

Purpose and scope of the Environmental Report

Regulatory permitting and compliance

Integrated Safety Management System and Environmental Management System

Pollution prevention

Air monitoring

Water monitoring

Terrestrial radiological monitoring

Biota

Radiological dose

Groundwater remediation

Comparison of tritium levels in various environmental media

Conclusion



Lawrence Livermore National Laboratory (LLNL) is a premier applied science 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, environmental, 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.

LLNL has been managed since its inception in 1952 by the University of California for the U.S. government. In May 2007, DOE selected Lawrence Livermore National Security, LLC (LLNS), to manage the Laboratory. The seven-year management contract term begins 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) within the Safety and Environmental Protection Directorate 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 3.3 square kilometers (1.3 square miles); and a rural Experimental Test Site, referred to as “Site 300,” near Tracy, California, which occupies 28.3 square kilometers (10.9 square miles). The Laboratory has a staff of more than 8000.

Purpose and Scope of the Environmental Report

The purposes of the *Environmental Report 2006* 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 LLNL's Environmental Protection Department Quality Assurance Management Plan, which is based on U.S. Department of Energy (DOE) Order 414.1C, Quality Assurance.

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 printed form and on compact disc and is also available to the public at <http://www.llnl.gov/saer/>, 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

In 1998, LLNL began the implementation of an Integrated Safety Management System (ISMS), which is designed to ensure the systematic integration of ES&H considerations into management and work practices so that missions are accomplished safely. Work Smart Standards (WSSs), based on applicable laws, regulations, and DOE orders, establish workplace ES&H controls and are an integral part of LLNL's ISMS. "Safety" in this context is synonymous with environment, safety, and health and encompasses protection of the public, workers, and the environment, including pollution prevention and waste minimization. LLNL regards protection of the environment as an essential component of its overall safety management system.

LLNL established its Environmental Management System (EMS) to meet the requirements of the International Organization for Standardization (ISO) 14001:1996, which was adopted by LLNL as a WSS in June 2004. Following internal audits, LLNL self-declared its conformance with ISO 14001:1996 in December 2005. The Livermore Site Office (LSO) of the NNSA subsequently validated LLNL's conformance with the condition that LLNL complete a corrective action plan (CAP), which was accomplished in 2006. The EMS

commits LLNL as an institution and all employees to responsible stewardship of all the environmental resources in their care.

In 2006, LLNL enhanced the environmental emphasis of its ISMS further by upgrading from ISO 14001:1996 to the ISO 14001:2004 EMS. Progress in 2006 includes the completion of various studies, implementation of exotic species control, and progress toward waste reduction targets for nine significant environmental aspects (environmental aspects are elements of an organization's activities, products or services that can interact with the environment). The significant environmental aspects are ecological resource disturbance, electrical energy use, fossil fuel consumption and renewable energy use, hazardous material use, mixed waste generation, municipal waste generation, nonhazardous materials use, radioactive materials use, and transuranic waste generation.

Pollution Prevention

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

In December 2006, NNSA/Headquarters selected two LLNL projects to receive NNSA Best-in-Class awards. The first award was for initiatives at Site 300 that resulted in saving 9.7 million gallons of water per year through recycling, environmental conservation, and improved operations efficiency. The initiatives also saved 68,000 kilowatt hours in electric pumping. The second award was for a project at the Livermore site, but due to its subject matter, it was categorized as Official Use Only and the details are not discussed in this report.

LLNL also conducted activities to promote employee awareness of P2, including the annual Earth Expo held in April to coincide with Earth Day, articles in the LLNL newspaper, and training for procurement staff.

Air Monitoring

LLNL operations involving radioactive materials had minimal impact on ambient air during 2006. 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 2006, radioactivity released to the atmosphere was monitored at 69 air effluent sampling locations at six facilities on the Livermore site and one at Site 300. In 2006, 0.67 terabecquerels (TBq) (18 curies [Ci]) of tritium was released from the Tritium Facility, and 1.0×10^{-4} TBq of tritium (2.8 mCi) was released from the

Decontamination and Waste Treatment Facility. None of the facilities monitored for gross alpha and gross beta radioactivity had emissions in 2006.

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 2006 for the Livermore site were about 10% lower than those in 2005; estimated releases at Site 300 were higher in 2006 than in 2005 due primarily to the operation of emergency generators during unplanned power outages. In 2006, LLNL eliminated two operations that had an annual potential to emit more than 2200 pounds of volatile organic compounds (VOCs). 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 2006, 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 2006, 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 2006, no discharges to the sanitary sewer exceeded any effluent limits for radioactive materials, and all the values were a fraction of the allowed limits. For nonradioactive materials, there was one excursion outside the permissible pH range (see *LLNL Environmental Report 2006*, **Section 5.1.1.2**); all other constituents were below allowed limits. All discharges to the Site 300 sewage evaporation and percolation ponds were within permitted limits, and groundwater monitoring 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 2006, 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). At Site 300 in 2006, data continued to show that most constituents are transported sorbed to suspended sediments and that concentrations remained below levels of environmental concern.

