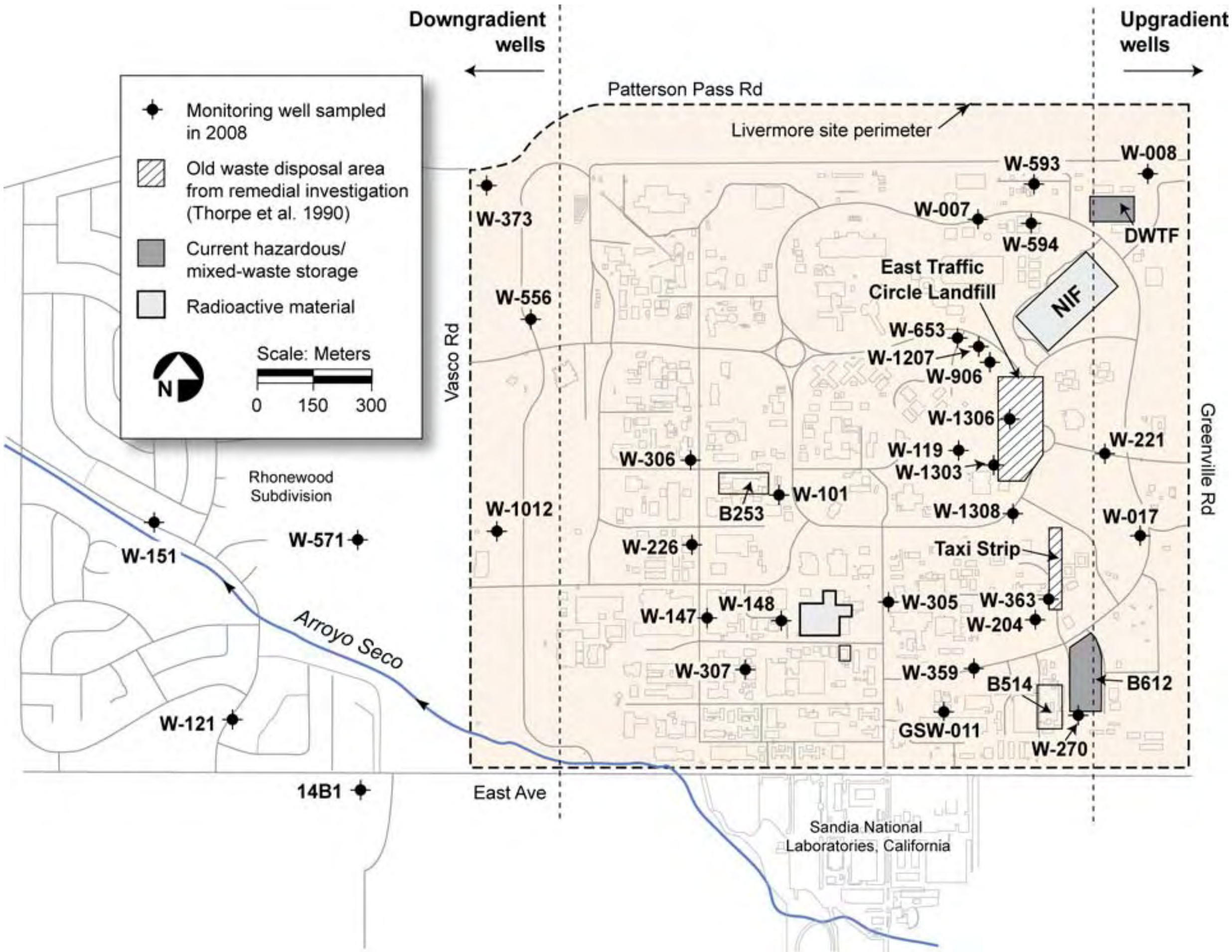

Figure 5-4. Routine surveillance groundwater monitoring wells at the Livermore site, 2008.

5.4.1.3 Livermore Site

Groundwater sampling locations within the Livermore site include areas where releases to the ground may have occurred in the recent past, where previously detected COCs have low concentrations that do not require CERCLA remedial action, and where baseline information needs to be gathered for the area near a new facility or operation. Wells selected for monitoring are screened in the uppermost aquifers and are downgradient from and as near as possible to the potential release locations. Well locations are shown in **Figure 5-4**. All analytical results are provided in **Appendix A**, **Section A.5**.

The Taxi Strip and East Traffic Circle Landfill areas (see **Figure 5-4**) are two potential sources of historical groundwater contamination. Samples from monitoring wells screened in HSU-2 (W-204) and HSU-3A (W-363) downgradient from the Taxi Strip area were analyzed in 2008 for copper, lead, zinc, plutonium-238, plutonium-239+240, and tritium. Samples from monitoring wells screened at least partially in HSU-2 (W-119, W-906, W-1303, W-1306, and W-1308) within and downgradient from the East Traffic Circle Landfill were analyzed for the same elements as the Taxi Strip area, plus radium-226 and radium-228. No concentrations of plutonium radioisotopes were detected above the radiological laboratory's minimum detectable activities. Concentrations of radium and tritium remained well below the drinking water MCLs. Of the trace metals, only zinc was detected in any of these seven monitoring wells during 2008. The zinc concentrations reported, however, (69 µg/L at W-119, 49 µg/L at W-204, and 11 µg/L at W-363) were all less than 2% of the secondary MCL for zinc in drinking water (5000 µg/L).

Although the National Ignition Facility (NIF) has not yet begun full operations, LLNL measures pH, conductivity, and tritium concentration of groundwater to establish a baseline. During 2008, tritium analyses were conducted on groundwater samples collected from wells W-653 and W-1207 (screened in HSU-3A and HSU-2, respectively) downgradient of NIF. Samples were also obtained downgradient from the DWTF from wells W-007, W-593, and W-594 (screened in HSU-2/3A, HSU-3A, and HSU-2, respectively) during 2008 and were analyzed for tritium. Monitoring results from the wells near NIF and DWTF showed no detectable concentrations of tritium, above the limit of sensitivity of the analytical method, in the groundwater samples collected during 2008. Monitoring will continue near these facilities to determine baseline conditions.

The former storage area around Building 514 and the hazardous waste/mixed waste storage facilities around Building 612 are also potential sources of contamination. The area and facilities are monitored by wells W-270 and W-359 (both screened in HSU-5), and well GSW-011 (screened in HSU-3A). Groundwater from these wells was sampled and analyzed for gross alpha, gross beta, americium-241, plutonium-238, plutonium-239+240, and tritium in 2007. No significant contamination was detected in the groundwater samples collected downgradient from these areas in 2008.

Groundwater samples were obtained from monitoring well W-307 (screened in HSU-1B), downgradient from Building 322. Soil samples previously obtained from this area showed concentrations elevated above the Livermore site's background levels for total chromium, copper, lead, nickel, zinc, and occasionally other metals. LLNL removed contaminated soils near Building 322 in 1999 and replaced them with clean fill. The area was then paved over, making it less likely that metals would migrate from the site. In 2008, the monitoring results for well W-307 showed only slight variations from the concentrations reported in recent years.

Groundwater samples were obtained downgradient from a location where sediments containing metals (including cadmium, chromium, copper, lead, mercury, and zinc) had accumulated in a storm water catch basin near Building 253. In 2008, the samples obtained from monitoring wells W-226 and W-306 (screened in HSU-1B and HSU-2, respectively) contained dissolved chromium and zinc at concentrations above their respective analytical reporting limits, but these concentrations remained low and essentially unchanged from last year.

Additional surveillance groundwater sampling locations, established in 1999, are in areas surrounding the Plutonium Facility and Tritium Facility. Potential contaminants include plutonium and tritium from these facilities, respectively. Plutonium is much more likely to bind to the soils than migrate into the groundwater. Tritium, as HTO, can migrate into groundwater if spilled in sufficient quantities. Upgradient of these facilities, well W-305 is screened in HSU-2; downgradient wells W-101, W-147, and W-148 are screened in HSU-1B. Groundwater samples collected from these wells during 2008 showed no detectable concentration, above the limit of sensitivity for the analytical method, of either plutonium-238 or plutonium-239+240.

In August 2000, elevated tritium activity was detected in the groundwater sampled at well W-148 (115 ± 5.0 Bq/L [3100 ± 135 pCi/L]). The activity was most likely related to local infiltration of storm water containing elevated tritium activity. Tritium activities in groundwater in this area had remained at or near the same level through 2005, but samples collected from well W-148 in 2006, 2007, and 2008 have shown significantly lower values—a downward trend ranging from approximately one-half to one-third of the August 2000 value. LLNL continues to collect groundwater samples from these wells periodically for surveillance purposes, primarily to demonstrate that tritium and plutonium contents remain below MCLs.

5.4.2 Site 300 and Environs

For surveillance and compliance groundwater monitoring at Site 300, LLNL uses DOE CERCLA wells and springs on site and private wells and springs off site. Representative groundwater samples are obtained at least once per year at every monitoring location; they are routinely measured for various elements (primarily metals), a wide range of organic compounds, general radioactivity (gross alpha and gross beta), uranium activity, and tritium activity. Groundwater from the shallowest water-bearing zone is the target of most of the monitoring because it would be the first to show contamination from LLNL operations at Site 300.

Brief descriptions of the Site 300 groundwater monitoring networks that are reported in this chapter are given below. (All analytical data from 2008 are included in **Appendix A**, **Section A.6**.)

5.4.2.1 Elk Ravine Drainage Area

The Elk Ravine drainage area, a branch of the Corral Hollow Creek drainage system, includes most of northern Site 300 (see **Figure 5-5**). Storm water runoff in the Elk Ravine drainage area collects in arroyos and quickly infiltrates into the ground. Groundwater from wells in the Elk Ravine drainage area is monitored for COCs to determine the impact of current LLNL operations on the system of underground flows that connects the entire Elk Ravine drainage area. The area contains eight closed landfills, known as Pits 1 through 5 and 7 through 9, and firing tables where explosives tests are conducted. None of the closed landfills has a liner, which is consistent with the disposal practices when the landfills were constructed. The following descriptions of monitoring networks within Elk Ravine begin with the headwaters area and proceed downstream. (See **Chapter 8** for a review of groundwater monitoring in this drainage area conducted under CERCLA.)

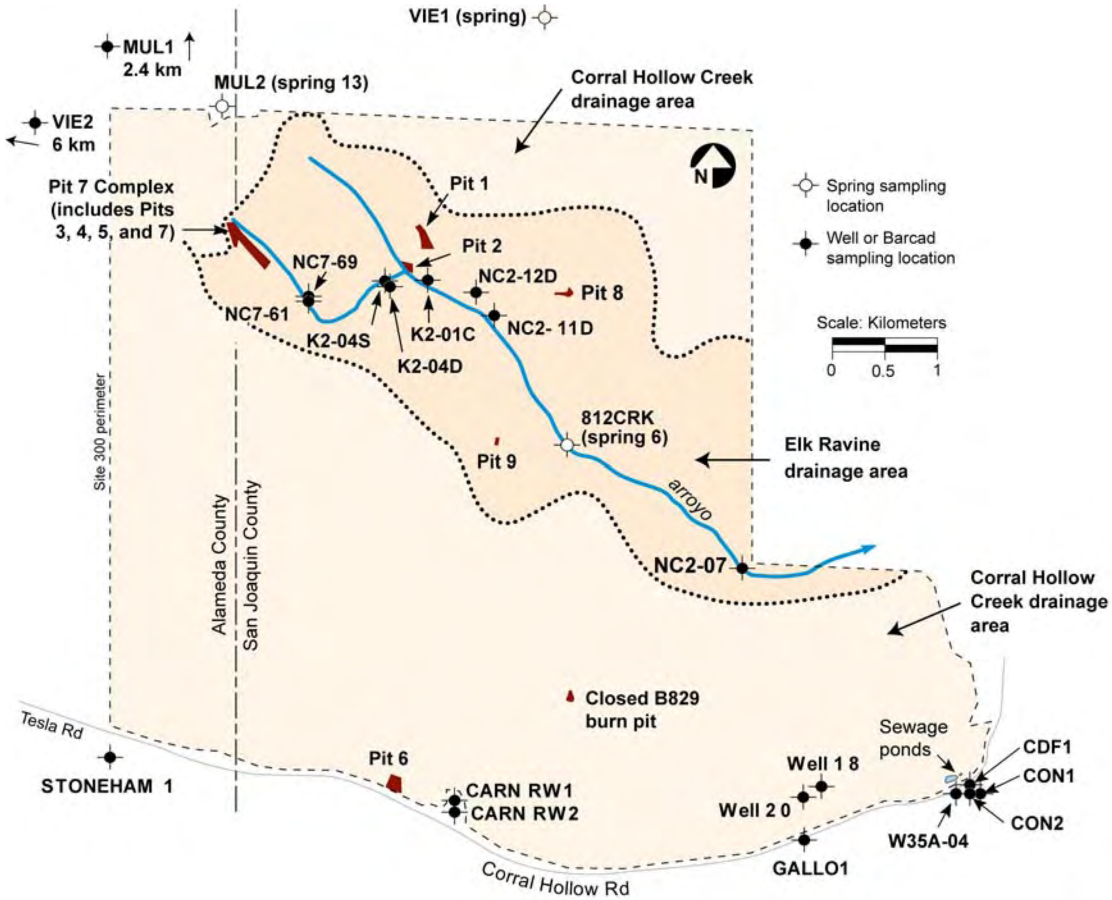

Figure 5-5. Surveillance groundwater wells and springs at Site 300, 2008.

Pit 7 Complex. Monitoring requirements for the Pit 7 landfill, which was closed under RCRA in 1993, are specified in WDR 93-100 administered by the CVRWQCB (1993, 1998) and in *LLNL Site 300 RCRA Closure and Post-Closure Plans—Landfill Pits 1 and 7* (Rogers/Pacific Corporation 1990). The main objective of this monitoring is the early detection of any new release of COCs from Pit 7 to groundwater.

For compliance purposes, LLNL obtained groundwater samples quarterly during 2008 from the Pit 7 monitoring well network. Samples were analyzed for inorganic COCs (mostly metallic elements), general radioactivity (gross alpha and beta), activity of certain radioisotopes (tritium, radium, uranium, and thorium), explosive compounds (HMX and RDX), and VOCs. For a detailed account of Pit 7 compliance monitoring during 2008, including well locations and tables and graphs of groundwater COC analytical data, see Blake and MacQueen (2009).

Elk Ravine. Groundwater samples were obtained on various dates in 2008 from the widespread Elk Ravine surveillance monitoring network shown in **Figure 5-5** (NC2-07, NC2-11D, NC2-12D, NC7-61, NC7-69, SPRING6 [812CRK], K2-04D, K2-04S, K2-01C). Samples from NC2-07 were analyzed for inorganic constituents (mostly metallic elements), general radioactivity (gross alpha and beta), tritium and uranium activity, and explosive compounds (HMX and RDX). Samples from the remaining wells were analyzed only for general radioactivity.

No new release of COCs from LLNL operations in Elk Ravine to groundwater is indicated by the chemical and radioactivity data obtained during 2008. The major source of contaminated groundwater beneath Elk Ravine is from historical operations in the Building 850 firing table area (Webster-Scholten 1994; Taffet et al. 1996). Constituents that are measured as part of the Elk Ravine drainage area surveillance monitoring network are listed in **Appendix B**.

The tritium activity in well NC7-61 decreased from 1080 Bq/L in 2007 to 990 Bq/L in 2008. This tritium activity remains elevated with respect to the background concentrations. Tritium, as HTO, has been released in the past in the vicinity of Building 850. The majority of the Elk Ravine surveillance network tritium measurements made during 2008 support earlier CERCLA studies that show that the tritium in the plume is diminishing over time because of natural decay and dispersion (Ziagos and Reber-Cox 1998). CERCLA modeling studies indicate that the tritium will decay to background levels before it can reach a site boundary.

Groundwater surveillance measurements of gross alpha, gross beta, and uranium radioactivity in Elk Ravine are all low and are indistinguishable from background levels. (Note that gross beta measurements do not detect the low-energy beta emission from tritium decay.) Additional detections of nonradioactive elements including arsenic, barium, chromium, selenium, vanadium, and zinc are all within the natural ranges of concentrations typical of groundwater elsewhere in the Altamont Hills.

Pit 1. Monitoring requirements for the Pit 1 landfill, which was closed under RCRA in 1993, are also specified in WDR 93-100 administered by the CVRWQCB (1993, 1998) and in Rogers/Pacific Corporation (1990). The main objective of this monitoring is the early detection of any release of COCs from Pit 1 to groundwater. LLNL obtained groundwater samples quarterly during 2008 from the Pit 1 monitoring well network. Samples were analyzed for inorganic COCs (mostly metallic elements), general radioactivity (gross alpha and beta), activity of certain radioisotopes (tritium, radium, uranium, and thorium), explosive compounds (HMX and RDX), and VOCs (EPA Methods 601 and 8260). Additional annual analyses were conducted on groundwater samples for extractable organics (EPA Method 625), as well as pesticides and PCBs (EPA Method 608). Compliance monitoring showed no new releases at Pit 1 in 2008; a detailed account of Pit 1 compliance monitoring during 2008, including well locations and tables and graphs of groundwater COC analytical data, is in Blake and MacQueen (2009).

5.4.2.2 Corral Hollow Creek Drainage Area

Pit 6. Compliance monitoring requirements for the closed Pit 6 landfill in the Corral Hollow Creek drainage area are specified in Ferry et al. (1998, 2002). Two Pit 6 groundwater monitoring programs, which operate under CERCLA, ensure compliance with all regulations. They are (1) the Detection Monitoring Plan (DMP), designed to detect any new release of COCs to groundwater from wastes buried in the Pit 6 landfill, and (2) the Corrective Action Monitoring Plan (CAMP), which monitors the movement and fate of historical releases. To comply with monitoring requirements, LLNL obtained groundwater samples monthly, quarterly, semiannually, and annually during 2008 from specified Pit 6 monitoring wells. No new releases were detected at Pit 6 in 2008; however, total uranium activities continued to exceed the statistical limit in one detection monitoring well. As reported in Jackson (2008), total uranium activities in groundwater samples collected from monitoring well EP6-08 were slightly above the statistical limit and a mass ratio analysis (uranium-235 to uranium-238) performed in 2008 indicates that the uranium is natural in origin. This issue continues to be under investigation. A detailed account of Pit 6 compliance monitoring during 2008, including well locations, tables of groundwater analytical data, and maps showing the distribution of COC plumes, is in Blake and Valett (2009).

Building 829 Closed High Explosives Burn Facility. Compliance monitoring requirements for the closed burn pits in the Corral Hollow Creek drainage area are specified in Mathews and Taffet (1997), and in LLNL (2001), as modified by DTSC (2003). As planned for compliance purposes, LLNL obtained groundwater samples during 2008 from the three wells in the Building 829 monitoring network. Groundwater samples from these wells, screened in the deep regional aquifer, were analyzed for inorganics (mostly metals), general minerals, turbidity, explosive compounds (HMX, RDX, and TNT), VOCs (EPA Method 624), extractable organics (EPA Method 625), pesticides (EPA Method 608), herbicides (EPA Method 615), general radioactivity (gross alpha and beta), radium activity, total organic carbon (TOC), total organic halides (TOX), and coliform bacteria.

During 2008, there were no confirmed COC detections above their respective statistical limits in groundwater samples from any of the Building 829 network monitoring wells. Among the inorganic constituents, perchlorate was not detected above its reporting limit in any sample. With the exception of barium in well W-892-15 (which remains below its statistical limit, but has shown a slightly increasing concentration trend over the last six years), the metal COCs that were detected showed concentrations that are not significantly different from background concentrations for the deep aquifer beneath the High Explosives Process Area. Similarly, all results for gross alpha and gross beta (the radioactive COCs) were below their statistical limit values. There were no organic or explosive COCs detected above reporting limits in any samples. For a detailed account of compliance monitoring of the closed burn pit during 2008, including well locations and tables and graphs of groundwater COC analytical data, see Revelli (2009b).

Water Supply Well. Water supply well 20, located in the southeastern part of Site 300 (**Figure 5-5**), is a deep, high-production well. The well is screened in the Neroly lower sandstone aquifer (Tnbs1) and can produce up to 1500 L/min (396 gal/min) of potable water. As planned for surveillance purposes, LLNL obtained groundwater samples quarterly during 2008 from well 20. Groundwater samples were analyzed for inorganic COCs (mostly metals), VOCs, general radioactivity (gross alpha and gross beta), and tritium activity. Quarterly measurements of groundwater from well 20 do not differ significantly from previous years. As in past years, the primary potable water supply well at Site 300 showed no evidence of contamination. Gross alpha, gross beta, and tritium activities were very low and are indistinguishable from background level activities.

5.4.2.3 Off-site Surveillance Wells and Springs

As planned for surveillance purposes, during 2008 LLNL obtained groundwater samples from two off-site springs (MUL2 and VIE1) and ten off-site wells (MUL1, VIE2, CARNRW1, CARNRW2, CDF1, CON1, CON2, GALLO1, STONEHAM1, and W35A-04) **(Figure 5-5)**. With the exception of one well, all off-site monitoring locations are near Site 300. The exception, well VIE2, is located at a private residence 6 km west of the site. It represents a typical potable water supply well in the Altamont Hills.

Samples from CARNRW2 and GALLO1 were analyzed at least quarterly for inorganic constituents (mostly metals), general radioactivity (gross alpha and beta), tritium activity, explosive compounds (HMX and RDX), and VOCs (EPA method 502.2). Additional annual analyses were conducted for uranium activity and extractable organic compounds (EPA Method 625) for samples collected from CARNRW2 only. In addition, CARNRW1 and CON2 samples were analyzed for VOCs; samples from well CARNRW1 were also sampled for perchlorate and tritium.

Groundwater samples were obtained once (annually) during 2008 from the remaining off-site surveillance monitoring locations: MUL1, MUL2, and VIE1 (north of Site 300); VIE2 (west of Site 300); and STONEHAM1, CON1, CDF1, and W-35A-04 (south of Site 300). Samples were analyzed for inorganic constituents (metals, nitrate, and perchlorate), general radioactivity (gross alpha and beta), tritium and uranium activity, explosive compounds (HMX and RDX), VOCs, and extractable organic compounds (EPA Method 625).

Generally, no constituents attributable to LLNL operations at Site 300 were detected in the off-site groundwater samples. Arsenic and barium were detected at the off-site locations, but their concentrations were below MCLs and are consistent with naturally occurring concentrations. Radioactivity measurements in samples collected from off-site groundwater wells are generally indistinguishable from naturally occurring activities.

5.5 Other Monitoring Programs

5.5.1 Rainwater

Rainwater is sampled and analyzed for tritium activity in support of DOE Order 5400.5. Rainwater is collected in stainless-steel buckets at fixed locations. The tritium activity of each sample is measured and all analytical results are provided in **Appendix A**, **Section A.7**.

5.5.1.1 Livermore Site and Environs

Rain sampling locations are shown in **Figure 5-6**. During 2008, LLNL collected rainwater samples following one rain event in the Livermore Valley. All of the rainwater sampling dates correspond to storm water runoff sampling. During 2008, no on-site measurement of tritium activity was above the MCL of 740 Bq/L (20,000 pCi/L) established by the EPA for drinking water. A 2007 internal analysis of the LLNL rain sampling network demonstrated that current discharges were not likely to produce activities greater than the analytical laboratory detection limit in rainwater beyond the Livermore site perimeter. Based on the analysis results, rain sampling is now done at only four locations on the Livermore site perimeter (see **Figure 5-6**). The maximum tritium activity measured in off-site rainwater samples during 2008 were estimated values below the minimum reporting limit of 3.7 Bq/L (100 pCi/L).

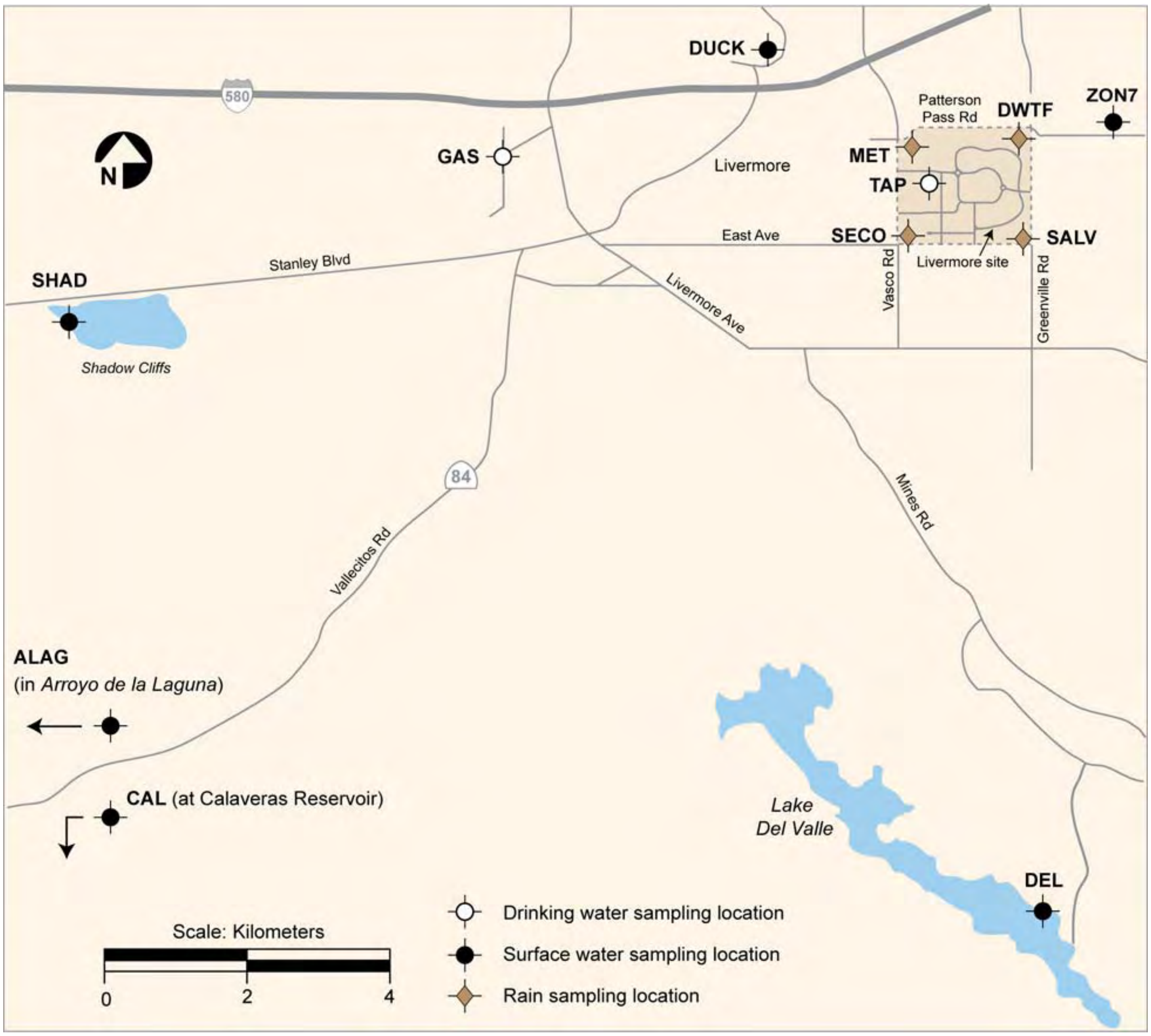

Figure 5-6. Livermore site and Livermore Valley sampling locations for rain, surface water, and drinking water, 2008.

5.5.1.2 Site 300 and Environs

During 2008, LLNL positioned two rain gauges at on-site locations ECP and PSTL (see **Figure 5-7**) to collect rainfall to measure tritium activity at Site 300. Rainfall samples are collected at the same time storm water samples are collected; however, no storm water samples were collected at Site 300 for calendar year 2008 because there were no storms that met the criteria for a qualifying event as defined in the General Industrial Storm Water Permit (97-03-DWQ). Therefore, no rainwater samples were collected at Site 300 in calendar year 2008. Historically, there have been no measureable activities in rainfall samples above analytical laboratory detection limits at this site.

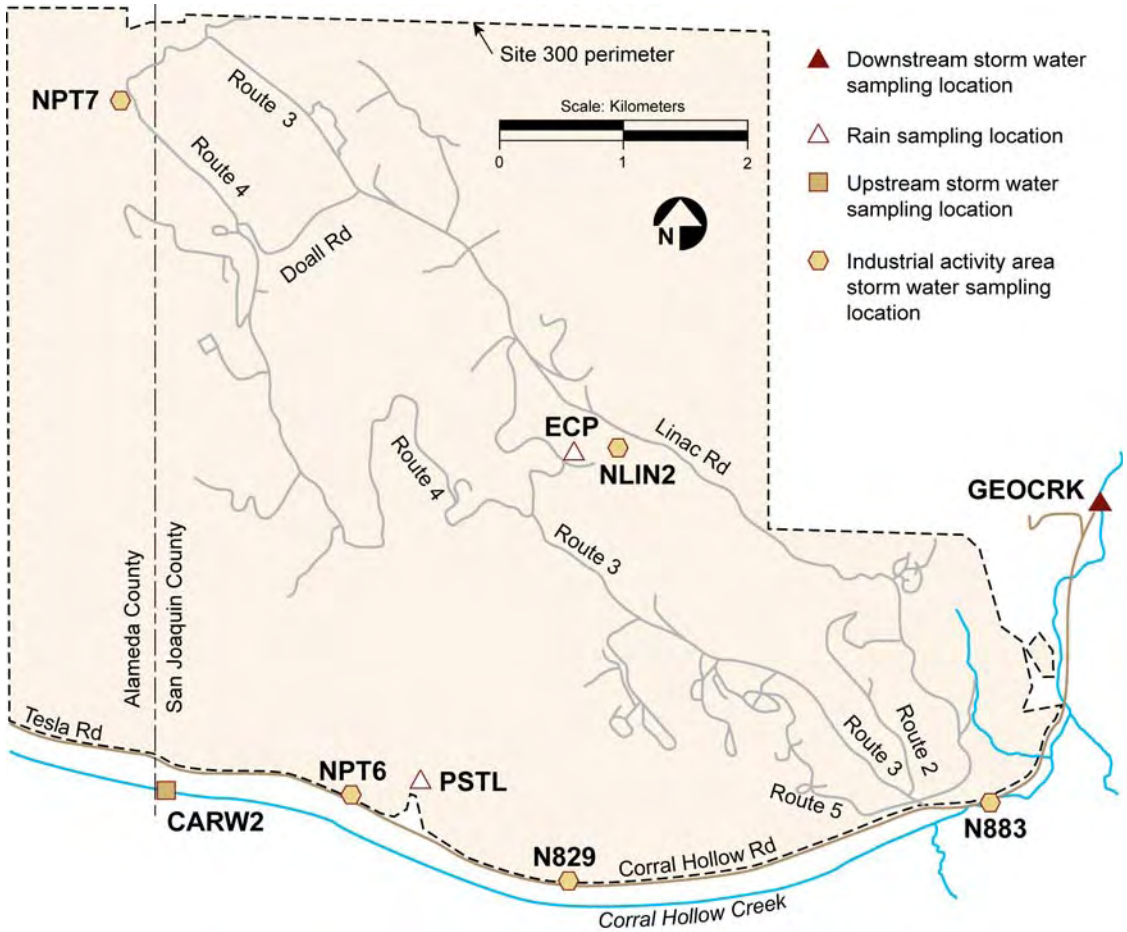

Figure 5-7. Storm water and rainwater sampling locations at Site 300, 2008.

5.5.2 Livermore Valley Surface Waters

LLNL conducts additional surface water surveillance monitoring in support of DOE Order 5400.5. Surface and drinking water near the Livermore site and in the Livermore Valley were sampled at the locations shown in **Figure 5-6** in 2008. Off-site sampling locations CAL, DEL, DUCK, ALAG, SHAD, and ZON7 are surface water bodies; of these, CAL, DEL, and ZON7 are also drinking water sources. GAS and TAP are drinking water outlets; radioactivity data from these two sources are used to calculate drinking water statistics (see **Table 5-7**).

Samples are analyzed according to written, standardized procedures summarized in Gallegos (2009). LLNL sampled these locations annually in 2008 for tritium, gross alpha, and gross beta. All analytical results are provided in **Appendix A**, **Section A.7**.

The median activity for tritium in all water location samples was estimated from calculated values to be below the analytical laboratory's minimum detectable activities, or minimum quantifiable activities. The maximum tritium activity detected in any sample collected in 2008 was 0.93 Bq/L (25.1 pCi/L), less than 1% of the drinking water MCL. Median activities for gross alpha and gross beta radiation in all water samples were less than 5% of their respective MCLs. Historically, concentrations of gross alpha and gross beta radiation in drinking water sources have fluctuated around the laboratory's minimum detectable activities. At these very low levels, the counting error associated with the measurements is nearly equal to, or in many cases greater than, the calculated values so that no trends are apparent in the data. Maximum activities detected for gross alpha and gross beta radioactivity both occurred in samples collected at DUCK. Although DUCK is not a drinking water source sampling location, these maximum values (gross alpha at 0.326 Bq/L [8.81 pCi/L] and gross beta at 0.277 Bq/L [7.49 pCi/L]) were still less than 60% and 15% of their respective drinking water MCLs (see **Table 5-7**).

Table 5-7. Radioactivity in surface and drinking waters in the Livermore Valley, 2008.

Location	Metric	Tritium (Bq/L)[(a)]	Gross alpha (Bq/L)[(a)]	Gross beta (Bq/L)[(a)]
All locations	Median	–0.93	0.019	0.084
	Minimum	–1.31	–0.0058	–0.024
	Maximum	0.93	0.326	0.277
	Interquartile range	1.04	0.067	0.074
Drinking water locations	Median	N/A[(b)]	N/A[(b)]	N/A[(b)]
	Minimum	–1.16	0.012	0.023
	Maximum	-–0.70	0.014	0.073
	Drinking water MCL	740	0.555	1.85

(a) A negative number means the sample radioactivity was less than the background radioactivity.

(b) Median value not available. See **Chapter 9** for an explanation of calculating summary statistics.

5.5.3 Lake Haussmann Release

Lake Haussmann can hold approximately 45.6 million L (37 acre-feet) of water and is located near the center of the Livermore site. It collects treated groundwater from surrounding groundwater treatment facilities TFD and TFE and portable treatment units, and from storm water runoff. Previous LLNL environmental reports detail the history of the construction and management, the regulatory drivers, sampling requirements, and discharge limits of Lake Haussmann, which was formerly called the Drainage Retention Basin (DRB) (see Harrach et al. 1995, 1996, 1997). LLNL collects discharge samples at location CDBX (**Figure 5-2)** and compares them with samples collected at location WPDC to identify any change in water quality. Written, standardized sample collection procedures are summarized in Gallegos (2009). State-certified laboratories analyze the collected samples for chemical and physical parameters. All analytical results are included in **Appendix A**, **Section A.7**.

The only limit exceeded for samples collected at CDBX and WPDC was the pH discharge limit of 8.5. Dry season and wet season pH has averaged 9.3 and 8.3, respectively, since 1992. The higher pH readings seen in Lake Haussmann discharge samples during the dry season correspond to the peak of the summer algal bloom within Lake Haussmann. While some metals were detected, no metals were above discharge limits. All organics and PCBs were below analytical detection limits. Pesticides, gross alpha, gross beta, and tritium levels were well below discharge limits.

5.5.4 Site 300 Drinking Water System Discharges

For most of CY 2008 (through December 9, 2008), LLNL maintained coverage under WDR 5-00-175, NPDES General Permit No. CAG995001, issued by the CVRWQCB for occasional large volume discharges from the Site 300 drinking water system that reach surface water drainage courses. The monitoring and reporting program that LLNL developed for these discharges was approved by the CVRWQCB. Discharges that are subject to these sampling and monitoring requirements are:

- Drinking water storage tanks: Discharges that have the potential to reach surface waters are monitored.
- System flushes: One flush per pressure zone per year is monitored for flushes that have the potential to reach surface waters.
- Dead-end flushes: All flushes that have the potential to reach surface waters and any discharge that continues for more than four months are monitored.

On June 12, 2008, the CVRWQCB adopted General Order R5-2008-0081 for low threat discharges, which superseded WDR 5-00-175. Dischargers covered under WDR 5-00-175 were automatically granted coverage under this General Order for a period of 180 days following its adoption (through December 9, 2008). On September 10, 2008, LLNL submitted a Notice of Intent (NOI) to cover these low threat discharges in the future under the recently adopted General Order. Subsequently, on February 19, 2009, the CVRWQCB issued a Notice of Applicability (NOA) that provides LLNL with coverage for these low threat discharges from the Site 300 drinking water system that reach surface water drainage courses under General Order R5-2008-0081-025, NPDES Permit No. CAG995001. Between December 9, 2008, and February 19, 2009, there were no surface water discharges from the Site 300 drinking water system.

Complete monitoring results from 2008 are detailed in the quarterly self-monitoring reports to the CVRWQCB. The annual testing, required by the CVRWQCB, was completed during the third quarter when LLNL conducted flushing of the drinking water system for water quality purposes. These system flush releases were monitored and met the effluent limits. With the exception of a waterline break, which occurred on October 9, 2008 (LLNL 2009a), all releases from the Site 300 drinking water system reaching surface waters quickly percolated into the drainage ditches or streambed and did not reach Corral Hollow Creek, the potential receiving water.

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6. Terrestrial Monitoring

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Lawrence Livermore National Laboratory monitors several aspects of the terrestrial environment. LLNL measures the radioactivity present in soil, vegetation, and wine, and the absorbed gamma radiation dose at ground-level receptors from terrestrial and atmospheric sources.

The LLNL terrestrial radioactivity monitoring program is designed to measure any changes in environmental levels of radioactivity. All monitoring activities follow U.S. DOE guidance criteria. On-site monitoring activities detect radioactivity released from LLNL that may contribute to radiological dose to the public or to biota; monitoring at distant locations not impacted by LLNL operations detects naturally occurring background radiation.

Terrestrial pathways from LLNL operations leading to potential radiological dose to the public include resuspension of soils, infiltration of constituents of runoff water through arroyos to groundwater, ingestion of locally grown foodstuffs, and external exposure to contaminated surfaces and radioactivity in air. Potential ingestion doses are calculated from measured concentrations in vegetation and wine; doses from exposure to ground-level external radiation are obtained directly from thermoluminescent dosimeters (TLDs) deployed for environmental radiation monitoring. Potential dose to biota (see **Chapter 7**) is calculated using a screening model that requires knowledge of radionuclide concentrations in soils and surface water.

Sampling for all media is conducted according to written, standardized procedures summarized in Gallegos (2009).

In addition to terrestrial radioactivity monitoring, LLNL monitors the abundance, distribution, and ecological requirements of plant and wildlife species, and conducts research relevant to the protection of rare plants and animals. Monitoring and research of biota on LLNL property is conducted to ensure compliance with requirements of the U.S. Endangered Species Act, the California Endangered Species Act, the Eagle Protection Act, the Migratory Bird Treaty Act, and other applicable regulations as they pertain to endangered, threatened, and other special status species, their habitats, and designated critical habitats that exist at both LLNL sites.

6.1 Soil Monitoring

The number of soil sampling locations are as follows:

Livermore site—7 (see **Figure 6-1**)

Livermore Valley—10, including 3 at the LWRP (see **Figure 6-2**)

Site 300—12 (see **Figure 6-3**)

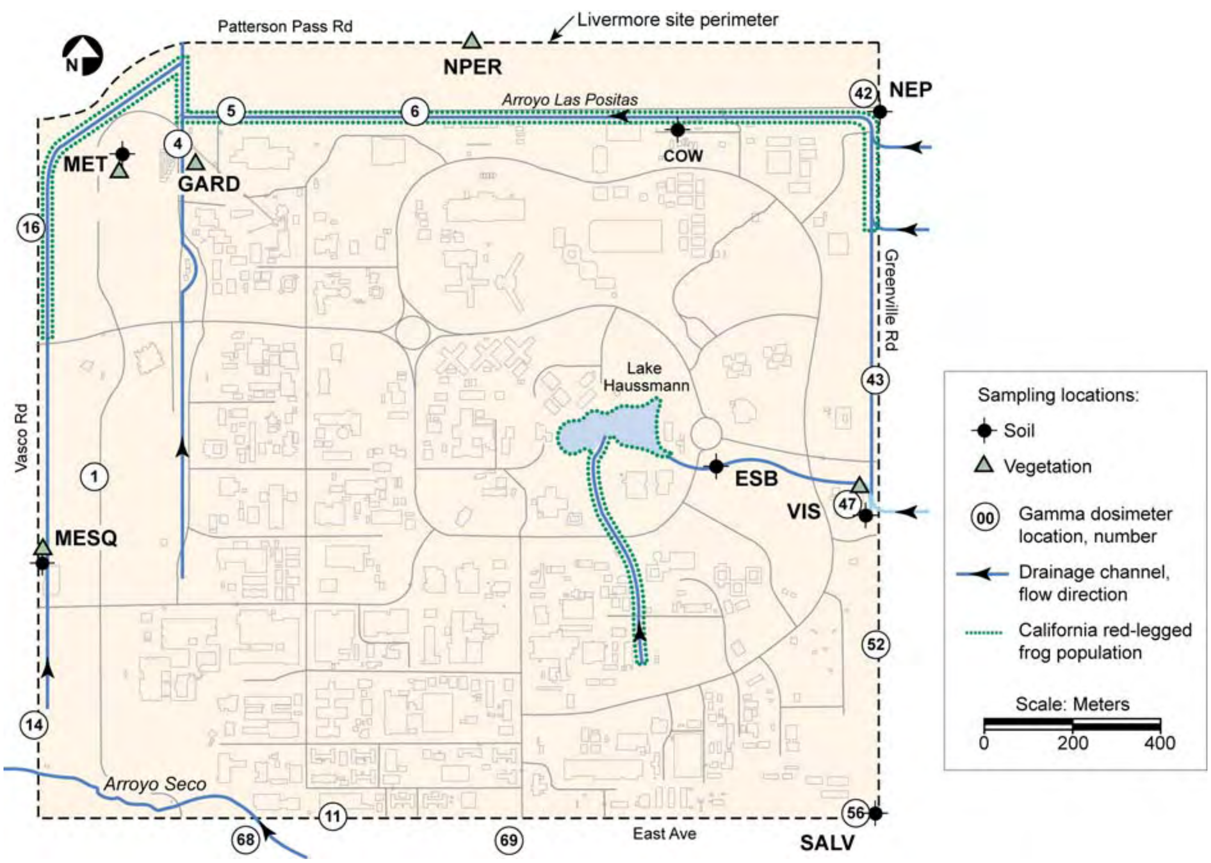

Figure 6-1. Soil and vegetation sampling locations, gamma dosimeter locations, and populations of the California red-legged frog, a threatened species, Livermore site, 2008.

These locations were selected to represent background concentrations (distant locations unlikely to be affected by LLNL operations) as well as areas with the potential to be affected by LLNL operations. Sampling locations also include areas with known contaminants, such as the LWRP and around explosives testing areas at Site 300.

Surface soil samples are collected from the top 5 cm of soil because aerial deposition is the primary pathway for potential contamination, and resuspension of materials from the surface into the air is the primary exposure pathway to nearby human populations. Two 1-m squares are chosen from which to collect the sample. Each sample is a composite consisting of 10 subsamples that are collected at the corners and center of each square by an 8.25-cm-diameter, stainless-steel core sampler.

Additional samples are collected for tritium, gross alpha, gross beta, and metals analyses. At one of the subsample locations, a 15-cm deep sample is taken for tritium analysis; this deeper sample is necessary to obtain sufficient water in the sample for tritium analysis. Vadose zone samples are collected at the same location as the tritium subsample but at increased depths. A 45- to 65-cm deep sample is also collected at location ESB for analysis for PCBs.

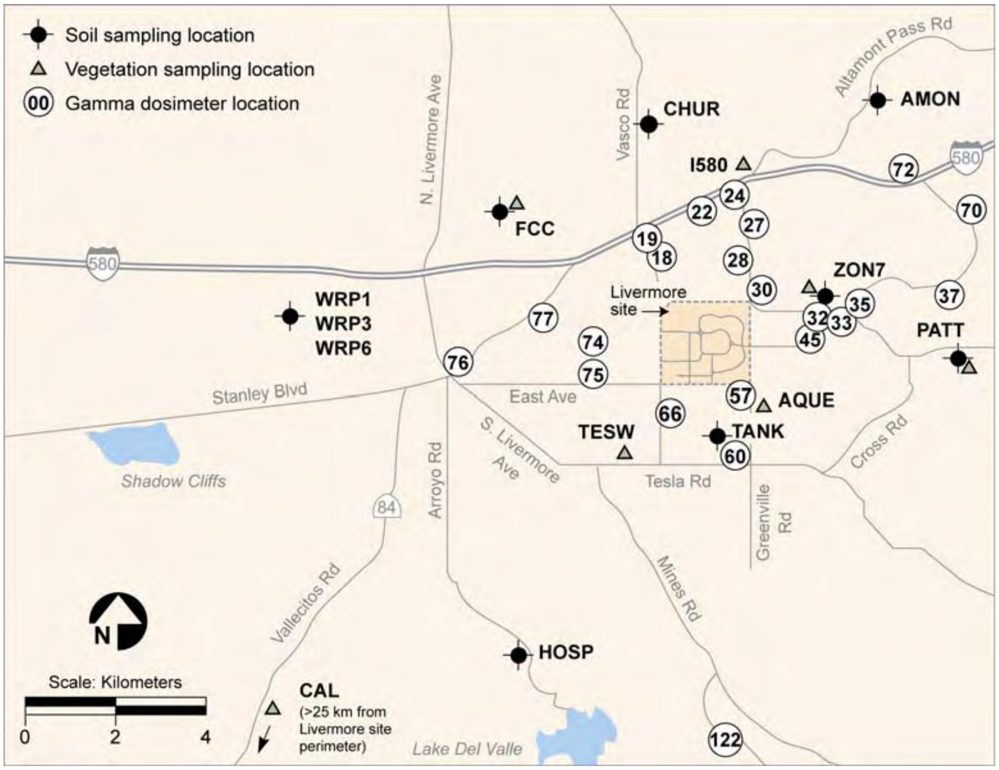

Figure 6-2. Soil and vegetation sampling locations and gamma dosimeter locations, Livermore Valley, 2008.

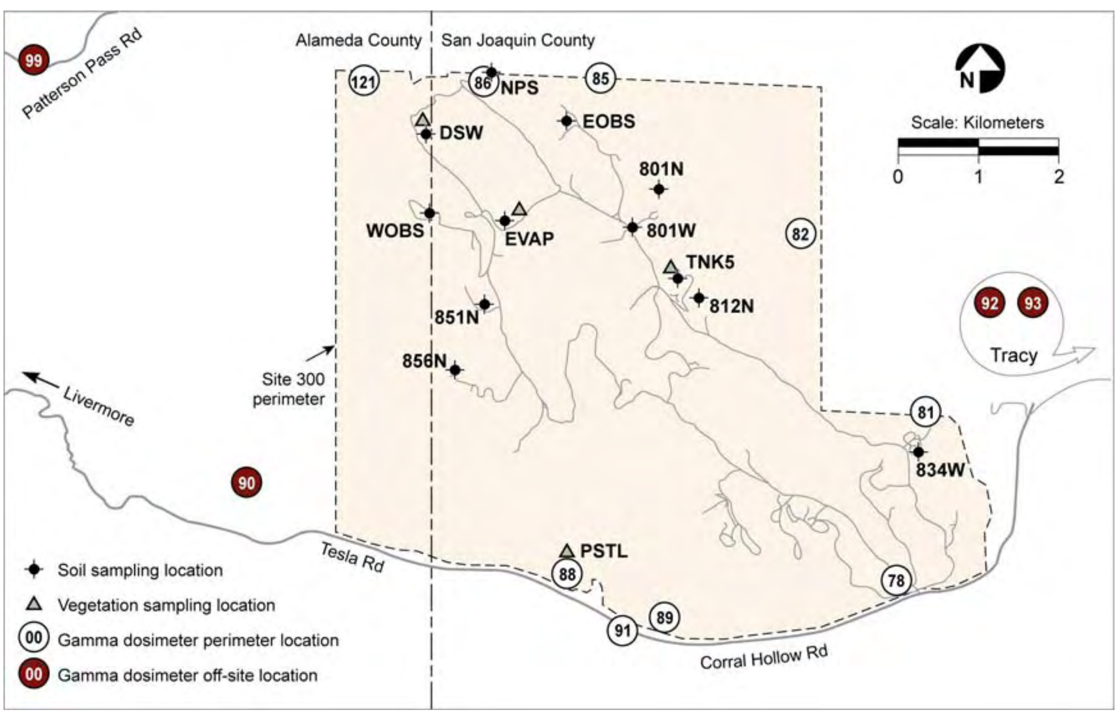

Figure 6-3. Soil and vegetation sampling locations and gamma dosimeter locations, Site 300 and off-site, 2008.

In 2008, surface soil samples in the Livermore Valley were analyzed for plutonium and gamma-emitting radionuclides; samples at selected locations were analyzed for tritium, gross alpha, and gross beta. Samples from Site 300 were analyzed for gamma-emitting radionuclides and beryllium.

Prior to radiochemical analysis, the surface soil is dried, sieved, ground, and homogenized. The plutonium content of a 100-g sample aliquot is determined by alpha spectrometry. Other sample aliquots (300 g) are analyzed by gamma spectrometry using a high-purity germanium (HPGe) detector for 47 radionuclides, including fission products, activation products from neutron interactions on steel, actinides, and natural products. Tritium is analyzed by liquid scintillation counting. For beryllium, 10-g subsamples are analyzed by atomic emission spectrometry. Standard EPA methods are used to analyze soil samples for PCBs.

6.1.1 Radiological Monitoring Results

The 2008 data on the concentrations of radionuclides in surface soil from the Livermore Valley sampling locations are provided in **Appendix A**, **Section A.8**.

The concentrations and distributions of all observed radionuclides in soil for 2008 are within the ranges reported in previous years and generally reflect worldwide fallout and naturally occurring concentrations. Slightly higher values at and near the Livermore site have been attributed to historical operations (Silver et al. 1974), including the operation of solar evaporators for plutonium-containing liquid waste in the southeast quadrant of the site. LLNL ceased operating the solar evaporators in 1976 and no longer engages in any other open-air treatment of plutonium-containing waste. Sampling at location ESB, which is in the drainage area for the southeast quadrant of the Livermore site, shows the effects of the historical operation of solar evaporators. The measured value for plutonium-239+240 at this location in 2008 was 2.0 mBq/dry g (5.4×10^{-2} pCi/dry g). Elevated levels of plutonium-239+240 resulting from an estimated 1.2×10^{9} Bq (32 mCi) plutonium release to the sanitary sewer in 1967 and earlier releases were again detected at LWRP sampling locations in 2008. The highest detected plutonium-239+240 value at the LWRP was 12.0 mBq/dry g (3.2×10^{-1} pCi/dry g). In addition, americium-241 was detected in one LWRP sample at a concentration of 4.6 mBq/dry g (1.2×10^{-1} pCi/dry g) and was most likely caused by the natural radiological decay of the trace concentrations of plutonium-241 that were present in these historical releases to the sewer.

The highest detected value for tritium in 2008 (4.4 Bq/L [120 pCi/L]) was at location COW, which is downwind of the Tritium Facility. In 2008, tritium emissions were consistent with the Tritium Facility's associated operations, as described in **Chapter 4**. All tritium concentrations were within the range of previous data.

The soils data for Site 300 for 2008 are provided in **Appendix A**, **Section A.8**. The concentrations and the distributions of all radionuclides observed in Site 300 soil for 2008 lie within the ranges reported in all years since monitoring began. At 10 of the 12 sampling locations, the ratio of uranium-235 to uranium-238 reflects the natural ratio of 0.00725. There is significant uncertainty in calculating the ratio, however, due to the difficulty of measuring low activities of uranium-238 by gamma spectrometry. The highest measured values for uranium-235 and uranium-238 in a single sample were 0.22 µg/g (0.018 Bq/g or 0.47 pCi/g) and 99 µg/g (1.2 Bq/g or 33 pCi/g), respectively. The uranium-235 to uranium-238 ratio in this sample is 0.0022, which at the levels of uncertainty associated with the analysis equals the ratio for depleted uranium of 0.002. Such values at Site 300 result from the use of depleted uranium in explosive experiments.

6.1.2 Nonradiological Monitoring Results

Nonradiological monitoring is limited to constituents of concern such as PCBs and beryllium. Samples taken at the Livermore site location ESB are analyzed for PCBs, and samples from Site 300 locations are analyzed for beryllium.

Aroclor 1260, a PCB, has been detected at location ESB since surveillance for PCBs began at this location in 2000. In 2008, samples analyzed for PCBs were found to be below regulatory reporting limits. The presence of PCBs suggests residual low-level contamination from the 1984 excavation of the former East Traffic Circle landfill (see **Chapter 5**). The previously detected concentrations are below the federal and state hazardous waste limits. LLNL will continue to consistently monitor for the next three years, unless the results continue to be below the regulatory reporting limits, at which time the need for PCB monitoring will be reassessed.

Beryllium results for soils at Site 300 were within the ranges reported since sampling began in 1991. The highest value, 5.3 mg/kg, was found in an area that has historically been used for explosives testing. This value is much lower than the 110 mg/kg detected in 2003. The differing results reflect the particulate nature of the contamination.

6.1.3 Environmental Impact on Soil

6.1.3.1 Livermore Site

Routine surface soil sample analyses indicate that the impact of LLNL operations on this medium in 2008 has not changed from previous years and remains insignificant. Most analytes of interest or concern were detected at background concentrations or in trace amounts or could not be measured above detection limits.

The highest value for plutonium-239+240 in 2008 (12.0 mBq/dry g [0.32 pCi/dry g]), measured at LWRP, is 2.6% of the National Council on Radiation Protection (NCRP) recommended screening limit of 470 mBq/g (12.7 pCi/g) for property used for commercial purposes (NCRP 1999).

LLNL has investigated the presence of radionuclides in local soils frequently over the years including possible impacts of the distribution to the public of sludge contaminated by the 1967 plutonium release (see Table 6-5 in the *Environmental Report 2006* [Mathews et al. 2007] for a list of previous studies.) The studies have consistently shown that the concentrations of radionuclides in local soils are below levels of health concern. In fact, the concentrations are of such low levels of health concern that the Agency for Toxic Substances and Disease Registry

(ATSDR) (2003) strongly recommended against further study of local soils for the purpose of identifying locations where plutonium-contaminated sludge from the 1967 release may remain.

6.1.3.2 Site 300

The concentrations of radionuclides and beryllium detected in soil samples collected at Site 300 in 2008 are within the range of previous data and are generally representative of background or naturally occurring levels. The uranium-235/uranium-238 ratios that are indicative of depleted uranium occurred near the firing tables. They result from the fraction of the firing table operations that disperse depleted uranium. The highest measured uranium-238 concentration was 99 µg/g (1.2 Bq/g or 33 pCi/g) and was well below the NCRP-recommended screening level for commercial sites (313 µg/g [3.9 Bq/g or 105 pCi/g]). These values occurred near Bunker 812 and are a result of historic operations at that location. In 2008, a Remedial Investigation/Feasibility Study was submitted for the Building 812 operating unit (OU) (Taffet et al. 2008). This Investigation/Feasibility Study specifies the nature and extent of contamination, risk assessment, and remedial alternatives for CERCLA cleanup of the site (see **Chapter 8**). Cleanup remedies have not yet been selected to address soil and groundwater contamination in the Building 812 OU.

6.2 Vegetation and Foodstuff Monitoring

Vegetation sampling locations at the Livermore site (see **Figure 6-1**) and in the Livermore Valley (see **Figure 6-2**) are divided for comparison into the following three groups:

- Near locations (AQUE, GARD, MESQ, NPER, MET, and VIS) are on-site or less than 1 km from the Livermore site perimeter.
- Intermediate locations (I580, PATT, TESW, and ZON7) are in the Livermore Valley and 1 to 5 km from the Livermore site perimeter.
- Far locations (FCC and CAL) are more than 5 km from the Livermore site perimeter; FCC is about 5 km away and CAL is more than 25 km away. Both locations are generally upwind of the Livermore site.

Tritium in vegetation due to LLNL operations is most likely to be detected at the Near and Intermediate locations and is highly unlikely to be detected at the Far locations.

Site 300 has four monitoring locations for vegetation (PSTL, TNK5, DSW, and EVAP) (see **Figure 6-3**). Vegetation at locations DSW and EVAP exhibit variable tritium concentrations due to occasional uptake of contaminated groundwater by the roots. At the other two locations, TNK5, and PSTL, the only likely potential source of tritium uptake is the atmosphere, although groundwater in the vicinity of PSTL is contaminated with low levels of tritium.

Vegetation is sampled and analyzed quarterly. Water is extracted from vegetation by freeze-drying and analyzed for tritiated water (HTO) using liquid scintillation techniques.

Wines for sampling in 2008 were purchased from a supermarket in Livermore. The wines represent the Livermore Valley, two other regions of California, and the Rhone Valley in France.

Wines were prepared for sampling using a method that separates the water fraction from the other components of the wine and were analyzed using an ultra-low-level scintillation counter.

6.2.1 Vegetation Monitoring Results

Median and mean concentrations of tritium in vegetation based on samples collected at the Livermore site, in the Livermore Valley, and Site 300 in 2008 are shown in **Table 6-1**. (See **Appendix A**, **Section A.9**, for quarterly tritium concentrations in plant water). The highest mean tritium concentration for 2008 was 8.3 Bq/L at the Near location VIS located on the east-central perimeter of the Livermore site. For Site 300, the highest mean concentration for 2008 was 27 Bq/L at EVAP located in an area where the groundwater is contaminated with tritium.

Median concentrations of tritium in vegetation at sampling locations at the Livermore site and in the Livermore Valley have decreased noticeably since 1989 (see **Figure 6-4**). Median concentrations at the Far locations have been below the detection limit of approximately 2.0 Bq/L since 1993. Median concentrations at the Intermediate locations have been below the detection limit since 1998, except in 2002 when the median concentration was 2.3 Bq/L. Median concentrations at the near locations were below detection limit between 2003 and 2005 and more recently have been below or slightly above the detection limit.

At Site 300, the median concentrations of tritium in vegetation at locations PSTL and TNK5 were below detection limit. The median concentration of tritium in vegetation at EVAP was 10 Bq/L.

6.2.2 Wine Monitoring Results

Tritium concentrations in wines purchased in 2008 are shown in **Table 6-2**. The highest concentration in a Livermore Valley wine is 1.8 Bq/L (48 pCi/L) from a wine made from grapes harvested in 2003. The highest concentration in a California (other than the Livermore Valley) wine is 320 Bq/L (8700 pCi/L) from a wine made from grapes harvested in 2006. The highest concentration in a Rhone Valley (France) wine is 6.8 Bq/L (184 pCi/L) from a wine made from grapes harvested in 2005.

Analysis of the wines purchased annually since 1977 have demonstrated the following relationship between the Livermore Valley, California, and the Rhone Valley wines: Tritium concentrations in the Rhone Valley wines are typically higher than tritium concentrations in the Livermore Valley wines. Tritium concentrations in the California (other than the Livermore Valley) wines are typically lower than tritium concentrations in the Livermore Valley wines. However, one of the two California wines sampled in 2008 did not follow this relationship and contained a higher level of tritium than in wines sampled in past years. To further investigate the much higher level of tritium (320 Bq/l), an attempt will be made to purchase and analyze the same wine and present the results in the 2009 annual environmental report.

Table 6.1. Median and mean concentrations of tritium in plant water for the Livermore site, Livermore Valley, and Site 300 sampled in 2008. The table includes mean annual ingestion doses calculated for 2008.

Sampling locations		Concentration of tritium in plant water (Bq/L) Median	Mean	Mean annual ingestion dose[a] (nSv/y)
NEAR (on-site or <1 km from Livermore site perimeter)	AQUE	1.5	1.6	<10[b]
	GARD	1.6	1.7	<10[b]
	MESQ	1.6	1.7	<10[b]
	MET	2.6	2.3	11
	NPER	3.1	2.9	14
	VIS	2.9	8.3	41
INTERMEDIATE (1–5 km from Livermore site perimeter)	I580	2.2	2.6	13
	PATT	0.93	1.1	<10[b]
	TESW	1.5	1.1	<10[b]
	ZON7	2.5	2.3	11
FAR (>5 km from Livermore site perimeter)	CAL	0.86	0.56	<10[b]
	FCC	0.92	0.56	<10[b]
Site 300	DSW[c]	(d)	2.4	(e)
	EVAP[c]	10	27	(e)
	PSTL	1.1	1.1	(e)
	TNK5	1.8	2.4	(e)

(a) Ingestion dose is based on conservative assumptions that an adult's diet is exclusively vegetables with this tritium concentration, and that meat and milk are derived from livestock fed on grasses with the same concentration of tritium. See **Table 6-3**.

(b) When concentrations are less than the detection limit (about 2.0 Bq/L), doses can only be estimated as being less than the dose at that concentration.

(c) Plants at these locations are rooted in areas of known subsurface contamination.

(d) Median not calculated because only three values are available for DSW.

(e) Dose is not calculated because there is no pathway to dose to the public.

