

4.16 HUMAN HEALTH AND SAFETY

This section describes the responsibilities of existing LLNL programs for assuring that their respective activities are executed in a manner protective of the general public, worker safety and health, and the environment.

Environment, Safety, and Health Functions and Responsibilities

It is the policy of NNSA and LLNL to operate in a manner that protects the health and safety of employees and the public, preserves the quality of the environment, and prevents property damage. ES&H is to be a priority consideration in the planning and execution of all work activities at LLNL. It is also the policy of LLNL to comply with applicable ES&H laws, regulations, and requirements; and with directives promulgated by DOE regarding occupational safety and health, as adopted in the LLNL Work Smart Standards. LLNL encourages public participation on matters of importance to the community related to environmental protection and health and safety. Public participation is encouraged through the initiation of communications and solicitation of public input to the decision-making process on matters of significant public interest and by providing access to information on LLNL ES&H activities (LLNL 1998d).

LLNL has implemented an Integrated Safety Management System (ISMS), in accordance with DOE P 450.4 to "...systematically integrate safety into management and work practices at all levels so that missions are accomplished while protecting the public, the worker, and the environment." The ISMS is a systematic approach to defining the scope of work, identifying, planning, and performing work that provides for early identification of hazards and associated control measures for hazardous mitigation or elimination. The ISMS process also forms the basis for work authorization and provides for both internal and external assessment through a continuous feedback and improvement loop for identifying both shortcomings and successes for incorporation into subsequent activities (LLNL 2003k). ISMS is discussed in detail in Appendix C.

The LLNL Director is responsible for the overall implementation and oversight of ES&H responsibilities and is assisted by the Senior Management Council and the ES&H Working Group. The Senior Management Council, composed of the Director (Chair), the Deputy Directors, and all Associate Directors, advises the LLNL Director on policies and oversees the effectiveness of activities and programs to implement those policies. The Senior Management Council is responsible for:

- Reviewing LLNL policies and recommending changes to the Director
- Ensuring the implementation of those policies and reviewing the effectiveness of their implementation
- Discussing accidents, incidents, audits, and reviews at LLNL and other NNSA contractor facilities to identify lessons learned and ensuring that those lessons are incorporated into LLNL operations
- Establishing and overseeing working groups and committees as appropriate
- Providing a forum to receive input from LLNL employees and ensuring that they are adequately informed

- Reviewing proposed exemptions to standards and regulations
- Reviewing and resolving outstanding institutional issues

The ES&H Working Group supports the Deputy Director for Operations and the Senior Management Council. Its broad membership and close association with the Deputy Director for Operations and Senior Management Council provides a key mechanism for LLNL-wide reviews of proposed ES&H policies and issues and for the development of effective ES&H guidance. The ES&H Working Group consists of assurance managers from each directorate and the heads of the ES&H functional organizations. ES&H Working Group responsibilities include the following:

- Responding to requests for reviews and studies by the Deputy Director for Operations
- Reviewing and developing LLNL implementation plans to meet Federal, state, and DOE requirements
- Addressing ES&H and quality assurance issues raised by the programs and preparing recommended actions for consideration by the Deputy Director for Operations and Senior Management Council
- Reviewing generic or institutional ES&H and quality assurance issues, and bringing those issues to the attention of the Deputy Director for Operations for policy development or change

The EPD assists LLNL managers to ensure that LLNL operations comply with applicable laws and regulations and that environmental impacts from LLNL operations are mitigated to the maximum extent possible. The EPD's key missions are as follows (LLNL 1996b):

- Assist LLNL programs in developing environmentally sound practices in their day-to-day tasks by: (1) conducting environmental evaluations and addressing requirements under NEPA, CEQA, and related Federal and state requirements; (2) identifying and developing methods to monitor, prevent, reduce, and clean up air emissions, wastewater discharges, and hazardous wastes; and (3) obtaining the permits or exemptions for air, water, and hazardous waste activities
- Ensure environmental compliance through environmental monitoring, risk assessment, and analysis for LLNL sites by evaluating the impact of ongoing LLNL operations on the surrounding environment by sample collection, analysis, data reduction, and other simulation modeling methods for water and air
- Develop and conduct cost-effective restoration and remediation
- Design and apply appropriate, cost-effective treatment technologies to manage hazardous and nonhazardous waste streams
- Develop and implement waste minimization and pollution abatement strategies
- Coordinate LLNL-wide D&D activities