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. As in other years, all constituents in groundwater away from the Livermore site were below allowable limits for drinking water. 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; all constituents in off-site wells near Site 300 were below allowable limits for drinking water.

Rainwater is analyzed for tritium. In 2006, the maximum concentration of tritium in rain collected on the Livermore site was 1.7% of the drinking water standard, and no off-site concentrations were above the lower limit of detection (0.5% of the drinking water standard). At Site 300, tritium concentrations in all rain samples were below detection limits.

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 5% 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, sediment, and vadose zone soils in 2006 was insignificant. Soils and sediments are analyzed for plutonium, gamma-emitting radionuclides, tritium, total and soluble metals, 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 1.3% 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 2006, uranium-238 concentrations in soils

at Site 300 were below NCRP-recommended screening levels. Beryllium concentrations were representative of background levels.

Vegetation and Livermore Valley wine were sampled for tritium. In 2006, the median 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 was 0.68% of the drinking water standard.

LLNL's extensive network of thermoluminescent dosimeters measures the natural terrestrial and cosmogenic background; in 2006, as in recent years, no impact from LLNL operations was detected.

Biota

Through monitoring and compliance activities in 2006, 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 (*Masticophis 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*).

In February and March of 2006, LLNL translocated California red-legged frogs to two new pools in Elk Ravine that were created in 2005 to replace wetlands maintained artificially by discharge from several buildings. In 2006, LLNL completed culvert replacement projects at Round Valley and Oasis to maintain the safety of fire trails at Site 300, resulting in the creation of a 0.089-hectare (0.22-acre) habitat pool at the Round Valley site to mitigate in part for impacts at the Oasis site.

LLNL took several actions to control invasive species in 2006. Most significantly, LLNL collaborated with the California Department of Fish and Game to apply the fish pesticide rotenone to Lake Haussmann to remove largemouth bass (*Micropterus salmoides*). Water quality and sediment monitoring following the rotenone application confirmed no long-term water quality impacts. Observations following the application confirmed that invasive, nonnative fish species were successfully removed from Lake Haussmann. Site 300's invasive species control efforts have been focused largely on dispatching feral pigs. In December 2006, five adult pigs (four females, one male) were discovered and dispatched.

The 2006 radiological doses calculated for biota at the Livermore site or Site 300 were far below screening limits set by DOE, even though extremely unlikely assumptions maximized the potential effect of LLNL operations on biota.

Radiological Dose

Annual radiological doses at the Livermore site and Site 300 in 2006 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 2006 was 0.045 microsieverts (μSv) (0.0045 millirem [mrem]) for the Livermore site and 0.16 μSv (0.016 mrem) at Site 300. Four sources of tritium at LLNL contributed nearly 100% of the dose received by the SW-MEI. The dose for 2006 was about 70% of the 2005 dose for the Livermore site. The dose to the SW-MEI at Site 300 was about 89% of the 2005 dose. There was one unplanned incident at the Livermore site that had the potential to release tritium, but given that there was no dose to employees handling the material, any potential dose to the public was negligible (see *LLNL Environmental Report 2006*, **Section 7.5.2**). There were no unplanned releases to the atmosphere from Site 300. Other than the potential release noted, there were no unplanned releases to the atmosphere at the Livermore site.

In **Figure EX-1**, calculated radiological doses to the SW-MEI from operations at each site in 2006 are compared with doses potentially received from the environment and from common activities (e.g., dental x-rays). As can be seen, the contribution of LLNL operations to unavoidable dose in 2006 was inconsequential.