The Livermore Valley wines represent vintages from 2002, 2003, 2005, 2006, and 2007; the California wines represent vintage from 2006; and the Rhone Valley wines represent vintage from 2005. Tritium concentrations must be decay-corrected to the year of harvest to correlate with tritium concentrations in air and soil to which the grape was exposed. In 2008, decay-corrected concentrations for Livermore Valley wine samples ranged from 0.69 to 2.4 Bq/L; for the two California wine samples, 370 and 0.84 Bq/L; and for the two Rhone Valley wine samples, 2.8 and 8.3 Bq/L.

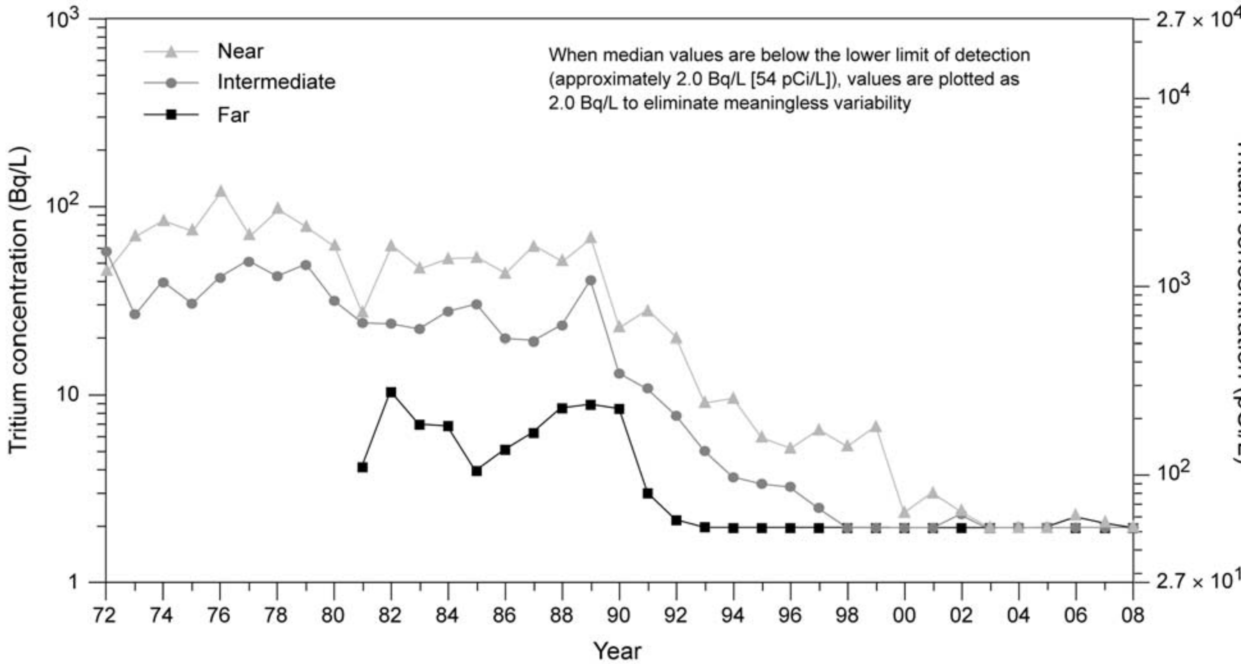

Figure 6-4. Median tritium concentrations in Livermore site and Livermore Valley plant water samples, 1972 to 2008.

Table 6-2. Tritium in retail wine, 2008(a,b)

Sample	Concentration by area of production (Bq/L)		
	Livermore Valley	**California**	**Europe**
1	0.41 ± 0.60	320 ± 3.1	6.8 ± 0.73
2	1.8 ± 0.63	0.73 ± 0.61	2.3 ± 0.65
3	0.60 ± 0.60		
4	0.30 ± 0.59		
5	0.083 ± 0.59		
6	0.43 ± 0.60		
Dose (nSv/y)(c)	2.2	390	8.3

(a) Radioactivities are reported here as the measured concentration and an uncertainty (±2σ counting error).

(b) Wines from a variety of vintages were purchased and analyzed for the 2008 sampling. Concentrations are those measured in March 2009.

(c) Calculated based on consumption of 52 L wine per year at maximum concentration (see **Chapter 7**). Doses account for contribution of OBT as well as of HTO.

6.2.3 Environmental Impact on Vegetation and Wine

6.2.3.1 Vegetation

Hypothetical annual ingestion doses for mean concentrations of tritium in vegetation are shown in **Table 6-1**. These hypothetical doses, from ingestion of HTO in vegetables, milk, and meat, were calculated from annual mean measured concentrations of HTO in vegetation using the transfer factors from **Table 6-3** based on U.S. Nuclear Regulatory Commission Regulatory Guide 1.109 (U.S. NRC 1977). The hypothetical annual ingestion dose, based on the highest observed mean HTO concentration in vegetation for 2008, was 41 nSv (4.1 µrem).

Table 6-3. Bulk transfer factors used to calculate inhalation and ingestion doses (in µSv) from measured concentrations in air, vegetation, and drinking water

Exposure pathway	Bulk transfer factors[a] times observed mean concentrations
Inhalation and skin absorption	0.21 x concentration in air (Bq/m^3); see **Chapter 4**
Drinking water	0.013 x concentration in drinking water (Bq/L); see **Chapter 5**
Food ingestion	0.0049 x concentration in vegetation (Bq/kg); factor obtained by summing contributions of 0.0011 for vegetables, 0.0011 for meat and 0.0027 for milk

(a) See Sanchez et al. (2003), Appendix C, for the derivation of bulk transfer factors.

Doses calculated based on Regulatory Guide 1.109 neglect the contribution from organically bound tritium (OBT). However, according to a panel of tritium experts, "the dose from OBT that is ingested in food may increase the dose attributed to tritium by not more than a factor of two, and in most cases by a factor much less than this" (ATSDR 2002, p. 27). Thus, the maximum estimated ingestion dose from LLNL operations for 2008, including OBT, is 82 nSv/y (8.2 µrem/y). This maximum dose is about 1/36,000 of the average annual background dose in the United States from all natural sources and about 1/120 the dose from a panoramic dental x-ray.

Ingestion doses of Site 300 vegetation were not calculated because neither people nor livestock ingest vegetation at Site 300.

6.2.3.2 Wine

For Livermore Valley wines purchased in 2008, the highest concentration of tritium (1.8 Bq/L [48 pCi/L]) was just 0.24% of the EPA's standard for maximal permissible level of tritium in drinking water (740 Bq/L [20,000 pCi/L]). Drinking one liter per day of the Livermore Valley wine with the highest concentration purchased in 2008 would have resulted in a dose of 15 nSv/y (1.5 µrem/y). A more realistic dose estimate, based on moderate drinking (one liter per week)[1] at the mean of the Livermore Valley wine concentrations (0.60 Bq/L [16 pCi/L]) would have

(1) Moderate consumption is higher than the average consumption of wine in California (15.7 L/yr) (Avalos 2005).

been 0.73 nSv/y (0.073 µrem/y). Both doses explicitly account for the added contribution of OBT.(2)

The potential dose from drinking Livermore Valley wines in 2008, including the contribution of OBT, even at the high consumption rate of one liter per day, and the highest observed concentration, would be about 1/670 of a single dose from a panoramic dental x-ray.

6.3 Ambient Radiation Monitoring

LLNL's ambient radiation monitoring program is designed to monitor for any changes in the natural radiation field due to LLNL operations. By sampling at enough locations in the surrounding community, the variance in the natural background from season to season and by location is measured and compared to a five-year trend. The long-term trend analysis allows the radiation field affects from operations to be readily recognized.

6.3.1 Methods and Reporting

Exposure to external radiation is measured by correlating the interaction of ionizing energy with its effect on matter that absorbs it. LLNL uses the Panasonic UD-814AS1 TLD, which contains three crystal elements of thulium-activated calcium sulfate ($CaSO_4$:Tm), to measure environmental gamma dose that is corrected for reading, 90-day normalization to actual quarterly exposure, and conversion to reported dose. The TLDs are then representative of external exposure to the public at these sample locations. Comparisons are made for LLNL perimeter locations to those of the Livermore Valley (background location) for the purposes of determining an elevated radiation field. This is similarly done for Site 300 and its nearby locations.

As a TLD absorbs ionizing energy, electron–hole pairs are created in the crystal lattice, trapping this absorbed energy in the crystal's excited state. The absorbed energy released in the form of light emission (glow curve) upon heating is proportional to the TLD absorbed dose which is calibrated to a known standard of cesium-137 gamma energy of 662 keV. The calculated result of the TLD exposure is then reported in the SI unit of Sv from the measured dose in mR.

To compare LLNL dose contributions with the natural background, the analysis is divided into three groups:

- comparison of the average quarterly dose (mSv) for the Livermore site, Livermore Valley, and Site 300 locations for the five-year period from 2004 to 2008
- comparison of the average quarterly dose (mSv) for the Livermore site and Livermore Valley locations in 2008
- comparison of average quarterly dose (mSv) for Site 300, city of Tracy, and Site 300 vicinity in 2008

The results of these comparisons are shown in **Figure 6-5**.

(2) Dose from wine was calculated based on the measured concentration of HTO multiplied by 1.3 to account for the potential contribution of OBT that was removed so that the tritium in wine could be counted using liquid scintillation counting. Dose coefficients for HTO and OBT are those of the International Commission on Radiological Protection (1996).

To obtain a true representation of local site exposure and determine any dose contribution from LLNL operations, an annual environmental monitoring compliance assessment is done in accordance with DOE Order 450.1 through a quarterly deployment cycle. TLDs are deployed at a height of 1 m, adhering to regulatory guidance.

For the purpose of reporting comparisons, data are reported as a “standard 90-day quarter” with the dose reported in millisievert (mSv; 1 mSv = 100 mrem).

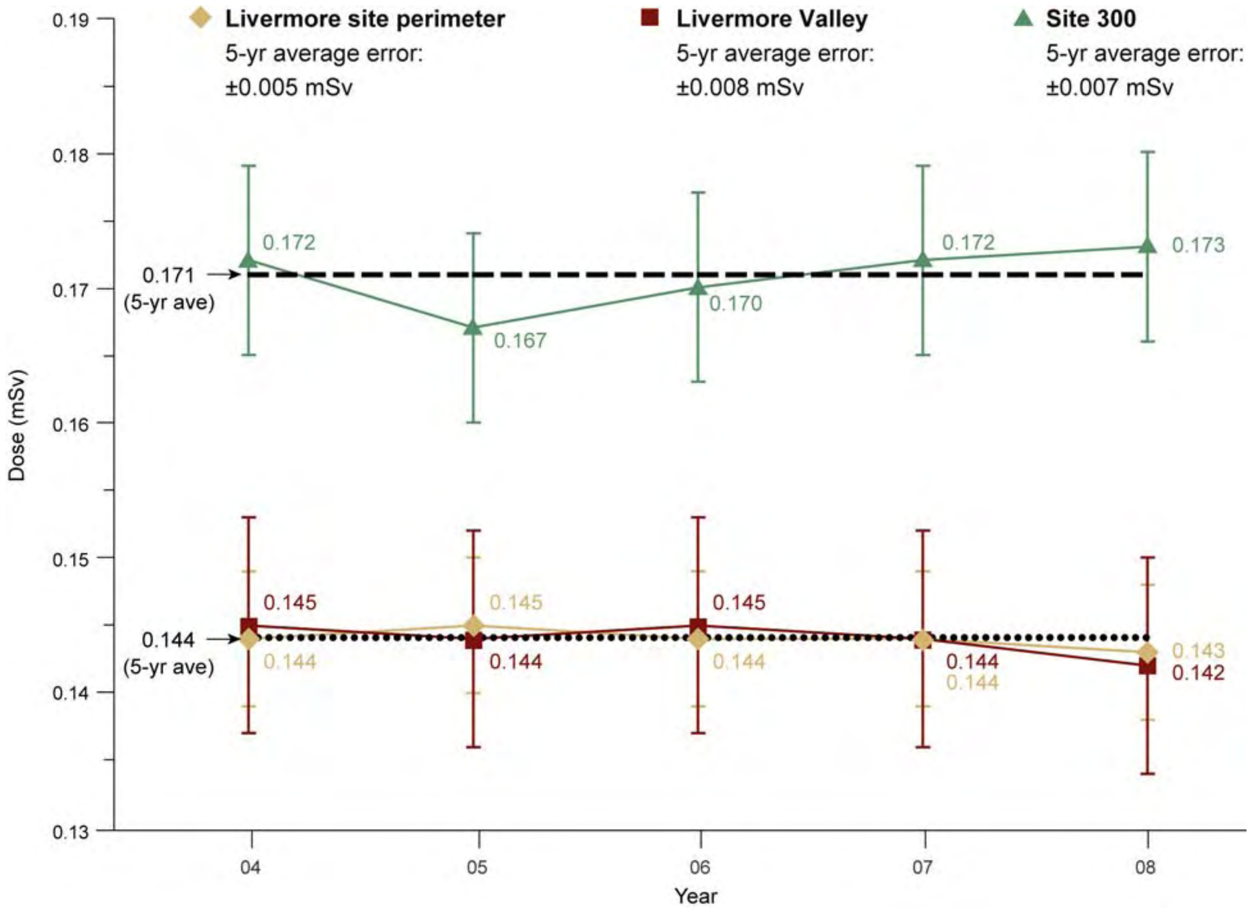

Figure 6-5. Comparison of the average quarterly dose for the Livermore site perimeter, Livermore Valley, and Site 300 monitoring locations from 2004 to 2008.

6.3.2 Monitoring Results

Figure 6-5 represents the average quarterly dose (in mSv) for the recent five-year period for the Livermore site perimeter, Livermore Valley and Site 300. Tabular data for each sampling location are provided in **Appendix A**, **Section A.9**.

The difference in the doses at the Livermore site perimeter, Livermore Valley, and Site 300 can be attributed directly to the difference in the geological substrates. The Neroly Formation in the region around Site 300 contains higher levels of naturally occurring thorium that provides the higher external radiation dose.

6.3.3 Environmental Impact from Laboratory Operations

There is no increased ambient radiation field produced as a direct result of LLNL operations for 2008 as measured by this network. Radiation dose trends remain consistent with annual average levels for each sample location and synonymous to natural background levels. As depicted in **Figure 6-5**, the annual average gamma radiation dose for the LLNL site perimeter and the Livermore Valley from 2004 to 2008 are statistically equivalent and show no discernible impact due to operations conducted at LLNL.

6.4 Special Status Wildlife and Plants

Special status wildlife and plant monitoring at LLNL focuses on species considered to be rare, threatened, or endangered (including species listed under the federal or California ESAs; species considered of concern by the California Department of Fish and Game [CDFG] and the USFWS; and species that require inclusion in NEPA and California Environmental Quality Act [CEQA] documents).

Five species that are listed under the federal ESAs are known to occur at Site 300—the California tiger salamander (*Ambystoma californiense*), California red-legged frog (*Rana aurora draytonii*), Alameda whipsnake (*Masticophus lateralis euryxanthus)*, valley elderberry longhorn beetle (*Desmocerus californicus dimorphus)*, and the large-flowered fiddleneck (*Amsinckia grandiflor*a). Although there are no recorded observations of the federally endangered San Joaquin kit fox (*Vulpes macrotis mutica*) at Site 300, this species is known to have historically occurred in the adjacent Carnegie and Tracy Hills areas (USFWS 1998). Because of the proximity of known observations of San Joaquin kit fox to Site 300, it is necessary to consider potential impacts to San Joaquin kit fox during activities at Site 300. California threatened Swainson's Hawks (*Buteo swainsoni*) and California-endangered Willow Flycatchers (*Empidonax traillii*) have been observed at Site 300 . The California red-legged frog is also known to occur at the Livermore site (see **Figure 6-1**).

Known observations of the five listed species and two California species of special concern (Western Burrowing Owl [*Athene cunicularia*] and Tricolored Blackbird [*Agelaius tricolor*]) are shown in **Figures 6-6** and **6-7**. Vertebrate species and rare invertebrate species known to occur at Site 300, including state and federally listed species and other species of special concern are listed in **Appendix C**. A similar list has not been prepared for the Livermore site.

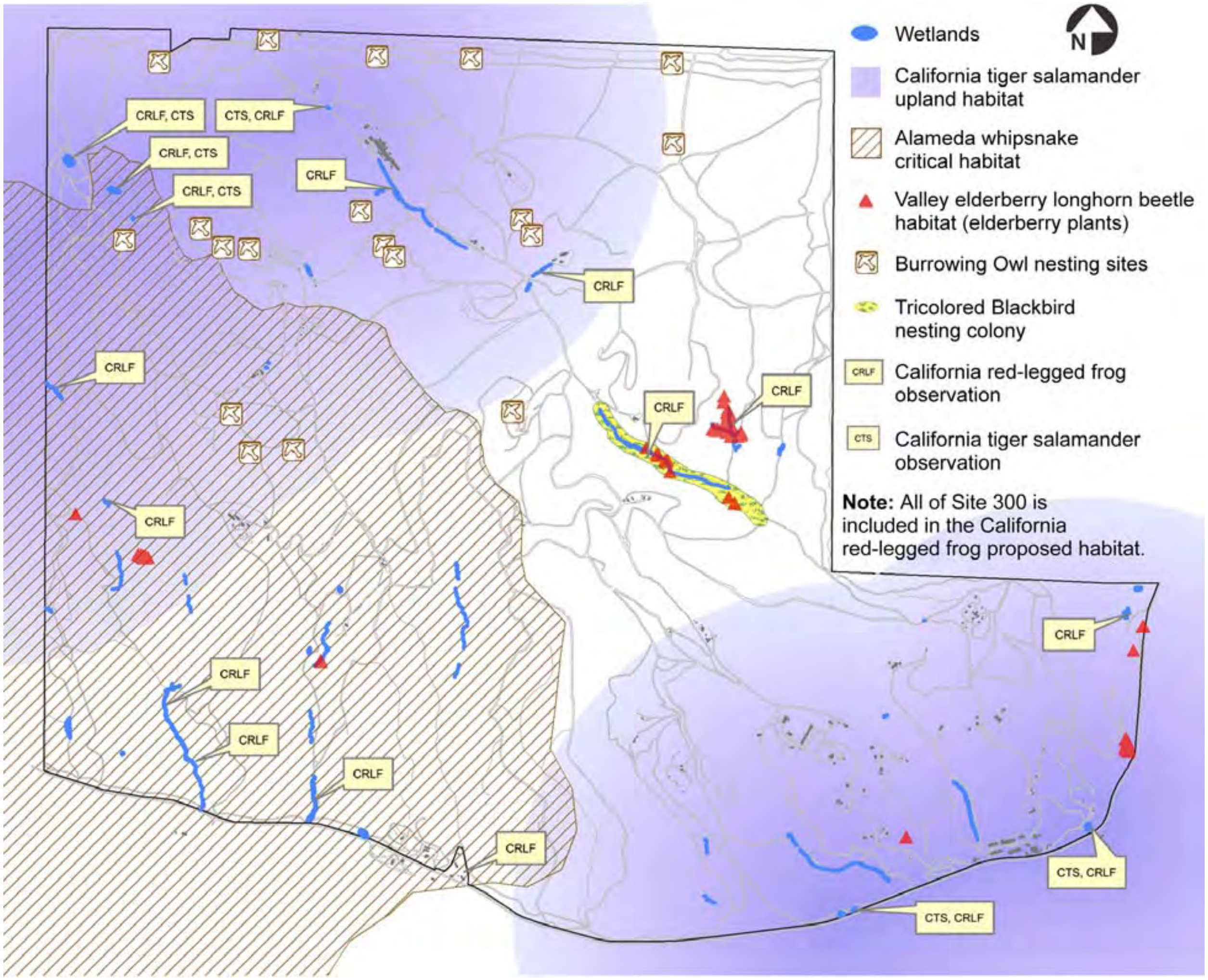

Figure 6-6. Distribution of special status wildlife, Site 300, 2008.

Including the federally endangered large-flowered fiddleneck, four rare plant species and four uncommon plant species are known to occur at Site 300. The four rare species—the large-flowered fiddleneck, the big tarplant (*Blepharizonia plumosa*), the round-leaved filaree *(California macrophylla)*, and the diamond-petaled California poppy (*Eschscholzia rhombipetala*)—are included in the California Native Plant Society (CNPS) List 1B (CNPS 2009). These species are considered rare and endangered throughout their range. The location of these four rare plant species at Site 300 is shown in **Figure 6-7**.

The four uncommon plant species—the gypsum-loving larkspur (*Delphinium gypsophilum* subsp. *gypsophilum*), California androsace (*Androsace elongata* subsp. *acuta*), stinkbells (*Fritillaria agrestis*), and hogwallow starfish (*Hesperevax caulescens*)—are all included on the CNPS List 4 (CNPS 2009). Past surveys have failed to identify any rare plants on the Livermore site (Preston 1997, 2002).

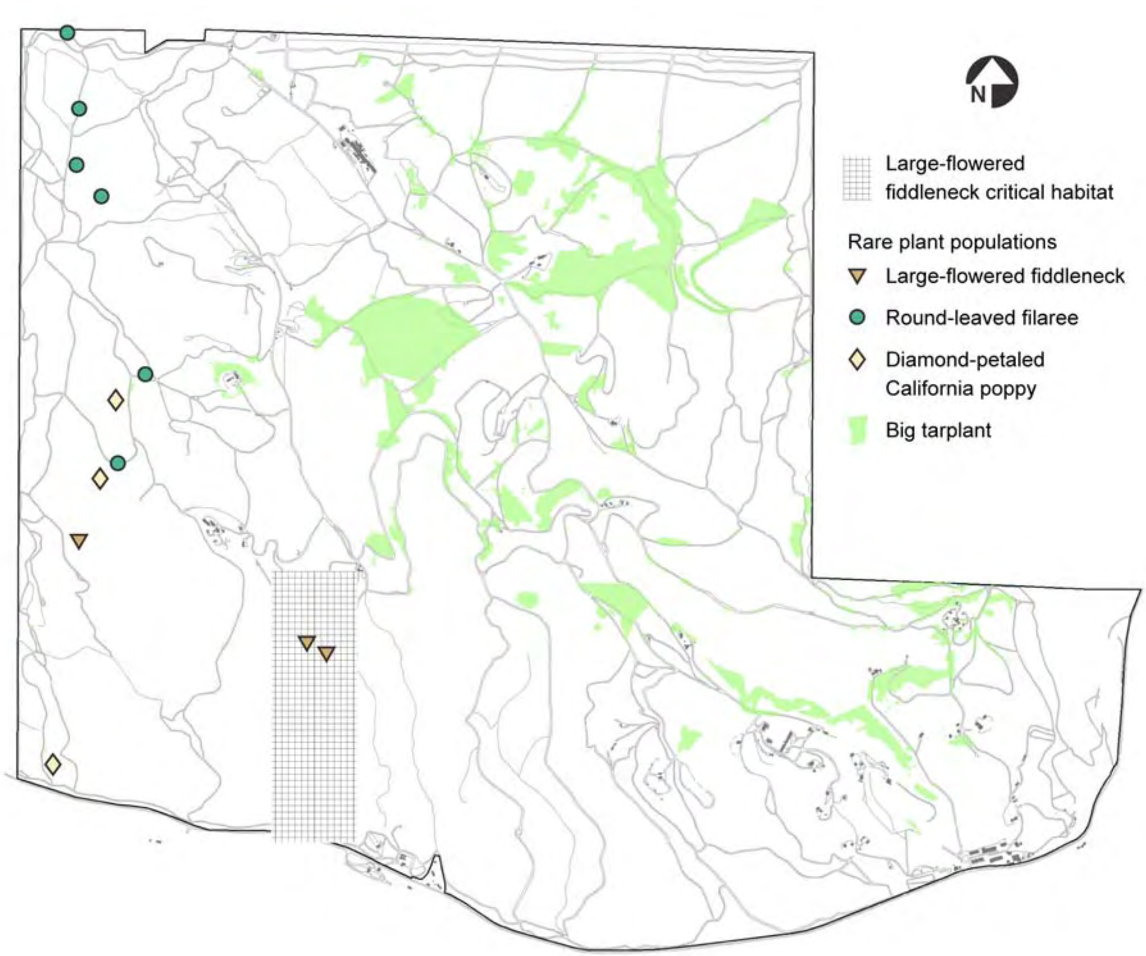

Figure 6-7. Distribution of special status plants, Site 300, 2008.

6.4.1 Compliance Activities

6.4.1.1 Arroyo Seco Restoration

LLNL conducted the third year of the five-year monitoring plan required by USFWS and ACOE for the restoration of the Arroyo Seco Management Plan project site. Monitoring at this site includes annual measurements of the survivorship of plants that were installed as part of the restoration and estimates of the percent cover of grasses and forbs, shrubs, and trees at the project site. Results of this monitoring are documented in Paterson (2008b). The mitigation and monitoring plan for this project lists annual success criteria based on the percent cover of grasses, shrubs, and trees at the project site, and requires LLNL to replace all trees and shrubs that do not survive during the first five years of monitoring. In 2008, the project site met the success criteria for grasses and shrubs in four monitoring zones with one exception: the percent cover of shrubs on the north bank (10%) was slightly lower than the success criterion for year three (12%). The percent cover of trees on the stream banks and on the north terrace was lower than the approved success criteria. Replacement planting was completed in the winter of 2007/2008, but survivorship was low for this planting.

6.4.1.2 Habitat Enhancement Projects

In late August 2005, LLNL implemented a habitat enhancement project for California red-legged frogs at Site 300 in accordance with a 2002 USFWS biological opinion (BO) and ACOE and RWQCB permits. California red-legged frogs were translocated to the new habitat enhancement pools in February and March of 2006. Monitoring demonstrated that California red-legged frogs successfully reproduced in these pools in 2006, 2007, and 2008. In 2008, 13 California red-legged frog egg masses were observed in the Upper Mid-Elk Ravine pool and 11 egg masses were seen in the lower pool. Although all egg masses successfully reared larvae and hundreds of recently metamorphed frogs were counted during fall daytime surveys, the pools dried before all larvae metamorphed.

In fall 2005, a depression in the northwest corner of Site 300 below Harrier pool was deepened and expanded to serve as mitigation for California tiger salamander habitat lost as a result of closing two man-made, high explosives rinse water ponds in the Process Area. In 2006, California tiger salamanders successfully bred and metamorphosed from the pool. In 2008, the pool received inadequate inundation and evaporated before the salamander larvae could reach maturity and leave the pond.

6.4.1.3 Oasis and Round Valley Culvert Replacement Projects

In 2006, LLNL completed culvert replacement projects at two Site 300 locations (the Oasis and Round Valley) where unpaved fire trails crossed intermittent drainages. The Round Valley project included the creation of a pool upstream of the project area in part as mitigation for the impacts at the Oasis site and to serve as enhanced habitat for amphibian species. These projects were completed under the USFWS BO for maintenance and operations of Site 300 and ACOE and RWQCB permits. The Round Valley pool did not receive enough water during the 2007/2008 winter to pool and afford potential breeding habitat for amphibians.

6.4.1.4 Pit 7 Remediation

In accordance with the requirements of the NEPA and CEQA documents for the Environmental Remediation of the Site 300 Pit 7 Complex, and the USFWS BO for maintenance and operations of Site 300, pre-construction rare plant surveys and wildlife surveys were conducted at the Pit 7 Remediation site in 2007 and 2008. Construction at this site started in October 2007 and ended in April 2008. Ongoing biological surveys were conducted throughout this period to ensure that any species discovered in the area received adequate protection.

Several small populations of the California androsace were found in rock outcroppings near the project site. Buffer zones were established around these rare plants during construction to avoid impacting this species. California androsace persisted at these locations after construction and was observed during surveys conducted in April 2008. Two Western Burrowing Owl nests were also discovered near the construction site, but these were not impacted, as construction did not start until after Burrowing Owls had fledged. During the winter of 2007/2008, two California tiger salamanders were relocated from within the project site in accordance with the requirements of the BO for this project.

6.4.1.5 Arroyo Mocho Boulder Removal Project

A pumping plant, which draws water from the Hetch Hetchy aqueduct, is the primary source of water for LLNL's Livermore site. Several large boulders fell into the channel of Arroyo Mocho below the pumping plant, potentially forcing the flow of the arroyo toward the hillside that the pumping plant is located on and resulting in an erosion hazard to this hillside and the pumping plant.

Arroyo Mocho and the surrounding area are habitat for California red-legged frog, California tiger salamander, and Alameda whipsnake. In 2007, two of these boulders were removed from Arroyo Mocho to mitigate erosion hazards. In 2008, an additional small boulder was removed from the stream channel. This work was conducted under an amendment to the 2004 BO for the Arroyo Mocho Road Improvement and Anadromous Fish Passage project. LLNL wildlife biologists monitored all in-channel work. No listed species were observed at the project site during boulder removal, and no impacts to special status species resulted from this project.

6.4.1.6 Arroyo Mocho Restoration

In 2008, LLNL implemented the fourth year of a five-year mitigation and monitoring plan for the restoration of the 2004 Arroyo Mocho Road Improvement and Anadromous Fish Passage project. This mitigation and monitoring plan is a requirement of the ACOE permit for this project. Success criteria for this restoration are based on the number of native species present and the percent cover of these species within three monitoring communities (low flood plain, sloping terrace and upland) at the project site. The project site currently includes a diverse collection of native riparian and upland plants. In 2006, 2007, and 2008, the number of native species observed at the site far exceeded the success criteria for species richness. The site met the success criteria for percent cover of native plants with one exception. In 2007 and 2008, the average percent cover of native plants in the sloping terrace was 44% (both years) compared to the success criteria of 45% in 2007 and 50% in 2008.

In an attempt to control exotic plants, as specified in the mitigation and monitoring plan, and increase the cover of native plants at the site, hand weeding of exotic species including yellow star thistle and bull thistle was conducted in 2008. The results of the monitoring are documented in Paterson (2009b).

6.4.2 Invasive Species Control Activities

Invasive species control is an important part of LLNL's effort to protect special status species at both sites. Prevention of the downstream dissemination of invasive species is also important to protect native species throughout our region. The bullfrog *(Rana catesbeiana)* and the largemouth bass *(Micropterus salmoides)* are significant threats to California red-legged frogs at the

Livermore site, and the feral pig (*Sus scrofa*) threatens California red-legged frog habitat at Site 300.

In 2008, to mitigate threats to California red-legged frog habitat, feral pigs were dispatched at Site 300. At the Livermore site, bullfrog control measures were implemented between May and September of 2008. Bullfrog control measures included dispatching adults and removing egg masses in Lake Haussmann and Arroyo Las Positas. To remove bullfrog tadpoles and invasive fish, the LLNL reach of Arroyo Las Positas was allowed to dry out in October of 2008 by temporarily halting groundwater discharges to the arroyo. During bullfrog control efforts conducted in July 2008 at Lake Haussmann more than 35 California red-legged frogs were observed in the Lake, and fewer than 10 bullfrogs were observed.

6.4.3 Surveillance Monitoring

6.4.3.1 Wildlife Monitoring and Research

Alameda Whipsnake. Since 2002, LLNL has participated in a study, in cooperation with the USFWS and four other agencies, to determine the effects of prescribed burns on the Alameda whipsnake. The USFWS issued a BO for this study that outlined the general conditions for conducting prescribed burns and gathering information about potential impacts to Alameda whipsnakes. Participation in this study allowed LLNL to obtain USFWS approval to conduct prescribed burns necessary for Site 300 operations in areas that support Alameda whipsnakes. Previous LLNL Environmental Reports document the study area and baseline conditions, and early results.

A prescribed burn was conducted at the burn site in the summer of 2003, and the post-burn monitoring has been conducted from the fall of 2003 through 2007. Both the burn and control sites were impacted by a wildfire in 2005. Although no whipsnake fatalities were documented during post-burn surveys, both trapping areas were burned severely and little remnant vegetation was left in the shrubland.

No whipsnakes were captured during the spring 2008 trapping period. Although the effects of the prescribed burn and subsequent impacts of the wildfire on the whipsnake are not yet determined, both the whipsnake and its habitat are adapted to periodic fire events and both the snake and vegetation are expected to recover from the fire in subsequent years.

Nesting Bird Surveys. LLNL conducts nesting bird surveys to ensure LLNL activities comply with the Migratory Bird Treaty Act and do not result in impacts to nesting birds. White-tailed Kites annually nest in the trees along the north, east, and south perimeter of the Livermore site. LLNL staff surveyed potential White-tailed Kite nesting sites during the spring of 2008; two pairs of White-tailed Kites successfully fledged young. Although White-tailed Kites are also known to occasionally nest at Site 300, site-wide kite surveys were not conducted at Site 300 in 2008 because kites do not typically nest in areas where they may be affected by programmatic activities.

Avian Monitoring Program. In 2008, LLNL continued its avian monitoring program, which was initiated in 2001. A constant effort mist netting station was established spanning Elk Ravine and Gooseberry Canyon at Site 300. Birds were captured using ten standard passerine mist nets once every ten days (approximately) throughout the breeding season (May through August). Captured birds were identified to species, banded, aged, sexed, measured, and weighed before being released. All of the species identified in these surveys are listed in **Appendix C**. Data from this program is contributed to the national Monitoring Avian Productivity and Survivorship (MAPS) program, which is operated by the Institute for Bird Population.

California Red-Legged Frog Egg Mass Surveys. LLNL continued diurnal visual surveys for California red-legged frog egg mass at the Livermore site in Arroyo Las Positas and in the habitat enhancement portion of Lake Haussmann. No egg masses were observed in Arroyo Las Positas in 2008. This is down from a maximum of 37 egg masses observed in 2001. Also, no egg masses were observed in the Habitat Enhancement portion of Lake Haussmann in 2008.

6.4.3.2 Rare Plant Research and Monitoring

Large-Flowered Fiddleneck. This species is known to exist naturally in only two locations—at the Site 300 Drop Tower and on a nearby ranch. The Drop Tower native population contained no large-flowered fiddleneck plants in 2008, and fewer than 20 plants each year for the past six years.

LLNL established an experimental population of the large-flowered fiddleneck at Site 300 beginning in the early 1990s. The size of the experimental population fluctuates as a result of seed bank enhancement efforts conducted in this population. The two experimental subpopulations combined contained 63 large-flowered fiddleneck plants in 2008.

Big Tarplant. The distribution of big tarplant was mapped at Site 300 using a handheld global positioning system (GPS) in September and October of 2008. This species is abundant at Site 300, especially in or near areas where prescribed burned are routinely conducted, although it is rare outside of Site 300. It is estimated that between approximately 57,000 and 157,000 individual big tarplants occurred at Site 300 in 2008.

Diamond-Petaled California Poppy. Currently three populations of this species are known to occur at Site 300; the population locations are referred to as Site 1, Site 2, and Site 3. Although the species is not listed under the federal or California ESAs, it is extremely rare and is currently known to occur only at Site 300 and in one location in San Luis Obispo County. A census of the three Site 300 populations was conducted in April 2008. In 2008, more than 7200 plants were found at Site 300. The most recently discovered population, Site 3, contained by far the largest number (more than 7000 plants). Numbers of plants at Sites 1 and 2 have been very small in recent years. In 2008, Site 1 had 153 plants, and Site 2 had 66 plants.

Round-Leaved Filaree. Six populations of round-leaved filaree are known to occur at Site 300. All populations occur in the northwest portion of the site. This species thrives in the disturbed soils of the annually graded fire trails at Site 300. Of the six populations, four occur on fire trails.

During the spring of 2007, the extent of the six populations was mapped using a handheld GPS, and the size of each population was estimated. The six populations combined were estimated to contain more than 8800 plants. In 2008, the majority of these plants (8600) occurred in the two populations that are not located in fire trails.

6.4.4 Environmental Impacts on Special Status Wildlife and Plants

Through monitoring and compliance activities in 2008, LLNL has been able to avoid impacts to special status wildlife and plants. In addition, LLNL continues to monitor and maintain several restoration sites and habitat enhancements that are beneficial to native plants and animals at the Livermore site and Site 300. Invasive species continue to be one of the largest threats to California red-legged frogs at the Livermore site and Site 300, and LLNL continued its program to remove invasive exotic species of amphibians and fish from the Livermore site, and feral pigs from Site 300 in 2008.

7. Radiological Dose Assessment

Nicholas A. Bertoldo • Gretchen M. Gallegos

Lawrence Livermore National Laboratory assesses potential radiological doses to biota, off-site individuals, and the population residing within 80 km of either of the two LLNL sites, the Livermore site and Site 300. These potential doses are calculated to determine the impact of LLNL operations, if any, on the general public and the environment, and to demonstrate compliance with regulatory standards set by the U.S. DOE and the U.S. EPA. For protection of the public, DOE has set the limit for prolonged exposure of a maximally exposed individual in an uncontrolled area at 1 mSv/y whole-body effective dose equivalent (EDE), which equals 100 mrem/y EDE. For occasional exposure, the limit is 5 mSv/y (500 mrem/y) EDE. EDEs and other technical terms are defined in the glossary and discussed in "Supplementary Topics on Radiological Dose" (see **Appendix D**).

A release of radioactive material to air would be the primary source pathway of public radiological exposure from LLNL operations. Therefore, LLNL expends a significant effort monitoring stack air effluent for radiological releases and ambient air for radiological impact due to LLNL operations and to ensure that the doses to the public are kept as low as reasonably achievable (ALARA) .

Measurements of radiological releases to air and modeling the dispersion of the released radionuclides are used to determine LLNL's dose to the public. Because LLNL is a DOE facility, it is subject to the requirements of 40 CFR Part 61, Subpart H of the National Emission Standards for Hazardous Air Pollutants (NESHAPs) – Radiological Air. The EPA's radiation dose standard for members of the public limits the EDE to 100 μSv/y (10 mrem/y) for air emissions. LLNL uses the EPA CAP88-PC computer model to demonstrate site compliance with NESHAPs regulations. CAP88-PC is used to evaluate the four principal exposure pathways: ingestion, inhalation, air immersion, and irradiation by contaminated ground surface. The relative significance of inhalation dose depends on radionuclide air emission from operations and dose from resuspended radionuclides in soil, whereas the ingestion dose is predicted on assumptions made about the radionuclide concentration in food from the assessment area contributing to the total dose.

In 2008, the radionuclides measured and modeled that contributed to individual and collective doses were tritium and plutonium 239+240 at the Livermore site and uranium-234, uranium-235, and uranium-238 at Site 300. All radionuclides measured at the Livermore site and Site 300 were used to assess dose to biota in 2008.

This chapter summarizes detailed radiological dose determinations and identifies trends over time while placing them in perspective with natural background and other sources of radiation exposure.

7.1 Air Dispersion and Dose Models

Computational models are needed to describe the transport and dispersion in air of contaminants and the doses to exposed persons via all pathways. CAP88-PC is the EPA-mandated computer model used by LLNL to compute individual or collective (i.e., population) radiological doses resulting from any radionuclide air emissions. The dispersion parameter file consisting of the meteorological model specific input parameters is prepared from data collected by each LLNL meteorological tower. The mathematical models and equations used in CAP88-PC are described by Parks (1992).

7.2 Identification of Key Receptors

Dose is assessed for two types of receptors. First is the dose to the site-wide maximally exposed individual (SW-MEI) member of the public. Second is the collective or “population” dose received by people who reside within 80 km of either of the two LLNL sites.

The SW-MEI is defined as the hypothetical member of the public at a single, publicly accessible location who receives the greatest LLNL-induced EDE from all sources at a site. In order for LLNL to comply with the NESHAPs regulation, the LLNL SW-MEI must not receive an EDE equal to or greater than 100 μSv/y (10 mrem/y) from any radioactive air emission. This hypothetical person is assumed to remain at the SW-MEI location 24 hours per day, 365 days per year, continuously breathing air having the predicted or observed radionuclide concentration, and consuming a specified fraction of food and drinking water[(1)] that is affected by the same predicted or observed air concentration caused by releases of radioactivity from the site. Thus, the SW-MEI dose is not received by any actual individual and is a conservative estimate of the highest possible dose that might be received by any member of the public predicated on the exposure conditions specified above.

In 2008, the SW-MEI at the Livermore site was located at the UNCLE Credit Union, about 10 m outside the site’s controlled eastern perimeter, and 957 m east-northeast of the Tritium Facility. The SW-MEI at Site 300 was located on the site’s south-central perimeter, which borders the Carnegie State Vehicular Recreation Area. The location was 3170 m south–southeast of the firing table at Building 851. The two SW–MEI locations are shown in **Figure 7-1**.

7.3 Results of 2008 Radiological Dose Assessment

This section summarizes the doses to the most exposed public individuals from LLNL operations in 2008, shows the temporal trends compared with previous years, presents the potential doses to the populations residing within 80 km of either the Livermore site or Site 300, and places the potential doses from LLNL operations in perspective with doses from other sources.

(1) Calculated for tritium only.

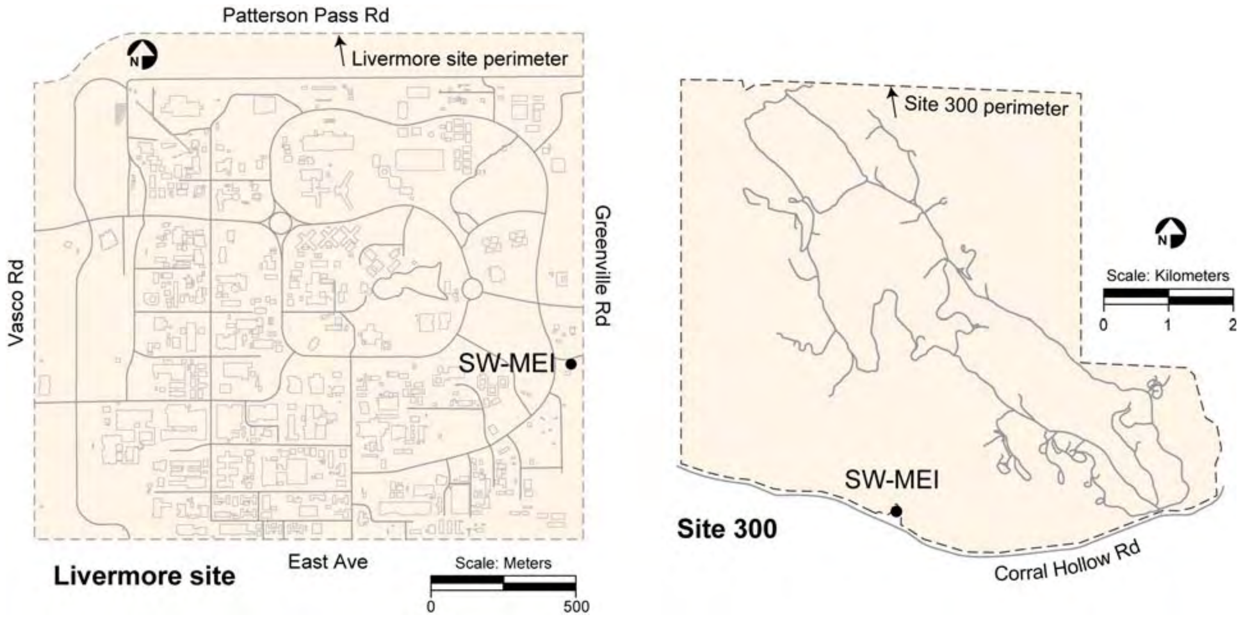

Figure 7-1. Location of the SW-MEI at the Livermore site and Site 300, 2008.

7.3.1 Total Dose to Site-Wide Maximally Exposed Individuals

The total dose to the SW-MEI from Livermore site operations in 2008 was 0.013 μSv/y (0.0013 mrem/y). Of this, the dose attributed to diffuse emissions (area sources) totaled 0.0096 μSv (0.00096 mrem) or 74%; the dose due to point sources was 0.0033 μSv 0.00033 mrem) or 26% of the total. The point source dose includes Tritium Facility elemental tritium gas (HT) emissions modeled as tritiated water (HTO), as directed by EPA Region IX.

Table 7-1 shows the facilities or sources that accounted for nearly 100% of the dose to the SW-MEI for the Livermore site and Site 300 in 2008. Although LLNL has nearly 150 sources with the potential to release radioactive material to air according to NESHAPs prescriptions, most are very minor. Nearly the entire radiological dose to the public in 2008 from LLNL operations came from no more than six sources. LLNL uses, with permission from EPA, surveillance monitoring in place of inventory-based modeling to account for dose contributions from the numerous minor sources.

In 2008 at Site 300, there were no outdoor firing table explosive experiments using depleted uranium to produce any emissions. No resuspension of depleted uranium was detected at the SW-MEI location from pre-existing concentrations. Radioactive emissions from Site 300 were solely from the Contained Firing Facility. The calculated dose to the SW-MEI (4.4×10^{-7} μSv/y [4.4×10^{-8} mrem/y]) was due to the isotopes uranium-238, uranium-235, and uranium-234 from depleted uranium used in the Contained Firing Facility.

Table 7-1. List of facilities or sources whose combined emissions accounted for nearly 100% of the SW-MEI doses for the Livermore site and Site 300 in 2008.

Site	Facility (source category)	CAP88-PC dose (µSv/y)[(a)]	CAP88-PC contribution to total dose
Livermore Site	Tritium Facility stacks (point source)	3.3×10^{-3}	5.8%
	Building 331 WAA, Building 612 Yard (diffuse sources)	4.6×10^{-3}	8.1%
	Southeast quadrant soil resuspension (diffuse source)	4.9×10^{-3}	86.0%
Site 300	Contained Firing Facility	4.4×10^{-7}	100%

(a) 1 µSv = 0.1 mrem

The doses to the SW-MEI from emissions at the Livermore site and Site 300 since NESHAPs reporting began are shown in **Table 7-2**. These SW-MEI dose estimates are conservative, predicting potential doses that are higher than actually would be experienced by any member of the public, and are all less than 10% of the federal standard of 100 µSv/y (10 mrem/y).

7.3.2 Doses from Unplanned Releases

There were no unplanned atmospheric releases of radionuclides at the Livermore site or Site 300 in 2008.

7.3.3 Collective Dose

Collective dose for both LLNL sites was calculated using CAP88-PC for a radius of 80 km from the site centers. Population centers affected by LLNL emissions within the 80-km radius include the nearby communities of Livermore and Tracy; the more distant metropolitan areas of Oakland, San Francisco, and San Jose; and the San Joaquin Valley communities of Modesto and Stockton. Within the 80-km radius specified by DOE, there are 7.22 million residents included for the Livermore site collective dose determination and 6.7 million for Site 300. The populations were derived using ORNL LandScan 2007 data and ESRI ARCMAP software.

The CAP88-PC result for potential collective dose attributed to 2008 Livermore site operations was 0.0014 person-Sv (0.14 person-rem); the corresponding collective dose from Site 300 operations was 9.8×10^{-8} person-Sv (9.8×10^{-6} person-rem).

Because LLNL is surrounded by a significant population residing within an 80-km radius, even a very small dose when multiplied by a large population number will result in a collective dose that overemphasizes the operational dose to the public at specific distances from the source. For this reason, the International Commission on Radiological Protection (ICRP) recommended that regulatory limits not be set in term of a collective dose (ICRP 2005). As in LLNL's case, when individual doses range greatly over large distances, the dose distribution are more appropriately characterized by subdividing the individual dose into several ranges whereby the population size, mean individual dose, collective dose, and associated uncertainties are representative of each range. (For further information, see NCRP [1995]).

Table 7-2. Doses calculated for the SW-MEI for the Livermore site and Site 300, 1990 to 2008.

Site	Year	Annual Dose (μSv)[a]	Site	Year	Annual Dose (μSv)[a]
Livermore site	2008	0.013	Site 300	2008	4.4×10^{-7}
	2007	0.031		2007	0.035
	2006	0.045		2006	0.16
	2005	0.065		2005	0.18
	2004	0.079		2004	0.26
	2003	0.44		2003	0.17
	2002	0.23		2002	0.21
	2001	0.17		2001	0.54
	2000	0.38		2000	0.19
	1999	1.2		1999	0.35
	1998	0.55		1998	0.24
	1997	0.97		1997	0.20
	1996	0.93		1996	0.33
	1995	0.41		1995	0.23
	1994	0.65		1994	0.81
	1993	0.66		1993	0.37
	1992	0.79		1992	0.21
	1991	2.34		1991	0.44
	1990	2.40		1990	0.57

(a) 1 μSv = 0.1 mrem

7.3.4 Doses to the Public Placed in Perspective

As a frame of reference to gauge the size of the LLNL doses, **Table 7-3** compares them to average doses received in the United States from exposure to natural background radiation and other sources. The collective dose is high even though the individual dose is very small. This is due to the high population density in the 80-km radius. Moreover, the overall contribution of dose from LLNL operations in 2008 is overshadowed by natural radiation.

Table 7-3. Comparison of radiation doses from LLNL sources to average doses from background (natural and man-made) radiation, 2008.

Location/source	Category	Individual dose[(a)] (μSv)[(c)]	Collective dose[(b)] (person-Sv)[(d)]
LLNL			
Livermore site sources	Atmospheric emissions	0.013	0.0014
Site 300 sources	Atmospheric emissions	4.4×10^{-7}	9.8×10^{-8}
Other sources[(e)] (background)	Natural radioactivity[(f,g)]		
	Cosmic radiation	300	2,170
	Terrestrial radiation	300	2,170
	Internal (food and water consumption)	400	2,888
	Radon	2,000	14,440
	Medical radiation (diagnostic procedures)[(f)]	530	3,827
	Weapons test fallout[(f)]	10	72
	Nuclear fuel cycle	4	29

(a) For LLNL sources, this dose represents that experienced by the SW-MEI.

(b) The collective dose is the combined dose for all individuals residing within an 80-km radius of LLNL (approximately 7.22 million people for the Livermore site and 6.7 million for Site 300), calculated with respect to distance and direction from each site. The Livermore site population estimate of 7.22 million people was used to calculate the collective doses for “Other sources.”

(c) 1 μSv = 0.1 mrem

(d) 1 person-Sv = 100 person-rem

(e) From National Council on Radiation Protection and Measurements (NCRP 1987a,b)

(f) These values vary with location.

(g) This dose is an average over the U.S. population.

7.4 Special Topics on Dose Assessment

LLNL demonstrates NESHAPs compliance for minor sources by comparing measured ambient air concentrations at the location of the SW-MEI to concentration limits set by the EPA in 40 CFR Part 61, Table 2, Appendix E. The radionuclides for which the comparison is made are tritium and plutonium-239+240 for the Livermore site SW-MEI and uranium-238 for the Site 300 SW-MEI. At the Livermore site, the average of the monitoring results for location CRED represents the SW-MEI. At Site 300, the minor source that has the potential to have a measurable effect is the resuspension of depleted uranium contaminated soil and is represented by location PSTL.

The standards contained in 40 CFR Part 61, Table 2, Appendix E, and the measured concentrations at the SW-MEI are presented in SI units in **Table 7-4**. As demonstrated by the calculation of the fraction of the standard, LLNL-measured air concentrations for tritium and plutonium-239+240 and uranium-238 are less than one–one-hundredth of the health protective standard for these radionuclides.

Table 7-4. Mean concentrations of radionuclides of concern at the location of the SW-MEI in 2008.

Location	Nuclide	EPA concentration standard (Bq/m^3)	Detection limit (approximate) (Bq/m^3)	Mean measured concentration (Bq/m^3)	Measured concentration as a fraction of the standard
Livermore SW-MEI	Tritium	56	0.037	1.8×10^{-2}(a,b)	3.2×10^{-4}
Livermore SW-MEI	Plutonium-239	7.4×10^{-5}	1.9×10^{-8}	7.0×10^{-9}(b)	9.5×10^{-5}
Site 300 SW-MEI	Uranium-238	3.1×10^{-4}	1.1×10^{-9}	6.3×10^{-7}(c)	2.0×10^{-3}

Note: 1 Bq = 2.7×10^{-11} Ci

(a) The measured tritium value includes contributions from all minor sources (including the Building 612 Yard and the Building 331 Outside Yard), Tritium Facility, and DWTF; it is not possible to differentiate the contributions of the Tritium Facility and DWTF from those of the minor sources.

(b) The mean measured concentration is less than the detection limit.

(c) The ratio for the mean uranium-235 and uranium-238 concentrations for 2008 is 0.00725, which is equal to the ratio of these isotopes for naturally occurring uranium. This value for uranium-238 is from naturally occurring uranium resuspended in the soil.

7.4.1 Estimate of Dose to Biota

Biota (flora and fauna) also need to be protected from potential radiological exposure from LLNL operations since their exposure pathways are unique to their environment (e.g., a ground squirrel may be exposed to dose by burrowing in contaminated soil). Thus, LLNL calculates potential dose to biota from LLNL operations according to *A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota* (U.S. DOE 2002) and by using the RESRAD-BIOTA computer code, a tool for implementing DOE’s graded approach to biota dose evaluation.

Limits on absorbed dose to biota are 10 mGy/d (1 rad/d) for aquatic animals and terrestrial plants, and 1 mGy/d (0.1 rad/d) for terrestrial animals. At LLNL in 2008, radionuclides contributing to dose to biota were americium-241, cesium-137, tritium, plutonium-238, plutonium-239, thorium-232, uranium-234, uranium-235, and uranium-238. In the 2008 LLNL assessment, the maximum concentration of each radionuclide measured in soils, and surface waters was used in the dose screening calculations. This approach resulted in an assessment that is extremely conservative, given that the maximum concentrations in the media are distributed over a very large area. Specifically, it accounts for the exposure at both the Livermore site and Site 300 and no plant or animal would likely be exposed to both. Furthermore, although biota would most likely live in and near permanent bodies of water (i.e., surface water), measurements of storm water runoff were used for the assessment because higher concentrations of radionuclides are measured in runoff than in surface waters.

In the RESRAD-BIOTA code, each radionuclide in each medium (e.g., soil, sediment, and surface water) is assigned a Biota Concentration Guide (BCG). Radionuclide concentrations in each medium are divided by the BCG, and the resulting fractions for each nuclide and medium are summed. For aquatic and riparian animals, the sum of the fractions for water exposure is added to the sum of the fractions for sediment exposure. Similarly, fractions for water and soil exposures are summed for terrestrial animals. If the sums of the fractions for the aquatic and terrestrial systems are both less than 1 (i.e., the dose to the biota does not exceed the screening limit), the site has passed the screening analysis and biota are assumed to be protected.

In 2008, the sum of the fractions for the aquatic system was 0.260, and the sum for the terrestrial system was 0.0279 with a total of 0.288 for the combined fraction. The predominant contribution is due to uranium in the Site 300 soil.

7.5 Environmental Impact

The annual radiological doses from all emissions at the Livermore site and Site 300 in 2008 were found to be well below the applicable standards for radiation protection of the public, in particular the NESHAPs standard. This standard limits to 100 µSv/y (10 mrem/y) the EDE to any member of the public arising as a result of releases of radioactive material to air from DOE facilities. Using an EPA-mandated computer model and actual LLNL meteorology appropriate to the two sites, potential doses to the LLNL SW-MEI members of the public from LLNL operations in 2008 were:

- Livermore site: 0.013 µSv (0.0013 mrem)—26% from point-source emissions; 74% from diffuse-source emissions.
- Site 300: 4.4×10^{-7} µSv (4.4×10^{-8} mrem)—100% from the Contained Firing Facility.

As noted earlier, the major radionuclides accounting for the doses were tritium and plutonium at the Livermore site and the three isotopes of depleted uranium (uranium-234, uranium-235, and uranium-238) at Site 300. The only significant exposure pathway contributing to dose from LLNL operations was release of radioactive material to air, leading to doses by inhalation and ingestion.

The collective EDE attributable to LLNL operations in 2008 was estimated to be 0.0014 person-Sv (0.14 person-rem) for the Livermore site and 9.8×10^{-8} person-Sv (9.8×10^{-6} person-rem) for Site 300. These doses include potentially exposed populations of 7.22 million people for the Livermore site and 6.7 million people for Site 300 living within 80 km of the site centers.

The doses to the SW-MEI, which represent the maximum doses that could be received by members of the public, resulting from Livermore site and Site 300 operations in 2008 were insignificant compared to both the federal standard and the dose received from natural background sources. The collective doses from LLNL operations in 2008 reflect the large population within the 80-km range of the Livermore site and Site 300.

Potential doses to aquatic and terrestrial biota from LLNL operations were assessed using RESRAD Biota and found to be well below DOE screening dose limits due to the extremely low levels of the radionuclides of concern present in the soil and water samples that represent the source of exposure for the biota.

Potential radiological doses from LLNL operations were well below regulatory standards and were very small compared with doses normally received from natural background radiation sources, even though highly conservative assumptions were used in the determination of LLNL doses. The potential maximum doses to the public indicate that LLNL's use of radionuclides had no credible impact on public health during 2008.

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8. Groundwater Investigation and Remediation

Valerie Dibley

During 2008, groundwater investigations and remediations under CERCLA continued at both the Livermore site and Site 300. Lawrence Livermore National Laboratory samples and analyzes groundwater from areas of known or suspected contamination. Portions of the two sites where soil or groundwater contains or may contain chemicals of concern are actively investigated to define the hydrogeology and nature and extent of the contamination and its source. Where necessary, remediation strategies are developed and evaluated in preparation for a CERCLA removal action or through the feasibility study process. An approved remedy for each area is developed in consultation with the regulatory agencies and the community.

This chapter reviews the distribution of contaminants in groundwater and the progress LLNL has made in removing contaminants from groundwater and from the unsaturated zone (soil vapor) at the Livermore site and Site 300. The sites are similar in that the contamination is, for the most part, confined on site. The sites differ in that Site 300, with an area of 28.3 km^2 (10.9 mi^2), is much larger than the Livermore site and has been divided into nine operable units (OUs) based on the nature and extent of contamination, and topographic and hydrologic considerations. The Livermore site at 3.3 km^2 (1.3 mi^2) is effectively one OU.

8.1 Livermore Site Ground Water Project

Initial releases of hazardous materials occurred at the Livermore site in the mid-to-late 1940s during operations at the Livermore Naval Air Station (Thorpe et al. 1990). There is also evidence that localized spills, leaking tanks and impoundments, and landfills contributed VOCs, fuel hydrocarbons, metals, and tritium to the unsaturated zone and groundwater in the post-Navy era. The Livermore site was placed on the U.S. Environmental Protection Agency National Priorities List in 1987.

An analysis of all environmental media showed that groundwater and both saturated and unsaturated soils are the only media that require remediation (Thorpe et al. 1990). Compounds that currently exist in groundwater at various locations beneath the site at concentrations above drinking water standards (MCLs) are TCE, PCE, 1,1-dichloroethylene, chloroform, 1,2-dichloroethylene, 1,1-dichloroethane, 1,2-dichloroethane, trichlorotrifluoroethane (Freon-113), trichlorofluoromethane (Freon-11), and carbon tetrachloride. PCE is also present at low concentrations slightly above the MCL in off-site plumes that extend from the southwestern corner of the Livermore site. LLNL operates groundwater extraction wells in both on-site and off-site areas. In addition, LLNL maintains an extensive network of groundwater monitoring wells in the off-site area west of Vasco Road.

8.1.1 Physiographic Setting

The general topography of the Livermore site is described in **Chapter 1**. The Livermore Valley groundwater system consists of several semiconfined aquifers. Rainfall from the surrounding hills and seasonal surface water in the arroyos recharge the groundwater system, which flows toward the east-west axis of the valley.

The thickest sediments and aquifers are present in the central and western portions of the Livermore Valley, where they form an important resource for the Zone 7 Water Agency. These sediments comprise two aquifers: the Livermore Formation and overlying alluvium. The Livermore Formation averages about 1000 m in thickness and occupies an area of approximately 250 km^2. The alluvium, which is about 100 m thick, is the principal water-producing aquifer within the valley.

8.1.2 Hydrogeology of the Livermore Site

Sediments at the Livermore site are grouped into four grain-size categories: clay, silt, sand, and gravel. Groundwater flow beneath the site occurs primarily in alluvial sand and gravel deposits, which are bounded by lower permeability clay and silt deposits. The alluvial sediments have been subdivided into nine HSUs beneath the Livermore site. HSUs are defined as sedimentary sequences whose permeable layers show evidence of being hydraulically interconnected. Six of the nine HSUs contain contaminants at concentrations above their MCLs: HSU-1B, -2, -3A, -3B, -4, and -5 (Blake et al. 1995; Hoffman et al. 2003). HSU-1A, -6, and -7 do not contain contaminants of concern above action levels.

8.1.3 Remediation Activities and Monitoring Results

In 2008, LLNL maintained 29 groundwater treatment facilities as funds allowed. The groundwater extraction wells and dual (groundwater and soil vapor) extraction wells produced more than 670 million L of groundwater and the treatment facilities removed nearly 38.5 kg of VOCs. Since remediation began in 1989, approximately 13.6 billion L of groundwater have been treated, resulting in removal of more than 2709 kg of VOCs. Detailed flow and mass removal by treatment facility area is presented in Valett et al. (2009).

LLNL also maintained 9 soil vapor treatment facilities as funds allowed in 2008. The soil vapor extraction wells and dual extraction wells produced more than 570,000 m^3 of soil vapor and the treatment facilities removed more than 53 kg of VOCs. Since initial operation, over 9.5 million m^3 of soil vapor has been extracted and treated, removing more than 2709 kg of VOCs from the subsurface. Detailed flow and mass removal by treatment facility area is presented in Valett et al. (2009).