The EPD is divided into three operating divisions, each with specific responsibilities (for more details, see Appendix C, Environment, Safety, and Health): RHWM Division, ERD, and Operations and Regulatory Affairs Division. The RHWM Division develops and improves

methods to ensure that wastes from LLNL operations have minimal environmental impacts. They operate LLNL's hazardous, radioactive, and mixed waste management systems. The ERD investigates and cleans up soil and groundwater contaminated by past activities of LLNL and its predecessors at the Livermore Site and Site 300. The Operations and Regulatory Affairs Division is the focal point for interactions with Federal, state, and local environmental regulatory agencies. It offers technical guidance and expertise on regulatory requirements and related compliance options, permitting issues, and monitoring techniques and technologies, as well as providing 24-hour emergency response for environmental incidents.

The Hazards Control Department, through its five ES&H teams, works with LLNL programs to minimize the risks presented by research and support activities. The hazards encountered include all biological, physical, and radiological agents from normal operating conditions to emergencies. The Hazards Control Department also provides safety analysis, and emergency preparedness and response training services and operates state-of-the-art analytical laboratories. The Hazards Control Department's primary responsibilities include monitoring operations to provide management with the information needed to maintain an acceptable-risk work environment, provide guidance in formulating LLNL's health and safety policies, directives, and standards; conduct facility design reviews; and specify any protective equipment that might be required by employees to perform their work assignments safely. The Hazards Control Department assists the programs in the implementation of the LLNL ISMS. In the ISMS context, the term safety is synonymous with the LLNL term ES&H. It encompasses protection of employees, the public, and the environment. The overall responsibility for implementing this belongs to line management.

The Health Services Department provides occupational health services for LLNL. This department works collaboratively with the Hazards Control Department and EPD. The Health Services Department Head serves the role of Chief Medical Officer at LLNL and provides input for health-related decisions made by LLNL management. The Health Services Department staff provides clinical services and employee assistance and offers the following occupational health services:

- Treatment for occupational and minor non-occupational injuries and illness
- Emergency care, stabilization, and transfer to local emergency room if necessary
- Return-to-work assistance after illness or injury
- Multidisciplinary work site inspections regarding health hazards and environmental conditions, medical surveillance, and qualification and fitness for duty examinations
- Educational programs designed to address health concerns in the workplace
- Health promotion services
- Physical therapy for occupational injuries or illness
- Decontamination and treatment for chemical or radiological exposures
- Employee assistance services

The Health Services Department also implements prevention programs for occupational illnesses and injuries, such as monitoring worker exposure data with the Hazards Control Department and

preventing Valley Fever (coccidioidomycosis) at Site 300. The programs mentioned above are further discussed in Appendix C.

4.16.1 Occupational Safety

4.16.1.1 Regulatory Setting

The Work Smart Standards, which includes Federal and state regulatory requirements, is a set of codes, standards, and regulations adopted between LLNL and NNSA (LLNL 1998e). Information on the contractual adoption of Work Smart Standards, as well as standards maintenance, flow down of requirements, and change control process, is included in Appendix C, Section C.2.2, of this LLNL SWEIS.

4.16.1.2 Lawrence Livermore National Laboratory Occupational Safety

Each employee at LLNL, from Director to laboratory worker, is required to know and understand the ES&H requirements of his or her assignment, the potential hazards in the work area, and the controls necessary for working safely. He or she must participate in all required ES&H training and health monitoring programs. All work assignments must be performed in full compliance with applicable ES&H requirements as published in LLNL manuals and guidelines and established in safety procedures. All employees are responsible for working in a manner that produces high quality results, preserves environmental quality, and protects the health and safety of workers and members of the public. Program implementation is a line management responsibility, with primary oversight of program implementation resting with the Hazards Control Department and Health Services Department (LLNL 1996b). These organizations are described briefly above and further discussed in Appendix C. An organization chart is also provided in Appendix C, Section C.2.2, of this LLNL SW/SPEIS.