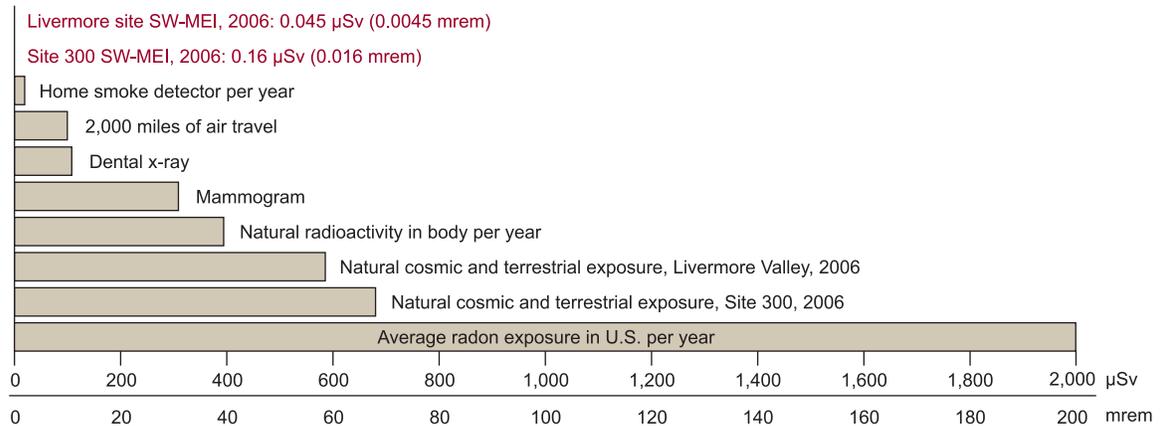


Figure EX-1. Radiological dose to a hypothetical member of the public living at the perimeter of the Livermore site or Site 300 (site-wide maximally exposed individual or SW-MEI) in 2006 compared to common annual radiological doses potentially received by an average individual.

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 eight Site 300 Operable Units (OUs). In addition, nitrate, perchlorate, tritium, high explosives, depleted uranium, organosilicate oil, and metals are found at one or more of the OUs.

In 2006, concentrations continued to decrease in most of the Livermore site VOC plumes due to active remediation and the removal of more than 255 kilograms (kg) of VOCs from both groundwater and soil vapor. VOC concentrations on the western margin of the site continued their decline, indicating effective hydraulic control of the boundary plumes. In the interior of the site, remediation activities, including soil vapor extraction, dual extraction, and groundwater extraction, have resulted in declines of VOC concentrations in source areas. In 2006, all of the “build out” milestones were completed, and the project was transferred from DOE’s Office of Environmental Management to the NNSA.

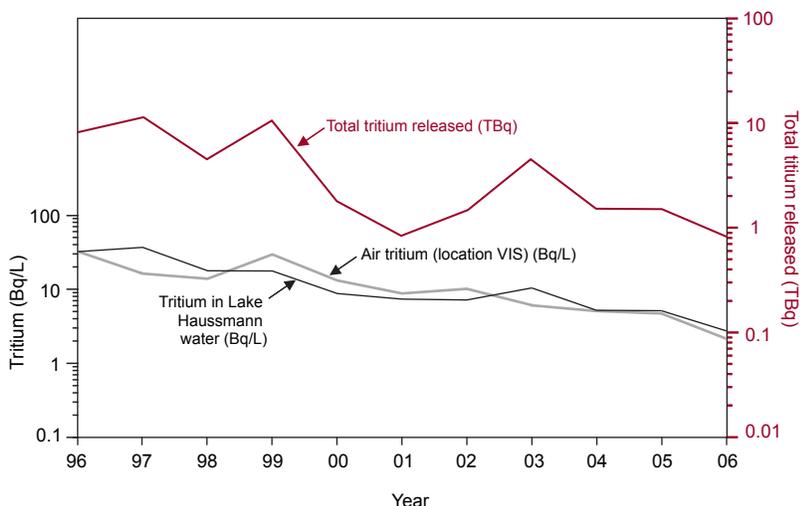
In 2006 at Site 300, perchlorate, nitrate, the high explosive RDX, and organosilicate oil were removed from groundwater in addition to about 50 kg of VOCs. Each Site 300 OU has a different profile of contaminants, but overall, groundwater and soil vapor extraction and natural attenuation continue to reduce the mass of contaminants in the subsurface. An additional four areas at Site 300 are under investigation; a final CERCLA remedy to address environmental contamination has not been reached.

Comparison of Tritium Levels in Various Environmental Media

In **Figure EX-2**, annual median concentrations of tritium in air moisture at sampling location VIS (on the eastern boundary of the Livermore site) and in Lake Haussmann water over the last eleven years are compared with total tritium releases to the atmosphere from Livermore site operations. Concentrations of tritium in air moisture at location VIS and water from Lake Haussmann in 2006 were less than 0.4% of the drinking water standard.

Generally, the correlation between concentrations in environmental media and annual releases of tritium to the atmosphere from LLNL site operations is weak. Differences are due to distance from the tritium sources to the location of the sampled medium, whether the released tritium was from a stack or an area source, the fraction of time the wind blew toward

Figure EX-2. Annual median concentrations of tritium in two environmental media at Livermore site locations compared with total annual releases of tritium from Livermore site operations.



the location, and how well the sample medium integrated tritium concentrations throughout the year. Nevertheless, a reasonable correlation may be seen between the concentrations in air moisture and those in Lake Haussmann.

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 2006 was more than 15,000 times smaller than 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.