During 2008, the Livermore GWP experienced a significant budget reduction that severely impacted operations. When the final FY 2008 Omnibus Appropriations Bill was passed by Congress, the Livermore GWP received only about 50% of its requested budget. Although funding was ultimately restored in late July 2008, the budget reduction necessitated a dramatic reduction in both staff and cleanup activities at the site. Consequently, enhanced source area remediation pilot tests begun in 2007 were put on hold and existing groundwater and soil vapor treatment operations were significantly curtailed during the year. LLNL continued to operate facilities until equipment or instrumentation failed. See Valett et al. (2009) for the current status of cleanup progress.

Groundwater concentration and hydraulic data collected and analyzed during 2008 indicate there was very little change in the VOC concentrations and areal extent of the contaminant plumes. Hydraulic containment along most portions of the western and southern boundaries of the site was maintained and limited progress was made towards cleanup of interior plumes and source areas. Since funding was restored in July 2008, an intensive effort has been underway to restore operations at Livermore site facilities that were shut down or now require repair due to deferred maintenance resulting from insufficient funding. This effort is expected to accelerate during 2009. With the ongoing reactivation of treatment facilities in the last quarter of 2008 and the first quarter of 2009, hydraulic control is expected to be fully restored along both the western and southern boundaries of the site by the end of March 2009.

8.1.4 Environmental Impacts

LLNL strives to reduce risks arising from chemicals released to the environment, to conduct all its restoration activities to protect environmental resources, and to preserve the health and safety of all site workers. LLNL’s environmental restoration project is committed to preventing present and future human exposure to contaminated soil and groundwater, preventing further contaminant migration of concentrations above drinking water standards, reducing concentrations of contaminants in groundwater, and minimizing contaminant migration from the unsaturated zone to the underlying groundwater.

Remedial solutions that have been determined to be most appropriate for individual areas of contamination are implemented. The selected remedial solutions, which include groundwater and soil vapor extraction and treatment, have been agreed upon by DOE and the regulatory agencies with public input and are designed to achieve the goals of reducing risks to human health and the environment and satisfying remediation objectives, regulatory standards for chemicals in water and soil, and other state and federal requirements.

8.2 Site 300 CERCLA Project

A number of contaminants were released to the environment during past LLNL Site 300 operations including waste fluid disposal to dry wells, surface spills, piping leaks, burial of debris in unlined pits and landfills, detonations at firing tables, and discharge of rinse water to unlined lagoons. Environmental investigations at Site 300 began in 1981. As a result of these investigations, VOCs, high explosive compounds, tritium, depleted uranium, organosilicate oil, nitrate, perchlorate, polychlorinated biphenyls, dioxins, furans, and metals were identified as contaminants of concern in soil, rock, groundwater, or surface water. This contamination is confined within the site boundaries with the exception of VOCs that are present in off-site monitor wells near the southern site boundary. LLNL maintains an extensive network of on-site and off-site wells to monitor this contamination. All characterized contaminant release sites that have a CERCLA pathway have been assigned to one of nine OUs based on the nature, extent, and sources of contamination, and topographic and hydrologic considerations. Site 300 was placed on the U.S. Environmental Protection Agency National Priorities List in 1990. Cleanup activities began at Site 300 in 1982 and are ongoing.

Background information for LLNL environmental characterization and restoration activities at Site 300 can be found in Webster-Scholten (1994) and the *Site-Wide Remediation Evaluation Summary Report for Lawrence Livermore National Laboratory Site 300* (Ferry et al. 2006).

8.2.1 Physiographic Setting and Geology of Site 300

Site 300 is located in the southeastern Altamont Hills of the Diablo range. The topography of Site 300 consists of a series of steep hills and canyons generally oriented northwest to southeast. The site is underlain by gently dipping sedimentary bedrock dissected by steep ravines. The bedrock consists of interbedded conglomerates, sandstones, siltstones, and claystones of the late Miocene Neroly Formation (Tn), and a Pliocene nonmarine unit (Tps). The bedrock units are locally overlain by mid- to late-Pleistocene terrace deposits and late-Pleistocene to Holocene floodplain, ravine fill, landslide, and colluvial deposits.

The bedrock within Site 300 has been slightly deformed into several gentle, low-amplitude folds. The locations and characteristics of these folds, in combination with the regional fault and fracture patterns, locally influence groundwater flow within the site.

8.2.2 Contaminant Hydrogeology of Site 300

Site 300 is a large and hydrogeologically diverse site. Due to the steep topography and structural complexity, stratigraphic units and groundwater contained within many of these units are discontinuous across the site. Consequently, site-specific hydrogeologic conditions govern the occurrence and flow of groundwater and the fate and transport of contaminants beneath each OU.

An HSU is a water-bearing zone that exhibits similar hydraulic and geochemical properties. At Site 300, HSUs have been defined consisting of one or more stratigraphic intervals that compose a single hydraulic system within one or more OU. Groundwater movement and contaminant migration in groundwater are discussed in the context of HSUs.

Groundwater contamination at Site 300 occurs in three types of water-bearing zones:

1. Quaternary deposits including the alluvium and weathered bedrock (Qal/WBR HSU), alluvial terrace deposits (Qt), and landslide deposits (Qls HSU).
2. Tertiary perched groundwater in fluvial sands and gravels (Tpsg HSU) and semilithified silts and clay of the Tps HSU.
3. Tertiary Neroly Formation bedrock including the $Tnsc_2$, $Tnbs_2$, $Tnsc_{1b}$ $Tnbs_1$, $Tnbs_0$, and $Tnsc_0$ HSUs.

Groundwater in bedrock is typically present under confined conditions in the southern half of the site but is often unconfined elsewhere. Recharge occurs where saturated alluvial valley fill is in contact with underlying permeable bedrock, and where bedrock strata crop out.

8.2.3 Remediation Activities and Monitoring Results

Cleanup activities were initiated at Site 300 in 1982 and are underway or are in the process of being implemented at all nine OUs. These activities include:

- Operating 20 groundwater and soil vapor extraction and treatment facilities.
- Capping and closing four landfills, six high explosives rinse water lagoons and one high explosives burn pit.
- Removal and/or closure of numerous dry wells throughout the site.
- Removal of contaminated soil from source areas throughout the site.
- Installation and sampling of over 680 groundwater monitor wells to track plume migration and remediation progress.

These remediation efforts have resulted in (1) the elimination of risk to on-site workers from contaminant exposure at eight locations throughout Site 300, (2) a reduction in maximum concentrations of the primary contaminant (VOCs) in Site 300 groundwater by 50% to 99%, and (3) the remediation of VOCs in the eastern General Services Area to meet cleanup standards.

In 2008, the Site 300 ERP operated 15 groundwater and 5 soil vapor treatment facilities. About 38 million L of groundwater were extracted and treated during 2008. The dual and soil vapor extraction wells together removed 2.3 million m^3 of contaminated soil vapor. The Site 300 treatment facilities removed nearly18 kg of VOCs, 0.13 kg of perchlorate, 1300kg of nitrate, 0.21 kg of the high explosive compound RDX and 0.0068 kg of silicone oils (TBOS/TKEBS) in 2008. Since groundwater remediation began in 1990, approximately 1389 million L of groundwater has been treated, resulting in removal of more than 520 kg of VOCs, 0.79 kg of perchlorate, 6600 kg of nitrate, 1.1 kg of RDX, and 9.5 kg of silicone oils. Detailed flow and mass removal by OU is presented in Dibley et al. (2009).

Cleanup remedies have been fully implemented and are operational in seven of the nine OUs at Site 300 to date (Operable Unit 8 and General Services Area, Building 834, Pit 6 Landfill, High Explosives Process Area, Building 854, an-d Building 832 Canyon OUs).

Groundwater concentration and hydraulic data collected and analyzed for Site 300 during 2008 provided evidence of continued progress in reducing contaminant concentrations in Site 300 soil vapor and groundwater, controlling and cleaning up contaminant sources, and mitigating risk to on-site workers. A more detailed description of remediation progress at the Site 300 OUs in 2008 is available in the *2008 Annual Compliance Monitoring Report for LLNL Site 300* (Dibley et al. 2009).

8.2.4 Planned Cleanup Activities

In 2007, a cleanup remedy was selected by the regulatory agencies and DOE for the Pit 7 Complex area in the *Final Amendment to the Interim Site-Wide Record of Decision for the Pit 7 Complex* at *Lawrence Livermore National Laboratory Site 300* (U.S. DOE 2007). In addition, construction began on a drainage diversion system to prevent releases from the Pit 7 Complex landfills and on an extraction and treatment system to remove uranium, VOCs, perchlorate, and nitrate from groundwater in this area. Institutional controls to prevent exposure, and monitoring of contaminants in groundwater are already underway at the Pit 7 Complex. The Pit 7 Complex drainage diversion system construction was completed in early 2008. The construction of the groundwater extraction and treatment system continued in 2008.

In 2008, the *Engineering Evaluation/Cost Analysis for PCB-, Dioxin-, and Furan-contaminated Soil at the Building 850 Firing Table* (Dibley et al. 2008a) was finalized. This document presented alternatives for the soil cleanup for regulatory and public consideration and input. The final remedy, soil excavation and solidification, was selected in an Action Memorandum (Dibley et al. 2008b). The engineered design of the selected remedy began in 2008 and will be finalized in 2009. The field implementation is scheduled for spring 2009.

Cleanup remedies have not yet been selected to address soil and groundwater contamination in Building 812 OU and for Freon contamination in Building 865 groundwater.

In 2008, a Remedial Investigation/Feasibility Study (RI/FS) was submitted for the Building 812 OU (Taffet et al. 2008). This document presented the results of remedial investigation to characterize contamination and the risk assessment, and present alternatives for the cleanup of soil and groundwater in the Building 812 area for regulatory and public consideration and input. A treatability test was requested by both the U.S. Environmental Protection Agency and the California Department of Toxic Substances Control to evaluate the potential effectiveness of the soil washing technology included as one of the Building 812 RI/FS soil alternatives. DOE agreed to conduct this treatability study to reduce uncertainties associated with this technology and allow for a better understanding of the limitations of this soil washing technology for site-specific conditions.

The results of the remedial investigation at Building 865 are still being reviewed by the regulatory agencies.[1]

8.2.5 Environmental Impacts

LLNL strives to reduce elevated risks arising from chemicals released to the environment at Site 300, to conduct its activities to protect ecological resources, and to protect the health and safety of site workers. LLNL’s cleanup remedies at Site 300 are designed and implemented to achieve the goals of reducing risks to human health and the environment and satisfying remediation action objectives, meeting cleanup standards for chemicals in water and soil, and preventing contaminant migration in groundwater to the extent technically and economically feasible. These remedies are selected by DOE and the regulatory agencies with public input. These actions include groundwater and soil vapor extraction and treatment; source control through the capping of lagoons and landfills, removal of contaminated soil, and hydraulic drainage diversion; and monitored natural attenuation, monitoring, and institutional controls.

(1) See the Environmental Community Relations website for the status of planned activities. Go to www-envirinfo.llnl.gov and click on “Recently completed environmental documents”.

9. Quality Assurance

Donald H. MacQueen • Gene Kumamoto

Quality assurance (QA) is a system of activities and processes put in place to ensure that products or services meet or exceed customer specifications. Quality control (QC) consists of activities used to verify that deliverables are of acceptable quality and meet criteria established in the quality planning process.

9.1 Quality Assurance Activities

Nonconformance reporting and tracking is a formal process used to ensure that problems are identified, resolved, and prevented from recurring. The LLNL EPD tracks problems using nonconformance reports (NCRs). NCRs are initiated when items or activities are identified that do not comply with procedures or other documents that specify requirements for EPD operations or that cast doubt on the quality of EPD reports, integrity of samples, or data *and* that are not covered by other reporting or tracking mechanisms. There were no laboratory nonconformances documented. Many minor sampling or data problems are resolved without an NCR being generated.

LLNL averts sampling problems by requiring formal and informal training on sampling procedures. Errors that occur during sampling generally do not result in lost samples but may require extra work on the part of laboratory or sampling and data management personnel to correct the errors.

LLNL addresses commercial analytical laboratory problems as they arise. Many of the documented problems concern minor documentation errors and are corrected soon after they are identified. Other problems, such as missed holding times, late analytical results, incorrect analysis and typographical errors on data reports, account for the remaining issues and are not tracked as nonconformances. These problems are corrected by the commercial laboratory reissuing reports or correcting paperwork and do not affect associated sample results.

LLNL participates in the Department of Energy Consolidated Auditing Program (DOECAP). Annual, on-site visits to commercial laboratories under contract to LLNL are part of the auditing program to ensure that accurate and defensible data are generated. The audit program is based on National Environmental Laboratory Accreditation Program (NELAP) requirements. All commercial laboratories used by LLNL EPD are DOE-qualified vendors. LLNL has qualified auditors under the DOECAP program in the areas of quality assurance, organic chemistry, inorganic chemistry, radiochemistry, laboratory information management, and hazardous material management. Audit reports, checklists, and Corrective Action Plans are maintained under the DOECAP program for qualified commercial labs. In FY2008, the laboratories certified by the State of California operating at LLNL as government owned and contractor operated were not internally assessed or qualified by EPD use due to budgetary and staff limitations.

9.2 Analytical Laboratories and Laboratory Intercomparison Studies

In 2008, LLNL had Blanket Service Agreements (BSAs) with nine commercial analytical laboratories and used two on-site analytical laboratories. All analytical laboratory services used by LLNL are provided by facilities certified by the State of California. LLNL works closely with these analytical laboratories to minimize problems and ensure that QA objectives are maintained.

LLNL uses the results of intercomparison performance evaluation program data to identify and monitor trends in performance and to draw attention to the need to improve laboratory performance. If a laboratory performs unacceptably for a particular test in two consecutive performance evaluation studies, LLNL may select another laboratory to perform the affected analyses until the original laboratory has demonstrated that the problem has been corrected. If an off-site laboratory continues to perform unacceptably or fails to prepare and implement acceptable corrective action responses, the LLNL Procurement Department formally notifies the laboratory of its unsatisfactory performance. If the problem persists, the off-site laboratory's BSA could be terminated. If an on-site laboratory continues to perform unacceptably, use of that laboratory could be suspended until the problem is corrected.

Although laboratories are also required to participate in laboratory intercomparison programs, permission to publish their results for comparison purposes was not granted for 2008. To obtain Mixed Analyte Performance Evaluation Program (MAPEP) reports that include the results from all participating laboratories, see http://www.inl.gov/resl/mapep/reports.html. MAPEP is a DOE program and the results are publicly available.

9.3 Duplicate Analyses

Duplicate (collocated) samples are distinct samples of the same matrix collected as close to the same point in space and time as possible. Collocated samples that are processed and analyzed by the same laboratory provide intralaboratory information about the precision of the entire measurement system, including sample acquisition, homogeneity, handling, shipping, storage, preparation, and analysis. Collocated samples that are processed and analyzed by different laboratories provide interlaboratory information about the precision of the entire measurement system (U.S. EPA 1987). Collocated samples may also identify errors such as mislabeled samples or data entry errors.

Tables 9-1, **9-2**, and **9-3** present summary statistics for collocated sample pairs, grouped by sample matrix and analyte. Samples from both the Livermore site and Site 300 are included. **Tables 9-1** and **9-2** are based on data pairs in which both values are detections (see **Section 9.4**). **Table 9-3** is based on data pairs in which either or both values are nondetections.

When there were more than eight data pairs with both results in each pair considered detections, precision and regression analyses were performed; those results are presented in **Table 9-1**. When there were eight or fewer data pairs with both results above the detection limit, the ratios of the individual duplicate sample pairs were averaged; the mean, minimum, and maximum ratios for selected analytes are given in **Table 9-2**. The mean ratio should be between 0.7 and 1.3. When either of the results in a pair is a nondetection, the other result should be a nondetection or less than two times the detection limit. **Table 9-3** identifies the sample media and analytes for which at least one pair failed this criterion. Media and analytes with fewer than four pairs are omitted from the table.

Table 9-1. Quality assurance collocated sampling: Summary statistics for analytes with more than eight pairs in which both results were above the detection limit.

Media	Analyte	N(a)	%RSD(b)	Slope	r^2(c)	Intercept
Air	Gross beta	98	15.8	0.958	0.94	1.94×10^{-5} (Bq/m^3)
	Beryllium(e)	14	69.4	0.48	0.48	2.1 (pg/m^3)
	Uranium-235	12	7.94	0.968	0.97	1.65×10^{-8} (μg/m^3
	Uranium-238	12	8.73	0.962	0.98	2.61×10^{-6} (μg/m^3)
	Tritium	22	23.6	0.959	0.96	0.001 (Bq/m^3)
Dose (TLD)	90-day radiological dose	31	2.94	0.955	0.92	0.786 (mrem)
Groundwater	Gross alpha(d)	11	40.6	0.29	0.19	0.16 (Bq/L)
	Gross beta(e)	47	16.6	0.641	0.76	0.0884 (Bq/L)
	Arsenic	25	13.5	1.01	0.99	–0.000696 (mg/L)
	Barium(e)	15	3.11	0.207	0.13	0.0468 (mg/L)
	Nitrate (as NO_3)	19	2.36	1	1	0.0734 (mg/L)
	Tritium	15	7.41	0.992	1	12.4 (Bq/L)
	Uranium-234+ uranium-233	18	9.44	1.04	0.98	–0.00307 (Bq/L)
	Uranium-235	15	29.7	0.897	0.92	0.000121 (Bq/L)
	Uranium-238	18	7.52	0.947	0.98	0.00108 (Bq/L)
Sewer	Gross beta(d)	52	16.1	0.479	0.25	0.000348 (Bq/mL)
	Acetone(d)	13	30.1	0.199	0.1	177 (μg/L)
	Chloroform(d)	13	20.2	0.789	0.79	0.442 (μg/L)

(a) Number of collocated pairs included in regression analysis.

(b) 75th percentile of percent relative standard deviations (%RSD) where %RSD = $\left(\frac{200}{\sqrt{2}}\right)\frac{|x_1 - x_2|}{x_1 + x_2}$ where x_1 and x_2 are the reported concentrations of each routine–collocated pair.

(c) Coefficient of determination.

(d) Outside acceptable range of slope or r^2 because of variability.

(e) Outside acceptable range of slope or r^2 because of outliers.

Table 9-2. Quality assurance collocated sampling: Summary statistics for selected analytes with eight or fewer pairs in which both results were above the detection limit.

Media	Analyte	N(a)	Mean ratio	Minimum ratio	Maximum ratio
Air	Gross alpha	5	1.3	0.41	2.7
Groundwater	Radium-226	4	1.2	0.83	1.5
	Thorium-228	1	1.3	1.3	1.3
OW	Gross alpha	1	0.88	0.88	0.88
	Gross beta	1	1	1	1
Runoff (from rain)	Gross beta	1	1.3	1.3	1.3
Soil	Cesium-137	3	1.1	0.82	1.6
	Potassium-40	3	1	1	1
	Plutonium-238	1	1.2	1.2	1.2
	Plutonium-239+240	2	0.94	0.82	1.1
	Radium-226	3	1	0.97	1
	Radium-228	3	1	0.98	1.1
	Thorium-228	3	0.98	0.92	1
	Uranium-235	3	0.92	0.74	1
	Uranium-238	1	1	1	1
Sewer	Gross alpha	3	1.2	0.76	1.8
	Tritium	2	0.98	0.68	1.3
Vegetation	Tritium	5	1.3	0.46	2.1

(a) Number of collocated pairs used in ratio calculations.

Precision is measured by the percent relative standard deviation (%RSD); see the EPA's *Data Quality Objectives for Remedial Response Activities: Development Process*, Section 4.6 (U.S. EPA 1987). Acceptable values for %RSD vary greatly with matrix, analyte, and analytical method; however, lower values represent better precision. The results for %RSD given in **Table 9-1** are the 75th percentile of the individual precision values. Routine and collocated sample results show good %RSD—90% of the pairs have %RSD of 29% or better; 75% have %RSD of 16% or better.

Table 9-3. Quality assurance collocated sampling: Summary statistics for analytes with at least four pairs in which one or both results were below the detection limit.

Media	Analyte	No. inconsistent pairs[(a)]	No. pairs	Percent inconsistent pairs
Air	Gross alpha	1	99	1
	Gross beta	1	6	17
Groundwater	Gross alpha	7	38	18
	Arsenic	2	11	18
	Cadmium	1	41	2.4
	Chromium	1	20	5
	Lead	1	41	2.4
	Nitrate (as NO_3)	1	7	14
	Zinc	3	39	7.7
Sewer	Gross alpha	7	50	14
	Toluene	1	12	8.3

(a) Inconsistent pairs are those for which one of the results is more than twice the reporting limit of the other.

Regression analysis consists of fitting a straight line to the collocated sample pairs. Good agreement is indicated when the data lie close to a line with a slope equal to 1 and an intercept equal to 0, as illustrated in **Figure 9-1**. Allowing for normal analytical and environmental variation, the slope of the fitted line should be between 0.7 and 1.3, and the absolute value of the intercept should be less than the detection limit. The coefficient of determination (r^2) should be greater than 0.8. These criteria apply to pairs in which both results are above the detection limit.

Collocated sample comparisons are more variable when the members of the pair are analyzed by different methods or with different criteria for analytical precision. For example, radiological analyses using different counting times or different laboratory aliquot sizes will have different amounts of variability. Different criteria are rarely, if ever, used with collocated sample pairs in LLNL environmental monitoring sampling. Different criteria are sometimes used in special studies if more than one agency is involved and each sets its own analytical criteria.

Data sets that do not meet LLNL regression analysis criteria fall into one of two categories: outliers and high variability. Outliers can occur because of data transcription errors, measurement errors, or real but anomalous results. Of the 18 data sets reported in **Table 9-1**, three did not meet the criterion for acceptability because of outliers. **Figure 9-2** illustrates a set of collocated pairs with one outlier.

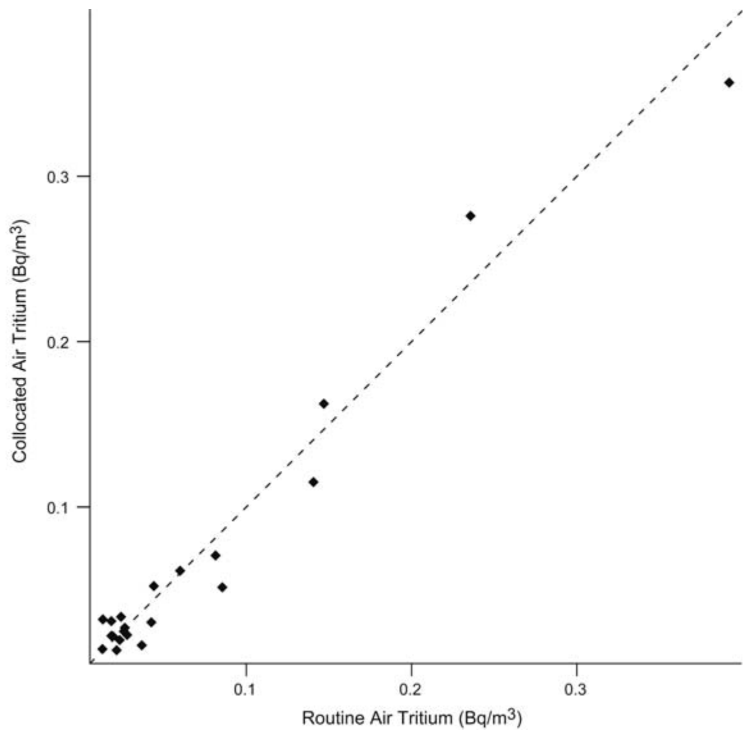

Figure 9-1. Example of data points that demonstrate good agreement between collocated sample results using tritium concentrations in air

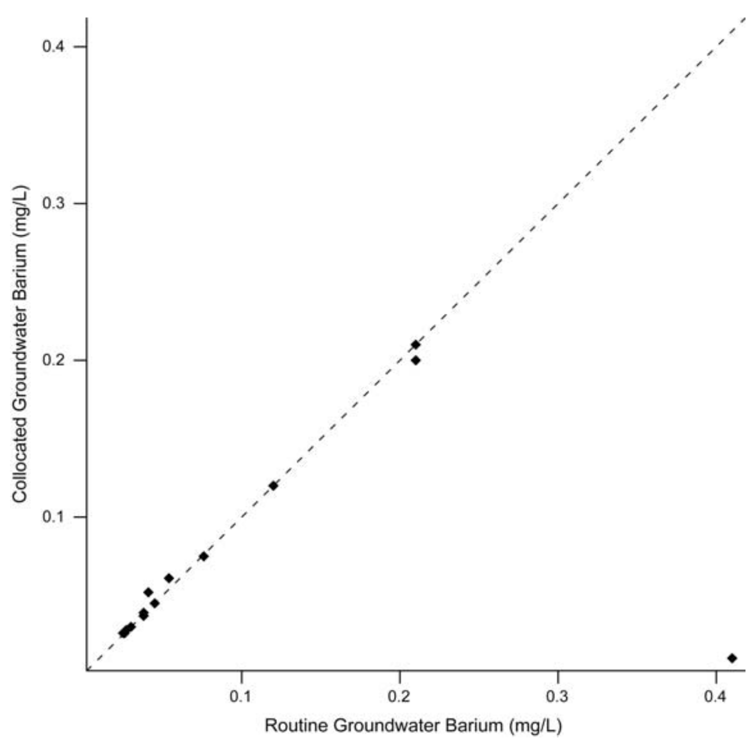

Figure 9-2. Example of data with one outlier using collocated groundwater barium concentrations

The second category, high variability, occurs when the measurement process inherently has substantial variability (see **Figure 9-3** for an example). It also tends to occur at extremely low environmental concentrations. Low concentrations of radionuclides on particulates in air highlight this effect because a small number of radionuclide-containing particles on an air filter can significantly affect results. Analyses of total organic carbon and total organic halides in water are particularly difficult to control. Of the 18 data sets listed in **Table 9-1**, four show sufficient variability in the results to make them fall outside the acceptable range.

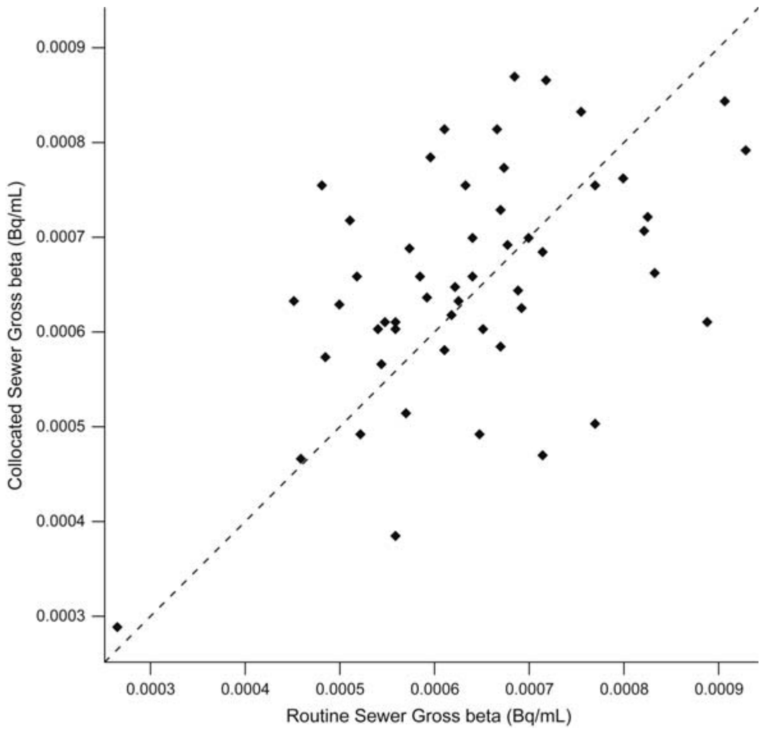

Figure 9-3. Example of variability using collocated sewer gross beta concentrations

9.4 Data Presentation

The data tables in **Appendix A** were created using computer scripts that retrieve data from a database, convert the data into Système International (SI) units when necessary, calculate summary statistics, format data as appropriate, format the table into rows and columns, and present a draft table. The tables are reviewed by the responsible analyst. Analytical laboratory data and the values calculated from the data are normally displayed with two, or at most three, significant digits. Significant trailing zeros may be omitted.

9.4.1 Radiological Data

Most of the data tables in **Appendix A** display radiological data as a result plus or minus (±) an associated 2σ uncertainty. This measure of uncertainty represents intrinsic variation in the measurement process, most of which is due to the random nature of radioactive decay (see

Section 9.6). The uncertainties are not used in summary statistic calculations. Any radiological result exhibiting a 2σ uncertainty greater than or equal to 100% of the result is considered a nondetection.

Some radiological results are derived from the number of sample counts minus the number of background counts inside the measurement apparatus. Therefore, a sample with a concentration at or near background may have a negative value. Such results are reported in the data tables and used in the calculation of summary statistics and statistical comparisons.

Some data tables provide a limit-of-sensitivity value instead of an uncertainty when the radiological result is below the detection criterion. Such results are displayed with the limit-of-sensitivity value in parentheses.

9.4.2 Nonradiological Data

Nonradiological data reported by the analytical laboratory as being below the reporting limit are displayed in tables with a less-than symbol (<). Reporting limit values are used in the calculation of summary statistics, as explained below.

9.5 Statistical Comparisons and Summary Statistics

Standard comparison techniques such as regression analysis, *t*-tests, and analysis of variance are used where appropriate to determine the statistical significance of trends or differences between means. When a comparison is made, the results are described as either “statistically significant” or “not statistically significant.” Other uses of the word “significant” in this report do not imply that statistical tests have been performed but relate to the concept of practical significance and are based on professional judgment.

Summary statistics are calculated according to Gallegos (2009). The usual summary statistics are the median, which is a measure of central tendency, and interquartile range (IQR), which is a measure of dispersion (variability). However, some data tables may present other measures at the discretion of the analyst.

The median indicates the middle of the data set (i.e., half of the measured results are above the median, and half are below). The IQR is the range that encompasses the middle 50% of the data set. The IQR is calculated by subtracting the 25th percentile of the data set from the 75th percentile of the data set. When necessary, the percentiles are interpolated from the data. Different software vendors may use slightly different formulas for calculating percentiles. Radiological data sets that include values less than zero may have an IQR greater than the median. In this report, at least four values are required to calculate the median and at least six values are required to calculate the IQR.

Summary statistics are calculated from values that, if necessary, have already been rounded, such as when units have been converted from picocuries to becquerels, and are then rounded to an appropriate number of significant digits. The calculation of summary statistics is also affected by the presence of nondetections. A nondetection indicates that no specific measured value is available; instead, the best information available is that the actual value is less than the reporting limit. Adjustments to the calculation of the median and IQR for data sets that include nondetections are described below.

For data sets with all measurements above the reporting limit and radiological data sets that include reported values below the reporting limit, all reported values, including any below the reporting limit, are included in the calculation of summary statistics.

For data sets that include one or more values reported as “less than the reporting limit,” the reporting limit is used as an upper bound value in the calculation of summary statistics.

If the number of values is odd, the middle value (when sorted from smallest to largest) is the median. If the middle value and all larger values are detections, the middle value is reported as the median. Otherwise, the median is assigned a less-than (<) sign.

If the number of values is even, the median is halfway between the middle two values (i.e., the middle two when the values are sorted from smallest to largest). If both of the middle two values and all larger values are detections, the median is reported. Otherwise, the median is assigned a less-than (<) sign.

If any value used to calculate the 25th percentile is a nondetection, or any value larger than the 25th percentile is a nondetection, the IQR cannot be calculated and is not reported.

The median and the IQR are not calculated for data sets with no detections.

9.6 Reporting Uncertainty in Data Tables

The measurement uncertainties associated with results from analytical laboratories are represented in two ways. The first of these, significant digits, relates to the resolution of the measuring device. For example, if an ordinary household ruler with a metric scale is used to measure the length of an object in centimeters, and the ruler has tick marks every one-tenth of a centimeter, the length can reliably and consistently be measured to the nearest tenth of a centimeter (i.e., to the nearest tick mark). An attempt to be more precise is not likely to yield reliable or reproducible results because it would require a visual estimate of a distance between tick marks. The appropriate way to report a measurement using this ruler would be, for example, 2.1 cm, which would indicate that the “true” length of the object is nearer to 2.1 cm than to 2.0 cm or 2.2 cm (i.e., between 2.05 and 2.15 cm). A measurement of 2.1 cm has two significant digits. Although not stated, the uncertainty is considered to be ± 0.05 cm. A more precise measuring device might be able to measure an object to the nearest one-hundredth of a centimeter; in that case a value such as “2.12 cm” might be reported. This value would have three significant digits and the implied uncertainty would be ± 0.005 cm. A result reported as “3.0 cm” has two significant digits. That is, the trailing zero is significant and implies that the true length is between 2.95 and 3.05 cm—closer to 3.0 than to 2.9 or 3.1 cm.

When performing calculations with measured values that have significant digits, all digits are used. The number of significant digits in the calculated result is the same as that of the measured value with the fewest number of significant digits.

Most unit conversion factors do not have significant digits. For example, the conversion from milligrams to micrograms requires multiplying by the fixed (constant) value of 1000. The value 1000 is exact; it has no uncertainty and therefore the concept of significant digits does not apply.

The other method of representing uncertainty is based on random variation. For radiological measurements, there is variation due to the random nature of radioactive decay. As a sample is measured, the number of radioactive decay events is counted and the reported result is calculated from the number of decay events that were observed. If the sample is recounted, the number of decay events will almost always be different because radioactive decay events occur randomly. Uncertainties of this type are reported as 2σ uncertainties. A 2σ uncertainty represents the range of results expected to occur approximately 95% of the time if a sample were to be recounted many times. A radiological result reported as, for example, "2.6 ± 1.2 Bq/g," would indicate that with approximately 95% confidence, the "true" value is in the range of 1.4 to 3.8 Bq/g (i.e., 2.6 – 1.2 = 1.4 and 2.6 + 1.2 = 3.8). When necessary, results are converted from pCi to Bq by multiplying by 0.037; this introduces extraneous digits that are not significant and should not be shown in data tables. For example, 5.3 pCi/g × 0.037 = 0.1961 Bq/g. The initial value, 5.3, has two significant digits, so the value 0.1961 would be rounded to two significant digits, that is, 0.20.

However, the rounding rule changes when there is a radiological uncertainty associated with a radiological result. In this case, data are presented according to the method recommended in Multi-Agency Radiological Laboratory Analytical Protocols (MARLAP) Section 19.3.7 (U.S. NRC/U.S. EPA 2004). First the uncertainty is rounded to the appropriate number of significant digits, after which the result is rounded to the same number of decimal places. For example, suppose a result and uncertainty after unit conversion are 0.1961 ± 0.05436, and the appropriate number of significant digits is two. First, 0.05436 is rounded to 0.054 (two significant digits). 0.054 has three decimal places, so 0.1961 is then rounded to three decimal places, i.e., 0.196. These would be presented in the data tables as 0.196 ± 0.054.

When rounding a value with a final digit of "5," the software that was used to prepare the data tables follows the IEEE Standard 754−1985, which is "go to the even digit." For example, 2.45 would be rounded down to 2.4, and 2.55 would be rounded up to 2.6.

The software that prepares the data tables pays careful attention to the details of rounding for significant digits. It should be noted, however, that these details are of little practical significance. For example, if a result of 5.6 is incorrectly rounded to 5.5 or 5.7, the introduced "error" is less than 2% (0.1/5.6 = 0.018). Such an error will rarely have any impact on the interpretation of the data with respect to human health or environmental impact.

9.7 Quality Assurance Process for the Environmental Report

Unlike the preceding sections, which focused on standards of accuracy and precision in data acquisition and reporting, this section describes the actions that are taken to ensure the accuracy of this data-rich environmental report, the preparation of which involves many operations and many people. The key elements that are used to ensure accuracy are described below.

Analytical laboratories send reports electronically, which are loaded directly into the database. This practice should result in perfect agreement between the database and data in printed reports from the laboratories. In practice, however, laboratory reporting is not perfect, so the EPD and ERD Data Management Teams (DMTs) carefully check incoming data throughout the year to make sure that electronic and printed reports from the laboratories agree. This aspect of QC is essential to the report's accuracy. Because of this ongoing QC of incoming data, data stored in the database and used to prepare the annual environmental report tables are unlikely to contain errors.

As described in **Section 9.4**, scripts are used to pull data from the database directly into the format of the table, including unit conversion and summary statistic calculations. All of the data tables contained in **Appendix A** were prepared for this report in this manner. For these tables, it is the responsibility of the appropriate analyst to check each year that the table is up-to-date (e.g., new locations/analytes added, old ones removed), that the data agree with the data he or she has received from DMT, and that the summary calculations have been done correctly.

For this 2008 environmental report, LLNL staff checked tables and figures in the body of the report. Forms to aid in the QC of tables and figures were distributed along with the appropriate figure, table, and text, and a coordinator kept track of the process. Items that were checked included clarity and accuracy of figure captions and table titles; data accuracy and completeness; figure labels and table headings; units; significant digits; and consistency with text. Completed QC forms and the corrected figures or tables were returned to the report editor, who, in collaboration with the responsible author, ensured that corrections were made.

9.8 Errata

Appendix E contains the protocol for errata in LLNL *Environmental Reports* and the errata for LLNL *Environmental Report 2007*.

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Acronyms and Glossary

Symbols and Units of Measure

ºC	degree centigrade
ºF	degree Fahrenheit
σ	sigma
aCi	attocurie (10^{-18} Ci)
µBq	microbecquerel (10^{-6} Bq)
µg/g	microgram per gram (10^{-6} g/g)
µg/L	microgram per liter (10^{-6} g/L)
µg/m^3	microgram per cubic meter (10^{-6} g/m^3)
µrem	microrem (10^{-6} rem)
µSv/y	microsievert per year
Bq	becquerel (*See also* definition in **Key Terms** section.)
Bq/g	becquerel per gram
Bq/kg	becquerel per kilogram
Bq/L	becquerel per liter
Bq/m^3	becquerel per cubic meter
Bq/mL	becquerel per milliliter
Ci	curie (*See also* definition in **Key Terms** section.)
cm	centimeter
ft	foot
g	gram
gal	gallon
gal/d	gallon per day
gal/min	gallon per minute
GBq	gigabecquerel (10^{9} Bq)
in.	inch
keV	kiloelectronvolt (10^{3} eV) (*See also* definition of “electronvolt” in **Key Terms** section.)
kg	kilogram (10^{3} g)
kg/d	kilogram per day (10^{3} g/d)
km	kilometer (10^{3} m)
L	liter
L/d	liter per day
L/y	liter per year
m	meter
mBq	millibecquerel (10^{-3} Bq)
mBq/g	millibecquerel per gram (10^{-3} Bq/g)
mBq/dry g	millibecquerel per dry gram (10^{-3} Bq/dry g)
mBq/m^3	millibecquerel per cubic meter (10^{-3} Bq/m^3)
mCi	millicurie (10^{-3} Ci)
mg/L	milligram/liter (10^{-3} g/L)
mi	mile
mph	mile per hour
mrem	millirem (10^{-3} rem) (*See also* definition of “rem” in **Key Terms** section.)
mrem/y	millirem per year (10^{-3} rem/y)
m/s	meter per second
mSv	millisievert (10^{-3} Sv)
mSv/y	millisievert per year (10^{-3} Sv/y)
MT	metric ton

nBq	nanobecquerel (10^{-9} Bq)
nSv	nanosievert (10^{-9} Sv)
nSv/y	nanosievert per year (10^{-9} Sv/y)
pCi	picocurie (10^{-12} Ci)
pCi/g	picocurie per gram (10^{-12} Ci/g)
pCi/dry g	picocurie per dry gram (10^{-12} Ci/dry g)
pCi/L	picocurie per liter (10^{-12} Ci/liter)
person-Sv	person-sievert (*See also* definition in **Key Terms** section.)
person-Sv/y	person-sievert/year
pg/L	picogram per liter (10^{-12} g/L)
pg/m^3	picogram per cubic meter (10^{-12} g/m^3)
Sv	sievert (*See also* definition in **Key Terms** section.)
TBq	terabecquerel (10^{12} Bq)

Acronyms and Abbreviations

%RSD	Percent relative standard deviation
ACCDA	Alameda County Community Development Agency
ACDEH	Alameda County Department of Environmental Health
ACOE	Army Corps of Engineers
ALARA	as low as reasonably achievable
ATSDR	Agency for Toxic Substances and Disease Registry
BAAQMD	Bay Area Air Quality Management District (*See also* definition in **Key Terms** section.)
BCG	Biota Concentration Guide
BO	biological opinion
BSA	Blanket Service Agreement
BSL	Biosafety Level
CAA	Clean Air Act
CalARP	California Accidental Release Prevention
CAMP	Corrective Action Monitoring Plan
CAR	Certified Appliance Recycler
CARB	California Air Resources Board
CCR	California Code of Regulations
CDFG	California Department of Fish and Game
CEI	Compliance Evaluation Inspection
CEQA	California Environmental Quality Act of 1970 (*See also* definition in **Key Terms** section.)
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act of 1980 (*See also* definition in **Key Terms** section.)
CFF	Contained Firing Facility
CFR	Code of Federal Regulations
CMWMA	California Medical Waste Management Act
CNPS	California Native Plant Society
CO	carbon monoxide
COC	constituent of concern
COD	chemical oxygen demand
CSA	container storage area
CSU	container storage unit
CUPA	Certified Unified Program Agencies

CVRWQCB	Central Valley Regional Water Quality Control Board (*See also* definition in **Key Terms** section.)
CWA	(Federal) Clean Water Act
DCG	derived concentration guide (*See also* definition in **Key Terms** section.)
DHS	(California) Department of Health Services
DMP	Detection Monitoring Plan
DMT	Data Management Team
DOE	(U.S.) Department of Energy (*See also* definition in **Key Terms** section.)
DOECAP	(U.S.) Department of Energy Consolidated Auditing Program
DOT	(U.S.) Department of Transportation
DPR	(California) Department of Pesticide Regulation
DTSC	(California Environmental Protection Agency) Department of Toxic Substances Control
DWTF	Decontamination and Waste Treatment Facility
E85	Vehicle fuel, 85% ethanol and 15% gasoline
EA	environmental assessment
EDE	effective dose equivalent (*See also* definition in **Key Terms** section.)
EDO	Environmental Duty Officer
EIS	environmental impact statement
EMP	Environmental Management Plan
EMS	Environmental Management System
EPA	Environmental Protection Agency (*See also* definition in **Key Terms** section.)
EPCRA	Emergency Planning and Community Right-to-Know Act of 1986 (*See also* definition in **Key Terms** section.)
EPD	(LLNL) Environmental Protection Department
EPEAT	Electronic Product Environmental Assessment Tool
EPL	effluent pollutant limit
EPP	Environmentally Preferable Purchasing
ERD	(LLNL) Environmental Restoration Department
ERP	Environmental Restoration Project
ES&H	Environment, Safety, and Health
ESA	Endangered Species Act
EWSF	Explosives Waste Storage Facility
EWTF	Explosives Waste Treatment Facility
FFA	Federal Facility Agreement (*See also* definition in **Key Terms** section.)
FFCA	Federal Facilities Compliance Act
FIFRA	Federal Insecticide, Fungicide, and Rodenticide Act
FY	fiscal year (*See also* definition in **Key Terms** section.)
GAC	granulated activated carbon
GPS	global positioning system
GSA	(U.S.) General Services Administration
GWP	(Livermore site) Ground Water Project, or Global Warming Potential
HPGe	high-purity germanium
HSU	hydrostratigraphic unit
HT/TT	tritiated hydrogen gas
HTO/TTO	tritiated water or tritiated water vapor
HWCL	Hazardous Waste Control Law (*See also* definition in **Key Terms** section.)
ICRP	International Commission on Radiological Protection
IEEE	Institute of Electrical and Electronics Engineers
IQR	Interquartile range (*See also* definition in **Key Terms** section.)

ISMS	Integrated Safety Management System
ISO	International Organization for Standardization
LEED	Leadership in Energy and Environmental Design
LEED-EB	Leadership in Energy and Environmental Design for Existing Buildings
LEPC	Local Emergency Planning Committee
LLNL	Lawrence Livermore National Laboratory
LLNS	Lawrence Livermore National Security, LLC
LWRP	Livermore Water Reclamation Plant
MAPEP	Mixed Analyte Performance Evaluation Program
MAPS	Monitoring Avian Productivity and Survivorship
MARLAP	Multi-Agency Radiological Laboratory Analytical Protocols
MCL	maximum contaminant level (*See also* definition in **Key Terms** section.)
MDC	minimum detectable concentration
MRP	Monitoring and Reporting Program
MSDS	material safety data sheet
NCR	nonconformance report
NCRP	National Council on Radiation Protection and Measurements
NELAP	National Environmental Laboratory Accreditation Program
NEPA	National Environmental Policy Act (*See also* definition in **Key Terms** section.)
NESHAPs	National Emissions Standards for Hazardous Air Pollutants
NHPA	National Historic Preservation Act
NIF	National Ignition Facility
NNSA	National Nuclear Security Administration
NOA	Notice of Applicability
NOI	Notice of Intent
NOV	notice of violation
NOx	nitrous oxides
NPDES	National Pollutant Discharge Elimination System (*See also* definition in **Key Terms** section.)
NRHP	National Register of Historic Places
OBT	organically bound tritium
ODS	ozone depleting substance
ORNL	Oak Ridge National Laboratory
OU	operable unit
P2	pollution prevention
PA	Programmatic Agreement
PCB	polychlorinated biphenyl
PCE	perchloroethylene (or perchloroethene); also called tetrachloroethylene or tetrachloroethene
PM-10	particulate matter with diameter equal to or less than 10 micrometer
POC	precursor organic compounds
PQL	practical quantitation limit (*See also* definition in **Key Terms** section.)
PRAD	(LLNL) Permits and Regulatory Affairs Division
QA	quality assurance (*See also* definition in **Key Terms** section.)
QC	quality control (*See also* definition in **Key Terms** section.)
RCRA	Resource Conservation and Recovery Act of 1976 (*See also* definition in **Key Terms** section.)
RHWM	(LLNL) Radioactive and Hazardous Waste Management Division
RI/FS	Remedial Investigation/Feasibility Study
RL	reporting limit
RMP	risk management plan
ROG/POC	reactive organic gases/precursor organic compounds
RWQCB	Regional Water Quality Control Board (*See also* definition in **Key Terms** section.)

SAA	satellite accumulation area
SARA	Superfund Amendment and Reauthorization Act of 1986 (*See also* definition in **Key Terms** section.)
SAT	(LLNL) Space Action Team
SDWA	Safe Drinking Water Act
SERC	State Emergency Response Commission
SFBRWQCB	San Francisco Bay Regional Water Quality Control Board (*See also* definition in **Key Terms** section.)
SFTF	Small Firearms Training Facility
SHPO	State Historic Preservation Officer
SI	Système International d'Unités (*See also* definition in **Key Terms** section.)
SJCEHD	San Joaquin County Environmental Health Department (*See also* definition in **Key Terms** section.)
SJCOES	San Joaquin County, Office of Emergency Services
SJVAPCD	San Joaquin Valley Air Pollution Control District (*See also* definition in **Key Terms** section.)
SMOP	Synthetic Minor Operating Permit
SMS	(LLNL) Sewer Monitoring Station
SOx	sulphur oxides
SPCC	Spill Prevention Control and Countermeasure
STP	Site Treatment Plan
SW-MEI	site-wide maximally exposed individual member (of the public) (*See also* definition in **Key Terms** section.)
SWPPP	Storm Water Pollution Prevention Plan
SWRCB	State Water Resources Control Board
TAG	Technical Assistance Grant
TBOS/TKEBS	tetrabutyl orthosilicate/tetrakis 2-ethylbutyl silane
TCE	trichloroethene (or trichloroethylene)
TLD	thermoluminescent dosimeter (*See also* definition in **Key Terms** section.)
TOC	total organic carbon (*See also* definition in **Key Terms** section.)
TOX	total organic halides (*See also* definition in **Key Terms** section.)
TRI	Toxics Release Inventory
Tri-Valley CAREs	Tri-Valley Communities Against a Radioactive Environment
TRU	transuranic (waste) (*See also* definition in **Key Terms** section.)
TSCA	Toxic Substances Control Act
TSS	total suspended solids (*See also* definition in **Key Terms** section.)
TTO	total toxic organic (compounds)
USFWS	U.S. Fish and Wildlife Service
USGBD	U.S. Green Building Council
VOC	volatile organic compound (*See also* definition in **Key Terms** section.)
WAA	waste accumulation area (*See also* definition in **Key Terms** section.)
WDAR	Waste Discharge Authorization Requirement
WDR	Waste Discharge Requirement
WGMD	(LLNL) Water Guidance and Monitoring Division
WRD	Water Resources Division (*See also* definition in **Key Terms** section.)

Metric and U.S. Customary Unit Equivalents

	From metric unit to U.S. customary equivalent unit		From U.S. customary unit to metric equivalent unit	
Category	Metric	U.S.	U.S.	Metric
Length	1 centimeter (cm)	0.39 inches (in.)	1 inch (in.)	2.54 centimeters (cm)
	1 millimeter (mm)	0.039 inches (in.)		25.4 millimeters (mm)
	1 meter (m)	3.28 feet (ft)	1 foot (ft)	0.3048 meters (m)
		1.09 yards (yd)	1 yard (yd)	0.9144 meters (m)
	1 kilometer (km)	0.62 miles (mi)	1 mile (mi)	1.6093 kilometers (km)
Volume	1 liter (L)	0.26 gallons (gal)	1 gallon (gal)	3.7853 liters (L)
		8.11×10^{-7} acre-feet	1 acre-foot	1.23×10^{6}liters (L)
	1 cubic meter (m^3)	35.32 cubic feet (ft^3)	1 cubic foot (ft^3)	0.028 cubic meters (m^3)
		1.35 cubic yards (yd^3)	1 cubic yard (yd^3)	0.765 cubic meters (m^3)
Weight	1 gram (g)	0.035 ounces (oz)	1 ounce (oz)	28.6 gram (g)
	1 kilogram (kg)	2.21 pounds (lb)	1 pound (lb)	0.373 kilograms (kg)
	1 metric ton (MT)	1.10 short ton (2000 pounds)	1 short ton (2000 pounds)	0.90718 metric ton (MT)
Area	1 hectare (ha)	2.47 acres	1 acre	0.40 hectares (ha)
Radioactivity	1 becquerel (Bq)	2.7×10^{-11} curie (Ci)	1 curie (Ci)	3.7×10^{10} becquerel (Bq)
Radiation dose	1 gray (Gy)	100 rad	1 rad	0.01 gray (Gy)
Radiation dose equivalent	1 sievert (Sv)	100 rem	1 rem	0.01 sievert (Sv)
Temperature	^{o}Fahrenheit = (^{o}Centigrade x 1.8) + 32		^{o}Centigrade = (^{o}Fahrenheit – 32) / 1.8	

Multipying Prefixes

Symbol	Prefix	Factor	Symbol	Prefix	Factor
v	vendeko	10^{-30}	da	deca	10^{1}
x	xenno	10^{-27}	h	hecto	10^{2}
y	yocto	10^{-24}	k	kilo	10^{3}
z	zepto	10^{-21}	M	mega	10^{6}
a	atto	10^{-18}	G	giga	10^{9}
f	femto	10^{-15}	T	tera	10^{12}
p	pico	10^{-12}	P	peta	10^{15}
n	nano	10^{-9}	E	exa	10^{18}
µ	micro	10^{-6}	Z	zetta	10^{21}
m	milli	10^{-3}	Y	yotta	10^{24}
c	centi	10^{-2}			
d	deci	10^{-1}			

Key Terms

Absorbed dose. Amount of energy imparted to matter by ionizing radiation per unit mass of irradiated material, in which the absorbed dose is expressed in units of rad or gray (1 rad = 0.01 gray).

Accuracy. Closeness of the result of a measurement to the true value of the quantity measured.

Action level. Defined by regulatory agencies, the level of pollutants which, if exceeded, requires regulatory action.

Alluvium. Sediment deposited by flowing water.

Alpha particle. Positively charged particle emitted from the nucleus of an atom, having mass and charge equal to those of a helium nucleus (two protons and two neutrons).

Ambient air. Surrounding atmosphere, usually the outside air, as it exists around people, plants, and structures; for monitoring purposes, it does not include air immediately adjacent to emission sources.

Analyte. Specific component measured in a chemical analysis.

Aquifer. Saturated layer of rock or soil below the ground surface that can supply usable quantities of groundwater to wells and springs, and be a source of water for domestic, agricultural, and industrial uses.

Bay Area Air Quality Management District (BAAQMD). Local agency responsible for regulating stationary air emission sources (including the LLNL Livermore site) in the San Francisco Bay Area.

Becquerel (Bq). SI unit of activity of a radionuclide, equal to the activity of a radionuclide having one spontaneous nuclear transition per second.

Beta particle. Negatively charged particle emitted from the nucleus of an atom, having charge, mass, and other properties of an electron.

California Environmental Quality Act of 1970 (CEQA). Statute that requires that all California state, local, and regional agencies document, consider, and disclose to the public the environmental implications of their actions.

Categorical discharge. Discharge from a process regulated by EPA rules for specific industrial categories.

Central Valley Regional Water Quality Control Board (CVRWQCB). Local agency responsible for regulating ground and surface water quality in the Central Valley.

Comprehensive Environmental Response, Compensation and Liability Act of 1980 (CERCLA). Administered by EPA, this federal law**,** also known as Superfund, requires private parties to notify the EPA of conditions that threaten to release hazardous substances or after the release of hazardous substances, and undertake short-term removal and long-term remediation.

Cosmic radiation. Radiation with very high energies originating outside the earth's atmosphere; it is one source contributing to natural background radiation.

Curie (Ci). Unit of measurement of radioactivity, defined as the amount of radioactive material in which the decay rate is 3.7×10^{10} disintegrations per second or 2.22×10^{12} disintegrations per minute; one Ci is approximately equal to the decay rate of 1 gram of pure radium.

Depleted uranium. Uranium having a lower proportion of the isotope uranium-238 than is found in naturally occurring uranium. The masses of the three uranium isotopes with atomic weights 238, 235, and 234 occur in depleted uranium in the weight-percentages 99.8, 0.2, and 5×10^{-4}, respectively. Depleted uranium is sometimes referred to as D-38 or DU.

Derived concentration guide (DCG). Concentrations of radionuclides in water and air that could be continuously consumed or inhaled for one year and not exceed the DOE primary radiation standard to the public (100 mrem/y EDE).

Dose. Energy imparted to matter by ionizing radiation; the unit of absorbed dose is the rad, equal to 0.01 joules per kilogram for irradiated material in any medium.

Dose equivalent. Product of absorbed dose in rad (or gray) in tissue and a quality factor representing the relative damage caused to living tissue by different kinds of radiation, and perhaps other modifying factors representing the distribution of radiation, etc. expressed in units of rem or sievert (1 rem = 0.01 sievert).

Dosimeter. Portable detection device for measuring the total accumulated exposure to ionizing radiation.

Downgradient. In the direction of groundwater flow from a designated area; analogous to downstream.

Effective dose equivalent (EDE). Estimate of the total risk of potential effects from radiation exposure, it is the summation of the products of the dose equivalent and weighting factor for each tissue. The weighting factor is the decimal fraction of the risk arising from irradiation of a selected tissue to the total risk when the whole body is irradiated uniformly to the same dose equivalent. These factors permit dose equivalents from nonuniform exposure of the body to be expressed in terms of an effective dose equivalent that is numerically equal to the dose from a uniform exposure of the whole body that entails the same risk as the internal exposure (ICRP 1980). The effective dose equivalent includes the committed effective dose equivalent from internal deposition of radionuclides and the effective dose equivalent caused by penetrating radiation from sources external to the body, and is expressed in units of rem (or sievert).

Effluent. Liquid or gaseous waste discharged to the environment.

Electronvolt (eV). A unit of energy equal to the amount of kinetic energy gained by an electron when it passes through a potential difference of 1 volt in a vacuum.

Emergency Planning and Community Right-to-Know Act of 1986 (EPCRA). Act that requires facilities that produce, use, or store hazardous substances to report releases of reportable quantities or hazardous substances to the environment.

Environmental impact statement (EIS). Detailed report, required by the National Environmental Policy Act, on the environmental impacts from a federally approved or funded project. An EIS must be prepared by a federal agency when a "major" federal action that will have "significant" environmental impacts is planned.

Federal facility. Facility that is owned or operated by the federal government, subject to the same requirements as other responsible parties when placed on the Superfund National Priorities List.

Federal facility agreement (FFA). Negotiated agreement that specifies required actions at a federal facility as agreed upon by various agencies (e.g., EPA, RWQCB, DOE).

Fiscal year (FY). LLNL's fiscal year is from October 1 through September 30.

Freon-11. Trichlorofluoromethane.

Freon-113. 1,1,2-trichloro-1,2,2-trifluoroethane; also known as CFC 113.

Gamma ray. High-energy, short-wavelength, electromagnetic radiation emitted from the nucleus of an atom, frequently accompanying the emission of alpha or beta particles.

Groundwater. All subsurface water.

Hazardous waste. Waste that exhibits ignitability, corrosivity, reactivity, and/or EP-toxicity (yielding toxic constituents in a leaching test), and waste that does not exhibit these characteristics but has been determined to be hazardous by EPA. Although the legal definition of hazardous waste is complex, according to EPA the term generally refers to any waste that, if managed improperly, could pose a threat to human health and the environment.

(California) Hazardous Waste Control Law (HWCL). Legislation specifying requirements for hazardous waste management in California.

Hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX). High-explosive compound.

Inorganic compounds. Compounds that either do not contain carbon or do not contain hydrogen along with carbon, including metals, salts, and various carbon oxides (e.g., carbon monoxide and carbon dioxide).

International Commission on Radiological Protection (ICRP). International organization that studies radiation, including its measurement and effects.

Interquartile range (IQR). Distance between the top of the lower quartile and the bottom of the upper quartile, which provides a measure of the spread of data.

Isotopes. Forms of an element having the same number of protons in their nuclei, but differing numbers of neutrons.

Lake Haussmann. Man-made, lined pond used to capture storm water runoff and treated water at the Livermore site. Formerly called Drainage Retention Basin (DRB).

Less than detection limits. Phrase indicating that a chemical constituent was either not present in a sample, or is present in such a small concentration that it cannot be measured by a laboratory's analytical procedure, and therefore is not identified or not quantified at the lowest level of sensitivity.

Livermore Water Reclamation Plant (LWRP). City of Livermore's municipal wastewater treatment plant, which accepts discharges from the LLNL Livermore site.

Low-level waste. Waste defined by DOE Order 5820.2A, which contains transuranic nuclide concentrations less than 100 nCi/g.

Maximum contaminant level (MCL). Highest level of a contaminant in drinking water that is allowed by the U.S. Environmental Protection Agency or California Department of Health Services.

Metric units. Except for temperature for which specific equations apply, U.S. customary units can be determined from metric units by multiplying the metric units by the U.S. customary equivalent. Similarly, metric units can be determined from U.S. customary equivalent units by multiplying the U.S. customary units by the metric equivalent.(*See also* **Metric and U.S. Customary Unit Equivalents** table in this Glossary.)

Mixed waste. Waste that has the properties of both hazardous and radioactive waste.

National Environmental Policy Act (NEPA). Federal legislation enacted in 1969 that requires all federal agencies to document and consider environmental impacts for federally funded or approved projects and the legislation under which DOE is responsible for NEPA compliance at LLNL.

National Pollutant Discharge Elimination System (NPDES). Federal regulation under the Clean Water Act that requires permits for discharges into surface waterways.

Nuclear Regulatory Commission (NRC). Federal agency charged with oversight of nuclear power and nuclear machinery and applications not regulated by DOE or the Department of Defense.

Nuclide. Species of atom characterized by the constitution of its nucleus. The nuclear constitution 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 capable of existing for a measurable length of time.

Part B permit. Second, narrative section submitted by generators in the RCRA permitting process that covers in detail the procedures followed at a facility to protect human health and the environment.

Perched aquifer. Aquifer that is separated from another water-bearing stratum by an impermeable layer.

Person-Sievert (person-Sv). The product of the average dose per person times the number of people exposed. 1 person-Sv = 100 person-rem.

pH. Measure of hydrogen ion concentration in an aqueous solution. The pH scale ranges from 0 to 14. Acidic solutions have a pH less than 7; basic solutions have a pH greater than 7; and neutral solutions have a pH of 7.

Pliocene. Geological epoch of the Tertiary period, starting about 12 million years ago.

PM-10. Fine particulate matter with an aerodynamic diameter equal to or less than 10 micrometer.

Point source. Any confined and discrete conveyance (e.g., pipe, ditch, well, stack).

Practical quantitation limit (PQL). Level at which the laboratory can report a value with reasonably low uncertainty (typically 10–20% uncertainty).

Pretreatment. Any process used to reduce a pollutant load before it enters the sewer system.

Quality assurance (QA). System of activities whose purpose is to provide the assurance that standards of quality are attained with a stated level of confidence.

Quality control (QC). Procedures used to verify that prescribed standards of performance are attained.

Quaternary. Geologic era encompassing the last 2 to 3 million years.