The Assurance Review Office is LLNL's institutional-level ES&H oversight organization reporting to the Deputy Director for Operations. The Assurance Review Office mission is to assist the Laboratory's Deputy Director for Operations in discharging his ES&H and related quality assurance responsibilities by providing independent, institutional-level oversight of LLNL's ES&H systems and nuclear facility safety. The Assurance Review Office also serves as a point of contact and coordinating agent for major DOE and University of California ES&H reviews, assessments, and audits. The Assurance Review Office's role is to conduct independent reviews of LLNL's ES&H and related quality assurance systems, including nuclear facility operations and the directorate self-assessment processes.

The Assurance Review Office evaluates the adequacy of existing ES&H systems relative to LLNL's ES&H policies and procedures and applicable ES&H laws, regulations, and directives. The results of the Assurance Review Office's reviews are communicated to the Deputy Director for Operations, directorates, nuclear facility management, and ES&H support organizations with the intent of facilitating improvements in LLNL's ES&H, nuclear facility safety, self-assessment, and institutional oversight programs. The Assurance Review Office is responsible for independently assessing conformance with LLNL's nuclear safety implementation plans prepared in accordance with the *Price-Anderson Amendments Act* rules. The Assurance Review Office maintains the institutional ES&H deficiency tracking system (DefTrack) to monitor actions taken

in response to its evaluations and assessments conducted by outside agencies and the directorates. The Assurance Review Office is precluded from assuming any line or programmatic responsibilities to ensure functional independence and appropriate segregation of responsibility (ARO 2003).

The LLNL ISMS addresses the identification of workplace hazards, control measures, safe work practices, and feedback and continuous improvement functions necessary to perform work safely at LLNL. This program articulates the institutional requirements for all LLNL operations, whether at the Livermore Site, Site 300, or Nevada Test Site, or at any other sites where LLNL personnel and contractors are working. The LLNL ISMS was implemented in 1998 with the updating of existing safety manuals and organization into a formal structure within the ISMS Plan. Additionally, in 1997, LLNL and the DOE Oakland, California office initiated the selection of Work Smart Standards to protect workers, the public, and the environment. These standards are the basis for selecting hazard controls and other processes at LLNL (LLNL 2003k).

Special Illness Prevention Program

Site 300 workers and visitors face the potential of contracting coccidioidomycosis, a respiratory disease commonly known as Valley Fever, caused by the fungus *Coccidioides immitis*. The disease is common in warm, dry alkaline areas including the entire San Joaquin Valley. Coccidioidomycosis is acquired from inhalation of the spores (arthroconidia). Once in the lungs, the arthroconidia transform into spherical cells called "spherules." An acute respiratory infection occurs 7 to 21 days after exposure and typically resolves rapidly. However, the infection may alternatively result in a chronic pulmonary condition or disseminate to the meninges, bones, joints, and subcutaneous and cutaneous tissues. About 25 percent of the patients with disseminated disease have meningitis (DoctorFungus 2002). The Health Services Department tests each employee or prospective employee for Valley Fever immunity before assignment to Site 300, subject to the availability of the antigen (see Appendix C). The test is currently unavailable and may remain unavailable beyond 2003. Based on the test results and physical factors (e.g., greater susceptibility or being pregnant), employees are counseled regarding increased risk, and the Health Services Department recommends if working at Site 300 is appropriate. An employee can work at Site 300 despite a contrary recommendation if an informed consent form is signed (LLNL 2000i).

Other Exposures and Potential Hazards

Exposures to Hazardous Materials

LLNL is an R&D facility in which a large variety of hazardous materials are used. LLNL operations represent a potential for exposure of some workers to hazardous materials (such as solvents, metals, and carcinogens). Typically operations are controlled so that those workers may be exposed to very low levels of a wide variety of chemicals that are below a threshold of concern throughout the duration of their research. A summary of radioactive materials and chemicals to which workers may be exposed can be found in Appendix B, Waste Management. Radioactive and hazardous wastes are also discussed in Appendix B. LLNL evaluates operations and prevents employee exposures to chemical hazards. Hazards Control tracks measured exposures to hazardous chemicals in an electronic database (LLNL 2002bk).

