APPENDIX A DESCRIPTION OF MAJOR PROGRAMS AND FACILITIES

Appendix A describes the programs, infrastructures, facilities, and future plans of Lawrence Livermore National Laboratory (LLNL) and the Sandia National Laboratories at Livermore (SNL, Livermore). It provides information on existing activities and facilities, as well as information on those activities anticipated to occur or facilities to be constructed over the next 5 to 10 years. The purpose of this appendix is to:

- present information that can be used to evaluate the proposed action and other EIS/EIR alternatives,
- identify activities that are part of the proposed action,
- distinguish proposed action activities from no action alternative activities, and
- provide supporting documentation for less detailed descriptions of these activities or facilities found in other sections and appendices of the EIS/EIR. Figure A-1 illustrates how this appendix interfaces with other sections and appendices of this EIS/EIR.

Most LLNL and all SNL, Livermore operations are located at sites near Livermore, California. LLNL also operates LLNL Site 300 near Tracy, California, and conducts limited activities at several leased properties near the LLNL Livermore site, as well as in leased offices in Los Angeles, California, and Germantown, Maryland. Figure A-2 and Figure A-3 show the regional location of the LLNL Livermore site, LLNL Site 300, and SNL, Livermore and their location with respect to the cities of Livermore and Tracy. While they are distinct operations managed and operated by different contractors, for purposes of this document LLNL Livermore and SNL, Livermore sites are addressed together because of their proximity.

The material presented in this appendix provides an overview of the LLNL and SNL, Livermore research programs, a description of the basic infrastructure of the three sites, and information on the activities within major facilities. Detailed descriptions of operations are limited to "selected facilities" considered to have potentially hazardous operations or inventories. Facilities associated with waste management, security, health services, and emergency response are also discussed. Initially, all buildings were considered to be described. Administrative buildings, office buildings, and nonlaboratory-type facilities without hazardous materials were then excluded. Light laboratory buildings, described in section 2.1.4, were also excluded from further description.

For each of the "selected facilities," a description of the potential hazards and of the wastes and effluents generated is presented in this appendix.

Section A.1 describes the major programs, support organizations, site infrastructure, facilities, and future plans of the LLNL Livermore site; section A.2 describes those of LLNL Site 300; and section A.3 describes the same for SNL, Livermore. Section A.4 presents a number of tabular inventories of generated wastes, chemicals and radionuclides, high explosives, and criteria air pollutants for facilities at each of the three sites. In addition, section A.4 includes figures showing waste accumulation areas at the LLNL Livermore site and LLNL Site 300.

A.1 LLNL LIVERMORE SITE

LLNL is a multiprogram laboratory operated by the University of California (UC) for the Department of Energy (DOE). The LLNL mission is to serve as a national resource of scientific, technical, and engineering capability with a special focus on national security. This mission includes research and development, strategic defense, arms control and treaty verification technology, energy, the environment, biomedicine, the economy, and education.

The LLNL Livermore site is located about 40 miles east of San Francisco at the southeast end of the Livermore Valley in southern Alameda County, California. The City of Livermore's central business district is located about 3 miles to the west. The LLNL Livermore site occupies a total area of approximately 1.3 sq mi (821 acres). Figure A-2 and Figure A-3 show the regional location of the LLNL Livermore site and its location with respect to the City of Livermore.

Additionally, LLNL conducts limited activities at various leased properties near the Livermore site. These include a storage area and office space at the Camp Parks facility in Dublin; a hanger at the Livermore Municipal Airport for an airplane that travels to and from the DOE Nevada Test Site located north of Las Vegas, Nevada; a combination office, childcare, and classroom facility at Almond Avenue Site in Livermore; a storage warehouse with a service shop for the assembly of laser components at Graham Court in the City of Livermore; and a combination office and training center at 2020 Research Drive in Livermore. These nearby offsite leased properties are shown on Figure A-3. These properties are considered part of the LLNL Livermore site for purposes of discussion in this document.

Although LLNL conducts some operations at the Nevada Test Site (NTS), these operations are covered in separate NEPA documentation for that site and are not addressed in this EIS/EIR. LLNL activities at NTS are not discussed for CEQA purposes because they have no impacts within California.

A.1.1 LLNL Programs

LLNL's mission is to serve as a national resource of scientific, technical, and engineering capability with a special focus on national security. Over the years, this mission has evolved to include a wide variety of activities, such as:

- Research, development, and test activities associated with all phases of the nuclear weapons life cycle and related tasks;
- Strategic defense research emphasizing kinetic- and directed-energy weapons;
- Arms control and treaty verification technology;
- Inertial confinement fusion for weapons physics research and for civilian energy applications;
- Atomic vapor laser isotope separation for defense and commercial applications;
- Magnetic fusion, including leadership of the United States effort on the International Thermonuclear Experimental Reactor;
- Other energy research in basic energy sciences, atmospheric sciences, fossil energy, and commercial nuclear waste;
- Biological, ecological, atmospheric, and geophysical sciences relevant to weapons, energy, health, and environmental issues, including assessment and guidance in the event of accidents and other emergencies;
- Charged-particle beam and free-electron laser research for defense and energy applications;
- Advanced laser and optical technology for military and civilian applications;
- Support of the Intelligence Community, the U.S. Department of Defense (DOD), the Nuclear Regulatory Commission (NRC), and other federal agencies;
- Technology transfer through patent and licensing of laboratory-developed technology, collaborative research with United States industry, and industry participation and partnership in LLNL programs;
- Science education through pre-college, university, and postgraduate programs; and
- Participation in the nationally directed initiative to understand the human genome at the molecular level, particularly gene ordering in the chromosomes, and molecular genetic toxicology and reproductive effects.

Current major programs are: Defense and Related Programs, Laser Fusion (also called Inertial Confinement Fusion), Laser Isotope Separation, Magnetic Fusion Energy, Biomedical and Environmental Research, Energy and Resources, and Environmental Restoration and Waste Management. These programs, which are discussed below, fulfill their missions through arrangements with scientific and institutional support organizations, scientific and technical personnel throughout the federal government, other national laboratories, and universities and industry throughout the world. Programs are conducted with a commitment to preserving the environment; ensuring employee and community health; and complying with applicable environmental, safety, and health regulations. In general, Laboratory facilities are grouped by program as illustrated in Figure A-4.

A.1.1.1 Defense and Related Programs

The Defense Program's mission is to ensure that the nuclear weapons in the nation's stockpile are safe, secure, reliable, and effective. The program develops and maintains the capabilities and technologies required to offer a range of options for future weapons systems, provides insight into possible developments in the field of nuclear weapons, and provides technical support for national objectives in verification and arms control. The major LLNL program elements are (LLNL, 1991s, 1991sa):

Nuclear Design

This subprogram carries out theoretical and experimental research in the physics of fission and thermonuclear explosives. It is responsible for exploring new concepts for advanced development of nuclear explosives and for maintaining a basic understanding of weapons phenomena.

This subprogram is also responsible for the advanced development of weapons systems, including physics and engineering, as well as surveillance in production, stockpile, and retirement. It is also responsible for the Advanced Conventional Weapons Program, and for analysis related to both nuclear and conventional weapons systems.

Nuclear Test—Experimental Science

This subprogram is responsible for conducting experimental underground detonations of nuclear weapons designs at the Nevada Test Site in a safe manner. It also performs physics experiments and measurements, including radiochemical measurements in support of these experiments.

Non Proliferation, Arms Control and International Security (This program was formerly titled "Special Projects")

The Non Proliferation, Arms Control and International Security's (NAI) primary mission is to manage LLNL interaction with DOE and other U.S. government agencies concerning matters of international issues including support for the foreign policy and foreign intelligence communitities. Using LLNL's knowledge and capabilities in nuclear and non-nuclear technologies, NAI advises the government on interpretation of foreign weapons developments and on issues involved in the negotiation of arms control treaties. A major effort is devoted to developing an improved understanding of, and means of preventing, foreign nuclear weapons proliferation. The program also conducts the Laboratory's Treaty Verification projects, providing technical advice and assistance to arms control policymakers, and conducts studies on weapons systems and their effects.

NAI also manages the LLNL Emergency Preparedness and Response Program, maintaining preparedness for onsite emergencies and providing technical support to federal agencies in responding to nuclear-related offsite emergencies.

Strategic Defense Initiative

The mission of this project is to conduct research for the technological advancement of a strategic defense system known as Brilliant Pebbles. This defense concept is ultimately to place small spacecraft into a low earth orbit; these spacecraft would be capable of detecting and destroying ballistic missiles through high velocity collisions.

A.1.1.2 Laser Fusion (Inertial Confinement Fusion)

In Laser Fusion, an array of high-power lasers focus on a tiny sphere that contains a mixture of deuterium and tritium gases. The goal is to compress the gases to a high enough temperature for a long enough time period for the deuterium and tritium nuclei to fuse and release significantly more energy than is contained in the high-powered lasers.

The near-term mission of the Laser Fusion program is to provide a laboratory capability to study problems important to thermonuclear weapons design and performance. The long-term goal is to develop Inertial Confinement Fusion reactors for commercial power, space propulsion, and other military and civilian applications (LLNL, 1991s, 1991sa).

The areas investigated include details of thermonuclear burn; the radiation, thermodynamic, and hydrodynamic properties of materials at high temperatures and densities; the physics principles of advanced nuclear weapon concepts; the physics of nuclear effects; and the vulnerability of mechanical and electrical systems to those nuclear effects (LLNL, 1991s, 1991sa).

The mission of the Advanced Laser Applications Program element is to exploit the investment made by DOE (and other agencies) and to apply the information to advanced technology development in solid-state lasers and electro-optics, charged-particle beams and accelerators, and image and signal processing.

A.1.1.3 Laser Isotope Separation

The goal of the Atomic Vapor Laser Isotope Separation program is to develop and demonstrate a process for the separation of isotopes of various materials (LLNL, 1991s, 1991sa). In this process, a material that consists of a mixture of isotopes is heated and vaporized. Laser light directed on the vapor selectively ionizes isotopes of interest, which are then collected on electrically charged plates.

Another goal of the Atomic Vapor Laser Isotope Separation Program is to develop other potential applications for the defense and commercial sectors. DOE is studying additional applications for AVLIS technologies in the general areas of isotope separation, separators, lasers, and electro-optics with the key objective of commercializing these technologies to support U.S. industrial competitiveness (LLNL, 1991sa).

The DOE Uranium-Atomic Vapor Laser Isotope Separation (U-AVLIS) Program is designed for research, development, and demonstration of an advanced technology for enriching uranium for nuclear reactor fuel. The U-AVLIS Program is at an advanced stage of technology development; with sufficient development of laser, separator, and uranium processing technologies to support demonstration of the technology with plant-scale systems and hardware.

The major objectives of the plant-scale technology demonstration are to validate the technology and engineering feasibility and to determine the validity of projected plant-scale economics. The plant-scale demonstration system, referred to as the Uranium Demonstration System (UDS), is composed of four major subsystems: (1) separators, (2) lasers, (3) feed preparation, and (4) product processing. These subsystems currently exist at two DOE sites: the laser and separator subsystems are located at LLNL and the uranium feed preparation and product processing subsystems are located at the Oak Ridge Gaseous Diffusion Plant (ORGDP) site near Oak Ridge, Tennessee.

Demonstration of uranium enrichment is in process in the Building 490 Complex at LLNL. Lower-level research and development (R&D) activities are expected to continue after the demonstration in support of uranium enrichment technology development and deployment. An environmental assessment (EA) for the demonstration of U-AVLIS at LLNL,and a Finding Of No Significant Impact, completed in May 1991, discussed the potential impacts to onsite and offsite environments predicted during the conduct of the Uranium Demonstration System at LLNL (LLNL, 1991sb).

The collective goal of the U-AVLIS Program is to develop and demonstrate an integrated technology for low-cost enrichment of uranium for commercial nuclear reactor fuel. Information and data from demonstrations at both LLNL and Oak Ridge will be used in concert with an Environmental Impact Statement (EIS), economic assessments, and other information to support a decision by the U.S. government on whether or not to deploy a U-AVLIS production plant (DOE, 1990a).

A.1.1.4 Magnetic Fusion Energy

The Magnetic Fusion Energy Program assists in the development and understanding of magnetic fusion technology, which is part of the international effort to harness the potential of thermonuclear fusion for use as commercial energy production. In magnetic fusion, a cloud (plasma) of ions and electrons confined by magnetic fields is heated by electromagnetic induction. If a plasma of deuterium and tritium can be kept at a sufficiently high temperature for a long enough period, their nuclei will fuse and yield energy.

The primary thrust of fusion development is to demonstrate the successful confinement of a burning thermonuclear plasma under conditions like those expected in a power-producing fusion reactor. The technical approach to achieving this goal is through development of the Tokamak concept (in which an axial magnetic field is superimposed on a toroidal [doughnut shaped] magnetic field).

DOE has also given LLNL the lead role in directing the United States effort in support of the International Thermonuclear Experimental Reactor (LLNL, 1991s, 1991sa).

A.1.1.5 Biomedical and Environmental Research

The mission of the Biomedical and Environmental Research Program is to understand the potential health and environmental consequences of the development and use of various energy sources. In particular, LLNL is finding ways to identify and measure genetic damage as an indicator of human health effects, examining local and global-scale environmental changes involving the atmosphere, and studying a variety of ecological effects resulting from energy production and use (LLNL, 1991s, 1991sa).

The area of greatest growth in current biological research is the human genome initiative; this is an international effort to map the human genetic code. LLNL has been designated as one of three DOE Human Genome Research Centers and is participating in the international effort to construct a physical map of the DNA in the 23 pairs of human chromosomes. Such a map is expected to help identify and isolate genes involved in many human diseases with a goal of understanding the causes and finding treatments.

Environmental research comprises fundamental research in the development of long-term payoff energy technologies and technologies for the remediation of waste-contaminated soil and ground water. Closely related to this is risk analysis and management; predicting the transport, diffusion, deposition, transformation, and atmospheric effects of pollutants; and modeling atmospheric processes.

A.1.1.6 Environmental Restoration and Waste Management

The Environmental Restoration and Waste Management Program's mission is twofold: to clean up contaminated soils and ground water; and to properly transport, treat, store, and dispose of wastes generated by LLNL operations (LLNL, 1991s, 1991sa).

An Environmental Technology Program was organized in late FY 1989 to develop, demonstrate, test, and evaluate technologies for reducing the costs and increasing the effectiveness of environmental restoration and waste management efforts. The program at LLNL emphasizes characterization of contamination and hazardous wastes, development and demonstration of innovative clean-up technologies, waste treatment and waste minimization, process improvements, robotics, and educational programs. The work will include laboratory experiments, temporary pilot facilities, and field tests and demonstrations.

A.1.1.7 Energy and Resources

LLNL carries out major research in reactor safety, basic energy sciences, fossil energy, and conservation and renewable energy. LLNL is assisting DOE in meeting safety requirements for certain small reactors that are much smaller than production or commercial reactors and may thus use different procedures to ensure safe operation (LLNL, 1991s, 1991sa).

LLNL research in basic energy sciences includes projects in materials sciences, chemical sciences, and geosciences. The materials sciences projects are directed toward fundamental understanding of important materials and processes. Chemical sciences projects model the chemical kinetics of combustion in laboratory and applied environments, with emphasis on hydrocarbon fuels. The LLNL geosciences projects are concerned with the source mechanisms of earthquakes in the western United States, the physical and mechanical properties of rocks, a predictive chemical model for petroleum generation, and investigation of the volcanic systems (LLNL, 1991s, 1991sa).

LLNL fossil energy research focuses on producing liquid fuels from nonpetroleum sources such as shale, gas, and coal. Its geothermal project supports DOE in the development and demonstration of geophysical techniques to monitor subsurface processes in geothermal fields, the development of seismic imaging methods for use in volcanic terrains, and the development of technologies needed for measurements in geothermal fields.

LLNL also has the responsibility for designing an engineered barrier system for the candidate waste repository at Yucca Mountain, Nevada. LLNL activities include development of design concepts for the system, characterization of candidate container materials, analysis of the near-field underground environment of the potential repository, and development of models to predict the behavior of emplaced nuclear waste (LLNL, 1991s, 1991sa).

A.1.2 Scientific and Institutional Support

The programs described in section A.1.1 carry out their missions through arrangements with the LLNL scientific and institutional support organizations described below (LLNL, 1991af).

A.1.2.1 Scientific Support

Scientific support organizations, including Physics, Engineering, Computation, and Chemistry and Materials Science, provide high technology assistance to LLNL programs. These scientific and technical assistance organizations may also have programmatic activities of their own.

Physics. The mission of the Physics Department is to pursue research on the forefront of physics in areas that are important to current and future LLNL programs; exploit unique facilities and expertise to initiate and carry out scientific and technical projects; interact vigorously with outside academic and technical communities; and recruit and develop outstanding scientists and leaders for LLNL.

The department's focus is on the disciplines of astrophysics, atomic physics, condensed-matter physics, nuclear physics, plasma physics, and computationally intensive topics, such as compressible hydrodynamics and transport theory. Future work will focus on superconductivity, nuclear data modeling, the study of electrons and nuclei, and computer modeling of nuclear weapons and fusion systems.

Work is increasingly directed toward projects funded outside of the nuclear weapons and fusion communities. This represents the successful transfer of expertise developed in other program areas. Three projects in this category include the Brilliant Pebbles Project supported by the SDI Organization, a cooperative effort with NASA in the development of an x-ray mirror, and a DOE Office of Energy Research project to analyze and understand the differences among various models of the atmospheric greenhouse effect.

Engineering. The mission of Engineering is to meet the goals of LLNL programs with technical and managerial excellence, to conduct research and development in preparation for future LLNL needs, and to support LLNL institutional goals.

Emphasis on new initiatives with industry, DOE laboratories and production facilities, and universities is an additional focus within Engineering. This LLNL-wide activity encompasses many technological capabilities of LLNL as well as the needs of industry.

Computation. The mission of Computation is to provide state-of-the-art computing services to LLNL, DOE, and organizations approved by DOE. Because state-of-the-art computation is a key enabling technology, the growth of computing capability and support must match and often lead the dynamic growth of key programs and disciplines. The pace of development depends in large measure on having the necessary tools. These tools must be designed, developed, and tested in advance of their application so that new research is not restrained.

Chemistry and Materials Science. As a disciplinary department, the mission of Chemistry and Materials Science is to provide scientific and technical expertise and leadership to support LLNL's many programs, perform work for others under reimbursable contracts, and conduct original research. In accomplishing this mission, the department seeks to advance the frontiers of science, develop a qualified and responsive scientific and technical staff, be innovative in advancing technologies with end applications, and increase its interactions with scientists in universities, governmental laboratories, and industry.

Research and development interests within Chemistry and Materials Science include innovations in chemical analysis and characterization, advanced materials, metallurgical science and technology, surfaces and interfaces, energetic materials and chemical synthesis, and energy-related research and development.

A.1.2.2 Institutional Support

Institutional support provides the services necessary to operate a research and development facility. The support population includes personnel spanning three directorates, totaling over 3400 employees, or about 30 percent of the LLNL staff (LLNL, 1991af).

The institutional support available at the site includes environmental protection, information systems, health services, safeguards and security, business operations, human resources, public affairs, legal counsel, controller, hazards control, and plant engineering. Some of these organizations also have programmatic activities.

A.1.3 Existing Infrastructure

Infrastructure that supports the LLNL Livermore site's operation includes drainage, parking, pathways, telephones, lighting and landscaping, as well as roads and utilities. LLNL will continue to maintain, expand, and upgrade this infrastructure under the proposed action and the no action alternative described in Section 3 of this document. Figures A-5 and Figure A-6 illustrate the site map and major roadways. Utilities serving the LLNL Livermore site include domestic water, low-conductivity cooling water, demineralized water, compressed air, natural gas, sanitary sewer, and electric power. These utilities are described below (LLNL, 1991af):

- The primary source of water at the site is the City of San Francisco's Hetch Hetchy Aqueduct, located six miles south of the LLNL Livermore site at the ocho Pumping Station (LLNL, 1991v). Water is pumped 850 feet to the surface by three pumps (2 active and one standby) at the rate of 1500 gal per minute per pump. This water flows by gravity in a pipeline to storage tanks located in the southern section of the SNL, Livermore. Both LLNL, Livermore site and SNL, Livermore are gravity fed from these tanks. In addition to LLNL's main water supply from Hetch Hetchy, LLNL also has a contract with the Alameda County Flood Control and Water Conservation

District for emergency water supply. The 5-year average of water consumption is 262 million gal per year.
- Low-conductivity cooling water is utilized for the cooling systems of buildings and equipment. It recirculates in a closed-loop system. The average daily cooling energy use is 47 megawatts.
- Demineralized water is generated onsite from domestic cold water. The average daily load was 16,000 gal and can peak to 22,000 gal per day.
- Compressed air is generated onsite. Average daily use is 2000 cu ft per minute, and can peak to 3200 cu ft per minute.
- Natural gas is supplied at 60 lb per sq in pressure by the Pacific Gas and Electric Company from its main. There is a backup propane system onsite, which requires propane delivery before being activated.
- Sanitary sewer discharge goes to the City of Livermore Water Reclamation Plant. A sewer-diversion facility is used to protect against the release of accidentally contaminated sewage to the City of Livermore treatment facilities. Current sewer discharges are 366,000 gal per day, and can peak to 710,000 gal per day.
- Electric power is supplied by Pacific Gas & Electric Company's Tesla substation and by Western Area Power Administration's Greenville substation. Electric power is distributed throughout LLNL and to SNL at 13.8 kilovolts. The system peak load is 67 megawatts.

A.1.4 Existing Facilities

The facilities located at the LLNL Livermore site are shown in Figure A-5. The following description of existing facilities is limited to "selected facilities." Facilities associated with waste management, security, health services, and emergency response are also briefly described. Facilities were selected because of their potentially hazardous operations or inventories. An overview of all other facilities is included in Table A-2.

The selected facilities at the LLNL Livermore site are described in sections A.1.4.1 through A.1.41, and are listed in Table A-1 with information on area, use, and the principal types of hazards present. Hazards are indicated as radiological, chemical, or other. Examples of radiological hazards include low-level ionizing radiation, which could cause cancer, genetic defects, and/or noninheritable birth defects. Examples of chemical hazards include chemicals that may be toxic, flammable, corrosive, poisonous, and/or carcinogenic. Examples of "other" hazards include high explosives, nonionizing radiation, the storage and handling of compressed gas cylinders, and electrical hazards. Figure A-7 highlights the select facilities. Facilities for which detailed descriptions are not presented are summarized in Table A-2

including the offsite leased properties described in section A.1.4.41.

Each selected facility is described with location, square footage, and operations; hazards assessment; and generated wastes and effluents. The discussion on generated wastes and effluents is kept to a minimum. For a more detailed discussion on waste generation and waste management, please refer to Appendix B.

A.1.4.1 Building 121

The Test Program facility, Building 121, is located in the southwest quadrant of the LLNL Livermore site. This 91,186 sq ft facility contains machine shops, laboratories, offices, and the Technical Information Department reports library (LLNL, 1989n).

The operations in this facility include the use of x-ray and electron generators, high-voltage pulsers, lasers, mechanical and electronic equipment, and use of radioactive and toxic materials to perform measurements related to the development of diagnostic techniques for interpretation of experiments on nuclear weapons tests (LLNL, 1989n).

Other operations include laser irradiation of toxic materials (LLNL, 1991x), the use of Febetron electron beam to develop diagnostic systems for gathering data from nuclear tests (LLNL, 1990am), measurement of leakage current on resistance of photoconductive detectors when illuminated by laser light (LLNL, 1989r), concurrent operation of multiple Class III and IV lasers (LLNL, 1990an), the use of a Ruby laser, a mode locked flash lamp pumped dye laser, and a nitrogen laser with dye cell for the purpose of pico- and nanosecond pulse generation used for streak camera calibrations.

This facility also houses the Pulsed Calibration Laboratory (LLNL, 1990ao), Hyjacs X-ray Laboratory (LLNL, 1991y), and Vacuum Barrier Permeation Leak Testing Laboratory (LLNL, 1990aq).

Hazards Assessment

Hazardous operations in this facility are associated with the use of x-ray generators, electron beam generators, laser equipment, high-voltage equipment, high-pressure systems, cryogenic systems, sealed radioactive sources, toxic materials, and machine tools (LLNL, 1989n). Other hazards include airborne particulates from toxic materials, photoconductive detectors activated by neutrons, dyes and solvents that are mutagenic and/or toxic, the use of carcinogenic solvents, and the use of hydrogen gas in vacuum systems.

All experiments are performed under the facility safety procedure and under the appropriate operational safety procedures. Hazardous materials are used only in designated areas, and enclosures such as a hood or a glovebox are used for toxic and radioactive materials. All chemicals are segregated and stored in separate areas and disposed of in separate containers to prevent the mixture of incompatible chemicals that could cause violent or toxic reactions (LLNL, 1989n).

The compressed gases are supplied through a two-stage regulator, and a pressure relief valve is installed on the discharge side of the regulator to protect the system. Personnel safety is ensured by electrical interlocks, and industrial approved safety glasses, goggles, or face shields are worn. Physical barriers and interlocked enclosures are used to prevent personnel exposure to direct radiation. Flashing lights are located near the radiation source to warn personnel when the radiation-producing machinery is in operation (LLNL, 1989n).

Hazardous materials are handled or stored only in designated locations. The use of flammable liquids is limited to the smallest quantity needed for the operation. The radioactive sealed sources are stored in a locked cabinet, and the use of these materials is allowed only in solid state. No fissile materials are allowed (LLNL, 1989n).

Generated Wastes and Effluents

This building generates radioactive and hazardous wastes, which are segregated, packaged, and labeled, and placed in the waste accumulation area in appropriate containers.

A.1.4.2 Building 131

The Engineering facility, Building 131, is located in the southwest quadrant of the LLNL Livermore site. The total area of the facility, consisting of three connecting buildings, is 284,386 sq ft. Building 131 contains approximately 400 offices and 100 shops and laboratory spaces for the mechanical and electronics engineering departments. The shops and laboratories support weapons test and assembly, as well as microelectronics and microfabrication work. The facility also has a high bay containing a large laboratory and shop operation and a aterials Management Vault storing controlled materials to support the weapons test program (LLNL, 1986d). The Microfabrication Laboratory currently located in Building 131 is scheduled to be relocated to Building 153 by the end of 1992.

Hazards Assessment

Hazardous materials used at this facility include corrosive and hazardous chemicals and gases, combustible and toxic metals, sealed radioactive sources, and other radioactive material in solid form. Operations within the high bay use flammable and combustible liquids, and combustible and toxic metals, such as lithium hydride, beryllium, and depleted uranium (LLNL, 1984c). The Engineering Research Division's microelectronics laboratories use liter quantities of toxic, corrosive, and flammable gases such as phosphine, silane, dichlorosilane, and hydrogen chloride (LLNL, 1986d, 1990ad).

The handling and storage of hazardous materials is controlled under the applicable operational safety procedures. Quantities of hazardous materials in the work area are limited to the minimum needed for each experiment. The use of a hood is required if the operation could potentially release material into the workplace (LLNL, 1990ae, 1990af, 1990ah). A number of alarms and failsafe features and an exhaust air system are included in the toxic gas delivery system (LLNL, 1984c).

Radiation sources are primarily limited to the high bay area. Small antistatic blowers containing sealed sources are used in the microfabrication laboratories. Use of a hood or glovebox enclosure is required if the operation could potentially expose workers. A health and safety technician monitors radiation levels at positions occupied by workers (LLNL, 1990at).

Other potentially hazardous operations in Building 131 include the use of lasers and x-ray generating equipment. Lasers are used for general research activities, measurements of electronic component systems, and machining of toxic materials and parts (LLNL, 1990z, 1990aa, 1990ab, 1990ac, 1990ad, 1990ag, 1990ah). Safety controls are in place to minimize the potential of personnel exposure to x rays and lasers. These include enclosing x-ray tubes in steel cabinets, safety covers and guards on laser devices, and having interlocks and shielding devices (LLNL, 1990z).

Generated Wastes and Effluents

Hazardous waste is accumulated at work station locations (known as satellite waste accumulation areas) and then transferred to a waste accumulation area located outside the building. Wastes generated in the high bay area are taken directly to the waste accumulation area (LLNL, 1988e).

A hood and ventilation system and spray booth exhaust system are used to vent gases and airborne particulates from the building. The exhaust system is equipped with a high efficiency particulate air filter.

A retention tank receives dilute rinsewater wastes from the microfabrication laboratories. The tank is emptied approximately once every month. The rinsewater is sampled to determine if the contents meet allowable discharge limits. If they do meet these limits, the rinsewater is released to the sanitary sewer. The microfabrication laboratories will be relocated to Building 153 by the end of 1992, and the retention system will remain in operation.

A.1.4.3 Building 132

Building 132 is located in the southwest quadrant of the LLNL Livermore site. This 368,500 sq ft facility comprises of the Defense Program Research Facility, Building 132N, and the Nuclear Test Technology Complex, Building 132S (LLNL, 1991ah, 1986f).