Rad. Unit of absorbed dose and the quantity of energy imparted by ionizing radiation to a unit mass of matter such as tissue, and equal to 0.01 joule per kilogram, or 0.01 gray.

Radioactive decay. Spontaneous transformation of one radionuclide into a different nuclide (which may or may not be radioactive), or de-excitation to a lower energy state of the nucleus by emission of nuclear radiation, primarily alpha or beta particles, or gamma rays (photons).

Radioactivity. Spontaneous emission of nuclear radiation, generally alpha or beta particles, or gamma rays, from the nucleus of an unstable isotope.

Radionuclide. Unstable nuclide. See also **nuclide** and **radioactivity**.

Regional Water Quality Control Board (RWQCB). California regional agency responsible for water quality standards and the enforcement of state water quality laws within its jurisdiction. California is divided into nine RWQCBs; the Livermore site is in the San Francisco Bay Region, and Site 300 is in the Central Valley Region.

Rem. Unit of radiation dose equivalent and effective dose equivalent describing the effectiveness of a type of radiation to produce biological effects; coined from the phrase “roentgen equivalent man,” and the product of the absorbed dose (rad), a quality factor (Q), a distribution factor, and other necessary modifying factors. 1 rem = 0.01 sievert.

Resource Conservation and Recovery Act of 1976 (RCRA). Program of federal laws and regulations that govern the management of hazardous wastes, and applicable to all entities that manage hazardous wastes.

Risk assessment. Qualitative and quantitative evaluation of the risk posed to human health and/or the environment by the actual or potential presence and/or use of specific pollutants.

Roentgen (R). Unit of measurement used to express radiation exposure in terms of the amount of ionization produced in a volume of air.

San Francisco Bay Regional Water Quality Control Board (SFBRWQCB). Local agency responsible for regulating ground and surface water quality in the San Francisco Bay Area.

San Joaquin County Environmental Health Department (SJCEHD). Local agency that enforces underground-tank regulations in San Joaquin County, including Site 300.

San Joaquin Valley Air Pollution Control District (SJVAPCD). Local agency responsible for regulating stationary air emission sources (including Site 300) in San Joaquin County.

Sanitary waste. Most simply, waste generated by routine operations that is not regulated as hazardous or radioactive by state or federal agencies.

Saturated zone. Subsurface zone below which all rock pore-space is filled with water; also called the phreatic zone.

Sensitivity. Capability of methodology or instrumentation to discriminate between samples having differing concentrations or containing varying amounts of analyte.

Sievert (Sv). SI unit of radiation dose equivalent and effective dose equivalent, that is the product of the absorbed dose (gray), quality factor (Q), distribution factor, and other necessary modifying factors. 1 sievert = 100 rem.

Site-wide maximally exposed individual (SW-MEI). Hypothetical person who receives, at the location of a given publicly accessible facility (such as a church, school, business, or residence), the greatest LLNL-induced effective dose equivalent (summed over all pathways) from all sources of radionuclide releases to air at a site. Doses at this receptor location caused by each emission source are summed, and yield a larger value than for the location of any other similar public facility. This individual is assumed to continuously reside at this location 24 hours per day, 365 days per year.

Specific conductance. Measure of the ability of a material to conduct electricity; also called conductivity.

Superfund. Common name used for the Comprehensive Environmental Response, Compensation and Liability Act of 1980 (CERCLA). California has also established a “State Superfund” under provisions of the California Hazardous Waste Control Act.

Superfund Amendments and Reauthorization Act (SARA). Enacted in 1986, these laws amended and reauthorized CERCLA for five years.

Surface impoundment. A facility or part of a facility that is a natural topographic depression, man-made excavation, or diked area formed primarily of earthen materials, although it may be lined with man-made materials. The impoundment is designed to hold an accumulation of liquid wastes, or wastes containing free liquids, and is not an injection well.

Système International d’Unités (SI). International system of physical units which include meter (length), kilogram (mass), kelvin (temperature), becquerel (radioactivity), gray (radioactive dose), and sievert (dose equivalent).

Thermoluminescent dosimeter (TLD). Device used to measure external beta or gamma radiation levels, and which contains a material that, after exposure to beta or gamma radiation, emits light when processed and heated.

Total dissolved solids (TDS). Portion of solid material in a waste stream that is dissolved and passed through a filter.

Total organic carbon (TOC). Sum of the organic material present in a sample.

Total organic halides (TOX). Sum of the organic halides present in a sample.

Total suspended solids (TSS). Total mass of particulate matter per unit volume suspended in water and wastewater discharges that is large enough to be collected by a 0.45 micron filter.

Tritium. Radioactive isotope of hydrogen, containing one proton and two neutrons in its nucleus, which decays at a half-life of 12.3 years by emitting a low-energy beta particle.

Transuranic waste (TRU). Material contaminated with alpha-emitting transuranium nuclides, which have an atomic number greater than 92 (e.g., plutonium-239), half-lives longer than 20 years, and are present in concentrations greater than 100 nCi/g of waste.

Unsaturated zone. Portion of the subsurface in which the pores are only partially filled with water and the direction of water flow is vertical; is also referred to as the vadose zone.

U.S. Department of Energy (DOE). Federal agency responsible for conducting energy research and regulating nuclear materials used for weapons production.

U.S. Environmental Protection Agency (EPA). Federal agency responsible for enforcing federal environmental laws. Although some of this responsibility may be delegated to state and local regulatory agencies, EPA retains oversight authority to ensure protection of human health and the environment.

Vadose zone. Partially saturated or unsaturated region above the water table that does not yield water to wells.

Volatile organic compound (VOC). Liquid or solid organic compounds that have a high vapor pressure at normal pressures and temperatures and thus tend to spontaneously pass into the vapor state.

Waste accumulation area (WAA). Officially designated area that meets current environmental standards and guidelines for temporary (less than 90 days) storage of hazardous waste before pickup by the Radioactive and Hazardous Waste Management Division for off-site disposal.

Wastewater treatment system. Collection of treatment processes and facilities designed and built to reduce the amount of suspended solids, bacteria, oxygen-demanding materials, and chemical constituents in wastewater.

Water table. Water-level surface below the ground at which the unsaturated zone ends and the saturated zone begins, and the level to which a well that is screened in the unconfined aquifer would fill with water.

Weighting factor. Tissue-specific value used to calculate dose equivalents which represents the fraction of the total health risk resulting from uniform, whole-body irradiation that could be contributed to that particular tissue.

Zone 7. Common name for the Alameda County Flood Control and Water Conservation District, Zone 7, which is the water agency for the Livermore–Amador Valley with responsibility for regional flood control and drinking water supply.

APPENDIX A
Data Tables

The data tables listed in this appendix are accessible on CD or https://saer.llnl.gov/. In the electronic version of this appendix, the data tables listed below are linked to the tables, which are read-only Excel files.

A.1 Air Effluent (Chapter 4)

A.1.1 Summary of gross alpha and gross beta (μBq/m$^{3)}$ in background locations for comparison to monitored air effluent emission points in 2008

A.1.2 Summary of gross alpha and gross beta (μBq/m^3) in air effluent samples from the monitored emission point at Livermore site, Building 235, 2008

A.1.3 Summary of gross alpha and gross beta (μBq/m^3) in air effluent samples from the monitored emission point at Livermore site, Building 491, 2008

A.1.4 Summary of gross alpha and gross beta (μBq/m^3) in air effluent samples from the monitored emission point at Livermore site, Building 695, 2008

A.1.5 Summary of tritium (Bq/m^3) in air effluent samples from the monitored emission point at Livermore site, Building 695, 2008

A.1.6 Summary of gross alpha and gross beta (μBq/m^3) in air effluent samples from the monitored emission points at Livermore site, Building 332, 2008

A.1.7 Summary of tritium in air effluent samples (Bq/m^3) from the monitored emission points at Livermore site, Building 331, 2008

A.1.8 Summary of gross alpha and gross beta (μBq/m^3) in air effluent samples from the monitored emission point at Site 300, Building 801, 2008

A.2 Ambient Air (Chapter 4)

A.2.1 Weekly gross alpha and gross beta concentrations (μBq/m^3) from air particulate samples from the Livermore perimeter locations, 2008

A.2.2 Tritium concentrations (mBq/m^3) in air on the Livermore site, 2008

A.2.3 Beryllium concentration (pg/m^3) in Livermore site and Site 300 air particulate samples, 2008

A.2.4 Beryllium-7 concentrations (mBq/m^3) composite for Livermore site and Site 300 air particulate samples, 2008

A.2.5 Plutonium-239+240 concentrations (nBq/m^3) in air particulate samples from the Livermore perimeter and Site 300 perimeter composite, 2008

A.2.6 Uranium mass concentrations (pg/m^3) in air particulate samples from Site 300 onsite and offsite locations, and the Livermore site (composite), 2008

A.2.7 Weekly gross alpha and gross beta concentrations (μBq/m^3) from air particulate samples from the Livermore Valley downwind locations, 2008

A.2.8 Tritium concentrations (mBq/m^3) in air, Livermore Valley, 2008

A.2.9 Weekly gross alpha and gross beta concentrations (μBq/m^3) from air particulate samples from Livermore Valley upwind location and the special interest location, 2008

A.2.10 Plutonium-239+240 concentrations (nBq/m^3) in air particulate samples from the Livermore Valley, 2008

A.2.11 Tritium concentrations (mBq/m^3) in air, Site 300, 2008

A.2.12 Weekly gross alpha and gross beta concentrations (μBq/m^3) from air particulate samples from Site 300 onsite and offsite locations, 2008

A.3 Livermore Site Wastewater (Chapter 5)

A.4 Storm Water (Chapter 5)

A.5 Livermore Site Groundwater (Chapter 5)

A.6 Site 300 Groundwater (Chapter 5)

A.7 Other Water (Chapter 5)

A.8 Soil (Chapter 6)

A.9 Ambient Radiation (Chapter 6)

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APPENDIX B
EPA Methods of Environmental Water Analysis

Table B-1. Inorganic constituents of concern in water samples, the analytical methods used to determine their concentrations, and their contractual reporting limits.

Constituent of concern		Analytical method	Reporting limit[(a,b)]
Metals and minerals (mg/L)	All alkalinities	SM 2310	1
	Aluminum	EPA 200.7 or 200.8	0.05 or 0.2
	Ammonia nitrogen (as N)	EPA 350.1 or SM 4500-NH3	0.03 or 0.1
	Antimony	EPA 204.2 or 200.8	0.005
	Arsenic	EPA 206.2 or 200.8	0.002
	Barium	EPA 200.7 or 200.8	0.025 or 0.01
	Beryllium	EPA 210.2 or 200.8	0.0005 or 0.0002
	Boron	EPA 200.7	0.05
	Bromide	EPA 300.0	0.5
	Cadmium	EPA 200.8 or SM 3113B	0.0005
	Calcium	EPA 200.7	0.5
	Chloride	EPA 300.0	1 or 0.5
	Chlorine (residual)	SM-4500-CL	0.1
	Chromium	EPA 218.2 or 200.8	0.01 or 0.001
	Chromium(VI)	EPA 218.4 or 7196	0.002
	Cobalt	EPA 200.7 or 200.8	0.025 or 0.05
	Copper	EPA 220.2, 200.7 or 200.8	0.001, 0.01 or 0.05
	Cyanide	EPA 335.2 or 4500-CN	0.02
	Fluoride	EPA 340.2 or 340.1	0.05
	Hardness, total (as $CaCO_3$)	SM 2320B	1
	Iron	EPA 200.7 or 200.8	0.1
	Lead	EPA 200.8 or SM3113B	0.002 or 0.005
	Magnesium	EPA 200.7 or 200.8	0.5
	Manganese	EPA 200.7 or 200.8	0.03
	Mercury	EPA 245.2 or 245.1	0.0002
	Molybdenum	EPA 200.7 or 200.8	0.025
	Nickel	EPA 200.7, 200.8 or SM 3113B	0.002, 0.005 or 0.1
	Nitrate (as NO_3)	EPA 353.2 300.0 or SM 4500-NO3	0.5
	Nitrite (as NO_2)	EPA 353.2or 300.0, SM 4500-NO2	0.5
	Ortho-phosphate	EPA 300.0 or SM4500	0.05
	Perchlorate	EPA 314.0	0.004
	Potassium	EPA 200.7	1
	Selenium	EPA 200.8 or SM 3113B	0.002
	Silver	EPA 200.8 or SM 3113B	0.001 or 0.0005
	Sodium	EPA 200.7	1 or 0.1
	Sulfate	EPA 300.0	1
	Surfactants	SM 5540C or EPA 425.1	0.5
	Thallium	EPA 279.2 or 200.8	0.001

Table B-1 (cont.). Inorganic constituents of concern in water samples, the analytical methods used to determine their concentrations, and their contractual reporting limits.

Constituent of concern		Analytical method	Reporting limit[a,b]
Metals and minerals (mg/L) (cont.)	Total dissolved solids	SM 2540C	1
	Total suspended solids	SM 2540D	1
	Total Kjeldahl nitrogen (as N)	EPA 351.2 or SM 4500-Norg	0.2
	Total phosphorus (as P)	EPA 365.4 or SM 4500-P	0.05
	Vanadium	EPA 200.7 or 200.8	0.02 or 0.025
	Zinc	EPA 200.7 or 200.8	0.02 or 0.05
General indicator parameters	pH (pH units)	SM 4500-H+	none
	Biochemical oxygen demand (mg/L)	SM 5210B	2
	Conductivity (µS/cm)	EPA 120.1	none
	Chemical oxygen demand (mg/L)	EPA 410.4	5
	Dissolved oxygen (mg/L)	SM 4500-O G	0.05
	Total organic carbon (mg/L)	EPA 9060 or SM 5310B	1
	Total organic halides (mg/L)	EPA 9020	0.02
	Toxicity, acute (fathead minnow)	EPA 600/4-AB5-013	NA
	Toxicity, chronic (fathead minnow)	EPA 1000	NA
	Toxicity, chronic (daphnid)	EPA 1002	NA
	Toxicity, chronic (green algae)	EPA 1003	NA
Radioactivity (Bq/L)	Gross alpha	EPA 900	0.074
	Gross beta	EPA 900	0.11
Radioisotopes (Bq/L)	Americium-241	U-NAS-NS-3050	0.0037
	Plutonium-238	U-NAS-NS-3050	0.0037
	Plutonium-239+240	U-NAS-NS-3050	0.0037
	Radon-222	EPA 913	3.7
	Radium-226	EPA 903	0.0093
	Radium-228	EPA 904	0.037
	Thorium-228	U-NAS-NS-3050	0.009
	Thorium-230	U-NAS-NS-3050	0.006
	Thorium-232	U-NAS-NS-3050	0.006
	Tritium	EPA 906	3.7
	Uranium-234	EPA 907	0.0037
	Uranium-235	EPA 907	0.0037
	Uranium-238	EPA 907	0.0037

(a) The number of decimal places displayed in this table vary by constituent. These variations reflect regulatory agency permit stipulations, or the applicable analytical laboratory contract under which the work was performed, or both.

(b) These reporting limits are for water samples with low concentrations of dissolved solids. If higher concentrations are present, limits are likely to be higher.

Table B-2. Organic constituents of concern in water samples and their contractual reporting limits of concentration, sorted by analytical method.

Constituent of concern	Reporting limit (µg/L)[(a,b)]
EPA Method 1664	
Oil & Grease	1000
EPA Method 420.1	
Phenolics	5
EPA Method 502.2	
1,1,1,2-Tetrachloroethane	0.2
1,1,1-Trichloroethane	0.2
1,1,2,2-Tetrachloroethane	0.2
1,1,2-Trichloroethane	0.2
1,1-Dichloroethane	0.2
1,1-Dichloroethene	0.2
1,1-Dichloropropene	0.2
1,2,3-Trichlorobenzene	0.2
1,2,3-Trichloropropane	0.2
1,2,4-Trichlorobenzene	0.2
1,2,4-Trimethylbenzene	0.2
1,2-Dichlorobenzene	0.2
1,2-Dichloroethane	0.2
1,2-Dichloropropane	0.2
1,3,5-Trimethylbenzene	0.2
1,3-Dichlorobenzene	0.2
1,3-Dichloropropane	0.2
1,4-Dichlorobenzene	0.2
2,2-Dichloropropane	0.2
2-Chlorotoluene	0.2
4-Chlorotoluene	0.2
Benzene	0.2
Bromobenzene	0.2
Bromochloromethane	0.2
Bromodichloromethane	0.2
Bromoform	0.2
Bromomethane	0.2
Carbon tetrachloride	0.2
Chlorobenzene	0.2
Chloroethane	0.2
Chloroform	0.2
Chloromethane	0.2
cis-1,2-Dichloroethene	0.2
cis-1,3-Dichloropropene	0.5
Dibromochloromethane	0.2
Dibromomethane	0.2
Dichlorodifluoromethane	0.2
Ethylbenzene	0.2
Freon 113	0.2
Hexachlorobutadiene	0.2
Isopropylbenzene	0.2
m- and *p*-Xylene isomers	0.2
Methylene chloride	0.2
n-Butylbenzene	0.2
n-Propylbenzene	0.2
Naphthalene	0.2
o-Xylene	0.2
Isopropyl toluene	0.2
sec-Butylbenzene	0.2
Styrene	0.2
tert-Butylbenzene	0.2
Tetrachloroethene	0.2
Toluene	0.2
trans-1,2-Dichloroethene	0.2
trans-1,3-Dichloropropene	0.2
Trichloroethene	0.2
Trichlorofluoromethane	0.2
Vinyl chloride	0.2
EPA Method 507	
Alachlor	0.5
Atraton	0.5
Atrazine	0.5
Bromacil	0.5
Butachlor	0.5
Diazinon	0.5
Dichlorvos	0.5
Ethoprop	0.5
Merphos	0.5
Metolachlor	0.5
Metribuzin	0.5
Mevinphos	0.5
Molinate	0.5
Prometon	0.5

Table B-2 (cont.). Organic constituents of concern in water samples and their contractual reporting limits of concentration, sorted by analytical method.

Constituent of concern	Reporting limit (µg/L)[(a,b)]
EPA Method 507 (cont.)	
Prometryn	0.5
Simazine	0.5
Terbutryn	0.5
EPA Method 524.2	
1,1,1,2-Tetrachloroethane	1
1,1,1-Trichloroethane	1
1,1,2,2-Tetrachloroethane	1
1,1,2-Trichloroethane	1
1,1-Dichloroethane	1
1,1-Dichloroethene	1
1,1-Dichloropropene	1
1,2,3-Trichlorobenzene	1
1,2,3-Trichloropropane	1
1,2,4-Trichlorobenzene	1
1,2,4-Trimethylbenzene	1
1,2-Dibromo-3-chloropropane	2
1,2-Dichlorobenzene	1
1,2-Dichloroethane	1
1,2-Dichloropropane	1
1,3,5-Trimethylbenzene	1
1,3-Dichlorobenzene	1
1,3-Dichloropropane	1
1,4-Dichlorobenzene	1
2-Chlorotoluene	1
4-Chlorotoluene	1
Benzene	1
Bromobenzene	1
Bromodichloromethane	1
Bromoform	1
Bromomethane	2
Carbon tetrachloride	1
Chlorobenzene	1
Chloroethane	2
Chloroform	1
Chloromethane	2
cis-1,2-Dichloroethene	1
cis-1,3-Dichloropropene	1
Dibromochloromethane	1
Dibromomethane	1
Dichlorodifluoromethane	2
Ethylbenzene	1
Ethylene dibromide	1
Freon-113	1
Hexachlorobutadiene	1
Isopropylbenzene	1
m- and *p*-Xylene isomers	1
Methylene chloride	1
n-Butylbenzene	1
n-Propylbenzene	1
Naphthalene	1
o-Xylene	1
Isopropyl toluene	1
sec-Butylbenzene	1
Styrene	1
tert-Butylbenzene	1
Tetrachloroethene	1
Toluene	1
trans-1,2-Dichloroethene	1
trans-1,3-Dichloropropene	1
Trichloroethene	0.5
Trichlorofluoromethane	1
Vinyl chloride	2
EPA Method 525	
2,4-Dinitrotoluene	0.5
2,6-Dinitrotoluene	0.5
4,4'-DDD	0.5
4,4'-DDE	0.5
4,4'-DDT	0.5
Acenaphthylene	0.5
Alachlor	0.5
Aldrin	0.5
Anthracene	0.5
Aroclor 1016 (PCB)	0.5
Aroclor 1221 (PCB)	0.5
Aroclor 1232 (PCB)	0.5
Aroclor 1242 (PCB)	0.5
Aroclor 1248 (PCB)	0.5

Table B-2 (cont.). Organic constituents of concern in water samples and their contractual reporting limits of concentration, sorted by analytical method.

Constituent of concern	Reporting limit (µg/L)[(a,b)]
EPA Method 525 (cont.)	
Aroclor 1254 (PCB)	0.5
Aroclor 1260 (PCB)	0.5
Atraton	0.5
Atrazine	0.5
Benzo(a)anthracene	0.5
Benzo(a)pyrene	0.5
Benzo(b)fluoranthene	0.5
Benzo(g,h,i)perylene	0.5
Benzo(k)fluoranthene	0.5
Bis(2-ethylhexyl)phthalate	0.5
Bromacil	0.5
Butachlor	0.5
Butylbenzylphthalate	0.5
Chlordane	0.5
Chloropropham	0.5
Chlorpyrifos	0.5
Chrysene	0.5
Di (2-ethylhexyl) adipate	0.5
Di-n-butylphthalate	0.5
Diazinon	0.5
Dibenzo(a,h)anthracene	0.5
Dichlorvos	0.5
Dieldrin	0.5
Diethylphthalate	0.5
Dimethylphthalate	0.5
Disulfoton	0.5
Endosulfan I	0.5
Endosulfan II	0.5
Endosulfan sulfate	0.5
Endrin	0.5
Endrin aldehyde	0.5
Ethoprop	0.5
Fluorene	0.5
Heptachlor	0.5
Heptachlor epoxide	0.5
Hexachlorobenzene	0.5
Hexachlorocyclopentadiene	0.5
Indeno(1,2,3-c,d)pyrene	0.5
Isophorone	0.5
Lindane	0.5
Merphos	0.5
Methoxychlor	0.5
Metolachlor	0.5
Metribuzin	0.5
Mevinphos	0.5
Pentachlorobenzene	0.5
Pentachlorophenol	0.5
Phenanthrene	0.5
Prometon	0.5
Prometryne	0.5
Propachlor	0.5
Pyrene	0.5
Simazine	0.5
Stirophos	0.5
Terbutryn	0.5
Toxaphene	0.5
EPA Method 547	
Glyphosate	20
EPA Method 601	
1,1,1-Trichloroethane	0.5
1,1,2,2-Tetrachloroethane	0.5
1,1,2-Trichloroethane	0.5
1,1-Dichloroethane	0.5
1,1-Dichloroethene	0.5
1,2-Dichlorobenzene	0.5
1,2-Dichloroethane	0.5
1,2-Dichloroethene (total)	0.5
1,2-Dichloropropane	0.5
1,3-Dichlorobenzene	0.5
1,4-Dichlorobenzene	0.5
2-Chloroethylvinylether	0.5
Bromodichloromethane	0.5
Bromoform	0.5
Bromomethane	0.5
Carbon tetrachloride	0.5
Chlorobenzene	0.5
Chloroethane	0.5

Table B-2 (cont.). Organic constituents of concern in water samples and their contractual reporting limits of concentration, sorted by analytical method.

Constituent of concern	Reporting limit (µg/L)[a,b]
EPA Method 601 (cont.)	
Chloroform	0.5
Chloromethane	0.5
cis-1,2-Dichloroethene	0.5
cis-1,3-Dichloropropene	0.5
Dibromochloromethane	0.5
Dichlorodifluoromethane	0.5
Freon-113	0.5
Methylene chloride	0.5
Tetrachloroethene *trans*-1,2-	0.5
Dichloroethene *trans*-1,3-	0.5
Dichloropropene	0.5
Trichloroethene	0.5
Trichlorofluoromethane	0.5
Vinyl chloride	0.5
EPA Method 608	
Aldrin	0.05
BHC, alpha isomer	0.05
BHC, beta isomer	0.05
BHC, delta isomer	0.05
BHC, gamma isomer (Lindane)	0.05
Chlordane	0.2
Dieldrin	0.1
Endosulfan I	0.05
Endosulfan II	0.1
Endosulfan sulfate	0.1
Endrin	0.1
Endrin aldehyde	0.1
Heptachlor	0.05
Heptachlor epoxide	0.05
Methoxychlor	0.5
4,4’-DDD	0.1
4,4’-DDE	0.1
4,4’-DDT	0.1
Toxaphene	1
EPA Method 615	
2,4,5-T	0.5
2,4,5-TP (Silvex)	0.2
2,4-D	1
2,4-Dichlorophenoxy acetic acid	2
Dalapon	10
Dicamba	1
Dichloroprop	2
Dinoseb	1
MCPA	250
MCPP	250
EPA Method 624	
1,1,1-Trichloroethane	1
1,1,2,2-Tetrachloroethane	1
1,1,2-Trichloroethane	1
1,1-Dichloroethane	1
1,1-Dichloroethene	1
1,2-Dichlorobenzene	1
1,2-Dichloroethane	1
1,2-Dichloroethene (total)	1
1,2-Dichloropropane	1
1,3-Dichlorobenzene	1
1,4-Dichlorobenzene	1
2-Butanone	20
2-Chloroethylvinylether	20
2-Hexanone	20
4-Methyl-2-pentanone	20
Acetone	10
Benzene	1
Bromodichloromethane	1
Bromoform	1
Bromomethane	2
Carbon disulfide	1
Carbon tetrachloride	1
Chlorobenzene	1
Chloroethane	2
Chloroform	1
Chloromethane	2
cis-1,2-Dichloroethene	1
cis-1,3-Dichloropropene	1
Dibromochloromethane	1
Dibromomethane	1
Dichlorodifluoromethane	2
Ethylbenzene	1
Freon 113	1
Methylene chloride	1

Table B-2 (cont.). Organic constituents of concern in water samples and their contractual reporting limits of concentration, sorted by analytical method.

Constituent of concern	Reporting limit (µg/L)[a,b]
EPA Method 624 (cont.)	
Styrene	1
Tetrachloroethene	1
Toluene	1
Total xylene isomers	2
trans-1,2-Dichloroethene	1
trans-1,3-Dichloropropene	1
Trichloroethene	0.5
Trichlorofluoromethane	1
Vinyl acetate	1
Vinyl chloride	1
EPA Method 625	
1,2,4-Trichlorobenzene	5
1,2-Dichlorobenzene	5
1,3-Dichlorobenzene	5
1,4-Dichlorobenzene	5
2,4,5-Trichlorophenol	5
2,4,6-Trichlorophenol	5
2,4-Dichlorophenol	5
2,4-Dimethylphenol	5
2,4-Dinitrophenol	25
2,4-Dinitrotoluene	5
2,6-Dinitrotoluene	5
2-Chloronaphthalene	5
2-Chlorophenol	5
2-Methylphenol	5
2-Methyl-4,6-dinitrophenol	25
2-Methylnaphthalene	5
2-Nitroaniline	25
3,3'-Dichlorobenzidine	10
3-Nitroaniline	25
4-Bromophenylphenylether	5
4-Chloro-3-methylphenol	10
4-Chloroaniline	10
4-Chlorophenylphenylether	5
4-Nitroaniline	25
4-Nitrophenol	25
Acenaphthene	25
Acenaphthylene	5
Anthracene	5
Benzo[*a*]a nthracene	5
Benzo[*a*]p yrene	5
Benzo[*b*]f luoranthene	5
Benzo[*g,h,i*]p erylene	5
Benzo[*k*]fluoranthene	5
Benzoic acid	25
Benzyl alcohol	10
Bis(2-chloroethoxy)methane	5
Bis(2-chloroisopropyl)ether	5
Bis(2-ethylhexyl)phthalate	5
Butylbenzylphthalate	5
Chrysene	5
Di-*n*-butylphthalate	5
Di-*n*-octylphthalate	5
Dibenzo[*a,h*]a nthracene	5
Dibenzofuran	5
Diethylphthalate	5
Dimethylphthalate	5
Fluoranthene	5
Fluorene	5
Hexachlorobenzene	5
Hexachlorobutadiene	5
Hexachlorocyclopentadiene	5
Hexachloroethane	5
Indeno[*1,2,3-c,d*]p yrene	5
Isophorone	5
m- and *p*-Cresol	5
N-Nitroso-di-*n*-propylamine	5
Naphthalene	5
Nitrobenzene	5
Pentachlorophenol	5
Phenanthrene	5
Phenol	5
Pyrene	5
EPA Method 632	
Diuron	0.1
EPA Method 8082	
Polychlorinated biphenyls (PCBs)	0.5
EPA Method 8140	
Bolstar	1
Chlorpyrifos	1
Coumaphos	1
Demeton	1
Diazinon	1

Table B-2 (cont.). Organic constituents of cncern in water samples and their contractual reporting limits of concentration, sorted by analytical method.

Constituent of concern	Reporting limit (µg/L)[a,b]
EPA Method 8140 (cont.)	
Dichlorvos	1
Disulfoton	1
Ethoprop	1
Fensulfothion	1
Fenthion	1
Merphos	1
Methyl Parathion	1
Mevinphos	1
Naled	1
Phorate	1
Prothiophos	1
Ronnel	1
Stirophos	1
Trichloronate	1
EPA Method 8260	
1,1,1,2-Tetrachloroethane	0.5
1,1,1-Trichloroethane	0.5
1,1,2,2-Tetrachloroethane	0.5
1,1,2-Trichloroethane	0.5
1,1-Dichloroethane	0.5
1,1-Dichloroethene	0.5
1,2,3-Trichloropropane	0.5
1,2-Dibromo-3-chloropropane	0.5
1,2-Dichloroethane	0.5
1,2-Dichloroethene (total)	0.5
1,2-Dichloropropane	0.5
2-Butanone	0.5
2-Chloroethylvinylether	0.5
2-Hexanone	0.5
4-Methyl-2-pentanone	0.5
Acetone	10
Acetonitrile	100
Acrolein	50
Acrylonitrile	50
Benzene	0.5
Bromodichloromethane	0.5
Bromoform	0.5
Bromomethane	0.5
Carbon disulfide	5
Carbon tetrachloride	0.5
Chlorobenzene	0.5
Chloroethane	0.5
Chloroform	0.5
Chloromethane	0.5
Chloroprene	5
Dibromochloromethane	0.5
Dichlorodifluoromethane	0.5
Ethanol	1000
Ethylbenzene	0.5
Freon-113	0.5
Methylene chloride	0.5
Styrene	0.5
Tetrachloroethene	0.5
Toluene	0.5
Total xylene isomers	0.5
Trichloroethene	0.5
Trichlorofluoromethane	0.5
Vinyl acetate	20
Vinyl chloride	0.5
cis-1,2-Dichloroethene	0.5
cis-1,3-Dichloropropene	0.5
trans-1,2-Dichloroethene	0.5
trans-1,3-Dichloropropene	0.5
EPA Method 8290	
1,2,3,4,6,7,8-HpCDD	0.00025
1,2,3,4,6,7,8-HpCDF	0.00025
1,2,3,4,7,8,9-HpCDF	0.00025
1,2,3,4,7,8-HxCDF	0.00025
1,2,3,6,7,8-HxCDD	0.00025
1,2,3,6,7,8-HxCDF	0.00025
1,2,3,7,8,9-HxCDD	0.00025
1,2,3,7,8,9-HxCDF	0.00025
1,2,3,7,8-PeCDD	0.0001
1,2,3,7,8-PeCDF	0.0001
2,3,4,6,7,8-HxCDF	0.00025
2,3,4,7,8-PeCDF	0.0001
2,3,7,8-TCDD	0.0001
2,3,7,8-TCDF	0.0001
OCDD	0.0005
OCDF	0.0005

Table B-2 (cont.). Organic constituents of concern in water samples and their contractual reporting limits of concentration, sorted by analytical method.

Constituent of concern	Reporting limit (µg/L)[a,b]
EPA Method 8330B	5 or 1
HMX[c]	5 or 1
RDX[d]	5
TNT[e]	0.0001

Constituent of concern	Reporting limit (µg/L)[a,b]
EPA Method 9131 or Standard Method 9221	MPN[f]/100mL
Fecal coliform bacteria	1 to 2
Total coliform bacteria	1 to 2

(a) The number of decimal places displayed in this table vary by constituent. These variations reflect regulatory agency permit stipulations, the applicable analytical laboratory contract under which the work was performed, or both.

(b) These reporting limits are for water samples with low concentrations of dissolved solids. If higher concentrations are present, limits are likely to be higher.

(c) HMX is octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine.

(d) RDX is hexahydro-1,3,5-trinitro-1,3,5-triazine.

(e) TNT is 2,4,6-trinitrotoluene.

(f) MPN = most probable number (of organisms).

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APPENDIX C
Wildlife Survey Results

Table C-1. Site 300 wildlife species list. Includes species for which there are verified observations; it is not intended to be a complete list of Site 300 species.

Taxa	Common Name	Scientific Name	Regulatory Status[a]	Source
Mammals	Pallid bat	*Antrozous pallidus*	CASSC	Rainey 2003
	Western red bat	*Lasiurus blossevillii*	CASSC	Rainey 2003
	Hoary bat	*Lasiurus cinereus*		Rainey 2003
	California myotis	*Myotis californicus*		Rainey 2003
	Western pipistrelle	*Pipistrellus hesperus*		Rainey 2003
	Brazilian free-tailed bat	*Tadarida brasiliensis*		Rainey 2003
	Desert cottontail	*Sylvilagus audubonii*		LLNL 2002; Clark et al. 2002
	Black-tailed jackrabbit	*Lepus californicus*		LLNL 2002; Clark et al. 2002
	Heermann's kangaroo rat	*Dipodomys heermanni*		LLNL 2002; West 2002
	California pocket mouse	*Chaetodipus californicus*		LLNL 2002; West 2002
	San Joaquin pocket mouse	*Perognathus inornatus inornatus*		Clark et al. 2002
	California ground squirrel	*Spermophilus beecheyi*		LLNL 2002
	Botta's pocket gopher	*Thomomys bottae*		LLNL 2002; West 2002
	California vole	*Microtus californicus*		LLNL 2002; West 2002
	House mouse	*Mus musculus*		LLNL 2002; West 2002
	Dusky-footed woodrat	*Neotoma fuscipes*		LLNL 2002; West 2002
	Brush mouse	*Peromyscus boylii*		LLNL 2002; West 2002
	Deer mouse	*Peromyscus maniculatus*		LLNL 2002; West 2002
	Western harvest mouse	*Reithrodontomys megalotis*		LLNL 2002; West 2002
	Coyote	*Canis latrans*		LLNL 2002; Clark et al. 2002
	Raccoon	*Procyon lotor*		LLNL 2002; Orloff 1986
	Long-tailed weasel	*Mustela frenata*		LLNL 2002 ; Orloff 1986
	Striped skunk	*Mephitis mephitis*		LLNL 2002; Orloff 1986
	Western spotted skunk	Spilogale gracilis		LLNL 2002; Orloff 1986
	American badger	Taxidea taxus	CASSC	LLNL 2002; Clark et al. 2002
	Bobcat	*Lynx rufus*		LLNL 2002; Clark et al. 2002
	Mountain Lion	*Puma concolor*		LLNL 2002
	Mule deer	*Odocoileus hemionus*		LLNL 2002; Clark et al. 2002
	Wild pig	*Sus scrofa*		LLNL 2002; Clark et al. 2002
Herpetofauna	Arboreal salamander	*Aneides lugubris*		Woollett 2005
	California tiger salamander	*Ambystoma californiense*	FT, CASSC	LLNL 2002
	California slender salamander	*Batrachoseps attenuatus*		Burkholder 2008
	California red-legged frog	*Rana draytonii*	FT, CASSC	LLNL 2002
	Pacific treefrog	*Pseudacris regilla*		LLNL 2002

Table C-1 (cont.). Site 300 wildlife species list. Includes species for which there are verified observations; it is not intended to be a complete list of Site 300 species.

Taxa	Common Name	Scientific Name	Regulatory Status[a]	Source
Herpetofauna (cont.)	Western spadefoot toad	*Spea hammondii*	CASSC	LLNL 2002
	Western toad	*Bufo boreas*		LLNL 2002
	Alameda whipsnake	*Masticophis lateralis euryxanthus*	FT, ST	Swaim 2002
	San Joaquin coachwhip	*Masticophis flagellum ruddocki*	CASSC	LLNL 2002
	Coast horned lizard	*Phrynosoma coronatum*	CASSC	LLNL 2002
	California legless lizard	*Anniella pulchra*	CASSC	Swaim 2002
	Side-blotched lizard	*Uta stansburiana*		LLNL 2002; Swaim 2002
	Western whiptail	*Aspidoscelis tigris*		LLNL 2002; Swaim 2002
	Western fence lizard	*Sceloporus occidentalis*		LLNL 2002; Swaim 2002
	Western skink	*Eumeces skiltonianus*		LLNL 2002; Swaim 2002
	Gilbert skink	*Eumeces gilberti*		LLNL 2002; Swaim 2002
	Southern alligator lizard	*Elgaria multicarinata*		LLNL 2002; Swaim 2002
	Racer	*Coluber constrictor*		LLNL 2002; Swaim 2002
	Gopher snake	*Pituophis catenifer*		LLNL 2002; Swaim 2002
	California kingsnake	*Lampropeltis getula californiae*		LLNL 2002; Swaim 2002
	Western rattlesnake	*Crotalus viridis*		LLNL 2002; Swaim 2002
	Night snake	*Hypsiglena torquata*		LLNL 2002; Swaim 2002
	Glossy snake	*Arizona elegans*		LLNL 2002; Swaim 2002
	Long-nosed snake	*Rhinocheilus lecontei*		LLNL 2002; Swaim 2002
	California black-headed snake	*Tantilla planiceps*		Swaim 2002
Birds	Pied-billed Grebe	*Podilymbus podiceps*	MBTA	LLNL 2003
	Double-crested Cormorant	*Phalacrocorax auritus*	MBTA	LLNL 2003
	Great Egret	*Ardea alba*	MBTA	LLNL 2003
	Turkey Vulture	*Cathartes aura*	MBTA	LLNL 2003
	Bufflehead	*Bucephala albeola*	MBTA	LLNL 2003
	Common Goldeneye	*Bucephala clangula*	MBTA	LLNL 2003
	Mallard	*Anas platyryynchos*	MBTA	LLNL 2003
	Northern Shoveler	*Anas clypeata*	MBTA	LLNL 2003
	Cinnamon Teal	*Anas cyanoptera*	MBTA	LLNL 2003
	Red-shouldered Hawk	*Buteo lineatus*	MBTA	LLNL 2003
	Osprey	*Pandion haliaetus*	MBTA	LLNL 2003
	Golden Eagle	*Aquila chrysaetos*	CAFPS, BCC, MBTA, EPA	LLNL 2003
	Rough-legged Hawk	*Buteo lagopus*	MBTA	LLNL 2003
	Ferruginous Hawk	*Buteo regalis*	MBTA	LLNL 2003

Table C-1 (cont.). Site 300 wildlife species list. Includes species for which there are verified observations; it is not intended to be a complete list of Site 300 species.

Taxa	Common Name	Scientific Name	Regulatory Status[(a)]	Source
Birds (cont.)	Red-tailed Hawk	*Buteo jamaicensis*	MBTA	LLNL 2003
	Swainson's Hawk	*Buteo swainsoni*	ST, MBTA	LLNL 2003
	White-tailed Kite	*Elanus leucurus*	CAFPS, MBTA	LLNL 2003
	Cooper's Hawk	*Accipiter cooperii*	MBTA	LLNL 2003
	Sharp-shinned Hawk	*Accipiter striatus*	MBTA	LLNL 2003
	Northern Harrier	*Circus cyaneus*	CASSC, MBTA	LLNL 2003
	Prairie Falcon	*Falco mexicanus*	MBTA	LLNL 2003
	American Kestrel	*Falco sparverius*	MBTA	LLNL 2003
	Wild Turkey	*Meleagris gallopavo*		LLNL 2003
	California Quail	*Callipepla californica*		LLNL 2003
	Virginia Rail	*Rallus limicola*	MBTA	U.S. DOE and UC 1992
	Killdeer	*Charadrius vociferus*	MBTA	LLNL 2003
	Greater Yellowlegs	*Tringa melanoleuca*	MBTA	LLNL 2003
	Wilson’s Snipe	*Gallinago delicata*	MBTA	LLNL 2003
	Mourning Dove	*Zenaida macroura*	MBTA	LLNL 2003
	Rock Dove	*Columba livia*		U.S. DOE and UC 1992
	Greater Roadrunner	*Geococcyx californianus*	MBTA	LLNL 2003
	Barn Owl	*Tyto alba*	MBTA	LLNL 2003
	Short-eared Owl	*Asio flammeus*	CASSC, MBTA	LLNL 2003
	Great Horned Owl	*Bubo virginianus*	MBTA	LLNL 2003
	Burrowing Owl	*Athene cunicularia*	CASSC, BCC, MBTA	LLNL 2003
	Western Screech Owl	*Megascops kennicottii*	MBTA	LLNL 2003
	Common Poorwill	*Phalaenoptilus nuttalii*	MBTA	LLNL 2003
	White-throated Swift	*Aeronautes saxatalis*	MBTA	LLNL 2003
	Allen’s Hummingbird	*Selasphorus sasin*	BCC, MBTA	U.S. DOE and UC 1992
	Rufous Hummingbird	*Selasphorus rufus*	MBTA	LLNL 2003
	Costa's Hummingbird	*Calypte costae*	BCC, MBTA	LLNL 2003
	Anna's Hummingbird	*Calypte anna*	MBTA	LLNL 2003
	Northern Flicker	*Colaptes auratus*	MBTA	LLNL 2003
	Nuttal's Woodpecker	*Picoides nuttallii*	BCC, MBTA	LLNL 2003
	Acorn Woodpecker	*Melanerpes formicivorus*	MBTA	U.S. DOE and UC 1992
	Ash-throated Flycatcher	*Myiarchus cinerascens*	MBTA	LLNL 2003
	Cassin's Kingbird	*Tyrannus vociferans*	MBTA	LLNL 2003
	Western Kingbird	*Tyrannus verticalis*	MBTA	LLNL 2003
	Western Wood-pewee	*Contopus sordidulus*	MBTA	U.S. DOE and UC 1992
	Willow Flycatcher	*Empidonax traillii*	SE, MBTA	van Hattem 2005
	Pacific-slope Flycatcher	*Empidonax difficillis*	MBTA	LLNL 2003

Table C-1 (cont.). Site 300 wildlife species list. Includes species for which there are verified observations; it is not intended to be a complete list of Site 300 species.

Taxa	Common Name	Scientific Name	Regulatory Status[a]	Source
Birds (cont.)	Black Phoebe	*Sayornis nigricans*	MBTA	LLNL 2003
	Say's Phoebe	*Sayornis saya*	MBTA	LLNL 2003
	Loggerhead Shrike	*Lanius ludovicianus*	CASSC, BCC, MBTA	LLNL 2003
	Western Scrub Jay	*Aphelocoma californica*	MBTA	LLNL 2003
	American Crow	*Corvus brachyrhynchos*	MBTA	LLNL 2003
	Common Raven	*Corvus corax*	MBTA	LLNL 2003
	Horned Lark	*Eremophila alpestris*	MBTA	LLNL 2003
	Tree Swallow	*Tachycineta bicolor*	MBTA	LLNL 2003
	Cliff Swallow	*Petrochelidon pyrrhonota*	MBTA	LLNL 2003
	Northern Rough Winged Swallow	*Stelgidopteryx serripennis*	MBTA	LLNL 2003
	Oak Titmouse	*Baeolphus inornatus*	BCC, MBTA	LLNL 2003
	Bushtit	*Psaltriparus minimus*	MBTA	LLNL 2003
	House Wren	*Troglodytes aedon*	MBTA	LLNL 2003
	Rock Wren	*Salpinctes obsoletus*	MBTA	LLNL 2003
	Bewick's Wren	*Thryomanes bewickii*	MBTA	LLNL 2003
	Ruby-crowned Kinglet	*Regulus calendula*	MBTA	LLNL 2003
	Hermit Thrush	*Catharus guttatus*	MBTA	LLNL 2003
	Swainson's Thrush	*Catharus ustulatus*	MBTA	LLNL 2003
	Western Buebird	*Sialia mexicana*	MBTA	LLNL 2003
	Mountain Bluebird	*Sialia currucoides*	MBTA	LLNL 2003
	American Robin	*Turdus migratorius*	MBTA	LLNL 2003
	Varied Thrush	*Ixoreus naevius*	MBTA	LLNL 2003
	California Thrasher	*Toxostoma redivivum*	MBTA	LLNL 2003
	Northern Mockingbird	*Mimus polyglottos*	MBTA	LLNL 2003
	European Starling	*Sturnus vulgaris*		LLNL 2003
	Cedar Waxwing	*Bombycilla garrulus*	MBTA	LLNL 2003
	Phainopepela	*Phainopepla nitens*	MBTA	LLNL 2003
	MacGillivary's Warbler	*Oporornis tolmiei*	MBTA	LLNL 2003
	Common Yellowthroat	*Geothlypis trichas*	BCC, MBTA	LLNL 2003
	Wilson's Warbler	*Wilsonia pusilla*	MBTA	LLNL 2003
	Orange-crowned Warbler	*Vermivora celata*	MBTA	LLNL 2003
	Yellow Warbler	*Dendroica petechia*	BCC, CASSC, MBTA	LLNL 2003
	Yellow-rumped Warbler	*Dendroica coronata*	MBTA	LLNL 2003
	Black-throated Gray Warbler	*Dendroica nigrescens*	MBTA	LLNL 2003
	Western Tanager	*Piranga ludoviciana*	MBTA	LLNL 2003
	Song Sparrow	*Melospiza melodia*	MBTA	LLNL 2003
	Lincoln's Sparrow	*Melospiza lincolnii*	MBTA	LLNL 2003

Table C-1 (cont.). Site 300 wildlife species list. Includes species for which there are verified observations; it is not intended to be a complete list of Site 300 species.

Taxa	Common Name	Scientific Name	Regulatory Status[a]	Source
Birds (cont.)	Fox Sparrow	*Passerella iliaca*	MBTA	LLNL 2003
	White-crowned Sparrow	*Zonotrichia leucophrys*	MBTA	LLNL 2003
	Golden-crowned Sparrow	*Zonotrichia atricapilla*	MBTA	LLNL 2003
	Dark-eyed Junco	*Junco hyemalis*	MBTA	LLNL 2003
	Black-throated Sparrow	*Amphispiza bilineata*	MBTA	LLNL 2003
	California Towhee	*Pipilo crissalis*	MBTA	LLNL 2003
	Vesper Sparrow	*Pooecetes gramineus*	MBTA	U.S. DOE and UC 1992
	Lark Sparrow	*Chondestes grammacus*	MBTA	LLNL 2003
	Bell's Sage Sparrow	*Amphispiza belli*	MBTA	LLNL 2003
	Savannah Sparrow	*Passerculus sandwichensis*	MBTA	LLNL 2003
	Grasshopper Sparrow	*Ammodramus savannarum*	CASSC, MBTA	LLNL 2003
	Rufous Crowned Sparrow	*Aimophila ruficeps*	MBTA	LLNL 2003
	Lazuli Bunting	*Passerina amoena*	MBTA	LLNL 2003
	Blue-grosbeak	*Passerina caerulea*	MBTA	LLNL 2003
	Black-headed Grosbeak	*Pheucticus melanocephalus*	MBTA	U.S. DOE and UC 1992
	Bullock's Oriole	*Icterus bullockii*	MBTA	LLNL 2003
	Brown-headed Cowbird	*Molothrus ater*	MBTA	LLNL 2003
	Red-winged Blackbird	*Agelaius phoeniceus*	MBTA	LLNL 2003
	Tricolored Blackbird	*Agelaius tricolor*	CASSC, BCC, MBTA	LLNL 2003
	Western Meadowlark	*Sturnella neglecta*	MBTA	LLNL 2003
	Brewer's Blackbird	*Euphagus cyanocephalus*	MBTA	LLNL 2003
	Lesser Goldfinch	*Carduelis psaltria*	MBTA	LLNL 2003
	House Finch	*Carpodacus mexicanus*	MBTA	LLNL 2003
Invertebrates	Valley elderberry longhorn beetle	*Desmocerus californicus dimorphus*	FT	Arnold 2002
	California fairy shrimp	*Linderiella occidentalis*		Weber 2002
	California clam shrimp	*Cyzicus californicus*		Weber 2002

(a) BCC = U.S. Fish and Wildlife Service Birds of Conservation Concern (US Fish and Wildlife Service 2008)
CAFPS = California Department of Fish and Game Fully Protected Species (CA Fish and Game Code Section 3511)
CASSC = California Species of Special Concern (CA Dept. of Fish and Game, Special Animals List, March 2006)
EPA = Eagle Protection Act
FT = Threatened under the Federal Endangered Species Act
MBTA = Migratory Bird Treaty Act
SE = Endangered under the State Endangered Species Act
ST = Threatened under the State Endangered Species Act

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APPENDIX D
Extra Resources

The documents listed below are accessible as PDFs on CD or at https://saer.llnl.gov, the website for the LLNL annual environmental report. In the electronic version of this appendix, the resources are linked to the PDFs.

Livermore Site Storm Water Monitoring for Waste Discharge Requirements 95-174, 2007–2008

Revelli, M.A. and K. Brunckhorst. (2008). *Lawrence Livermore National Laboratory Livermore Site Annual Storm Water Monitoring Report for Waste Discharge Requirements 95-174, Annual Report 2007–2008*. Livermore, California: Lawrence Livermore National Laboratory, UCRL-AR-126783-08.

LLNL Ground Water Project Annual Report, 2008

Valett, J., P. McKereghan, E. Folsom, and M. Dresen, eds (2009). *LLNL Ground Water Project 2008 Annual Report*. Livermore, California: Lawrence Livermore National Laboratory, UCRL-AR-126020-08.

LLNL NESHAPs Annual Report, 2008

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APPENDIX E
Errata

Protocol for Errata in LLNL Environmental Reports

The primary form of publication for the LLNL Environmental Report is electronic: the report is posted on the Internet. A limited number of copies are also printed and distributed, including to local libraries. If errors are found after publication, the Internet version is corrected. Because the printed versions cannot be corrected, errata for these versions are published in a subsequent report. In this way, the equivalency of all published versions of the report is maintained.

In 1998, LLNL established the following protocol for post-publication revisions to the environmental report: (1) the environmental report website must clearly convey what corrections, if any, have been made and provide a link to a list of the errata, (2) the Internet version must be the most current version, incorporating all corrections, and (3) the electronic and printed versions must be the same in that the printed version plus errata, if any, must provide the same information as the Internet version.

LLNL environmental reports from 1994 through 2008 can be accessed at https://saer.llnl.gov/.

Record of Changes to Environmental Report 2007

The following changes have been made to the Internet version of *Environmental Report 2007*.

- Page 1-4, Figure 1-2: The "calm" wind speed for the Livermore site was changed from 1>7.0 (mph) to >15.6 (mph).
- Page 3-6, Table 3-3: The "FY 2007" column was changed to read as follows:

Waste Category	FY 2007
Routine hazardous waste generated	138 MT
Routine low-level waste generated	197 m^3
Routine mixed waste generated	30 m^3
Routine TRU/mixed TRU waste generated	No change

- Page AC-6, Metric and U.S. Customary Unit Equivalents table: In the "Radioactivity" row of the "From U.S. customary unit to metric equivalent unit" column, 3.7×10^{-10} becquerel (Bq) was changed to 3.7×10^{10} becquerel (Bq).

Record of Changes to Environmental Reports 2002

- Page C-4, Table C-2, footnote (b): The clause after the semicolon, “to account for skin absorption, DOE and ICRP multiply inhalation rate by 1.5,” was changed to “because skin absorption and inhalation have the same dose conversion factor, and because the uptake of the body by skin absorption is 0.5 times the uptake by inhalation, DOE and ICRP account for skin absorption dose by multiplying the inhalation dose by a factor of 1.5.”
- Page GL-7, Metric and U.S. Customary Unit Equivalents table: In the “Radioactivity” row of the “From U.S. customary unit to metric equivalent unit” column, 3.7×10^{-10} becquerel (Bq) was changed to 3.7×10^{10} becquerel (Bq).

Record of Changes to Environmental Reports 2001 and 2003–2006

- Glossary (see page numbers below), Metric and U.S. Customary Unit Equivalents table: In the “Radioactivity” row of the “From U.S. customary unit to metric equivalent unit” column, 3.7×10^{-10} becquerel (Bq) was changed to 3.7×10^{10} becquerel (Bq).