Workers are provided with information and training on identified hazards to protect them from exposure. LLNL has several programs and procedures in place to provide direction for monitoring, handling, storing, and using these materials. These programs and safety procedures include the Hazard Communication Program, Chemical Hygiene Program, Respiratory Protection Program, and written safety procedures for handling and use of carcinogens and biohazard materials. Work activities are periodically monitored with measurements performed at personal breathing zones and general work areas. ES&H monitoring records indicate that personnel exposure to hazardous materials is maintained well below established regulatory requirements and exposure guidelines. Additional information regarding worker exposure to toxic materials is found in Appendix C (LLNL 2000i).

Biohazards

Biological operations at LLNL include using and safely handling biohazardous materials, agents, or their components (e.g., microbial agents, bloodborne pathogens, recombinant deoxyribonucleic acid [DNA], and human or primate cell cultures), and research proposals and activities concerning animal or human subjects. Biological materials can cause illness and infection. Examples of potential sources of exposure to biological hazards are as follows:

- Human fluids, secretions, or feces
- Class II and III etiologic agents
- Infectious agents from animal infestation or droppings
- Biological toxins
- Human cell and tissue culture systems
- Research involving animals
- Research involving allergens of biological origin (e.g., certain plants and animal products, danders, urine, and some enzymes)
- Laundry soiled with blood or other potentially infectious materials
- Contaminated sharps
- Unfixed human tissues or organs

Personnel exposure to biological hazards is minimized using administrative controls, engineered controls, and personal protective equipment. By analyzing the hazards for each specific operation, LLNL personnel develop and implement the appropriate controls to protect themselves, the community, and the environment from potential exposure (LLNL 2000i).

Carcinogens

Carcinogens are only used in LLNL operations when it is not possible to use a noncarcinogenic material. Any use of carcinogens requires stringent controls to be in place to prevent exposures to workers, the public, and the environment. Examples of operations where carcinogenic materials may be encountered include:

- Brazing with cadmium-containing alloys or grinding of cadmium-coated work pieces
- Work that generates or involves contact with soots and tars
- Use of mineral oil products that may contain polyaromatic hydrocarbons
- Electric arc discharge machining
- Discharging of gas propellants in a vacuum
- Handling refractory ceramic fibers
- Welding stainless steels (due to the formation of hexavalent chromium compounds and nickel oxide)
- Chromium plating and other operations that disperse hexavalent chromium compounds or irritatingly strong concentrations of sulfuric acid into the air
- Generating hardwood dust, including carpentry and cabinet-making activities
- Spraying hexavalent chromium compounds including, but not limited to, primers, paints, and sealants containing barium, calcium, sodium, strontium, or zinc chromate
- Handling inorganic arsenic compounds and arsenic metal, including gallium arsenide, in a manner that can result in exposure to arsenic
- Handling animals in research activities involving carcinogens
- Using or synthesizing of carcinogens in laser chemistry or biochemistry laboratories
- Using asbestos, beryllium, laser dyes, or lead and lead compounds

At LLNL, chemical carcinogens are used by employees only when required by a specific research project. The use of chemical carcinogens is addressed in the Chemical Hygiene Plan and the ES&H Manual requirements (LLNL 2000i). The program addresses control and storage of chemicals, preparation of work plans, worker safety, personnel protective measures, engineering controls, and waste management.

As addressed previously, worker exposures to certain hazardous materials are monitored by industrial hygiene staff and tracked using an occupational exposure database. Likewise,

personnel may be monitored for certain chemical agents by way of routine medical examinations performed by the Health Services Department.

The use, synthesis, and storage of carcinogens must be evaluated by an industrial hygienist. Depending on the nature of the chemical use, the quantity of material involved, and the control measures engaged, procedural guidance might be required for the performance of work using carcinogens.

The purchase and receipt of chemical carcinogens is primarily controlled through procurement administrative controls. Authorization for the purchase of carcinogens requires either a current Operation Safety Plan or the approval of the area industrial hygienist. Occupational Safety and Health Administration (OSHA)-regulated carcinogens may only be purchased with approval of the Hazards Control Department.

All employees who work with carcinogens must receive sufficient information and training so that they may work safely and understand the relative significance of the potential hazard they may encounter (LLNL 2000i).