Although separately conceived and funded the Defense Program Research Facility and the Nuclear Test Technology Complex were co-located to foster communications between the nuclear design and test personnel, and to achieve lower cost through shared facilities and infrastructures. A common main entrance and lobby includes briefing rooms, resource centers, and their respective lobbies. They also share a common central plant, site utilities, and other site works. Building 132 opened in FY 1992.

The Defense Programs Research Facility, Building 132N, is a modern engineering and chemistry facility. The first floor houses the engineering and development activities, relocated from Building 131 high bay, with program effort toward new and developing technologies to fulfill a primary and continuing need of the Defense Programs at LLNL.

The advance manufacturing development in Building 132N features Computer Aided Engineering and Computer Integrated Manufacturing (CAE/CIM) for machining, joining, and assembly. New manufacturing techniques such as a disposable workspace lathe and specialized work stations will be developed in conjunction with Laboratory efforts in robotics and other machine tool initiatives.

The second floor of Building 132N houses the chemistry activities relocated from Building 222. This laboratory provides material characterization, provides service support for tests, and provides stockpile support.

The Nuclear Test Technology Complex, Building 132S, integrates the nuclear test program experimental and office facilities presently located in Buildings 121 and 255W and several trailers. The laboratories, equipment, and offices provide support in current test activities and research and development leading to new diagnostic measurement technologies (LLNL, 1987e). The components of the Nuclear Test Program housed in this facility include:

- Prompt Diagnostics Program, which measures the radiation emitted by a device during its explosion.
- Field Operations Group, which manages the execution of LLNL-designed nuclear tests at the Nevada Test Site.

Hazards Assessment

Hazardous operations in Building 132S are similar to those found in Building 121 and Building 255W. They include operations associated with the use of x-ray generators, electron beam generators, laser equipment, high voltage equipment, high pressure systems, cryogenic systems, sealed radioactive sources, toxic materials, flammable gases, and machine tools. Hazardous materials include laser dyes, solvents, and beryllium. Safety controls include barriers, interlock systems, warning light systems, and remote area monitoring used to prevent personnel exposure.

The hazardous materials used in Building 132N are similar to Buildings 131 (high bay area) and 222, which include corrosive and hazardous chemicals and gases, toxic metals such as lithium hydride and beryllium, depleted uranium, laser dyes, solvents, inorganic acids, halogens, organometallics, and inorganic compounds (LLNL, 1984c, 1989l, 1991j).

The facility features precise temperature and humidity controls, cleanliness, and circulation of large volumes of fresh air with particulates filtered through local exhausts. A liquid waste retention system isolates hazardous waste generation.

Generated Wastes and Effluents

All hazardous, radioactive, and mixed wastes generated in Building 132S are segregated, packaged, and labeled, and placed in the waste accumulation area in appropriate containers. Building 132S has two retention tanks for collection of common liquid wastes. These retention tanks are sampled and analyzed, and, if the waste meets the Livermore Water Reclamation Plant criteria, are discharged to the sanitary sewer.

Building 132N applies modern methods of carrying out analytical chemistry, relying on electronic instrumentation rather than wet chemistry techniques. Therefore, the wastes generated are in smaller quantities than the original operations conducted in Buildings 131 (high bay) and 222. The wastes generated include flammable organics, radioactive wastes, corrosives, toxic metals, and laser dyes. The retention tank system segregates these wastes. Air effluents include volatile organic compounds, gases, and airborne particulates. The laboratories are equipped with exhaust hoods and with high efficiency particulate air filters.

A.1.4.4 Building 141 Complex

Electronics Engineering has laboratories, electronics repair, and manufacturing activities in the Building 141 Complex, located southeast of the intersection of Fourth Street and Avenue A of the LLNL Livermore site. This complex, a total area of 50,360 sq ft, is managed by Electronics Engineering. It houses activities of the Engineering Services Division, the Engineering Research Division, and the Nuclear Energy Systems Division (LLNL, 1990n).

This complex is primarily used for the repair and calibration of electronic instruments and for the fabrication of experimental printed circuit boards; and it consists of shop areas, a solvent tank area, and an outside area with rinse tanks, sumps, wastewater retention systems, and waste accumulation areas. Pulsed power laboratories, semiconductor laboratories and an imaging laboratory are also located in this complex.

Hazards Assessment

The hazards are associated with flammable liquids, high voltage electrical systems, ionizing and nonionizing radiation, toxic materials, and lasers. These hazards are from the operations with chromating, printed-circuit-board development, chemical etching and milling, and rail gun and pulsed power units.

Numerous engineering and safety controls are in place. Laboratory practices involve minimizing the use and storage of chemicals as well as labeling and segregation of materials kept on site. The hood and ventilation system consists of eight exhaust hoods. In the event of ventilation system failure, all work is stopped. Operations that require the use of high-voltage systems or that produce ionizing radiation are equipped with interlock systems to safeguard personnel from electric shock or radiation hazards (LLNL, 1990n).

Electronics fabrication uses a variety of hazardous chemicals, such as solvents, metals, and acid solutions. These solutions are used in the preparation of metal surfaces for the manufacture of printed circuit boards (LLNL, 1990n).

Generated Wastes and Effluents

The solid-state devices operations, the electronics fabrication, and pulsed power operations are the facility operations that require handling of hazardous materials and the generation of wastes (LLNL, 1990n).

The solid-state devices area is a satellite operation of the Building 131 microfabrication laboratories. It produces solid-state integrated circuits using the chemicals and processes customarily found in commercial and university semiconductor research, development, and production. Several liter quantities of chemicals such as acids, basic solvents, and elemental materials and compounds are needed to perform semiconductor work. The amount of waste discharge from this operation is small due to the low production level. Waste solvents such as alcohol, methyl-ethyl-ketone, and acetone are collected in small containers; chlorinated solvents are segregated from nonchlorinated solvents.

There are two separate retention-tank systems at Building 141, one for metal finishing rinsewaters (plating printing), and one for the semiconductor rinsewater (electronic fabrication). The metal finishing tanks are sampled for pH, metals, cyanide, and solvents. If the semiconductor tanks meet the discharge criteria, they are discharged to the sanitary sewer.

A.1.4.5 Building 151

Building 151 is located in the southwestern quadrant of the LLNL Livermore site. The building has a total area of 99,408 sq ft. The Nuclear Chemistry Division uses this facility to develop and apply radiochemical techniques to a broad range of analytical measurements and scientific studies in support of LLNL programs (LLNL, 1984a, 1990s).

Hazardous and radioactive materials are used in small quantities for individual experiments, including flammable liquids, acids, toxic metals and gases, and carcinogenic chemicals. Most of the laboratories are equipped with exhaust hoods.

Hazards Assessment

The main hazards are ionizing radiation, toxic chemicals, and flammable solvents. The use of toxic or radioactive materials is limited to the counting rooms, experimental laboratories, and dissolver wing areas of the building. Radioactive solid and gaseous debris samples are analyzed in this facility. The debris samples are obtained from cavities created by the detonation of nuclear devices at the Nevada Test Site.

Solid samples are dissolved and analyzed using multiple acid treatments within gloveboxes. The system is completely enclosed and is operated under negative pressure (relative to room air). All exhaust air is sent through a dual alkaline spray scrubber system to remove acid mists and residual moisture. The treated air is then passed through a bank of 12 electrostatic precipitators to remove any particulate matter and residual moisture before being exhausted to the atmosphere.

Generated Wastes and Effluents

The retention tank system and the waste accumulation area handle potentially radioactive wastes in Building 151. Wastewater potentially contaminated with radionuclides, metals, and acids discharged to sinks in chemistry labs and shops and to floor drains in the clean room is sent to the retention tanks. When full, the retention tanks are sampled. If the wastewater meets the sewer discharge criteria, it is released to the sanitary sewer. If it is unacceptable for release, it is transferred to Hazardous Waste Management for treatment.

Additional waste-related systems include the dissolver box scrubber, the concrete sump located in the basement, the hoods and ventilation system, and an acid dip station. The dissolver box scrubber is used to remove acid fumes that are produced within gloveboxes used to handle radioactive sources.

A.1.4.6 Building 153

The Microfabrication Laboratory, Building 153, is located in the southwestern quadrant of the LLNL Livermore site. This 20,000-sq-ft laboratory will be used for microelectronics fabrication operations, and consists of 6 principal laboratory working areas, 3 dry laboratories, a clean room dressing area, and packaging and machine room areas (SAI, 1989). The Microfabrication Laboratory currently in Building 131 is scheduled to be relocated to Building 153 by the end of 1992.

Hazards Assessment

The principal hazards are associated with use of various chemicals during the fabrication of silicon and gallium arsenide integrated circuits. Some of these chemicals include acids, bases, solvents, resins, phosphates, fluorides, iodides, and some toxic and reactive gases (SAI, 1989).

The chemicals are used only in chemical clean hoods, and the maximum quantity used at any time is limited to small amounts such as 500 mL in a 1000 mL beaker. Personnel safety is ensured by toxic materials storage and handling systems. Toxic gases are handled only in gas cabinets, and adequate ventilation and safety valves are provided for added protection.

Generated Wastes and Effluents

The microelectronics fabrication operations generate liquid and solid hazardous wastes, and atmospheric releases of small quantities of gases and organic vapors. The hazardous liquid wastes consist primarily of acids and organic solvents. Acid wastes are diluted and kept in 5-gal carboys. Other wastes are segregated and kept in separate containers. These wastes are sampled, analyzed for chemical content, and labeled.

Solid wastes include paper, plastic, and contaminated cloth. Wastes that are contaminated with hazardous or toxic materials are segregated and stored in approved containers, and disposed of by Hazardous Waste Management.

The gases from fume hoods feed into a 15-meter exhaust stack. Since the quantities of gases used are small, the release of gases under the worst-case condition will not exceed the Emergency Response Planning Guidelines (SAI, 1989).

A.1.4.7 Building 161

Building 161, a development laboratory, is a 6137-sq-ft building in the west-central portion of the LLNL Livermore site. It is used for research in the Advanced Processing Technology (APT) Program, in which tuned lasers are used to ionize metal isotopes selectively so that they can be separated by electric fields (LLNL, 1989k). Development of waste treatment technologies is also performed.

Hazards Assessment

Building 161 contains numerous lasers and SIS test chambers. Electron beam sources are used to ionize metals such as aluminum, copper, hafnium, tin, nickel, zirconium, and the lanthanides (elements with atomic numbers from 57 through 71). Other hazardous materials present are chemicals (toxic, corrosive, flammable, reactive, ignitable), mercury, and laser dyes (LLNL, 1989k).

High voltages (tens of kilovolts) are encountered in the electron guns within the SIS vacuum chambers. Shielding is provided to protect workers from the large x-ray fluxes produced when the electron beams impinge on the metals being vaporized.

The target metals may react with their surroundings. In porous, finely divided form, or vapor deposits, lanthanides are highly pyrophoric and can burn in air. They react with water to form hydrogen and steam; this reaction can occur on a time scale faster than relief valves can respond to. Lanthanides, mercury, and the dyes used in the tunable lasers are toxic.

The strong laser beams constitute a hazard to the eyes.

Generated Wastes and Effluents

Shoe covers, gloves, and half-mask respirators with mercury-approved cartridges are supplied for protection, particularly against mercury. These and other material contaminated with mercury become waste after use.

Hazardous dye solution waste is disposed of in designated drums in the waste accumulation areas. Dimethylsulfoxide wastes are collected in separate flammable-liquid safety cans. Rinse or wastewater potentially contaminated with dye or dye solutions is disposed of into drains connected to special laser dye retention tank systems.

Wastes are generated from processes using molten salts, aqueous solutions, acids, bases, gas scrubbers, and organic materials such as solvents and oils. Wastes from these processes are disposed of in designated drums in the waste accumulation areas.

Loose material in vacuum chambers and ventilation enclosures is removed and disposed of as hazardous waste, including oxidized deposits and large pieces of metal.

A.1.4.8 Buildings 162, 164, 165, 166, 168, and 169

The 160 series buildings are located in the northwest quadrant of the LLNL Livermore site. The buildings along with their operations are summarized below (LLNL, 1990t, 1990ai).

Facility	Uses	Size (sq ft)
	Laser labs, Neodymium glass laser, Crystal Growth Lab, Laser-pumped Laser Test Facility, X ray Diffraction, High Temperature Furnaces,	

Buliding 162	Flashlamp pumped lasers, Non-Linear Crystal Development Lab, Reactive Atmosphere Processing Station, and Environmental Chambers.	19,840
Building 164	Preparation of intermetallic Uranium-238 alloys.	204
Building 165	Use of hydrogen in brazing vessel.	8,347
Building 166	Diode-Pumped Solid-State Laser lab, Laser Micro-Optics Research Facility, Metal Organic Chemical Vapor Deposition System, Ground State Depletion Facility, Pyrochemical Demonstration System, Semi-conductor Device Fabrication Facility, Laser Diode Characterization Facility, Semiconductor Wafer Thinning, Tilt Pour Mock-up Facility, chemical separations, and chemical treatment.	10,860
Building 168	X-ray diffraction characterization of materials.	3,194
Building 169	Ethanol dye amplifier test loop.	3,450

Hazards Assessment

Hazards within these facilities are associated with high voltages, x-ray radiation, chemical reactions, toxicity of materials, pyrophoric metals, toxic gases, caustic chemicals, acid burns, and fire. Facility safety features are provided to reduce the hazards, providing multilevel protection against accident or injury to operational personnel.

Generated Wastes and Effluents

There are many different types of hazardous and toxic wastes generated from this complex of buildings. The wastes include combinations of aluminum, arsenic, phosphorous, antimony, arsine, and chlorine. Zinc and silicon may also be present in small amounts.

Wastes are generated from processes using molten salts, aqueous solutions, acids, bases, gas scrubbers, and organic materials such as solvents and oils. Wastes from these processes are disposed of in designated drums in the waste accumulation areas.

A.1.4.9 Buildings 171, 173, 174, 177, and 179

The 170 series buildings are located in the northwestern quadrant of the LLNL Livermore site. The building sizes and operations are described below (LLNL, 1990aj).

Facility	Uses	Size (sq ft)
Building	Dye Laser Development Lab, Vacuum Test Unit, characterization of metal alloys in MINERVA	8,388

171	chambers, Dye Lab, Optical Loss Measurement Facility, and Helium-Neon Lasers.	
Building 173	Laser Welding Shop.	413
Building 174	Cyclops Laser Facility, Laser Spectroscopy, Janus Laser Facility, Uranium Soft X ray Laser, Amplifier Test Facility, Ultra-Short Pulse Research Laser, and Picosecond/Subpicosecond Laser Spectroscopy of materials.	20,365
Building 177	Regulis Test Facility, Process Lab, Extractor Test Facility, Advanced Concepts Lab, Laser Development Lab, Scanning Auger Microprobe, Interim Metallography Facility, Sample Preparation, Inductivity Coupled Plasma-Mass Spectro-metry, Schultz Vacuum Furnace, and Radioactive Materials Storage and Handling Area.	13,271
Building 179	Quantum Physics Laboratory, Dye Mixing Facili- ties, Surface Physics Studies.	2,728

Hazards Assessment

There are many hazards associated with the 170 series buildings operations from the use of hazardous and radioactive materials including laser dyes, solvents, flammable liquids and natural, depleted and/or enriched uranium. Personnel may be exposed to x rays, high power laser beams, high voltages, heat and skin burns, and overpressure of vacuum chambers.

The hazards are mitigated by interlocks on each laser, remote operations whenever possible, x-radiation shielding, design of the separator chamber walls to provide protection against x rays, operation of ventilation systems, including high efficiency particulate air filters, administrative and operation procedures to control the spread of radioactivity, and personnel safety training.

Generated Wastes and Effluents

The generated wastes include various hazardous and radioactive chemicals. The wastes are generated in small quantities from experimental laboratories.

A.1.4.10 Building 175

Building 175, the Laser Research Building–AVLIS (also referred to as the Mars Facility) is a 16,407-sq-ft heavy-laboratory building located in the west-central portion of the LLNL Livermore site. It contains the following activities, all of which directly support research and development activities of the uranium separators within the Uranium-Atomic Vapor Laser Isotope Separation (U–AVLIS) Program (LLNL, 1990j):

The Mars experimental system, which uses an electron beam to vaporize natural or depleted uranium for subsequent evaluation of ion extraction, source development, and material handling subsystems. Materials testing also is done in the Mars system.
- The Mars laser vapor diagnostics experiment, which measures the properties of the uranium vapor for evaluation of equipment performance and development of systems control techniques.
- The Plasma Spray System, which applies special coatings to samples for material testing and to experimental parts in support of Mars and other AVLIS-related activities.

Natural and depleted uranium is used in the Mars experiment. Because of the administrative limits placed on certain types of materials, the total quantity of uranium metal in the facility is not permitted to be over 10,000 kg with 3,000 kg in process. The maximum amount of uranium-235 isotope (contained in enriched uranium) is limited to less than a minimum critical mass as defined by ANSI standard 8.1-1983 (LLNL, 1990j).

Hazards Assessment

Hazards of operations include high voltages (up to 70 kV); high currents at low voltage; x rays; ionizing radiation; lasers; visible and ultraviolet radiation; microwave radiation; radioactive material (but enriched uranium may not be part of the experimental system, so that there is no threat of criticality); flammable and pyrophoric materials (especially finely divided uranium metal); interactions of molten metal with water; toxic and carcinogenic materials; metal welding fumes and gas; oxygen deficiency in the pit below the vacuum vessel; and the usual industrial hazards (LLNL, 1990j).

Generated Wastes and Effluents

Activities in Building 175 generate several kinds of hazardous and low-level radioactive wastes as well as several gaseous effluent streams. Primary waste streams and effluent sources requiring controls are the following (LLNL, 1990j):

- Gaseous and particulate effluents. Uranium oxide particulates and Freon-113 used for parts cleaning.
- Liquid wastes. Back-up cooling water, possibly contaminated if there is a loss of the recirculating cooling water system; laser dye solution wastes; and conventional wastes such as pump oil, cleaning solvents, etc.
- Solid wastes. Low-level radioactive waste (e.g., paper, plastic, rubber); noncompactible low-level radioactive waste generated from the process vessel and large uranium metal pieces no longer useful; and solid waste from the Plasma Spray System.
- Solid/liquid wastes. Potentially reactive uranium metal from the experiments is placed in water in order to limit contact with oxygen and to provide cooling. The resulting waste is partially oxidized uranium metal in a water bath, which must be disposed of as low-level radioactive waste.

A.1.4.11 Building 191

Building 191, the High Explosives Application Facility, is located in the LLNL Livermore site northwest quadrant. The building size is 122,178 sq ft and includes 13,000 sq ft of office space. This facility was constructed to provide LLNL with a centralized high explosives research facility with modern diagnostic and testing equipment, and is currently LLNL's center for the study of chemical high explosives and their application to conventional explosive and nuclear device systems (LLNL, 1989p, 1990o).

Hazards Assessment

Hazardous materials in Building 191 are used in high explosive (HE) synthesis and formulation, HE properties characterization, shock-loading experiments, detonation experiments, and various support shop operations. See Table A-32 for descriptions of high explosive storage areas in Building 191. Hazardous materials used include explosives, propellants used in the shock-loading systems, reagent grade chemicals, and adhesives. All classes of chemicals (inorganic acids, bases, and salts), in addition to a wide range of organic compounds including aliphatics, aromatics, alcohols, ethers, aldehydes, and ketones are used in the facility (LLNL, 1989p).

The main radiological hazards are associated with the x-ray machine used to radiograph components and assemblies prior to detonation experiments. This machine is heavily shielded with concrete to minimize radiation exposure. The second source of radiation is the flash x-ray generator, which is used as a diagnostic tool in a firing chamber (LLNL, 1989p). The firing chambers were designed for experiments utilizing beryllium and depleted uranium when associated washdown systems are implemented.

Generated Wastes and Effluents

The firing chambers and high explosive chemistry operation are the two primary sources of potentially hazardous waste. The firing detonation of gun propellants in one of the firing chambers generates water, carbon dioxide, and nitrogen. Smaller quantities of carbon monoxide and nitrogen oxides are also produced. Some of the residues contain mutagenic compounds. Detonations of high explosives produce toxic gases. Chemistry operations generate small quantities of solid, liquid, and gaseous wastes. These wastes include miscellaneous solvents, organic compounds, adhesives, acetone, isopropyl alcohol, and epoxy-based adhesives (LLNL, 1989p). Other hazardous wastes include beryllium and depleted uranium that are used in the firing chambers.

Airborne particulates from the firing chambers are channeled through air filter bags. HEPA filters are installed for the 10 kg gun tank. Negative pressure hoods are located in all chemistry areas to exhaust effluent gases.

The wastewater retention system consists of two central, aboveground waste retention tanks. The two tanks are surrounded by a berm capable of containing the entire volume of both tanks. All rinsewater is collected in the waste retention system and sampled prior to discharge. This system is considered a nonhazardous system and the tank's contents are routinely discharged to a sanitary sewer after sampling and analysis.

Several photographic development labs in the High Explosive Application Facility generate spent photographic solution wastes. These wastes are collected in carboys. Rinsewater used in the process is discharged to the LLNL sanitary sewer system because previous samples have shown the concentration of photographic chemicals is consistently far below acceptable release levels (LLNL, 1987b, 1990s).

A.1.4.12 Physics Department Experimental Facilities

The Physics Department operates two accelerators and three low hazard laboratory complexes as listed below (Phillips, 1991).

Facility	Uses	Size (sq ft)
Building 190	10 MV Tandem Accelerator Lab, Accelerator Mass Spectrometry and other accelerator uses	8,152
Building 194	100 MeV Electron Accelerator, Laser Lab, Superconducting Materials Lab, Mechanical Shop, Electronic Shop	42,715
Building 292	Experimental Labs, Target Preparation for AMS, Mechanical Shops, Detector Test and Calibration Labs	19,334

AIT/O Complex	Laser Labs, Optics Labs, Semiconductor Fabrication Labs, Experimental Labs	51,600
Building 212	Electron Beam Ion Trap, L-Division Laser, Lab for Experimental Astrophysics, Two-stage Light-gas Gun, X ray calibration, Mechanical Shop, Electronic Shop	50545

The first four of these facilities are located in the northwest quadrant and the last one is in the southwest quadrant of the LLNL Livermore Site. The AIT/O Complex includes Buildings 181, 182, 183, 184, 197, 198, and several trailers.

Hazards Assessment

The hazards associated with these facilities are typical of light labs with some special considerations for the uses noted above and described in detail in the operational safety procedures developed for each operation. These hazards include low levels or limited quantities of x-ray radiation, laser radiation, toxic gases, magnetic or radio-frequency fields, combustible or flammable materials, sealed radioactive sources for calibration, explosives (less than 450 g black powder), and other hazardous materials including carcinogens in laser dyes. These experimental facilities may also include vacuum, high-pressure gas, cryogenic, or high-voltage/power electrical systems. In addition, the accelerator beams are locally intense radiation sources and may produce residual radioactivity in those materials which they strike. The use of small research quantities (<1 mg) of tritium is contemplated in future experiments. These tritium sources or targets will be doubly contained to prevent release to the environment and monitored to assure containment (Phillips, 1991).

Administrative control and mechanical and electronic safety devices are used to help mitigate these potential hazards. Administrative controls include personnel training, maintaining lists of qualified operators, tracking all shipments of hazardous or radioactive materials to ensure that limits are not exceeded, periodic or continuous monitoring for x rays, radioactivity, toxicity, or oxygen deficiency, and requiring a hazard analysis for any new experimental project in these facilities.

Engineering controls associated with operations in Physics Experimental Facilities include safety interlocks to limit personnel access to certain areas during operation, radiation shielding, protective equipment or clothing, protective storage cabinets or filtered hoods, automatic systems to monitor and limit the release of toxic gases or the production of radiation and various methods of warning personnel of the operation of experiments with potential hazards. Shielded areas, previously used for accelerator and/or nuclear physics research, are locked up and access is controlled by the facilities coordinator and the Hazards Control technicians assigned to those facilities where there is a potential for contamination.

Generated Wastes and Effluents

The Physics Department maintains two waste accumulation areas, one in the northwest quadrant and another in the southwest quadrant. Only small quantities of waste are produced by the research scale operations conducted in these facilities. Hazardous liquid waste is generated primarily in the machine shop areas of these facilities. These hazardous wastes include organic solvents, diluted acids, solder flux and waste oil. Solid waste includes waste metals from the machine shops, plastics, glassware, and contaminated equipment. Waste materials, both liquid and solid, are collected in containers at the waste accumulation areas (Phillips, 1991).

Buildings 194 and 197 have monitored stacks to disperse small amounts of gaseous effluents generated by their operations. These gaseous effluents include radioactive isotopes of oxygen and nitrogen with half-lives of 2 and 10 minutes, and dust particles from Building 194. The air emissions are filtered through high efficiency particulate air filters and discharged to the atmosphere from a 30-meter stack. Building 197 operations include the use of small amounts of toxic gas in various semiconductor production processes. Effluent from these processes is collected, monitored, and discharged through two 15-meter stacks. Small amounts of gaseous effluents are generated during some operations in Building 212, primarily during operation of the gas gun. The gas emissions are filtered through high efficiency particulate air filters and discharged to the atmosphere.

In Building 212, sumps for the three target rooms receive water from floor drains. Even though the target areas are currently not in use and are secured, wastewater which might accumulate in the target rooms is collected and pumped from the sump to a retention tank outside. This wastewater is then tested, and if it meets the discharge criteria, it is released to the sanitary sewer.

A.1.4.13 Building 222 Complex

The Building 222 Complex, located in the southwest quadrant of the LLNL Livermore site, consists of nine buildings (221 through 229) and several trailers. The complex includes chemical laboratories, offices, and machining and storage facilities. The wide range of work performed here includes the bench-scale synthesis and testing of chemical compounds, intralaboratory and consulting services, analytical chemical analysis, bench-scale polymers and composite technology development, and other special bench-scale research and development projects (LLNL, 1989l, 1991j, 1991p).

The chemistry facility, Building 222, is the main facility for the study of analytical and physical chemistry at LLNL. Total area is about 65,599 sq ft and includes about 60 laboratories, offices, and storage areas. Current activities include environmental sample analysis, synthesis and analysis of chemical compounds, including laser dyes, and specialized research projects. Several of the operations involve the use of small lasers and x-ray generators (LLNL, 1976).

Some of the facilities in the complex were used in the development and study of explosives, but more recently all of the explosives research work has been moved to Building 191, the High Explosives Application Facility. However, small amounts of explosives (<10 g) are still analyzed for chemical constituents as part of normal analytical chemistry operations. The six buildings being (or which have been) converted to other uses are:

- Building 224 - will be used for environmental analytical work.
- Building 225 - may be used for energy research, surface science, or similar bench-scale research.
- Building 226 - used for environmental analytical work.
- Building 227 - used for polymer research and for work associated with LLNL intelligence and treaty-verification support.
- Building 228 - used for Building 226 waste retention system.
- Building 229 - used to store a few hundred lb of beryllium hydride.

Hazards Assessment

The hazards associated with the Building 222 Complex include handling small quantities of hazardous materials involved in research and development activities. These include radioactive materials, laser dyes, high explosives, solvents, inorganic acids, bases and salts, organic compounds (including aliphatics, aromatics, alcohols, ethers, aldehydes and ketones), halogens, organometallics, and inorganic compounds. Several rooms in the Building 222 Complex are equipped with special safety features to prevent personnel access during operation. These measures include safety interlock systems and warning lights outside the entrances (LLNL, 1989l).

Generated Wastes and Effluents

Hazardous waste is accumulated in satellite accumulation areas and then transferred to a waste accumulation area to the north of Building 227. This area consists of two steel transportainers that have been subdivided into six storage bays, four of which are in current use for storing hazardous wastes. These storage bays are designated for specific types of waste: two for flammables, one for radioactive waste, and one for corrosive waste. The other two bays are used for storage; one is used for the storage of toxic gas and the other provides storage space. Explosive waste is temporarily stored in work station accumulation areas and then transferred to a waste accumulation area designed to store explosives in Building 191.

Wastewater from laboratory sinks in the complex is collected in a PVC-lined, single-wall 10,000-gal concrete tank. When the tank is full, the wastewater is pumped to an above-ground portable tank and held while it is tested. If it falls within acceptable limits, the wastewater is released to the sanitary sewer. If not, Hazardous Waste Management removes it for treatment or offsite disposal. LLNL is constructing a new wastewater retention system using aboveground tanks to replace this tank system. It will have four tanks with working capacities of less than 5000 gal each.

The laboratories are equipped with exhaust hoods, some of which vent through high efficiency particulate air filters into the atmosphere. Several areas with a large number of hoods (including Building 227 and sections of Building 222) are equipped with manifold systems that allow all of the exhausts to be released through a single stack system.

A.1.4.14 Building 231 Complex

The Development and Assembly Facility, Building 231, is a large experimental, manufacturing, assembly, test, and materials-handling facility located in the southwestern quadrant of the site. Building 231 houses research and development activities conducted by Chemistry and Materials Science (Materials Division), Engineering (Engineering Sciences, Materials Fabrication, Nuclear Energy Systems, Nuclear Test Engineering, and Weapons Engineering Divisions), Safeguards and Security (Materials Management Division), and Special Projects Program (J Division). Management oversight for Building 231 is provided by the Engineering Directorate through Engineering Sciences Division.