Report Year	Page number
2001	GL-7
2003	GL-7
2004	GL-7
2005	GL-9
2006	GL-1

Data Workbooks

Data Workbooks

AF-LOWVOL

A.1.1 Summary of gross alpha and gross beta (µBq/m^3) in background locations for comparison to monitored air effluent emission points in 2008

Analyte Location	No. > MDC[(a)]	Minimum	Median	Maximum
Gross alpha				
FCC	12 of 53	-18.8	51.4	374
HOSP	5 of 53	-17.6	38.1	278
WCP	12 of 51	-4.85	51.1	270
Gross beta				
FCC	51 of 53	117	744	2930
HOSP	48 of 53	90.7	533	2390
WCP	49 of 51	75.1	618	2390

(a) MDC = minimum detectable concentration

AE-235

A.1.2 Summary of gross alpha and gross beta (μBq/m^3) in air effluent samples from the monitored emission point at Livermore site, Building 235, 2008

Analyte Emission Point	No. > MDC[a]	Minimum	Median	Maximum
Gross alpha				
PAM_1	0 of 53	-16.1	-3.58	67.7
Gross beta				
PAM_1	0 of 53	-118	-2	144

(a) MDC = minimum detectable concentration

A.1.3 Summary of gross alpha and gross beta ($\mu Bq/m^3$) in air effluent samples from the monitored emission points at Livermore site, Building 491, 2008

Analyte Emission Point	No. > MDC[(a)]	Minimum	Median	Maximum
Gross alpha				
PAM_1	1 of 26	-2.45	1.19	792
Gross beta				
PAM_1	5 of 26	-9.4	18	1390

(a) MDC = minimum detectable concentration

A.1.4 Summary of gross alpha and gross beta (µBq/m^3) in air effluent samples from the monitored emission point at Livermore site, Building 695, 2008

Analyte Emission Point	No. > MDC[(a)]	Minimum	Median	Maximum
Gross alpha				
PAM_1	1 of 53	-28.2	-1.53	67.3
Gross beta				
PAM_1	1 of 53	-47.4	-2.23	156

(a) MDC = minimum detectable concentration

AE-695H3

A.1.5 Summary of tritium (Bq/m^3) in air effluent samples from the monitored emission point at Livermore site, Building 695, 2008

Analyte Emission Point	No. > MDC[a]	Minimum	Median	Maximum
HT[b]				
BUBBLER1	0 of 52	-5.35	0.881	6.78
HTO[c]				
BUBBLER1	20 of 52	-0.571	5.55	16.1

(a) MDC = minimum detectable concentration
(b) HT = tritiated hydrogen gas
(c) HTO = tritiated water and water vapor

A.1.6 Summary of gross alpha and gross beta (µBq/m^3) in air effluent samples from the monitored emission points at Livermore site, Building 332, 2008

Analyte Emission Point	No. > MDC[a]	Minimum	Median	Maximum
Gross alpha				
SP-1B	0 of 53	-10.5	-2.52	67.7
SP-1A	0 of 53	-11.3	-2.5	91.4
SP-2A	0 of 53	-8.36	-2.5	67.3
SP-2B	0 of 53	-12	-2.5	50.7
SP-3	0 of 53	-11	-2.51	42.6
SP-4	0 of 53	-11	-3.92	62.9
SP-6A	0 of 53	-10.6	-2.51	22.5
SP-6B	0 of 53	-8.84	-3.96	21
SP-7B	0 of 53	-12.1	-2.5	21.2
SP-7A	0 of 53	-9.62	-2.52	22.4
SP-8	0 of 31	-10.3	-2.5	47.4
SP-9	0 of 31	-10.5	-2.51	21.2
SP-10	0 of 53	-8.84	-2.52	21.2
SP-11	0 of 53	-11.3	-2.5	73.6
SP-12	0 of 53	-12.9	-3.96	42.9
Gross beta				
SP-1B	0 of 53	-63.3	7.03	80.7
SP-1A	2 of 53	-65.5	12.5	304
SP-2A	0 of 53	-67	-5.81	114
SP-2B	0 of 53	-81.4	-4.22	109
SP-3	0 of 53	-62.2	13.9	112
SP-4	0 of 53	-66.6	-1.39	144
SP-6A	0 of 53	-78.8	-2.28	78.8
SP-6B	0 of 53	-101	-4.26	119
SP-7B	0 of 53	-101	-4.26	128
SP-7A	0 of 53	-95.8	-5.4	160
SP-8	0 of 31	-48.1	21.8	136
SP-9	0 of 31	-62.9	-4.22	130
SP-10	0 of 53	-101	-5.77	115
SP-11	0 of 53	-83.3	-2.29	85.1
SP-12	0 of 53	-96.2	-4.96	125

(a) MDC = minimum detectable concentration

AE-331

A.1.7 Summary of tritium in air effluent samples (Bq/m^3) from the monitored emission points at Livermore site, Building 331, 2008

Analyte Emission Point	equip.id	No. > MDC[a]	Minimum	Median	Maximum
HT[b]					
Stack1	BUBBLER1	52 of 52	50.6	184	2120
Stack2	BUBBLER2	15 of 52	-6.88	4.38	72.9
HTO[c]					
Stack1	BUBBLER1	52 of 52	172	280	2610
Stack2	BUBBLER2	46 of 52	5.23	22.7	137

(a) MDC = minimum detectable concentration
(b) HT = tritiated hydrogen gas
(c) HTO= tritiated water and water vapor

AE-801

A.1.8 Summary of gross alpha and gross beta (μBq/m^3) in air effluent samples from the monitored emission point at Site 300, Building 801, 2008

Analyte Emission Point	No. > MDC(a)	Minimum	Median	Maximum
Gross alpha				
PAM_1	7 of 36	-3.63	19.4	153
Gross beta				
PAM_1	30 of 36	48.8	184	832

(a) MDC = minimum detectable concentration

AF-ABLS

A.2.1 Weekly gross alpha and gross beta concentrations (μBq/m³) from air particulate samples from the Livermore perimeter locations, 2008[(a)]

Date	Gross alpha CAFE	Gross alpha COW	Gross alpha CRED	Gross alpha MESQ	Gross alpha MET	Gross alpha SALV	Gross alpha VIS
8-Jan	3.9 ± 28.2	-3.9 ± 23.9	34.3 ± 41.1	27.1 ± 38.8	11.5 ± 32.0	34.7 ± 41.4	3.8 ± 28.1
15-Jan	-3.3 ± 20.5	3.3 ± 24.2	3.3 ± 24.0	-9.9 ± 15.9	9.9 ± 27.5	16.5 ± 30.5	16.4 ± 30.2
22-Jan	3.3 ± 24.3	16.6 ± 30.5	9.9 ± 27.6	16.6 ± 30.6	23.2 ± 33.1	3.3 ± 24.3	29.6 ± 35.3
29-Jan	-9.9 ± 15.8	3.3 ± 24.2	22.9 ± 32.6	3.3 ± 24.3	9.9 ± 27.5	-3.3 ± 20.5	3.3 ± 24.0
5-Feb	-3.3 ± 20.4	-3.3 ± 20.4	3.3 ± 23.9	3.3 ± 24.3	3.3 ± 24.2	-10.0 ± 16.0	-3.3 ± 20.3
12-Feb	3.3 ± 24.1	36.3 ± 37.7	9.8 ± 27.1	9.9 ± 27.5	9.9 ± 27.4	23.1 ± 33.0	16.4 ± 30.0
19-Feb	36.5 ± 37.7	23.2 ± 33.2	-3.3 ± 20.3	29.6 ± 35.3	-3.3 ± 20.5	9.9 ± 27.5	9.9 ± 27.6
26-Feb	3.3 ± 24.1	3.3 ± 24.1	22.9 ± 32.6	16.4 ± 30.1	9.8 ± 27.3	-9.8 ± 15.7	29.7 ± 35.4
4-Mar	-3.3 ± 20.6	(b)	9.9 ± 27.5	-11.4 ± 18.3	3.3 ± 24.2	36.5 ± 38.1	-3.3 ± 20.6
11-Mar	43.3 ± 40.3	9.9 ± 27.6	29.8 ± 35.6	9.8 ± 27.3	29.9 ± 35.6	16.5 ± 30.4	-10.0 ± 16.0
18-Mar	-3.3 ± 20.6	3.3 ± 24.3	9.9 ± 27.5	-3.3 ± 20.3	16.5 ± 30.4	3.3 ± 24.2	3.3 ± 24.4
25-Mar	10.0 ± 27.7	23.3 ± 33.2	3.3 ± 24.4	9.9 ± 27.3	3.3 ± 24.3	3.3 ± 24.3	23.4 ± 33.4
1-Apr	28.7 ± 34.3	22.3 ± 31.8	41.8 ± 38.8	34.7 ± 36.0	60.3 ± 44.0	28.6 ± 34.1	48.8 ± 41.1
7-Apr	12.1 ± 33.4	20.1 ± 36.9	-4.0 ± 24.6	19.9 ± 36.5	-4.0 ± 24.9	20.2 ± 37.0	4.0 ± 29.3
15-Apr	26.1 ± 31.1	20.3 ± 28.9	2.9 ± 21.2	14.3 ± 26.3	54.8 ± 40.0	2.9 ± 21.2	8.7 ± 24.2
22-Apr	3.3 ± 24.3	29.8 ± 35.5	3.3 ± 24.1	22.9 ± 32.7	3.3 ± 24.2	23.0 ± 32.9	-3.3 ± 20.5
29-Apr	-9.8 ± 15.7	22.8 ± 32.6	16.3 ± 29.9	3.2 ± 23.6	3.3 ± 23.9	38.1 ± 54.4	3.3 ± 24.1
6-May	3.4 ± 24.7	57.0 ± 44.8	16.8 ± 30.8	9.9 ± 27.6	10.1 ± 27.9	29.5 ± 35.2	16.9 ± 31.0
13-May	-3.3 ± 20.5	23.2 ± 33.1	23.1 ± 33.0	22.9 ± 32.7	-3.3 ± 20.5	16.5 ± 30.3	-10.0 ± 16.0
20-May	29.8 ± 35.6	3.3 ± 24.3	-3.3 ± 20.5	3.3 ± 24.0	9.9 ± 27.5	29.4 ± 35.1	43.3 ± 40.3
27-May	16.6 ± 30.5	3.3 ± 24.3	3.3 ± 24.2	-9.7 ± 15.6	23.2 ± 33.0	-3.4 ± 20.8	16.6 ± 30.6
3-Jun	16.5 ± 30.4	36.3 ± 37.7	16.5 ± 30.2	3.2 ± 23.6	9.9 ± 27.4	30.1 ± 35.9	9.9 ± 27.6
10-Jun	-3.3 ± 20.6	23.2 ± 33.2	23.2 ± 33.0	9.7 ± 27.0	3.3 ± 24.3	28.8 ± 34.4	23.3 ± 33.3
17-Jun	36.3 ± 37.7	9.9 ± 27.4	23.0 ± 32.8	36.0 ± 37.4	9.9 ± 27.3	-3.4 ± 20.8	42.9 ± 40.0
24-Jun	16.5 ± 30.4	9.9 ± 27.5	29.7 ± 35.4	23.3 ± 33.3	9.9 ± 27.4	30.3 ± 36.1	16.6 ± 30.6
1-Jul	29.4 ± 35.1	23.1 ± 32.9	22.9 ± 32.7	22.8 ± 32.6	3.3 ± 24.1	23.2 ± 33.2	29.7 ± 35.4
8-Jul	3.4 ± 24.8	70.3 ± 48.1	16.7 ± 30.7	9.7 ± 26.9	30.0 ± 35.9	29.2 ± 34.7	16.9 ± 31.0
15-Jul	42.9 ± 40.0	42.9 ± 39.6	23.0 ± 32.8	35.5 ± 36.9	49.2 ± 41.8	36.0 ± 37.4	29.8 ± 35.5
22-Jul	9.9 ± 27.5	16.5 ± 30.4	9.9 ± 27.4	23.8 ± 34.0	3.3 ± 24.2	-10.4 ± 16.6	-3.3 ± 20.6
29-Jul	10.0 ± 27.7	3.3 ± 24.3	23.2 ± 33.2	3.3 ± 24.1	29.8 ± 35.6	16.6 ± 30.5	-3.3 ± 20.7
5-Aug	3.3 ± 24.2	23.1 ± 33.0	-3.3 ± 20.4	16.3 ± 30.0	-9.9 ± 15.8	16.3 ± 30.0	-3.3 ± 20.6
12-Aug	9.9 ± 27.6	9.9 ± 27.5	3.3 ± 24.1	16.3 ± 29.9	3.3 ± 24.2	-3.4 ± 21.1	-3.3 ± 20.6

19-Aug	9.9 ± 27.5	49.6 ± 41.8	3.3 ± 24.1	47.4 ± 40.0	16.5 ± 30.3	16.8 ± 30.9	3.3 ± 24.3
26-Aug	3.3 ± 24.3	3.3 ± 24.2	3.3 ± 24.1	3.4 ± 24.8	9.9 ± 27.5	16.5 ± 30.4	9.9 ± 27.6
2-Sep	3.3 ± 24.3	-3.3 ± 20.5	42.9 ± 39.6	16.5 ± 30.4	16.5 ± 30.3	23.5 ± 33.5	3.3 ± 24.3
9-Sep	42.9 ± 40.0	36.4 ± 37.7	96.2 ± 54.4	22.8 ± 32.6	23.1 ± 32.9	36.5 ± 37.7	30.1 ± 35.9
16-Sep	67.0 ± 45.9	16.0 ± 29.4	22.3 ± 31.9	17.1 ± 47.4	35.0 ± 36.3	22.5 ± 32.1	-3.2 ± 19.9
23-Sep	51.8 ± 44.0	3.4 ± 25.2	30.2 ± 36.0	18.4 ± 51.1	24.1 ± 34.4	31.0 ± 37.0	3.4 ± 25.3
30-Sep	55.9 ± 43.7	42.6 ± 39.6	(b)	-3.9 ± 24.1	22.8 ± 32.6	35.2 ± 36.6	9.6 ± 26.6
7-Oct	3.3 ± 24.0	9.7 ± 26.8	-3.3 ± 20.3	23.4 ± 42.9	22.3 ± 31.9	36.7 ± 38.1	9.9 ± 27.5
14-Oct	9.8 ± 27.1	3.3 ± 24.4	16.7 ± 30.8	22.9 ± 32.7	23.5 ± 33.5	10.0 ± 27.6	-3.4 ± 20.9
21-Oct	49.6 ± 41.8	22.9 ± 32.7	22.9 ± 32.7	29.4 ± 35.0	35.7 ± 37.0	43.3 ± 40.3	55.9 ± 43.7
28-Oct	92.1 ± 54.4	51.4 ± 43.3	44.4 ± 41.1	30.2 ± 36.1	72.5 ± 49.6	106.0 ± 57.7	85.8 ± 52.9
4-Nov	22.8 ± 32.6	16.2 ± 29.8	54.4 ± 42.6	35.4 ± 36.8	35.7 ± 37.0	62.5 ± 45.5	22.5 ± 32.2
11-Nov	10.1 ± 27.9	3.3 ± 24.5	3.3 ± 24.0	9.9 ± 27.5	3.3 ± 24.4	-3.4 ± 21.1	23.9 ± 34.2
18-Nov	36.6 ± 38.1	29.9 ± 35.7	30.3 ± 36.1	10.9 ± 30.2	23.2 ± 33.2	62.5 ± 45.5	3.3 ± 24.0
25-Nov	16.4 ± 30.2	56.2 ± 44.0	10.0 ± 27.8	9.8 ± 27.2	23.1 ± 33.0	30.2 ± 36.0	43.7 ± 40.7
2-Dec	3.3 ± 24.3	49.9 ± 42.2	75.8 ± 49.2	42.6 ± 39.6	23.2 ± 33.1	30.1 ± 35.9	56.6 ± 44.4
9-Dec	3.3 ± 24.0	29.9 ± 35.6	3.3 ± 24.2	16.3 ± 30.0	3.3 ± 24.2	-3.3 ± 20.6	10.0 ± 27.7
15-Dec	10.9 ± 30.2	32.8 ± 39.2	62.2 ± 48.5	32.6 ± 38.8	54.8 ± 46.2	(c)	64.0 ± 49.9
16-Dec	(c)	(c)	(c)	(c)	(c)	9.9 ± 27.5	(c)
23-Dec	20.4 ± 29.2	51.4 ± 40.0	-8.7 ± 13.9	26.8 ± 32.0	15.1 ± 27.7	16.6 ± 30.5	20.8 ± 29.7
29-Dec	-3.8 ± 23.6	19.3 ± 35.4	3.9 ± 28.2	3.8 ± 27.7	19.2 ± 35.3	3.9 ± 28.5	-3.9 ± 24.0
Detection frequency	8 of 52	9 of 51	7 of 51	2 of 52	5 of 52	4 of 52	8 of 52
Median	9.97	20.3	16.5	16.4	13.3	21.4	9.95
IQR[(d)]	25.6	28	19.9	15.3	20	26.5	22
Maximum	92.1	70.3	96.2	47.4	72.5	106	85.8

Date	Gross beta CAFE	Gross beta COW	Gross beta CRED	Gross beta MESQ	Gross beta MET	Gross beta SALV	Gross beta VIS
8-Jan	333 ± 150	305 ± 146	191 ± 128	300 ± 146	304 ± 146	294 ± 145	303 ± 145
15-Jan	309 ± 132	290 ± 130	320 ± 132	385 ± 142	338 ± 136	290 ± 130	400 ± 142
22-Jan	426 ± 147	440 ± 148	388 ± 142	429 ± 148	488 ± 154	392 ± 143	422 ± 146
29-Jan	68.8 ± 94.7	131 ± 106	135 ± 105	147 ± 109	49.6 ± 91.4	88.1 ± 98.4	87.7 ± 97.7
5-Feb	126 ± 105	141 ± 107	154 ± 108	127 ± 105	112 ± 102	176 ± 114	77.7 ± 95.8
12-Feb	342 ± 136	411 ± 144	333 ± 134	444 ± 149	403 ± 144	329 ± 134	433 ± 147
19-Feb	340 ± 136	325 ± 134	388 ± 141	275 ± 127	310 ± 132	338 ± 135	345 ± 137
26-Feb	58.8 ± 92.5	140 ± 107	91.8 ± 98.0	135 ± 106	126 ± 104	139 ± 106	49.6 ± 91.0
4-Mar	253 ± 125	(b)	151 ± 109	141 ± 120	275 ± 127	195 ± 116	239 ± 123
11-Mar	551 ± 162	335 ± 136	411 ± 145	400 ± 142	426 ± 147	488 ± 154	381 ± 142

18-Mar	238 ± 122	146 ± 108	189 ± 115	264 ± 125	156 ± 110	155 ± 110	142 ± 108
25-Mar	263 ± 126	364 ± 139	340 ± 137	250 ± 123	344 ± 137	228 ± 121	328 ± 135
1-Apr	381 ± 138	242 ± 120	481 ± 150	354 ± 134	477 ± 149	246 ± 120	337 ± 134
7-Apr	306 ± 151	335 ± 155	314 ± 151	273 ± 145	235 ± 140	231 ± 140	264 ± 144
15-Apr	326 ± 123	300 ± 120	426 ± 134	374 ± 127	292 ± 118	414 ± 133	327 ± 123
22-Apr	334 ± 135	444 ± 149	317 ± 132	254 ± 124	266 ± 126	289 ± 129	367 ± 139
29-Apr	324 ± 133	291 ± 128	295 ± 129	363 ± 137	272 ± 125	288 ± 186	255 ± 124
6-May	334 ± 137	295 ± 131	309 ± 133	374 ± 141	314 ± 134	359 ± 138	311 ± 134
13-May	262 ± 126	310 ± 132	199 ± 117	263 ± 125	276 ± 127	299 ± 130	229 ± 121
20-May	329 ± 135	218 ± 120	270 ± 127	235 ± 121	242 ± 122	225 ± 119	263 ± 126
27-May	175 ± 113	112 ± 103	151 ± 109	186 ± 113	179 ± 114	114 ± 104	123 ± 105
3-Jun	213 ± 118	169 ± 112	212 ± 118	165 ± 109	169 ± 112	231 ± 122	228 ± 121
10-Jun	147 ± 109	156 ± 110	117 ± 104	86.6 ± 96.6	137 ± 107	179 ± 111	176 ± 114
17-Jun	414 ± 145	284 ± 128	265 ± 125	320 ± 132	293 ± 130	231 ± 122	291 ± 130
24-Jun	353 ± 138	276 ± 127	366 ± 139	360 ± 139	337 ± 135	403 ± 145	437 ± 148
1-Jul	178 ± 112	107 ± 101	159 ± 110	177 ± 112	159 ± 110	262 ± 126	155 ± 110
8-Jul	144 ± 110	264 ± 127	152 ± 110	180 ± 111	147 ± 109	294 ± 128	139 ± 109
15-Jul	451 ± 149	500 ± 155	507 ± 155	444 ± 146	466 ± 151	474 ± 151	271 ± 127
22-Jul	262 ± 125	223 ± 120	159 ± 110	170 ± 114	232 ± 121	264 ± 130	161 ± 111
29-Jul	278 ± 128	161 ± 111	258 ± 125	207 ± 117	248 ± 124	219 ± 120	182 ± 115
5-Aug	146 ± 108	141 ± 107	222 ± 120	172 ± 111	227 ± 120	135 ± 105	190 ± 115
12-Aug	185 ± 115	141 ± 107	174 ± 112	196 ± 115	146 ± 108	145 ± 110	161 ± 111
19-Aug	227 ± 121	246 ± 123	269 ± 126	236 ± 118	174 ± 112	251 ± 125	156 ± 110
26-Aug	88.4 ± 98.8	131 ± 105	117 ± 103	90 ± 101	132 ± 106	122 ± 104	175 ± 113
2-Sep	290 ± 130	257 ± 125	327 ± 134	374 ± 140	429 ± 147	333 ± 137	330 ± 135
9-Sep	514 ± 157	448 ± 149	522 ± 158	466 ± 150	514 ± 156	533 ± 159	522 ± 159
16-Sep	359 ± 135	500 ± 152	418 ± 142	327 ± 198	396 ± 139	433 ± 145	455 ± 148
23-Sep	426 ± 151	311 ± 136	455 ± 152	485 ± 233	451 ± 154	385 ± 145	282 ± 132
30-Sep	588 ± 164	418 ± 145	(b)	570 ± 181	522 ± 157	622 ± 165	562 ± 159
7-Oct	253 ± 123	180 ± 111	250 ± 123	193 ± 151	276 ± 124	186 ± 115	252 ± 124
14-Oct	343 ± 135	351 ± 138	381 ± 142	381 ± 141	367 ± 141	345 ± 137	400 ± 145
21-Oct	640 ± 170	599 ± 165	733 ± 178	703 ± 175	696 ± 174	758 ± 182	677 ± 174
28-Oct	1260 ± 229	1050 ± 212	1220 ± 226	1160 ± 219	1110 ± 218	1360 ± 238	1150 ± 221
4-Nov	599 ± 164	596 ± 164	610 ± 164	581 ± 161	577 ± 162	566 ± 162	540 ± 157
11-Nov	226 ± 122	171 ± 113	178 ± 112	213 ± 119	287 ± 130	126 ± 108	211 ± 121
18-Nov	481 ± 154	673 ± 174	788 ± 187	581 ± 174	770 ± 184	688 ± 174	699 ± 175
25-Nov	331 ± 134	781 ± 184	796 ± 186	847 ± 189	892 ± 194	1010 ± 206	733 ± 181
2-Dec	1020 ± 206	1550 ± 247	1590 ± 249	1370 ± 232	1640 ± 253	1640 ± 254	1370 ± 234
9-Dec	870 ± 191	947 ± 200	925 ± 197	1080 ± 209	914 ± 196	1040 ± 208	840 ± 191

15-Dec	345 ± 146	685 ± 185	622 ± 179	655 ± 181	855 ± 203	(c)	692 ± 189
16-Dec	(c)	(c)	(c)	(c)	(c)	773 ± 183	(c)
23-Dec	60.7 ± 83.6	190 ± 108	241 ± 111	188 ± 106	168 ± 104	238 ± 122	304 ± 122
29-Dec	74 ± 108	148 ± 122	281 ± 142	150 ± 121	147 ± 122	149 ± 123	165 ± 126
Detection frequency	47 of 52	51 of 51	50 of 51	50 of 52	51 of 52	51 of 52	49 of 52
Median	325	291	309	288	292	290	297
IQR[(d)]	166	259	232	245	277	206	244
Maximum	1260	1550	1590	1370	1640	1640	1370

(a) See *Environmental Report 2008,* Figure 4-1 for map of sampling locations.
(b) No sample due to power (GFI) malfunction
(c) Different sample dates occur when samples could not be collected on scheduled sampling date, or sampler ran longer than 1 week.
(d) IQR = interquartile range

A.2.2 Tritium concentrations (mBq/m^3) in air on the Livermore site, 2008

Week	Month	ARAC	CAFE	COW	CRED	DWTF	MESQ	MET	OPT[c]	B298[d]	POOL	SALV	SECO	VIS
1	Jan	(b)	12.5 ± 15.7	14.4 ± 13.1	24.8 ± 12.7	51.8 ± 27.4	13.0 ± 12.2	16.5 ± 13.1	-	-	42.2 ± 13.4	12.2 ± 13.9	36.0 ± 13.5	0.9 ± 11.7
3	Jan	4.1 ± 18.1	6.5 ± 13.9	11.2 ± 15.5	8.6 ± 14.9	5.3 ± 14.4	-0.0 ± 15.1	-9.2 ± 14.9	-11.3 ± 14.4	-	32.2 ± 15.5	12.7 ± 16.2	11.3 ± 15.8	4.4 ± 14.4
5	Feb	9.1 ± 15.8	1.5 ± 13.5	9.1 ± 16.9	4.6 ± 13.2	30.0 ± 13.5	10.0 ± 10.7	1.4 ± 13.9	11.0 ± 12.2	-	26.0 ± 14.2	4.0 ± 14.2	3.0 ± 14.5	2.9 ± 13.2
7	Feb	18.3 ± 13.1	17.0 ± 11.6	9.7 ± 12.7	20.4 ± 12.0	23.7 ± 12.9	18.1 ± 11.5	18.8 ± 12.8	9.2 ± 10.7	-	47.7 ± 13.1	2.5 ± 11.2	25.9 ± 13.2	13.2 ± 11.4
9	Mar	3.0 ± 13.0	13.2 ± 11.4	26.8 ± 15.0	29.1 ± 12.9	7.6 ± 13.1	13.0 ± 11.9	17.8 ± 13.3	27.3 ± 11.9	-	40.7 ± 13.3	7.6 ± 11.8	26.5 ± 14.6	13.7 ± 12.1
11	Mar	11.6 ± 17.1	-2.3 ± 14.1	17.7 ± 13.9	-10.9 ± 14.5	7.4 ± 16.3	-1.6 ± 13.8	21.1 ± 17.0	15.2 ± 13.9	-	17.3 ± 15.8	-3.2 ± 14.5	8.9 ± 16.8	0.9 ± 14.7
13	Apr	-9.6 ± 15.0	0.3 ± 14.5	11.8 ± 14.9	11.9 ± 15.4	26.4 ± 16.9	-0.7 ± 14.0	1.5 ± 13.6	19.5 ± 14.5	-	45.1 ± 16.9	0.3 ± 14.8	9.6 ± 14.9	5.9 ± 15.1
15	Apr	-4.7 ± 17.0	38.1 ± 17.6	30.4 ± 17.4	29.5 ± 17.6	40.7 ± 19.5	-28.6 ± 15.7	21.5 ± 16.5	25.0 ± 16.5	-	72.5 ± 19.9	19.3 ± 17.4	28.5 ± 17.2	32.6 ± 17.5
17	May	8.6 ± 15.8	10.7 ± 15.9	17.0 ± 15.7	-2.7 ± 15.5	(b)	-0.2 ± 14.9	-4.0 ± 13.9	14.7 ± 15.0	-	41.1 ± 17.5	-3.8 ± 14.8	-0.6 ± 15.1	16.0 ± 15.8
19	May	17.0 ± 17.8	6.7 ± 17.6	24.5 ± 17.2	7.5 ± 16.9	18.3 ± 17.4	18.6 ± 17.2	2.0 ± 15.8	22.1 ± 16.9	-	37.7 ± 20.0	0.3 ± 16.7	-6.2 ± 16.7	26.0 ± 17.6
21	May	3.8 ± 21.6	22.1 ± 22.5	46.2 ± 21.9	14.3 ± 21.5	85.5 ± 24.3	19.2 ± 21.6	(b)	112.0 ± 22.8	-	14.1 ± 24.1	-1.5 ± 21.1	-13.6 ± 20.4	7.5 ± 21.3
23	Jun	10.3 ± 13.9	14.6 ± 14.0	14.6 ± 13.1	13.9 ± 13.4	42.6 ± 14.5	9.3 ± 12.9	-9.7 ± 11.1	120.0 ± 16.7	-	69.9 ± 17.5	-5.7 ± 12.5	5.0 ± 12.7	6.5 ± 13.0
25	Jun	1.7 ± 13.9	32.0 ± 14.9	36.9 ± 14.2	27.8 ± 14.1	59.9 ± 16.0	23.1 ± 14.2	24.5 ± 12.7	48.5 ± 14.3	-	77.7 ± 18.1	19.7 ± 13.4	10.2 ± 12.8	18.8 ± 13.2
27	Jul	15.0 ± 26.3	22.5 ± 27.9	-1.9 ± 22.6	11.6 ± 25.3	81.4 ± 37.4	-20.5 ± 25.2	-18.0 ± 21.9	-	64.4 ± 23.6	-5.8 ± 26.0	-8.9 ± 23.6	-12.8 ± 24.6	0.4 ± 21.1
29	Jul	8.8 ± 20.6	19.8 ± 19.9	23.4 ± 17.1	45.1 ± 23.1	34.1 ± 17.6	3.9 ± 17.5	13.9 ± 15.2	-	63.6 ± 19.2	44.4 ± 18.1	3.0 ± 16.1	26.6 ± 16.9	22.3 ± 15.8
31	Aug	2.6 ± 15.0	1.5 ± 20.4	27.9 ± 16.5	3.1 ± 14.6	34.1 ± 17.6	7.1 ± 16.9	45.9 ± 15.7	-	1050.0 ± 39.6	34.5 ± 17.9	-1.5 ± 14.8	-0.3 ± 15.2	31.4 ± 18.1
33	Aug	4.1 ± 15.2	28.1 ± 17.3	24.2 ± 16.7	12.7 ± 16.5	(b)	8.4 ± 18.0	-0.8 ± 14.4	-	599.0 ± 30.4	15.7 ± 17.8	0.4 ± 15.1	0.2 ± 16.1	13.0 ± 16.0
35	Sep	14.7 ± 11.6	23.5 ± 13.7	36.8 ± 12.1	31.3 ± 11.1	39.6 ± 13.0	22.6 ± 11.8	40.7 ± 13.2	-	280.0 ± 18.8	91.0 ± 16.7	12.0 ± 11.3	28.20 ± 9.92	36.40 ± 8.92
37	Sep	3.9 ± 19.9	14.2 ± 19.2	5.6 ± 19.1	7.4 ± 21.8	44.0 ± 19.6	11.3 ± 21.3	9.1 ± 18.9	-	186.0 ± 22.6	52.2 ± 22.2	-8.1 ± 21.2	14.9 ± 20.6	1.9 ± 18.5
39	Oct	15.4 ± 20.2	20.5 ± 19.2	12.4 ± 17.8	45.5 ± 20.5	27.0 ± 17.6	4.8 ± 20.6	9.9 ± 19.6	-	236.0 ± 20.9	87.7 ± 22.9	18.3 ± 18.3	29.3 ± 19.0	17.9 ± 18.2
41	Oct	46.6 ± 16.0	24.3 ± 13.6	31.9 ± 14.0	2.1 ± 11.1	26.3 ± 13.0	24.8 ± 13.5	51.1 ± 14.5	-	392.0 ± 23.5	65.5 ± 15.1	19.1 ± 11.4	15.8 ± 13.7	26.5 ± 13.0
43	Oct	79.6 ± 15.9	52.9 ± 15.0	35.4 ± 14.2	48.1 ± 13.7	54.0 ± 15.4	50.7 ± 16.2	74.0 ± 16.1	-	141.0 ± 17.2	108.0 ± 16.8	39.6 ± 13.3	44.0 ± 15.7	40.0 ± 14.1
45	Nov	41.1 ± 16.9	7.7 ± 16.5	18.5 ± 15.8	15.1 ± 14.9	5.3 ± 16.5	15.8 ± 17.0	39.6 ± 17.6	-	147.0 ± 21.2	58.8 ± 17.7	4.0 ± 14.5	23.8 ± 18.2	17.5 ± 17.1
47	Nov	37.7 ± 14.7	21.3 ± 14.7	21.1 ± 14.4	18.6 ± 13.0	29.4 ± 15.2	27.5 ± 14.8	44.0 ± 15.8	-	112.0 ± 17.8	58.5 ± 15.5	3.7 ± 12.5	33.2 ± 15.8	31.4 ± 15.1
49	Dec	23.4 ± 12.7	77.0 ± 15.3	8.2 ± 12.5	15.5 ± 11.7	22.9 ± 13.2	32.2 ± 13.6	47.7 ± 13.7	-	106.0 ± 16.4	102.0 ± 15.9	25.5 ± 11.8	47.4 ± 14.8	24.5 ± 14.7
51	Dec	12.0 ± 10.2	31.0 ± 11.6	14.8 ± 10.4	23.8 ± 10.7	34.0 ± 11.6	17.3 ± 10.9	18.4 ± 10.7	-	146.0 ± 15.8	56.6 ± 12.0	12.00 ± 9.66	8.99 ± 9.69	26.9 ± 14.7
	Median	10.3	18.4	18.1	14.7	32	12.2	17.8	20.8	147	46.4	3.85	13.1	16.8
	IQR[e]	13.2	15.6	15.7	19.3	19.5	15	38.1	18.8	168	33.5	13.6	24.3	20.3
	Median Percent of DCG[f]	0.00028	0.0005	0.00049	0.0004	0.00086	0.00033	0.00048	0.00056	0.004	0.0013	0.0001	0.00035	0.00045
	Mean Dose (nSv)[g]	<5	<5	<5	<5	7.27	<5	<5	7.22	57	10.8	<5	<5	<5

Note: Radioactivities are reported as the measured concentration and an uncertainty (± 2σ) counting error.
(a) See *Environmental Report 2008,* Figure 4-1 for map of sampling locations.
(b) Lost sample
(c) Removed from surveillance network.
(d) Start of new sample collection.
(e) IQR = Interquartile range
(f) DCG = Derived Concentration Guide of 3.7E+06 mBq/m^3 for tritium in air. Percent of DCG is calculated from the median concentration.
(g) This annual dose is calculated from the mean concentration and represents the effective dose equivalent from inhalation and skin absorbtion. When the mean dose is based on a concentration less than the lower limit of detection (about 25 mBq/m^3), the dose is assumed to be less than that calculated from the lower limit of detection (i.e., 5 nSv/year).

A.2.3 Beryllium concentration (pg/m^3) in Livermore site and Site 300 air particulate samples, 2008[a]

Month	Livermore Site Perimeter CAFE	Livermore Site Perimeter COW	Livermore Site Perimeter MESQ	Livermore Site Perimeter MET	Livermore Site Perimeter SALV	Livermore Site Perimeter VIS	Site 300 Perimeter 801E	Site 300 Perimeter TNK5	Site 300 Perimeter EOBS	Site 300 Perimeter GOLF	Site 300 Off site TCDF
Jan	2.8	3	3	2.8	1.9	2.8	3.1	(b)	2.8	3	5
Feb	3.5	3.6	3.9	3.9	2.7	3.5	2.3	(b)	2.2	2.8	5
Mar	5.2	5.5	5	5.1	4.1	4.5	(b)	4.4	3.6	4.2	6.2
Apr	9.2	8.7	8.4	9.8	8.6	8.7	(b)	8.8	7.8	9.9	13
May	11	14	12	9.1	10	8.6	(b)	22	14	14	29
Jun	7.7	9.8	10	8.7	9.2	9.2	(b)	10	8.8	8.8	16
Jul	10	8.3	8.9	6.8	8.9	8	(b)	9.9	9.4	8.3	17
Aug	11	9.8	9.5	10	10	12	(b)	9.5	11	10	16
Sep	68	60	62	64	60	69	(b)	58	81	76	120
Oct	11	12	11	12	11	12	(b)	11	18	16	22
Nov	4.8	5	5.5	6.1	5.3	6	(b)	5.9	5.9	6.6	8.4
Dec	2	3.4	3.7	3.5	3.3	3.1	(b)	2.5	2.6	3.3	3.7
Detection frequency	12 of 12	12 of 12	12 of 12	12 of 12	12 of 12	12 of 12	2 of 2	10 of 10	12 of 12	12 of 12	12 of 12
Median	8.4	8.5	8.6	7.8	8.8	8.3	(c)	9.7	8.3	8.6	14
IQR[d]	6.5	5.7	5.5	5.1	6.1	5.6	(c)	4.1	8.4	7	12
Maximum	68	60	62	64	60	69	3.1	58	81	76	120
Median Percent of ACL	0.084	0.085	0.086	0.078	0.088	0.083	0.027	0.097	0.083	0.086	0.14
ACL[e]	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000

(a) See *Environmental Report 2008,* Figures 4-1, 4-2, and 4-3 for maps of sampling locations.
(b) The 801E sample location was relocated to TNK5 for safer access.
(c) A minimum of six samples is needed for median and IQR calculations.
(d) IQR = Interquartile range
(e) ACL=Ambient concentration limit of 10,000 pg/m^3 is established by the Bay Area Air Quality Management Air District. Median percent of ACL is calculated from the median value.

AF-BE7

A.2.4 Beryllium-7 concentrations (mBq/m^3) composite for Livermore site and Site 300 air particulate samples, 2008[(a)]

Month	LLNL Composite	Site 300 Composite
Jan	2.570 ± 0.201	1.860 ± 0.138
Feb	2.690 ± 0.209	0 ± 0
Mar	3.45 ± 2.52	3.560 ± 0.260
Apr	3.240 ± 0.238	3.350 ± 0.245
May	2.470 ± 0.184	32.10 ± 2.23
Jun	3.020 ± 0.239	4.400 ± 0.277
Jul	2.130 ± 0.167	2.200 ± 0.140
Aug	2.760 ± 0.210	5.180 ± 0.377
Sep	4.070 ± 0.303	53.30 ± 3.92
Oct	4.880 ± 0.347	5.590 ± 0.411
Nov	2.060 ± 0.225	3.770 ± 0.270
Dec	2.450 ± 0.178	3.150 ± 0.225
Detection frequency	12 of 12	11 of 12
Median	2.72	3.66
IQR[(b)]	0.828	2.37
Maximum	4.88	53.3

(a) See *Environmental Report 2008,* Figures 4-1 and 4-2 for maps of sampling locations.
(b) IQR = interquartile range

AF-PULSS3

A.2.5 Plutonium-239+240 concentrations (nBq/m^3) in air particulate samples from the Livermore perimeter and Site 300 perimeter composite, 2008[(a)]

Month	Livermore Site Perimeter CAFE	Livermore Site Perimeter COW	Livermore Site Perimeter CRED	Livermore Site Perimeter MESQ	Livermore Site Perimeter MET	Livermore Site Perimeter SALV	Livermore Site Perimeter VIS	Site 300 Perimeter Perimeter Composite
Jan	-2.86 ± 2.58	-1.50 ± 3.64	5.70 ± 7.81	0.75 ± 6.22	1.12 ± 5.18	-1.69 ± 5.77	-3.28 ± 4.26	-0.60 ± 3.69
Feb	4.5 ± 14.7	-0.4 ± 10.5	-3.42 ± 6.33	3.16 ± 9.51	0 ± 0	2.5 ± 20.8	-4.1 ± 14.2	1.89 ± 2.69
Mar	-10.5 ± 27.4	5.0 ± 15.9	7.0 ± 11.9	-2.90 ± 7.58	-3.77 ± 6.51	-2.58 ± 6.73	-1.06 ± 3.92	0.94 ± 7.66
Apr	-5.4 ± 13.2	-2.21 ± 5.33	-2.1 ± 13.1	2.6 ± 12.0	-0.33 ± 7.77	2.6 ± 21.6	10.1 ± 13.9	3.58 ± 2.85
May	-1.99 ± 6.40	-3.70 ± 4.81	2.3 ± 10.2	-1.30 ± 4.77	0.63 ± 5.96	3.85 ± 6.07	5.36 ± 9.66	6.25 ± 4.51
Jun	11.0 ± 12.8	6.0 ± 14.5	-0.5 ± 13.1	0.0 ± 11.1	-10.1 ± 14.3	-6.96 ± 5.36	8.1 ± 12.8	3.32 ± 4.48
Jul	-2.16 ± 7.84	-5.07 ± 7.70	12.1 ± 12.1	7.5 ± 12.2	-6.6 ± 14.1	-1.68 ± 6.07	16.5 ± 15.8	3.15 ± 5.03
Aug	4.11 ± 7.66	-0.78 ± 7.70	7.73 ± 7.55	-1.84 ± 4.48	-1.6 ± 15.3	2.59 ± 7.81	6.40 ± 8.29	2.30 ± 4.33
Sep	1.75 ± 8.07	13.6 ± 16.4	13.2 ± 16.9	-3.9 ± 10.2	0.0 ± 10.8	2.71 ± 8.77	12.3 ± 11.4	4.59 ± 4.14
Oct	-1.47 ± 9.06	4.51 ± 7.10	1.41 ± 6.51	4.29 ± 9.10	8.2 ± 13.5	11.4 ± 10.6	7.8 ± 14.1	3.43 ± 6.22
Nov	0.00 ± 5.70	-2.89 ± 9.92	-1.21 ± 6.07	17.6 ± 55.9	3.88 ± 9.73	17.0 ± 74.7	4.3 ± 11.1	3.61 ± 3.96
Dec	5.00 ± 7.92	3.58 ± 6.84	-9.4 ± 10.4	-1.92 ± 4.66	-3.09 ± 5.70	3.52 ± 8.84	5.22 ± 7.66	1.20 ± 2.65
Detection frequency	0 of 12	0 of 12	2 of 12	0 of 12	0 of 12	1 of 12	2 of 12	3 of 12
Median	-0.735	-0.61	1.86	0.374	-0.163	2.62	5.88	3.24
IQR[(b)]	6.55	7.02	8.59	5.3	4.01	5.28	5.65	1.87
Maximum	11	13.6	13.2	17.6	8.25	17	16.5	6.25
Median Percent of DCG	(c)	(c)	0.00025	0.00005	(c)	0.00035	0.00079	0.00044
DCG[(d)]	740000	740000	740000	740000	740000	740000	740000	740000

(a) See *Environmental Report 2008,* Figures 4-1 and 4-2 for maps of sampling locations.
(b) IQR = interquartile range
(c) Median percent of DCG is calculated only when the median is greater than zero.
(d) DCG is the Derived Concentration Guide established by the DOE and is amount of plutonium-239+240 that can be inhaled continuously 365 days a year without exceeding the DOE primary radiation protection standard for the public.

AF-URAN

A.2.6 Uranium mass concentrations (pg/m^3) in air particulate samples from Site 300 onsite and offsite locations, and the Livermore site (composite), 2008[(a)]

Month	801E Uranium-235	801E Uranium-238	801E U235/U238 ratio[(b)]	TNK5 Uranium-235	TNK5 Uranium-238	TNK5 U235/U238 ratio[(b)]	ECP Uranium-235
Jan	0.08510 ± 0.00848	12.20 ± 1.20	0.006980 ± 0.000977	(c)	(c)	(c)	0.08150 ± 0.00772
Feb	0.05650 ± 0.00528	7.540 ± 0.674	0.007490 ± 0.000969	(c)	(c)	(c)	0.04630 ± 0.00793
Mar	(c)	(c)	(c)	0.07430 ± 0.00881	10.20 ± 1.20	0.00728 ± 0.00122	0.0693 ± 0.0104
Apr	(c)	(c)	(c)	0.19600 ± 0.00913	27.00 ± 1.23	0.007260 ± 0.000473	0.2020 ± 0.0175
May	(c)	(c)	(c)	0.2010 ± 0.0925	29.4 ± 13.5	0.00684 ± 0.00444	0.2120 ± 0.0349
Jun	(c)	(c)	(c)	0.2010 ± 0.0189	28.60 ± 2.67	0.007030 ± 0.000931	0.2130 ± 0.0178
Jul	(c)	(c)	(c)	0.1370 ± 0.0420	19.80 ± 6.06	0.00692 ± 0.00300	0.1680 ± 0.0345
Aug	(c)	(c)	(c)	0.1770 ± 0.0163	25.20 ± 2.30	0.007020 ± 0.000911	0.2080 ± 0.0374
Sep	(c)	(c)	(c)	0.3170 ± 0.0544	44.00 ± 7.54	0.00720 ± 0.00175	0.5160 ± 0.0336
Oct	(c)	(c)	(c)	0.4410 ± 0.0285	61.20 ± 3.92	0.007210 ± 0.000656	0.5260 ± 0.0457
Nov	(c)	(c)	(c)	0.1800 ± 0.0435	25.30 ± 6.07	0.00711 ± 0.00242	0.2000 ± 0.0523
Dec	(c)	(c)	(c)	0.05280 ± 0.00439	7.620 ± 0.612	0.006930 ± 0.000801	0.06480 ± 0.00556
Detection frequency	2 of 2	2 of 2	2 of 2	10 of 10	10 of 10	10 of 10	12 of 12
Median	(d)	(d)	(d)	0.188	26.2	0.00707	0.201
IQR[(e)]	(d)	(d)	(d)	0.054	8.05	0.000255	0.134
Maximum	0.0851	12.2	0.00749	0.441	61.2	0.00728	0.526
Median Percent of DCG	0.00015	0.0033	0.0000024	0.0004	0.0087	0.0000024	0.00043
DCG[(f)]	47000	300000	300000	47000	300000	300000	47000
Maximum Percent of DCG	0.00018	0.0041	0.0000025	0.00094	0.02	0.0000024	0.0011

(a) See *Environmental Report 2008,* Figures 4-1 and 4-2 for maps of sampling locations. Livermore composite consists of samples from CAFE, COW, MESQ, MET, SALV, and VIS.
(b) Naturally occurring uranium has a ratio of 0.0073; values less than that indicate the presence of depleted uranium, which has a ratio of 0.002.
(c) The 801E sample location was relocated to TNK5 for safer access.
(d) Median and IQR are calculated only with 6 or more samples.
(e) IQR = Interquartile range
(f) DCG is the Derived Air Concentration Guide established by the DOE and is the amount of uranium that can be inhaled continuously 365 days a year without exceeding the DOE primary radiation protectio

ECP Uranium-238	ECP U235/U238 ratio(b)	EOBS Uranium-235	EOBS Uranium-238	EOBS U235/U238 ratio(b)	GOLF Uranium-235	GOLF Uranium-238	GOLF U235/U238 ratio(b)
11.10 ± 1.04	0.007340 ± 0.000978	0.07520 ± 0.00280	10.300 ± 0.358	0.007300 ± 0.000372	0.08700 ± 0.00617	12.000 ± 0.811	0.007250 ± 0.000710
6.29 ± 1.07	0.00736 ± 0.00178	0.04680 ± 0.00531	6.330 ± 0.673	0.00739 ± 0.00115	0.06310 ± 0.00722	8.580 ± 0.971	0.00735 ± 0.00118
9.34 ± 1.40	0.00742 ± 0.00157	0.06870 ± 0.00483	9.240 ± 0.631	0.007440 ± 0.000729	0.08490 ± 0.00288	11.400 ± 0.358	0.007450 ± 0.000344
27.40 ± 2.34	0.007370 ± 0.000897	0.2030 ± 0.0239	27.80 ± 3.25	0.00730 ± 0.00121	0.2190 ± 0.0113	30.10 ± 1.52	0.007280 ± 0.000525
28.60 ± 4.65	0.00741 ± 0.00172	0.2160 ± 0.0435	31.10 ± 6.20	0.00695 ± 0.00197	0.2170 ± 0.0484	30.10 ± 6.66	0.00721 ± 0.00226
29.00 ± 2.41	0.007340 ± 0.000866	0.20500 ± 0.00966	28.20 ± 1.29	0.007270 ± 0.000477	0.1890 ± 0.0249	25.50 ± 3.35	0.00741 ± 0.00138
23.30 ± 4.77	0.00721 ± 0.00209	0.1470 ± 0.0316	20.20 ± 4.31	0.00728 ± 0.00220	0.1230 ± 0.0241	16.60 ± 3.22	0.00741 ± 0.00204
28.80 ± 5.16	0.00722 ± 0.00183	0.2050 ± 0.0432	28.80 ± 6.03	0.00712 ± 0.00211	0.1980 ± 0.0369	27.40 ± 5.08	0.00723 ± 0.00190
71.70 ± 4.65	0.007200 ± 0.000661	0.4870 ± 0.0276	67.70 ± 3.78	0.007190 ± 0.000572	0.3960 ± 0.0494	54.70 ± 6.79	0.00724 ± 0.00127
72.80 ± 6.29	0.007230 ± 0.000885	0.5770 ± 0.0644	80.40 ± 8.94	0.00718 ± 0.00113	0.4750 ± 0.0388	65.60 ± 5.33	0.007240 ± 0.000834
27.10 ± 7.07	0.00738 ± 0.00273	0.1990 ± 0.0366	27.10 ± 4.95	0.00734 ± 0.00190	0.1750 ± 0.0236	23.70 ± 3.18	0.00738 ± 0.00140
8.630 ± 0.726	0.007510 ± 0.000902	0.0667 ± 0.0161	8.95 ± 2.15	0.00745 ± 0.00254	0.06670 ± 0.00584	9.130 ± 0.787	0.007310 ± 0.000898
12 of 12	12 of 12	12 of 12	12 of 12	12 of 12	12 of 12	12 of 12	12 of 12
27.2	0.00735	0.201	27.4	0.00729	0.182	24.6	0.00729
18.2	0.00016	0.134	19.3	0.000165	0.131	18.2	0.000148
72.8	0.00751	0.577	80.4	0.00745	0.475	65.6	0.00745
0.0091	0.0000025	0.00043	0.0092	0.0000024	0.00039	0.0082	0.0000024
300000	300000	47000	300000	300000	47000	300000	300000
0.024	0.0000025	0.0012	0.027	0.0000025	0.001	0.022	0.0000025

n standard for the public. DCG values are not used in isotopic ratios.

NPS Uranium-235	NPS Uranium-238	NPS U235/U238 ratio[b]	PSTL Uranium-235	PSTL Uranium-238	PSTL U235/U238 ratio[b]	TCDF Uranium-235	TCDF Uranium-238
0.0750 ± 0.0102	10.20 ± 1.37	0.00735 ± 0.00141	0.00410 ± 0.00107	0.555 ± 0.141	0.00739 ± 0.00269	0.14500 ± 0.00934	19.50 ± 1.16
0.04750 ± 0.00959	6.42 ± 1.24	0.00740 ± 0.00207	0.2500 ± 0.0202	34.20 ± 2.72	0.007310 ± 0.000829	0.1010 ± 0.0110	13.60 ± 1.47
0.07140 ± 0.00855	9.62 ± 1.13	0.00742 ± 0.00124	0.2690 ± 0.0255	37.10 ± 3.52	0.007250 ± 0.000972	0.1300 ± 0.0161	17.50 ± 2.14
0.2200 ± 0.0140	30.20 ± 1.91	0.007280 ± 0.000654	0.5590 ± 0.0352	79.20 ± 4.95	0.007060 ± 0.000626	0.3370 ± 0.0252	46.20 ± 3.43
0.2080 ± 0.0697	28.40 ± 9.51	0.00732 ± 0.00347	0.596 ± 0.171	82.8 ± 23.6	0.00720 ± 0.00291	0.395 ± 0.137	54.8 ± 18.9
0.1880 ± 0.0213	25.30 ± 2.83	0.00743 ± 0.00118	0.2270 ± 0.0234	30.70 ± 3.15	0.00739 ± 0.00108	0.4220 ± 0.0341	57.60 ± 4.64
0.1580 ± 0.0271	21.30 ± 3.64	0.00742 ± 0.00180	0.3520 ± 0.0436	48.00 ± 5.91	0.00733 ± 0.00128	0.394 ± 0.138	53.9 ± 18.8
0.2010 ± 0.0329	27.40 ± 4.48	0.00734 ± 0.00170	0.391 ± 0.103	54.3 ± 14.3	0.00720 ± 0.00268	0.3950 ± 0.0912	54.2 ± 12.5
0.4740 ± 0.0680	65.40 ± 9.35	0.00725 ± 0.00147	0.4490 ± 0.0406	61.70 ± 5.57	0.007280 ± 0.000930	0.7410 ± 0.0563	104.00 ± 7.88
0.5170 ± 0.0514	71.20 ± 7.02	0.00726 ± 0.00102	0.5830 ± 0.0688	81.60 ± 9.60	0.00714 ± 0.00119	0.862 ± 0.104	121.0 ± 14.6
0.1750 ± 0.0236	23.70 ± 3.17	0.00738 ± 0.00140	0.4360 ± 0.0595	60.90 ± 8.22	0.00716 ± 0.00137	0.3250 ± 0.0443	44.10 ± 6.01
0.06360 ± 0.00423	8.480 ± 0.557	0.007500 ± 0.000701	0.1850 ± 0.0262	25.20 ± 3.56	0.00734 ± 0.00147	0.0963 ± 0.0124	12.80 ± 1.63
12 of 12	12 of 12	12 of 12	12 of 12	12 of 12	12 of 12	12 of 12	12 of 12
0.182	24.5	0.00736	0.372	51.2	0.00727	0.366	50
0.137	18.8	0.00011	0.232	32.8	0.000142	0.26	36.5
0.517	71.2	0.0075	0.596	82.8	0.00739	0.862	121
0.00039	0.0082	0.0000025	0.00079	0.017	0.0000024	0.00078	0.017
47000	300000	300000	47000	300000	300000	47000	300000
0.0011	0.024	0.0000025	0.0013	0.028	0.0000025	0.0018	0.04

TCDF U235/U238 ratio[b]	WCP Uranium-235	WCP Uranium-238	WCP U235/U238 ratio[b]	WOBS Uranium-235	WOBS Uranium-238	WOBS U235/U238 ratio[b]	Livermore composite Uranium-235
0.007440 ± 0.000652	0.09760 ± 0.00666	14.000 ± 0.934	0.006970 ± 0.000665	0.08010 ± 0.00698	11.100 ± 0.950	0.007220 ± 0.000881	0.07840 ± 0.00606
0.00743 ± 0.00114	0.06870 ± 0.00447	9.880 ± 0.580	0.006950 ± 0.000609	0.05250 ± 0.00775	7.06 ± 1.02	0.00744 ± 0.00154	0.06090 ± 0.00325
0.00743 ± 0.00129	0.08400 ± 0.00814	12.00 ± 1.16	0.007000 ± 0.000958	0.07430 ± 0.00911	9.98 ± 1.20	0.00744 ± 0.00128	0.08470 ± 0.00695
0.007290 ± 0.000769	0.2430 ± 0.0290	34.60 ± 4.08	0.00702 ± 0.00118	0.1970 ± 0.0202	26.70 ± 2.72	0.00738 ± 0.00107	0.2250 ± 0.0265
0.00721 ± 0.00353	0.1860 ± 0.0315	26.50 ± 4.45	0.00702 ± 0.00167	0.1870 ± 0.0837	25.3 ± 11.3	0.00739 ± 0.00467	0.1710 ± 0.0202
0.007330 ± 0.000836	0.2130 ± 0.0320	32.60 ± 4.88	0.00653 ± 0.00139	0.1710 ± 0.0208	23.20 ± 2.78	0.00737 ± 0.00126	0.1600 ± 0.0490
0.00731 ± 0.00361	0.1410 ± 0.0429	20.40 ± 6.17	0.00691 ± 0.00297	0.1470 ± 0.0382	20.10 ± 5.20	0.00731 ± 0.00268	0.1030 ± 0.0312
0.00729 ± 0.00238	0.1800 ± 0.0378	26.60 ± 5.55	0.00677 ± 0.00200	0.1650 ± 0.0238	22.50 ± 3.23	0.00733 ± 0.00149	0.1430 ± 0.0481
0.007120 ± 0.000765	0.4210 ± 0.0407	58.50 ± 5.64	0.007200 ± 0.000983	0.4090 ± 0.0350	56.10 ± 4.78	0.007290 ± 0.000880	0.2200 ± 0.0172
0.00712 ± 0.00122	0.4870 ± 0.0556	69.70 ± 7.95	0.00699 ± 0.00113	0.5490 ± 0.0313	75.60 ± 4.23	0.007260 ± 0.000580	0.3290 ± 0.0397
0.00737 ± 0.00142	0.2310 ± 0.0314	32.40 ± 4.38	0.00713 ± 0.00137	0.1700 ± 0.0338	23.00 ± 4.56	0.00739 ± 0.00208	0.1360 ± 0.0284
0.00752 ± 0.00136	0.07370 ± 0.00829	10.10 ± 1.12	0.00730 ± 0.00115	0.0694 ± 0.0125	9.44 ± 1.69	0.00735 ± 0.00187	0.33300 ± 0.00768
12 of 12	12 of 12	12 of 12	12 of 12	12 of 12	12 of 12	12 of 12	12 of 12
0.00732	0.183	26.6	0.007	0.168	22.8	0.00736	0.152
0.00016	0.14	19.6	0.000108	0.111	14.8	0.000085	0.123
0.00752	0.487	69.7	0.0073	0.549	75.6	0.00744	0.333
0.0000024	0.00039	0.0088	0.0000023	0.00036	0.0076	0.0000025	0.00032
300000	47000	300000	300000	47000	300000	300000	47000
0.0000025	0.001	0.023	0.0000024	0.0012	0.025	0.0000025	0.00071

Livermore composite Uranium-238	Livermore composite U235/U238 ratio[(b)]
10.700 ± 0.806	0.007330 ± 0.000791
8.310 ± 0.419	0.007330 ± 0.000538
11.500 ± 0.926	0.007370 ± 0.000847
31.20 ± 3.67	0.00721 ± 0.00120
23.70 ± 2.78	0.00722 ± 0.00120
21.90 ± 6.68	0.00731 ± 0.00316
14.00 ± 4.23	0.00736 ± 0.00315
19.80 ± 6.64	0.00722 ± 0.00343
30.30 ± 2.36	0.007260 ± 0.000801
45.90 ± 5.53	0.00717 ± 0.00122
18.60 ± 3.86	0.00731 ± 0.00215
44.700 ± 0.959	0.007450 ± 0.000235
12 of 12	12 of 12
20.8	0.00731
17.2	0.000118
45.9	0.00745
0.007	0.0000024
300000	300000
0.015	0.0000025

A.2.7 Weekly gross alpha and gross beta concentrations (µBq/m^3) from air particulate samples from the Livermore Valley downwind locations, 2008[(a)]

Date	Gross alpha AMON	Gross alpha CPET	Gross alpha PATT	Gross alpha TANK	Gross alpha ZON7
8-Jan	19.5 ± 35.8	11.5 ± 32.0	(b)	34.6 ± 41.1	19.4 ± 35.6
15-Jan	-3.3 ± 20.5	3.3 ± 24.2	10.3 ± 28.6	-3.3 ± 20.3	-10.0 ± 16.0
22-Jan	-9.9 ± 15.9	-9.9 ± 15.8	10.0 ± 27.6	3.2 ± 23.5	10.0 ± 27.7
29-Jan	3.3 ± 24.2	-9.8 ± 15.8	9.9 ± 27.6	9.9 ± 27.5	3.3 ± 24.3
5-Feb	-10.0 ± 16.1	-9.8 ± 15.8	-3.3 ± 20.5	3.3 ± 24.3	3.3 ± 24.3
12-Feb	3.3 ± 24.3	9.8 ± 27.2	-3.3 ± 20.5	3.3 ± 24.2	23.2 ± 33.0
19-Feb	16.6 ± 30.6	16.5 ± 30.3	-3.3 ± 20.5	3.3 ± 24.0	10.0 ± 27.7
26-Feb	-3.3 ± 20.4	3.2 ± 23.5	-3.2 ± 20.0	3.4 ± 24.8	16.1 ± 29.6
4-Mar	-3.3 ± 20.4	3.2 ± 23.8	-9.9 ± 15.8	9.7 ± 26.9	3.3 ± 24.0
11-Mar	3.3 ± 24.0	22.6 ± 32.3	36.3 ± 37.7	3.4 ± 24.7	29.5 ± 35.2
18-Mar	-9.9 ± 15.8	10.0 ± 27.7	-3.3 ± 20.6	-3.3 ± 20.2	-9.9 ± 15.8
25-Mar	22.8 ± 32.6	16.3 ± 30.0	23.6 ± 33.6	3.2 ± 23.8	-3.3 ± 20.7
1-Apr	3.3 ± 24.1	182.0 ± 87.0	54.8 ± 42.9	36.7 ± 38.1	35.2 ± 36.5
7-Apr	11.7 ± 32.3	11.7 ± 32.5	-3.9 ± 24.3	19.3 ± 35.4	11.7 ± 32.3
15-Apr	14.4 ± 26.4	14.2 ± 26.1	-2.9 ± 17.9	8.7 ± 24.0	8.6 ± 23.9
22-Apr	9.6 ± 26.6	15.7 ± 28.8	9.7 ± 26.8	49.6 ± 42.2	22.4 ± 32.0
29-Apr	-3.3 ± 20.6	23.1 ± 32.9	-10.1 ± 16.1	28.9 ± 34.4	29.9 ± 35.7
6-May	3.3 ± 24.4	9.9 ± 27.4	10.1 ± 27.9	36.9 ± 38.5	3.3 ± 24.4
13-May	9.8 ± 27.3	35.7 ± 37.0	-10.1 ± 16.1	3.2 ± 23.7	9.8 ± 27.3
20-May	75.5 ± 48.8	3.2 ± 23.8	36.3 ± 37.7	-3.4 ± 20.8	42.6 ± 39.6
27-May	29.5 ± 35.2	-3.2 ± 20.1	3.3 ± 24.2	9.7 ± 27.0	16.4 ± 30.1
3-Jun	16.2 ± 29.7	22.6 ± 32.3	9.9 ± 27.4	10.1 ± 28.1	9.8 ± 27.2
10-Jun	23.2 ± 33.2	-9.8 ± 15.6	3.3 ± 24.3	22.8 ± 32.5	-9.8 ± 15.8
17-Jun	-3.3 ± 20.2	61.0 ± 44.8	9.8 ± 27.3	-3.3 ± 20.2	-3.3 ± 20.2
24-Jun	29.6 ± 35.3	48.8 ± 41.1	16.5 ± 30.4	23.6 ± 33.8	9.8 ± 27.3
1-Jul	15.9 ± 29.2	16.1 ± 29.6	28.8 ± 34.4	42.6 ± 39.6	41.4 ± 38.5
8-Jul	10.2 ± 28.3	16.4 ± 30.2	58.5 ± 45.5	29.2 ± 34.7	10.2 ± 28.3
15-Jul	42.6 ± 39.6	67.7 ± 46.2	30.0 ± 35.8	74.7 ± 48.5	35.9 ± 37.4
22-Jul	28.7 ± 34.3	3.2 ± 23.7	22.3 ± 31.9	-3.3 ± 20.6	3.2 ± 23.2
29-Jul	22.6 ± 32.2	9.8 ± 27.1	9.9 ± 27.4	3.4 ± 24.8	22.8 ± 32.6
5-Aug	16.8 ± 30.9	16.2 ± 29.7	3.4 ± 24.7	3.2 ± 23.8	-10.0 ± 16.0
12-Aug	55.5 ± 43.7	29.0 ± 34.6	43.7 ± 40.3	16.3 ± 30.0	23.2 ± 33.2
19-Aug	28.9 ± 34.5	68.1 ± 46.6	35.0 ± 36.4	9.7 ± 27.0	41.1 ± 38.1
26-Aug	3.3 ± 24.0	16.2 ± 29.7	-3.3 ± 20.3	3.3 ± 24.5	9.9 ± 27.4
2-Sep	42.9 ± 40.0	55.1 ± 43.3	30.9 ± 36.9	16.1 ± 29.6	10.2 ± 28.3
9-Sep	55.1 ± 43.3	55.1 ± 43.3	23.1 ± 32.9	29.9 ± 35.7	29.4 ± 35.1
16-Sep	3.3 ± 24.4	53.6 ± 41.8	9.7 ± 26.8	30.0 ± 35.8	41.4 ± 38.5
23-Sep	36.4 ± 37.7	29.9 ± 35.7	29.5 ± 35.1	22.6 ± 32.3	61.8 ± 45.1
30-Sep	55.1 ± 43.3	34.5 ± 35.9	15.8 ± 29.0	55.9 ± 43.7	23.0 ± 32.9
7-Oct	-3.3 ± 20.4	22.6 ± 32.3	23.0 ± 32.8	23.6 ± 33.7	16.3 ± 30.0
14-Oct	9.8 ± 27.2	29.5 ± 35.2	(b)	3.2 ± 23.8	3.3 ± 23.9
21-Oct	10.1 ± 27.9	28.8 ± 34.3	3.3 ± 24.1	48.8 ± 41.4	29.3 ± 35.0
28-Oct	41.8 ± 38.8	77.0 ± 49.9	83.2 ± 51.4	71.4 ± 49.2	122.0 ± 59.9
4-Nov	29.4 ± 35.0	47.7 ± 40.3	23.0 ± 32.8	16.2 ± 29.8	22.9 ± 32.6
11-Nov	16.3 ± 30.0	9.8 ± 27.3	36.1 ± 37.4	-10.0 ± 16.0	32.1 ± 33.3
18-Nov	10.0 ± 27.8	28.7 ± 34.3	-10.1 ± 16.1	22.3 ± 31.8	19.0 ± 34.9
25-Nov	36.1 ± 37.4	42.6 ± 39.6	9.7 ± 26.9	37.4 ± 38.8	22.5 ± 32.2
2-Dec	35.2 ± 36.5	-3.2 ± 20.1	55.9 ± 43.7	22.3 ± 31.8	9.8 ± 27.0
9-Dec	23.5 ± 33.6	29.2 ± 34.8	16.5 ± 30.4	16.5 ± 30.3	16.4 ± 30.2
15-Dec	79.9 ± 54.8	47.7 ± 44.4	35.2 ± 41.8	50.3 ± 46.6	58.1 ± 49.2
23-Dec	32.0 ± 33.3	21.0 ± 30.0	14.7 ± 27.0	8.7 ± 24.2	14.6 ± 26.8
29-Dec	3.8 ± 27.6	-11.3 ± 18.1	26.5 ± 37.7	(c)	-3.8 ± 23.3
Detection frequency	8 of 52	12 of 52	5 of 50	7 of 51	7 of 52
Median	16	16.4	10.2	16.1	16.2
IQR[(d)]	26.2	25	26	26.2	22
Maximum	79.9	182	83.2	74.7	122

Date	Gross beta AMON	Gross beta CPET	Gross beta PATT	Gross beta TANK	Gross beta ZON7
8-Jan	132 ± 121	354 ± 153	(b)	343 ± 151	357 ± 154
15-Jan	257 ± 125	179 ± 113	232 ± 125	273 ± 126	273 ± 128
22-Jan	343 ± 136	194 ± 115	345 ± 137	249 ± 121	403 ± 145
29-Jan	131 ± 105	11.1 ± 83.2	74.0 ± 96.2	64.0 ± 94.0	180 ± 114
5-Feb	104 ± 102	58.8 ± 92.5	49.9 ± 91.8	122 ± 104	132 ± 106
12-Feb	248 ± 124	159 ± 110	329 ± 134	179 ± 113	295 ± 130
19-Feb	210 ± 118	194 ± 115	262 ± 126	301 ± 130	297 ± 131
26-Feb	136 ± 106	67.0 ± 92.1	142 ± 105	130 ± 107	95.1 ± 97.3
4-Mar	198 ± 116	181 ± 112	179 ± 113	209 ± 116	240 ± 122
11-Mar	245 ± 122	321 ± 131	318 ± 133	407 ± 146	511 ± 155
18-Mar	150 ± 108	123 ± 105	234 ± 122	96.2 ± 98.4	107 ± 102
25-Mar	286 ± 128	286 ± 128	320 ± 135	313 ± 131	327 ± 135
1-Apr	269 ± 126	511 ± 196	249 ± 121	388 ± 143	359 ± 135
7-Apr	200 ± 132	354 ± 155	298 ± 147	243 ± 137	341 ± 152
15-Apr	286 ± 117	340 ± 122	363 ± 127	367 ± 127	314 ± 121
22-Apr	323 ± 131	334 ± 130	222 ± 117	349 ± 137	309 ± 129
29-Apr	273 ± 128	294 ± 130	246 ± 124	342 ± 133	205 ± 118
6-May	370 ± 141	361 ± 138	407 ± 145	374 ± 142	292 ± 130
13-May	269 ± 126	337 ± 134	250 ± 125	147 ± 107	317 ± 132
20-May	312 ± 132	365 ± 137	396 ± 143	202 ± 118	331 ± 134
27-May	188 ± 114	148 ± 107	170 ± 112	157 ± 108	164 ± 110
3-Jun	199 ± 115	293 ± 128	217 ± 119	277 ± 130	291 ± 128
10-Jun	205 ± 118	196 ± 114	146 ± 108	134 ± 105	131 ± 105
17-Jun	215 ± 118	377 ± 138	340 ± 135	253 ± 123	347 ± 135
24-Jun	298 ± 130	403 ± 142	392 ± 142	385 ± 144	403 ± 143
1-Jul	117.0 ± 99.9	199 ± 114	290 ± 127	226 ± 120	200 ± 113
8-Jul	111 ± 105	216 ± 118	226 ± 124	181 ± 112	215 ± 121
15-Jul	492 ± 153	522 ± 155	662 ± 173	481 ± 151	511 ± 155
22-Jul	271 ± 124	303 ± 129	326 ± 131	239 ± 123	218 ± 116
29-Jul	180 ± 111	267 ± 125	232 ± 121	179 ± 115	229 ± 120
5-Aug	95 ± 101	251 ± 122	139 ± 109	105.0 ± 99.9	196 ± 117
12-Aug	164 ± 110	250 ± 122	162 ± 112	215 ± 118	205 ± 118
19-Aug	216 ± 117	228 ± 119	252 ± 121	233 ± 120	273 ± 123
26-Aug	116 ± 102	199 ± 115	135 ± 105	128 ± 106	121 ± 104
2-Sep	262 ± 126	440 ± 147	311 ± 136	349 ± 135	396 ± 146
9-Sep	470 ± 150	662 ± 171	551 ± 161	644 ± 171	555 ± 160
16-Sep	444 ± 149	477 ± 148	381 ± 139	385 ± 142	533 ± 155
23-Sep	392 ± 142	403 ± 144	459 ± 149	359 ± 137	551 ± 159
30-Sep	507 ± 154	740 ± 175	507 ± 151	581 ± 164	455 ± 149
7-Oct	217 ± 119	298 ± 128	155 ± 109	184 ± 116	243 ± 122
14-Oct	344 ± 135	426 ± 145	(b)	350 ± 135	429 ± 146
21-Oct	747 ± 182	866 ± 188	696 ± 175	740 ± 179	851 ± 189
28-Oct	977 ± 199	1440 ± 241	1180 ± 219	1280 ± 230	1240 ± 223
4-Nov	540 ± 158	681 ± 170	514 ± 156	592 ± 163	677 ± 172
11-Nov	187 ± 114	207 ± 117	260 ± 125	196 ± 117	273 ± 117
18-Nov	599 ± 167	825 ± 184	751 ± 183	622 ± 165	906 ± 212
25-Nov	799 ± 185	792 ± 184	744 ± 178	877 ± 196	921 ± 194
2-Dec	1320 ± 225	1580 ± 246	1190 ± 218	1390 ± 231	1490 ± 240
9-Dec	999 ± 206	1040 ± 205	788 ± 185	1020 ± 206	1010 ± 204
15-Dec	888 ± 211	725 ± 191	803 ± 206	699 ± 194	651 ± 189
23-Dec	264 ± 115	224 ± 112	198 ± 107	162 ± 100	175 ± 103
29-Dec	138 ± 118	249 ± 136	139 ± 120	(c)	138 ± 118
Detection frequency	51 of 52	49 of 52	48 of 50	49 of 51	51 of 52
Median	263	312	294	277	312
IQR[(d)]	188	244	186	204	256
Maximum	1320	1580	1190	1390	1490

(a) See *Environmental Report 2008,* Figure 4-3 for map of sampling locations.
(b) No sample for this time period due to power (GFI) malfunction.
(c) Different sample dates occur when samples could not be collected on scheduled sampling date, or sampler ran longer than 1 week.
(d) IQR = interquartile range

A.2.8 Tritium concentrations (mBq/m3) in air, Livermore Valley, 2008[(a)]

Week	Month	AMON	CPET	FIRE	HOSP	PATT	VET	ZON7
1	Jan	9.3 ± 12.6	6.7 ± 13.7	11.0 ± 12.6	7.5 ± 11.4	0.7 ± 10.7	7.4 ± 13.1	27.0 ± 15.2
3	Jan	6.2 ± 18.5	-6.2 ± 15.5	-18.2 ± 14.5	0.1 ± 14.0	-20.4 ± 12.6	-25.3 ± 14.7	4.7 ± 15.0
5	Feb	3.3 ± 15.0	2.4 ± 14.0	5.1 ± 14.2	-7.0 ± 12.8	1.6 ± 12.4	10.5 ± 15.0	1.3 ± 13.6
7	Feb	3.0 ± 12.0	7.1 ± 12.4	5.2 ± 10.9	-6.7 ± 10.4	5.7 ± 11.1	4.6 ± 11.2	-3.7 ± 11.3
9	Mar	14.5 ± 13.1	17.1 ± 13.5	-2.0 ± 11.3	-5.0 ± 11.2	19.1 ± 12.0	12.8 ± 12.0	10.0 ± 12.6
11	Mar	8.7 ± 16.4	-7.0 ± 15.8	-5.5 ± 14.4	-25.2 ± 14.3	-6.1 ± 14.3	-8.9 ± 14.4	-12.5 ± 15.0
13	Apr	-4.5 ± 16.1	9.2 ± 17.1	8.7 ± 15.3	-15.8 ± 15.1	11.8 ± 15.1	(b)	-4.0 ± 15.4
15	Apr	30.1 ± 19.1	32.6 ± 19.0	33.8 ± 17.7	-4.0 ± 17.8	-0.0 ± 16.9	-13.3 ± 15.2	8.4 ± 18.2
17	May	4.0 ± 16.6	-1.6 ± 16.5	8.3 ± 15.4	7.2 ± 17.6	-10.9 ± 15.2	7.8 ± 14.3	1.1 ± 15.1
19	May	11.4 ± 18.8	24.1 ± 17.8	6.2 ± 17.1	-2.7 ± 20.7	-2.6 ± 17.4	13.4 ± 16.3	0.2 ± 16.4
21	May	-20.9 ± 23.5	27.2 ± 22.1	12.7 ± 21.6	-2.2 ± 30.3	0.6 ± 21.6	7.2 ± 20.0	14.1 ± 21.2
23	Jun	8.2 ± 15.6	26.3 ± 14.3	-4.7 ± 12.8	-2.0 ± 12.8	4.7 ± 13.3	10.7 ± 12.3	24.0 ± 13.8
25	Jun	29.3 ± 15.7	43.7 ± 15.4	14.5 ± 14.0	-1.6 ± 13.6	-0.7 ± 12.0	12.6 ± 12.8	34.7 ± 14.1
27	Jul	-21.8 ± 24.0	32.0 ± 27.3	-18.0 ± 23.2	-9.7 ± 25.3	7.1 ± 22.2	-14.9 ± 21.9	8.4 ± 25.9
29	Jul	15.2 ± 16.7	48.5 ± 20.0	-9.2 ± 16.7	-3.4 ± 17.5	12.9 ± 16.3	14.6 ± 15.9	19.6 ± 18.7
31	Aug	9.7 ± 16.2	32.9 ± 15.9	-6.6 ± 15.0	12.9 ± 18.4	3.9 ± 14.6	0.8 ± 14.4	18.1 ± 17.5
33	Aug	-4.4 ± 16.5	40.0 ± 17.2	-7.0 ± 16.5	5.0 ± 19.8	-10.1 ± 14.2	10.7 ± 15.9	4.8 ± 17.4
35	Sep	9.69 ± 9.77	27.1 ± 11.7	8.29 ± 9.95	4.7 ± 14.1	9.99 ± 7.92	4.8 ± 10.7	12.30 ± 9.88
37	Sep	-4.7 ± 19.3	11.0 ± 19.2	8.6 ± 20.1	-3.5 ± 18.0	-11.0 ± 18.0	-11.1 ± 17.9	-3.7 ± 17.2
39	Oct	15.7 ± 19.6	14.8 ± 18.3	-0.1 ± 18.7	-6.8 ± 19.2	-14.4 ± 15.0	2.1 ± 16.3	-6.6 ± 15.2
41	Oct	16.1 ± 14.8	11.7 ± 13.0	10.7 ± 14.8	-6.1 ± 12.1	2.8 ± 17.1	14.2 ± 12.1	-4.7 ± 10.4
43	Oct	31.9 ± 13.8	45.9 ± 15.2	33.1 ± 17.0	15.7 ± 13.8	19.2 ± 14.5	21.3 ± 14.4	27.9 ± 12.6
45	Nov	17.5 ± 15.7	21.2 ± 18.8	11.2 ± 18.3	8.3 ± 16.4	16.5 ± 17.3	3.4 ± 16.1	-11.1 ± 13.3
47	Nov	8.8 ± 13.1	6.2 ± 15.1	15.9 ± 13.1	10.8 ± 13.8	21.5 ± 15.5	11.2 ± 13.7	3.6 ± 12.2
49	Dec	15.8 ± 12.1	33.3 ± 13.3	20.1 ± 12.7	13.1 ± 12.6	15.7 ± 11.9	10.0 ± 12.1	22.6 ± 11.7
51	Dec	9.51 ± 9.88	40.7 ± 12.1	1.1 ± 10.7	-5.77 ± 9.95	3.31 ± 9.69	19.7 ± 11.3	9.07 ± 9.47
	Median	9.4	22.6	7.25	-2.46	3.03	7.84	6.62
	IQR[(c)]	12.1	25.2	15.2	12.7	13.5	10.5	19.8
	Median Percent of DCG[(e)]	0.00025	0.00061	0.0002	(e)	0.000082	0.00021	0.00018
	Mean Dose (nSv)[(f)(g)]	<5	<5	<5	(e)	<5	<5	<5

(a) See *Environmental Report 2008,* Figure 4-3 for map of sampling locations.