Beryllium Disease Prevention Program

Beryllium metal, alloys, and compounds are widely used at LLNL and other DOE facilities because of the materials' nuclear properties as moderators (i.e., reflectors) of neutrons. Favorable mechanical properties have also resulted in beryllium's widespread use in the aerospace industry. The addition of 2 percent or less beryllium to copper forms an alloy with high strength and hardness, properties that have made the alloy useful in electronics, automotive, defense, and aerospace industries worldwide. Beryllium oxide (also known as beryllia) can be formed into beryllia ceramics, which have an exceptional combination of high thermal conductivity, electrical resistivity, and dielectric properties. Beryllium ceramics are used widely in electronics, laser, automotive, and defense applications (LLNL 2000i).

Although solid beryllium poses no health hazard, inhaling beryllium particulates (such as dust, mists, or welding fumes) can produce acute or chronic lung disease. Skin irritation may result from direct contact with soluble beryllium compounds, and healing is impaired in beryllium-contaminated wounds. Health effects from beryllium are caused by the body's immune system response to inhaled dust or fumes containing beryllium metal, alloys, or compounds. This immune system response to beryllium is similar to an allergic reaction and may evolve over many years, even decades. Early evidence of this reaction may be detected by a blood test; i.e., the beryllium lymphocyte proliferation test, before there is evidence of damage to the lungs. Positive test results indicate beryllium sensitization. Sensitization is not a disease. There is no impairment from or symptoms of, sensitization itself.

The body's reaction may continue to progress and cause damage to the lungs. Chronic beryllium disease is said to exist when there is evidence of harmful effects to the lungs; i.e., when healthy lung tissue becomes damaged and changes from functioning lung tissue to fibrotic tissue. Damage to the lungs may be detected early by biopsy before there are symptoms (such as shortness of breath). Damage such as fibrosis may progress to the point that symptoms are severe enough to disable or cause death.

LLNL's Beryllium Disease Prevention Program addresses a new DOE effort designed to reduce the number of workers exposed to beryllium, minimize the levels of beryllium exposure, and ensure early detection of beryllium-related disease. LLNL's control program consists of:

- Workplace evaluations and establishment of controls
- Training
- Medical surveillance

The Beryllium Disease Prevention Program is part of long-standing beryllium control efforts at LLNL that predate any Federal mandates. These controls, plus a high level of awareness of the hazards of beryllium among scientists, engineers, technicians, and other staff who work in areas where beryllium is used, have resulted in a low beryllium disease rate at LLNL.

Workplace exposure questionnaires and the availability of a new blood test are two major enhancements to LLNL's Beryllium Disease Prevention Program. The blood test, called the lymphocyte proliferation test, detects sensitivity to beryllium. Employees who become sensitized are more likely to develop beryllium lung disease.

For most people, chronic beryllium disease results from significant exposures to beryllium from activities such as machining or working with powder or dust. A small percentage of individuals can develop chronic beryllium disease from a very low level of dust. Chronic beryllium disease, a poorly understood lung disease, may take years or even decades to develop, and the primary symptom is shortness of breath on exertion. The lymphocyte proliferation test can identify individuals who have a greater risk of getting chronic beryllium disease, because their bodies have developed a response to the metal (a positive sensitivity).

As part of the hazard assessment process, everyone involved in beryllium work is evaluated to determine if DOE's criteria for classification as a "beryllium worker" is met. This determination is made by both program management and the ES&H team industrial hygienist. ES&H Manual Document 14.4, "Implementation of Chronic Beryllium Prevention Program Requirements" identifies the requirements and provides guidance for making the determination (LLNL 2000i). Part of the process is the "Beryllium Occupational History Questionnaire." This is filled out by everyone involved in beryllium work. A copy is maintained by the Hazards Control Department and Chemical and Biological Safety Section and a copy is forwarded to the Health Services Department and placed in the employee's medical record. The questionnaire provides important information to both the Health Services Department and the Hazards Control Department about current and past exposure potential.

If an employee has a confirmed positive (meaning two consecutive positive lymphocyte proliferation tests), additional medical testing (e.g., bronchoscopy, etc.) will be recommended to determine if the employee actually has beryllium disease. Positive sensitivity does not necessarily mean that disease is present. Health Services Department clinicians provide health counseling, which include a recommendation to eliminate any work with beryllium. All lymphocyte proliferation test results are managed in a medically confidential manner. Training on beryllium hazards is available from the Hazards Control Department.