Building 231 consists of 132,328 sq ft of laboratory, shop, and office space. There are about 100 separate laboratories and shops and 64 offices. There is a central high bay area, having

30-ton and 7.5-ton bridge cranes, and four high bay wings, each having limited capacity (1- to 10-ton) bridge cranes. The following activities are conducted in the building:

• Plastics fabrication	A full service plastics manufacturing and development operation including formulation, cast/curing, injection and rotomolding molding, vacuum forming, high temperature inert-atmosphere autoclave bonding, composite layup manufacturing, and polymer spray coating. Supporting equipment and facilities include chemical hoods, high energy power sources, and chemical storage areas.
• Polymer composite research	Continuous fiber composite development and winding operation including polymer formulation and characterization laboratories, large capacity numerically controlled winding machinery and chemical hoods.
• Measurement and calibration services	Force, pressure, flow, and temperature calibration laboratories, straingage laboratory, and vibration and modal analysis engineering services. Equipment includes various high pressure and high vacuum electronic instrumentation.
• Materials test and evaluation services	Comprehensive laboratory for mechanical property characterization of diverse materials including beryllium, depleted uranium, other metals, polymers, composites, and ceramics. Laboratory equipment includes numerous high capacity hydraulic and electromechanical numerically controlled test machinery, vacuum and inert-atmosphere furnaces, fracture and

fatigue test apparatus, an integrated computer network for data acquisition and analysis, a high-pressure test cell, and an energy-enhanced drop tower.

- Materials processing research — Comprehensive materials processing laboratory for evaluating structure-property relationships and enhancing material properties through process metallurgy.Conventional and research materials in limited quantities are explored including toxic materials and depleted uranium. Equipment includes warm rolling mills, forging press, chemical-vapor deposition system, electron-beam welders, saws, electric discharge machine tool, metallography laboratory, scanning electron microscope, numerous high-temperature vacuum furnaces, high-energy power sources, chemical hoods, and gloveboxes.
- Weapon systems development — System assembly and procedure laboratory in support of weapon engineering. Operations and equipment may include high energy laser welding, robotics, vacuum systems, and thin film sputtering systems. Research materials may include controlled quantities of toxic and radioactive non-fissile materials.
- Test canister assembly — High-bay assembly operation for preparing test canisters for use in Nevada Test Site events. Operations and equipment include multi-ton cranes, heavy duty welding and cutting equipment, polymer casting operations, precision alignment, a six-story pit/tower facility, and high energy power sources.
- Special projects — Several small laboratories for supporting special project activity. Equipment and operations include applications using class IV lasers, vacuum systems, limited quantities of high pressure gases, chemical hoods, high energy power sources, and precision measuring equipment.
- Vacuum processing services — A comprehensive thin-film deposition facility. Equipment includes numerous computer controlled high vacuum sputtering systems, high energy power sources, and thin-film diagnostic instrumentation.
- Machining — An area shop with assorted turning and milling machinery, saws, drill presses and hand tools. Work generally is of a routine nature involving conventional materials. However, graphite-epoxy machining is conducted in support of fiber composites research.
- Materials handling and management — An alarmed, limited access vault provides for receiving, inspecting, weighing, storing, packaging, servicing and shipping of radioactive/nuclear, plutonium and uranium contaminated non-fissile, and other controlled materials. Other activities include degreasing and oxidation of uranium-235, maintaining/repairing valves and other items used in the Plutonium Facility (Building 332), and storing historical samples of controlled materials.

In summary, Building 231 encompasses eleven separate technology areas conducting operations that employ numerous toxic, radioactive, or otherwise hazardous materials, components and procedures.

Hazards Assessment

The potential hazards in this facility are exposure to radiation and radioactive materials; exposure to carcinogenic, corrosive, and toxic materials; exposure to vapors and high intensity light from open flame welding; handling and exposure to high explosives, hydrogen gas and other flammable or combustible liquids and gases; handling and operating high pressure systems, lasers, sealed radioactive sources, and high voltage equipment; operating and exposure to rotating equipment, other machine tools, cranes, and heavy plates, cylinders, and other objects being lifted; exposure to excessive noise; and exposure to glovebox leakage, implosions, and explosions.

Among the prevailing hazardous materials that may be handled in limited quantities are the following: uranium-235 and depleted uranium (D-38) in solid form, plutonium-contaminated non-fissile materials, beryllium, fibrous carbon materials, toxic resins and epoxies, methylene chloride, chloroform, ethylene dichloride, acetone, other solvents, tungsten hexafluoride, and acids used in chemical etching.

To insure their safe conduct, activities in Building 231 are governed by two Facility Safety Procedures (FSPs), one covering the vault and the other covering all other activities. Any hazardous activity not specifically discussed in either FSP requires an individual Operating Safety Procedure, reviewed by the facility management and others, and posted in the work area. These documents detail the processes that must be followed, any needed precautions, the responsible and approved personnel, training requirements and contingency plans.

Various safeguards, including air monitoring and alarms for nuclear criticality, hydrogen buildup and fire, are provided throughout the building where needed. Of special note, work areas in the vault are equipped with continuous air monitors to detect the release of radioactive materials. If an alarm sounds, personnel in the work areas must immediately exit to a "clean" area (LLNL, 1975).

The work areas within the vault are kept at negative pressure (relative to the outside environment). Outside air is first filtered, then passed through the "clean" area and into the work areas. The exhaust from the rooms and gloveboxes is filtered by two high-efficiency particulate air (HEPA) filters at all times. A backup power system assures that the negative pressure in the vault can be maintained even in an emergency. If the exhaust system is not working, all work involving radioactive and hazardous materials stops.

Generated Wastes and Effluents

Wastewater is collected in a sump along the east side of the building. The sump is a PVC tank enclosed in an underground concrete vault that provides secondary containment. The wastewater from the sump is pumped to two aboveground carbon steel retention tanks located in a bermed concrete area. Wastewater in these tanks is sampled, and if within acceptable discharge levels, the wastewater is released to the sanitary sewer. If unacceptable for release, it is transferred to Hazardous Waste Management.

Hydraulic pumps supporting various test machinery are centrally located in concrete pits located inside and outside the building. Hydraulic lines to the machinery are routed through concrete trenches. Existing floor drains in the pits are sealed to prevent contamination of storm sewers with pump oil. Regular pump maintenance includes inspection for any oil accumulation in the pits and trenches.

Portable vacuum pumps used in the building are required to have secondary containment of pump oil to avoid inadvertent contamination of open sewer drains. Permanent banks of large vacuum roughing pumps are generally located outside the building or in enclosed equipment rooms to control noise. Precautions are also taken to prevent sewer contamination from these.

Hazardous waste generated in the various work areas in the building is held temporarily in those areas, using approved containers with proper labeling. Periodically, this waste is transferred to two hazardous waste accumulation areas located outside the south end of the building. One area, for radioactive and controlled materials waste, is managed by Materials Management in accordance with all existing regulations. The second area is for all other hazardous waste. This area meets all requirements for such facilities and includes a double-contained steel shed fitted with approved fire safety provisions.

Chemical hoods and gloveboxes approved for use with radioactive materials and beryllium are vented through HEPA filters and monitored periodically by health and safety technicians for proper operation. Both fiber composite winding machines are located in well-ventilated areas. The larger winding facility is fully contained in an isolated room with a single-pass air-conditioning system that exhausts through a roof stack to the atmosphere. In addition, this facility can employ a portable close-capture enclosure system for use around the workplace when necessary. With the close-capture system in place, any toxic vapors associated with the winding operation are contained and particulates in the enclosure exhaust stream are trapped in HEPA filters in the ducts leading to the roof stack.

A.1.4.15 Building 232

The High Pressure–High Temperature Laboratory is located in Building 232, part of the Building 231 Complex of the LLNL Livermore site. It occupies the southern 77 ft of the building, with the northern 40 ft, a covered, open area storage space, controlled by the Materials Management Division. The laboratory consists of one, single-story building of approximately 2030 sq ft divided into a light laboratory area and an area consisting of four rooms designed to contain high-pressure experiments (Beach, 1991).

The High Pressure–High Temperature Laboratory is a single-user facility dedicated to high pressure–high temperature thermodynamic and materials properties experiments. The facility contains a small lathe, three gloveboxes, a hood, several large-capacity presses, and a variety of pressure vessels and pressure-generating equipment.

Hazards Assessment

The significant hazards in the High Pressure–High Temperature Laboratory are associated with the energy stored in highly compressed gases and liquids. In addition to inert gases and flammable liquids (hydrocarbon oils), hydrogen and oxygen are used as pressure media. Infrequent work with beryllium and depleted uranium result in their specific hazards. Hazards are identified and controlled by the Facility Safety Procedure and Operating Safety Procedures (Beach, 1991). The open area storage includes controlled materials which may be hazardous and/or radioactive.

Generated Wastes and Effluents

The small amount of wastes generated (less than 3.0 lb of U-238 in 1990) is stored in appropriate laboratory containers, then transferred to the waste accumulation area in Building 235. The single sink in the building is connected to the Building 231 retention system. The single hood is ventilated directly into the atmosphere (Beach, 1991).

A.1.4.16 Building 235

The Weapons Materials Research and Development Facility, Building 235, is located in the southwestern quadrant of the LLNL Livermore site. This 88,732 sq ft facility includes both laboratories and offices. Routine operations involve the use of chemicals, electron microscopes, surface analysis equipment (such as ESCA, Auger, and SIMS), sputtering equipment, x-ray equipment, high vacuum systems, a 200-kV ion implanter, a 4-MV ion accelerator, and several Class IV lasers. Activities include particle characterization, optical metallography, varied uses of lasers, physical vapor deposition, and specialized research projects. The building is authorized for the handling of radioactive materials and beryllium, as well as sealed radioactive sources (Beach, 1991).

Hazards Assessment

The hazards associated with Building 235 include laser operations and the handling of radionuclides, as well as the many hazardous and toxic materials involved in research and development activities, such as beryllium, sealed radioactive sources, radioactive materials, solvents, and other chemical reagents. Rooms in which lasers are operated are equipped with special safety features to prevent personnel access during laser operation (Beach, 1991).

Generated Wastes and Effluents

Hazardous waste is accumulated at work station locations (known as satellite waste accumulation areas) and then transferred to a waste accumulation area. Aqueous laboratory wastes from identified laboratory sinks are collected in an underground sump and then pumped into one of two aboveground retention tanks located on the west side of the building. The tank contents are periodically analyzed and, if the waste meets water quality criteria, are discharged to the sanitary sewer system. Most laboratories are equipped with exhaust hoods that vent through high efficiency particulate air filters to the atmosphere (Beach, 1991).

A.1.4.17 Building 241

The Building 241 Complex is located in the southwest quadrant of the LLNL Livermore site. It consists of a 2-story building and several trailers. The complex includes laboratories, offices, and machining and storage facilities. Also included is a large high-low bay area which houses heavy equipment for materials processing. The total floor area is approximately 56,344 sq ft.

A wide range of materials research is conducted in Building 241. The major activities include characterization of materials, using such techniques as x-ray diffraction, x-ray fluorescence, TEM, and SEM (electron optics equipment); studies on the long-term corrosion of metals; application of specialized coatings, including beryllium; oil shale research, including coal pyrolysis and retorting; the development of new materials for high-performance armor; the study of metal protective coatings for weapons fire safety; hot processing of materials, including isostatic pressing; the handling of toxic and atmospherically sensitive materials in gloveboxes; and the handling of controlled and classified components (Beach, 1991).

Hazards Assessment

The potential hazards associated with Building 241 include nonionizing radiation, high temperatures and pressures, and the handling of various hazardous materials, including beryllium, lithium compounds, and depleted uranium. Controls for these hazards are specified in both facility and operational safety procedures (Beach, 1991).

Generated Wastes and Effluents

Waste materials are collected at work stations (satellite waste accumulation areas) and then moved to a waste accumulation area on the south side of the building. The building also has a laboratory waste system which is currently being upgraded. Many of the laboratories are equipped with exhaust hoods, some of which vent through high efficiency particulate air filters into the atmosphere (Beach, 1991).

A.1.4.18 Building 243

The Energy Research Facility, Building 243, is located in the southwestern quadrant of the LLNL Livermore site. This 18,661 sq ft facility houses one-of-a-kind high pressure equipment and laboratories used for the testing and analysis of rocks and other materials. Other Energy Program/Earth Sciences Department activities performed in this facility include x-ray microanalysis, x-ray fluorescence, bioremediation experiments, rock cutting/crushing/polishing, high-temperature furnace, low-level laser, and machine shop activities.

The research in Building 243 is conducted in support of basic energy sciences, fossil energy projects, the Yucca Mountain Project, the Environmental Restoration and Waste Management Program, Laboratory directed research and development, and defense programs.

Hazards Assessment

The common hazards in this facility are physical hazards associated with the testing and analysis of rocks and other materials. There are no radioactive materials. Sealed radioactive sources may be allowed in the facility for the appropriate experiment.

Generated Wastes and Effluents

No appreciable waste streams are generated from Building 243.

A.1.4.19 Building 251

The Heavy Element Facility, Building 251, is located in the western portion of the LLNL Livermore site. This 35,677 sq ft facility is operated by the Nuclear Chemistry Division of Nuclear Test–Experimental Science. Operations include the development and preparation of radioactive sources and tracers to be used in the analysis of underground nuclear tests, the processing of samples from these underground tests, and the preparation and analysis of radionuclides for a variety of research and development experiments, some of which support waste management. These operations involve the use of multicurie quantities of transuranic radioisotopes and special nuclear material (LLNL, 1986e).

Hazards Assessment

The building is divided into three zones: the high potential hazard zone which includes areas where radioactive materials are stored or handled; the intermediate potential hazard zone which includes buffer areas such as hallways and change rooms; and the low potential hazard zone, which includes "clean" areas such as offices and bathrooms. Radioactive material is stored in four secured areas; the majority is stored in specially designed pits located in Room 1320.

To avoid risk of criticality, limits are placed on the amount of fissile material allowed in each work station. These limits are 700 g of uranium-235, 520 g of uranium-233, 450 g of plutonium-239, or 450 g of any combination of these three radionuclides. These limits are derived from DOE Order 5480.5 11.C (3.g.) as those limits that require alarm systems and emergency procedures. When in solution or dispersible state, lower limits of 220 g of plutonium-239, 250 g of uranium-233, 350 g of uranium-235, or 220 g of a combination of these materials are not allowed without an operational safety procedure. To minimize risks of contamination incidents, limits have been placed on transuranic materials "at risk." They are 5 Ci in the unhardened areas of the building and 5000 Ci in the seismically hardened area of the building.

Most activities involving radioactive materials are performed in gloveboxes. The exhaust from these enclosures is filtered by two high efficiency particulate air filters before entering a collection manifold. From there, it passes through an additional high efficiency particulate air filter and is exhausted through a vertical stack. Spent filters are containerized and picked up by Hazardous Waste Management for disposal.

Continuous air monitors are present in all work areas where radionuclides are handled to detect any release. In addition, four continuous air monitors are on the building exhausts. These would detect any radionuclide release to the environment. Criticality alarms are present in work areas; however, these alarms are currently being used as area radiation monitors since the amount of fissile material used is insufficient to achieve criticality.

Generated Wastes and Effluents

Wastes include transuranic, low-level radioactive, mixed, and nonradioactive hazardous wastes. This waste is removed by the Hazardous Waste Management Division, and managed as described in Appendix B.

Wastewater from the facility drains into two steel sumps on the southern side of the building. These sumps are carbon steel tanks encased in a concrete vault for secondary containment. When the sumps are filled, the wastewater is pumped to two aboveground fiberglass retention tanks. These tanks rest on concrete pilings above concrete which is painted with Epoxy. The wastewater is analyzed prior to disposal. If it falls within an acceptable range, the water is released to the sanitary sewer. If it is unacceptable for release, it is transferred to Hazardous Waste Management for treatment.

A.1.4.20 Building 255

The Calibration Laboratory, Building 255, is located in the central portion of the LLNL Livermore site. This 21,378 total sq ft facility is divided into two sections, each housing independent operations. The eastern portion of the building houses the calibration and standards laboratory; the western portion contains the laboratory for development of diagnostic techniques (LLNL, 1988f, 1990q).

The calibration and standards unit of the Hazards Control Department uses the eastern portion of the building to conduct radiation dosimetry calibrations with both sealed and unsealed sources and radiation-generating equipment. It is equipped with shielded irradiation cells, a control room, an instrument calibration range, support laboratories, and offices. Radiation sources used for calibration generate beta, gamma, and x rays, and neutrons.

The western portion of Building 255 is used for the development of diagnostic techniques and the calibration of diagnostic instruments used to interpret nuclear weapons tests experiments. It contains shielded and unshielded rooms containing calibration and testing equipment, support laboratories, offices, and a machine shop. The work performed here includes irradiation experiments involving a variety of x-ray generation equipment and sealed radiation sources (LLNL, 1988g).

Hazards Assessment

The hazards present at this facility are those associated with handling fissile material and intense x-ray and gamma-ray sources. The quantities of fissile material allowed in the building are strictly limited to control the risk of criticality. These limits are 0.35 kg of uranium-235, 0.25 kg of uranium-233, 0.22 kg of plutonium-239, or 0.22 kg of any combination of these materials (LLNL, 1988f).

Those rooms and storage cells in the eastern portion of the building containing radioactive sources are equipped with safety interlocks and warning light systems to prevent entry during operations. A remote area monitoring system provides a readout at the control console and initiate both an audible and a visual alarm if radiation is present in the cell and the cell door is open. The cell used for the storage of radioactive sources is further equipped with a continuous air monitor (LLNL, 1988f).

As in the east portion of the building, the western portion has numerous safety mechanisms, including safety interlock systems, warning light systems, and remote area monitoring, that are used in irradiation areas to prevent personnel exposure (LLNL, 1988g).

Generated Wastes and Effluents

Operations in Building 255 produce small quantities of radioactive waste, alcohol, solvents, waste oil, and spent batteries. This material is collected in satellite waste accumulation areas, then moved to a waste accumulation area at Building 253. From there, waste is picked up by Hazardous Waste Management.

A.1.4.21 Building 298

The Fusion Target Fabrication Facility, Building 298, is located in the northwest quadrant of the LLNL Livermore site. This 47,764 sq ft facility supports the ICF Program, tritium research, target development, and target fabrication for NOVA and NOVA Upgrade/National Ignition Facility. The operations within the facility include glass and plastic sphere generation, chemical analysis, characterization, organic coating and levitation, inorganic coating, assembly development, fuel fill, cryogenics, and an advanced research laboratory (LLNL, 1991ab).

Hazards Assessment

The principal hazards within this facility include fire, the operation of chemical and physical laboratories, exposure to laser beams, the use of vacuum and gas pressure systems, and leakage of cryogenic fluids. The facility is equipped with an automatic sprinkler system; access to lasers is controlled by warning signs, lights, signals, intercom systems, and door interlocks; the vacuum and pressure systems use engineering and operational safeguards; and the cryogenic fluid system has been designed in accordance with LLNL safety standards (LLNL, 1991ab).

Other operational and safety controls include radiation protection monitors, alarms, and controls; HEPA filtered air flow hoods for depleted uranium in the sputtering assembly area; radiation shielding for the radiographic machines. A tritium handling control system which includes a primary and secondary containment system, a recovery system, and a gas purification system was designed to handle the 2 g of tritium, and was procured but never installed in Building 298 due to budget constraints. These systems were delivered and installed in Building 331 to handle the Inertial Confinement Fusion target tritium handling needs.

Generated Wastes and Effluents

Wastes generated from this facility include hazardous wastes and low-level radioactive wastes contaminated primarily with depleted uranium, tritium, and thorium (LLNL, 1991ab).

A.1.4.22 Building 321 Complex

The Building 321 Complex is located in the southwestern quadrant of the LLNL Livermore site. This complex includes the following buildings:

Building No.	Name	Size (sq ft).
321	Materials Fabrication Shop	148,806
322	Plating Shop	5,960
322A	Plating Shop Annex	195
326	Material Fabrication Shop	3,456
329	Laser Weld Shop	4,226

Building 321 consists of 3 separate buildings, 321A, 321B, and 321C. Building 321A is a general machinery, heat treatment, and testing facility; Building 321B is a machine tool services facility; and Building 321C consists of a sheet metal and welding shop. The complex contains the special materials shop (for uranium and beryllium machining), precision shop, ceramics shop, lap shop, a vault, inspection laboratory, assembly shops, forming shop, metal coating finishing shop, metal fabrication shop, heat treat shop, general machine shop (main bay), several small support shops, an optics facility, vacuum processes lab, glass laboratory, machine tool services shop, and a precision systems development facility (LLNL, 1990y).

Hazards Assessment

Sources of potential hazards in this complex include lasers, machining tools and parts with sharp edges, high voltage and arc welding flash, high temperature operations, hazardous and radioactive materials and hazardous and radioactive wastes.

The Materials Fabrication Shop (Building 321) performs routine machining and forming operations on metals or compounds of uranium, thorium, cobalt, beryllium, and lithium hydride. The forming shop and the heat treat shop are limited to heating, forming, and treating depleted uranium and beryllium.

The Ceramics Shop performs machining operations on natural or depleted uranium and beryllium as metal, alloys, compounds, metal oxides, or ceramics. The Laser Weld Shop (Building 329) performs welding operations on depleted uranium and beryllium.

The Plating Shop (Building 322) and the Chemical Etching Facility (located in Building 326) perform plating, etching, and finishing operations on metals including depleted or natural uranium.

The complex is equipped with contamination control areas, for processing such toxic and radioactive materials as arsenic, beryllium, uranium, thorium, lithium hydride, and mercury compounds. Dust is captured by high efficiency particulate air filters.

Enclosures and close-capture systems such as hoods and gloveboxes are provided when working with radioactive and toxic material. The machine tools are provided with ventilation systems that aspirate the fine particulates and mists and capture them in high efficiency particulate air filters.

In recent years, no uranium-235 parts or assemblies have been processed that could become critical; however, the complex is capable of handling such parts, if required. Two rooms of Materials Fabrication Shop are equipped with nuclear accident dosimeters and criticality alarms. Special criticality evaluations and safety procedures are required for such work (LLNL, 1990y).

The Plating Shop, Building 322, uses, stores, and disposes of chemicals used in the electroplating industry, including cyanide, arsenic, nitric acid, hydrochloric acid, sodium hydroxide, ammonium sulfate, acetone, and perchloroethylene. Concentrated liquid plating waste solutions are collected and transferred to a holding tank to the east of the building (LLNL, 1990y).

Generated Wastes and Effluents

Wastes consist of chips of radioactive and hazardous material, contaminated wipes, scrapped parts made of toxic material, and unusable excess material. Hazardous waste is stored temporarily in appropriate leak-proof, labeled containers (LLNL, 1990o).

Liquid effluents are segregated and collected in labeled drums according to these five categories:

- Washwater and cutting fluid or coolant (water soluble).
- Oils and other pure hydrocarbons (combustibles).
- Flammable organic solvent (e.g., alcohol, benzene).
- Chlorinated organic solvents (e.g., trichloroethane).
- Electroplating solutions and rinsewaters.

Radionuclide-contaminated water is collected in the ceramics shop tanks or drums.

There are three waste accumulation areas at this complex where temporary (up to 90 days) storage of liquid and solid wastes is permitted:

- Eastern side of Building 321C, near the northeast corner. Radioactive wastes from the ceramics shop and lap shop are stored here.
- Area south of Building 321 stores the hazardous wastes generated from the main bay shop, precision shop, and machine tools services.
- Eastern side of Building 322 provides storage for hazardous wastes from the plating shop.

Airborne emissions from this complex include toxic gases (acetylene, evaporated solvents) and dust or fine particles (chips, grinding dust, weld sputtering).

A.1.4.23 Buildings 327 and 239

Buildings 327 and 239, Radiography Buildings, have floor areas of 25,854 and 14,590 sq ft respectively. They are located in the south-central portion of the LLNL Livermore site. They contain nondestructive evaluation (NDE) facilities used in support of LLNL Site 300, NTS, Tonopah Test Range, DOE contractor laboratories, and the Lawrence Berkeley Laboratory (LLNL, 1990r).

Hazards Assessment

Equipment in these buildings includes lasers, linear accelerators, isotope sources, and flash x-ray equipment. With lasers, the hazard is the potential for eye damage if the beam is observed directly; when using the high-power laser, skin damage is also possible, and there may be a fire hazard if the direct beam shines on flammable materials. Linear accelerators present the hazards of high voltages (up to 4.75 Kv) and large x-ray fluxes (peaks up to 3000 rad/m at 1 meter). The high-energy electrons in this equipment can ionize atmospheric oxygen to form ozone, which can cause irritation of the eyes and respiratory tract, headaches, and coughing. Isotope sources present the hazard of radiation. Flash x-ray equipment also presents the hazards of high voltages and high but short-duration x-ray fluxes (LLNL, 1990r).

Material to be evaluated can include radioactive, explosive, and toxic materials. Only nondestructive use of these materials is permitted.

Fissile materials in solid, nondispersable form at any work station are limited to 18.5 kg of enriched uranium or 4.5 kg of plutonium or uranium-233; fissile-material limits for these materials in dispersible or soluble form are limited to 0.35 kg and 0.22 kg, respectively. These materials are not dispersed or changed in form in the facility, and they are not stored in the building. This material is included in the Building 332 and 334 inventories.

Generated Wastes and Effluents

Acids, solvents, and chemicals are segregated and stored in separate storage areas and disposed of in separate containers to prevent the mixture of incompatible chemicals that could cause violent or toxic reactions. In general, all radioactive, toxic, and chemical wastes are placed in containers approved by Hazards Control and the Hazardous Waste Management Division.

A.1.4.24 Building 331

The Hydrogen Research Facility (formerly known as the Tritium Research Facility), Building 331, is located in the southwest quadrant of the LLNL Livermore site. Research laboratories in this building conduct experiments with hydrogen isotopes, including tritium gases and hydrides. The 28,728 sq ft building contains laboratories and offices. The northern side of the building will house the light isotope monitoring area, and the southern side houses the Hydrogen Research Facility area.

The Hydrogen Research Facility area laboratories will be used primarily for inertial confinement, fusion-directed, experimental work with the isotopes of hydrogen gas, metal hydrides in contained beds, and small amounts of experimental metal hydrides and tritium-labeled compounds. Physics Department experiments, including the neutrino experiment, are conducted in the Hydrogen Research Facility area; this area is also used to conduct beryllium hydride and lithium-beryllium hydride work. Tritium is not used in conjunction with beryllium.

The light isotope monitoring area was previously used as a tritium laboratory. Equipment used in these laboratories is either being moved to the Hydrogen Research Facility area or will be decontaminated and decommissioned. Only monitoring and surveillance operations are planned in this area (LLNL, 1990az, 1991l, 1991m, 1990f).

In 1990 the mission of the Hydrogen Research Facility was changed. This change would eventually decrease the tritium limits from 300 g to 5 g to accommodate programmatic changes in this Facility, and thereby would reduce emissions.

Hazards Assessment

The principal hazard in the Hydrogen Research Facility area is the handling of gram quantities of tritium either as a gas or as a degradable hydride. Other hazards are associated with high-pressure gas handling, x-ray and laser equipment, chemicals and flammable materials, high magnetic fields, and cryogenic liquid handling.

The bulk of the tritium inventory is in elemental form or metal hydrides capable of being turned into elemental form by heating. A small amount of tritium is used in the labeling of compounds or in the synthesis of lithium hydride. There will be no deliberate experimental use of tritiated water. Some tritiated water is formed in the tritium cleanup systems for removing tritium from glovebox atmospheres.

The small quantity of residual tritium inside unused equipment is the principal hazard in the light isotope monitoring area.

The Hydrogen Research Facility is divided into two zones which have different relative hazards. All experimental laboratories and tritium handling activities are inside the radioactive materials area. The radioactive materials area is separated by double doors from the offices and shop area. The ventilation system creates air flow from the clean areas (office space) toward areas of increasing potential contamination (i.e. radioactive materials area hall to lab to hood). The system is designed to quickly dilute and exhaust tritium through two 100-ft-high stacks. The amount of tritium in the air of the radioactive materials area is constantly being measured by the continuous air monitoring system (LLNL, 1991l, 1991m).

The continuous air monitoring system consists of hood monitors, room monitors, and stack monitors. Alarms from these monitors provide operators and emergency response personnel an indication of where a release has occurred and the concentrations in the hoods, rooms, and stacks. The room alarms indicate that personnel must leave the rooms and move to the radioactive materials area corridor or leave the radioactive materials area. Stack alarms require personnel to leave the radioactive materials area and assemble in the facility conference room.

The tritium monitoring equipment is electrically connected to the uninterruptible power supply and emergency power system. If power is lost, the uninterruptible power supply will provide power for the time it takes the emergency diesel generator to start and assume the load (approximately 15 seconds).

Generated Wastes and Effluents

The generated wastes from the Hydrogen Research Facility include tritium-contaminated solvents and water, tritium-contaminated solid handling materials, and hazardous wastes in the form of oils, solvents, and chlorinated solvents. Tritium gas is the primary gaseous effluent.

The movement of radioactive materials in and out of Building 331 is controlled by the Materials Management group. All solid and liquid radioactive waste generated within the facility is assayed and appropriately packaged before it is released to Hazardous Waste Management for treatment and/or disposal (LLNL, 1991l, 1991m).