(b) Lost sample

(c) IQR = Interquartile range

(d) Not a valid statistic.

(e) DCG = Derived Concentration Guide of 3.7E+06 mBq/m^3 for tritium in air. Percent of DCG is calculated from the median concentration.

(f) This annual dose is calculated from the mean concentration and represents the effective dose equivalent from inhalation and skin absorbtion.

(g) When the mean dose is based on a concentration less than the lower limit of detection (about 25 mBq/m3), the dose is assumed to be less than that calculated from the lower limit of detection (i.e., 5 nSv/year).

A.2.9 Weekly gross alpha and gross beta concentrations ($\mu Bq/m^3$) from air particulate samples from Livermore Valley upwind locations and the special interest location, 2008 [(a)]

Date	Gross alpha CHUR	Gross alpha FCC	Gross alpha FIRE	Gross alpha HOSP	Gross alpha LWRP
8-Jan	3.9 ± 28.3	-3.9 ± 23.9	(b)	19.2 ± 35.4	41.8 ± 43.3
15-Jan	29.3 ± 35.0	3.3 ± 24.0	3.7 ± 27.1	-9.9 ± 15.9	-9.4 ± 15.1
22-Jan	42.6 ± 39.2	3.3 ± 23.9	(c)	3.3 ± 24.0	16.2 ± 29.7
29-Jan	-3.3 ± 20.5	9.7 ± 26.8	-3.2 ± 19.6	23.1 ± 33.0	-9.9 ± 15.8
5-Feb	-3.3 ± 20.5	3.3 ± 24.4	14.3 ± 39.6	10.1 ± 27.9	3.3 ± 23.9
12-Feb	16.4 ± 30.1	-9.8 ± 15.7	9.7 ± 26.9	23.0 ± 32.8	9.7 ± 27.0
19-Feb	23.0 ± 32.8	9.9 ± 27.4	16.1 ± 29.6	9.7 ± 26.8	22.3 ± 31.8
26-Feb	3.2 ± 23.8	-3.3 ± 20.3	10.0 ± 27.7	3.4 ± 24.6	-3.4 ± 20.8
4-Mar	3.3 ± 24.0	-9.9 ± 15.8	9.1 ± 25.2	-3.3 ± 20.5	-3.3 ± 20.2
11-Mar	22.9 ± 32.6	55.9 ± 43.7	-9.5 ± 15.2	-9.9 ± 15.9	-3.3 ± 20.4
18-Mar	-9.8 ± 15.6	-3.3 ± 20.3	3.3 ± 23.9	3.3 ± 24.3	-9.8 ± 15.7
25-Mar	9.8 ± 27.2	3.3 ± 24.2	22.6 ± 32.3	3.3 ± 24.1	22.8 ± 32.6
1-Apr	-3.3 ± 20.2	-9.8 ± 15.8	23.3 ± 33.3	16.5 ± 30.3	16.4 ± 30.0
7-Apr	19.4 ± 35.6	35.2 ± 41.8	11.7 ± 32.4	11.7 ± 32.4	42.6 ± 44.0
15-Apr	8.6 ± 23.8	8.7 ± 24.0	14.4 ± 26.5	2.9 ± 21.2	25.8 ± 30.8
22-Apr	16.1 ± 29.6	-3.2 ± 20.1	3.3 ± 23.9	35.9 ± 37.4	9.7 ± 26.9
29-Apr	16.5 ± 30.3	3.3 ± 24.3	22.4 ± 32.0	9.8 ± 27.3	29.2 ± 34.8
6-May	-9.9 ± 15.9	16.7 ± 30.7	23.4 ± 33.4	-10.1 ± 16.2	-3.3 ± 20.5
13-May	29.5 ± 35.2	9.9 ± 27.4	-9.8 ± 15.7	16.5 ± 30.4	-9.8 ± 15.7
20-May	16.4 ± 30.1	16.5 ± 30.3	9.8 ± 27.1	16.4 ± 30.1	9.7 ± 26.9
27-May	9.7 ± 27.0	16.3 ± 30.0	-10.1 ± 16.1	18.9 ± 34.8	28.6 ± 34.2
3-Jun	3.3 ± 24.0	16.5 ± 30.2	9.7 ± 26.7	10.1 ± 28.0	16.8 ± 30.8
10-Jun	9.9 ± 27.4	23.2 ± 33.1	3.3 ± 24.1	16.4 ± 30.2	3.3 ± 24.1
17-Jun	9.7 ± 26.9	16.3 ± 29.9	36.3 ± 37.7	9.9 ± 27.5	9.8 ± 27.2
24-Jun	35.4 ± 36.9	9.7 ± 27.0	49.9 ± 42.2	16.2 ± 29.8	29.0 ± 34.6
1-Jul	9.7 ± 26.8	22.7 ± 32.4	47.0 ± 43.7	50.3 ± 42.6	23.3 ± 33.3
8-Jul	17.0 ± 31.2	-10.2 ± 16.4	35.7 ± 37.0	3.3 ± 24.0	16.4 ± 30.2
15-Jul	42.2 ± 39.2	62.2 ± 45.1	36.2 ± 37.7	49.2 ± 41.4	9.6 ± 26.6
22-Jul	22.3 ± 31.9	-3.3 ± 20.3	3.4 ± 25.0	9.9 ± 27.4	9.9 ± 27.3
29-Jul	-3.3 ± 20.2	4.0 ± 29.0	-3.3 ± 20.5	16.5 ± 30.4	-3.4 ± 21.3
5-Aug	-3.4 ± 21.0	16.9 ± 31.2	3.2 ± 23.7	9.8 ± 27.2	9.7 ± 26.8
12-Aug	9.6 ± 26.6	22.6 ± 32.3	56.2 ± 44.0	-3.3 ± 20.7	16.5 ± 30.5
19-Aug	3.2 ± 23.4	-3.3 ± 20.4	16.4 ± 30.2	9.8 ± 27.3	23.0 ± 32.8
26-Aug	10.0 ± 27.8	22.9 ± 32.7	23.0 ± 32.8	-9.9 ± 15.8	9.8 ± 27.0
2-Sep	28.9 ± 34.5	9.7 ± 26.9	41.1 ± 38.1	22.5 ± 32.1	22.8 ± 32.6
9-Sep	16.2 ± 29.8	61.8 ± 45.1	43.3 ± 40.0	75.8 ± 49.2	42.9 ± 40.0
16-Sep	30.2 ± 36.0	23.5 ± 33.6	16.6 ± 30.6	16.8 ± 31.0	16.3 ± 30.0
23-Sep	55.9 ± 43.7	9.9 ± 27.6	23.4 ± 33.4	23.1 ± 33.0	29.4 ± 35.1
30-Sep	29.1 ± 34.7	55.1 ± 43.3	16.1 ± 29.5	42.2 ± 39.2	42.2 ± 39.2
7-Oct	9.7 ± 26.8	16.2 ± 29.7	9.9 ± 27.6	10.1 ± 28.0	-3.4 ± 20.8
14-Oct	61.8 ± 45.1	3.3 ± 24.0	9.7 ± 26.8	-3.2 ± 19.7	22.2 ± 31.8
21-Oct	30.2 ± 36.0	30.4 ± 36.3	30.1 ± 35.9	37.0 ± 38.5	57.0 ± 44.8
28-Oct	28.8 ± 34.4	80.3 ± 49.6	69.2 ± 47.4	42.6 ± 39.6	74.7 ± 48.5
4-Nov	35.7 ± 37.0	61.8 ± 45.1	34.8 ± 36.2	23.3 ± 33.3	62.2 ± 45.5
11-Nov	22.9 ± 32.6	9.8 ± 27.3	10.1 ± 28.0	3.2 ± 23.7	19.9 ± 28.3
18-Nov	29.6 ± 35.3	36.5 ± 38.1	9.9 ± 27.4	10.0 ± 27.7	34.6 ± 41.4
25-Nov	29.9 ± 35.7	36.8 ± 38.1	49.6 ± 41.8	16.4 ± 30.1	61.8 ± 45.1
2-Dec	36.0 ± 37.4	49.2 ± 41.8	16.5 ± 30.2	16.5 ± 30.4	9.8 ± 27.2
9-Dec	16.3 ± 30.0	36.1 ± 37.4	3.3 ± 24.1	29.4 ± 35.0	35.9 ± 37.4
15-Dec	49.2 ± 45.9	(d)	83.6 ± 54.0	11.2 ± 31.1	79.6 ± 54.4
16-Dec	(d)	30.1 ± 35.9	(d)	(d)	(d)
23-Dec	26.3 ± 31.4	16.1 ± 29.7	26.8 ± 32.0	25.8 ± 30.7	31.6 ± 32.8
29-Dec	18.8 ± 34.5	11.3 ± 31.3	3.8 ± 28.0	56.6 ± 47.7	34.4 ± 41.1
Detection frequency	5 of 52	7 of 52	8 of 50	6 of 52	7 of 52
Median	16.4	13.7	15.2	14	16.6
IQR[(e)]	20	21.9	24.1	19.7	20.3
Maximum	61.8	80.3	83.6	75.8	79.6

Date	Gross beta CHUR	Gross beta FCC	Gross beta FIRE	Gross beta HOSP	Gross beta LWRP
8-Jan	411 ± 161	238 ± 137	(b)	366 ± 154	407 ± 158
15-Jan	357 ± 137	263 ± 125	222 ± 130	238 ± 122	349 ± 132
22-Jan	603 ± 165	481 ± 152	(c)	230 ± 120	477 ± 150
29-Jan	136 ± 107	128 ± 103	139 ± 103	92.9 ± 99.2	68.8 ± 94.7
5-Feb	112 ± 102	132 ± 107	86 ± 134	119 ± 105	96.6 ± 98.8
12-Feb	344 ± 135	316 ± 132	374 ± 138	241 ± 122	459 ± 149
19-Feb	307 ± 131	280 ± 128	263 ± 123	353 ± 135	312 ± 129
26-Feb	110 ± 101	107 ± 101	176 ± 114	114 ± 104	109 ± 103
4-Mar	368 ± 138	145 ± 108	58.8 ± 86.2	290 ± 130	267 ± 125
11-Mar	474 ± 151	342 ± 136	112.0 ± 99.2	426 ± 147	388 ± 142
18-Mar	158 ± 109	188 ± 114	262 ± 124	137 ± 107	183 ± 113
25-Mar	306 ± 131	236 ± 122	307 ± 130	365 ± 139	366 ± 138
1-Apr	268 ± 125	178 ± 112	292 ± 130	275 ± 127	377 ± 139
7-Apr	323 ± 149	178 ± 129	257 ± 141	325 ± 150	367 ± 155
15-Apr	318 ± 121	215 ± 108	370 ± 128	451 ± 138	381 ± 128
22-Apr	358 ± 136	346 ± 135	403 ± 142	381 ± 140	440 ± 146
29-Apr	294 ± 130	314 ± 132	300 ± 128	264 ± 125	341 ± 134
6-May	320 ± 134	303 ± 132	357 ± 139	364 ± 141	343 ± 136
13-May	202 ± 116	241 ± 122	273 ± 126	204 ± 117	249 ± 123
20-May	216 ± 118	203 ± 117	262 ± 124	462 ± 150	261 ± 124
27-May	186 ± 113	120 ± 103	216 ± 120	139 ± 119	173 ± 109
3-Jun	192 ± 115	212 ± 118	193 ± 113	202 ± 118	124 ± 106
10-Jun	102 ± 101	161 ± 111	92.5 ± 98.4	126 ± 104	174 ± 112
17-Jun	336 ± 134	267 ± 125	388 ± 142	251 ± 124	292 ± 128
24-Jun	358 ± 136	261 ± 124	466 ± 152	275 ± 125	403 ± 142
1-Jul	194 ± 114	242 ± 121	296 ± 138	265 ± 127	215 ± 120
8-Jul	199 ± 119	210 ± 121	186 ± 113	139 ± 106	245 ± 123
15-Jul	437 ± 146	396 ± 142	448 ± 148	477 ± 152	488 ± 151
22-Jul	219 ± 116	183 ± 113	230 ± 124	236 ± 121	212 ± 118
29-Jul	182 ± 112	283 ± 146	194 ± 115	127 ± 105	182 ± 117
5-Aug	213 ± 121	159 ± 112	119 ± 102	149 ± 108	157 ± 108
12-Aug	174 ± 110	166 ± 110	194 ± 116	172 ± 113	88.4 ± 98.4
19-Aug	215 ± 116	275 ± 127	216 ± 118	221 ± 119	240 ± 122
26-Aug	109 ± 103	135 ± 105	126 ± 104	117 ± 103	186 ± 113
2-Sep	347 ± 134	316 ± 131	338 ± 132	338 ± 133	396 ± 141
9-Sep	351 ± 135	433 ± 146	551 ± 161	540 ± 159	533 ± 158
16-Sep	348 ± 138	426 ± 148	307 ± 132	349 ± 139	414 ± 144
23-Sep	440 ± 148	368 ± 140	440 ± 149	357 ± 138	396 ± 142
30-Sep	477 ± 151	644 ± 169	596 ± 162	533 ± 157	625 ± 167
7-Oct	161 ± 108	209 ± 116	238 ± 122	158 ± 112	226 ± 121
14-Oct	422 ± 145	426 ± 146	540 ± 157	307 ± 128	437 ± 144
21-Oct	718 ± 179	873 ± 195	840 ± 191	559 ± 164	758 ± 184
28-Oct	1140 ± 212	1270 ± 222	1230 ± 222	918 ± 196	1240 ± 221
4-Nov	666 ± 171	511 ± 155	585 ± 160	474 ± 153	581 ± 163
11-Nov	282 ± 127	236 ± 121	271 ± 128	124 ± 102	212 ± 106
18-Nov	840 ± 189	703 ± 177	707 ± 176	437 ± 148	1070 ± 228
25-Nov	803 ± 187	770 ± 185	1020 ± 206	607 ± 166	1010 ± 202
2-Dec	1790 ± 262	1970 ± 274	1510 ± 243	984 ± 202	1570 ± 246
9-Dec	1230 ± 221	1090 ± 211	1010 ± 204	936 ± 197	1150 ± 214
15-Dec	925 ± 214	(d)	762 ± 193	744 ± 194	866 ± 208
16-Dec	(d)	892 ± 195	(d)	(d)	(d)
23-Dec	240 ± 112	293 ± 128	214 ± 110	193 ± 104	331 ± 122
29-Dec	127 ± 116	275 ± 139	235 ± 135	211 ± 130	291 ± 144
Detection frequency	52 of 52	52 of 52	47 of 50	51 of 52	49 of 52
Median	319	271	282	275	346
IQR[(e)]	228	204	232	241	230
Maximum	1790	1970	1510	984	1570

(a) See *Environmental Report 2008,* Figure 4-3 for map of sampling locations.
(b) No sample for this period due to power (GFI) malfunction.
(c) No sample for this period due to sampler malfunction.
(d) Consecutive sample dates occur when samples could not be collected on scheduled sampling date, or when a sampler ran longer than 1 week.
(e) IQR = interquartile range

A.2.10 Plutonium-239+240 concentrations (nBq/m^3) in air particulate samples from the Livermore Valley, 2008[a]

Month	Valley upwind CHUR	Valley upwind FCC	Valley upwind FIRE	Valley upwind HOSP	Valley downwind AMON	Valley downwind CPET	Valley downwind PATT	Valley downwind TANK	Valley downwind ZON7	Special interest LWRP
Jan	-0.76 ± 4.66	0.82 ± 9.58	-4.7 ± 11.4	-4.00 ± 7.40	-2.96 ± 7.81	3.34 ± 7.10	0.97 ± 7.96	8.4 ± 14.3	-4.48 ± 3.20	30.3 ± 17.5
Feb	0.84 ± 9.69	-9.21 ± 5.99	-7.51 ± 6.84	-4.03 ± 3.67	1.5 ± 12.2	2.2 ± 10.1	-7.51 ± 7.77	-8.07 ± 5.85	-0.57 ± 5.03	5.4 ± 13.1
Mar	3.65 ± 8.73	-2.89 ± 9.92	-0.34 ± 8.07	-15.8 ± 14.4	-2.91 ± 7.07	6.70 ± 8.58	-3.85 ± 6.62	-1.1 ± 10.4	-0.25 ± 6.03	33.0 ± 18.2
Apr	-1.50 ± 9.25	-4.88 ± 9.03	12.7 ± 21.8	2.2 ± 10.2	-2.22 ± 4.44	4.4 ± 10.5	8.4 ± 27.3	3.3 ± 24.0	-0.90 ± 8.88	55.9 ± 27.8
May	-0.24 ± 5.74	-2.86 ± 7.51	8.7 ± 12.0	0.72 ± 9.77	8.84 ± 7.96	3.51 ± 7.73	5.07 ± 5.74	4.8 ± 12.0	3.46 ± 7.40	37.4 ± 16.7
Jun	4.7 ± 12.4	3.22 ± 8.70	-1.2 ± 11.2	-2.4 ± 15.0	-4.51 ± 6.84	-1.4 ± 12.2	-3.5 ± 11.9	4.7 ± 10.3	-6.6 ± 13.6	37.4 ± 26.6
Jul	-3.29 ± 8.62	7.1 ± 12.0	11.2 ± 10.1	20.4 ± 39.2	1.6 ± 17.5	3.88 ± 8.55	9.6 ± 15.1	1.48 ± 6.62	-1.03 ± 9.84	50.7 ± 23.5
Aug	3.12 ± 6.88	1.15 ± 5.18	2.35 ± 5.18	-5.11 ± 7.73	2.62 ± 8.29	18.0 ± 12.1	6.51 ± 7.36	-0.50 ± 4.29	3.60 ± 6.18	4.1 ± 19.1
Sep	2.08 ± 9.62	3.77 ± 7.66	23.1 ± 23.0	-2.62 ± 8.95	-3.37 ± 6.96	20.4 ± 18.0	-2.68 ± 8.62	8.3 ± 12.0	1.92 ± 5.77	4.55 ± 9.69
Oct	0.47 ± 5.51	4.1 ± 10.8	7.40 ± 8.36	3.4 ± 10.8	9.5 ± 10.4	-0.9 ± 12.4	-0.68 ± 5.92	6.51 ± 8.33	7.84 ± 7.14	18.7 ± 19.5
Nov	3.96 ± 7.58	0.62 ± 5.85	2.63 ± 5.81	5.3 ± 11.4	0.8 ± 10.3	1.36 ± 6.07	-0.18 ± 4.33	3.96 ± 6.73	-3.96 ± 8.51	5.81 ± 7.88
Dec	-1.02 ± 6.29	-1.29 ± 7.96	-2.7 ± 11.5	1.28 ± 5.74	-0.22 ± 5.36	16.4 ± 11.5	-20.3 ± 53.3	-1.15 ± 7.10	-1.1 ± 10.8	3.85 ± 9.25
Detection frequency	0 of 12	0 of 12	2 of 12	0 of 12	1 of 12	3 of 12	0 of 12	0 of 12	1 of 12	6 of 12
Median	0.655	0.722	2.49	-0.852	0.269	3.7	-0.428	3.62	-0.736	24.5
IQR[b]	4.08	6.22	10.9	6.54	4.78	7.14	9	5.84	4.11	32.2
Maximum	4.74	7.07	23.1	20.4	9.51	20.4	9.62	8.44	7.84	55.9
Median Percent of DCG	0.000089	0.000098	0.00034	(c)	0.000036	0.0005	(c)	0.00049	(c)	0.0033
DCG(d)	740000	740000	740000	740000	740000	740000	740000	740000	740000	740000

(a) See *Environmental Report 2008*, Figures 4-1, 4-2, and 4-3 for maps of sampling locations.
(b) IQR = Interquartile range
(c) Median percent of DCG calculated only when medians are greater than zero.
(d) DCG is the Derived Concentration Guide established by the DOE and is the amount of plutonium-239+240 that can be inhaled continuously 365 days a year without exceeding the DOE primary radiation protection standard for the public.

AT-S3

A.2.11 Tritium concentrations (mBq/m^3) in air, Site 300, 2008[a]

Week	Month	PSTL
1	Jan	8.3 ± 10.7
3	Jan	-21.3 ± 13.4
5	Feb	-9.7 ± 11.1
7	Feb	11.3 ± 10.9
9	Mar	2.6 ± 11.9
11	Mar	-16.5 ± 13.0
13	Apr	-2.6 ± 13.8
15	Apr	5.1 ± 16.0
17	Apr	-3.5 ± 13.8
19	May	16.9 ± 15.1
21	May	9.1 ± 20.8
23	Jun	-8.0 ± 11.4
25	Jun	19.6 ± 10.4
27	Jul	31.9 ± 25.4
29	Jul	21.3 ± 15.8
31	Aug	-4.2 ± 11.4
33	Aug	(b)
35	Sep	-1.10 ± 8.88
37	Sep	5.1 ± 15.8
39	Oct	-13.2 ± 17.0
41	Oct	-2.7 ± 12.0
43	Oct	18.8 ± 12.6
45	Nov	0.1 ± 14.6
47	Nov	-5.5 ± 13.0
49	Dec	17.4 ± 13.0
51	Dec	(b)
	Median	1.32
	IQR[c]	17.2
	Median Percent of DCG[d]	0.000036
	Mean Dose (nSv)[e][f]	<5

(a) See *Environmental Report 2008,* Figure 4-2 for map of sampling locations.

(b) Lost sample

(c) IQR = Interquartile range

(d) DCG = Derived Concentration Guide of 3.7E+06 mBq/m^3 for tritium in air. Percent of DCG is calculated from the median concentration.

(e) This annual dose is calculated from the mean concentration and represents the effective dose equivalent from inhalation and skin absorbtion.

(f) When the mean dose is based on a concentration less than the lower limit of detection (about 25 mBq/m^3), the dose is assumed to be less than that calculated from the lower limit of detection (i.e., 5 nSv/year).

A.2.12 Weekly gross alpha and gross beta concentrations (μBq/m^3) from air particulate samples from Site 300 onsite and offsite locations, 2008[(a)]

Date	Gross alpha 801E	Gross alpha TNK5	Gross alpha PSTL	Gross alpha ECP	Gross alpha EOBS	Gross alpha GOLF	Gross alpha NPS	Gross alpha WCP	Gross alpha WOBS	Gross alpha TCDF
9-Jan	(b)	(c)	22.9 ± 32.7	9.9 ± 27.5	16.5 ± 30.3	3.3 ± 24.0	16.1 ± 29.5	9.7 ± 27.0	-9.8 ± 15.8	-3.5 ± 21.9
16-Jan	11.5 ± 16.4	(c)	23.1 ± 33.0	16.7 ± 30.7	3.3 ± 24.3	3.3 ± 24.2	3.2 ± 23.7	3.3 ± 24.0	9.9 ± 27.5	16.4 ± 30.2
23-Jan	9.7 ± 27.0	(c)	23.0 ± 32.8	16.6 ± 30.5	23.1 ± 33.0	49.2 ± 41.8	9.7 ± 26.7	3.2 ± 23.8	9.8 ± 27.2	55.1 ± 43.3
30-Jan	29.4 ± 35.1	(c)	3.3 ± 24.4	16.7 ± 30.7	3.3 ± 24.5	9.9 ± 27.5	-3.2 ± 20.1	-9.8 ± 15.8	3.3 ± 24.3	3.3 ± 24.2
6-Feb	3.2 ± 23.8	(c)	3.3 ± 24.0	-3.3 ± 20.6	-9.9 ± 15.9	-3.3 ± 20.4	-9.7 ± 15.5	9.8 ± 27.1	3.3 ± 24.2	-9.8 ± 15.7
13-Feb	3.3 ± 24.1	(c)	35.5 ± 36.9	-10.2 ± 16.2	16.6 ± 30.5	3.3 ± 24.5	3.4 ± 24.6	23.2 ± 33.1	16.8 ± 30.8	-3.5 ± 21.8
20-Feb	-9.9 ± 15.9	(c)	-3.4 ± 20.8	3.4 ± 24.6	3.3 ± 24.0	3.2 ± 23.8	-3.4 ± 20.8	16.4 ± 30.2	9.9 ± 27.6	3.5 ± 25.5
27-Feb	(c)	-3.3 ± 20.2	3.3 ± 24.3	-10.0 ± 16.0	-9.8 ± 15.7	16.5 ± 30.3	-10.4 ± 16.6	-9.7 ± 15.5	9.8 ± 27.0	17.4 ± 31.9
5-Mar	(c)	-9.9 ± 15.8	3.3 ± 24.4	3.4 ± 24.9	16.5 ± 30.3	-3.3 ± 20.6	3.4 ± 24.8	10.0 ± 27.7	-10.1 ± 16.1	-3.6 ± 22.1
12-Mar	(c)	16.2 ± 29.7	22.9 ± 32.7	-10.0 ± 16.0	3.2 ± 23.8	9.7 ± 26.9	-3.3 ± 20.4	3.2 ± 23.8	9.8 ± 27.3	31.3 ± 37.4
19-Mar	(c)	-9.8 ± 15.7	3.3 ± 24.4	-9.9 ± 15.9	16.5 ± 30.3	3.3 ± 24.3	-3.4 ± 20.8	3.3 ± 24.1	-9.9 ± 15.9	-3.5 ± 21.7
26-Mar	(c)	-3.2 ± 20.0	16.4 ± 30.0	36.2 ± 37.7	3.2 ± 23.6	22.8 ± 32.5	3.3 ± 23.9	9.7 ± 27.0	16.4 ± 30.0	3.5 ± 25.4
2-Apr	(c)	3.3 ± 24.2	-3.3 ± 20.6	-3.4 ± 20.9	-3.3 ± 20.6	-3.3 ± 20.6	-3.4 ± 20.9	10.0 ± 27.8	-10.1 ± 16.2	-10.7 ± 17.2
9-Apr	(c)	9.7 ± 27.0	23.0 ± 32.9	9.9 ± 27.6	-3.3 ± 20.2	42.6 ± 39.6	23.2 ± 33.0	3.3 ± 24.0	-3.3 ± 20.4	-3.5 ± 21.7
16-Apr	(c)	3.4 ± 24.8	14.0 ± 25.8	3.5 ± 25.3	10.2 ± 28.2	9.9 ± 27.6	24.0 ± 34.3	30.6 ± 36.5	36.7 ± 38.1	24.8 ± 35.4
23-Apr	(c)	16.1 ± 29.6	35.9 ± 42.9	10.1 ± 28.2	16.2 ± 29.8	48.8 ± 41.4	49.2 ± 41.8	29.2 ± 34.8	16.3 ± 30.0	52.2 ± 44.0
30-Apr	(c)	3.3 ± 23.9	36.3 ± 37.7	23.5 ± 33.6	3.3 ± 24.0	3.3 ± 24.1	-3.3 ± 20.6	3.3 ± 24.1	-3.3 ± 20.5	10.5 ± 29.2
7-May	(c)	62.5 ± 45.5	23.3 ± 33.2	10.1 ± 28.1	23.1 ± 33.0	36.4 ± 37.7	50.3 ± 42.6	9.9 ± 27.5	30.0 ± 35.8	17.7 ± 32.5
14-May	(c)	-3.3 ± 20.2	42.9 ± 40.0	3.4 ± 24.5	9.8 ± 27.2	9.8 ± 27.3	16.6 ± 30.5	9.8 ± 27.3	-3.3 ± 20.5	76.6 ± 55.9
21-May	(c)	16.1 ± 29.6	40.0 ± 57.4	16.6 ± 30.5	16.1 ± 29.7	3.2 ± 23.8	22.9 ± 32.7	22.7 ± 32.4	16.3 ± 30.0	25.8 ± 30.7
28-May	(c)	3.2 ± 23.7	43.3 ± 40.3	10.2 ± 28.2	-9.9 ± 15.8	16.6 ± 30.5	24.8 ± 35.3	9.9 ± 27.5	3.3 ± 24.4	7.8 ± 21.7
4-Jun	(c)	16.2 ± 29.7	(d)	3.3 ± 24.4	29.2 ± 34.9	29.4 ± 35.0	3.8 ± 27.8	3.3 ± 24.0	29.6 ± 35.3	23.6 ± 33.7
10-Jun	(c)	11.5 ± 31.9	3.9 ± 28.5	-4.0 ± 24.4	19.2 ± 35.3	27.0 ± 38.5	35.2 ± 41.8	(b)	(b)	19.5 ± 35.9
18-Jun	(c)	14.1 ± 26.0	2.9 ± 20.9	32.0 ± 33.3	19.9 ± 28.4	19.9 ± 28.5	14.4 ± 26.5	31.2 ± 22.7	14.9 ± 17.7	27.3 ± 32.5
25-Jun	(c)	48.8 ± 41.4	23.1 ± 32.9	104.0 ± 56.6	16.2 ± 29.8	16.4 ± 30.2	16.5 ± 30.3	48.5 ± 41.1	48.8 ± 41.1	49.9 ± 46.2
2-Jul	(c)	90.3 ± 55.9	-4.2 ± 26.0	84.7 ± 52.2	23.2 ± 33.2	29.7 ± 35.4	23.5 ± 33.5	-3.3 ± 20.7	64.0 ± 46.6	47.4 ± 56.6
9-Jul	(c)	44.0 ± 40.7	(d)	37.0 ± 38.5	26.5 ± 48.8	3.3 ± 24.1	14.8 ± 41.1	33.7 ± 40.0	64.0 ± 49.9	42.6 ± 44.4
16-Jul	(c)	42.9 ± 40.0	62.2 ± 45.5	77.3 ± 50.3	55.5 ± 43.3	29.5 ± 35.1	30.3 ± 55.9	78.8 ± 46.6	73.6 ± 45.5	38.5 ± 40.3
23-Jul	(c)	81.4 ± 50.3	(b)	37.0 ± 38.5	9.8 ± 27.2	3.3 ± 24.1	16.6 ± 30.5	16.4 ± 30.2	3.3 ± 24.2	30.2 ± 36.0
24-Jul	(c)	(b)	37.7 ± 35.0	(b)	(b)	(b)	(b)	(b)	(b)	(b)
30-Jul	(c)	36.1 ± 37.4	27.0 ± 38.5	10.5 ± 29.3	9.9 ± 27.4	16.5 ± 30.4	16.7 ± 30.7	23.1 ± 32.9	43.3 ± 40.0	12.4 ± 34.3
6-Aug	(c)	-9.7 ± 15.5	16.4 ± 30.1	3.4 ± 24.8	-9.8 ± 15.7	-3.3 ± 20.2	16.5 ± 30.3	(b)	(b)	14.2 ± 26.1
13-Aug	(c)	-3.3 ± 20.2	9.9 ± 27.5	23.8 ± 34.0	29.6 ± 35.3	9.9 ± 27.4	-10.0 ± 15.9	-4.92 ± 7.88	18.2 ± 18.9	43.7 ± 37.0

20-Aug	(c)	3.2 ± 23.5	69.9 ± 54.4	30.0 ± 35.8	16.1 ± 29.6	-3.2 ± 20.1	11.0 ± 30.4	16.1 ± 29.6	9.7 ± 27.0	19.1 ± 35.1
27-Aug	(c)	-3.3 ± 20.5	41.8 ± 38.8	-3.5 ± 21.4	-3.3 ± 20.7	3.3 ± 24.5	-3.9 ± 24.3	16.7 ± 30.8	3.4 ± 24.7	17.1 ± 31.5
3-Sep	(c)	3.3 ± 23.9	10.2 ± 28.3	37.4 ± 38.8	29.4 ± 35.1	49.2 ± 41.8	29.8 ± 35.6	42.6 ± 39.6	16.5 ± 30.3	46.2 ± 42.9
10-Sep	(c)	42.2 ± 39.2	55.9 ± 43.7	90.6 ± 53.6	49.2 ± 41.4	49.2 ± 41.4	56.2 ± 44.0	62.2 ± 45.5	36.3 ± 37.7	83.2 ± 51.4
17-Sep	(c)	(b)	29.4 ± 35.1	76.6 ± 49.6	42.2 ± 39.2	9.8 ± 27.1	96.2 ± 54.4	61.4 ± 44.8	61.8 ± 45.1	42.2 ± 39.2
24-Sep	(c)	(b)	49.6 ± 41.8	64.0 ± 46.6	16.4 ± 30.2	23.1 ± 32.9	43.7 ± 40.3	63.3 ± 46.2	43.3 ± 40.3	37.4 ± 38.8
30-Sep	(c)	23.9 ± 16.4	11.3 ± 31.4	42.9 ± 44.8	41.8 ± 43.3	3.8 ± 27.7	27.2 ± 38.8	41.8 ± 43.3	34.4 ± 41.1	11.5 ± 31.8
8-Oct	(c)	-2.9 ± 17.6	32.1 ± 33.3	2.9 ± 21.5	8.6 ± 23.8	26.1 ± 31.2	8.8 ± 24.5	44.8 ± 37.7	31.1 ± 57.4	43.7 ± 37.0
15-Oct	(c)	29.5 ± 35.1	22.9 ± 32.7	10.1 ± 28.0	23.0 ± 32.8	9.9 ± 27.4	37.7 ± 44.8	109.0 ± 57.0	58.8 ± 49.6	49.9 ± 42.2
21-Oct	(c)	9.7 ± 26.9	62.9 ± 45.9	36.7 ± 38.1	35.7 ± 37.0	48.8 ± 41.4	29.9 ± 35.6	81.8 ± 50.3	23.0 ± 32.9	3.3 ± 24.2
29-Oct	(c)	68.4 ± 47.0	69.2 ± 47.4	50.3 ± 42.6	108.0 ± 56.6	29.6 ± 35.3	76.6 ± 49.6	75.5 ± 49.2	82.5 ± 51.1	116.0 ± 58.8
5-Nov	(c)	48.5 ± 41.1	25.9 ± 30.9	77.0 ± 49.9	48.8 ± 41.4	9.8 ± 27.2	38.5 ± 40.0	20.9 ± 58.1	57.0 ± 44.8	42.9 ± 40.0
12-Nov	(c)	9.8 ± 27.3	-11.6 ± 18.5	3.4 ± 24.8	49.2 ± 41.8	-3.3 ± 20.4	-3.3 ± 20.6	29.7 ± 35.4	29.9 ± 35.7	16.6 ± 30.6
19-Nov	(c)	16.2 ± 29.9	55.9 ± 43.7	50.3 ± 42.9	16.3 ± 30.0	29.5 ± 35.2	44.4 ± 52.9	22.9 ± 32.8	3.3 ± 24.2	10.0 ± 27.7
25-Nov	(c)	(b)	96.2 ± 59.2	43.3 ± 45.1	41.8 ± 43.7	65.1 ± 51.1	38.8 ± 46.2	26.8 ± 38.1	65.9 ± 51.4	42.9 ± 44.4
3-Dec	(c)	40.7 ± 25.1	95.1 ± 49.9	56.2 ± 41.1	25.6 ± 30.6	37.4 ± 34.6	31.9 ± 33.2	(d)	66.6 ± 43.3	32.1 ± 33.3
10-Dec	(c)	22.7 ± 32.4	16.4 ± 30.2	3.4 ± 24.7	48.8 ± 41.4	22.9 ± 32.7	3.3 ± 24.2	-3.9 ± 24.0	36.4 ± 37.7	3.3 ± 24.5
18-Dec	(c)	48.5 ± 38.1	54.8 ± 40.0	50.7 ± 39.6	60.3 ± 41.4	54.8 ± 40.0	55.1 ± 40.3	25.9 ± 30.9	32.0 ± 33.3	14.7 ± 26.9
23-Dec	(c)	-4.5 ± 28.3	4.6 ± 33.8	33.2 ± 47.4	-4.6 ± 28.4	68.8 ± 58.5	-4.7 ± 28.8	23.0 ± 42.2	13.9 ± 38.5	23.4 ± 42.9
30-Dec	(c)	3.2 ± 23.7	-	30.1 ± 35.9	3.2 ± 23.8	3.3 ± 23.9	29.5 ± 35.2	-9.7 ± 15.6	-9.8 ± 15.7	42.9 ± 40.0
Detection frequency	0 of 6	12 of 42	14 of 49	11 of 52	8 of 52	10 of 52	7 of 52	11 of 49	12 of 50	13 of 52
Median	6.51	12.8	23.1	16.6	16.4	13.2	16.6	16.7	16.4	21.4
IQR[(e)]	7.8	36.3	31.9	35.4	25.9	26.2	27.4	27.9	33.3	33.4
Maximum	29.4	90.3	96.2	104	108	68.8	96.2	109	82.5	116

Date	Gross beta 801E	Gross beta TNK5	Gross beta PSTL	Gross beta ECP	Gross beta EOBS	Gross beta GOLF	Gross beta NPS	Gross beta WCP	Gross beta WOBS	Gross beta TCDF
9-Jan	(b)	(c)	301 ± 130	233 ± 122	212 ± 118	320 ± 132	272 ± 124	280 ± 127	188 ± 114	536 ± 166
16-Jan	296.0 ± 82.1	(c)	333 ± 135	249 ± 125	291 ± 130	411 ± 145	218 ± 117	353 ± 137	329 ± 134	374 ± 139
23-Jan	388 ± 140	(c)	400 ± 142	296 ± 131	242 ± 122	385 ± 141	249 ± 121	374 ± 139	263 ± 125	470 ± 150
30-Jan	154 ± 108	(c)	98 ± 101	162 ± 112	69.6 ± 95.8	78.8 ± 96.9	86.6 ± 96.6	111 ± 102	45.1 ± 90.6	112 ± 102
6-Feb	181 ± 112	(c)	154 ± 108	64.4 ± 94.4	88.4 ± 98.4	107 ± 101	81.4 ± 95.1	39.6 ± 88.1	155 ± 110	158 ± 109
13-Feb	385 ± 141	(c)	388 ± 139	268 ± 128	364 ± 139	437 ± 149	328 ± 136	403 ± 144	358 ± 139	466 ± 157
20-Feb	301 ± 131	(c)	289 ± 131	289 ± 131	235 ± 121	341 ± 134	231 ± 122	288 ± 128	320 ± 134	385 ± 146
27-Feb	(c)	91.4 ± 97.7	83.6 ± 97.7	133 ± 107	121 ± 103	92.9 ± 99.2	77.0 ± 99.9	71.8 ± 93.2	96.2 ± 98.4	133 ± 110
5-Mar	(c)	260 ± 125	229 ± 121	185 ± 117	218 ± 119	205 ± 118	242 ± 125	157 ± 111	330 ± 136	360 ± 146
12-Mar	(c)	265 ± 124	414 ± 144	278 ± 128	285 ± 127	345 ± 134	336 ± 135	385 ± 139	407 ± 144	411 ± 150
19-Mar	(c)	221 ± 119	132 ± 107	166 ± 112	102 ± 101	185 ± 114	124 ± 106	221 ± 119	184 ± 114	196 ± 121

26-Mar	(c)	367 ± 137	278 ± 127	260 ± 125	287 ± 127	333 ± 134	374 ± 139	342 ± 135	325 ± 133	360 ± 143
2-Apr	(c)	222 ± 120	195 ± 116	377 ± 142	185 ± 115	224 ± 121	251 ± 126	323 ± 135	256 ± 126	366 ± 147
9-Apr	(c)	228 ± 119	327 ± 134	185 ± 115	196 ± 115	192 ± 115	228 ± 121	182 ± 113	212 ± 118	231 ± 126
16-Apr	(c)	330 ± 137	403 ± 129	303 ± 135	392 ± 145	451 ± 150	361 ± 142	403 ± 147	403 ± 145	511 ± 164
23-Apr	(c)	353 ± 135	477 ± 173	444 ± 151	332 ± 133	323 ± 132	407 ± 144	365 ± 137	411 ± 144	396 ± 148
30-Apr	(c)	225 ± 119	314 ± 132	280 ± 130	245 ± 122	222 ± 120	253 ± 125	246 ± 123	257 ± 125	298 ± 136
7-May	(c)	585 ± 164	418 ± 146	596 ± 168	370 ± 140	548 ± 161	357 ± 139	474 ± 152	481 ± 154	367 ± 146
14-May	(c)	437 ± 147	551 ± 161	536 ± 161	316 ± 132	426 ± 146	503 ± 156	514 ± 156	599 ± 166	407 ± 165
21-May	(c)	324 ± 131	269 ± 190	374 ± 140	359 ± 136	385 ± 139	354 ± 137	459 ± 148	315 ± 131	314 ± 120
28-May	(c)	195 ± 114	200 ± 117	204 ± 119	164 ± 111	199 ± 117	192 ± 121	165 ± 111	181 ± 114	111.0 ± 84.7
4-Jun	(c)	190 ± 113	(d)	176 ± 114	295 ± 128	239 ± 121	222 ± 132	268 ± 125	212 ± 118	242 ± 124
10-Jun	(c)	225 ± 134	188 ± 130	249 ± 141	136 ± 120	204 ± 132	292 ± 146	(b)	(b)	167 ± 127
18-Jun	(c)	455 ± 136	407 ± 131	525 ± 146	400 ± 130	308 ± 119	388 ± 130	433.0 ± 95.5	381.0 ± 91.4	392 ± 135
25-Jun	(c)	403 ± 142	403 ± 144	555 ± 163	440 ± 147	377 ± 140	396 ± 142	448 ± 147	477 ± 151	433 ± 162
2-Jul	(c)	403 ± 152	319 ± 157	268 ± 129	122 ± 105	174 ± 112	148 ± 110	157 ± 111	233 ± 123	426 ± 201
9-Jul	(c)	455 ± 152	(d)	286 ± 131	396 ± 198	236 ± 121	224 ± 162	312 ± 144	302 ± 143	200 ± 132
16-Jul	(c)	803 ± 186	518 ± 156	966 ± 203	618 ± 167	492 ± 153	666 ± 255	592 ± 153	640 ± 159	544 ± 166
23-Jul	(c)	455 ± 149	(b)	685 ± 176	536 ± 158	485 ± 153	455 ± 150	426 ± 146	536 ± 159	440 ± 150
24-Jul	(c)	(b)	477 ± 140	(b)	(b)	(b)	(b)	(b)	(b)	(b)
30-Jul	(c)	437 ± 147	305 ± 146	585 ± 171	459 ± 150	374 ± 140	327 ± 135	462 ± 151	459 ± 151	344 ± 159
6-Aug	(c)	270 ± 125	316 ± 132	548 ± 162	411 ± 143	329 ± 134	314 ± 132	(b)	(b)	316 ± 120
13-Aug	(c)	400 ± 142	352 ± 137	448 ± 152	418 ± 145	284 ± 128	345 ± 137	352.0 ± 88.1	311.0 ± 84.0	306 ± 121
20-Aug	(c)	365 ± 136	403 ± 166	459 ± 151	422 ± 144	369 ± 138	407 ± 154	448 ± 147	313 ± 131	202 ± 130
27-Aug	(c)	291 ± 130	340 ± 134	374 ± 144	269 ± 127	167 ± 112	349 ± 154	133 ± 107	266 ± 128	221 ± 123
3-Sep	(c)	474 ± 151	551 ± 164	607 ± 169	562 ± 161	422 ± 145	422 ± 146	411 ± 144	414 ± 145	411 ± 151
10-Sep	(c)	492 ± 152	503 ± 155	951 ± 201	677 ± 173	381 ± 140	610 ± 167	633 ± 168	544 ± 160	718 ± 179
17-Sep	(c)	(b)	459 ± 149	833 ± 190	910 ± 194	555 ± 160	810 ± 187	766 ± 180	707 ± 175	659 ± 171
24-Sep	(c)	(b)	319 ± 133	433 ± 149	488 ± 153	400 ± 143	422 ± 147	477 ± 153	462 ± 152	411 ± 147
30-Sep	(c)	444.0 ± 78.4	485 ± 167	766 ± 202	636 ± 185	518 ± 171	629 ± 187	640 ± 185	747 ± 198	733 ± 196
8-Oct	(c)	184 ± 102	243 ± 112	300 ± 121	331 ± 122	212 ± 108	311 ± 122	292 ± 121	193 ± 190	328 ± 124
15-Oct	(c)	368 ± 138	363 ± 138	481 ± 155	592 ± 165	377 ± 140	503 ± 181	500 ± 155	651 ± 190	525 ± 159
21-Oct	(c)	677 ± 172	747 ± 181	1100 ± 213	1060 ± 207	899 ± 194	1140 ± 216	818 ± 186	958 ± 199	866 ± 191
29-Oct	(c)	1270 ± 224	1160 ± 216	1250 ± 226	1650 ± 252	1240 ± 222	1170 ± 219	1470 ± 240	1740 ± 260	1520 ± 245
5-Nov	(c)	659 ± 170	496 ± 142	688 ± 176	755 ± 179	677 ± 173	603 ± 172	1280 ± 352	625 ± 171	770 ± 182
12-Nov	(c)	173 ± 112	159 ± 125	179 ± 115	164 ± 110	222 ± 120	229 ± 122	189 ± 115	229 ± 121	307 ± 132
19-Nov	(c)	962 ± 198	799 ± 185	1190 ± 222	1080 ± 209	814 ± 186	844 ± 242	1000 ± 203	1150 ± 216	1070 ± 211
25-Nov	(c)	(b)	729 ± 196	921 ± 219	925 ± 215	744 ± 197	1040 ± 242	788 ± 202	666 ± 190	825 ± 208
3-Dec	(c)	1080 ± 142	1470 ± 222	1520 ± 230	1610 ± 231	1440 ± 221	1450 ± 222	(d)	1260 ± 208	1550 ± 230
10-Dec	(c)	932 ± 196	1050 ± 208	947 ± 202	1280 ± 224	1320 ± 228	1010 ± 205	1380 ± 256	1210 ± 222	1110 ± 214

18-Dec	(c)	359 ± 125	400 ± 131	426 ± 137	548 ± 147	440 ± 136	396 ± 131	470 ± 139	492 ± 142	696 ± 164
23-Dec	(c)	161 ± 142	344 ± 172	333 ± 174	262 ± 159	256 ± 159	239 ± 157	122 ± 137	219 ± 154	282 ± 165
30-Dec	(c)	194 ± 114	(b)	211 ± 119	204 ± 115	201 ± 115	174 ± 112	247 ± 122	211 ± 118	242 ± 122
Detection frequency	6 of 6	41 of 42	47 of 49	51 of 52	50 of 52	50 of 52	49 of 52	46 of 49	48 of 50	52 of 52
Median	298	366	363	376	362	357	347	385	344	388
IQR[(e)]	154	229	188	342	321	221	230	230	303	234
Maximum	388	1270	1470	1520	1650	1440	1450	1470	1740	1550

(a) See *Environmental Report 2008, F*igures 4-1, 4-2, 4-3 for maps of sampling locations.
(b) Nonconsecutive sample dates occur when samples could not be collected on scheduled sampling date, or sampler ran longer than 1 week.
(c) The sample location 801E was moved to location TNK5 for safer access.
(d) Missed sample due to air sampler malfunction.
(e) IQR = interquartile range

SW-ABH3

A.3.1 Daily monitoring results for gross alpha, gross beta, and tritium in the Livermore site sanitary sewer effluent, 2008

Month Day	Gross alpha (µBq/mL)	Gross beta (µBq/mL)	Tritium (mBq/mL)
Jan			
1	18.4 (<121)	0.128 (<0.171)	-1.82 (<10.7)
2	-57.4 (<125)	0.265 ± 0.125	0.788 (<10.2)
3	-51.4 (<134)	0.651 ± 0.150	0.00799 (<10.3)
4	-49.6 (<130)	0.377 ± 0.132	0.544 (<10.2)
5	-45.5 (<120)	0.131 (<0.171)	3.20 (<10.5)
6	36.9 (<162)	0.400 ± 0.132	0.104 (<10.4)
7	-0.117 (<145)	0.448 ± 0.134	-2.47 (<10.4)
8	149 (<196)	0.725 ± 0.152	-1.76 (<10.3)
9	13.7 (<141)	0.799 ± 0.160	0.135 (<10.4)
10	195 ± 125	0.821 ± 0.156	-3.24 (<10.3)
11	112 (<151)	0.892 ± 0.161	0.814 (<10.4)
12	261 ± 152	0.470 ± 0.136	-0.847 (<10.5)
13	123 (<165)	0.500 ± 0.140	1.38 (<10.7)
14	155 (<162)	0.599 ± 0.144	-1.68 (<10.4)
15	221 ± 148	0.751 ± 0.150	-1.83 (<10.5)
16	84.7 (<160)	0.673 ± 0.148	1.39 (<10.3)
17	194 ± 130	0.592 ± 0.142	-7.88 (<10.8)
18	52.5 (<167)	0.688 ± 0.151	-5.85 (<10.8)
19	16.6 (<163)	0.462 ± 0.139	2.19 (<10.7)
20	112 (<175)	0.426 ± 0.136	-0.618 (<10.5)
21	145 (<169)	0.388 ± 0.132	3.53 (<10.4)
22	137 (<161)	0.659 ± 0.151	-0.988 (<11.0)
23	162 (<169)	0.718 ± 0.151	3.41 (<10.2)
24	105 (<165)	0.662 ± 0.146	2.34 (<10.4)
25	85.5 (<161)	0.666 ± 0.147	2.64 (<10.4)
26	107 (<168)	0.522 ± 0.141	-0.844 (<10.5)
27	44.0 (<138)	0.440 ± 0.136	-1.71 (<10.4)
28	111 (<130)	0.588 ± 0.141	-5.59 (<10.4)
29	51.8 (<123)	0.870 ± 0.157	5.07 (<10.6)
30	84.7 (<113)	0.518 ± 0.140	-1.92 (<10.6)
31	11.1 (<111)	0.614 ± 0.147	1.06 (<10.6)
Feb			
1	55.5 (<104)	0.581 ± 0.145	-3.61 (<10.6)
2	76.2 (<102)	0.488 ± 0.137	-8.03 (<11.1)
3	20.1 (<94.0)	0.209 ± 0.119	4.55 (<10.2)
4	51.1 (<95.1)	0.326 ± 0.127	0.955 (<10.7)
5	43.3 (<101)	0.640 ± 0.147	-2.63 (<11.1)
6	42.2 (<99.5)	0.640 ± 0.147	-0.448 (<10.5)
7	49.6 (<92.9)	0.636 ± 0.146	-2.51 (<11.0)
8	41.8 (<98.8)	0.633 ± 0.146	-1.11 (<10.8)
9	79.2 (<92.1)	0.282 ± 0.124	-3.65 (<10.8)
10	189.0 ± 92.8	0.291 ± 0.122	-1.24 (<10.7)
11	69.9 (<93.2)	0.283 ± 0.125	0.343 (<10.5)
12	56.6 (<107)	0.832 ± 0.158	-3.70 (<10.7)
13	33.5 (<106)	0.451 ± 0.135	6.18 (<10.3)
14	86.2 (<101)	0.511 ± 0.138	1.66 (<10.1)
15	-23.0 (<102)	0.707 ± 0.148	4.03 (<10.1)
16	21.3 (<101)	0.254 ± 0.122	2.92 (<10.4)
17	9.36 (<88.1)	0.0829 (<0.170)	-1.08 (<10.5)
18	-0.175 (<87.3)	0.145 (<0.170)	-3.14 (<10.5)
19	52.5 (<98.8)	0.474 ± 0.137	1.57 (<10.1)
20	-22.5 (<100)	0.670 ± 0.147	4.48 (<10.4)
21	-12.4 (<106)	0.670 ± 0.147	1.76 (<10.2)
22	49.9 (<118)	0.644 ± 0.148	0.966 (<10.7)
23	51.1 (<96.2)	0.388 ± 0.132	6.18 (<10.3)
24	65.5 (<87.3)	0.274 ± 0.123	2.63 (<10.4)
25	10.1 (<96.6)	0.281 ± 0.124	-0.529 (<10.7)
26	11.3 (<113)	0.648 ± 0.149	-5.99 (<10.8)
27	22.7 (<109)	0.548 ± 0.142	-2.94 (<10.4)
28	42.9 (<102)	0.788 ± 0.158	3.61 (<10.1)
29	-25.4 (<111)	1.120 ± 0.169	0.577 (<10.7)
Mar			
1	19.8 (<94.0)	0.418 ± 0.134	-2.47 (<10.7)
2	-0.211 (<87.0)	0.215 ± 0.120	-0.178 (<10.7)
3	52.9 (<99.5)	0.585 ± 0.146	2.70 (<10.3)
4	32.3 (<102)	0.644 ± 0.148	-0.0770 (<10.3)
5	88.4 (<91.8)	0.677 ± 0.149	-7.07 (<10.5)
6	57.4 (<89.9)	0.762 ± 0.152	-4.03 (<10.6)
7	-10.2 (<88.8)	0.688 ± 0.151	-2.96 (<10.4)
8	27.8 (<87.3)	0.407 ± 0.130	4.07 (<10.3)
9	28.7 (<89.5)	0.254 ± 0.122	-0.851 (<10.7)
10	48.5 (<91.0)	0.485 ± 0.136	2.01 (<10.4)
11	9.62 (<92.1)	0.622 ± 0.143	-5.18 (<10.9)
12	116.0 ± 77.8	0.821 ± 0.156	-0.359 (<10.5)
13	60.7 (<94.0)	0.518 ± 0.140	0.135 (<10.4)
14	195 ± 113	0.677 ± 0.149	-5.36 (<10.8)
15	9.18 (<86.6)	0.388 ± 0.132	-5.92 (<10.9)
16	-18.7 (<86.6)	0.132 (<0.170)	-4.77 (<10.5)
17	20.1 (<94.0)	0.422 ± 0.135	-4.33 (<10.5)
18	9.92 (<95.5)	0.744 ± 0.156	1.70 (<10.1)
19	82.9 (<110)	0.544 ± 0.141	-5.14 (<10.4)
20	-11.8 (<107)	0.622 ± 0.143	1.25 (<10.4)
21	71.4 (<111)	0.718 ± 0.151	0.354 (<10.5)