LLNL's Health Services Department offers medical screening and surveillance to beryllium-associated workers. These are workers in any one of the following categories:

- Beryllium workers
- A worker whose work history shows he or she may have been exposed to airborne beryllium
- A current worker who shows signs or symptoms of beryllium exposure
- A current worker who is receiving medical removal protection benefits

Although the Beryllium Disease Prevention Program is open only to current LLNL employees, DOE has developed medical screening options for former employees who may have had beryllium exposure. The *Energy Employees Occupational Illness Compensation Program Act* of 2000 as amended concerns workers involved in various ways with the nation's atomic weapons program. Part A of the Act provides Federal monetary and medical benefits to workers having radiation-induced cancer, beryllium illness, or silicosis. Eligible workers include DOE employees, DOE contractor employees, as well as workers at an "atomic weapons employer facility" in the case of radiation-induced cancer and illness.

LLNL analyzes Site 300 soils for beryllium. Soils at the Livermore Site were analyzed for beryllium from 1991 to 1994. However, analysis for beryllium was discontinued at the Livermore Site in 1995, because it was never measured above background values (LLNL 2001v).

Physical Hazards

LLNL employees could also be exposed to physical hazards such as non-ionizing radiation, to include static magnetic and electric fields, extremely low frequency fields, radio frequency fields, and microwaves, noise, electric shock, tripping hazards, and lasers. The ES&H Manual provides procedural guidance for mitigating these types of hazards, and occurrences of such hazards are monitored by the Hazards Control Department.

Occupational Injuries

LLNL records occupational injuries pursuant to DOE orders that use OSHA criteria. Total recordable case rates for injury and illness incidence at LLNL varied from an annual average of 6.9 to 3.0 per 200,000 hours worked from 1996 to 2002. During this time, total lost and restricted day case rates ranged from 2.8 to 0.9 per 200,000 hours worked (LLNL 2002ck, LLNL 2003u). The total recordable case rate for LLNL workers is more than for DOE and its contractors at other facilities, which varied from 3.5 to 2.4 per 200,000 hours worked. During this time, total lost day case rates for DOE varied from 1.7 to 0.9 per 200,000 hours worked. No fatalities occurred at LLNL between 1996 and 2002 (DOE 2002f).

4.16.2 Human Health and Worker Safety (Radiological Effects)

The environment potentially affected by radiological site releases includes air, water, and soil. These transport pathways (the environmental medium through which a contaminant moves)

require an associated exposure pathway (e.g., inhaling air, drinking water, or dermal contact with soil) to affect human health. The specific resource sections in this LLNL SW/SPEIS (e.g., Air Quality and Water) describe the existing conditions of the environmental media.

4.16.2.1 Public Health

A radiation dose is calculated to determine the health impact from exposure to radiation. The dose is a function of the exposure pathway (external, inhalation, or ingestion) and the type and quantity of radionuclide involved. The transport pathway (air, water, soil) concentrations, uptake parameters, usage rates, exposure duration, and radionuclide-specific dose factors determine the dose. The dose is always presented in this document (unless otherwise noted) as the Committed Effective Dose Equivalent, which weights the impacts on particular organs so that the dose from radionuclides that affect different organs can be compared on a similar (effect on whole body) risk basis. Health impacts (cancer fatalities) are calculated from the risk factor of 0.0006 fatal cancers to the general population expected per person-rem effective dose equivalent (Lawrence 2002).

The levels of exposure from the small quantities of radiation released from LLNL can be put in perspective by considering the doses received in the U.S. from exposure to natural and man-made background radiation. Table 4.16.2.1-1 compares the dose received from background and from a recent year of LLNL operations, 1999. The year 1999 is used because the doses received from LLNL operations were generally the greatest of the 5-year period 1998 through 2002. The air transport pathway results in almost all of the doses to the public from LLNL, either directly or through deposition and subsequent ingestion.