Solid wastes generally include dried molecular sieves and solidified vacuum pump oils. These wastes are analyzed for tritium content, contained in metal drums, and sent for processing and shipment to an approved disposal site.

A.1.4.25 Building 332

The Plutonium Facility, Building 332, is located in the southwest quadrant of the LLNL Livermore site. This building has a total area of 88,723 sq ft, including radioactive materials laboratories, change rooms, storage vaults, a fan loft, a basement, equipment rooms, and offices. There are currently 20 laboratories in which radioactive materials are handled within the radioactive materials areas of the facility. This number could be increased to approximately 24, based on programmatic needs (Beach, 1991).

The major activities at the facility include testing plutonium-bearing engineering assemblies, developing and demonstrating improved plutonium fabrication techniques, and fundamental and applied research in plutonium metallurgy.

The Materials Management Division is responsible for all shipments of radioactive and other controlled materials to and from Building 332 as well as movement within the building. This Division also controls storage of these materials in the building vaults. The vaults are equipped to handle large quantities of fissile, radioactive, and certain other special materials required for programmatic operations.

Criticality safety controls for the vaults include specially designed storage racks and/or containers to control the spacing of stored fissile materials, and mass limits for each storage location or rack cell within a storage vault.

Criticality safety controls also specify mass limits for each work station and each laboratory. The basic administrative work station plutonium limit is 220 g. A larger quantity can be authorized by management in an operational safety procedure. In general, the administrative limit for plutonium in a laboratory is 20 kg.

In addition to operations involving plutonium, Building 332 allows metallurgical processing operations involving enriched uranium (Oralloy). These include melting, casting, welding, machining, and assembly of components in configurations which include other materials as well as plutonium. Chemical analyses can also be conducted on few gram-sized samples in support of these activities. Uranium machine turnings will be converted to oxide so that they may be safely recycled at the Y-12 plant (Kass, 1991). A laboratory scale project using chlorine and hydrogen chloride gas is also being performed at this facility.

Hazards Assessment

The primary potential hazard in this facility is exposure to airborne radioactive material. Plutonium is the material of primary concern (Beach, 1991).

The facility is divided physically and operationally into zones of relative potential hazard. Storage and work with radioactive materials is limited to the radioactive materials area.

Exposure to airborne radioactive material within the facility is controlled by handling material in forms or enclosures that prevent its release to the worker's breathing zone. Release of radioactive material to the environment is controlled by handling the material in the radioactive materials area, which has a controlled ventilation system. Within the radioactive materials area, pressure gradients are maintained so that air always flows from clean areas toward areas of increasing contamination potential. In addition, entry into the radioactive materials area is through air locks that maintain the pressure gradient. All exhaust from the gloveboxes and laboratory areas is filtered through multiple stages of high efficiency particulate air filters; this exhaust is continuously sampled and monitored for radioactive contamination prior to release from the facility. Processing in gloveboxes is usually done under an inert gas atmosphere (nitrogen or argon), since finely divided plutonium may spontaneously ignite in moist air.

Any contamination within a glovebox is confined to its ventilation zone. Only in the case of a spill would decontamination of a room or the building become necessary.

Currently three diesel generators back up a commercial power system (this system is being modified to a configuration in which two independent diesel generators back up the commercial power supply system). These generators can assume full load in 60 seconds. Battery power is supplied to all equipment that cannot tolerate an interruption in supplied power and is important to safety. Battery power is provided, for example, to the fire alarm and criticality alarm systems.

In addition to the engineered controls supplied to keep radioactive materials out of the worker's breathing zone, workers are further protected by the use of continuous air monitors which continually monitor the breathing zone air for radioactivity and sound an alarm if the activity exceeds a preset level. Gaseous effluents from the facility are also monitored in this fashion after passing through their final stage of high-efficiency particulate air filtration. To provide a lower limit of detection than is possible with the continuous air monitors, passive air sampling (which does not have alarming capability) is also conducted in work areas and before gases are exhausted from the facility.

Enriched uranium is a fissile material. Quantities will be present that must be properly controlled to prevent assembly of a critical mass. Enriched uranium is a reactive metal which is radiologically active (alpha emitter). Fine powders, oxide, or metal involved in a fire have the potential for dispersal. Personnel handling dispersible forms are at risk for internal contamination and must be properly protected (Kass, 1991).

Generated Wastes and Effluents

Plutonium-contaminated liquids are generated by operations within this facility, and these consist of cleaning or lubricating fluids and contaminated oil and aqueous solutions used in analytical and metallurgical operations. All plutonium-contaminated liquid wastes generated (in liter quantities) within the facility are either solidified prior to disposal as solid waste, or retained in approved containers prior to pickup by Hazardous Waste Management for treatment or disposal (Beach, 1991).

Small quantities of trichloroethylene are discharged into the atmosphere within permitted limits from the glovebox exhaust systems.

Two 750-gal tanks are used to collect nonradioactive aqueous laboratory wastes. The aqueous wastes may contain a small amount of acid waste (sulfuric acid, chromic acid, phosphoric acid, fluoroboric acid, and nitric acid) and/or metal salts (nickel, beryllium, copper, and silver). When a tank becomes full, the contents are analyzed for radioactive and hazardous contaminates. If the waste meets the criteria of the Livermore Water Reclamation Plant (LWRP), it is discharged to the sanitary sewer system.

Solid radioactive waste consists of material that is removed from gloveboxes in sealed plastic bags and placed into DOT-approved containers, and of low-level contaminated waste, considered contaminated because of its history and association rather than by its measured radioactivity. There are five specific categories of waste which may be generated: transuranic waste (all waste from gloveboxes), low-level waste (all waste from the radioactive materials area except waste from gloveboxes unless surveyed and shown to be nonradioactive), mixed waste (hazardous waste co-contaminated with radioactive waste), hazardous waste (hazardous waste sampled and shown to be free of radionuclides), and clean waste (nonhazardous, nonradioactive waste disposed of via municipal landfill). Waste in all of these categories is evaluated for radionuclide content before transportation by Hazardous Waste Management to the dry waste processing facility at Building 612.

The waste stream from the enriched uranium metallurgical processing operations will consist of gloves and kimwipes used in handling the material, modest amounts of machining liquids and solvents, as well as occasional casting molds (Kass, 1991).

A.1.4.26 Building 334

Building 334, the Hardened Engineering Test Building, is located in the southwest quadrant of the LLNL Livermore site and provides 18,900 sq ft of laboratory space. This facility performs two main activities (LLNL, 1988i):

- Conducting intrinsic radiation measurements. Nonexplosive, plutonium-bearing assemblies are used in these experiments to determine the occupational radiation exposure to personnel during transportation, storage, and handling of nuclear weapons.
- Physical testing of these components to various combinations of vibration, acceleration, mechanical and thermal shock, and thermal cycling. These tests simulate the harsh conditions to which the components may be subjected over their lifetime in storage, transportation, and use.

The building has two 3-story high bay test rooms, two control rooms, an entry and signal amplifier room, a mechanical equipment room, and supporting utilities. One test bay houses the intrinsic radiation activities; the other, the engineering test bay. Each bay is equipped with a high efficiency particulate air ventilation system. The separation of bays and the independent ventilation systems ensure that events in one bay do not affect the other.

Hazards Assessment

The potential hazards associated with Building 334 are primarily related to the presence of radioactive materials.

The release of radioactive material from the Hardened Engineering Test Building is prevented by multiple confinement barriers, including metal barriers around the radioactive source material in the intrinsic radiation bay and the engineering test bay (confinement); walls and equipment enclosures (physical barriers); and the ventilation system (dynamic barrier).

Under normal operating conditions, radioactive material is contained within the component being tested. If radioactive materials leak into the bays, they are confined within the building by the ventilation system. The system recirculates each bay's air through two stages of high efficiency particulate air filters (LLNL, 1988i).

External dosimetry alone is used to monitor operator doses. If specific test conditions warrant, the health physicist can require bioassay monitoring procedures.

Each bay contains continuous air monitors designed to provide immediate warning if airborne radioactive contamination exists. If radiation levels exceed a preset level, continuous air monitors in each room sound an audible local alarm to warn bay occupants and send a signal to the alarm panels in the control rooms and to the LLNL emergency operations center.

A 40-kw emergency generator provides power in the event of an outage. Emergency power is provided for air monitoring systems, fire and security alarms, and the lighting of the two bays (LLNL, 1988i).

Generated Wastes and Effluents

This facility is used for measurement and testing only. No radioactive or hazardous wastes are generated.

A.1.4.27 Building 335

Building 335, is located within the superblock in the southwest quadrant of the LLNL Livermore site. This 12,270-sq-ft facility contains the Control Laser Laboratory and the Auxiliary Laser Facility (LLNL, 1990ar, 1990as).

The Control Laser Laboratory operations involve mixing of laser dye solutions and the operation of two types of continuous wave lasers, argon ion and tuneable dye, with outputs of up to 20 watts. Laser light is transmitted via fiber optics and enclosed optical systems for use in the experimental areas (LLNL, 1990ar).

The Auxiliary Laser Facility uses several high-power lasers of various wavelengths operating simultaneously. The several lasers are Helium-Neon, Krypton ion, Argon ion, Titanium sapphire, and Dye laser (LLNL, 1990as).

Hazards Assessment

The hazards associated with operations in Building 335 include exposure to high-power laser light, high voltage, toxic and flammable solutions of laser dye in solvent; electrical hazards; mutagenic dye concentrate handling; solvent handling; and laser beam hazards (LLNL, 1990ar; 1990as).

Some of the operational and personnel controls include restricted access to lasers and safety door interlocks to interrupt the laser beam if doors are opened; eye protection requirement; installation of laser covers and beam tubes; all high-voltage locations are shielded with grounded enclosures; pumps and reservoirs containing flammable liquids are placed on spill pans; dye solutions are capped off or covered when not in use, and stored in the designated cabinets; and lasers are operated with strict operating controls.

Plutonium contamination hazard is possible in Building 335 due to accident conditions in Building 332. In the event of an accident, measures have been taken to prevent a subsequent release of material to Building 335 and the outside environment. The laser tubing that connects these two buildings is installed with shutters at two locations and is interlocked with Building 332 seismic and criticality alarm sensors (LLNL, 1990as).

Generated Wastes and Effluents

The wastes generated from operations in Building 335 include used dye powders or dye solutions, dye-contaminated solid objects, and Dimethylsulfoxide wastes. The solid objects are sealed in polyethylene plastic bags and stored in sealed drums. The dye wastes are stored in containers located in the outside waste accumulation area. There is also a laser dye retention tank system located in this facility. All wastes are handled by Hazardous Waste Management for treatment, storage, and disposal.

A.1.4.28 Building 341

The Physics Research Facility, Building 341, is located in the southwest quadrant of the LLNL Livermore site. This 46,067-sq-ft building contains a variety of isolated, interlocked, and remotely controlled major experimental facilities for high-energy operations. The experimental studies within the facility include the use of high-energy electrical systems, explosives, high-velocity experiments using gun systems, development and testing of optics, laser systems, flash x-ray generators, and hydro-diagnostics equipment (LLNL, 1990m).

The experimental facilities within Building 341, where required, are designed with hardened construction, soundproofing, special ventilation, fire protection, safety interlocks, run-safe switches, and warning devices to minimize hazardous conditions to personnel (LLNL, 1990m).

Depleted uranium in metal form is used in Building 341 for a number of commercial applications other than fuel for nuclear reactors. These applications include: ballasts, armor-piercing ammunition, hardening of steel, and photographic enhancement. In the first three applications it is used primarily because of its very high density (depleted uranium weighs about twice as much as an equal volume of lead).

Hazards Assessment

The primary hazards within this building are from work involving high-velocity projectiles, high-energy electrical storage systems, high-pressure operations, laser operations, use of toxic and radioactive materials, x-ray producing equipment, flammable gases and liquids, detonators, explosives, and high-speed rotating cameras (LLNL, 1990m).

Some of the operational and safety controls include warning light systems for hazardous operations, safety interlock systems for personnel entry, use of protective clothing and equipment, use of hazardous materials only in designated areas with equipment approved for the type of operation, remote operation of the high-speed rotor cameras, insulation and shielding of high-voltage systems, and high ventilation rates for enclosed spaces and vaults (LLNL, 1990m).

Detonators are stored in magazettes outside of the east wall of the building. These magazettes contain a maximum of seven approved Department of Transportation "Class C" shipping containers that resemble a standard suitcase. The detonators within each shipping container are spaced so that the detonation or firing of a single detonator will not cause the remaining detonators in the shipping container to ignite. This is referred to as a "nonpropagating configuration." Detonators are also stored in Room 1015 and are limited to 90 detonators in a nonpropagating configuration. Detonator use is restricted to approved areas and these areas are electrically interlocked and equipped with physical key lockouts (LLNL, 1990m).

Operations involving radioactive material are performed in areas designed to minimize both personnel exposure and the probability of releasing radioactivity into uncontrolled areas. The operation of the two-stage gun system involves radioactive contamination, shrapnel produced from the projectiles, targets, or failure of the high-pressure section of the gun. Remote key-controlled firing, safety interlocks, and strict adherence to operational controls are required to prevent injuries and damage to property (LLNL, 1990m).

The advanced armor studies use rifles up to 40 mm to launch both inert and depleted uranium rods up to 200 g in size. The rods impact and penetrate inert targets, and the fragments are collected in a catch tank filled with energy-absorbing material. The measurement equipment includes flash radiography, continuous wave x rays, optical photography, soft recovery of the impact fragments, and electrical pin diagnostics. The hazards in this operation include explosion, shrapnel, x-ray exposure, high-voltage shock, inhalation of smoke, and loose radioactive particles. Some of the hazards control include interlocked doors and equipment, remote operations, containment box ventilated through high efficiency particulate air filters, air monitoring, x-ray safety boxes, and electrical isolation of explosives (LLNL, 1990m).

Generated Wastes and Effluents

Hazardous wastes such as photographic materials, waste oils, acids, bases, and contaminated clothing are produced in this facility. Explosives wastes and radioactive fragments are also produced. All wastes are handled by Hazardous Waste Management for proper treatment, storage, and disposal.

A.1.4.29 Building 343

The High Pressure Laboratory, Building 343, is located in the southwest quadrant of the LLNL Livermore site. This 36,599-sq-ft facility is used for tests and experiments with high pressure systems. The high pressure systems utilize gases and liquids, and the fabrication and assembly of equipment for such systems. The operations include the use of radioactive and toxic materials (LLNL, 1990p).

Depleted uranium in metal form is used in Building 343 (as it is used in Building 341) for a number of commercial applications other than fuel for nuclear reactors.

Hazards Assessment

Hazards that are associated with the high pressure systems include rupture of pressurized equipment, contamination by toxic or radioactive material, or the ignition of flammable gases. Facility safety procedures are established that restrict the quantity, containment, physical state, type, and energy potential of the hazardous materials (LLNL, 1990p).

The materials permitted in this facility are inert or nonpoisonous gases; inert or flammable liquids or solids; beryllium, lithium hydride, or any alkali metal, provided it is confined to a pressure containment vessel; toxic solids and liquids; sealed radioactive sources; natural thorium and natural and depleted uranium; and other nonfissile radioactive materials (LLNL, 1990p).

The materials that are prohibited include poisonous, radioactive, or toxic gases such as cyanogen, chlorine, fluorine, and hydrogen fluoride; oxygen for use in pressure tests and experiments; air over 10,000 psi; uranium-233, uranium-235, and plutonium-239 isotopes in any form or quantity; liquid alkali metals; and explosives (LLNL, 1990p).

The operational and safety controls include vessel and cell access control, electrical interlocks for controlling the hazard, and proper training for personnel.

Generated Wastes and Effluents

All radioactive, toxic, hazardous chemical, mixed, explosive, and flammable wastes are placed in containers. The wastes are properly segregated and labeled before being handled by Hazards Control and Hazardous Waste Management. The containers are placed in the waste accumulation area for a maximum of nine months or until the container is full, whichever comes first (LLNL, 1990p).

A.1.4.30 Building 360 Complex

The Building 360 Complex, the biomedical buildings, consists of seven permanent buildings (Buildings 361, 362, 363, 364, 365, 366, and 367) with a combined floor area of 92,794 sq ft located in the center of the LLNL Livermore site, together with a number of trailers.

The several buildings of this complex are used in fulfilling the mission of the Biomedical and Environmental Research Program, which is to develop an improved understanding of the implications to humans and their environment of energy development and consumption. This embraces laboratory, field, and analysis activities covering fundamental mechanisms, phenomenology, socioeconomic effects, strategies for control and safety, and comprehensive assessment (LLNL, 1986c, 1989m, 1990h, 1990i).

Hazards Assessment

The hazards of this work include radiological, chemical, and biological hazards. Radiological concerns include a Cesium-137 Irradiation Facility with a 4335 Ci 137Cs source; and the use in various laboratories of tritium, carbon-14, phosphorus-32, sulfur-35, strontium-85, and iodine-125. Chemical hazards include the usual laboratory chemicals and, in addition, a number of toxic and carcinogenic materials. These include benzene, toluene, xylenes, and phosgene, among others. Biological work includes experiments with materials up to Biosafety Level 2, which term is defined by the National Institutes of Health, the Center for Disease Control, and the National Cancer Institute to include agents of moderate potential hazard such as *E. coli* K12, mouse tissues, untransformed normal human cell lines, fixed samples of human tissue, and work with experimental animals (mice). It excludes human tumor cells and potentially infectious cells and secretions.

Generated Wastes and Effluents

Biological wastes are sterilized in autoclaves, except for those containing carcinogens. These are inactivated chemically or, when this is not possible, disposed of in an appropriately labeled carcinogen/radioactive waste container.

Liquid and solid wastes are placed in containers designated for the purpose for later pickup by Hazards Control personnel. Some sinks and floor drains are piped directly to retention tanks to hold wastes temporarily until analysis for pH and activity can be made. Retention tanks are not used for carcinogens and toxic materials; only liquids that can be pH-adjusted and otherwise made to conform to sewage discharge limits are permitted in these tanks.

Toxic waste is bagged, labeled, and transferred to the local toxic waste holding area. Carcinogens are packaged and transferred directly to toxic waste control. Animal carcasses are double-bagged and kept in freezers until they are picked up by Hazards Control.

A.1.4.31 Building 391

The Inertial Confinement Fusion Laser Facility, Building 391, is located in the north central section of the LLNL Livermore site. This 188,161 sq ft building houses the NOVA laser fusion irradiation facility. The building contains a master oscillator room and film calibration facility; a laser bay and switchyard; a ten-beam target bay; a NOVA two-beam target bay; and NOVA power conditioning and control systems (LLNL, 1991u).

In FY 1994, activities will begin to prepare for the NOVA-Upgrade/National Ignition Facility. The internal arrangement of the building will be modified over a several year period, and a larger, more powerful laser system will be assembled (see section A.1.5.3, NOVA-Upgrade/National Ignition Facility Planning and Design, Fiscal Year 1993).

The maximum allowable tritium inventory will be 5 g (see section A.1.5.3, NOVA-Upgrade/National Ignition Facility Tritium Limits).

Hazards Assessment

The hazards at Building 391 are associated with laser beams; high voltage; falling or exposed objects; oxygen deficiency if the laser amplifiers or the nitrogen distribution system are open; explosion of components; hazardous radiation in the form of neutrons and x rays; possible contamination of the target chamber with tritium, beryllium, and other materials; remotely operable rotating equipment; and vacuum and pressure systems (LLNL, 1991d).

Because of the many hazards present, this facility has several extensive operational and safety controls. These controls include a safety interlock system that controls access to hazardous areas; electrical equipment designed with shielded cables and connectors and interlocked housings to prevent inadvertent electrical shock; warning announcement and light systems; work prohibitions beneath any heavy equipment not securely fastened in place; and an air-handling system designed to provide fresh air and prevent oxygen depletion. Operational safety procedures are followed for each experiment and appropriate signs are posted on equipment and access doors.

Generated Wastes and Effluents

The generated wastes include hazardous wastes and low-level radioactive wastes containing tritium, thorium, and deuterium (LLNL, 1991u).

A.1.4.32 Building 411

The Central Stores, Building 411, is located in the southeast quadrant of the LLNL Livermore site. This 72,997-sq-ft building is managed by the Supply and Distribution Department and handles all onsite receiving, storage, and offsite shipment of materials (LLNL, 1991h). This facility is also used for loading and transportation of properly packaged DOT Class C explosives from listed receiving points to LLNL, as a backup for LLNL Site 300 high explosives transportation (LLNL, 1990al). The eastern end of Building 411 is a shop area where metal plates and rods are cut to the size ordered.

Hazards Assessment

The hazards are associated with accidental spill of materials during transportation and handling. The building is equipped with fire alarms and sprinkler system, and in general, any accidental spills are cleaned and disposed of by Hazardous Waste Management. No radionuclides are handled here. The transportation of DOT Class C explosives presents a minimum hazard to personnel and property. Properly packaged DOT Class C explosives will withstand the rigors of transportation without incident (LLNL, 1990al). The hazards in the shop area include the use of cutting tools, solvents, cutting fluids, epoxies, and coolants.

Generated Wastes and Effluents

The generated wastes from the storage and shipping areas may include any accidentally spilled materials and contaminated wipes. The shop area generates spent flammable liquids, epoxies, and used coolant. The generated liquid wastes are stored in a waste accumulation area.

A.1.4.33 Building 412

Building 412 is located in the southeast quadrant of the LLNL Livermore site. The major portion of this 28,093-sq-ft building is currently used for environmental research and includes service shops and laboratories in which experiments involving lasers and spectrometers are conducted. Other experiments involve extremely high temperatures and pressures.

The eastern section of the building contains six hot cells that are currently unused. These cells and the associated air filtration/scrubber system are contaminated with low levels of mixed fission products and are in caretaker standby condition with a maintenance and monitoring program (LLNL, 1990ak, 1989f).

Hazards Assessment

Various toxic chemicals and radioactive materials are used in experiments involving lasers, spectrometers, high temperatures, and high pressures. The specific chemicals used include hydrogen chloride gas, methane, and chloroform. Radioactive materials used are cobalt-60 sources, and carbon-14 labeled trichloroethylene (TCE) and chloroform. Both TCE and chloroform are toxic, and chloroform is also a carcinogen. Carbon-14 is a low energy beta emitter that does not require shielding (LLNL, 1990ak).

Other worker hazards involve potential injury to eyes or skin from exposure to laser beams, electricity hazards, and hazards with chemicals used in column chromatography.

Generated Wastes and Effluents

Only small quantities of wastes are generated in this building. Liquid wastes generated consist of chemicals, vacuum pump oil, and spent solvents. Wastes are placed in a waste accumulation area north of the building (LLNL, 1990ak).

Small quantities of gaseous effluents include chlorinated solvents, chloroform, toluene, and benzene (LLNL, 1991a).

A.1.4.34 Building 490 Complex

This complex of buildings, located in the northern quadrant of the LLNL Livermore site, includes Buildings 490, 491, 492, 493, and 494. These buildings support operation of two laser technology program facilities: the laser demonstration facilities (Buildings 490, 492, and 494), and the separator demonstration facilities (Buildings 490, 491, 493, and 494), as well as related research and development activities. Chemical processing may also be performed in Building 494. The buildings total 219,450 sq ft (LLNL, 1987g, 1990at, 1989o).

The operations performed at the 490 complex support both the Atomic Vapor Laser Isotope Separation process for uranium enrichment and waste treatment development activities. Metallic uranium is vaporized within a crucible in the separator and is illuminated by red-orange dye-laser light, selectively photoionizing the uranium-235 isotopes (LLNL, 1987g). The positively charged uranium-235 is preferentially extracted on negatively charged collector plates. The nonionized atoms proceed through the extractor region and are collected on roof plates. These two streams, one enriched and the other depleted in the isotope U-235, are drawn off as liquid, cast, and stored for later use.

The Laser Demonstration Facility includes a complete laser system, optics instrumentation support facilities, utility systems, refurbishment facilities, and the optical transport system required to demonstrate fully integrated uranium enrichment laser system operation at plant scale. Building 490 contains the main laser corridors, laser control room, central computer system, dye/optics assembly facility, copper-laser refurbishment facility, copper-laser oven/dry room, a dye laser system, and small mechanical and electrical workshops and assembly rooms. The Dye Pump Annex, Building 492, houses all the pumps, filters, piping, and equipment for the dye-amplifier pump systems as well as chiller systems for copper and dye laser systems. Stainless steel piping is employed underground between Buildings 490 and 492 for transporting mixed dye and ethanol and is the primary storage reservoir (LLNL, 1987g). Building 494 houses the assembly work supporting copper laser assembly and is "light industrial" in nature.

The Separator Demonstration Facility in Building 490 contains the uranium separator and areas for receipt, inspection, and storage of the separator pod assemblies and parts. Pods are transported for refurbishment from Building 490 to Building 491 through an enclosed transporter equipped with a high efficiency particulate air filter and an inert gas supply.

Building 491 houses the separator pod disassembly area, oxidation ovens, grit blasters, coating equipment, change rooms, a receiving and shipping area for component storage and assembly of sealed containers of natural or depleted uranium, and of small quantities of enriched uranium as well. During refurbishment, separator pods are disassembled and cleaned, uranium alloy is removed from separator components, and components are refurbished and/or replaced for use in the separator demonstration facility.

Building 493 is used primarily for component storage and assembly, as well as sealed storage of AVLIS feed, classified materials and low-level radioactive wastes. A second activity in Building 493 is off-line development and testing of components and subsystems that do not involve vaporization or open handling of uranium or uranium alloy. Other materials and equipment in this building include uranium-free separator pods and parts, electronic instrumentation, equipment and supplies for refurbishment in Building 491, and Separator Demonstration Facility equipment (LLNL, 1991k). Building 493 may store up to 80,000 kg of uranium at one time. Building 494 is used primarily as a warehouse for materials and equipment storage. It may also be used for waste treatment development activities. This may include such operations as sorting, cleaning, pyrochemical treatment, and aqueous treatment.

Hazards Assessment

Hazards associated with operations in the Building 490 Complex result from the presence of high-power electrical systems; high-power laser beams; ionizing radiation; toxic substances such as heavy metals, corrosives, salts, laser dyes, uranium in molten, solid, and oxidized condition, asphyxiants (e.g. nitrogen, Freon, etc.), alumina dust, acids, and flammable liquids. Features that mitigate these hazards include design of the separator chamber walls to provide protection against x rays; operation of ventilation systems, including high-efficiency particulate air filters during refurbishment operations; design of the refurbishment equipment and procedures to control the spread of radioactivity; and design of the separator to safely contain accidents involving molten uranium-water reactions or a breach of the separator vacuum vessel (LLNL, 1987g).

Operational safety requirements limit the uranium-235 enrichment to 5 percent; the quantities are also limited to less than a minimum critical mass as specified in ANSI standard 8.1-1983.

Generated Wastes and Effluents

Liquid wastes containing low levels of uranium are collected in carboys. Wastewater drains into the 2000-gal underground wastewater retention tank. Approximately 80 percent of the input material becomes scrap uranium-bearing items that are collected, stored, and disposed of in accordance with the LLNL Hazardous Waste Management Program (LLNL, 1990at).

Used dye/alcohol solution is pumped to 55-gal stainless-steel drums or tank trailers. Solid wastes, including dye filters, are sent to Hazardous Waste anagement for disposal.

Wastes are generated from processes using molten salts, aqueous solutions, acids, bases, gas scrubbers, and organic materials such as solvents and oils. Wastes from these processes are disposed of in designated drums in the waste accumulation areas.

Wastewaters used for cleaning optical components are placed in a designated drain leading to a 210-gal holding tank located in a metal-floored shed by the northeast corner of Building 490. The tank is equipped with a level sensor and an alarm. Wastewaters consist of acetic acid solutions and other associated rinsewaters.

Buildings 490 and 491 contain Freon, which is used as a heat transfer and electrically insulating medium (LLNL, 1987g). Fugitive Freon emissions are abated using controls approved by the Bay Area Air Quality Management District (BAAQMD).

The emission control system uses best available control technology based on a low- temperature vapor condenser as described below.

- To control losses due to displaced vapor when filling a tank, the dead spaces of the sending and receiving tanks are connected in a closed system. To prevent pressure buildup in the tanks during these transfers, check valves allow vapor flow into the vapor recovery condenser. This way emissions to the atmosphere due to vapor displacement are controlled. The Freon system can breathe in air as needed to prevent negative pressure conditions.
- A major "potential" source of emissions is the release of Freon vapor from the enclosures after they are opened. These emissions are reduced by draining and evacuating the enclosure. The vacuum pump discharge is routed to the vapor recovery condenser.
- Fugitive emissions are minimized by draining all lines and venting them to the condenser before opening. This includes Freon handling components opened for maintenance.
- The vapor recovery condenser is the emissions abatement device for the entire Freon system. The condenser, operating at -26·F, is able to recover 96 percent of the Freon.

Data for 1989 indicated that an average of 41 lb were lost daily to the environment (LLNL, 1989o). Improved Freon vapor capture capabilities were installed in 1990 and 1991, and new equipment requiring cooling is being designed to operate with alternative coolants.