22	51.4 (<95.8)	0.370 ± 0.130	3.88 (<10.2)
23	47.0 (<87.3)	0.112 (<0.170)	1.89 (<10.6)
24	-0.0618 (<86.2)	0.232 ± 0.121	3.42 (<10.5)
25	168.0 ± 97.2	0.496 ± 0.139	-0.192 (<10.5)
26	11.8 (<112)	0.651 ± 0.150	-0.237 (<10.5)
27	46.6 (<109)	0.759 ± 0.152	1.86 (<10.8)
28	-0.247 (<113)	0.710 ± 0.149	2.45 (<10.3)
29	33.3 (<104)	0.407 ± 0.130	-4.40 (<10.7)
30	-0.0581 (<91.8)	0.206 ± 0.120	3.14 (<10.5)
31	-9.95 (<91.4)	0.403 ± 0.133	0.599 (<10.4)
Apr			
1	132.0 ± 88.7	0.807 ± 0.153	2.02 (<10.5)
2	9.66 (<91.0)	0.500 ± 0.140	-1.77 (<10.4)
3	27.0 (<84.0)	0.544 ± 0.141	0.944 (<10.2)
4	10.2 (<96.9)	0.633 ± 0.146	1.22 (<10.4)
5	130.0 ± 79.2	0.374 ± 0.131	-1.65 (<10.6)
6	64.0 (<85.1)	0.204 ± 0.118	-1.16 (<10.4)
7	-0.0906 (<89.9)	0.327 ± 0.127	2.89 (<10.7)
8	-22.5 (<102)	0.662 ± 0.146	2.03 (<10.6)
9	42.9 (<100)	0.540 ± 0.140	-0.329 (<10.8)
10	66.6 (<104)	0.596 ± 0.143	4.11 (<10.4)
11	329 ± 128	0.585 ± 0.140	3.39 (<10.4)
12	9.88 (<93.6)	0.302 ± 0.124	5.70 (<10.2)
13	201.0 ± 98.4	0.116 (<0.170)	-1.94 (<10.8)
14	9.66 (<91.0)	0.426 ± 0.132	1.75 (<10.4)
15	61.4 (<95.5)	0.625 ± 0.144	0.127 (<10.4)
16	-0.152 (<96.6)	0.511 ± 0.138	2.93 (<10.6)
17	108.0 ± 80.8	0.466 ± 0.135	4.07 (<10.1)
18	9.95 (<94.0)	0.525 ± 0.137	0.422 (<10.2)
19	-18.2 (<84.0)	0.244 ± 0.120	5.44 (<10.3)
20	9.32 (<87.0)	0.113 (<0.169)	2.93 (<10.3)
21	681 ± 163	0.298 ± 0.119	1.01 (<10.6)
22	-41.4 (<95.8)	0.570 ± 0.142	5.70 (<10.1)
23	-29.3 (<90.6)	0.625 ± 0.144	0.0858 (<10.3)
24	9.25 (<87.0)	0.533 ± 0.139	0.792 (<10.3)
25	41.4 (<96.9)	0.607 ± 0.146	2.59 (<10.3)
26	9.66 (<89.9)	0.272 ± 0.122	5.03 (<10.2)
27	9.58 (<89.2)	0.184 ± 0.118	-1.35 (<10.4)
28	146.0 ± 88.9	0.299 ± 0.123	-5.14 (<10.5)
29	-31.4 (<96.9)	0.644 ± 0.148	-3.33 (<10.8)
30	20.8 (<97.3)	0.648 ± 0.149	2.80 (<10.3)
May			
1	30.3 (<94.0)	0.581 ± 0.145	-2.31 (<10.5)
2	39.2 (<91.4)	0.551 ± 0.143	0.699 (<10.2)
3	18.8 (<87.7)	0.448 ± 0.134	2.12 (<10.1)
4	9.40 (<87.7)	0.149 (<0.170)	-2.71 (<10.7)
5	2280 ± 296	0.385 ± 0.112	7.29 (<9.95)
6	55.1 (<102)	0.770 ± 0.154	-1.87 (<10.5)
7	31.9 (<99.2)	0.559 ± 0.140	3.37 (<10.3)
8	22.8 (<107)	0.633 ± 0.146	-1.01 (<10.6)
9	89.2 (<119)	0.644 ± 0.148	-2.88 (<10.5)
10	134 (<156)	0.544 ± 0.141	1.21 (<10.6)
11	-12.3 (<113)	0.241 ± 0.120	-1.70 (<10.6)
12	-11.1 (<102)	0.381 ± 0.130	-2.01 (<10.5)
13	35.7 (<111)	0.644 ± 0.148	2.72 (<10.6)
14	48.5 (<90.6)	0.714 ± 0.150	-0.300 (<10.3)
15	577 ± 173	0.607 ± 0.140	-3.11 (<10.5)
16	97.7 (<114)	0.670 ± 0.147	0.462 (<10.5)
17	111.0 ± 78.8	0.433 ± 0.134	4.03 (<10.3)
18	51.1 (<95.1)	0.344 ± 0.127	4.85 (<10.4)
19	18.5 (<86.2)	0.362 ± 0.130	4.74 (<10.1)
20	61.8 (<115)	0.507 ± 0.137	-4.40 (<10.8)
21	88.8 (<118)	0.692 ± 0.145	3.47 (<10.4)
22	21.8 (<102)	0.592 ± 0.142	-7.77 (<10.8)
23	84.7 (<98.8)	0.614 ± 0.141	-1.69 (<10.5)
24	-27.8 (<85.8)	0.188 ± 0.117	-7.44 (<10.8)
25	27.9 (<86.6)	0.203 ± 0.118	5.88 (<9.95)
26	27.6 (<85.8)	0.238 ± 0.119	5.66 (<10.0)
27	38.5 (<89.9)	0.433 ± 0.134	5.00 (<10.1)
28	61.8 (<95.8)	0.522 ± 0.141	-3.27 (<10.7)
29	42.9 (<101)	0.777 ± 0.155	8.33 (<10.4)
30	-0.232 (<101)	0.640 ± 0.147	-1.97 (<10.5)
31	200.0 ± 94.1	0.228 ± 0.116	5.36 (<10.1)
Jun			
1	36.7 (<85.5)	0.172 ± 0.114	0.714 (<10.4)
2	48.5 (<90.3)	0.407 ± 0.130	0.792 (<10.1)
3	45.5 (<106)	0.651 ± 0.143	-0.562 (<10.4)
4	52.9 (<98.4)	0.459 ± 0.133	1.24 (<10.1)
5	20.8 (<96.9)	0.343 ± 0.127	-4.29 (<10.8)
6	21.5 (<101)	0.699 ± 0.147	-7.25 (<11.1)
7	175.0 ± 94.3	0.360 ± 0.126	-1.25 (<10.4)
8	82.5 (<95.8)	0.367 ± 0.128	-8.40 (<10.8)
9	37.4 (<116)	0.559 ± 0.140	-4.85 (<10.8)
10	68.4 (<106)	0.588 ± 0.141	4.37 (<10.2)
11	47.4 (<110)	0.610 ± 0.140	3.55 (<10.2)
12	29.8 (<92.9)	0.799 ± 0.152	-2.11 (<10.6)
13	58.8 (<91.4)	0.618 ± 0.142	5.62 (<10.2)
14	115.0 ± 77.3	0.451 ± 0.131	0.744 (<10.4)
15	67.3 (<89.5)	0.311 ± 0.124	-0.0444 (<10.6)
16	196.0 ± 98.2	0.470 ± 0.136	-0.488 (<10.8)
17	218 ± 102	0.703 ± 0.148	-0.359 (<10.6)

	18	28.6 (<89.2)	0.481 ± 0.135	-4.96 (<10.7)
	19	60.7 (<94.4)	0.644 ± 0.148	-5.03 (<10.5)
	20	48.5 (<90.6)	0.511 ± 0.138	-1.67 (<10.4)
	21	28.5 (<88.4)	0.321 ± 0.125	2.03 (<10.3)
	22	38.8 (<90.3)	0.282 ± 0.124	1.27 (<10.2)
	23	99.5 ± 74.6	0.470 ± 0.136	1.29 (<10.4)
	24	69.2 (<91.8)	0.747 ± 0.149	-0.249 (<10.5)
	25	38.5 (<90.3)	0.688 ± 0.151	5.00 (<10.4)
	26	199 ± 107	0.633 ± 0.146	-0.0280 (<10.1)
	27	-0.234 (<110)	0.588 ± 0.141	6.77 (<10.1)
	28	-20.9 (<96.2)	0.451 ± 0.135	-3.10 (<10.7)
	29	30.4 (<94.4)	0.169 ± 0.115	4.77 (<9.99)
	30	53.3 (<99.5)	0.385 ± 0.131	-0.596 (<10.3)
Jul				
	1	40.3 (<126)	0.677 ± 0.149	-2.62 (<10.1)
	2	68.1 (<127)	0.755 ± 0.151	3.57 (<10.1)
	3	26.0 (<123)	0.762 ± 0.152	1.13 (<10.6)
	4	21.6 (<102)	0.536 ± 0.139	1.89 (<10.2)
	5	40.0 (<92.9)	0.396 ± 0.131	3.48 (<10.6)
	6	474 ± 152	0.299 ± 0.119	4.88 (<10.1)
	7	-12.2 (<111)	0.522 ± 0.141	0.773 (<10.4)
	8	39.6 (<124)	0.648 ± 0.149	-4.11 (<10.7)
	9	120 (<125)	0.714 ± 0.150	3.57 (<10.4)
	10	48.8 (<114)	0.699 ± 0.147	-1.14 (<10.6)
	11	34.1 (<106)	0.662 ± 0.146	0.873 (<10.4)
	12	40.3 (<93.6)	0.272 ± 0.122	-2.17 (<10.4)
	13	93.2 (<96.2)	0.218 ± 0.118	3.77 (<10.1)
	14	165.0 ± 48.0	0.451 ± 0.131	1.34 (<10.4)
	15	33.8 (<105)	0.555 ± 0.139	4.81 (<10.3)
	16	52.5 (<98.0)	0.485 ± 0.136	-1.04 (<10.5)
	17	44.4 (<105)	0.688 ± 0.151	-2.56 (<10.6)
	18	21.6 (<103)	0.511 ± 0.138	-2.97 (<10.7)
	19	-10.9 (<97.3)	0.343 ± 0.127	-3.74 (<10.6)
	20	19.6 (<92.5)	0.254 ± 0.122	6.73 (<10.2)
	21	31.2 (<98.0)	0.363 ± 0.131	-4.59 (<10.7)
	22	544 ± 169	0.559 ± 0.140	-1.37 (<10.4)
	23	47.4 (<111)	0.574 ± 0.143	-7.62 (<10.8)
	24	-11.1 (<92.9)	0.692 ± 0.152	8.62 (<9.55)
	25	9.03 (<92.5)	0.581 ± 0.145	-4.22 (<10.2)
	26	-20.5 (<92.1)	0.426 ± 0.132	1.39 (<9.92)
	27	40.3 (<95.1)	0.426 ± 0.132	4.44 (<10.2)
	28	31.0 (<98.8)	0.514 ± 0.139	21.90 ± 5.92
	29	108.0 ± 76.7	0.807 ± 0.153	43.70 ± 6.55
	30	48.5 (<92.5)	0.770 ± 0.154	2.95 (<10.1)
	31	47.0 (<89.2)	0.648 ± 0.149	-4.51 (<10.5)
Aug				
	1	110.0 ± 77.8	0.681 ± 0.150	1.51 (<10.1)
	2	37.0 (<86.6)	0.254 ± 0.122	7.62 (<9.51)
	3	38.1 (<89.2)	0.281 ± 0.124	-4.18 (<10.2)
	4	68.1 (<90.6)	0.433 ± 0.134	0.392 (<9.99)
	5	69.9 (<94.0)	0.851 ± 0.162	-8.10 (<10.5)
	6	58.8 (<111)	0.699 ± 0.147	2.22 (<9.58)
	7	-1.39 (<115)	0.707 ± 0.148	-5.00 (<10.4)
	8	33.4 (<107)	0.622 ± 0.143	2.97 (<9.88)
	9	35.7 (<113)	0.448 ± 0.134	5.33 (<9.73)
	10	223 ± 109	0.362 ± 0.127	7.14 (<9.95)
	11	219 ± 109	0.503 ± 0.136	0.555 (<10.0)
	12	232 ± 130	0.914 ± 0.165	9.47 ± 5.68
	13	158 ± 119	0.666 ± 0.147	-0.725 (<9.92)
	14	91.4 (<124)	0.759 ± 0.152	-3.16 (<9.47)
	15	22.8 (<112)	0.777 ± 0.155	1.96 (<9.47)
	16	455 ± 146	0.311 ± 0.121	4.77 (<9.36)
	17	29.5 (<93.2)	0.381 ± 0.130	-0.718 (<9.62)
	18	21.2 (<101)	0.329 ± 0.128	0.988 (<9.32)
	19	21.9 (<107)	0.644 ± 0.148	3.42 (<9.51)
	20	22.7 (<111)	0.596 ± 0.143	-3.15 (<9.95)
	21	42.6 (<101)	0.596 ± 0.143	-1.13 (<9.92)
	22	54.0 (<102)	0.629 ± 0.145	0.574 (<9.47)
	23	29.5 (<92.5)	0.414 ± 0.133	2.79 (<9.25)
	24	48.8 (<91.0)	0.257 ± 0.121	-2.27 (<9.73)
	25	43.3 (<101)	0.388 ± 0.132	-7.36 (<9.95)
	26	208 ± 108	0.747 ± 0.149	5.07 (<9.29)
	27	66.6 (<104)	0.770 ± 0.154	-1.22 (<9.62)
	28	492 ± 157	0.770 ± 0.154	-0.907 (<9.44)
	29	-0.673 (<104)	0.659 ± 0.145	-0.255 (<9.44)
	30	-0.529 (<99.9)	0.540 ± 0.140	2.21 (<9.44)
	31	48.8 (<91.0)	0.296 ± 0.124	12.50 ± 5.64
Sep				
	1	29.2 (<91.4)	0.253 ± 0.121	3.54 (<9.25)
	2	108 (<113)	0.662 ± 0.146	-5.07 (<9.62)
	3	68.4 (<107)	0.585 ± 0.140	1.64 (<9.25)
	4	377 ± 128	0.570 ± 0.142	-2.20 (<9.36)
	5	128.0 ± 90.6	0.762 ± 0.152	-2.21 (<10.1)
	6	437 ± 140	0.729 ± 0.153	0.518 (<9.92)
	7	67.3 (<105)	0.396 ± 0.131	7.51 (<8.44)
	8	45.5 (<108)	0.522 ± 0.141	-5.29 (<10.2)
	9	369 ± 136	0.673 ± 0.148	2.67 (<9.36)
	10	320 ± 128	0.888 ± 0.160	-7.58 (<9.77)
	11	28.7 (<91.4)	0.718 ± 0.151	5.48 (<9.80)
	12	20.2 (<96.6)	0.599 ± 0.144	5.22 (<9.92)
	13	18.6 (<88.1)	0.388 ± 0.132	6.62 (<9.80)

	14	-0.329 (<85.8)	0.335 ± 0.127	8.95 (<10.1)
	15	18.8 (<89.9)	0.544 ± 0.141	-0.751 (<10.5)
	16	-1.15 (<104)	0.962 ± 0.164	0.185 (<10.2)
	17	40.0 (<93.6)	0.511 ± 0.138	-9.69 (<10.4)
	18	69.2 (<132)	0.648 ± 0.149	-2.91 (<10.5)
	19	208 ± 133	0.633 ± 0.146	7.84 (<9.84)
	20	49.6 (<93.2)	0.455 ± 0.137	-3.85 (<10.7)
	21	123.0 ± 82.3	0.369 ± 0.129	4.81 (<10.5)
	22	145.0 ± 97.2	0.718 ± 0.151	4.26 (<10.1)
	23	88.8 (<104)	0.533 ± 0.139	-3.00 (<10.4)
	24	155.0 ± 99.0	0.559 ± 0.140	-1.95 (<10.5)
	25	86.2 (<100)	0.614 ± 0.141	2.15 (<9.88)
	26	225 ± 106	0.773 ± 0.155	5.74 (<10.1)
	27	81.4 (<94.4)	0.422 ± 0.131	-2.06 (<10.3)
	28	58.1 (<89.9)	0.176 ± 0.114	2.20 (<10.4)
	29	81.4 (<94.7)	0.507 ± 0.137	7.40 (<10.3)
	30	-0.159 (<101)	0.607 ± 0.146	3.06 (<10.1)
Oct				
	1	149.0 ± 95.4	0.610 ± 0.140	6.73 (<10.2)
	2	45.5 (<107)	0.770 ± 0.154	-9.36 (<10.5)
	3	88.1 (<103)	0.718 ± 0.151	7.36 (<10.3)
	4	183.0 ± 95.2	0.470 ± 0.136	-2.01 (<10.2)
	5	411 ± 131	0.352 ± 0.123	2.55 (<9.80)
	6	114.0 ± 80.9	0.340 ± 0.126	0.00814 (<10.4)
	7	101 (<118)	0.766 ± 0.153	7.25 (<9.99)
	8	54.8 (<103)	0.592 ± 0.142	1.35 (<9.95)
	9	155.0 ± 99.0	0.710 ± 0.149	7.70 (<8.95)
	10	33.7 (<105)	0.629 ± 0.145	10.10 ± 5.64
	11	19.4 (<91.0)	0.474 ± 0.137	-10.4 (<10.6)
	12	629 ± 164	0.262 ± 0.115	-11.5 (<10.0)
	13	31.1 (<96.9)	0.470 ± 0.136	-0.729 (<10.2)
	14	92.1 (<108)	0.740 ± 0.155	7.03 (<9.44)
	15	888 ± 213	0.618 ± 0.142	6.10 (<9.77)
	16	72.9 (<114)	0.740 ± 0.148	-6.44 (<10.6)
	17	25.3 (<120)	0.803 ± 0.153	-7.70 (<10.9)
	18	45.1 (<105)	0.400 ± 0.132	-4.59 (<10.7)
	19	101.0 ± 75.8	0.444 ± 0.133	-2.87 (<10.5)
	20	56.6 (<106)	0.544 ± 0.141	3.43 (<9.84)
	21	141 ± 100	0.851 ± 0.153	1.66 (<9.99)
	22	11.5 (<110)	0.570 ± 0.142	1.54 (<9.73)
	23	536 ± 166	0.781 ± 0.148	10.20 ± 5.80
	24	34.0 (<108)	0.814 ± 0.155	12.90 ± 6.07
	25	459 ± 147	0.607 ± 0.140	-0.0123 (<10.2)
	26	55.5 (<104)	0.522 ± 0.141	9.47 ± 5.59
	27	23.5 (<112)	0.610 ± 0.147	8.36 (<9.47)
	28	50.7 (<120)	0.740 ± 0.148	1.91 (<9.84)
	29	11.1 (<112)	0.929 ± 0.158	1.35 (<9.99)
	30	23.8 (<114)	0.648 ± 0.149	-0.684 (<10.1)
	31	132.0 ± 93.5	0.699 ± 0.147	-0.648 (<9.99)
Nov				
	1	574 ± 161	0.368 ± 0.125	2.51 (<10.1)
	2	470 ± 141	0.392 ± 0.126	-2.05 (<10.3)
	3	214 ± 111	0.570 ± 0.142	-2.11 (<10.2)
	4	153 ± 102	0.873 ± 0.157	-3.58 (<10.1)
	5	280 ± 123	0.640 ± 0.147	-3.57 (<10.5)
	6	807 ± 194	0.673 ± 0.141	-0.825 (<10.2)
	7	35.5 (<111)	0.784 ± 0.157	-2.89 (<10.4)
	8	11.2 (<107)	0.596 ± 0.143	1.20 (<9.84)
	9	42.6 (<99.2)	0.551 ± 0.143	1.42 (<9.95)
	10	22.0 (<104)	0.492 ± 0.138	4.44 (<9.99)
	11	64.4 (<120)	0.707 ± 0.148	8.62 (<9.92)
	12	181 ± 105	0.633 ± 0.146	-4.44 (<10.1)
	13	58.8 (<110)	0.707 ± 0.148	5.62 (<9.06)
	14	72.9 (<113)	0.762 ± 0.152	0.123 (<9.10)
	15	83.6 (<112)	0.599 ± 0.144	-6.59 (<9.40)
	16	168.0 ± 97.2	0.636 ± 0.146	4.14 (<8.95)
	17	474 ± 147	0.411 ± 0.127	6.84 (<8.73)
	18	213 ± 115	0.684 ± 0.151	0.142 (<9.36)
	19	102 (<120)	0.832 ± 0.158	5.40 (<8.70)
	20	455 ± 159	0.766 ± 0.153	2.23 (<9.47)
	21	533 ± 170	0.729 ± 0.153	0.640 (<9.51)
	22	10.1 (<96.6)	0.488 ± 0.137	-2.08 (<9.92)
	23	477 ± 148	0.540 ± 0.135	-4.70 (<9.62)
	24	-0.396 (<102)	0.673 ± 0.148	0.544 (<9.95)
	25	22.1 (<105)	0.980 ± 0.167	1.82 (<9.25)
	26	11.7 (<113)	0.670 ± 0.147	0.784 (<9.47)
	27	-0.304 (<105)	0.503 ± 0.136	-0.784 (<9.62)
	28	10.6 (<99.9)	0.302 ± 0.124	1.73 (<9.10)
	29	955 ± 200	0.414 ± 0.124	5.11 (<9.18)
	30	41.1 (<95.8)	0.381 ± 0.130	4.26 (<9.44)
Dec				
	1	34.6 (<108)	0.533 ± 0.139	0.555 (<9.62)
	2	99.5 (<133)	0.888 ± 0.160	-3.30 (<9.62)
	3	168 ± 102	0.907 ± 0.163	15.50 ± 5.58
	4	33.2 (<105)	0.740 ± 0.148	2.53 (<9.51)
	5	95.1 (<98.8)	0.759 ± 0.152	3.22 (<9.51)
	6	57.4 (<107)	0.551 ± 0.138	1.52 (<9.21)
	7	76.2 (<88.8)	0.466 ± 0.135	5.25 (<9.14)
	8	37.7 (<88.8)	0.585 ± 0.140	-1.65 (<9.55)
	9	263 ± 113	0.825 ± 0.157	0.0740 (<9.55)
	10	266 ± 112	0.684 ± 0.144	-4.14 (<9.40)

11	9.51 (<92.9)	0.699 ± 0.147	2.70 (<9.58)
12	93.6 (<97.3)	0.777 ± 0.155	-1.04 (<9.36)
13	82.1 (<95.5)	0.414 ± 0.133	-3.77 (<9.58)
14	93.6 ± 70.2	0.288 ± 0.121	3.26 (<9.21)
15	9.29 (<87.7)	0.269 ± 0.121	-4.11 (<9.69)
16	65.1 (<102)	0.770 ± 0.154	1.81 (<9.32)
17	87.0 (<90.6)	0.825 ± 0.157	4.44 (<8.88)
18	48.5 (<113)	0.684 ± 0.151	2.84 (<8.92)
19	82.1 (<95.5)	0.342 ± 0.127	-1.66 (<9.21)
20	360 ± 123	0.388 ± 0.128	-3.59 (<9.40)
21	-0.104 (<88.1)	0.323 ± 0.126	0.0644 (<9.36)
22	30.3 (<94.0)	0.278 ± 0.122	-0.488 (<9.32)
23	88.8 (<104)	0.551 ± 0.138	18.60 ± 5.97
24	-0.208 (<102)	0.559 ± 0.140	14.30 ± 5.71
25	9.51 (<89.2)	0.253 ± 0.121	0.103 (<9.55)
26	55.9 (<86.6)	0.00677 (<0.169)	-0.182 (<9.25)
27	137.0 ± 83.5	0.231 ± 0.118	5.66 (<9.10)
28	-0.0773 (<89.9)	0.236 ± 0.120	-3.04 (<9.62)
29	30.6 (<95.1)	0.300 ± 0.123	12.20 ± 5.63
30	20.8 (<97.3)	0.388 ± 0.132	122.00 ± 8.16
31	105.0 ± 79.1	0.622 ± 0.143	4.00 (<9.25)

Note: The activities shown in this table are measured concentrations and their associated 2σ counting errors. Mininum detectable concentration (MDC) is shown in parentheses when calculated concentration is less than the MDC.

SW-FLOW

A.3.2 Daily flow totals for Livermore site sanitary sewer effluent (ML), 2008

Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	0.642	1.102	0.587	1.2	1.313	0.678	1.107	0.847	0.525	0.817	0.703	0.86
2	1.182	0.628	0.592	1.17	1.21	1.246	1.024	0.481	0.988	1.027	0.739	0.847
3	1.076	0.577	1.231	1.268	0.643	1.212	0.916	0.531	0.993	0.897	1.013	0.892
4	1.555	1.271	1.301	1.068	0.642	1.243	0.628	1.041	1.312	0.619	1.018	0.845
5	0.794	1.149	1.187	0.576	1.304	1.203	0.586	0.987	0.953	0.546	1.054	0.809
6	0.781	1.133	1.263	0.59	1.384	0.908	0.676	1.079	0.491	0.992	1.037	0.664
7	1.471	1.183	1.114	1.198	1.368	0.518	1.203	1.116	0.628	1.007	0.784	0.455
8	1.372	1.057	0.641	1.144	1.238	0.52	1.089	0.869	1.051	0.86	0.531	0.88
9	1.547	0.588	0.585	1.237	1.343	1.11	1.153	0.542	1.025	0.967	0.521	0.887
10	1.629	0.534	1.231	1.138	1.511	1.092	1.08	0.6	1.047	0.774	0.887	0.955
11	1.604	1.193	1.307	1.028	1.476	1.096	1.07	1.092	1.072	0.364	0.878	0.94
12	1.056	1.218	1.261	0.666	1.574	1.111	0.783	1.233	0.966	0.384	0.927	0.808
13	1.132	1.172	1.313	0.709	1.202	0.966	0.763	1.043	0.436	0.926	0.911	0.542
14	1.784	1.222	1.128	1.3	1.155	0.562	1.242	1.015	0.463	0.908	0.749	0.424
15	1.693	1.088	0.633	1.272	1.192	0.677	1.103	0.894	1.047	0.877	0.379	0.91
16	1.796	0.63	0.659	1.338	1.032	1.138	1.246	0.668	1.046	1.015	0.377	0.785
17	1.82	0.601	1.26	1.31	0.537	1.098	1.206	0.502	1.062	0.751	0.877	0.965
18	1.602	0.711	1.195	1.139	0.527	1.162	0.996	1.128	1.304	0.503	0.858	0.97
19	1.137	1.316	1.131	0.701	1.159	1.149	0.725	1.167	1.217	0.495	0.941	0.925
20	1.174	1.245	1.181	0.756	1.068	0.881	0.697	1.157	0.485	0.965	0.878	0.578
21	1.31	1.202	1.032	1.317	1.147	0.494	1.172	1.113	0.462	1.054	0.736	0.532
22	1.927	1.129	0.619	1.34	1.211	0.534	1.01	1.004	0.972	0.91	0.424	0.941
23	1.849	0.663	0.598	1.234	1.074	1.06	1.03	0.68	0.939	1.049	0.402	0.924
24	1.724	0.666	0.702	1.22	0.803	1.026	1.054	0.609	0.938	0.702	0.905	0.731
25	1.556	1.46	1.184	1.051	0.838	1.007	0.878	1.109	1.031	0.507	0.839	0.626
26	1.102	1.572	1.191	0.705	0.826	1.003	0.476	0.999	0.799	0.475	0.752	0.506
27	0.786	1.313	1.175	0.653	1.374	0.897	0.576	1.021	0.514	0.885	0.375	0.438
28	1.454	1.359	1.005	1.264	1.264	0.512	1.079	1.026	0.556	0.969	0.4	0.459
29	1.35	1.116	0.642	1.237	1.239	0.553	0.956	0.765	1.022	1.005	0.337	0.652
30	1.306	-	0.582	1.205	1.036	1.05	0.999	0.594	0.933	1.023	0.351	0.657
31	1.284	-	1.246	-	0.627	-	1.038	0.539	-	0.869	-	0.553

Weekend and holiday daily flow totals are shown in the shaded areas. The daily sample flow volume is for the 24 hours of the sampling day.

SW-FLOWSUM

A.3.3 Monthly and annual flow summary statistics for Livermore site sanitary sewer effluent (ML), 2008

Period Statistic	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	2008
Weekends & Holidays													
Total	10.406	6.885	7.401	6.934	9.816	6.788	6.142	7.344	5.861	5.986	5.043	5.27	83.876
Minimum	0.794	0.588	0.587	0.576	0.537	0.494	0.476	0.481	0.436	0.364	0.337	0.438	0.337
Maximum	1.604	1.129	1.128	1.139	1.511	1.05	1.07	1.004	1.217	0.897	0.784	0.925	1.604
Mean	1.301	0.861	0.822	0.867	0.982	0.754	0.768	0.734	0.733	0.665	0.56	0.659	0.806
Weekdays													
Total	32.089	23.213	23.375	25.1	24.501	20.918	23.419	20.107	20.416	19.156	16.54	17.69	266.524
Minimum	0.642	0.534	0.582	0.59	0.527	0.52	0.576	0.502	0.462	0.384	0.351	0.424	0.351
Maximum	1.927	1.572	1.313	1.34	1.574	1.246	1.246	1.233	1.312	1.054	1.054	0.97	1.927
Mean	1.395	1.105	1.062	1.141	1.167	0.996	1.018	0.957	0.928	0.871	0.788	0.769	1.017
All days													
Total	42.495	30.098	30.776	32.034	34.317	27.706	29.561	27.451	26.277	25.142	21.583	22.96	350.4
Minimum	0.642	0.534	0.582	0.576	0.527	0.494	0.476	0.481	0.436	0.364	0.337	0.424	0.337
Maximum	1.927	1.572	1.313	1.34	1.574	1.246	1.246	1.233	1.312	1.054	1.054	0.97	1.927
Mean	1.371	1.038	0.993	1.068	1.107	0.924	0.954	0.886	0.876	0.811	0.719	0.741	0.957

A.3.4 Monthly 24-hour composite results for metals in Livermore site sanitary sewer effluent, 2008

Composite dates	Ag	Al	As	Be	Cd	Cr	Cu	Fe	Hg	Ni	Pb	Zn
9-Jan	<0.01	0.11	0.0098	<0.01	<0.005	<0.01	0.038	0.36	<0.0002	<0.005	<0.002	0.1
6-Feb	<0.01	0.17	<0.002	<0.01	<0.005	<0.01	0.028	0.48	<0.0002	<0.005	<0.002	0.12
4-Mar	<0.01	0.13	0.0027	<0.01	<0.005	<0.01	0.036	0.52	<0.0002	<0.005	<0.002	0.097
2-Apr	<0.01	0.12	0.0026	<0.01	<0.005	<0.01	0.047	0.69	<0.0002	<0.005	<0.002	0.11
7-May	<0.01	0.15	0.0052	<0.01	<0.005	<0.01	0.034	0.52	<0.0002	<0.005	<0.002	0.074
4-Jun	<0.01	0.15	0.0047	<0.01	<0.005	<0.01	0.057	0.49	<0.0002	<0.005	0.0028	0.087
2-Jul	<0.01	0.14	0.0026	<0.01	<0.005	<0.01	0.068	0.52	<0.0002	<0.005	0.0043	0.087
6-Aug	<0.01	0.15	0.0045	<0.01	<0.005	<0.01	0.054	0.6	<0.0002	0.0051	0.0025	0.1
3-Sep	<0.01	0.22	0.0049	<0.01	<0.005	<0.01	0.062	0.67	<0.0002	<0.005	0.003	0.1
8-Oct	<0.01	0.14	0.0065	<0.01	<0.005	<0.01	0.048	0.62	<0.0002	<0.005	0.0025	0.083
5-Nov	<0.01	0.12	0.0024	<0.01	<0.005	<0.01	0.054	0.7	<0.0002	<0.005	0.0028	0.075
3-Dec	<0.01	0.13	0.01	<0.01	<0.005	<0.01	0.029	0.98	<0.0002	<0.005	0.002	0.096
Detection frequency	0 of 12	12 of 12	11 of 12	0 of 12	0 of 12	0 of 12	12 of 12	12 of 12	0 of 12	1 of 12	7 of 12	12 of 12
Minimum	<0.01	0.11	<0.002	<0.01	<0.005	<0.01	0.028	0.36	<0.0002	<0.005	<0.002	0.074
Maximum	<0.01	0.22	0.01	<0.01	<0.005	<0.01	0.068	0.98	<0.0002	0.0051	0.0043	0.12
Median	(a)	0.14	0.0046	(a)	(a)	(a)	0.048	0.56	(a)	<0.005	0.0023	0.096
IQR [(b)]	(a)	0.022	0.0029	(a)	(a)	(a)	0.019	0.16	(a)	(c)	(c)	0.014
EPL [(d)]	0.2	(e)	0.06	(e)	0.14	0.62	1	(e)	0.01	0.61	0.2	3
Maximum Percent of EPL	<5.0	(e)	17	(e)	<3.6	<1.6	6.8	(e)	<2.0	0.84	2.2	4

(a) Not applicable because there are no detections. See *Environmental Report 2008*, Chapter 9.
(b) IQR = interquartile range
(c) Not applicable because of the large number of nondetections. See *Environmental Report 2008*, Chapter 9.
(d) EPL = Effluent pollutant limit
(e) There is no EPL for this parameter; therefore, no comparison can be calculated.

A.3.5 Monthly monitoring results for physical and chemical characteristics of the Livermore site sanitary sewer effluent, 2008

Sample type Analyte type	Analyte	EPA Method	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
24-hour composite sample														
Alkalinity (mg/L)	Bicarbonate Alk (as CaCO3)	310.1	290	250	220	230	220	220	220	220	210	240	230	290
	Carbonate Alk (as CaCO3)	310.1	<5	<5	<5	<5	<5	<2.5	<2.5	<5	<5	<5	<5	<5
	Hydroxide Alk (as CaCO3)	310.1	<5	<5	<5	<5	<5	<2.5	<2.5	<5	<5	<5	<5	<5
	Total Alkalinity (as CaCO3)	Calc	290	250	220	230	220	220	220	220	210	240	230	290
Anions (mg/L)	Bromide	300	0.27	0.17	1	0.18	<0.1	<0.1	0.15	0.32	0.38	1.2	0.78	0.97
	Chloride	300	180	47	51	45	58	50	-	49	68	66	63	85
	Fluoride	300	0.23	0.1	0.12	0.094	0.074	0.093	0.17	0.2	<0.05	0.056	0.22	0.91
	Nitrate (as N)	300	0.16	<0.1	<0.1	<0.1	0.76	0.1	<0.1	0.4	<0.1	<0.1	<0.1	<0.1
	Nitrate (as NO3)	Calc	0.7	<0.5	<0.5	<0.5	3.3	<0.5	<0.5	1.8	<0.5	<0.44	<0.5	<0.5
	Nitrite (as N)	353.2	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.05	<0.5	<0.5	<0.5	<0.5
	Nitrite (as NO2)	Calc	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.17	<0.5	<0.5
	Ortho-Phosphate	365.1	11	17	16	14	12	13	17	16	22	15	14	17
	Sulfate	300	44	15	9.2	12	12	10	8.8	11	11	10	9.6	11
Nutrients (mg/L)	Ammonia Nitrogen (as N)	350.1	44	56	52	42	48	45	50	51	48	52	53	64
	Total Kjeldahl Nitrogen	351.2	42	60	43	60	48	51	55	60	54	57	56	65
	Total Organic Carbon (TOC)	415.1	26	31	30	28	23	24	26	25	27	26	26	29
	Total Phosphorus (as P)	365.4	5	6.4	5.5	7.6	5.8	6.4	7.4	7.2	10	7.1	7.2	8.2
Oxygen demand (mg/L)	Biochemical Oxygen Demand	SM17-5210B	75	94	87	100	81	85	76	85	73	83	79	87
	Chemical Oxygen Demand	410.4	180	210	220	230	150	180	170	180	200	190	240	240
Solids (mg/L)	Settleable Solids	160.5	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.3	<0.1	<0.1	<0.1	0.1
	Total dissolved solids (TDS)	160.1	580	230	220	220	240	220	230	230	250	260	240	300
	Total suspended solids (TSS)	160.2	57	62	58	75	51	56	59	64	65	63	65	63
	Volatile Solids	160.4	120	73	110	130	110	200	140	120	190	130	250	93
Total metals (mg/L)	Aluminum	200.7	0.11	0.17	0.13	0.12	0.15	0.15	0.14	0.15	0.22	0.14	0.12	0.13
	Arsenic	200.8	0.0098	<0.002	0.0027	0.0026	0.0052	0.0047	0.0026	0.0045	0.0049	0.0065	0.0024	0.01
	Beryllium	200.8	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	Cadmium	200.8	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
	Calcium	200.7	39	11	13	12	15	11	12	11	15	14	13	18
	Chromium	200.7	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	Copper	200.8	0.038	0.028	0.036	0.047	0.034	0.057	0.068	0.054	0.062	0.048	0.054	0.029
	Iron	200.7	0.36	0.48	0.52	0.69	0.52	0.49	0.52	0.6	0.67	0.62	0.7	0.98
	Lead	200.8	<0.002	<0.002	<0.002	<0.002	<0.002	0.0028	0.0043	0.0025	0.003	0.0025	0.0028	0.002
	Magnesium	200.7	14	3.5	3.1	2.8	2.9	2.2	2.2	2.1	2.4	2.6	2.2	2.7
	Mercury	245.1	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
	Nickel	200.8	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.0051	<0.005	<0.005	<0.005	<0.005
	Potassium	200.7	23	22	20	20	21	18	19	20	20	21	19	25
	Selenium	200.8	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
	Silver	200.7	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	Sodium	200.7	120	39	38	39	52	37	42	37	51	48	43	65
	Zinc	200.7	0.1	0.12	0.097	0.11	0.074	0.087	0.087	0.1	0.1	0.083	0.075	0.096
Grab sample														
Total oil and grease (mg/L)	Oil and Grease - 07:01 AM	1664HEM	15	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Oil and Grease - 07:07 AM	1664HEM	(a)	(a)	(a)	(a)	(a)	(a)	11	(a)	(a)	(a)	(a)	(a)
	Oil and Grease - 10:01 AM	1664HEM	35	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Oil and Grease - 10:07 AM	1664HEM	(a)	(a)	(a)	(a)	(a)	(a)	8.6	(a)	(a)	(a)	(a)	(a)
	Oil and Grease - 02:01 PM	1664HEM	36	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Oil and Grease - 02:07 PM	1664HEM	(a)	(a)	(a)	(a)	(a)	(a)	15	(a)	(a)	(a)	(a)	(a)
	Oil and Grease - 04:01 PM	1664HEM	32	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
	Oil and Grease - 04:07 PM	1664HEM	(a)	(a)	(a)	(a)	(a)	(a)	6.4	(a)	(a)	(a)	(a)	(a)
Volatile organic compounds (µg/L)	1,1,1-Trichloroethane	624	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
	1,1,2,2-Tetrachloroethane	624	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
	1,1,2-Trichloroethane	624	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
	1,1-Dichloroethane	624	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
	1,1-Dichloroethene	624	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
	1,2-Dichlorobenzene	624	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
	1,2-Dichloroethane	624	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
	1,2-Dichloroethene (total)	624	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1

	1,2-Dichloropropane	624	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
	1,3-Dichlorobenzene	624	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
	1,4-Dichlorobenzene	624	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
	2-Butanone	624	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
	2-Chloroethylvinylether	624	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
	2-Hexanone	624	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
	4-Methyl-2-pentanone	624	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
	Acetone	624	260	250	250	310	370	180	270	370	520	290	270	180
	Benzene	624	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
	Bromodichloromethane	624	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
	Bromoform	624	1.6	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
	Bromomethane	624	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
	Carbon disulfide	624	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
	Carbon tetrachloride	624	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
	Chlorobenzene	624	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
	Chloroethane	624	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
	Chloroform	624	3.6	4.3	4.8	5.8	7.7	6.1	8.5	6.2	3.2	5.8	3.2	1
	Chloromethane	624	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
	Dibromochloromethane	624	1.8	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
	Dibromomethane	624	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
	Dichlorodifluoromethane	624	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
	Ethylbenzene	624	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
	Freon 113	624	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
	Methylene chloride	624	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
	Styrene	624	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
	Tetrachloroethene	624	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
	Toluene	624	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	1.7
	Total xylene isomers	624	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
	Trichloroethene	624	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
	Trichlorofluoromethane	624	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
	Vinyl acetate	624	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
	Vinyl chloride	624	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
	cis-1,2-Dichloroethene	624	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
	cis-1,3-Dichloropropene	624	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
	trans-1,2-Dichloroethene	624	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
	trans-1,3-Dichloropropene	624	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Other (mg/L)	Total Cyanide	335.4/335.2	(b)	(b)	(b)	<0.02	(b)	(b)	(b)	(b)	(b)	(b)	<0.03	(b)

(a) The requirement to sample for oil & grease has been suspended until further notice based on the LWRP letter of April 1, 1999. LLNL collects these samples semiannually as part of the source control program.

(b) Sampling for this parameter is required on a semiannual (April and November) rather than a monthly basis.

SW-MONH3

A.3.6 Monthly composite results for tritium for the Livermore site and LWRP effulent, 2008

Month	Tritium (Bq/L) WRD[a]	Tritium (Bq/L) B196
Jan	0.84 ± 1.77	1.38 ± 1.81
Feb	-1.56 ± 2.48	1.76 ± 2.58
Mar	0.54 ± 2.29	-0.19 ± 2.27
Apr	8.21 ± 2.70	5.81 ± 2.62
May	2.40 ± 1.68	1.95 ± 1.66
Jun	0.98 ± 1.61	1.42 ± 1.64
Jul	2.14 ± 2.70	3.85 ± 2.82
Aug	-0.50 ± 1.58	0.44 ± 1.61
Sep	-0.33 ± 1.57	2.40 ± 1.69
Oct	-0.72 ± 1.45	1.01 ± 1.53
Nov	-0.27 ± 1.57	1.10 ± 1.61
Dec	0.73 ± 1.58	8.40 ± 1.89

Note: The activities shown in this table are measured concentrations and their associated 2σ counting errors.

WRD = Water Resources Division

SW-WKMET

A.3.7 Weekly composite metals in Livermore site sanitary sewer effluent, 2008

Composite dates[(a)]	Ag	As	Cd	Cr	Cu	Hg	Ni	Pb	Zn
2-Jan	<0.01	<0.002	<0.005	<0.01	0.025	0.00022	<0.005	<0.002	<0.05
9-Jan	<0.01	0.0037	<0.005	<0.01	0.022	<0.0002	<0.005	<0.002	0.072
16-Jan	<0.01	0.016	<0.005	<0.01	0.026	<0.0002	<0.005	<0.002	0.057
23-Jan	<0.01	0.0074	<0.005	<0.01	0.021	<0.0002	<0.005	<0.002	<0.05
30-Jan	<0.01	0.0059	<0.005	<0.01	0.022	<0.0002	<0.005	<0.002	0.067
6-Feb	<0.01	0.0031	<0.005	<0.01	0.03	<0.0002	<0.005	<0.002	0.08
13-Feb	<0.01	0.0023	<0.005	<0.01	0.03	<0.0002	<0.005	<0.002	0.079
20-Feb	<0.01	0.0024	<0.005	<0.01	0.027	<0.0002	<0.005	<0.002	0.066
27-Feb	<0.01	<0.002	<0.005	<0.01	0.026	<0.0002	<0.005	<0.002	0.079
5-Mar	<0.01	0.0027	<0.005	<0.01	0.027	<0.0002	<0.005	<0.002	0.067
12-Mar	<0.01	0.003	<0.005	<0.01	0.025	<0.0002	<0.005	<0.002	0.058
19-Mar	<0.01	0.0031	<0.005	<0.01	0.024	<0.0002	<0.005	<0.002	0.085
26-Mar	<0.01	<0.002	<0.005	<0.01	0.028	<0.0002	<0.005	<0.002	0.066
2-Apr	<0.01	<0.002	<0.005	<0.01	0.02	<0.0002	<0.005	<0.002	0.063
9-Apr	<0.01	<0.002	<0.005	<0.01	0.023	<0.0002	<0.005	<0.002	0.069
16-Apr	<0.01	0.0029	<0.005	<0.01	0.024	<0.0002	<0.005	<0.002	0.069
23-Apr	<0.01	0.0037	<0.005	<0.01	0.024	<0.0002	<0.005	<0.002	0.07
30-Apr	<0.01	0.0025	<0.005	<0.01	0.042	<0.0002	<0.005	<0.002	0.05
8-May	<0.01	0.0087	<0.005	<0.01	0.024	<0.0002	<0.005	<0.002	0.068
14-May	<0.01	0.0042	<0.005	<0.01	0.022	<0.0002	<0.005	<0.002	0.068
21-May	<0.01	0.0032	<0.005	<0.01	0.026	<0.0002	<0.005	<0.002	<0.05
28-May	<0.01	0.0028	<0.005	<0.01	0.016	<0.0002	<0.005	<0.002	<0.05
4-Jun	<0.01	0.0035	<0.005	<0.01	0.029	<0.0002	<0.005	<0.002	<0.05
11-Jun	<0.01	0.0039	<0.005	<0.01	0.027	<0.0002	<0.005	<0.002	0.053
18-Jun	<0.01	0.0046	<0.005	<0.01	0.026	<0.0002	<0.005	<0.002	<0.05
25-Jun	<0.01	0.0027	<0.005	<0.01	0.028	<0.0002	<0.005	<0.002	0.055
2-Jul	<0.01	0.0077	<0.005	<0.01	0.038	<0.0002	<0.005	0.0023	0.075
9-Jul	<0.01	0.0079	<0.005	<0.01	0.047	<0.0002	<0.005	0.004	0.072
16-Jul	<0.01	0.0056	<0.005	<0.01	0.06	<0.0002	<0.005	0.0064	0.055
23-Jul	<0.01	0.0043	<0.005	<0.01	0.03	<0.0002	<0.005	<0.002	0.053
30-Jul	<0.01	0.0046	<0.005	<0.01	0.03	<0.0002	0.0054	<0.002	<0.05
6-Aug	<0.01	0.0045	<0.005	<0.01	0.032	<0.0002	<0.005	<0.002	0.063
13-Aug	<0.01	0.0052	<0.005	<0.01	0.035	<0.0002	<0.005	0.0024	0.074
20-Aug	<0.01	0.0028	<0.005	<0.01	0.062	<0.0002	<0.005	0.0054	0.085

27-Aug	<0.01	0.0044	<0.005	<0.01	0.051	<0.0002	<0.005	0.0082	0.056
3-Sep	<0.01	0.0033	<0.005	<0.01	0.032	<0.0002	<0.005	<0.002	0.074
10-Sep	<0.01	0.0077	<0.005	<0.01	0.034	<0.0002	<0.005	0.0022	<0.05
17-Sep	<0.01	0.0034	<0.005	<0.01	0.039	<0.0002	<0.005	<0.002	<0.05
24-Sep	<0.01	0.0056	<0.005	<0.01	0.042	<0.0002	<0.005	0.002	0.055
1-Oct	<0.01	0.0043	<0.005	<0.01	0.032	<0.0002	<0.005	<0.002	<0.05
8-Oct	<0.01	0.0045	<0.005	<0.01	0.037	<0.0002	<0.005	0.003	0.055
15-Oct	<0.01	0.0026	<0.005	<0.01	0.028	<0.0002	<0.005	<0.002	0.052
22-Oct	<0.01	0.0054	<0.005	<0.01	0.033	<0.0002	<0.005	<0.002	<0.05
29-Oct	<0.01	0.0044	<0.005	<0.01	0.032	<0.0002	<0.005	<0.002	<0.05
5-Nov	<0.01	0.0029	<0.005	<0.01	0.048	<0.0002	<0.005	0.0038	0.052
12-Nov	<0.01	0.0025	<0.005	<0.01	0.033	<0.0002	<0.005	<0.002	0.055
19-Nov	<0.01	0.0028	<0.005	<0.01	0.035	<0.0002	<0.005	<0.002	0.06
26-Nov	<0.01	0.002	<0.005	<0.01	0.024	<0.0002	<0.005	<0.002	0.051
3-Dec	<0.01	0.0062	<0.005	<0.01	0.035	<0.0002	<0.005	0.0021	0.079
10-Dec	<0.01	0.0029	<0.005	<0.01	0.028	<0.0002	<0.005	<0.002	0.067
17-Dec	<0.01	0.0023	<0.005	<0.01	0.027	<0.0002	<0.005	<0.002	0.068
24-Dec	<0.01	0.0025	<0.005	<0.01	0.02	<0.0002	<0.005	<0.002	<0.05
31-Dec	<0.01	0.0029	<0.005	<0.01	0.015	<0.0002	<0.005	<0.002	<0.05
Detection frequency	0 of 53	48 of 53	0 of 53	0 of 53	53 of 53	1 of 53	1 of 53	11 of 53	39 of 53
Minimum	<0.01	<0.002	<0.005	<0.01	0.015	<0.0002	<0.005	<0.002	<0.05
Maximum	<0.01	0.016	<0.005	<0.01	0.062	0.00022	0.0054	0.0082	0.085
Median	(b)	0.0033	(b)	(b)	0.028	<0.0002	<0.005	<0.002	0.057
IQR(c)	(b)	0.0019	(b)	(b)	0.01	(d)	(d)	(d)	(d)
EPL(e)	0.2	0.06	0.14	0.62	1	0.01	0.61	0.2	3
Maximum Percent of EPL	<5.0	27	<3.6	<1.6	6.2	2.2	0.89	4.1	2.8

(a) Ending date of composite period
(b) Not applicable because there are no detections. See *Environmental Report 2008,* Chapter 9.
(c) IQR = Interquartile range
(d) Not applicable because of the large number of nondetections. See *Environmental Report 2008,* Chapter 9.
(e) EPL = Effluent pollutant limit

RO-LSMET

A.4.1 Metals detected in storm water runoff (µg/L), Livermore site, 2008

Analyte	Date	Type	Arroyo Seco Site influent ASS2	Arroyo Seco Site effluent ASW	Arroyo Las Positas Site influent ALPE	Arroyo Las Positas Site influent ALPO	Arroyo Las Positas Site influent GRNE	Arroyo Las Positas Site effluent WPDC	Drainage Retention Basin DRB effluent CDBX
Beryllium	4-Jan	Total	<0.2	<0.2	0.3	0.3	<0.2	<0.2	<0.2
Cadmium	4-Jan	Total	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Chromium(VI)	4-Jan	Total	<2	<2	<2	<2	<2	<2	<2
Copper	4-Jan	Total	7	11	23	15	5	15	5
Lead	4-Jan	Total	<5	6	11	6	<5	6	<5
Mercury	4-Jan	Total	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Zinc	4-Jan	Total	180	110	90	38	110	150	33

RO-LSNR

A.4.2 Nonradioactive constituents (other than metals) detected in storm water runoff, Livermore site, 2008

Location										
Group	Arroyo	Arroyo Seco	Arroyo Seco	Arroyo Las Positas	Arroyo Las Positas	Arroyo Las Positas	Arroyo Las Positas	Drainage Retention Basin	Drainage Retention Basin	Drainage Retention Basin
		Site influent ASS2	Site effluent ASW	Site influent ALPE	Site influent ALPO	Site influent GRNE	Site effluent WPDC	DRB influent CDB	DRB influent CDB2	DRB effluent CDBX
Physical (mg/L)										
Chemical oxygen demand (mg O/L)	4-Jan	<25	45	75	140	<25	64	36	41	<25
Dissolved oxygen (mg O/L)	4-Jan	11	11	11	11	11	11	11	10	10
Total suspended solids	4-Jan	20	72	370	250	130	160	88	49	41
Total dissolved solids	4-Jan	24	91	300	460	100	120	83	93	240
pH (pH units)	4-Jan	6.95	7.52	8.02	8.12	7.2	7.42	7.22	7.02	8.06
Anions/General Minerals (mg/L)										
Nitrate (as NO3)	4-Jan	1.3	4.3	2.6	6.6	20	3.6	3	1.5	6.3
Ortho-Phosphate	4-Jan	0.17	0.19	<0.05	0.07	0.29	<0.05	<0.05	0.088	<0.05
Herbicides (µg/L)										
Bromacil	4-Jan	<0.5	<0.5	21	20	110	<0.5	<0.5	3.2	<0.5
Diazinon	4-Jan	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Diuron	4-Jan	2	2.5	59	72	12	18	<1	3.9	<1
Glyphosate	4-Jan	5.7	<5	7.2	6.4	17	6.1	<5	<5	6.8
Miscellaneous organics (mg/L)										
Oil and grease	4-Jan	<5	<5	<5	<5	<5	<5	<5	<5	<5
Total organic carbon	4-Jan	6.4	7.8	7.7	5.6	3.5	9.4	(a)	(a)	5.2

(a) Analysis was not conducted for that sampling event.

A.4.3 Routine gross alpha, gross beta, and tritium sampling in storm water runoff, Livermore site, 2008

Parameter Date		Arroyo Seco Site influent ASS2	Arroyo Seco Site effluent ASW
Gross alpha (Bq/L)			
	4-Jan	0.020 ± 0.020	0.039 ± 0.041
Gross beta (Bq/L)			
	4-Jan	0.140 ± 0.041	0.150 ± 0.044
Tritium (Bq/L)			
	4-Jan	1.7 ± 2.0	0.8 ± 2.0

Parameter Date		Arroyo Las Positas Site influent ALPE	Arroyo Las Positas Site influent ALPO	Arroyo Las Positas[(a)] Site influent GRNE	Arroyo Las Positas Site effluent WPDC
Gross alpha (Bq/L)					
	4-Jan	0.24 ± 0.10	0.27 ± 0.15	0.120 ± 0.052	0.098 ± 0.055
Gross beta (Bq/L)					
	4-Jan	0.390 ± 0.089	0.41 ± 0.10	0.220 ± 0.063	0.230 ± 0.055
Tritium (Bq/L)					
	4-Jan	1.2 ± 2.1	1.0 ± 2.0	-1.0 ± 1.9	3.3 ± 2.0

Parameter Date		Drainage Retention Basin[(a)] DRB influent CDB	Drainage Retention Basin DRB influent CDB2	Drainage Retention Basin DRB effluent CDBX
Gross alpha (Bq/L)				
	4-Jan	0.060 ± 0.041	0.021 ± 0.031	0.100 ± 0.055
Gross beta (Bq/L)				
	4-Jan	0.150 ± 0.052	0.150 ± 0.044	0.120 ± 0.037
Tritium (Bq/L)				
	4-Jan	-0.2 ± 2.0	1.3 ± 1.9	2.2 ± 2.0

(a) A negative number means the sample radioactivity was less than the background radioactivity inside the measurement apparatus.

GW-LSMETALS

A.5.1 Livermore site metals surveillance wells, 2008

Type Constituents of concern	W-307	W-226	W-306
	2-Apr	2-Apr	2-Apr
Inorganic (μg/L)[(a)]			
Field pH (pH units)	7.06	7.45	7.73
Field Conductivity (μS/cm)	987	932	853
Water temperature (Degrees C)	18.5	18	19.2
Aluminum	<50	<50	<50
Antimony	<2	<2	<2
Arsenic	<2	<2	<2
Barium	270	210	97
Beryllium	<0.8	<0.8	<0.8
Boron	660	580	1200
Cadmium	<1	<1	<1
Chromium	10	21	28
Chromium(VI)	10	20	29
Cobalt	<50	<50	<50
Copper	3	<2	<2
Iron	<50	<50	<50
Lead	<1	<1	<1
Manganese	<10	<10	<10
Mercury	<0.2	<0.2	<0.2
Molybdenum	<1	1	2
Nickel	<2	<2	<2
Selenium	<2	<2	<2
Silver	<1	<1	<1
Thallium	<1	<1	<1
Vanadium	<10	<10	<10
Zinc	17	10	14

(a) Nondetections of nonradioactive constituents are shown as less than (<) the reporting limit (RL) for that analysis.

GW-514612

A.5.2 Livermore site Buildings 514 and 612 area surveillance wells, 2008

Type Constituents of concern	W-270	W-270	W-359	W-359	GSW-011	GSW-011
	1-Apr	1-Oct	1-Apr	1-Oct	3-Apr	1-Oct
Inorganic (µg/L)						
Field pH (pH units)	7.69	7.94	7.49	7.9	7.33	7.7
Field Conductivity (µS/cm)	802	804	655	643	868	851
Water temperature (Degrees C)	19	24.4	19.6	22.5	22.1	25.5
Radioactive (Bq/L)(a)						
Gross alpha	(b)	0.081 ± 0.052	(b)	0.008 ± 0.044	(b)	0.100 ± 0.070
Gross beta	(b)	0.063 ± 0.044	(b)	0.039 ± 0.026	(b)	0.110 ± 0.041
Americium 241	-0.0004 ± 0.0014	(b)	-0.0001 ± 0.0019	(b)	-0.0007 ± 0.0020	(b)
Plutonium 238 (mBq/L)	0.35 ± 0.70	(b)	0.6 ± 1.0	(b)	-0.3 ± 1.1	(b)
Plutonium 239+240 (mBq/L)	0.00 ± 0.35	(b)	-0.09 ± 0.35	(b)	-0.20 ± 0.27	(b)
Tritium	-2.5 ± 2.0	0.4 ± 1.8	-0.3 ± 2.0	0.3 ± 1.8	2.4 ± 2.0	2.8 ± 1.8

(a) Nondetections of radioactive constituents are equal to or are less than the 2σ uncertainty shown. A negative number means the sample radioactivity was less than the background radioactivity inside the measurement apparatus. The result is zero when the measured sample radioactivity is equal to the measured background radioactivity.
(b) Analysis was not conducted for that sampling event.

GW-DWTF

A.5.3 Livermore site near Decontamination and Waste Treatment Facility (DWTF) surveillance wells, 2008

Type Constituents of concern	W-007	W-593	W-594
	1-Apr	1-Apr	1-Apr
Inorganic (µg/L)			
Field pH (pH units)	7.56	7.27	7.5
Field Conductivity (µS/cm)	2370	2330	1140
Water temperature (Degrees C)	17.8	18.4	18.4
Radioactive (Bq/L)[(a)]			
Tritium	0.6 ± 2.0	-2.5 ± 2.0	-2.9 ± 2.0

(a) Nondetections of radioactive constituents are equal to or are less than the 2σ uncertainty shown. A negative number means the sample radioactivity was less than the background radioactivity inside the measurement apparatus. The result is zero when the measured sample radioactivity is equal to the measured background radioactivity.

GW-EASTTCLFA

A.5.4 Livermore site East Traffic Circle Landfill surveillance wells 1308 and 1303, 2008

Type Constituents of concern	W-1308	W-1303
	31-Jan	31-Jan
Inorganic (µg/L)[a]		
Field pH (pH units)	7.42	6.87
Field Conductivity (µS/cm)	1040	1220
Water temperature (Degrees C)	17.8	15.3
Copper	<10	<10
Lead	<50	<50
Zinc	<10	<10
Radioactive (Bq/L)[b]		
Plutonium 238 (mBq/L)	2.1 ± 1.9	-0.7 ± 1.1
Plutonium 239+240 (mBq/L)	0.47 ± 0.70	-0.09 ± 0.52
Radium 226 (mBq/L)	4.6 ± 6.3	5.1 ± 5.6
Radium 228 (mBq/L)	6 ± 13	5 ± 11
Tritium	12.0 ± 2.4	10.0 ± 2.3

(a) Nondetections of nonradioactive constituents are shown as less than (<) the reporting limit (RL) for that analysis.

(b) Nondetections of radioactive constituents are equal to or are less than the 2σ uncertainty shown. A negative number means the sample radioactivity was less than the background radioactivity inside the measurement apparatus. The result is zero when the measured sample radioactivity is equal to the measured background radioactivity.