The risk of the hypothetical site-wide MEI contracting a fatal cancer from exposure to 1999 releases is 7.2×10^{-8} and 2.1×10^{-8} from the Livermore Site and Site 300, respectively. These same releases are unlikely (0.008 cancers calculated) to increase the number of LCFs in the population surrounding LLNL above those that occur naturally. The average annual cancer death rate nationally is 171.4 per 100,000 population; for California the rate is 161.7 per 100,000 population (Ries et al. 2002). Thus, approximately 11,000 fatal cancer deaths per year would be expected to naturally occur in the population of approximately 7 million people within 50 miles of LLNL.

TABLE 4.16.2.1-1.—Comparison of Radiation Dose Received from Background and Lawrence Livermore National Laboratory Operations for 1999

| Location/Source | Individual Dose to Site-wide MEI ^a (millirem) | Population Dose ^a (person-rem) |
|---------------------------------------|---|--|
| Livermore Site | | |
| Atmospheric emissions | 0.12 | 1.7 |
| Site 300 | | |
| Atmospheric emissions | 0.035 | 11 |
| Other (background)^b | | |
| Natural background | | |
| Cosmic radiation | 30 | 190,000 |
| Terrestrial radiation | 30 | 190,000 |
| Food consumption | 40 | 250,000 |
| Radon | 200 | 1,250,000 |
| Man-made background | | |
| Medical (diagnostic) | 53 | 330,000 |
| Weapons test fallout | 1.1 | 6,800 |
| Nuclear fuel cycle | 0.4 | 2,500 |

Sources: LLNL 2000g, LLNL 2002cc.

^a See Section 4.10, Air Quality, for description of site-wide maximally exposed individual (MEI) and population dose.

^b Average over the U.S. population; values vary with location.

4.16.2.2 Worker Health and Safety

The LLNL Hazards Control Department provides training, planning, and documentation support to site programs to minimize potential risks to workers and the environment. The department implements the ES&H Manual that specifies health and safety management, controls, and procedures in the workplace (LLNL 2000i). The manual requires that all individuals employed at LLNL wear a dosimetry badge; visitors are also required to wear such a badge if they enter a radiation area. A dosimetry badge measures external exposure to radiation.

Internal exposure is typically monitored by bioassays (e.g., urinalysis, whole-body scans, lung counts). Routine bioassays are done on workers who, under typical conditions, are likely to receive a dose from an occupational exposure of 0.1 rem or more in one year. Others who could be assayed include occupationally exposed minors, members of the public, and pregnant workers who are likely to receive internal doses of at least 0.05 rem (or, in the case of pregnant workers, an equivalent dose to the embryo/fetus).

The applicable regulatory standard for radiological workers (those given unescorted access to radiation areas) is 5 rem per year (internal + external) (10 CFR Part 835). Table 4.16.2.2-1 lists the distribution of annual radiation doses (external + internal) received by LLNL workers for the recent 5-year period of 1998 through 2002.

TABLE 4.16.2.2-1.—Distribution of Worker Doses for 1998 through 2002

| Dose Range (rem) | Number of Workers | | | | |
|--|-------------------|-------------|-------------|-------------|-------------|
| | 1998 | 1999 | 2000 | 2001 | 2002 |
| ≥ 2 | 0 | 0 | 0 | 0 | 0 |
| 1.5 – 1.999 | 0 | 0 | 0 | 0 | 3 |
| 1.000 – 1.499 | 0 | 1 | 1 | 3 | 4 |
| 0.5 – 0.999 | 4 | 6 | 3 | 7 | 10 |
| 0.1 – 0.499 | 8 | 24 | 22 | 26 | 30 |
| 0.01 – 0.099 | 85 | 106 | 112 | 126 | 115 |
| < 0.01 | 7,236 | 8,868 | 8,855 | 8,721 | 8,979 |
| Total (Population) Worker Dose (person-rem) | 6.9 | 14.9 | 12.7 | 18.4 | 28.0 |

Source: LLNL 2003as.

As seen in Table 4.16.2-2, the maximum individual worker dose for this period was less than 2 rem. Even with safety procedures and controls in place, inadvertent exposures can occur. There were no such occurrences from 1998 through 2001. There was one such instance in 2002; a worker's fingers were inadvertently exposed as a result of handling unsealed radioactive material. The worker population dose, when multiplied by the risk factor, implies that it is unlikely (0.02 cancers calculated for 2002 exposures) that an additional fatal cancer would result from occupational exposure at LLNL.