Freon used as an electrically insulating coolant may be degraded by electric arcing of the components. Freon that is suspect of degradation is pumped from electronic equipment to an outdoor storage tank. Most used Freon has little to no high-voltage degradation and is pumped to the same waste Freon storage tank located in a bermed outdoor storage area. This Freon is returned to the supplier for distillation and eventual reuse by LLNL (LLNL, 1990d).

A.1.4.35 Building 511

The Crafts Shop, Building 511, is located in the southeast quadrant of the LLNL Livermore site. This 75,480-sq-ft facility is used as a crafts shop for electrical and mechanical equipment assembly, disassembly, and repairs.

This facility supports the LLNL Livermore site field operations, including routine electrical equipment inspections; repair and installation in electrical/communication vaults, manholes, and trenches (LLNL, 1990au); repairing refrigerant tubing (LLNL, 1990av); disassembly, repair, and maintenance of vacuum pumps (LLNL, 1990aw); and visual inspections, maintenance, and electrical installations in manholes and underground vaults (LLNL, 1988m).

Hazards Assessment

Hazards associated with operations in this facility include the use of potential flammable atmospheres, oxygen deficiency atmospheres, asbestos, or PCB oils; zinc or cadmium present as a plating material causing toxic fumes when exposed to flames; the use of fluorocarbon refrigerants, which when heated break down chemically into hydrofluoric acid, hydrochloric acid, phosgene, and other toxic vapors; vacuum pumps that are contaminated with beryllium, mercury, radioactive materials, heavy metals, and toxic compounds; and electrical shock hazards to the personnel.

Strict operational and safety controls are followed to avoid the many hazards associated with the field operations. Some of the controls include proper ventilation of manholes and vaults during work activities; cleanup of asbestos and PCB oils is performed under proper guidance from Hazards Control; personnel will not enter any confined space where tests show any flammable atmosphere or reduction of normal oxygen; refrigerants are removed from the tubing being repaired to avoid exposure to heat; safety eye protection and gloves are required; the vacuum pumps are decontaminated before being sent to Building 511 for maintenance and repairs; and the decontaminated vacuum pumps are repaired in a ventilated enclosure equipped with a catch tray or edge curbs to contain spilled oils.

Generated Wastes and Effluents

The wastes generated from the activities at Building 511 include solvents, contaminated oils, and equipment cleaning rinsewaters. All contaminated wastes are handled by Hazardous Waste Management for proper treatment and/or disposal.

A.1.4.36 Building 518

The Gas Cylinder Dock, Building 518, is located in the southeast quadrant of the LLNL Livermore site. This facility is a storage dock area for gas cylinders, solvent drums, and oil drums. The total gross area for the building is 3,263 sq ft. It supplies industrial gases, chemicals, liquids, and petroleum products to LLNL users.

Hazards Assessment

The hazards at this facility are primarily associated with handling compressed gas cylinders and with the presence of large quantities of various industrial chemicals.

Generated Wastes and Effluents

This facility is used primarily as a loading dock and storage dock. There is a small amount of hazardous waste generated from the cleanup of spilled chemicals. The waste is moved to the waste accumulation area at Building 411 for storage.

A.1.4.37 Building 520

The 400 sq ft Pesticide Handling and Storage Building, Building 520, is located in the southeastern portion of the LLNL Livermore site, and is used for the storage of herbicides, insecticides, and rodenticides in varying quantities. At any one time, about 80 percent of the materials are stored in steel cabinets. The building is constructed of galvanized sheeting over steel framing (LLNL, 1991z).

Hazards Assessment

The hazardous materials involved at this building are herbicides, insecticides and rodenticides. Licensed personnel mix and dilute pesticides in a work area next to Building 520. All mixed pesticides are used at the LLNL Livermore site in accordance with labeled instructions. The empty spray tanks are rinsed, and the rinsewater is sprayed out on other target areas. All empty containers are rinsed three times and stored in a steel box until picked up (LLNL, 1991z).

Generated Wastes and Effluents

Liquid wastes generated at this facility include pesticide-contaminated rinsewaters. The wastes are stored in 55-gal containers in an adjacent waste accumulation area until picked up by Hazardous Waste Management. Solid wastes (outdated pesticides) are tagged and sent to Hazardous Waste Management for proper disposal. Empty triple-rinsed pesticide containers are taken to the Pleasanton refuse transfer station every Tuesday, where they are inspected by the Alameda Agricultural Department prior to disposal (LLNL, 1991z, 1987f).

A.1.4.38 Building 622

The Propane Air Plant, Building 622, is located in the southeast quadrant of the LLNL Livermore site. This 1,535 sq ft building and the three associated 30,000-gal liquid propane tanks provide backup utility service for LLNL boilers and heaters. Substitute fuel gas is produced by vaporizing liquid propane, diluting it with compressed air to the same specific heat as natural gas, and then metering it into the gas pipeline which serves both LLNL and SNL, Livermore.

The propane gas system is operated only for PG&E curtailments and for testing and operating training. The system is started up four times a year to ensure that it works properly and that the mechanical components are exercised and that all boilers and heaters operate satisfactorily. The tests are also used to train the operators. Twice a year propane-air gas is supplied to the entire laboratory, and twice a year the plant is run only on the flare stack. The tanks are normally kept empty and only one tank is filled or partially filled for curtailments, testing, and training.

The entire propane plant is a stand-alone operation equipped with:

- An emergency generator for electrical power.
- Compressed nitrogen for instrumentation and pneumatic valves.
- One boiler that operates on propane-air mixed gas or natural gas or methane gas cylinders.

Several upgrades have been made to the propane plant to remain in compliance with regulatory code changes. These upgrades have also improved the safety, reliability, and overall operability of the plant.

Hazards Assessment

Potential hazards include fire and explosion from propane and the propane tank system. Installed safety features include relief valves on all pressurized equipment (including the propane tanks, boilers, compressors, pumps, and the condensate tank), flame sensors on the boilers, a flame arrestor on the flare, and emergency shut-off valves at the propane loading area and propane tanks. During startup operation of the system, adherence to preventative maintenance schedules helps to locate mechanical and electrical problems prior to emergencies. A water spray protection system has also been installed on the tanks.

Generated Wastes and Effluents

Little hazardous waste is produced from this facility other than oil and hydraulic fluid used in the instrumentation, pumps, and one boiler. Small quantities of boiler blowdown are produced from the steam boiler and are discharged to the sewer. The compressors are housed inside a special room containing sound-absorbing materials. Fugitive air emissions are minimized by scheduled preventive maintenance.

A.1.4.39 Waste Management Facilities

The LLNL Hazardous Waste Management facilities at the LLNL Livermore site are as follows (for further detail, including section on hazards assessment, see Appendix B):

Building 233. The Materials Management Facility, Building 233, is located in the southwest quadrant of the LLNL Livermore site. This 4900 sq ft building is used for the storage of controlled materials and wastes, and contains one office. The storage area includes a vault, several secured rooms, and an adjoining fenced-in canopy area along the east side of the building.

Building 419. The Size Reduction and Solidification Facility, Building 419, is located in the southeast quadrant of the LLNL Livermore site. The building size is 7687 total sq ft, of which 1504 sq ft is office space. This facility has been used for equipment decontamination, size reduction, and solidification of mixed waste. Due to seismic concerns, the facility is not in current use and is undergoing closure. A future solidification unit will be located in Building 332. This unit will solidify transuranium waste.

Building 514 Area. Building 514 Area, site of the liquid waste storage and disposal facilities, is located in the southeast quadrant of the LLNL Livermore site. Buildings 514 and 514A are located in this area. These buildings have a combined area of 4920 sq ft and house the wastewater filtration unit and the silver recovery unit. In addition, a wastewater treatment tank farm consisting of six 1800-gal treatment tanks, a 25,000-gal storage tank, and three retention tanks is located outside the facility. Storage areas 514-1, 514-2, and 514-3 are covered concrete pads.

Building 513 described below is also located in this area.

Building 513. The Container and Liquid Waste Storage Facility, Building 513, is located within the Building 514 Area in the southeast quadrant of the LLNL Livermore site. This facility has an area of 3500 sq ft, and houses a solidification operation, a mixed waste shredder, and a mixed waste storage area.

Building 612 Area. The Building 612 Area, is located in the southeast quadrant of the LLNL Livermore site, directly east of Building 514 Area. Buildings 612 and 614 within this Area have a combined area of 11,973 sq ft. This area is used to receive wastes from LLNL generators. It also houses the drum crushing operation for nonradioactive containers, provides mixed and radioactive waste storage areas, provides a space for the labpacking operation for nonradioactive hazardous waste, provides space for the bulking operation for corrosive waste, and houses the waste compacting facility. Areas 612-1, 612-2, 612-3, 612-4, and 612-5 are used to store wastes and containers. These storage areas are fenced; some have enclosed tents. Area 612-3 is undergoing closure. Buildings 624 and 625 described below are also located within the Building 612 Area.

Building 624. Building 624 is located in the southeast quadrant of the LLNL Livermore site inside Building 612 Area. The 240 sq ft building houses offices for technicians, and adjacent to the building are storage areas (612-2) for hazardous and mixed wastes. This building was previously used as an incinerator which was approved for dismantling and removal in 1991.

Building 625. The waste storage and shipping facility, Building 625, is located in the southeast quadrant of the LLNL Livermore site at the north end of the Building 612 Area. The 4800 sq ft building houses the handling and storage of non-RCRA wastes such as polychlorinated biphenyls (PCBs), asbestos and transuranic wastes. Plans are to move the PCB and asbestos waste to Building 693 when the real time radiography facility (RTRF) equipment is constructed in Building 625.

Building 693. The chemical waste storage facility, Building 693, is located in the northeast portion of the LLNL Livermore site, and replaces the hazardous waste drum and container storage area (Building 612-3). The 9600 sq ft building contains four bays, each 30 ft by 80 ft.

A.1.4.40 Security, Medical, and Emergency Response Facilities

Security

The Security Facility, Building 271, is located in the central portion of the LLNL Livermore site. This 13,780 sq ft facility houses routine security and emergency response services. The Safeguards and Security Program is designed to establish an effective system of safeguards and security measures, to maintain employee security awareness and training, and to monitor system procedures and plans to keep consistent with DOE regulations.

Routine security services include access controls, fixed access, and surveillance points, random vehicle and foot patrols, response elements, and response team elements. Emergency response services provide contingency plans for work stoppages, bomb threats, natural disasters, sitewide evacuations, call-out procedures, satellite command center activation procedures, executive protection, special nuclear material alarm response procedures, non-special nuclear material response procedures, and civil disorders.

Medical Facilities

The Health Services Department, Building 663, is located in the eastern portion of the LLNL Livermore site. This 24,560 sq ft building houses a comprehensive occupational health program designed to provide optimal clinical and preventive medical support for the employees at LLNL. The services provided include evaluation and initial treatment of medical emergencies, limited medical and x-ray studies, physical/occupational therapy, and health education/health promotion activities.

The Health Services Department provides services in compliance with all applicable state and federal laws and accepted standards of medical and nursing practice. Injuries and illnesses are reported to the Health Services Department during working hours. The Fire Department provides ambulance services 24 hours a day, 7 days a week.

Biomedical wastes generated from this facility include needles, syringes, gauze, gloves, and other materials that could be contaminated with infectious agents. Spent alcohols are also generated. All wastes are handled by Hazardous Waste Management for proper disposal.

Emergency Response

The emergency response facilities include the Emergency Operations Center, Building 313, the Fire Department Emergency Dispatch Center, also in Building 313, the Fire Station, Building 323, and a number of satellite command centers located throughout the Laboratory. In case of an emergency, telephone communications link the command center with the satellite command centers. There are additional radio communications as backup for the redundant phone communications. (Refer to Appendix J for details on the emergency planning and response procedures.) Buildings 313 and 323 are located in the southwest quadrant of the LLNL Livermore site, the size of these facilities is 4339 sq ft and 25,662 sq ft, respectively.

A.1.4.41 Offsite Leased Properties

LLNL conducts limited activities at various leased properties described below and listed in Table A-2 (LLNL, 1991b). The nearby offsite leased properties are shown on Figure A-3. These properties provide support services (e.g., office space) similar to those found in facilities onsite (such as the office facilities illustrated in Table A-2). LLNL-related operations contribute little if any environmental effects at these sites. The facilities are briefly described as follows:

- A 40,000 sq ft storage area at the Camp Parks facility in Dublin, California. This facility stores equipment and office furniture.
- 2020 Research Drive in Livermore, California, is a combination office and training area for the property management group. The 10,148 sq ft leased space includes 3260 sq ft of office space and 2698 sq ft of training area.
- The Almond Avenue Site in Livermore, California, is a combination office, childcare, and classroom facility totaling 30,700 sq ft. This facility also contains a small classroom laboratory.
- Graham Court in Livermore, California, is a storage warehouse with a small service shop for the assembly of laser components. The total leased space is 23,028 sq ft, including 18,000 sq ft of storage area, 2800 sq ft of service shop, and 280 sq ft of office space.
- The F27 hangar at the Livermore Municipal Airport is a storage hangar for an airplane shuttle to and from the Nevada Test Site located north of Las Vegas, Nevada. The total leased space is 20,620 sq ft and includes 177 sq ft of office space.
- A leased office space in Los Angeles, California.

Another LLNL offsite leased property is an office space, located in Germantown, Maryland.

A.1.5 Program Projections, the LLNL Livermore Site

This section describes the projects and program projections under the proposed action for the LLNL Livermore site. Projects required to maintain the existing infrastructure (such as building maintenance, minor modification to buildings, general landscaping, road maintenance, and similar support activities) under the no action alternative are also described here. These projects are described in sections A.1.5.1, A.1.5.2, and A.1.5.3, respectively. New facilities are summarized in Table A-3, and upgrades, operational, and maintenance projects are summarized in Table A-4. The proposed operational modifications are also summarized in Table A-4. Figure A-8 shows the locations of these projects.

A.1.5.1 Funded Construction Projects, the LLNL Livermore Site

The fiscal year (FY) next to the project name is defined as the year funding starts or started for project design. It is reasonable to expect that these projects would be funded in the fiscal year cited for each project.

Decontamination and Waste Treatment Facility, Fiscal Year 1986

The Decontamination and Waste Treatment Facility would replace and vastly upgrade the waste management facilities at LLNL that are currently used to process, treat, and store hazardous, radioactive, and mixed wastes. The Decontamination and Waste Treatment Facility would be a waste management complex capable of treating about 75 percent of treatable wastes compared with the approximately 10 percent that is currently treated.

Hazardous, low-level radioactive, and low-level mixed wastes that are generated by LLNL programs would be received for consolidation, processing, treatment, and packaging before offsite shipment and disposal. Enclosed interim storage would also be provided. Combustible, organo-mixed wastes, both liquid and solid, originally intended to be incinerated, will not be treated at this facility. Alternative technologies for such wastes are in the research and development stage and may become the basis for a separate mixed waste treatment facility.

The Decontamination and Waste Treatment Facility would consist of several buildings of varying size and function that would form a fully integrated complex. The largest, in both size and number of operations, is the Waste Treatment Building. This building will house mixed and hazardous aqueous waste treatment equipment, an organic liquids bulking facility, an acid/base neutralization facility, silver recovery equipment, and activated carbon filtration units. Process control and monitoring systems and a process chemistry laboratory will also be included in the building.

Other buildings and operations in the complex include decontamination; receiving, classification and solid waste processing; reactive waste materials treatment and storage; radioactive and clean storage; and operational support. The Operational Support Building is the entry point into the complex and provides office space, conference and training rooms, a library, records storage, and a computer center. Although not a part of the Decontamination and Waste Treatment Facility, the recently completed Chemical Waste Storage Building is also located within the complex. Safety Analysis and environmental documentation specific to the Decontamination and Waste Treatment Facility project will be prepared to analyze and assess project impacts. Air and RCRA permits will be obtained prior to the construction of the facility.

Figure A-8 Program projections at the LLNL Livermore site
Electric Power System Replacement and Upgrades, Fiscal Year 1991

This project proposes specific solutions for making electrical replacements and upgrades to the electrical utility infrastructure. These will result in a sufficient and reliable supply of electrical power, improved flexibility for operations and will provide for changes in power requirements (LLNL, 1989g, 1989h; DOE, 1991).

Most of the electrical utility facilities now in place at the LLNL Livermore site are the result of responses to programmatic and administrative needs over the past 40 years which have extended much of the existing electrical system beyond its original design capacity and which limit operational flexibility and capacity for added load growth.

This project will include:

- Electrical power system replacements and upgrades.
- Distribution system reliability improvements.
- Equipment and personnel safety corrections.
- Upgrade of the LLNL South Main Substation at Building 424.

Infrastructure Modernization, Fiscal Year 1992

The objective of the infrastructure modernization project is to rehabilitate and upgrade portions of the mechanical utility systems, sanitary sewer system, roads, and building roofs. The separate subprojects are as follows (LLNL, 1990x):

- Low-conductivity water system rehabilitation. This project consists of replacements for deteriorated equipment at the low-conductivity water station. The pumps, fans, and drives; tower fill material; intake louvers; drift eliminators; sprinkler piping; and corroded supports and fastenings will be replaced in the 40-megawatt cooling tower. Seven heat exchangers will be replaced, and the 100,000-gal deionized water storage tank will be replaced with three 30,000-gal corrosion-resistant tanks. The low-conductivity water system rehabilitation will require construction at Building 325.
- Domestic water system upgrade. Replacement of 8000 linear ft of 10-inch supply piping with 16-inch piping to upgrade supply reliability and flow rate from the Hetch Hetchy Mocho Pumping Station. In addition, a 700,000-gal water tank will be installed and an old 206,000-gal deteriorated tank demolished. This project will also upgrade the Zone 7 backup supply system with two new fire-rated pumps. A third pump will provide pressure regulation service.

Tank Upgrades, Fiscal Year 1992

This is a required project to assure that LLNL tank systems meet the environmental regulations enacted to prevent the accidental release of hazardous substances into the atmosphere, soil, surface water, and ground water (LLNL, 1990r).

The LLNL Livermore site and LLNL Site 300 maintain over 300 tanks serving as storage vessels for various types of materials: products, hazardous waste, nonhazardous waste, mixed wastes, rinsewater retention tanks, and water tanks. They range in size from 17 gal to over 100,000 gal, though most are 250 to 10,000 gal. This project includes 124 tank systems, 12 of which are no longer required and will be closed. The remaining 112 systems will be upgraded (retrofitted or replaced).

Laser Guide Star Experiment, Fiscal Year 1992

This project would conduct research and demonstration of a technology for overcoming the atmospheric distortion that has traditionally limited ground-based astronomical images, by producing telescopic images as high in resolution as if the telescopes were located in space (DOE, 1992).

The demonstration would project a laser beam from the Laser Demonstration Facility, Building 490, up through the atmosphere into space, and create an "image" or guide star by exciting sodium atoms concentrated in a natural band at an altitude about 60 miles above the Earth. The yellow glow of the excited sodium atoms would be a constant-point light source that would allow corrections for astronomical distortions.

Sanitary Sewer Rehabilitation Project, Fiscal Year 1992

The sanitary sewer system was installed in stages as the site developed and expanded. It is constructed primarily of vitrified clay pipe, and contains a total of 56,715 linear ft of main sewer lines, 39,865 linear ft of laterals, and 235 manholes (LLNL, 1990ba).

A comprehensive master plan in 1989 assessed the condition of the sewer system. An infiltration study and a video camera inspection were conducted for 11,600 ft of sanitary sewers throughout the site. The infiltration study and the video investigation has shown that exfiltration (leakage) of wastewater is possible from the LLNL sewer lines. The sanitary sewer rehabilitation project aims at reducing the infiltration and exfiltration problem.

The project will consist of the following:

- Video camera evaluation of the complete sanitary sewer system.
- Application of two types of sewer rehabilitation: inversion lining and replacement.

- Division of the LLNL Livermore site into eight sewer basins.
- Preconstruction. Prior to construction, a detailed determination of conditions will be made. This will determine the length of pipe to be replaced or rehabilitated. This determination will involve video camera inspections of all main lines and laterals, and a field survey to establish the locations and invert elevations of all mains and laterals.
- Postconstruction. Upon completion of rehabilitation replacement work, a closed- circuit television inspection will be performed to provide a reference for future maintenance work.

The rehabilitation priorities will be placed on areas with a history of maintenance problems. Both rehabilitation techniques and replacement of pipes will be used for corrective work. The method selections will be refined upon the analysis of the results of the preconstruction television inspection.

There are numerous physical and operational constraints associated with the design and construction of this project. Physical constraints include problems assessing the existing sanitary sewer system, numerous utilities which share the same corridors with the sanitary sewer system, and security boundaries which will affect the sequencing of construction activities. Operational constraints include the impact of the construction on the lab operations. Bypass pumping and weekend construction will be planned to mitigate this impact.

A.1.5.2 Budgeted Construction Projects, the LLNL Livermore Site

The following construction projects are budgeted but not yet funded. It is reasonable to expect that these projects would be funded in the fiscal year cited for each project.

Inertial Confinement Fusion Users Support Facility, Fiscal Year 1993

This facility would provide a laser optics support laboratory and clean room assembly areas. The project supports the ongoing inertial confinement fusion program by providing experiment preparation and support areas (LLNL, 1991e).

Large and often delicate equipment and materials would be routinely received at the facility from outside vendors and exchanged with Building 391 NOVA experiment areas. The building design would include safety, environmental, energy conservation, and workplace environmental considerations.

Genomics Research Laboratory, Fiscal Year 1993

The genomics research laboratory would support the human genome project for the Biomedical Environmental Research Program. The building would be organized into laboratory and office areas (LLNL, 1991e).

Modifications for Energy Management, Fiscal Year 1993

The in-house energy management retrofit and metering project consists of energy conservation and efficiency retrofit projects to reduce LLNL's energy consumption and energy costs. Types of projects include high efficiency lighting systems; enhanced heating, ventilation, air conditioning control systems; cogeneration systems; thermal energy storage; and alternate fuel projects. Electric power metering projects are also included (LLNL, 1991e).

Atmospheric Emergency Response Facility, Fiscal Year 1993

The proposed facility would house the Atmospheric and Geophysical Sciences Division. This is the focal point for atmospheric research at LLNL and includes the atmospheric release advisory capability, a project that serves the emergency preparedness needs of the Department of Energy, Department of Defense, and other federal and state agencies (LLNL, 1991e).

The facility would include the following seven areas:

- Climate and climate change group. This group evaluates the effects of changes in atmospheric composition of climates.
- Radiation and global chemical interactions group. This group studies the radiative, chemical, and dynamic processes that determine the global atmosphere.
- Atmospheric microphysics and chemistry group. This group is concerned with the radiative and chemical interactions of chemical species injected into the lower atmosphere.
- Mesoscale and fluid dynamics group. This group develops improved fluid dynamics models to describe atmospheric transport and diffusion processes.
- Heavy gases and toxic group. This group conducts research on heavy gas dispersion by means of field experiments and model development.
- Model applications and nuclear effects group. This group improves the models for specific applications and performs environmental impact assessments of actual nuclear events.
- Atmospheric Release Advisory Capability (ARAC) Group. This group is responsible for development and operation of the division's capabilities for responding in cases of accidental releases of radionuclides and toxins.

The first six areas focus on the research and development activities, while the seventh (ARAC Group) supports emergency response capabilities.

The proposed facility is a 2-story building with a penthouse. It would have a gross floor area of approximately 40,000 sq ft. The building would include offices, computer space, an operations center and other support spaces to house the Atmospheric and Geophysical Sciences Division research activities.

The facility would be an office-type building; it would use power and water and would generate domestic sewage and office-type waste. There would be no use of hazardous materials and no hazardous or radioactive wastes would be generated in this facility. The building would be located in the west central area of the LLNL Livermore site, near Building 174. The facility would replace several 25-year-old trailer complexes that are deteriorating but currently house the Laboratory's Atmospheric and Geophysical Sciences Division.

NOVA-Upgrade/National Ignition Facility Planning and Design, Fiscal Year 1993

Building 391 would house the Inertial Confinement Fusion facility, known as NOVA-Upgrade/National Ignition Facility. The NOVA Laser Facility is currently housed in this building. In FY 1995, activities would begin at Building 391 to prepare for the upgrade facility. The internal arrangement of the building would be modified, and a larger, more powerful laser system would be assembled. In addition to a complete laser system, the building would house a target area (target chamber room), optics instrumentation, utility systems, laser component refurbishment facilities, a control room, a computer system, and a limited number of offices. NOVA-Upgrade/National Ignition Facility would be operational in the October 1998 to December 1999 time frame (Stone, 1991; LLNL, 1991w).

The facility would be used to advance the understanding and demonstrate the scientific feasibility of inertial confinement fusion. The planned experiments would begin at a level similar to the present NOVA target experiments (yield of less than 40 J). Later, the program would address ignition, propagation, and burn in higher yield experiments (yield of less than 20 MJ).

In the facility, fuel pellets containing tritium and deuterium would be illuminated with laser light in the target chamber. The x-ray induced energy would ablate the pellet surface, causing compression and heating of the pellets to thermonuclear burn conditions. Some fraction of the tritium (less than 30 percent) would be consumed in fusion reactions within the pellet. The remainder would be exhausted to a tritium collection system. Here, the tritium would either be oxidized and adsorbed on a molecular sieve bed or collected as a metal hydride, and then would be disposed of according to existing regulations.

Fuel pellets, containing tritium and deuterium, would be provided for the experiments from Building 298 or an offsite location. The maximum quantity in transit between the two buildings at any time would be no more than 2 Ci (0.2 mg). Transport to Building 391 would take place in certified shipping containers. These would be high-pressure, stainless steel containers with secondary containment (Stone, 1991).

During the operation of NOVA-upgrade/National Ignition Facility when tritium will be used, some will accumulate in the facility. As the inventory in Building 391 increases, the inventory in Building 298 will decrease correspondingly, keeping the proposed combined inventory at or below 5 g.

Some amount of tritium would be retained on the target chamber walls. Periodic decontamination of the chamber interior of tritium would be required (as on Nova) to minimize contamination of material or personnel.

Neutrons emitted in fusion reactions interact with all exposed materials and result in residual radioactivity. The chamber shielding and the thick walls and roof of the facility prevent any significant dose to the public from unattenuated neutrons and prompt gamma rays. The public would also be completely shielded from residual radiation from the facility (ICF, 1991).

Worker access to the experiment area would be restricted until 24 hours after a 100 kJ yield shot. With the shielding provided, this period is adequate to allow for the decay of sodium-24 created from the activation of the aluminum alloy chamber, and space frame and the concrete (ICF, 1991). The dose rate would then be at a level consistent with the occupational exposure goal (200 mrem/yr). A longer delay period would be required before re-entry for higher yield shots. Other structures in the target area would also activate and provide a potential source of dose to re-entering workers. The surface dose rates at these locations would also be at a level consistent with the occupational exposure goal.

Some activation of air in the target area can be expected. After a 20 MJ shot, approximately 30 mCi of argon-41 would be produced. Release of this air to the environment immediately after a shot would present an insignificant hazard to the public. If this air is circulated and mixed in the ventilation system, this would bring the concentration of argon-41 in the target area to acceptable levels within hours after a target shot (ICF, 1991).

NOVA-Upgrade/National Ignition Facility would have five systems for radiation monitoring (ICF, 1991). The Remote Area Monitoring System would be located in the target area and control rooms. The Continuous Air Monitoring System would be used to alert personnel of unusual levels of airborne radioactivity, including tritium, in the target room and in the tritium handling facilities. Effluents exhausted from the target and tritium rooms would be monitored for quantities of radioactive gas. Portable radiation survey meters would be used during re- entry into the target room and during maintenance on the target chamber, as is done currently on NOVA following shots with significant neutron yield. Finally, the NOVA interlock and personnel access system will be upgraded as appropriate to enhance personnel protection.

Additional hazards associated with NOVA-Upgrade/National Ignition Facility include the high-power laser system itself, a high-power electrical system, and optics cleaning chemicals. Features to mitigate these hazards include operation of the ventilation system, safety equipment, training of staff, and administrative controls.

Solid low-level radioactive waste generated at NOVA-Upgrade/National Ignition Facility would include the target debris, the ablated/fractured disposable target stalk section, and the recondensed first wall material. The estimated annual solid waste generation is 25 g of lead, approximately 24 kg of carbon, 5 g of cryogenic support materials, and approximately 1 kg of aluminum, for a total of about 25 kg, most of which is carbon (ICF, 1991). Low-level tritiated solid wastes would include shrapnel and condensed material ablated from the target positioner, first wall, and cryogenic system. In addition, there would be the tritium in the target chamber exhaust collection system.

Liquid waste would consist of solvents used to decontaminate the chamber first wall and to clean condensates from the blast shields. Although the waste solvent would be classified as mixed waste because of the tritium contamination, the hazard level would be very low. About 20 gal of solvent are required to scrub the first wall (ICF, 1991). Cleaning of debris shields may be required on a bi-weekly basis. One gallon of ethanol would be used to clean the shields, giving an annual mixed waste quantity of about 500 gal of ethanol. These wastes would be temporarily stored in appropriate leak-proof, labeled containers and then transferred to Hazardous Waste Management for disposal.