GW-EASTTCLFB

A.5.5 Livermore site East Traffic Circle Landfill surveillance wells 119 and 1306, 2008

Type Constituents of concern	W-119 13-Feb	W-1306 31-Jan
Inorganic (μg/L)[(a)]		
Field pH (pH units)	(b)	7.13
Field Conductivity (μS/cm)	1010	1820
Water temperature (Degrees C)	17.5	16.7
Copper	<10	<10
Lead	<50	<50
Zinc	69	<10
Radioactive (Bq/L)[(c)]		
Plutonium 238 (mBq/L)	-0.1 ± 1.1	0.3 ± 1.2
Plutonium 239+240 (mBq/L)	1.8 ± 1.1	0.00 ± 0.41
Radium 226 (mBq/L)	4.9 ± 5.2	0.0 ± 4.4
Radium 228 (mBq/L)	-8 ± 11	11 ± 10
Tritium	7.8 ± 2.1	2.5 ± 1.9

(a) Nondetections of nonradioactive constituents are shown as less than (<) the reporting limit (RL) for that analysis.

(b) Data not available for that sampling event.

(c) Nondetections of radioactive constituents are equal to or are less than the 2σ uncertainty shown. A negative number means the sample radioactivity was less than the background radioactivity inside the measurement apparatus. The result is zero when the measured sample radioactivity is equal to the measured background radioactivity.

GW-EASTTCLFC

A.5.6 Livermore site East Traffic Circle Landfill surveillance well 906, 2008

Type	
Constituents of concern	W-906
	31-Jan
Inorganic (µg/L)[(a)]	
Field pH (pH units)	7.69
Field Conductivity (µS/cm)	2140
Water temperature (Degrees C)	16.9
Copper	<10
Lead	<50
Zinc	<10
Radioactive (Bq/L)[(b)]	
Plutonium 238 (mBq/L)	0.33 ± 0.67
Plutonium 239+240 (mBq/L)	0.26 ± 0.26
Radium 226 (mBq/L)	6.4 ± 5.2
Radium 228 (mBq/L)	6 ± 11
Tritium	2.6 ± 1.8

(a) Nondetections of nonradioactive constituents are shown as less than (<) the reporting limit (RL) for that analysis.

(b) Nondetections of radioactive constituents are equal to or are less than the 2σ uncertainty shown. A negative number means the sample radioactivity was less than the background radioactivity inside the measurement apparatus. The result is zero when the measured sample radioactivity is equal to the measured background radioactivity.

GW-LSNITRATE

A.5.7 Nitrate concentrations in selected Livermore site surveillance wells, 2008

Area Location	Screened in HSU	Sampling date	Nitrate as NO3 (mg/L)
Nitrate wells			
W-1012	2	17-Jan	31
W-1012	2	30-Jul	30
W-571	1B	17-Jan	34

GW-B331

A.5.8 Livermore site Tritium Facility surveillance wells, 2008

Area Location	Screened in HSU	Sampling date	Tritium (Bq/L)
Upgradient of Tritium Facility			
W-305	2	1-Apr	4.8 ± 2.1
W-305	2	7-Oct	7.4 ± 2.1
Downgradient of Tritium Facility			
W-101	1B	2-Apr	9.2 ± 2.3
W-101	1B	1-Oct	11.0 ± 2.3
W-147	1B	2-Apr	8.2 ± 2.2
W-147	1B	14-Oct	6.0 ± 2.2
W-148	1B	2-Apr	40.0 ± 4.8
W-148	1B	14-Oct	37.0 ± 4.4

GW-LSOFF

A.5.9 Livermore site perimeter off-site surveillance wells, 2008

Type Constituents of concern	14B1	14B1	W-121	W-121	W-151	W-151	W-571	W-571
	15-Jan	11-Sep	15-Jan	29-Jul	15-Jan	29-Jul	17-Jan	24-Jul
Inorganic (µg/L)								
Field pH (pH units)	7.73	7.46	8.07	7.82	7.83	7.49	8.16	7.73
Field Conductivity (µS/cm)	881	856	762	745	908	938	847	848
Water temperature (Degrees	17	18.8	13.3	20.6	14.1	19.1	16	19.5
General minerals (mg/L)[(a)]								
Bromide	<0.5	(b)	<0.5	(b)	<0.5	(b)	0.5	(b)
Chloride	97	(b)	84	(b)	98	(b)	85	(b)
Fluoride	0.2	(b)	0.3	(b)	0.2	(b)	0.4	(b)
Nitrate	39	(b)	32	(b)	41	(b)	34	(b)
Ortho-Phosphate	0.2	(b)	0.2	(b)	0.2	(b)	0.2	(b)
Sulfate	43	(b)	42	(b)	44	(b)	35	(b)
Radioactive (Bq/L)[(c)]								
Gross alpha	0.050 ± 0.063	(b)	-0.034 ± 0.059	(b)	0.110 ± 0.067	(b)	0.038 ± 0.078	(b)
Gross beta	0.069 ± 0.032	(b)	0.058 ± 0.031	(b)	0.061 ± 0.032	(b)	0.06 ± 0.12	(b)
Radium 226 (mBq/L)	4.7 ± 4.4	(b)	2.1 ± 4.4	(b)	4.9 ± 4.8	(b)	2.2 ± 4.4	(b)
Tritium	1.2 ± 1.8	8.6 ± 2.2	1.0 ± 1.8	-2.5 ± 2.0	0.4 ± 1.8	-1.8 ± 2.0	2.1 ± 1.9	-1.0 ± 2.0

(a) Nondetections of nonradioactive constituents are shown as less than (<) the reporting limit (RL) for that analysis.
(b) Analysis was not conducted for that sampling event.
(c) Nondetections of radioactive constituents are equal to or are less than the 2σ uncertainty shown. A negative number means the sample radioactivity was less than the background radioactivity inside the measurement apparatus. The result is zero when the measured sample radioactivity is equal to the measured background radioactivity.

GW-LSON

A.5.10 Livermore site perimeter on-site surveillance wells, 2008

Type Constituents of concern	W-1012 17-Jan	W-1012 30-Jul	W-556 17-Jan	W-556 11-Aug	W-373 17-Jan	W-373 11-Aug
Inorganic (µg/L)						
Field pH (pH units)	7.75	7.27	7.8	7.25	7.97	7.24
Field Conductivity (µS/cm)	927	911	1220	1150	958	956
Water temperature (Degrees C)	16.1	22.1	15.8	20.1	14	19.9
Chromium(VI)	16	(a)	17	(a)	10	(a)
General minerals (mg/L)[(b)]						
Bromide	<0.5	(a)	0.6	(a)	0.7	(a)
Chloride	77	(a)	210	(a)	140	(a)
Fluoride	0.3	(a)	0.2	(a)	0.5	(a)
Nitrate	31	30	40	(a)	10	(a)
Ortho-Phosphate	0.1	(a)	0.1	(a)	0.1	(a)
Sulfate	36	(a)	40	(a)	63	(a)
Radioactive (Bq/L)[(c)]						
Gross alpha	0.150 ± 0.070	(a)	0.140 ± 0.092	(a)	0.100 ± 0.074	(a)
Gross beta	0.096 ± 0.037	(a)	0.71 ± 0.16	(a)	0.026 ± 0.031	(a)
Tritium	2.6 ± 1.9	2.2 ± 2.0	1.0 ± 1.8	1.8 ± 2.0	6.3 ± 2.1	4.5 ± 2.1

(a) Analysis was not conducted for that sampling event.
(b) Nondetections of nonradioactive constituents are shown as less than (<) the reporting limit (RL) for that analysis.
(c) Nondetections of radioactive constituents are equal to or are less than the 2σ uncertainty shown. A negative number means the sample radioactivity was less than the background radioactivity inside the measurement apparatus. The result is zero when the measured sample radioactivity is equal to the measured background radioactivity.

GW-NIF

A.5.11 Livermore site near the National Ignition Facility (NIF) surveillance wells, 2008

Type Constituents of concern	W-653	W-1207
	5-Jun	1-Apr
Inorganic (μg/L)		
Field pH (pH units)	7.4	7.4
Field Conductivity (μS/cm)	1237	2130
Water temperature (Degrees C)	18.5	17.9
Radioactive (Bq/L)[(a)]		
Tritium	1.1 ± 1.9	-0.4 ± 2.0

(a) Nondetections of radioactive constituents are equal to or are less than the 2σ uncertainty shown. A negative number means the sample radioactivity was less than the background radioactivity inside the measurement apparatus. The result is zero when the measured sample radioactivity is equal to the measured background radioactivity.

GW-LSPU

A.5.12 Livermore site Plutonium Facility surveillance wells, 2008

Type Constituents of concern	W-305	W-305	W-101	W-101	W-148	W-148	W-147	W-147
	1-Apr	7-Oct	2-Apr	1-Oct	2-Apr	14-Oct	2-Apr	14-Oct
Inorganic (µg/L)								
Field pH (pH units)	7.54	7.24	7.27	7.38	7.62	6.84	7.38	7.62
Field Conductivity (µS/cm)	774	767	939	947	987	1130	977	949
Water temperature (Degrees C)	19.2	25.8	18.1	26.6	18.1	17.4	17.3	19.7
Radioactive (mBq/L)[(a)]								
Plutonium 238	-0.1 ± 1.1	(b)	-0.07 ± 0.85	(b)	0.17 ± 0.52	(b)	0.22 ± 0.89	(b)
Plutonium 239+240	-0.21 ± 0.27	(b)	-0.14 ± 0.44	(b)	0.08 ± 0.33	(b)	0.14 ± 0.14	(b)

(a) Nondetections of radioactive constituents are equal to or are less than the 2σ uncertainty shown. A negative number means the sample radioactivity was less than the background radioactivity inside the measurement apparatus. The result is zero when the measured sample radioactivity is equal to the measured background radioactivity.
(b) Analysis was not conducted for that sampling event.

A.6.1 Site 300 annually monitored off-site surveillance wells, 2008

Type Constituents of concern[a]	MUL1	MUL2	STONEHAM1	VIE1	VIE2	W-35A-04	W-35A-04
	4-Aug	4-Aug	16-Jul	7-Aug	4-Aug	22-Oct	20-Nov
Inorganic (µg/L)							
Arsenic	(b)	<2	<2	14	<2	5.6	3.7
Barium	(b)	<25	30	38	31	45	46
Beryllium	(b)	<0.5	<0.5	<0.5	<0.5	<0.5	(b)
Cadmium	(b)	<0.5	<0.5	<0.5	<0.5	<0.5	<50
Chromium	(b)	<1	<1	<1	<1	1.2	<1
Cobalt	(b)	<25	<25	<25	<25	<50	(b)
Copper	(b)	<10	<10	<10	<10	<10	2.3
Lead	(b)	<2	<2	<2	<2	<2	<5
Mercury	(b)	<0.2	<0.2	<0.2	<0.2	<0.2	(b)
Molybdenum	(b)	<25	<25	<25	<25	<25	<50
Nickel	(b)	<5	<5	<5	<5	<5	<2
Nitrate (mg/L)	(b)	8.8	2	(b)	26	14	12
Perchlorate (mg/L)	(b)	<0.004	<0.004	<0.004	<0.004	<0.004	(b)
Potassium (mg/L)	(b)	9.6	(b)	5.7	(b)	5.1	6.1
Selenium	(b)	3.1	<2	5	<2	4.4	4.2
Silver	(b)	<0.5	<0.5	<0.5	<0.5	<0.5	(b)
Thallium	(b)	<1	<1	<1	<1	<1	(b)
Vanadium	(b)	<25	<25	29	<25	<10	<20
Zinc	(b)	<20	<20	<20	190	<10	<20
Organic (µg/L)[c]							
EPA 502.2	(b)	0 of 60	0 of 60	0 of 60	(b)	0 of 60	(b)
EPA 625	(b)	0 of 62	0 of 62	0 of 62	0 of 62	0 of 62	(b)
Explosive (µg/L)							
HMX[d]	(b)	<1	<1	<1	<1	<1	(b)
RDX[e]	(b)	<1	<1	<1	<1	<1	(b)
Radioactive (Bq/L)[f]							
Gross alpha	0.06 ± 0.11	0.01 ± 0.12	0.38 ± 0.20	0.170 ± 0.089	0.28 ± 0.18	0.20 ± 0.16	(b)
Gross beta	0.240 ± 0.044	0.280 ± 0.074	0.11 ± 0.12	0.130 ± 0.041	0.15 ± 0.10	0.260 ± 0.055	(b)
Tritium	-1.2 ± 2.0	-1.7 ± 2.0	-0.1 ± 1.9	-2.3 ± 2.0	0.3 ± 2.0	-0.6 ± 1.9	(b)
Uranium (calculated total)	(b)	0.0250 ± 0.0036	0.210 ± 0.017	0.1100 ± 0.0088	0.170 ± 0.012	0.130 ± 0.011	(b)

(a) Constituent nondetections other than radioactive are shown as less than (<) the reporting limit (RL) for that analysis.
(b) An analysis was not conducted for that sampling event.
(c) See *Environmental Report 2008,* Appendix B for EPA methods 502.2 and 625 constituents and their RLs.
(d) HMX is octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine.
(e) RDX is hexahydro-1,3,5-trinitro-1,3,5-triazine.
(f) Nondetections of radioactive constituents are equal to or less than their 2σ uncertainty shown. A negative number means the sample radioactivity was less than the background radioactivity.

GW-CDF1

A.6.2 Site 300 off-site surveillance well CDF1, 2008

Type	
Constituents of concern[a]	CDF1
	8-Jan
Inorganic (µg/L)	
Arsenic	4.4
Barium	<25
Beryllium	<0.5
Cadmium	<0.5
Cobalt	<25
Copper	<10
Lead	<2
Nickel	<5
Vanadium	<25
Zinc	<20
Organic (µg/L)[b]	
EPA 502.2	0 of 60
Explosive (µg/L)	
HMX[c]	<1
RDX[d]	<1
Radioactive (Bq/L)[e]	
Gross alpha	-0.071 ± 0.092
Gross beta	0.300 ± 0.074
Tritium	-3.0 ± 1.8

(a) Constituent nondetections other than radioactive are shown as less than (<) the reporting limit (RL) for that analysis.

(b) See *Environmental Report 2008,* Appendix B, for EPA Method 502.2 constituents and RLS.

(c) HMX is octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine.

(d) RDX is hexahydro-1,3,5-trinitro-1,3,5-triazine.

(e) Nondetections of radioactive constituents are equal to or less than their 2σ uncertainty shown. A negative number means the sample radioactivity was less than the background radioactivity.

GW-CON1

A.6.3 Site 300 off-site surveillance well CON1, 2008

Type	
Constituents of concern[a]	CON1
	8-Jan
Inorganic (µg/L)	
Arsenic	<2
Barium	<25
Beryllium	<0.5
Cadmium	<0.5
Cobalt	<25
Copper	<10
Lead	<2
Nickel	<5
Vanadium	<25
Zinc	<20
Organic (µg/L)[b]	
EPA 502.2	0 of 60
Explosive (µg/L)	
HMX[c]	<1
RDX[d]	<1
Radioactive (Bq/L)[e]	
Gross alpha	-0.21 ± 0.16
Gross beta	0.320 ± 0.096
Tritium	-2.6 ± 1.8

(a) Constituent nondetections other than radioactive are shown as less than (<) the reporting limit (RL) for that analysis.

(b) See *Environmental Report 2008,* Appendix B, for EPA Method 502.2 constituents and RLS.

(c) HMX is octahydro-1,3,5,6-tetranitro-1,3,5,7-tetrazocine.

(d) RDX is hexahydro-1,3,5-trinitro-1,3,5-triazine.

(e) Nondetections of radioactive constituents are equal to or less than their 2σ uncertainty shown. A negative number means the sample radioactivity was less than the background radioactivity.

GW-CON2

A.6.4 Site 300 off-site surveillance well CON2, 2008

Type Constituents of concern	CON2	CON2	CON2	CON2	CON2	CON2	CON2	CON2	CON2	CON2	CON2	CON2
	8-Jan	14-Feb	11-Mar	9-Apr	13-May	12-Jun	14-Jul	12-Aug	11-Sep	7-Oct	11-Nov	10-Dec
Organic (μg/L)[(a)]												
EPA 601	0 of 32	0 of 32	0 of 32	0 of 32	0 of 32	0 of 32	0 of 32	0 of 32	0 of 32	0 of 32	0 of 32	0 of 32

(a) See *Environmental Report 2008,* Appendix B, for EPA Method 601 constituents and reporting limits.

GW-ELKRAV

A.6.5 Elk Ravine surveillance wells, Site 300, 2008

Type														
Constituents of concern[(a)]	NC7-61	NC7-61	NC7-61	NC7-69	NC7-69	K2-04D	K2-04S	K2-01C	K2-01C	NC2-12D	NC2-11D	812CRK (Spring 6)	NC2-07	NC2-07
	23-Apr	13-Oct	17-Nov	30-Apr	21-Oct	22-Apr	22-Apr	16-Jan	16-Apr	17-Apr	1-May	1-May	6-May	14-Oct
Inorganic (μg/L)														
Arsenic	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	37	40
Barium	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	44	38
Beryllium	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	<0.5	<0.5
Cadmium	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	<0.5	<0.5
Chromium	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	<1	<1
Cobalt	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	<25	<25
Copper	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	<10	<10
Lead	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	<2	<2
Mercury	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	<0.2	<0.2
Molybdenum	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	<25	<25
Nickel	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	<5	<5
Nitrate (mg/L)	(b)	(b)	63	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	-	-
Selenium	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	3.4	3.3
Silver	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	<0.5	<0.5
Thallium	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	<1	<1
Vanadium	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	26	48
Zinc	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	<20	<20
Organic (μg/L)[(c)]														
EPA 601	(b)	(b)	(b)	0 of 32	1 of 32	(b)	(b)	(b)	0 of 32	(b)	(b)	(b)	(b)	(b)
Chloromethane	(b)	(b)	(b)	(b)	1.4	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)
Explosive (μg/L)														
HMX[(d)]	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	<1	<1
RDX[(e)]	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	<1	<1
Radioactive (Bq/L)[(f)]														
Gross alpha	0.140 ± 0.081	(b)	(b)	-0.010 ± 0.029	(b)	0.086 ± 0.052	0.086 ± 0.059	0.40 ± 0.13	(b)	0.049 ± 0.044	0.200 ± 0.081	0.16 ± 0.10	0.094 ± 0.078	0.220 ± 0.096
Gross beta	0.220 ± 0.041	(b)	(b)	0.180 ± 0.036	(b)	0.160 ± 0.035	0.150 ± 0.033	0.140 ± 0.041	(b)	0.160 ± 0.048	0.190 ± 0.048	0.210 ± 0.078	0.260 ± 0.044	0.200 ± 0.052
Tritium	1100 ± 110	990 ± 100	(b)	(b)	(b)	(b)	(b)	220 ± 22	(b)	(b)	(b)	-0.1 ± 1.8	-0.8 ± 1.8	-0.2 ± 2.0

(a) Constituent nondetections other than radioactive are shown as less than (<) the reporting limit (RL) for that analysis.
(b) An analysis was not conducted for that sampling event.
(c) See *Environmental Report 2008,* Appendix B for EPA method 601 constituents and RLs.
(d) HMX is octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine.
(e) RDX is hexahydro-1,3,5-trinitro-1,3,5-triazine.
(f) Nondetections of radioactive constituents are equal to or less than their 2σ uncertainty shown. A negative number means the sample radioactivity was less than the background radioactivity.

GW-GALLO1

A.6.6 Site 300 off-site surveillance well GALLO1, 2008

Type Constituents of concern	GALLO1	GALLO1	GALLO1	GALLO1	GALLO1	GALLO1
	9-Jan	9-Apr	14-May	9-Jul	13-Aug	8-Oct
Inorganic (µg/L)[a]						
Arsenic	2.9	4.3	(b)	5.1	(b)	4.6
Barium	<25	<25	(b)	<25	(b)	<25
Beryllium	<0.5	<0.5	(b)	<0.5	(b)	<0.5
Cadmium	<0.5	<0.5	(b)	<0.5	(b)	<0.5
Cobalt	<25	<25	(b)	<25	(b)	<25
Copper	<10	<10	(b)	<10	(b)	<10
Lead	<2	<2	(b)	<2	(b)	<2
Nickel	<5	<5	(b)	<5	(b)	<5
Nitrate (mg/L)	<0.5	(b)	<0.5	(b)	<0.44	<0.5
Perchlorate (mg/L)	<0.004	(b)	<0.004	(b)	<0.004	<0.004
Vanadium	<25	<25	(b)	<25	(b)	<25
Zinc	<20	<20	(b)	<20	(b)	40
Organic (µg/L)[c]						
EPA 502.2	0 of 60	0 of 60	(b)	0 of 60	(b)	1 of 60
Trichloroethene	(b)	(b)	(b)	(b)	(b)	0.51
Radioactive (Bq/L)[d]						
Gross alpha	-0.07 ± 0.12	0.026 ± 0.092	(b)	0.002 ± 0.067	(b)	0.23 ± 0.17
Gross beta	0.130 ± 0.052	0.110 ± 0.059	(b)	0.140 ± 0.037	(b)	0.150 ± 0.070
Tritium	-1.3 ± 1.8	1.9 ± 1.8	(b)	-0.3 ± 2.0	(b)	-0.8 ± 1.8

(a) Constituent nondetections other than radioactive are shown as less than (<) reporting limit (RL) for that analysis.
(b) An analysis was not conducted for that sampling event.
(c) See *Environmental Report 2008,* Appendix B, for EPA Method 502.2 constituents and RLs.
(d) Nondetections of radioactive constituents are equal to or less than the 2σ uncertainty shown. A negative number means the sample radioactivity was less than the background radioactivity.

GW-WELL18

A.6.7 Site 300 potable supply well 18, 2008

Type Constituents of concern[a]	WELL18	WELL18	WELL18	WELL18	WELL18	WELL18	WELL18	WELL18	WELL18	WELL18	WELL18	WELL18
	9-Jan	13-Feb	12-Mar	9-Apr	14-May	11-Jun	9-Jul	13-Aug	10-Sep	8-Oct	12-Nov	9-Dec
Inorganic (µg/L)												
Nitrate (mg/L)	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<1	<0.44	<0.5	<0.5	<0.5	<0.5
Explosive (µg/L)												
HMX[b]	<1	<1	<1	<1	<1	<1	<1	<1	<0.74	<0.81	<0.67	<1
RDX[c]	<1	<1	<1	<1	<1	<1	<1	<1	<0.74	<0.81	<0.67	<1

(a) Constituent nondetections other than radioactive are shown as less than (<) the reporting limit (RL) for that analysis.
(b) HMX is octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine.
(c) RDX is hexahydro-1,3,5-trinitro-1,3,5-triazine.

GW-WELL20

A.6.8 Site 300 potable supply well 20, 2008

Type Constituents of concern[a]	WELL20	WELL20	WELL20	WELL20	WELL20	WELL20	WELL20	WELL20	WELL20	WELL20	WELL20	WELL20
	9-Jan	13-Feb	12-Mar	9-Apr	14-May	11-Jun	9-Jul	13-Aug	10-Sep	8-Oct	12-Nov	9-Dec
Inorganic (µg/L)												
Arsenic	<2	(b)	(b)	10	(b)	(b)	<2	(b)	(b)	<2	(b)	(b)
Barium	15	(b)	(b)	<25	(b)	(b)	<25	(b)	(b)	410	(b)	(b)
Beryllium	<0.5	(b)	(b)	<0.5	(b)	(b)	<0.5	(b)	(b)	<0.5	(b)	(b)
Cadmium	<0.5	(b)	(b)	<0.5	(b)	(b)	<0.5	(b)	(b)	<0.5	(b)	(b)
Chromium	<1	(b)	(b)	<1	(b)	(b)	<1	(b)	(b)	<1	(b)	(b)
Cobalt	<25	(b)	(b)	<25	(b)	(b)	<25	(b)	(b)	<25	(b)	(b)
Copper	<10	(b)	(b)	<10	(b)	(b)	<10	(b)	(b)	<10	(b)	(b)
Lead	<2	(b)	(b)	<2	(b)	(b)	<2	(b)	(b)	<2	(b)	(b)
Mercury	<0.2	(b)	(b)	<0.2	(b)	(b)	<0.2	(b)	(b)	<0.2	(b)	(b)
Molybdenum	<25	(b)	(b)	50	(b)	(b)	<25	(b)	(b)	<25	(b)	(b)
Nickel	<5	(b)	(b)	<5	(b)	(b)	<5	(b)	(b)	<5	(b)	(b)
Nitrate (mg/L)	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.44	<0.5	<0.5	<0.5	<0.5
Potassium (mg/L)	9	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)
Selenium	<2	(b)	(b)	<2	(b)	(b)	<2	(b)	(b)	<2	(b)	(b)
Silver	<0.5	(b)	(b)	<0.5	(b)	(b)	<0.5	(b)	(b)	<0.5	(b)	(b)
Thallium	<1	(b)	(b)	<1	(b)	(b)	<1	(b)	(b)	<1	(b)	(b)
Vanadium	<25	(b)	(b)	<25	(b)	(b)	<25	(b)	(b)	<25	(b)	(b)
Zinc	<10	(b)	(b)	<20	(b)	(b)	<20	(b)	(b)	62	(b)	(b)
Organic (µg/L)												
EPA 502.2[c]	0 of 60	0 of 60	0 of 60	0 of 60	0 of 60	0 of 60	0 of 60	0 of 60	0 of 60	0 of 60	0 of 60	0 of 60
Explosive (µg/L)												
HMX[d]	<1	<1	<1	<1	<1	<1	<0.8	<1	<0.72	<0.77	<0.76	<0.9
RDX[e]	<1	<1	<1	<1	<1	<1	<0.8	<1	<0.72	<0.77	<0.76	<0.9
Radioactive (Bq/L)[f]												
Gross alpha	-0.110 ± 0.096	(b)	(b)	0.008 ± 0.067	(b)	(b)	-0.067 ± 0.052	(b)	(b)	0.15 ± 0.11	(b)	(b)
Gross beta	0.280 ± 0.067	(b)	(b)	0.250 ± 0.044	(b)	(b)	0.300 ± 0.044	(b)	(b)	0.270 ± 0.059	(b)	(b)
Tritium	-2.6 ± 1.8	(b)	(b)	1.4 ± 1.8	(b)	(b)	0.2 ± 2.0	(b)	(b)	0.1 ± 1.8	(b)	(b)

(a) Constituent nondetections other than radioactive are shown as less than (<) the reporting limit (RL) for that analysis.
(b) An analysis was not conducted for that sampling event.
(c) See *Environmental Report 2007,* Appendix B for EPA method 502.2 constituents and its RLs.
(d) HMX is octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine.
(e) RDX is hexahydro-1,3,5-trinitro-1,3,5-triazine.
(f) Nondetections of radioactive constituents are equal to or less than their 2σ uncertainty shown. A negative number means the sample radioactivity was less than the background radioactivity.

A.7.1 Dry season (June 1 to September 30, 2008) monitoring data for releases from Lake Haussmann

Analyte type Analyte	CDBX	CDBX	CDBX	CDBX	WPDC	WPDC	WPDC	WPDC
	24-Jun	23-Jul	19-Aug	24-Sep	24-Jun	23-Jul	19-Aug	24-Sep
Biological aquatic bioassay								
Acute aquatic toxicity								
Fathead minnow survival (percent survival)	100	100	90	100	95	100	90	100
General minerals (mg/L)								
pH	9.8	9.5	9.5	9.2	8.7	8.4	8.5	8.6
Total metals (mg/L)								
Aluminum	<0.05	<0.05	<0.05	<0.05	0.75	0.37	0.22	0.72
Antimony	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Arsenic	<0.002	0.002	<0.002	<0.002	<0.002	0.0021	<0.002	<0.002
Barium	0.072	0.091	0.098	0.12	0.12	0.11	0.11	0.12
Beryllium	<0.0002	<0.0002	<0.0008	<0.0008	<0.0002	<0.0002	<0.0008	<0.0008
Boron	2	2.3	2.3	2.2	1.3	1.7	1.1	1.2
Cadmium	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Chromium	<0.003	<0.003	<0.003	<0.003	0.011	0.01	0.012	0.015
Cobalt	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Copper	<0.002	<0.002	<0.002	<0.002	0.002	0.002	<0.002	0.0023
Hexavalent Chromium	0.0023	0.0023	0.00099	0.0017	0.0083	0.0071	0.011	0.011
Iron	<0.05	<0.05	<0.05	<0.05	1	0.52	0.28	0.88
Lead	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Manganese	0.0029	0.0013	0.0033	0.0026	0.014	0.013	0.007	0.015
Mercury	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
Molybdenum	0.0035	0.0034	0.0032	0.0035	0.0024	0.0031	0.0026	0.0025
Nickel	<0.002	<0.002	<0.002	<0.002	0.0028	0.0027	0.0022	0.0037
Selenium	<0.002	<0.002	<0.002	0.002	<0.002	<0.002	<0.002	<0.002
Silver	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Thallium	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Vanadium	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.011
Zinc	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Polychlorinated biphenyls (μg/L)								
PCB 1016	<0.5	<0.5	<0.5	<0.5	(a)	(a)	(a)	(a)
PCB 1221	<0.5	<0.5	<0.5	<0.5	(a)	(a)	(a)	(a)
PCB 1232	<0.5	<0.5	<0.5	<0.5	(a)	(a)	(a)	(a)
PCB 1242	<0.5	<0.5	<0.5	<0.5	(a)	(a)	(a)	(a)
PCB 1248	<0.5	<0.5	<0.5	<0.5	(a)	(a)	(a)	(a)
PCB 1254	<0.5	<0.5	<0.5	<0.5	(a)	(a)	(a)	(a)
PCB 1260	<0.5	<0.5	<0.5	<0.5	(a)	(a)	(a)	(a)
Miscellaneous organics (mg/L)								
Total suspended solids (TSS)	<1.2	1.2	6.3	8	19	23	32	46

(a) no sample required

A.7.2 Wet season (October 1 to May 31, 2008) monitoring data for releases from Lake Haussmann

Analyte type Analyte	CDBX	CDBX	WPDC
	13-Oct	1-Dec	13-Oct
Biological aquatic bioassay			
Acute aquatic toxicity			
Fathead minnow survival (percent survival)	100	(a)	100
Chronic aquatic toxicity			
Fathead minnow growth	100	(a)	(a)
Fathead minnow survival	100	(a)	(a)
Algae growth	100	(a)	(a)
Water flea reproduction	75	100	(a)
Water flea survival	100	(a)	(a)
General minerals (mg/L)			
pH	8.7	(a)	8.8
Total dissolved solids (TDS)	(a)	(a)	590
Specific Conductance	(a)	(a)	1500
Total metals (mg/L)			
Aluminum	<0.05	(a)	0.71
Antimony	<0.002	(a)	<0.002
Arsenic	<0.002	(a)	<0.002
Barium	0.17	(a)	0.11
Beryllium	<0.0002	(a)	<0.0002
Boron	2.5	(a)	1.3
Cadmium	<0.001	(a)	<0.001
Chromium	0.003	(a)	<0.003
Cobalt	<0.05	(a)	<0.05
Copper	<0.002	(a)	<0.002
Hexavalent Chromium	0.0024	(a)	0.013
Iron	<0.05	(a)	0.87
Lead	<0.001	(a)	<0.001
Manganese	0.0033	(a)	0.0016
Mercury	<0.0002	(a)	<0.0002
Molybdenum	0.0031	(a)	<0.001
Nickel	<0.002	(a)	<0.002
Selenium	0.002	(a)	<0.002
Silver	<0.001	(a)	<0.001
Thallium	<0.001	(a)	<0.001
Vanadium	<0.01	(a)	<0.01
Zinc	<0.05	(a)	<0.05
Volatile organic compounds (µg/L)			
Bromodichloromethane	<0.5	(a)	(a)
Bromoform	<0.5	(a)	(a)
Bromomethane	<1	(a)	(a)
Carbon tetrachloride	<0.5	(a)	(a)
Chlorobenzene	<0.5	(a)	(a)
Chloroethane	<0.5	(a)	(a)
2-Chloroethylvinylether	<10	(a)	(a)
Chloroform	<0.5	(a)	(a)
Chloromethane	<0.5	(a)	(a)
Dibromochloromethane	<0.5	(a)	(a)
1,2-Dichlorobenzene	<0.5	(a)	(a)
1,3-Dichlorobenzene	<0.5	(a)	(a)
1,4-Dichlorobenzene	<0.5	(a)	(a)
Dichlorodifluoromethane	<0.5	(a)	(a)
1,1-Dichloroethane	<0.5	(a)	(a)
1,2-Dichloroethane	<0.5	(a)	(a)
1,1-Dichloroethene	<0.5	(a)	(a)
cis-1,2-Dichloroethene	<0.5	(a)	(a)
trans-1,2-Dichloroethene	<0.5	(a)	(a)
1,2-Dichloroethene (total)	<1	(a)	(a)
1,2-Dichloropropane	<0.5	(a)	(a)
cis-1,3-Dichloropropene	<0.5	(a)	(a)
trans-1,3-Dichloropropene	<0.5	(a)	(a)
Freon 113	<0.5	(a)	(a)
Methylene chloride	<1	(a)	(a)
1,1,2,2-Tetrachloroethane	<0.5	(a)	(a)
Tetrachloroethene	<0.5	(a)	(a)
1,1,1-Trichloroethane	<0.5	(a)	(a)
1,1,2-Trichloroethane	<0.5	(a)	(a)
Trichloroethene	<0.5	(a)	(a)
Vinyl chloride	<0.5	(a)	(a)
Trichlorofluoromethane	<0.5	(a)	(a)
Polychlorinated biphenyls (µg/L)			
PCB 1016	<0.5	(a)	(a)
PCB 1221	<0.5	(a)	(a)
PCB 1232	<0.5	(a)	(a)
PCB 1242	<0.5	(a)	(a)
PCB 1248	<0.5	(a)	(a)
PCB 1254	<0.5	(a)	(a)
PCB 1260	<0.5	(a)	(a)
Miscellaneous organics (mg/L)			
Chemical Oxygen Demand (mg O/L)	<25	(a)	(a)
Total Organic Carbon (TOC)	3.3	(a)	(a)
Total suspended solids (TSS)	1.2	(a)	20
Radioactive (Bq/L)[b]			
Gross alpha	0.18 ± 0.13	(a)	(a)
Gross beta	0.092 ± 0.063	(a)	(a)
Tritium	5.8 ± 2.0	(a)	(a)

(a) No sample required
(b) Radioactivities are reported as the measured concentration and an uncertainty (±2σ counting error). If the concentration is less than or equal to the uncertainty, the result is considered to be a nondetection.

RA-H3

A.7.3 Tritium activities in rain water samples collected in the vicinity of the Livermore site, 2008

Site Location	7-Jan[a]
Livermore site	
VIS	-0.8 ± 1.8
MET	-0.4 ± 1.8
DWTF	0.6 ± 1.8
Livermore Valley	
ESAN	-0.3 ± 1.8
ZON7	0.3 ± 1.8
GTES	0.2 ± 1.8
VET	0.0 ± 1.8

(a) Nondetections of radioactive constituents are equal to or are less than the 2σ uncertainty shown. A negative number means the sample radioactivity was less than the background radioactivity inside the measurement apparatus.

DW-RAD

A.7.4 Radioactivity (Bq/L) in surface and drinking water in Livermore Valley, 2008

Site Location	Date	Tritium[a]	Gross alpha[a]	Gross beta[a]
Drinking waters				
GAS	24-Jul	-1.16 ± 1.92	0.0117 ± 0.0370	0.0729 ± 0.0337
TAP	24-Jul	-0.70 ± 1.92	0.0135 ± 0.0259	0.0233 ± 0.0237
Surface waters				
CAL	24-Jul	-0.31 ± 1.92	0.0098 ± 0.0289	0.0562 ± 0.0240
DEL	24-Jul	0.93 ± 1.96	-0.0058 ± 0.0229	0.0955 ± 0.0300
DUCK	24-Jul	-1.31 ± 1.89	0.326 ± 0.237	0.277 ± 0.152
ALAG	24-Jul	0.23 ± 1.92	0.0622 ± 0.0444	0.1160 ± 0.0322
SHAD	24-Jul	-1.24 ± 1.92	0.1280 ± 0.0666	0.1410 ± 0.0444
ZON7	24-Jul	-1.20 ± 1.96	0.0240 ± 0.0248	-0.0238 ± 0.0289

(a) Nondetections of radioactive constituents are equal to or are less than the 2σ uncertainty shown. A negative number means the sample radioactivity was less than the background radioactivity inside the measurement apparatus.

SO-VAL

A.8.1 Radionuclides in soils in the Livermore Valley, 2008

Area Location	Cesium-137 (Bq/dry g)	Potassium-40 (Bq/dry g)	Thorium-232 (µg/dry g)[(a)]	Uranium-235 (µg/dry g)[(b)]	Uranium-238 (µg/dry g)[(c)]	U235/U238 ratio	Gross alpha (Bq/dry g)	Gross beta (Bq/dry g)	Plutonium-238 (mBq/dry g)	Plutonium-239+240 (mBq/dry g)	Americium-241 (mBq/dry g)	Tritium (Bq/L)
Livermore Valley soil												
L-AMON-SO	0.00270 ± 0.00028	0.5810 ± 0.0139	8.00 ± 0.18	0.0170 ± 0.0093	1.3 ± 2.4	(d)	(e)	(e)	0.0031 ± 0.0017	0.095 ± 0.017	<2.3	(e)
L-CHUR-SO	0.00290 ± 0.00019	0.4660 ± 0.0196	7.40 ± 0.21	0.0230 ± 0.0091	2.2 ± 1.2	0.0100 ± 0.0070	(e)	(e)	0.0035 ± 0.0021	0.099 ± 0.019	<1.1	(e)
L-COW-SO	0.00028 ± 0.00018	0.5180 ± 0.0124	6.40 ± 0.13	0.0110 ± 0.0073	1.9 ± 1.1	0.0058 ± 0.0051	(e)	(e)	0.00110 ± 0.00088	0.057 ± 0.011	<0.55	(e)
L-ESB-SO	0.00092 ± 0.00023	0.4140 ± 0.0124	7.30 ± 0.18	0.0250 ± 0.0087	2.1 ± 1.0	0.0120 ± 0.0070	0.100 ± 0.069	0.30 ± 0.16	0.220 ± 0.037	2.00 ± 0.31	<0.95	4.4 ± 1.7
L-FCC-SO	0.00160 ± 0.00020	0.3920 ± 0.0102	6.00 ± 0.14	0.0150 ± 0.0071	1.20 ± 0.88	0.012 ± 0.011	(e)	(e)	0.0016 ± 0.0013	0.0130 ± 0.0037	<0.68	(e)
L-HOSP-SO	0.00150 ± 0.00017	0.3960 ± 0.0127	5.70 ± 0.17	0.018 ± 0.011	1.6 ± 1.3	0.011 ± 0.011	(e)	(e)	0.0022 ± 0.0015	0.057 ± 0.011	<1	(e)
L-MESQ-SO	0.00048 ± 0.00020	0.3520 ± 0.0106	5.90 ± 0.18	0.0150 ± 0.0085	1.30 ± 0.84	0.0120 ± 0.0099	(e)	(e)	0.0014 ± 0.0012	0.0180 ± 0.0044	<0.49	(e)
L-MET-SO	0.00140 ± 0.00020	0.5480 ± 0.0110	7.00 ± 0.15	0.0170 ± 0.0068	2.4 ± 2.0	0.0071 ± 0.0065	(e)	(e)	0.0009 ± 0.0012	0.055 ± 0.011	<2.2	(e)
L-NEP-SO	0.00083 ± 0.00015	0.5220 ± 0.0125	6.90 ± 0.14	0.0180 ± 0.0068	2.1 ± 1.2	0.0086 ± 0.0059	0.079 ± 0.062	0.19 ± 0.15	0.0026 ± 0.0014	0.0320 ± 0.0068	<0.7	2.8 ± 1.6
L-PATT-SO	0.00085 ± 0.00028	0.4960 ± 0.0128	7.30 ± 0.18	0.0150 ± 0.0084	1.3 ± 1.0	0.012 ± 0.011	(e)	(e)	0.0014 ± 0.0014	0.0350 ± 0.0078	<1.2	(e)
L-SALV-SO	0.00150 ± 0.00020	0.4260 ± 0.0136	6.70 ± 0.15	0.0190 ± 0.0074	1.60 ± 0.89	0.0120 ± 0.0081	0.150 ± 0.075	0.11 ± 0.13	0.0160 ± 0.0043	0.160 ± 0.028	<0.74	2.7 ± 1.6
L-TANK-SO	0.00150 ± 0.00020	0.34000 ± 0.00884	5.50 ± 0.12	0.0095 ± 0.0080	1.40 ± 0.68	0.0068 ± 0.0066	(e)	(e)	0.0033 ± 0.0018	0.059 ± 0.011	<0.51	(e)
L-VIS-SO	0.00071 ± 0.00017	0.3770 ± 0.0113	6.40 ± 0.19	0.0190 ± 0.0077	1.60 ± 0.82	0.0120 ± 0.0078	0.130 ± 0.074	0.08 ± 0.14	0.0190 ± 0.0053	0.340 ± 0.056	<0.52	2.8 ± 1.9
L-ZON7-SO	0.00031 ± 0.00026	0.3470 ± 0.0125	6.70 ± 0.19	0.035 ± 0.012	3.7 ± 1.3	0.0095 ± 0.0046	(e)	(e)	0.0040 ± 0.0018	0.0330 ± 0.0070	<1.2	(e)
Median	0.0012	0.42	6.7	0.018	1.6	0.011	0.12	0.15	0.0028	0.057	(f)	2.8
IQR	0.00076	0.132	1.1	0.004	0.77	0.0034	(g)	(g)	0.0024	0.064	(g)	(g)
Maximum	0.0029	0.581	8	0.035	3.7	0.012	0.15	0.3	0.22	2	<2.3	4.4
LWRP soil												
L-WRP1-SO	0.00430 ± 0.00039	0.4000 ± 0.0111	7.40 ± 0.25	0.0170 ± 0.0083	1.8 ± 1.4	0.0094 ± 0.0087	(e)	(e)	0.550 ± 0.090	12.0 ± 1.8	4.6 ± 2.8	(e)
L-WRP3-SO	0.00032 ± 0.00018	0.37700 ± 0.00755	6.60 ± 0.12	0.0130 ± 0.0061	1.80 ± 0.86	0.0072 ± 0.0048	(e)	(e)	0.0290 ± 0.0075	0.64 ± 0.10	<0.54	(e)
L-WRP6-SO	0.00030 ± 0.00017	0.40300 ± 0.00884	6.90 ± 0.14	0.0160 ± 0.0092	1.90 ± 0.97	0.0084 ± 0.0065	(e)	(e)	0.0340 ± 0.0072	0.63 ± 0.10	<0.71	(e)
Median	(f)	(f)	(f)	(f)	(f)	(f)	(f)	(f)	(f)	(f)	(f)	(f)
IQR	(g)	(g)	(g)	(g)	(g)	(g)	(g)	(g)	(g)	(g)	(g)	(g)
Maximum	0.0043	0.403	7.4	0.017	1.9	0.0094	(e)	(e)	0.55	12	4.6	(e)

Note: Radioactivities are reported as the measured concentration and an uncertainty (± 2σ counting error), or as being less than or equal to the detection limit. If the concentration is less than or equal to the uncertainty or the detection limit, the result is considered to be a nondetection. See the *Environmental Report 2008,* Chapter 9.
(a) Thorium-232 activities can be determined by multiplying the mass concentration provided in the table in µg/dry g by the specific activity of thorium-232, i.e., 0.004044 Bq/µg or 0.1093 pCi/µg.
(b) Uranium-235 activities can be determined by multiplying the mass concentration provided in the table in µg/dry g by the specific activity of uranium-235, i.e., 0.080 Bq/µg or 2.16 pCi/µg.
(c) Uranium-238 activities can be determined by multiplying the mass concentration provided in the table in µg/dry g by the specific activity of uranium-238, i.e., 0.01245 Bq/µg or 0.3367 pCi/µg.
(d) Ratio not calculated because the uranium-238 value was less than the reporting limit.
(e) Analysis not required.
(f) Median not calculated because of small number of samples.
(g) Interquartile range not calculated because of small number of samples.

A.8.2 Radionuclides and beryllium in soil at Site 300, 2008

Location	Cesium-137 (Bq/dry g)	Potassium-40 (Bq/dry g)	Thorium-232 (µg/dry g)[a]	Uranium-235 (µg/dry g)[b]	Uranium-238 (µg/dry g)[c]	U235/U238 ratio	Beryllium (mg/kg)
3-801N-SO	0.00190 ± 0.00023	0.4480 ± 0.0152	12.00 ± 0.30	0.028 ± 0.011	6.4 ± 1.6	0.0044 ± 0.0020	0.49
3-801W-SO	0.00280 ± 0.00038	0.5030 ± 0.0141	10.00 ± 0.24	0.031 ± 0.011	5.7 ± 1.7	0.0054 ± 0.0025	<0.2
3-812N-SO	0.00130 ± 0.00025	0.3850 ± 0.0146	13.00 ± 0.32	0.220 ± 0.019	99.0 ± 5.5	0.00220 ± 0.00023	5.3
3-834W-SO	0.00290 ± 0.00033	0.4480 ± 0.0125	11.00 ± 0.21	0.016 ± 0.011	1.5 ± 1.1	0.011 ± 0.011	0.5
3-851N-SO	0.00200 ± 0.00037	0.4370 ± 0.0131	14.00 ± 0.31	0.024 ± 0.013	3.1 ± 1.5	0.0077 ± 0.0056	0.57
3-856N-SO	0.00150 ± 0.00026	0.37400 ± 0.00977	10.00 ± 0.21	0.0200 ± 0.0075	1.90 ± 0.81	0.0110 ± 0.0060	<0.2
3-DSW-SO	0.00400 ± 0.00030	0.4330 ± 0.0112	9.20 ± 0.18	0.0270 ± 0.0086	3.2 ± 1.9	0.0084 ± 0.0057	<0.2
3-EOBS-SO	0.00140 ± 0.00024	0.4880 ± 0.0157	10.00 ± 0.27	0.021 ± 0.012	2.6 ± 2.3	0.0081 ± 0.0085	<0.2
3-EVAP-SO	0.00130 ± 0.00031	0.3680 ± 0.0125	14.00 ± 0.33	0.034 ± 0.013	3.2 ± 1.8	0.0110 ± 0.0072	<0.2
3-NPS-SO	0.00280 ± 0.00022	0.5850 ± 0.0117	7.80 ± 0.14	0.0150 ± 0.0080	1.60 ± 0.90	0.0094 ± 0.0073	<0.2
3-TNK5-SO	0.00180 ± 0.00021	0.4880 ± 0.0127	9.20 ± 0.17	0.0190 ± 0.0091	2.6 ± 1.1	0.0073 ± 0.0047	<0.2
3-WOBS-SO	0.00280 ± 0.00021	0.3880 ± 0.0117	8.00 ± 0.22	0.0140 ± 0.0090	1.9 ± 1.6	0.0074 ± 0.0078	<0.2
Median	0.002	0.442	10	0.022	2.8	0.0079	<0.2
IQR	0.0013	0.101	3.1	0.011	1.9	0.003	(d)
Maximum	0.004	0.585	14	0.22	99	0.011	5.3

Note: Radioactivities are reported as the measured concentration and an uncertainty (± 2σ counting error), or as being less than or equal to the detection limit. If the concentration is less than or equal to the uncertainty or the detection limit, the result is considered to be a nondetection. See the *Environmental Report 2008*, Chapter 9.

(a) Thorium-232 activities can be determined by multiplying the mass concentration provided in the table in µg/dry g by the specific activity of thorium-232, i.e., 0.004044 Bq/µg or 0.1093 pCi/µg.

(b) Uranium-235 activities can be determined by multiplying the mass concentration provided in the table in µg/dry g by the specific activity of uranium-235, i.e., 0.080 Bq/µg or 2.16 pCi/µg.

(c) Uranium-238 activities can be determined by multiplying the mass concentration provided in the table in µg/dry g by the specific activity of uranium-238, i.e., 0.01245 Bq/µg or 0.3367 pCi/µg.

(d) Interquartile range not calculated because of small number of samples.

TLD-LS

A.9.1 Calculated dose from TLD environmental radiation measurements, Livermore site perimeter, 2008

Location[a]	Jan-Mar[b]	Apr-Jun[b]	Jul-Sep[b]	Oct-Dec[b]	Annual Dose[c]
L-001-TD	0.146 ± 0.005	0.142 ± 0.002	0.147 ± 0.012	0.141 ± 0.008	0.576 ± 0.015
L-004-TD	0.137 ± 0.005	0.159 ± 0.008	0.162 ± 0.007	0.146 ± 0.007	0.604 ± 0.014
L-005-TD	0.155 ± 0.005	0.161 ± 0.011	0.169 ± 0.002	0.153 ± 0.011	0.638 ± 0.016
L-006-TD	0.150 ± 0.003	0.159 ± 0.004	0.163 ± 0.002	0.156 ± 0.012	0.628 ± 0.013
L-011-TD	0.118 ± 0.002	0.122 ± 0.009	0.129 ± 0.008	0.128 ± 0.006	0.497 ± 0.014
L-014-TD	0.136 ± 0.018	0.142 ± 0.007	0.146 ± 0.005	0.134 ± 0.003	0.558 ± 0.020
L-016-TD	0.140 ± 0.010	0.141 ± 0.004	0.144 ± 0.003	0.139 ± 0.003	0.564 ± 0.012
L-042-TD	0.138 ± 0.012	0.152 ± 0.005	0.150 ± 0.006	0.145 ± 0.004	0.585 ± 0.015
L-043-TD	0.132 ± 0.011	0.136 ± 0.014	0.149 ± 0.007	0.139 ± 0.008	0.556 ± 0.021
L-047-TD	0.132 ± 0.011	0.135 ± 0.013	0.133 ± 0.009	0.131 ± 0.010	0.531 ± 0.022
L-052-TD	0.134 ± 0.009	0.145 ± 0.019	0.150 ± 0.010	0.143 ± 0.009	0.572 ± 0.025
L-056-TD	0.131 ± 0.008	0.141 ± 0.004	0.136 ± 0.005	0.134 ± 0.007	0.542 ± 0.012
L-068-TD	0.141 ± 0.010	0.149 ± 0.013	0.157 ± 0.008	0.146 ± 0.009	0.593 ± 0.020
L-069-TD	0.131 ± 0.011	0.134 ± 0.004	0.141 ± 0.007	0.136 ± 0.014	0.542 ± 0.020
Mean[d]	0.137 ± 0.005	0.144 ± 0.006	0.148 ± 0.006	0.141 ± 0.004	0.570 ± 0.020

(a) See *Environmental Report 2008,* Figure 6-1 for location reference.
(b) The quarterly sample error represents 2 standard deviations of the measured elements.
(c) The associated annual error is calculated as twice the rms location error.
(d) The uncertainty associated with quarterly mean dose is represented by 2 Standard Error of the site-wide location averages.

TLD-VAL

A.9.2 Calculated dose from TLD environmental radiation measurements, Livermore Valley, 2008

Location[a]	Jan-Mar	Apr-Jun	Jul-Sep	Oct-Dec	Annual Dose[b]
V-018-TD	0.115 ± 0.013	0.111 ± 0.006	0.116 ± 0.002	0.120 ± 0.009	0.462 ± 0.017
V-019-TD	0.129 ± 0.007	0.134 ± 0.007	0.134 ± 0.011	0.128 ± 0.003	0.525 ± 0.015
V-022-TD	0.149 ± 0.017	0.154 ± 0.007	0.164 ± 0.009	0.153 ± 0.018	0.620 ± 0.027
V-024-TD	0.147 ± 0.012	0.149 ± 0.011	0.153 ± 0.008	0.142 ± 0.004	0.591 ± 0.019
V-027-TD	0.136 ± 0.009	0.136 ± 0.009	0.149 ± 0.011	0.135 ± 0.006	0.556 ± 0.018
V-028-TD	(c)	0.141 ± 0.011	0.149 ± 0.009	0.133 ± 0.009	0.564 ± 0.023
V-030-TD	0.140 ± 0.005	0.142 ± 0.007	0.145 ± 0.004	0.139 ± 0.018	0.566 ± 0.020
V-032-TD	0.136 ± 0.008	0.141 ± 0.005	0.153 ± 0.016	0.139 ± 0.009	0.569 ± 0.021
V-033-TD	0.142 ± 0.010	0.155 ± 0.020	0.158 ± 0.001	0.153 ± 0.014	0.608 ± 0.026
V-035-TD	0.134 ± 0.008	0.136 ± 0.003	0.146 ± 0.018	0.135 ± 0.004	0.551 ± 0.020
V-037-TD	0.140 ± 0.013	0.146 ± 0.002	0.151 ± 0.007	0.146 ± 0.010	0.583 ± 0.018
V-045-TD	0.133 ± 0.006	0.144 ± 0.014	0.156 ± 0.009	0.144 ± 0.011	0.577 ± 0.021
V-057-TD	0.147 ± 0.007	0.163 ± 0.012	0.164 ± 0.008	0.152 ± 0.005	0.626 ± 0.017
V-060-TD	0.145 ± 0.011	0.138 ± 0.008	0.152 ± 0.012	(c)	0.580 ± 0.024[d]
V-066-TD	0.140 ± 0.006	0.152 ± 0.006	0.152 ± 0.013	0.145 ± 0.004	0.589 ± 0.016
V-070-TD	0.145 ± 0.010	0.139 ± 0.002	0.152 ± 0.006	0.140 ± 0.009	0.576 ± 0.015
V-072-TD	0.159 ± 0.009	0.172 ± 0.013	0.177 ± 0.008	0.170 ± 0.002	0.678 ± 0.018
V-074-TD	0.126 ± 0.010	0.133 ± 0.011	0.134 ± 0.003	0.140 ± 0.003	0.533 ± 0.015
V-075-TD	0.117 ± 0.014	0.121 ± 0.014	0.120 ± 0.008	0.122 ± 0.014	0.480 ± 0.026
V-076-TD	0.138 ± 0.013	0.140 ± 0.009	(c)	0.133 ± 0.008	0.548 ± 0.024[d]
V-077-TD	0.135 ± 0.005	0.143 ± 0.013	0.143 ± 0.006	0.138 ± 0.005	0.559 ± 0.016
V-122-TD	(c)	0.166 ± 0.022	0.169 ± 0.009	0.157 ± 0.002	0.656 ± 0.032[d]
Mean[e]	0.138 ± 0.005	0.143 ± 0.006	0.149 ± 0.006	0.141 ± 0.005	0.573 ± 0.021

(a) See *Environmental Report 2008,* Figure 6-2 for location reference.
(b) The associated annual error is calculated as twice the rms location error.
(c) Data not available due to missing or damaged TLD.
(d) When TLD data is missing, the annual dose is calculated as four times the average of available quarterly data.
(e) The uncertainty associated with quarterly mean dose is represented by 2 Standard Error of the site-wide location averages.

TLD-3OFF

A.9.3 Calculated dose from TLD environmental radiation measurements, Site 300 vicinity, 2008

Area Location[a]	Jan-Mar	Apr-Jun	Jul-Sep	Oct-Dec	Annual Dose[b]
Tracy					
3-092-TD	0.143 ± 0.008	0.150 ± 0.014	0.188 ± 0.109	0.152 ± 0.006	0.633 ± 0.110
3-093-TD	0.160 ± 0.017	0.157 ± 0.003	0.176 ± 0.031	0.171 ± 0.018	0.664 ± 0.040
Mean[c]	0.152 ± 0.017	0.154 ± 0.007	0.182 ± 0.012	0.162 ± 0.019	0.649 ± 0.031
Other off-site					
3-090-TD	0.166 ± 0.005	0.172 ± 0.013	0.178 ± 0.014	0.177 ± 0.007	0.693 ± 0.021
3-099-TD	0.144 ± 0.008	0.147 ± 0.010	0.156 ± 0.006	0.157 ± 0.008	0.604 ± 0.016
Mean[c]	0.155 ± 0.022	0.160 ± 0.025	0.167 ± 0.022	0.167 ± 0.020	0.648 ± 0.089

(a) See *Environmental Report 2008,* Figure 6-3 for location reference.
(b) The associated annual error is calculated as twice the rms location error.
(c) The uncertainty associated with quarterly mean dose is represented by 2 Standard Error of the site-wide location average.

TLD-S3

A.9.4 Calculated dose from TLD environmental radiation measurements, Site 300 perimeter, 2008

Location[a]	Jan-Mar	Apr-Jun	Jul-Sep	Oct-Dec	Annual Dose[b]
3-078-TD	0.143 ± 0.014	0.145 ± 0.004	0.160 ± 0.008	0.149 ± 0.006	0.597 ± 0.018
3-081-TD	0.174 ± 0.013	0.183 ± 0.008	0.180 ± 0.017	0.183 ± 0.017	0.720 ± 0.028
3-082-TD	0.156 ± 0.003	0.169 ± 0.011	0.178 ± 0.002	0.167 ± 0.010	0.670 ± 0.015
3-085-TD	0.150 ± 0.002	0.165 ± 0.009	0.229 ± 0.160	0.160 ± 0.005	0.704 ± 0.160
3-086-TD	0.157 ± 0.012	0.174 ± 0.014	0.181 ± 0.009	0.170 ± 0.018	0.682 ± 0.027
3-088-TD	0.167 ± 0.011	0.176 ± 0.004	0.173 ± 0.019	0.162 ± 0.007	0.678 ± 0.023
3-089-TD	0.171 ± 0.012	0.183 ± 0.014	0.222 ± 0.013	0.174 ± 0.009	0.750 ± 0.024
3-091-TD	0.153 ± 0.007	0.174 ± 0.008	0.216 ± 0.096	0.164 ± 0.006	0.707 ± 0.097
3-121-TD	0.176 ± 0.005	0.183 ± 0.012	0.200 ± 0.010	0.175 ± 0.014	0.734 ± 0.022
Mean[c]	0.161 ± 0.008	0.172 ± 0.008	0.193 ± 0.016	0.167 ± 0.007	0.694 ± 0.030

(a) See *Environmental Report 2008,* Figure 6-3 for location reference.
(b) The associated annual error is calculated as twice the rms location error.
(c) The uncertainty associated with quarterly mean dose is represented by 2 Standard Error of the site-wide location average.

Table A.9.5 Quarterly concentrations of tritium in plant water (Bq/L) for the Livermore site, Livermore Valley, and Site 300, 2008[(a)]

Area Location[(b)]	Q1	Q2	Q3	Q4	Median	Mean
within 1 km						
AQUE	2.5 ± 2.2	1.9 ± 2.2	1.0 ± 1.6	1.1 ± 1.7	1.5	1.6
GARD	0.7 ± 2.2	2.9 ± 2.2	1.2 ± 1.6	2.1 ± 1.8	1.6	1.7
MESQ	1.5 ± 2.2	1.4 ± 2.2	1.6 ± 1.6	2.3 ± 1.8	1.6	1.7
MET	1.0 ± 2.2	2.0 ± 2.2	3.2 ± 1.7	3.1 ± 1.8	2.6	2.3
NPER	1.2 ± 2.2	5.0 ± 2.3	5.8 ± 1.8	-0.4 ± 1.6	3.1	2.9
VIS	2.2 ± 2.3	26.0 ± 2.7	3.6 ± 1.7	1.4 ± 1.7	2.9	8.3
1 - <5 km						
I580	4.6 ± 2.3	2.3 ± 2.2	2.1 ± 1.6	1.3 ± 1.7	2.2	2.6
PATT	-0.3 ± 2.2	2.8 ± 2.2	2.0 ± 1.6	-0.1 ± 1.7	0.93	1.1
TESW	1.7 ± 2.2	-0.2 ± 2.1	1.7 ± 1.6	1.4 ± 1.8	1.5	1.1
ZON7	2.7 ± 2.3	2.3 ± 2.2	3.5 ± 1.7	0.6 ± 1.7	2.5	2.3
more than 5 km						
CAL	-2.0 ± 2.1	2.5 ± 2.2	0.1 ± 1.5	1.6 ± 1.7	0.86	0.56
FCC	-0.8 ± 2.1	1.2 ± 2.2	0.7 ± 1.6	1.1 ± 1.7	0.92	0.56
Site 300						
DSW	0.5 ± 2.2	4.3 ± 2.2	2.5 ± 1.6	(c)	(d)	2.4
EVAP	3.5 ± 2.3	86.0 ± 3.7	17.0 ± 2.2	0.9 ± 1.7	10	27
PSTL	1.1 ± 2.2	1.4 ± 2.2	1.1 ± 1.6	0.7 ± 1.7	1.1	1.1
TNK5	5.1 ± 2.4	2.3 ± 2.2	1.3 ± 1.6	1.0 ± 1.7	1.8	2.4

(a) Radioactivities are reported as the measured concentration and an uncertainty (±2σ counting error). If the concentration is less than or equal to the uncertainty, the result is considered to be a nondetection. See *Environmental Report 2008,* Chapter 9.
(b) See *Environmental Report 2008,* Figures 6-1, 6-2, and 6-3 for location reference.
(c) No vegetation was available for sample collection.
(d) Median not calculated because only three values are available.