<>Buildings 332 and 334 Plutonium Administrative Limits, FY 1993

LLNL is currently reducing the plutonium administrative limit for the combined Buildings 332 and 334 from 700 kg to

200 kg, with the inventory (actual inventory quantities are classified) being reduced accordingly. The reduction will be accomplished by shipping inventory to offsite DOE facilities and is targeted for completion during Fiscal Year 1993.

Building 331 (Hydrogen Research Facility) Tritium Limits, FY 1993

This proposed operational modification project would eventually decrease the tritium limits from 300 g to 5 g to accommodate programmatic changes in Building 331, the Hydrogen Research Facility.

Appendix A Part 3

A.1.5.3 Proposed Construction Projects

The following construnction projects are proposed but not yet funded. It is reasonable to expect that these projects would be funded in the fiscal year cited for each project.

Verification, Intelligence, and Special Technology Analysis (VISTA) Center, Fiscal Year 1994 (formerly Foreign Technology Assessment Center, Fiscal Year 1993)

This facility would provide for the Non-Proliferation, Arms Control and International Security's (NAI) expanding activities in making the technological capabilities and knowledge of LLNL available to the U.S. Intelligence Community. In addition, it would coordinate LLNL's emergency preparedness and response functions (LLNL, 1987d).

The new facility would provide offices and various work spaces for LLNL's Non-Proliferation, Arms Control and International Security Program. The program now occupies Building 261 and some adjacent temporary units. A series of building additions over the years have provided for successive programmatic occupants and their expanding activities. The existing building is currently overcrowded.

A group of rooms in Building 111 houses about ten additional special projects personnel in the emergency response program. There are no current plans to alter that arrangement.

Building 212/292 Decontamination, Fiscal Year 1994

This project proposes to decontaminate and restore Buildings 212 and 292, which are being used to support several weapons research projects (LLNL, 1991e).

Hazards Control Health & Safety Facility, Fiscal Year 1994

The proposed Hazard Control Health and Safety Facility would provide laboratory space for Safety Research, Bioassay Radiation Dosimetry, and Industrial Hygiene. This facility would also provide offices, health and safety training classrooms, a central health and safety library, and various support functions (LLNL, 1991e).

Roof Replacement, Fiscal Year 1994

The roofs of over 100 buildings at LLNL have exceeded their life expectancy of 20 years. Most of these also have deteriorated to the point where they require frequent repairs. The roofs identified for inclusion in this project's scope of work have severe problems, including membrane failure and possible structural damage (LLNL, 1991e).

Building Electrical Code Improvement, Fiscal Year 1994

This project is to provide improvements in the electric code compliance in the low-voltage systems within the Laboratory's buildings. This project consists of thousands of individual replacements and upgrades within approximately 565 laboratory, support and general purpose facilities at the LLNL Livermore site and at LLNL Site 300. These items were identified by field sampling surveys to determine electrical code compliance profiles of the individual buildings (LLNL, 1991e).

Plutonium Facility Upgrade, Fiscal Year 1994

This project would provide for the technological upgrade of the weapons-oriented plutonium effort at LLNL. Approximately 16,250 sq ft of Building 332 is proposed to receive major improvements, including new equipment, new capabilities, and state-of-the-art gloved enclosures (LLNL, 1991e).

Civil Infrastructure Modernization, Fiscal Year 1994

This project addresses the needed rehabilitation of the paved roads and parking lots on the LLNL Livermore site. Deterioration of over half of the 13 miles of roadway system and much of the 2.51 million sq ft of parking lots have reached a point where major reconstruction or structural overlay is required (LLNL, 1991e).

Upgrade Fire Alarm System, Fiscal Year 1994

This project upgrades the obsolete fire alarm systems of the LLNL Livermore site buildings. The existing fire alarm systems would be replaced with new, low-voltage type components in approximately the same location as existing. Each system would be reevaluated and changed as needed (LLNL, 1991e).

Waste Minimization Project, Fiscal Year 1994

The waste minimization implementation project consists of an engineering laboratory building and modernizations to Buildings 322 and 1412. This project would reduce waste generation and thus is part of LLNL's waste minimization program (LLNL, 1991e).

Mixed Waste Treatment Facility, Fiscal Year 1994

The Mixed Waste Treatment Facility (MWTF) is planned to provide treatment capacity for LLNL combustible, organo-mixed wastes. The best of the demonstration technologies for the treatment development would be the basis for the Mixed Waste Treatment Facility design.

Modification for Energy Management Project, Fiscal Year 1994

This project would offer energy conservation through retrofitting various buildings at the LLNL Livermore site and LLNL Site 300 (LLNL, 1991e).

Plutonium Facility Increment V, Fiscal Year 1994

This project would provide an addition of a vault, a radiography room, and a transportation dock to the Plutonium Facility, Building 332. This addition would total 15,000 sq ft.

Hazards Control Fire Science Facility, Fiscal Year 1995

This new Hazard Control Fire Science Facility would replace and consolidate existing facilities located in Buildings 324 and 328. The new facility would include laboratory and control rooms, test cells and equipment storage, and associated offices and support areas (LLNL, 1991e).

Building 191 Hazardous Firing Upgrade, Fiscal Year 1995

This project would provide additional firing tanks that would be used for experiments with hazardous materials. Three tank sizes would be included for differing experiment types: a 125-G, 1-Kg, and 20-Kg tank, with the largest increasing the explosive yield capability of the facility above the current 10 Kg. The capability to wash down and collect hazardous materials, and to minimize the resultant volume of hazardous materials would be included in this project as well as office space to house additional personnel (LLNL, 1991e).

Building 131 General & Environmental Upgrade, Fiscal Year 1995

This project would modernize the electrical and mechanical portions of the building as well as increase the seismic strength of the structure. Obsolete mechanical equipment and electrical distribution hardware would be replaced. The basic building would be strengthened to meet current seismic standards (LLNL, 1991e).

Nano Scale Materials Facility Upgrade, Fiscal Year 1995

This project would provide modern laboratory space and state-of-the-art instrumentation to help acquire a fundamental understanding of the controlling and limiting conditions in materials at the atomic scale. Rehabilitation and refurbishment of approximately 8000 sq ft of existing facilities is planned (LLNL, 1991e).

Atomic Physics Research Laboratory, Fiscal Year 1995

The proposed Atomic Physics Research Facility consists of several atomic-based research facilities, including the research laser and picosecond laser, electron beam ion trap, super electron beam ion trap and ECRIS, housed in a laboratory and support structure (LLNL, 1991e).

Northwest Low Conductivity Cooling Water Station, Fiscal Year 1995

This project would add an 11-megawatt addition to the existing 33-megawatt northwest station. This station supplies low conductivity cooling water in a closed system to facilities in the northwest and north central areas of the LLNL Livermore site (LLNL, 1991e).

Building 322 Plating Facility, Fiscal Year 1995

Building 322 houses the major electroplating, anodizing, electropolishing, and a variety of cleaning facilities under the general heading of plating facility. This activity would tighten controls and complete the move to a closed system operation (LLNL, 1991e).

Stack Construction and Monitoring Upgrades, Fiscal Year 1995

This project would provide structural upgrades to stacks and provide increased air effluent monitoring capability. There is a need to organize and combine existing stacks on LLNL facilities with multimission sources; this project provides the mechanical modification necessary to accomplish this (LLNL, 1991e).

Building 321 General & Environmental Upgrade, Fiscal Year 1996

Building 321 houses major general and precision machining operations, weld shop, sheet metal shop, optics, glass blowing, ceramics, and heat treatment facilities in support of the entire Laboratory. The proposed project would renovate and upgrade the present facilities (LLNL, 1991e).

Replace Deteriorated Offices, Fiscal Year 1996

Construction of approximately 34,000 sq ft of office space is planned, along with removal of Buildings 213, 319, and trailer complexes 2175 and 3177 (LLNL, 1991e).

Earth Sciences Building, Fiscal Year 1996

The proposed Earth Sciences Building would be a multistory structure. It would provide office and light laboratory space, including conference rooms, a library, computer centers, and other supporting areas. The facility would provide space for interdisciplinary environmental restoration and waste management research, development and technology, energy, and defense program activities (LLNL, 1991e).

Building 141 General Upgrade, Fiscal Year 1996

This project calls for modernization of Building 141 with special emphasis on the printed wiring board facility. The current chemistry and processing equipment is approaching obsolescence, and hazardous waste disposal costs are rapidly increasing. A new facility would provide for total closed loop processing with no hazardous effluent. In addition, the basic building electrical and mechanical utility systems would be upgraded (LLNL, 1991e).

Retention Tank Upgrade, Fiscal Year 1996

This project would provide modern retention tank facilities for Buildings 241, 281, and 227. These buildings have a large number of bench scale operations involving liquids. Regulations require double wall containment (piping and tanks) for systems that may contain hazardous waste at some point (LLNL, 1991e).

Building 151 Effluent Systems Upgrade, Fiscal Year 1996

This project would remove from the roof of Building 151 the existing fume hood exhaust stacks and fans. The exhaust systems would be replaced with a central scrubbed exhaust manifold and stack that can be continuously monitored for emissions. The existing single-walled retention tanks will be replaced at the north of Building 151. The underground waste lines would be upgraded by replacement with a double contained system that includes a leak monitor (LLNL, 1991e).

Non-Proliferation Annex, Fiscal Year 1997 (formerly Treaty Verification Center, Fiscal Year 1996)

The Non-Proliferation Facility would be an annex to the Verification, Intelligence, and Special Technology Analysis (VISTA) Center. With Building 261, these buildings would form the central facility for the Non-Proliferation, Arms Control and International Security (NAI Program (LLNL, 1991e).

Building 253 Refurbish/Replace, Fiscal Year 1997

This project would provide major refurbishment of the existing hazards control facility Building 253. Refurbishment would include structural upgrade; heating, ventilation, and air conditioning system replacement; electrical upgrades; and roofing and fixture replacement.

East Avenue, Fiscal Year 1998

DOE proposes to acquire East Avenue between South Vasco and Greenville roads. This acquisition is being considered for the following alternatives (DOE, 1990):

- Gates at both ends with unlimited access to the public.
- Gates at both ends with limited access to the public.

Under unlimited access, East Avenue would remain open to the public following acquisition. Fences, gates, signs, a vehicle turn-around area, and traffic stacking lanes would be installed so that the road could be closed to the public if necessary. Security requirements would determine if East Avenue access should be controlled on a permanent basis (DOE, 1990).

Under restricted access, the controls would be for vehicles, personnel, or a combination of both. The vehicle control would allow in all cars with Laboratory decals, while the personnel control would require identity verification (touch-badge) for every person entering. A variation would require vehicle control during normal working hours and touch-badge at all other times.

Other alternatives that were considered include a 300- to 500-ft security zone along each side of the road, and would require removal and reconstruction of structures; looping part of the roadway; hardening sensitive facilities; and no action, which would result in continued unacceptable risk. These alternatives are no longer being considered due to the high costs and high risks involved (DOE, 1990).

Fusion Target Tritium Limits, Building 298, Fiscal Year 2000

This proposed operational modification project increases the tritium administrative limits to 5 g to accommodate operational changes in Building 298.

NOVA-Upgrade/National Ignition Facility Tritium Limits, Building 391, Fiscal Year 2000

This proposed operational modification project increases the tritium administrative limits to 5 g to accommodate operational changes in Building 391.

Integrated Demonstration Facility, Fiscal Year (not available at this time)

The Integrated Demonstration Facility, tentatively proposed by LLNL, would be a research and development center for demonstrating best available technologies for treating LLNL mixed waste.

A.4 WASTE AND INVENTORY DATA·ALL SITES

Waste and inventory data for all sites (LLNL Livermore site, LLNL Site 300, and SNL, Livermore) are listed in Table A-14 through Table A-34. In addition, Figure A-18 and Figure A-19 highlight the locations of the waste accumulation areas at the LLNL Livermore site and LLNL Site 300. The waste accumulation areas for SNL, Livermore are located within each laboratory building (see Tables A–10 and A–11 for the list of these laboratories).

Waste and inventory data includes:

- Hazardous Waste Generation for the Selected Facilities, 1990 data (Table A-14, Table A-15, and Table A-16)
- Low-level Radioactive Mixed Waste Generation for the Selected Facilities, 1990 data (Table A-17, Table A-18, and Table A-19).
- Low-level Radioactive Waste Generation for the Selected Facilities, 1990 data (Table A-20, Table A-21, and Table A-22).
- Radioactive Materials Inventories for the Selected Facilities (Tables A-23, Table A-24, and Table A-25).
- Chemical Inventories for the Selected Facilities (Table A-26, Table A-27, and Table A-28).
- Estimated Emission Rates, based on Fuel usage data (Table A-29, Table A-30, and Table A-31).
- High Explosives Storage Areas (Table A-32, Table A-33, and Table A-34).

The waste data listed in Tables A-14 through A-22 represent only the selected facilities described in Appendix A. For a complete list of waste generated and for description of waste types and how they are managed, please refer to Appendix B.

The inventory data listed in Tables A-23 through A-28 also represents the selected facilities described in this Appendix. The tables show typical quantities rather than maximum limits. These chemicals and radioactive materials are subject to change as laboratory experimental requirements change.

The chemical inventory data for LLNL Livermore site listed in Table A-26 was obtained from the 1989 data base used to prepare the LLNL Livermore site Hazardous Material Business Plan for Alameda County. The chemical inventory data for the LLNL Site 300 listed in Table A-27 was also obtained from the 1989 data base used to prepare the LLNL Site 300 Hazardous Materials Management Plan for San Joaquin County. The chemical inventory data for SNL, Livermore listed in Table A-27 were obtained from the SNL, Livermore report, *1990 Chemical Inventory by Chemical (updated July 3, 1991)*. The chemical inventory data for LLNL Livermore site and the LLNL Site 300 was modified by Laboratory input to reflect the July 1991 quantities.

Additionally, the chemical inventory data presented in this Appendix for all three sites were reduced from an extensive list and were limited to extremely hazardous chemicals greater than 1 lb and all other chemicals greater than 500 lb present in these selected buildings. Therefore, some chemicals listed in the building descriptions may be used in smaller quantities and may not appear in the tables.

The radioactive materials inventories listed in Tables A-23 through A-25 for the selected facilities were obtained from LLNL and SNL, Livermore in July 1991. These inventories were further modified by Laboratory input to reflect October 1991 quantities. Therefore, some radioactive materials listed in building descriptions may not be present in the facility in October 1991 and hence do not appear in the table.

APPENDIX A GLOSSARY

Accelerator	An apparatus for imparting high velocities to charged particles.
Budgeted construction	Construction for which Congress has not yet appropriated the necessary funds but that appears in the proposed FY 1993 DOE budget.
Curie (Ci)	A special unit of activity. One curie equals 37 billion nuclear transformations per second.
Depleted uranium	Uranium from which most of the uranium-235 isotope has been removed.
Energetic Waste	Chemically energetic waste with the potential to react explosively; nuclear explosives are not included.
Engineered barrier	In the context of a high-level waste repository, a barrier to release of radioactivity made by man, such as a corrosion- resistant container.
Explosives	*See* High explosives.
Fissile	Capable of being fissioned by slow neutrons. The principal fissile isotopes are U-233, U-235, and Pu-239.
Fission	The splitting of a heavy atomic nucleus into two nuclei of lighter elements, accompanied by the release of energy and generally one or more neutrons. Fission can occur spontaneously or be induced by neutron bombardment.
Flash x-ray	An x-ray apparatus that emits short pulses of x rays useful for examining the behavior of rapidly changing mechanical systems.
Floodplain	The valley floor adjacent to the incised channel of a stream, which may be inundated during high water.
Funded construction	Construction for which Congress has already appropriated the necessary funds.
Fusion	The energy-releasing process in which atoms of very light elements such as deuterium and tritium combine to produce heavier elements.
Glovebox	A sealed box in which workers, while remaining outside and using gloves attached to and passing through openings in the box, can safely handle and work with radioactive materials, other hazardous materials, and nonhazardous air-sensitive compounds.
Hazardous waste	Any solid, semisolid, liquid, or gaseous waste that is ignitable, corrosive, toxic, or reactive as defined by RCRA and identified or listed in 40 C.F.R. part 261.
High explosives (HE)	Chemically energetic materials with the potential to react explosively; nuclear explosives are not included.
Human genome	A set of chromosomes with the genes they contain.
Hydrodynamic testing	Testing the properties of solid materials or the behavior of components made of such materials by subjecting them to strong shock from explosives or high-velocity impact.
Infrastructure	Utilities and other physical support systems needed to operate a laboratory or test facility. Included are electric distribution systems, water supply systems, sewage disposal systems, roads, etc.
Magazine	An approved structure designed for the storage of explosives, excluding operating buildings.
Mixed waste	Radioactive waste also containing RCRA-designated hazardous constituents.
Natural uranium	Uranium as it occurs in nature. The natural substance is 99.28 percent uranium-238, 0.72 percent uranium-235, and 0.0055 percent uranium-234. Only the uranium-235 isotope is fissionable by slow neutrons.
Plasma	A cloud of charged particles containing about equal numbers of positive ions and electrons and

	exhibiting some properties of a gas but differing from a gas in being a good conductor of electricity and being affected by magnetic fields.
Special Isotope Separation (SIS)	At LLNL, the process of Atomic Vapor Laser Isotope Separation applied to plutonium.
Tritium	A radioactive isotope of the element hydrogen, with two neutrons and one proton in its nucleus. Common symbols for the isotope are H3 and T.
U-AVLIS	At LLNL, the process of Atomic Vapor Isotope Separation applied to uranium.
Uranium	*See* Natural uranium.
Wetland	Land or areas with abundant moisture, saturated or inundated during some portion of the year, or plant species tolerant of such conditions.

APPENDIX A REFERENCES

Beach, R., 1991, *Comments on Appendix A to the EIS/EIR, Buildings 232, 235, 241, and 332,* Chemistry and Materials Science, Lawrence Livermore National Laboratory, Livermore, CA, July 1991.

Bloom, G. H., 1990, *High Explosion Burn Studies*, Lawrence Livermore National Laboratory, Livermore CA, February 1990.

DOE, 1990, *Environmental Assessment, Acquisition of East Avenue, Alameda County, California*, U.S. Department of Energy, San Francisco Operations Office, Oakland, CA, September 1990.

DOE, 1990a, *Uranium Enrichment Enterprise, 1990 Strategy Report*, U.S. Department of Energy, March 1990.

DOE, 1991, *Environmental Assessment for Electric Utility System Distribution, Replacement and Upgrades*, Lawrence Livermore National Laboratory, Livermore, CA, January 1991.

DOE, 1992, *Finding of No Significant Impact for The Laser Guide Star Experiment at Lawrence Livermore National Laboratory*, United States Department of Energy, Draft, January 1992.

ICF, 1991, *NOVA-Upgrade—Definition and Description, ICF Program,* (In Preparation) Lawrence Livermore National Laboratory, Livermore, CA, July 1991.

Kass, J. N., 1991, *EIS/EIR Input for Oralloy Work in Building 332*, Lawrence Livermore National Laboratory, Livermore, CA, July 1991.

Knezovich, J. P. and J. L. Daniels, 1991, *Biodegradation of High Explosive Wastes*, Lawrence Livermore National Laboratory, Livermore, CA, August 1989.

LLNL, 1975, *Safety Analysis Report for Building 231 Central Vault*, Lawrence Livermore National Laboratory, Livermore, CA, August 1975.

LLNL, 1976, *Safety Evaluation Report for Building 225 Detonation Study Facility*, Lawrence Livermore National Laboratory, Livermore, CA, November 1976.

LLNL, 1982, *Site 300 Revitalization Facilities, Conceptual Design Report, Plant Engineering Department,* Lawrence Livermore National Laboratory, Livermore, CA, October 1982.

LLNL, 1984a, *A Safety Analysis of the Nuclear Chemistry Building 151*, Lawrence Livermore National Laboratory, Livermore, CA, June 1984.

LLNL, 1984b, *Building 857 Operations,* LLNL Site 300 Safety and Operational Manual, Procedure Number 601, Lawrence Livermore National Laboratory, Livermore, CA, October 1984.

LLNL, 1984c, *Safety Analysis Report, Building 131,* Lawrence Livermore National Laboratory, Livermore, CA, November 1984.

LLNL, 1985, *Site 300 Facilities Revitalization, Part I, Supplemental Conceptual Design Report,* Lawrence Livermore National Laboratory, Livermore, CA, March 1985.

LLNL, 1986a, *CAM Sample System Bldg 332*, Lawrence Livermore National Laboratory, Livermore, CA, June 1986.

LLNL, 1986c, *Facility Safety Procedure, Biomedical and Environmental Research Program Carcinogen Facility Operations*, Lawrence Livermore National Laboratory, Livermore, CA, January 1986.

LLNL, 1986d, *Facility Safety Procedures, Electronics Engineering Operation Building 131*, Lawrence Livermore National Laboratory, Livermore, CA, December 1986.

LLNL, 1986e, *Heavy Element Facility (Building 251) Nuclear Chemistry Division*, Lawrence Livermore National Laboratory, Livermore, CA, March 1986.

LLNL, 1986f, *Nuclear Test Technology Complex, Revised Conceptual Design Report,* Prepared by Holmes & Narver, Inc. for Lawrence Livermore National Laboratory, Livermore, CA, March 1986.

LLNL, 1986g, *Safeguards & Security Enhancements II*, Lawrence Livermore National Laboratory, Livermore, CA, March 1986.

LLNL, 1987a, *Building 834 Operations,* LLNL Site 300 Safety and Operational Manual, Procedure Number 634, Lawrence Livermore National Laboratory, Livermore, CA, July 1987.

LLNL, 1987b, *Environmental Assessment Construction and Operation of the High Explosives Test Building*, Lawrence Livermore National Laboratory, Livermore, CA, August 1987.

LLNL, 1987d, *Foreign Technology Assessment Building, Conceptual Design Report,* Prepared by ED2 International for Lawrence Livermore National Laboratory, Livermore, CA, December 1987.

LLNL, 1987e, *Nuclear Test Technology Complex Supplemental Conceptual Design Criteria,* Lawrence Livermore National Laboratory, Livermore, CA, arch 1987.

LLNL, 1987f, *Record of Administrative Proceedings Environmental Impact Report* Volume 4, Table 4-1—Hazardous Mixed and Radioactive Waste Streams, Lawrence Livermore National Laboratory, Livermore, CA, September 18, 1987.

LLNL, 1987g, *Safety Analysis Report of Combined AVLIS Full-Scale Demonstration Facility– Building 490, Refurbishment Facility– Building 491, Laser Dye Pump Facility–Building 492*, Lawrence Livermore National Laboratory, Livermore, CA, May 1987.

LLNL, 1987h, *Site 300 Facilities Revitalization—1 Supplemental Conceptual Design Report,* Lawrence Livermore National Laboratory, Livermore, CA, March 1987.

LLNL, 1987i, *Weapons Test Facilities,* LLNL Site 300 Safety and Operational Manual, Procedure Number 600, Lawrence Livermore National Laboratory, Livermore, CA, October 1987.

LLNL, 1988a, *Building 823 Operations*, LLNL Site 300 Safety and Operational Manual, Procedure Number 220, Lawrence Livermore National Laboratory, Livermore, CA, October 1988.

LLNL, 1988b, *Closure Plan for the Decommissioned High Explosives Rinse-Water Lagoons at LLNL Site 300,* Lawrence Livermore National Laboratory, Livermore, CA, May 31, 1988.

LLNL, 1988c, *Disposal of Explosives,* LLNL Site 300 Safety and Operational Manual, Procedure Number 401, Lawrence Livermore National Laboratory, Livermore, CA, October 1988.

LLNL, 1988d, *Explosives Isostatic Pressing, Building 817 Complex*, LLNL Site 300 Safety and Operational Manual, Procedure Number 221, Lawrence Livermore National Laboratory, Livermore, CA, October 1988.

LLNL, 1988e, *Facility Assessment Visual Site Inspection Report,* Prepared by A. T. Kearney Inc. & The Earth Technology Corporation, Lawrence Livermore National Laboratory, Livermore, CA.

LLNL, 1988f, *Facility Safety Procedures, Calibrations and Standards Operations Building 255E*, Lawrence Livermore National Laboratory, Livermore, CA, May 1988.

LLNL, 1988g, *Facility Safety Procedures, High Explosives Technology Operation, Building 225, Annual Review*, Lawrence Livermore National Laboratory, Livermore, CA, February 1988.

LLNL, 1988h, *Facility Safety Procedures, Radioactive and Hazardous Waste Treatment and Storage Facilities: Buildings 693, 883, and the 612 Complex*, Lawrence Livermore National Laboratory, Livermore, CA, December 1988.

LLNL, 1988i, *Final Safety Analysis Report for the Hardened Engineering Test Building*, Lawrence Livermore National Laboratory, Livermore, CA, October 1988.

LLNL, 1988j, *Flash X Ray Operations, Building 801*, LLNL Site 300 Safety and Operational Manual, Procedure Number 311, Lawrence Livermore National Laboratory, Livermore, CA, November, 1988.

LLNL, 1988k, *Laser Doppler Interferometry Operations*, LLNL Site 300 Safety and Operations Manual, Procedure Number 312, Lawrence Livermore National Laboratory, Livermore, CA, November 1988.

LLNL, 1988l, *Radiographic Inspection in Building 809, Bay 2*, LLNL Site 300 Safety and Operational Manual, Procedure Number 219, Lawrence Livermore National Laboratory, Livermore, CA, October 1988.

LLNL, 1988m, *Work in LLNL Electrical Manholes or Underground Vaults*, Operational Safety Procedure, Number 511.8, Lawrence Livermore National Laboratory, Livermore, CA, December 1988.

LLNL, 1989a, *155 mm Gun Firing, Building 850*, LLNL Site 300 Safety and Operational Manual, Procedure Number 309, Lawrence Livermore National Laboratory, Livermore, CA, October 1989.

LLNL, 1989b, *1988 Review of Radionuclide Stack Sampling Systems*, Lawrence Livermore National Laboratory, Livermore, CA, March 22, 1989.

LLNL, 1989c, *Building 854 Operations*, LLNL Site 300 Safety and Operational Manual, Procedure Number 654, Lawrence Livermore National Laboratory, Livermore, CA, March 1989.

LLNL, 1989d, *Building 865–ATA Operations*, LLNL Site 300 Safety and Operational Manual, Procedure Number 900, Lawrence Livermore National Laboratory, Livermore, CA, March 1989

LLNL, 1989e, *Chemistry Areas, LLNL Site 300 Safety and Operational anual, Procedures 700 through 723*, Lawrence Livermore National Laboratory, Livermore, CA.

LLNL, 1989f, *Defense, Decontamination and Decommissioning, Fiscal Year 1991*, Lawrence Livermore National Laboratory, Livermore, CA, May 17, 1989.

LLNL, 1989g, *Electrical Power System Replacements and Upgrades, Volume I of II, Conceptual Design Report*, Prepared by Holmes & Narver, Inc. for Lawrence Livermore National Laboratory, Livermore, CA, February 1989.

LLNL, 1989h, *Electrical Power System Replacements and Upgrades, Volume II of II, Conceptual Design Report*, Prepared by Holmes & Narver, Inc. for Lawrence Livermore National Laboratory, Livermore, CA, February 1989.

LLNL, 1989i, *ES&H Improvements (90-D-103) Fiscal Year 1990 Supplemental Line Item*, Lawrence Livermore National Laboratory, Livermore, CA.

LLNL, 1989j, *Explosives Machining–Buildings 806-A, 806-B, 807, 809, 828*, LLNL Site 300 Safety and Operational Manual, Procedure Number 213, Lawrence Livermore National Laboratory, Livermore, CA, September 1989.

LLNL, 1989k, *Facility Safety Procedures, Building 161 Operations*, Lawrence Livermore National Laboratory, Livermore, CA, December 1989.

LLNL, 1989l, *Facility Safety Procedures, Building 222 Complex*, Lawrence Livermore National Laboratory, Livermore, CA, December 1989.

LLNL, 1989m, *Facility Safety Procedure, Guidelines for Working with Biohazardous Materials*, Lawrence Livermore National Laboratory, Livermore, CA, August 1989.

LLNL, 1989n, *Facility Safety Procedures, "L" Division Operations, Building 121*, Lawrence Livermore National Laboratory, Livermore, CA, November 1989.

LLNL, 1989o, *Freon Data 1989*, *Freon Permit #3019 for Power Supply Refurbishment Area, Room 490-1024*, *1989 Calendar Year*, Lawrence Livermore National Laboratory, Livermore, CA, 1989.

LLNL, 1989p, *High Explosives Applications Facility, Final Safety Analysis Report*, Lawrence Livermore National Laboratory, Livermore, CA, January 1989.

LLNL, 1989q, *Magazines and Explosives Storage*, LLNL Site 300 Safety and Operational Manual, Procedure Number 118, Lawrence Livermore National Laboratory, Livermore, CA, March 1989.

LLNL, 1989r, *Neutron Damaged Gaas: Cr, Gaas, and Inp Detectors*, Operational Safety Procedure, Number 121.28, Lawrence Livermore National Laboratory, Livermore, CA, March 1989.

LLNL, 1989s, *Operation of Tank Truck Carrying Waste Water from Explosives Processing and Photo Rinse Operations*, LLNL Site 300 Safety and Operational Manual, Procedure Number 403, Lawrence Livermore National Laboratory, Livermore, CA, July 1989.

LLNL, 1989t, *Pesticides Mixing and Explosives Decontamination Operations*, *Building 819*, LLNL Site 300 Safety and Operational Manual, Procedure Number 402, Lawrence Livermore National Laboratory, Livermore, CA, May 1989.

LLNL, 1989u, *Radiation Safety Procedure*, *Building 851*, LLNL Site 300 Safety and Operations Manual, Procedure Number 308, Lawrence Livermore National Laboratory, Livermore, CA, October 1989.

LLNL, 1989v, *Remedial Investigation of the High Explosives Burn Pit Facility, Building 829 Complex*, Lawrence Livermore National Laboratory, Livermore, CA, August 1989.

LLNL, 1989w, *Site 300 Map*, Lawrence Livermore National Laboratory, Livermore, CA, December 1989.

LLNL, 1990a, *Action Description Memorandum For Contained Firing at Bunker 801*, *Site 300*, Lawrence Livermore National Laboratory, Livermore, CA, October 1990.

LLNL, 1990b, *Action Description Memorandum for Revitalizing Site 300*, Lawrence Livermore National Laboratory, Livermore, CA, August 1990.

LLNL, 1990c, *Action Description Memorandum for Revitalizing Site 300*, Lawrence Livermore National Laboratory, Livermore, CA, April 1990.

LLNL, 1990d, *Application for an Authority to Construct/Permit to Operate for Building 490 Freon Refurbishment Area, Source No. 6004*, Lawrence Livermore National Laboratory, Livermore, CA, December 1990.

LLNL, 1990e, *Building 836 Operations*, LLNL Site 300 Safety and Operational Manual, Procedure Number 636, Lawrence Livermore National Laboratory, Livermore, CA, June 1990.

LLNL, 1990f, *Emergency Response Plan (Draft) for Building 331–Release of Tritium to the Environment (1981–1990)*, Lawrence Livermore National Laboratory, Livermore, CA, February 27, 1990.

LLNL, 1990g, *Environmental Procedure for Characterization, Accumulation, and Temporary Storage of Hazardous Waste in Containers*, LLNL Site 300 Safety and Operational Manual, Procedure Number 406, Lawrence Livermore National Laboratory, Livermore, CA, October 1990.

LLNL, 1990h, *Facility Safety Procedure, Biomedical and Environmental Research Program, Bioanalytical Chemistry Facility,* Lawrence Livermore National Laboratory, Livermore, CA, October 1990.

LLNL, 1990i, *Facility Safety Procedure, Biomedical and Environmental Research Program Facilities,* Lawrence Livermore National Laboratory, Livermore, CA, March 1990.

LLNL, 1990j, *Facility Safety Procedure, Building 175 Operations*, Lawrence Livermore National Laboratory, Livermore, CA, July 1990.

LLNL, 1990k, *Facility Safety Procedures, Building 231 General Operation*, Lawrence Livermore National Laboratory, Livermore, CA, September 1990.

LLNL, 1990l, *Facility Safety Procedures, Building 231 Vault, 232 Fenced Compound, 233, 234 General Operations*, Lawrence Livermore National Laboratory, Livermore, CA, January 1990.

LLNL, 1990m, *Facility Safety Procedure, Building 341, High Energy Research Operations,* Lawrence Livermore National Laboratory, Livermore, CA, April 1990.

LLNL, 1990n, *Facility Safety Procedures, General Operations Electronics Engineering, Building 141*, Lawrence Livermore National Laboratory, Livermore, CA, April 1990.

LLNL, 1990o, *Facility Safety Procedures, High Explosives Applications Facilities (HEAF) Building 191*, Lawrence Livermore National Laboratory, Livermore, CA, February 1990.

LLNL, 1990p, *Facility Safety Procedure, High Pressure Laboratory Operations, Building 343,* Lawrence Livermore National Laboratory, Livermore, CA, January 1990.

LLNL, 1990q, *Facility Safety Procedures, L-Division Operations Building 255 West*, Lawrence Livermore National Laboratory, Livermore, CA, January 1990.

LLNL, 1990r, *Facility Safety Procedures, Nondestructible Evaluation Facilities Safety Procedures,* Lawrence Livermore National Laboratory, Livermore, CA, February 1990.

LLNL, 1990s, *Facility Safety Procedures, Nuclear Chemistry Division, Building 151,* Lawrence Livermore National Laboratory, Livermore, CA, January 1990.

LLNL, 1990t, *Final Safety Analysis Document for DOE Comment for the OCVD Crystal Growth Facility in Building l66,* Lawrence Livermore National Laboratory, Livermore, CA, January 1990.

LLNL, 1990u, *Firing Table Debris Waste Management Procedures,* LLNL Site 300 Safety and Operational Manual, Procedure Number 404, Lawrence Livermore National Laboratory, Livermore, CA, September 1990.

LLNL, 1990v, *General Firing Facility Operations,* LLNL Site 300 Safety and Operational Manual, Procedure Number 301, Lawrence Livermore National Laboratories, Livermore, CA, April 1990.

LLNL, 1990w, *Heavy Element Facility (Building 251) Nuclear Chemistry Division*, Lawrence Livermore National Laboratory, Livermore, CA, April 1990.

LLNL, 1990x, *Infrastructure Modernization Fiscal Year 1992, Conceptual Design Report*, Prepared by ICF Kaiser Engineers (California) Corporation for Lawrence Livermore National Laboratory, Livermore, CA, March 1990.

LLNL, 1990y, *Facility Safety Procedure 321*, Lawrence Livermore National Laboratory, Livermore, CA, May 1990.

LLNL, 1990z, *Operational Safety Procedure #131.83, Cabinet Radiography of R Program Ports,* Lawrence Livermore National Laboratory, Livermore, CA, July 1990.

LLNL, 1990aa, *Operational Safety Procedure #131.89, Opto-Electric Calibration Facility*, Lawrence Livermore National Laboratory, Livermore, CA, October 1990.

LLNL, 1990ab, *Operational Safety Procedure #131.91, X Ray Radiographic Centrification on the D.E.A. CMM, Building 131 Room 1460*, Lawrence Livermore National Laboratory, Livermore, CA, May 1990.

LLNL, 1990ac, *Operational Safety Procedure #131.99, Unattended Transmission, Continuum X Ray Gauging–R Program Materials*, Lawrence Livermore National Laboratory, Livermore, CA, January 1990.

LLNL, 1990ad, *Operational Safety Procedure #131.100, Excimer Laser achining of Toxic Material*, Lawrence Livermore National Laboratory, Livermore, CA, August 1990.

LLNL, 1990ae, *Operational Safety Procedure #131.101, Florod Laser Welder Alignment or Maintenance*, Lawrence Livermore National Laboratory, Livermore, CA, September 1990.

LLNL, 1990af, *Operational Safety Procedure #131.108, Laser Operational Safety Procedure for Building 131, Rooms 1275, 1277, and 1278*, Lawrence Livermore National Laboratory, Livermore, CA, December 1990.

LLNL, 1990ag, *Operational Safety Procedure #131.109, Microwave Engineering Facility*, Lawrence Livermore National Laboratory, Livermore, CA, November 1989.

LLNL, 1990ah, *Operational Safety Procedure #131.111, Assembly Radiography in Building 131, Rooms 1345 and 1345A*, Lawrence Livermore National Laboratory, Livermore, CA, February 1990.

LLNL, 1990ai, *Operational Safety Procedures, Buildings 161, 162, 164, 165, 168, and 169*, Lawrence Livermore National Laboratory, Livermore, CA.

LLNL, 1990aj, *Operational Safety Procedures, Buildings 171, 174, 177, and 179*, Lawrence Livermore National Laboratory, Livermore, CA.

LLNL, 1990ak, *Operational Safety Procedures, Building 412*, Lawrence Livermore National Laboratory, Livermore, CA, 1990.

LLNL, 1990al, *Operational Safety Procedure, No. 411.2, Transportation of DOT Class C Explosives*, Lawrence Livermore National Laboratory, Livermore, CA, September 1990.

LLNL, 1990am, *Operational Safety Procedure, Number 121.10, Febetron Electron Beam to Develop Diagnostic Systems*, Lawrence Livermore National Laboratory, Livermore, CA, July 1990.

LLNL, 1990an, *Operational Safety Procedure, Number 121.32, Laser Operational Safety Procedure for B-121, Rooms 1154b, 1158, 1162, and 1166*, Lawrence Livermore National Laboratory, Livermore, CA, April 1990.

LLNL, 1990ao, *Operational Safety Procedure, Number 121.40, Pulsed Calibration Laboratory*, Lawrence Livermore National Laboratory, Livermore, CA, November 1990.

LLNL, 1990aq, *Operational Safety Procedure, Number 121.44, Vacuum Barrier Permeation and Leak Testing Laboratory*, Lawrence Livermore National Laboratory, Livermore, CA, June 1990.

LLNL, 1990ar, *Operational Safety Procedure, Number 335.1, Control Laser Laboratory*, Lawrence Livermore National Laboratory, Livermore, CA, October 1990.

LLNL, 1990as, *Operational Safety Procedure, Number 335.3, Auxiliary Laser Facility (ALF)*, Lawrence Livermore National Laboratory, Livermore, CA, February 1990.

LLNL, 1990at, *Operational Safety Procedure Number 391 Supplement 30, OT and R Photometer*, Lawrence Livermore

National Laboratory, Livermore, CA, November 1990.

LLNL, 1990au, *Operational Safety Procedure, Number 511.3, Confined Space Entry— Electrical and Communication Spaces*, Lawrence Livermore National Laboratory, Livermore, CA, September 1990.

LLNL, 1990av, *Operational Safety Procedure, Number 511.6, The Proper Repair of Refrigerant Lines,* Lawrence Livermore National Laboratory, Livermore, CA, October 1990.

LLNL, 1990aw, *Operational Safety Procedure*, *Number 511.7, Receival and Disassembly of Potentially Contaminated Vacuum Pumps*, Lawrence Livermore National Laboratory, Livermore, CA, October 1990.

LLNL, 1990az, *Safety Analysis Report Tritium Facility, Building 331, Tritium Technology UCRL-AR-106001*, Lawrence Livermore National Laboratory, Livermore, CA, September 1990.

LLNL, 1990ba, *Sanitary Sewer Rehabilitation Project, Conceptual Design Report*, Prepared by CH2M HILL for Lawrence Livermore National Laboratory, Livermore, CA, March 1990.

LLNL, 1990bb, *Site 300 Contained Firing Facilities Conceptual Design Report*, Prepared by Holmes and Narver for Lawrence Livermore National Laboratory, Livermore, CA, April 1990.

LLNL, 1990bc, *Radionuclide Inventory Information*, Lawrence Livermore National Laboratory, Livermore, CA, September 1990 (updated November 1991).

LLNL, 1990bd, *Radionuclide Inventory Information*, Lawrence Livermore National Laboratory, Livermore, CA, September 1990 (updated November 1991).

LLNL, 1991a, *AB2588 Air Toxics Risk Screening Document for LLNL Plant 255*, Lawrence Livermore National Laboratory, Livermore, CA, February 1991.

LLNL, 1991b, *Addresses of Leased Property and Uses*, Lawrence Livermore National Laboratory, CA, March 1991.

LLNL, 1991c, *Biodegradation of High Explosive Wastes*, Lawrence Livermore National Laboratory, Livermore, CA, February 1991.

LLNL, 1991d, *Brief Environmental Assessment for the Cheap Access to Orbit (CATO) Experimental Tests (Formally SHARP) at Lawrence Livermore National Laboratory*, Livermore, CA, July 1991.

LLNL, 1991e, *Budgeted and Proposed Future Projects*, Lawrence Livermore National Laboratory, Livermore, CA.

LLNL, 1991f, *Building 822 (Cells A,B,C, and D), Storage of Detonators in 822-C*, LLNL Site 300 Operational Safety Procedure Number 822-900801-1, Lawrence Livermore National Laboratory, Livermore, CA, April 1991.

LLNL, 1991g, *Defense Programs Research Facility*, Project Data Sheets, Lawrence Livermore National Laboratory, Livermore, CA, May 1991.

LLNL, 1991h, *Description of Building 411, Supply and Distribution*, Lawrence Livermore National Laboratory, Livermore, CA, September 1991.

LLNL, 1991i, *Development Plan Site 300*, Lawrence Livermore National Laboratory, Livermore, CA, April 1991.

LLNL, 1991j, *DPRF, C&MS Building Occupancy & Migration Plans, Extension of FSP for Building 225*, Lawrence Livermore National Laboratory, Livermore, CA, April 1991.

LLNL, 1991k, *Draft, Safety Analysis Document for the Separator Demonstration Facilities Complex*, Lawrence Livermore Laboratory, Livermore, CA, February 1991.

LLNL, 1991l, *Facility Safety Procedures, Hydrogen Research Facility Building 331 Draft Version 2.0*, Lawrence Livermore National Laboratory, Livermore, CA, April 1991.

LLNL, 1991m, *Facility Safety Procedures, Light Isotope Monitoring Area Building 331 Draft Version 2.0*, Lawrence Livermore National Laboratory, Livermore, CA, April 1991.

LLNL, 1991n, *Facility Info for EIS/EIR 2/14/91*, Lawrence Livermore National Laboratory, Livermore, CA, February 1991.

LLNL, 1991o, *HC/Pop Sq Ft Update 1/2/91*, Lawrence Livermore National Laboratory, Livermore, CA, February 1991.

LLNL, 1991p, *Hepa Filter and Hood Report for Building 222, 226, 227*, Lawrence Livermore National Laboratory, Livermore, CA, March 1991.

LLNL, 1991q, *Historical Shot Samples Storage,* LLNL Site 300 Operational Safety Procedure Number 857-851212-2, Lawrence Livermore National Laboratory, Livermore, CA, January 1991.

LLNL, 1991r, *Information Related to B819*—Interdepartmental letterhead from Lynn Cleland and Joe Lambert, July 1991.

LLNL, 1991s, *Institutional Plan, Fiscal Years 1991–1996*, Lawrence Livermore National Laboratory, Livermore, CA, April 1991.

LLNL, 1991t, *Iron Horse Source Test*, Lawrence Livermore National Laboratory, Livermore CA, January 1991.

LLNL, 1991u, *Environmental Impact Assessment for the NOVA Projects, Building 391 Complex,* Lawrence Livermore National Laboratory, Livermore, CA.

LLNL, 1991v, *Domestic Water System, Mechanical Utilities Systems Master Plan*, Lawrence Livermore National Laboratory, Livermore, CA.

LLNL, 1991w, *Nova Upgrade—Definition and Description, LLNL ICF Program,* Lawrence Livermore National Laboratory, Livermore, CA, August 1991

LLNL, 1991x, *Operational Safety Procedure, Number 121.11, Laser Irradiation of Toxic Materials*, Lawrence Livermore National Laboratory, Livermore, CA, January 1991.

LLNL, 1991y, *Operational Safety Procedure, Number 121.42, Hyjacs X-ray Laboratory,* Lawrence Livermore National Laboratory, Livermore, CA, April 1990.

LLNL, 1991z, *Operational Safety Procedure No. 520.3, Pesticide Handling and Storage*, Lawrence Livermore National Laboratory, Livermore, CA, March 1991.

LLNL, 1991aa, *Request for Proposal (RFP), B147894, for the Preparation of a RCRA Part B Application for the Construction of a New High Explosive Open Burning/Open Detonation Facility at LLNL Site 300,* Lawrence Livermore National Laboratory, Livermore, CA, May 1991.

LLNL, 1991ab, *Safety Analysis of the Fusion Target Development Facility (FTDF), Building 298,* Lawrence Livermore National Laboratory, Livermore, CA.

LLNL, 1991ac, *Security Report*, Lawrence Livermore National Laboratory, Livermore, CA, March 1991.

LLNL, 1991ad, *Site 300 HE Burn Information for Pit 1 and 3, and the Iron Horse*, Lawrence Livermore National Laboratory, Livermore, CA.

LLNL, 1991ae, *Site 300 Sq Ft Breakdown*, Lawrence Livermore National Laboratory, Livermore, CA, 1991.

LLNL, 1991af, *Site Development Plan*, Lawrence Livermore National Laboratory, Livermore, CA, April 1991.

LLNL, 1991ag, *Waste Accumulation Areas at Site 300,* Lawrence Livermore National Laboratory, Livermore, CA, May 1991.

LLNL, 1991ah, *Defense Programs Research Facility, Revised Conceptual Design Report*, Lawrence Livermore National Laboratory, Livermore, CA, 1991.

LLNL, 1991be, *Additional Information-Extremely Hazardous and Radioactive aterials Inventory*, Lawrence Livermore National Laboratory, Livermore, CA, June 1991.

LLNL, 1991bf, *Hazardous Waste Management EIS/EIR Report, Hazardous Waste Received, 1990 Data,* Lawrence Livermore National Laboratory, Livermore, CA, November 1991.

LLNL, 1991sa, *Institutional Plan, Fiscal Years 1992 — 1997,* Lawrence Livermore National Laboratory, Livermore, CA, December 1991.

LLNL, 1991sb, *Environmental Assessment for the Demonstration of Uranium-Atomic Vapor Laser Isotope Separation (U-AVLIS) at Lawrence Livermore National Laboratory*, Lawrence Livermore National Laboratory, Livermore, CA, ay 1991.

LLNL 1992a, *Description of Proposed Projects* EWSF/EWTF, Lawrence Livermore National Laboratory, Livermore, CA, January 1992.

Odell, B. N. and H. E. Pfeifer, 1981a, *Safety Assessment Document for the Dynamic Test Complex (Building 836),* Lawrence Livermore National Laboratory, Livermore, CA, November 1981.

Odell, B. N. and H. E. Pfeifer, 1981b, *Safety Assessment Document for the Environmental Test Complex (Building 834) at Site 300,* Lawrence Livermore National Laboratory, Livermore, CA, March 1981.

Ornellas, D., 1980, *The Products of Detonation and Burning of Explosives in Air,* Lawrence Livermore National Laboratory, Livermore, CA, September 1980.

Phillips, T., 1991, *Physics Department Experimental Facilities*, Lawrence Livermore National Laboratory, Livermore, CA, July 1991.

Ragaini, R., 1989, *High Explosive Rinse-Water Lagoons Closure Plan emorandum,* Lawrence Livermore National Laboratory, Livermore, CA, September 1989.

Ragaini, R., 1990, *Air Toxics Inventory Plan (AB2588), Iron Horse Thermal Treatment Enclosure, Site 300, Tracy, California,* Lawrence Livermore National Laboratory, Livermore, CA, September 1990.

SAI, 1989, *Action Description Memorandum for Construction and Operation of a Microfabrication Facility–Building 153 at Lawrence Livermore National Laboratory,* Prepared by Science Applications International Corporation, Lawrence Livermore National Laboratory, Livermore, CA, April 1989.

SNL, 1989, *Institutional Plan FY 1989–FY 1994*, Sandia National Laboratories, Albuquerque, NM and Livermore, CA.

SNL, Livermore, 1983, *Operating Instructions, Tritium Research Lab*, Sandia National Laboratories, Livermore, Livermore, CA, November 1983.

SNL, Livermore, 1988, *Defense Engineering Laboratory, Design Summary Title I,* Sandia National Laboratories, Livermore, Livermore, CA, December 1988.

SNL, Livermore, 1989a, *Building 956, Safe Operating Procedure for Testing Items Containing High Explosives (U),* Sandia National Laboratories, Livermore, Livermore, CA, October 1989.

SNL, Livermore, 1989b, *Safety Analysis Report for the Tritium Research Laboratory*, Sandia National Laboratories, Livermore, Livermore, CA, August 1989.

SNL, Livermore, 1990a, *Emergency Preparedness Manual,* Sandia National Laboratories, Livermore, Livermore, CA, 1990.

SNL, Livermore, 1990b, *High Pressure Facility, Office, Building 966,* Sandia National Laboratories, Livermore, Livermore, CA, May 1990.

SNL, Livermore, 1990c, *Preliminary Hazard Assessments, Electronics Laboratory, Building 910, Room 309 and 121G, Division 8176,* Sandia National Laboratories, Livermore, Livermore, CA, April 1991.

SNL, Livermore, 1990d, *Preliminary Hazard Assessment, Environmental Test Facility (Chambers), Building 955 Rooms 106, 107, and 108, Building 956 Room 101,* Sandia National Laboratories, Livermore, Livermore, CA, November 1990.

SNL, Livermore, 1990e, *Safe Chemical Handling Procedures for the Electronics Prototype Fabrication Area, Building 910, Rooms 310, B, C, D, E, and Room 11,* Sandia National Laboratories, Livermore, Livermore, CA, February 1990.

SNL, Livermore, 1990g, *Safe Handling Procedures for the Electronics Prototype Fabrication Area,* Sandia National Laboratories, Livermore, Livermore, CA, February 1990.

SNL, Livermore, 1990h, *Safe Operating Procedure for Building 979, Revision B,* Sandia National Laboratories, Livermore, Livermore, CA, December 1990.

SNL, Livermore, 1990i, *Safe Operating Procedure, for the Combustion Research Facility, Building 906,* Sandia National Laboratories, Livermore, Livermore, CA, April 1990.

SNL, Livermore, 1990k, *Safe Operating Procedure for the Electroplating Research Facilities, Division 8316, Building 913,* Sandia National Laboratories, Livermore, Livermore, CA, April 1990.

SNL, Livermore, 1991a, *Area 8 Incinerator Safe Operating Procedures, Contingency Plan, and Unit Description and Design Information,* Sandia National Laboratories, Livermore, Livermore, CA, June 1991.

SNL, Livermore, 1991c, *Chemical Inventory By Chemical, Updated 7/3/91*, Sandia National Laboratories, Livermore, Livermore, CA, July 1991.

SNL, Livermore, 1991d, *Description of Facility, Preliminary Hazard Assessment, Photographic Laboratory, Building 913 Room 156*, Sandia National Laboratories, Livermore, Livermore, CA, February 1991.

SNL, Livermore, 1991e, *Environmental, Safety & Health Enhancement Project, Proposed Construction Project, Fiscal Year 1994,* Sandia National Laboratories, Livermore, Livermore, CA.

SNL, Livermore, 1991f, *Infrastructure Modernization Project, Proposed Construction Project, Fiscal Year 1994,* Sandia National Laboratories, Livermore, Livermore, CA.

SNL, Livermore, 1991g, *Listing of Hazardous Waste Generated by Building 910, 913, 9lb, 923, 927 and 963*, Sandia National Laboratories, Livermore, Livermore, CA, April 1991.

SNL, Livermore, 1991h, *Main Electrical Service and Switchgear, Funded Construction Project, Fiscal Year 1993,* Sandia National Laboratories, Livermore, Livermore, CA.

SNL, Livermore, 1991i, *Preliminary Hazard Assessment, Area 8 Explosive Storage Magazine, Building 982 Rooms*

100 and 101, Sandia National Laboratories, Livermore, Livermore, CA, February 1991.

SNL, Livermore, 1991j, *Preliminary Hazard Assessment, Building 910 Facilities, Tabs 1 through 10,* Sandia National Laboratories, Livermore, Livermore, CA, 1991

SNL, Livermore, 1991k, *Preliminary Hazard Assessment Building 910, Printed Wiring Board Development*, Sandia National Laboratories, Livermore, Livermore, CA, April 1991.

SNL, Livermore, 1991l, *Preliminary Hazard Assessment, Building 913/1286 Polymer Physics Lab, Chemical Storage Sheds, F&H Polymer Chemistry and Physics*, Sandia National Laboratories, Livermore, Livermore, CA, March 1991.

SNL, Livermore, 1991m, *Preliminary Hazard Assessment, Building 913, Plastics Laboratory, Plastics Chemical Inventory*, Sandia National Laboratories, Livermore, Livermore, CA, March 1991.

SNL, Livermore, 1991n, *Preliminary Hazard Assessment, Building 914 Gauging Laboratory Room 137*, Sandia National Laboratories, Livermore, Livermore, CA, March 1991.

SNL, Livermore, 1991o, *Preliminary Hazard Assessment, Building 914 Room 118A, Dye Penetrant and Magnetic Particle Laboratory,* Sandia National Laboratories, Livermore, Livermore, CA, March 1991.

SNL, Livermore, 1991p, *Preliminary Hazard Assessment, Building 914 Visual Laboratory Room 136*, Sandia National Laboratories, Livermore, Livermore, CA, March 1991.

SNL, Livermore, 1991q, *Preliminary Hazard Assessment, Building 978, Dynamic Aerospace and Mass Properties Facility,* Sandia National Laboratories, Livermore, Livermore, CA.

SNL, Livermore, 1991r, *Preliminary Hazard Assessment, Centrifuge 16 ft, Building 972 Room 100*, Sandia National Laboratories, Livermore, Livermore, CA, June 1991.

SNL, Livermore, 1991s, *Preliminary Hazard Assessment, Cluster Chemistry Laboratory, Building 9lb Room 158,* Sandia National Laboratories, Livermore, Livermore, CA, March 1991.

SNL, Livermore, 1991t, *Preliminary Hazard Assessment, Component Development Laboratory, Building 979* Sandia National Laboratories, Livermore, Livermore, CA, March 1991.

SNL, Livermore, 1991u, *Preliminary Hazard Assessment, Component Development Laboratory, Building 979,* Sandia National Laboratories, Livermore, Livermore, CA, April 1991.

SNL, Livermore, 1991v, *Preliminary Hazard Assessment, Composites Laboratory, Building 913, Room 100 B, C, and D,* Sandia National Laboratories, Livermore, Livermore, CA, March 1991.

SNL, Livermore, 1991w, *Preliminary Hazard Assessment, Composites echanical Testing Laboratory, Building 913 Room 111,* Sandia National Laboratories, Livermore, Livermore, CA, March 1991.

SNL, Livermore, 1991y, *Preliminary Hazard Assessments, Electronic Laboratory, Building 910, Room 309, Division 8176,* Sandia National Laboratories, Livermore, Livermore, CA, April 1991.

SNL, Livermore, 1991z, *Preliminary Hazard Assessment, Excited State Spectroscopy Laboratory, Building 916 Room 157,* Sandia National Laboratories, Livermore, Livermore, CA, March 1991.

SNL, Livermore, 1991aa, *Preliminary Hazard Assessment, Explosive Component Installation, Explosive Component Storage Room, and Testing of Explosive Components in Building 966,* Sandia National Laboratories, Livermore, Livermore, CA, March 1991.

SNL, Livermore, 1991ab, *Preliminary Hazard Assessment, Flight Test Assembly Building 983,* Sandia National Laboratories, Livermore, Livermore, CA, May 1991.

SNL, Livermore, 1991ac, *Preliminary Hazard Assessment, Force, Mass and Torque Laboratory, Building 914 Room 117,* Sandia National Laboratories, Livermore, Livermore, CA, February 1991.

SNL, Livermore, 1991ad, *Preliminary Hazard Assessment, Heat Treatment Facility, Building 924,* Sandia National Laboratories, Livermore, Livermore, CA, March 1991.

SNL, Livermore, 1991ae, *Preliminary Hazard Assessment, High Pressure Facility, Modification Shop and Assembly Laboratories, Building 966 Rooms 102, 104, 104A,* Sandia National Laboratories, Livermore, Livermore, CA, March 1991.

SNL, Livermore, 1991af, *Preliminary Hazard Assessment, High Pressure Facility, Test Cells, Building 966,* Sandia National Laboratories, Livermore, Livermore, CA, March 1991.

SNL, Livermore, 1991ag, *Preliminary Hazard Assessment, High Pressure Hydrogen Test Facility, Building 976,* Sandia National Laboratories, Livermore, Livermore, CA, March 1991.

SNL, Livermore, 1991ah, *Preliminary Hazard Assessment, High Resolution Electron Microscopy Laboratory, Building 916 Room 126,* Sandia National Laboratories, Livermore, Livermore, CA, February 1991.

SNL, Livermore, 1991ai, *Preliminary Hazard Assessment, High Resolution Electron Microscopy Lab Sample Preparation Room, Building 916 Room 126,* Sandia National Laboratories, Livermore, Livermore, CA, March 1991.

SNL, Livermore, 1991aj, *Preliminary Hazard Assessment, Holography and Interferometric Diagnostic Laboratories, Building 914, Rooms 142, 122 and 122A,* Sandia National Laboratories, Livermore, Livermore, CA, March 1991.

SNL, Livermore, 1991ak, *Preliminary Hazard Assessment, Hydrogen Charging at Elevated Temperature, Building 966 Cell 113,* Sandia National Laboratories, Livermore, Livermore, CA, March 1991.

SNL, Livermore, 1991al, *Preliminary Hazard Assessment, Ion Beam Analysis Laboratory, Building 916 Rooms 104 and 104A,* Sandia National Laboratories, Livermore, Livermore, CA, March 1991.

SNL, Livermore, 1991am, *Preliminary Hazard Assessment, Ion Beam Analysis Laboratory, Building 916 Rooms 104 and 104A,* Sandia National Laboratories, Livermore, Livermore, CA, February 1991.

SNL, Livermore, 1991an, *Preliminary Hazard Assessment, Joining Laboratory, Building 913, Room 144/148,* Sandia National Laboratories, Livermore, Livermore, CA, February 1991.

SNL, Livermore, 1991ao, *Preliminary Hazard Assessment, Laser Chemistry Laboratory, Building 916 Room 156,* Sandia National Laboratories, Livermore, Livermore, CA, February 1991.

SNL, Livermore, 1991ap, *Preliminary Hazard Assessment, Laser Plasma Source Laboratory Advanced Materials Division, Building 916, Division 8342,* Sandia National Laboratories, Livermore, Livermore, CA, February 1991.

SNL, Livermore, 1991aq, *Preliminary Hazard Assessment, Laser Plasma Source Laboratory, Building 916 Room 108,* Sandia National Laboratories, Livermore, Livermore, CA, February 1991.

SNL, Livermore, 1991ar, *Preliminary Hazard Assessment, Laser Spectroscopy of Interfaces Laboratory, Building 916 Room 136,* Sandia National Laboratories, Livermore, Livermore, CA, February 1991.

SNL, Livermore, 1991as, *Preliminary Hazard Assessment, Machine Shop, Building 913 Room 119,* Sandia National Laboratories, Livermore, Livermore, CA, February 1991.

SNL, Livermore, 1991at, *Preliminary Hazard Assessment, Materials Synthesis and Analysis Laboratory, Building 916 Room 120,* Sandia National Laboratories, Livermore, Livermore, CA, February 1991.

SNL, Livermore, 1991au, *Preliminary Hazard Assessment, Mechanical Test Activity Areas, Building 976 Cell 2, Building 913 Rooms 111, 118,* Sandia National Laboratories, Livermore, Livermore, CA, March 1991.

SNL, Livermore, 1991av, *Preliminary Hazard Assessment, Mechanics of aterials Laboratory, Building 914, Rooms 127, 140, 121, 124, 144,* Sandia National Laboratories, Livermore, Livermore, CA, January 1991.

SNL, Livermore, 1991aw, *Preliminary Hazard Assessment, Metal Hydride Laboratory, Building 916 Room 116*, Sandia National Laboratories, Livermore, Livermore, CA, March 1991.

SNL, Livermore, 1991ax, *Preliminary Hazard Assessment, Neutron Radiography System, Building 976*, Sandia National Laboratories, Livermore, Livermore, CA, April 1991.

SNL, Livermore, 1991ay, *Preliminary Hazard Assessment, Nonlinear Optics Laboratory, Building 916 Room 153,* Sandia National Laboratories, Livermore, Livermore, CA, April 1991.

SNL, Livermore, 1991az, *Preliminary Hazard Assessment, Nonlinear Optics Technician Work Area, Building 916 Room 151*, Sandia National Laboratories, Livermore, Livermore, CA, March 1991.

SNL, Livermore, 1991ba, *Preliminary Hazard Assessment, Number 831001, etallography Laboratory, Building 913 Room 129C,* Sandia National Laboratories, Livermore, Livermore, CA, March 1991.

SNL, Livermore, 1991bb, *Preliminary Hazard Assessment, Number 831053, Ultrasonics Preparation Room, Building 914, Room 118,* Sandia National Laboratories, Livermore, Livermore, CA, March 1991.

SNL, Livermore, 1991bc, *Preliminary Hazard Assessment, Oil Shed, Building 913-4, Room 1*, Sandia National Laboratories, Livermore, Livermore, CA, February 1991.

SNL, Livermore, 1991bd, *Preliminary Hazard Assessment, Optical Spectroscopy of Gaseous and Solid Samples Laboratory, Building 916 Room 134*, Sandia National Laboratories, Livermore, Livermore, CA, March 1991.

SNL, Livermore, 1991be, *Preliminary Hazard Assessment, Optical Spectroscopy of Solid Samples Laboratory, Building 916 Room 154*, Sandia National Laboratories, Livermore, Livermore, CA, February 1991.

SNL, Livermore, 1991bf, *Preliminary Hazard Assessment, Powder Materials Facility, Building 916 Rooms 162 and 164*, Sandia National Laboratories, Livermore, Livermore, CA, March 1991.

SNL, Livermore, 1991bg, *Preliminary Hazard Assessment, Radiography Laboratory, Building 923,* Sandia National Laboratories, Livermore, Livermore, CA, April 1991.

SNL, Livermore, 1991bh, *Preliminary Hazard Assessment, Reactive Ion Etching Laboratory, Building 916 Room 106*, Sandia National Laboratories, Livermore, Livermore, CA, March 1991.

SNL, Livermore, 1991bi, *Preliminary Hazard Assessment, Rough Draft, Firing Facility, Buildings 973 and 974*, Sandia National Laboratories, Livermore, Livermore, CA.

SNL, Livermore, 1991bj, *Preliminary Hazard Assessment, Scanning Transmission Electron Microscopy Lab-1200 Ex and 200 Cx STEMs, Building 913 Rooms 115 D and F,* Sandia National Laboratories, Livermore, Livermore, CA, arch 1991.

SNL, Livermore, 1991bk, *Preliminary Hazard Assessment, Sheet Metal Shop, Building 913, Room 138,* Sandia National Laboratories, Livermore, Livermore, CA, February 1991.

SNL, Livermore, 1991bl, *Preliminary Hazard Assessment, Shock Lab, Building 972 Rooms 110, 110B, and 110C*, Sandia National Laboratories, Livermore, Livermore, CA, June 1991.

SNL, Livermore, 1991bm, *Preliminary Hazard Assessment, Special Materials and Special Handling Laboratory*, *Building 916 Rooms 160 and 160A,* Sandia National Laboratories, Livermore, Livermore, CA, March 1991.

SNL, Livermore, 1991bn, *Preliminary Hazard Assessment, Spin, Building 978 Rooms 110, 111, 112*, Sandia National Laboratories, Livermore, Livermore, CA, June 1991.

SNL, Livermore, 1991bo, *Preliminary Hazard Assessment, Supercritical Water Flow Reactor, Building 906 Room 107*, Sandia National Laboratories, Livermore, Livermore, CA, April 1991.

SNL, Livermore, 1991bp, *Preliminary Hazard Assessment, Ultrafast Spectroscopy of Condensed Media Laboratory, Building 916 Room 138,* Sandia National Laboratories, Livermore, Livermore, CA, February 1991.

SNL, Livermore, 1991bq, *Preliminary Hazard Assessment, Ultrasonics Testing Facility, Building 914, Rooms 118B, 116, 116 A and B,* Sandia National Laboratories, Livermore, Livermore, CA, March 1991.

SNL, Livermore, 1991br, *Preliminary Hazard Assessment, Vibration Laboratory, Building 955/956 Rooms 106/102, 103, and 104,* Sandia National Laboratories, Livermore, Livermore, CA, June 1991.

SNL, Livermore, 1991bs, *Qualitative Risk Assessment, Building 978, W79 Development and JTA Flight Test Unit with Recovery System Installation and Mass Properties Measurement,* Sandia National Laboratories, Livermore, Livermore, CA, February 1991.

SNL, Livermore, 1991bt, *Resource Consumption at the SNL, Livermore Facility for the Last 5 Years (Power, Natural Gas, and Water)*, Sandia National Laboratories, Livermore, Livermore, CA, 1991.

SNL, Livermore, 1991bu, *Safe Operating Procedure for the Valve/Explosive Component Loading and Testing, Building 966,* Sandia National Laboratories, Livermore, Livermore, CA, February 1991.

SNL, Livermore, 1991bv, *Safety Assessment Burner Engineering Research Laboratory Building 906, Room 130*, Sandia National Laboratories, Livermore, Livermore, CA, January 1991.

SNL, Livermore, 1991bw, *Site & Seismic Modernization Proposed Construction Project Fiscal Year 1997,* Sandia National Laboratories, Livermore, Livermore, CA.

SNL, Livermore, 1991bx, *Summary by Buildings,* Sandia National Laboratories, Livermore, Livermore, CA, May 1991.

SNL, Livermore, 1991by, *Tritium Research Laboratory Facility Description*, Sandia National Laboratories, Livermore, Livermore, CA, May 1991.

SNL, Livermore, 1991ca, *Waste Description and Amounts by Building*, Sandia National Laboratories, Livermore, Livermore, CA, April 1991 (Updated November 1991).

SNL, Livermore, 1991cb, *Mixed Waste and Low-level Waste Information, 1990 and 1991 Data*, Sandia National Laboratories, Livermore, Livermore, CA, July 1991.

SNL, Livermore, 1991cc, *Sandia Radionuclide Inventory*, Sandia National Laboratories, Livermore, Livermore, CA, December 1991.

SNL, Livermore, 1991cd, *SNL, Livermore Product Information by Building*, Sandia National Laboratories, Livermore, Livermore, CA, July 1991.

SNL, Livermore, 1992, *Stereolithography, Draft Preliminary Hazard Assessment*, Sandia National Laboratories, Livermore, Livermore, CA, June 1991.

SNL, Livermore, 1992a, *Incinerator Part B Application*, Sandia National Laboratory, Livermore, Livermore, CA, April 1992.

Stone, G., 1991, *Interoffice Memorandum*, Lawrence Livermore National Laboratory, Livermore, CA, July 1991.

Woodward-Clyde, 1984, *Design Report, Waste Impoundment Ponds for Site 300, Lawrence Livermore National Laboratory, University of California, Livermore, California*, Woodward-Clyde Consultants, Walnut Creek, CA, April 1984.

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B.2 APPLICABLE LAWS, REGULATIONS, AND ORDERS

B.2.1 Waste Management Regulatory Environment

Management of hazardous, radioactive, mixed and medical wastes generated at LLNL and SNL, Livermore is accomplished under an extensive network of federal, state, and local laws and regulations and DOE orders and requirements. Table B-2 lists the major laws and orders that govern waste management practices at the Laboratories.

Table B-2 Federal, State, and Local Regulatory Requirements Affecting Waste Management at LLNL and SNL, Livermore

Laws, Regulations and Requirements	**Responsible Agencies**
Atomic Energy Act of 1954 (42 U.S.C. sections 2011 et seq.)	U.S. Department of Energy
U.S. Department of Energy Organization Act of 1977 (42 U.S.C. sections 7101 et seq.)	U.S. Department of Energy
Resource Conservation and Recovery Act (42 U.S.C. sections 6901 et seq.)	U.S. Environmental Protection Agency
Comprehensive Environmental Response Compensation and Liability Act/Superfund Amendments and Reauthorization Act (42 U.S.C. sections 9601 et seq.)	U.S. Environmental Protection Agency
Toxic Substances Control Act (15 U.S.C. sections 601 et seq.)	U.S. Environmental Protection Agency
Clean Water Act (33 U.S.C. sections 1251 et seq.)	U.S. Environmental Protection Agency
Clean Air Act (42 U.S.C. sections 1857 et seq.)	U.S. Environmental Protection Agency
California Hazardous Waste Control Act (Health and Safety Code sections 25100 et seq.)	California Environmental Protection Agency, Department of Toxic Substances Control
California Porter-Cologne Water Quality Act (Water Code sections 13000 et seq.)	California Environmental Protection Agency, Water Resources Control Board and Regional Water Quality Control Boards

California Clean Air Act (Health and Safety Code section 39000 et seq.)	California Environmental Protection Agency, Air Resources Board
California Proposition 65—Safe Drinking Water and Toxic Enforcement Act (Health and Safety Code sections 25249.5 et seq.) (SNL, Livermore only)	California Environmental Protection Agency
The Hazardous Waste Source Reduction and Management Review Act of 1989 (Health and Safety Code sections 25244.12 et seq.)	California Environmental Protection Agency, Department of Toxic Substance Control
"Hazardous Materials" Department of the California Highway Patrol (13 C.C.R. Chapter 6)	California Highway Patrol
DOE Order 5820.2A "Radioactive Waste Management" (DOE, 1988a)	U.S. Department of Energy
DOE Order 5400.3 "Hazardous and Radioactive Mixed Waste Program" (DOE, 1989)	U.S. Department of Energy
DOE Order 5480.3 "Safety Requirements for the Packaging and Transportation of Hazardous Materials, Hazardous Substances, and Hazardous Wastes" (DOE, 1985)	U.S. Department of Energy
"Nevada Test Site Defense Waste Acceptance Criteria, Certification, and Transfer Requirement" (DOE, 1988b)	U.S. Department of Energy, Nevada Operations Office
California Health and Safety Code, Chapter 6.1–Medical Waste Management Act	Alameda County
City of Livermore Municipal Code, Section 13.32	City of Livermore, California

Note: This table lists some of the more pertinent regulatory requirements that govern waste management practices at LLNL and SNL, Livermore. The table does not include all the regulations affecting waste management.

B.2.2 Implementation of Regulatory Requirements

In order for waste generators and waste management staff to comply with regulatory and operational requirements, the Environmental Protection Department at LLNL and the Environmental Protection Department at SNL, Livermore have developed a number of guidance documents. The basis for these documents includes the federal, state, local, and DOE regulations and requirements summarized in Table B-2. These documents provide the protocols for laboratory personnel to meet the requirements.

At LLNL, the documents for providing guidance on managing radioactive, hazardous, mixed, and medical wastes include:

- Hazardous Waste Management Plan (LLNL, 1989c)
- Guidelines for Waste Accumulation Areas (Hirabayashi, 1989)
- The New Hazardous Waste Management Requisition System (LLNL, 1988c)
- Hazardous Waste Management Quality Assurance Plan (LLNL, 1990g)
- Low-Level, Mixed, and Hazardous Waste Certification Program Plan (LLNL, 1989d)
- Health and Safety Manual (LLNL, 1990h)
- Transuranic Waste Program Certification and Quality Assurance Plan (LLNL, 1990i)
- Preparation Guide for Generators of Hazardous Chemicals and Radioactive Waste at LLNL (Huss, 1987)
- Onsite Hazardous Material Packaging and Transportation Safety Manual (LLNL, 1991k)

Health Services Department (HSD) Procedure for Handling Medical Waste (LLNL, 1991d)
- Waste Minimization and Pollution Prevention Awareness Plan (LLNL, 1991n)

At SNL, Livermore, the principal guidance documents for managing hazardous, radioactive, and mixed wastes include:

- Low-Level Radioactive Waste Certification Program Plan (SNL, Livermore, 1991g)
- Low-Level Radioactive Waste Quality Assurance Plan (SNL, Livermore, 1991f)
- SNL, Livermore Onsite Hazardous Waste Acceptance Criteria (SNL, Livermore, 1989c)
- Hazardous Waste Management Facility Contingency Plan (SNL, Livermore, 1991e)
- Implementation Plan for DOE Order 5820.2A, Radioactive Waste Management (SNL, Livermore, 1989b)
- Environmental Safety and Health Manual (SNL, Livermore, 1991b)
- Guidelines for the Storage of Hazardous Waste (SNL, Livermore, 1991d)
- Spill Prevention Control and Countermeasure Plan (SNL, Livermore, 1990c)
- Hazardous Material Sampling and Analysis Plan (SNL, Livermore, 1990b)
- Hazardous Waste Operation Plan (SNL, Livermore, 1991n)
- Site Specific Plan (SNL, Livermore, 1991i)
- Guidelines for Hazardous Waste Generators (SNL, Livermore, 1991c)
- Waste Minimization and Pollution Prevention Awareness Plan (SNL, Livermore, 1991o)

These guidance documents, supplemented by specific implementation procedures, provided information for this appendix. During the writing of this EIS/EIR, the most up-to-date version of the guidance documents were referenced. However, the guidance documents are updated and revised on a periodic basis, so more recent versions of some of the documents may now exist.

APPENDIX B WASTE MANAGEMENT

This appendix summarizes existing onsite waste management activities and conditions for radioactive, hazardous, mixed, and medical waste generated at the Lawrence Livermore National Laboratory (LLNL) and Sandia National Laboratories, Livermore (SNL, Livermore). Reference to LLNL without specifying the LLNL Livermore site includes Site 300, plus any offsite LLNL leased properties that may ship waste to the LLNL Livermore site. This appendix discusses the practices of onsite waste handling, packaging, and treatment; treatment and storage units; and estimates of waste generation. Transportation of waste is discussed in Appendix K. Figure B-1 shows how Appendix B is organized. Figure B-2 illustrates where additional information on waste management operations is found within this EIS/EIR and how Appendix B interfaces with other appendices.

Several terms are used to describe waste management responsibilities and operating practices at LLNL and SNL, Livermore. These key terms are defined as follows:

Waste Generator. Any individual or group of individuals that generate radioactive, mixed, hazardous, or medical wastes and/or nonsewerable wastewater at LLNL or SNL, Livermore. Waste generator responsibilities are discussed in section B.3.1.1.

Waste Management Staff. Group of individuals whose sole responsibility is to manage wastes generated at the Laboratories (including offsite leased properties) and perform tasks associated with the management of those wastes. The responsibilities of this group, which includes members of the environmental protection organizations at the respective Laboratories, are summarized in section B.3.1.2. (In some cases, this staff may be supported by other persons or groups also performing waste management activities.)

Waste Management Facilities. One or more of the waste management units as defined in sections B.4.2.1, B.4.3.1, or B.5.1 for LLNL Livermore site, LLNL Site 300, and SNL, Livermore respectively.

Waste Accumulation Area. An area specifically designated for temporary collection and storage of wastes until they are picked up by the waste management staff. Hazardous and mixed waste may only be stored in these areas for up to 90 days. Radioactive waste may also be stored in these areas prior to being transferred to Waste Management storage facilities or being shipped offsite. Radioactive wastes may be stored indefinitely in these areas as long as storage is in compliance with DOE Order 5820.2A and relating laws and regulations. Medical wastes are not stored in these areas, but are accumulated at generator facilities. Laboratory guidelines have been developed for proper use of these areas (Hirabayashi, 1989).

Satellite Accumulation Area. A place where a generator may maintain waste containers at or near the point of generation (e.g., in laboratories or machine shops) to collect small quantities of wastes. Hazardous and mixed wastes may be accumulated in limited quantities for periods up to 9 months or until 55 gal of a hazardous waste or 1 qt of an extremely hazardous waste has been accumulated. Radioactive waste may be accumulated indefinitely, as long as appropriate rules and regulations are followed. An extensive list of guidelines must be met to establish a satellite waste accumulation area (Hirabayashi, 1989).

Offsite Leased Property. Facilities external to the LLNL Livermore site that are authorized to ship waste to the site. These include LLNL facilities at the Livermore Municipal Airport, Graham Court, Research Drive, Almond Avenue School, and the Camp Parks facility. (Appendix A lists these facilities.)

Retention System. Collection tanks and associated pumping and piping used to collect wastewater that may contain contaminants at levels above allowable limits for discharge into the sanitary sewer system. The collection tanks isolate the wastewater from the sewer until sampling and analysis results determine if the water is sewerable (based on release limits), or if it requires processing and/or alternate disposition. Retention systems provide isolation of potentially contaminated liquids to prevent unacceptable release. At SNL, Livermore, the retention system is called the Liquid

Effluent Control System (LECS); however, the term retention system is used throughout this document for consistency.

Sewerable. Wastewater that meets site release criteria for discharge to the sanitary sewer system and, therefore, is dischargeable to the sewer.

Nonsewerable. Wastewater that does not meet site release criteria for discharge to the sanitary sewer system and cannot be adjusted for discharge. The wastewater is not discharged to the sanitary sewer system, but is instead handled and disposed of as a hazardous waste.

B.1 WASTE MANAGED AT LLNL AND SNL, LIVERMORE

The types of waste managed by LLNL and SNL, Livermore waste management organizations include five categories: radioactive waste, hazardous waste, mixed waste, medical waste, and industrial (nonsewerable) wastewater. These waste types, defined in the following sections, are generated in various forms and quantities as a result of the numerous research and support activities performed at the Laboratories. Although not classified as hazardous waste, LLNL and SNL, Livermore manage industrial (nonsewerable) wastewater as hazardous waste, shipping it to a licensed treatment, storage, or disposal facility. In addition to these wastes, this appendix discusses sanitary sewer effluent controls that monitor allowable releases and prevent unacceptable releases of radioactive and/or hazardous constituents to the sewer system.

Nonhazardous refuse generated in uncontaminated areas such as administrative buildings and offices is collected and disposed through usual industrial practices (i.e., in a sanitary landfill) and is addressed in sections 4.4 and 5.1.3 of this EIS/EIR.

B.1.1 Waste Type Definitions

The following types of waste are generated at LLNL and/or SNL, Livermore.

Radioactive Waste

Radioactive waste is material that contains radionuclides regulated under the Atomic Energy Act of 1954, as amended, and is of negligible economic value given the cost of recovery. The radioactive waste generated at LLNL may be classified as either transuranic or low-level waste, while SNL, Livermore generates only low-level waste.

- Transuranic waste is waste, without regard to source or form, that is contaminated with alpha-emitting radionuclides of atomic number greater than 92 (uranium) and with half-lives greater than 20 years in concentrations greater than 100 nanocuries per gram. This type of waste is usually generated at LLNL from the use of plutonium and other transuranic isotopes in nuclear weapons research and development.
- Low-level waste is waste containing radioactivity not classified as high-level waste, transuranic waste, spent nuclear fuel, or specified byproduct material, as defined by DOE Order 5820.2A. Test specimens of fissionable material irradiated for research and development only, and not for the production of power or plutonium, may be classified as low-level waste, provided the concentration of transuranic radionuclides is less than 100 nanocuries per gram. Low-level waste is generated at LLNL and SNL, Livermore from research and development activities that use radioactive materials.

There are several classes of radioactive wastes that are not generated at LLNL or SNL, Livermore. Types of radioactive waste not generated at LLNL or SNL, Livermore include irradiated fuel removed from a reactor (i.e., spent fuel), high-level waste from reprocessing spent fuel, and tailings produced by the extraction or concentration of uranium or thorium from ore.

Hazardous Waste

Hazardous waste is waste that is designated hazardous by Environmental Protection Agency (EPA) regulations found in 40 C.F.R. 261 and/or by the State of California per Title 22 of the California Code of Regulations (see section B.2). As used throughout this appendix, the term "hazardous waste" refers to nonradioactive hazardous waste.

Mixed Waste

Mixed waste is waste containing both radionuclides as defined by the Atomic Energy Act and hazardous components as defined by 42 USC 6901 et seq. (RCRA). LLNL Livermore site generates both low-level mixed and transuranic mixed waste while LLNL Site 300 and SNL, Livermore generate only low-level mixed waste.

Medical Waste

Medical waste (as defined in the California Health and Safety Code, Chapter 6.1) includes but is not limited to the following:

Biohazardous Waste

- Discarded live and attenuated vaccines.
- Discarded material contaminated with recognizable fluid blood, fluid blood products, containers, or equipment containing blood that is fluid.
- Discarded material contaminated with excretion, exudate, or secretions known to be infected with a highly communicable disease agent.
- Animal carcasses and animal waste products suspected of being contaminated with infectious agents.

Sharps Waste

- Any device having acute rigid corners, edges, or protuberances capable of cutting or piercing, including, but not limited to (1) hypodermic needles, syringes, blades, and needles with attached tubing; and (2) broken glass items such as pipettes and blood vials contaminated with medical waste.

Nonsewerable Industrial Wastewater

Nonsewerable industrial wastewater is wastewater that contains constituents at concentrations greater than allowed to be discharged to the sanitary sewer but does not meet the criteria to be designated as hazardous waste. This waste is managed as hazardous waste by the Laboratories.

B.1.2 Waste Generated by Site

Waste generated at LLNL and SNL, Livermore may be in solid, liquid, or gaseous form and contain hazardous and/or radioactive constituents. Table B-1 shows the types of waste generated and managed by site at LLNL and SNL, Livermore.

The sites specifically addressed in Appendix B include the LLNL Livermore site, LLNL Site 300, and SNL, Livermore. For purposes of discussion in this document, the LLNL offsite leased properties are considered part of the LLNL Livermore site. The relative quantities of waste generated from these offsite leased properties are relatively insignificant (i.e., on the order of a few waste drums per year from each facility) compared to the quantities generated by the three main sites. Wastes generated from offsite leased properties are included in the total quantities presented for the LLNL Livermore site.

Gaseous waste is also not discussed in detail in Appendix B. Relative to waste management operations, gaseous waste consists of used compressed gases from research activities that are containerized and require treatment/disposal as a hazardous, radioactive, or mixed waste. These wastes are not processed onsite, but are shipped offsite to approved treatment, storage, and disposal facilities. In addition, the relative quantities of gaseous waste generated at the LLNL Livermore site are small compared to other waste streams.

Table B-1 Waste Types Generated by Site

	Radioactive		Mixed			
Waste Generation	**LLW**	**TRU**	**LLW**	**TRU**	**Hazardous**	**Medical**
Solid						
LLNL Livermore site	X	X	X	X	X	X
LLNL Site 300	X		X		X	X
SNL, Livermore	X		X		X	X
Liquid						
LLNL Livermore site	X	X	X	X	X	
LLNL Site 300	X		X		X	
SNL, Livermore	X		X		X	
Gaseous*						
LLNL Livermore site	X		X		X	
LLNL Site 300						
SNL, Livermore						

* Gaseous waste is not processed by the waste management staff but is only stored prior to shipment offsite for treatment and disposal; it is, therefore, not discussed in detail.
LLW = Low-level waste.
TRU = Transuranic waste.

APPENDIX B GLOSSARY

Activity	The number of nuclear transformations occurring in a given quantity of material per unit time. See Curie; Radioactivity.
Alpha, alpha particle	A heavy particle consisting of two neutrons and two protons and thus having a charge of +2; the nucleus of a helium-4 atom.
Americium	An artificial radioactive element of atomic number 95. Am-241 is produced by the beta decay of Pu-241.
Beryllium	A toxic metal of atomic number 4. Natural beryllium consists entirely of Be-9.
Beta particle	Charged particle emitted from the nucleus of an atom, with a mass and charge equal in magnitude to that of the electron.
Curie (Ci)	A special unit of activity. One curie equals 37 billion nuclear transformations per second.
Department of Health Services, Toxic Substances Control Program (DHS)	The state agency with responsibility for administering the California Hazardous Waste Control Law. Effective July 17, 1991 this program became the Department of Toxic Substances Control within the newly formed California Environmental Protection Agency.
Detonators	A device used to initiate detonation in a high explosive. Typically these are much more sensitive to shock than the HE they initiate.
Explosives	*See* High explosives.
Exponential notation	A means of expressing large or small numbers in powers of ten. For instance, 4.3×106 = 4,300,000 and 4.3×10¾5 = 0.000043. This relationship is also sometimes expressed in the form 4.3E+6 = 4,300,000 and 4.3E¾5 = 0.000043.
Firing table	A table placed on a gravel or concrete pad on which experiments with explosives are set up and, when ready, fired. The term is also used to refer to the pad on which the test is conducted.
Gross alpha	The concentration of all alpha-emitting radionuclides in a sample.
Gross beta	The concentration of all beta-emitting radionuclides in a sample.
Hazardous waste	Any solid, semisolid, liquid, or gaseous waste that is ignitable, corrosive, toxic, or reactive as defined by RCRA and identified or listed in 40 C.F.R. part 261.
HEPA filter (High Efficiency Particulate Air)	Filter material that captures entrained particles from an air stream, usually with efficiencies in the range of 99.95 percent and above for particle sizes of 0.3 micron. Filter material is usually a paper or fiber sheet that is pleated to increase its surface area.
High explosives (HE)	Chemically energetic materials with the potential to react explosively; nuclear explosives are not included.
High-level waste (HLW)	Radioactive waste resulting from the reprocessing of spent nuclear fuel. Discarded, unreprocessed spent fuel is also high-level waste. It is characterized by intense penetrating radiation and by high heat-generation rates.
Hood	An enclosure or canopy provided with a draft to carry off toxic or otherwise noxious vapors.
Inventory	The amount of a radioactive or hazardous material present in a building or laboratory.
Low-level	Waste that contains radioactivity and is not classified as high-level waste, transuranic waste, or spent

waste (LLW)	nuclear fuel or byproduct material.
Low specific activity	"'Low Specific Activity material (LSA)' means any of the following: "(1) Uranium or thorium ores and physical or chemical concentrates of those ores. "(2) Unirradiated natural or depleted uranium or unirradiated natural thorium. "(3) Tritium oxide in aqueous solutions provided the concentration does not exceed 5.0 millicuries per milliliter. "(4) Material in which the radioactivity is essentially uniformly distributed and in which the estimated average concentration of contents does not exceed: "(i) 0.0001 millicurie per gram of radionuclides for which the A2 quantity* is not more than .05 curie; "(ii) 0.005 millicurie per gram of radionuclides for which the A2 quantity* is more than .05 curie, but not more than 1 curie; or "(iii) 0.3 millicurie per gram of radionuclides for which the A2 quantity* is more than 1 curie. "(5) Objects of nonradioactive materials externally contaminated with radioactive material, provided that the radioactive material is not readily dispersible and the surface contamination, when averaged over an area of 1 square meter, does not exceed 0.0001 millicurie (220,000 disintegrations per minute) per square centimeter of radionuclides for which the A2 quantity* is not more than .05 curie, or 0.001 millicurie (2,200,000 disintegrations per minute) per square centimeter for other radionuclides" (49 C.F.R. section 173.403(n)). * "'A2 quantities' are the maximum activities of radioactive material permitted in the package being transported. These quantities are listed in 49 C.F.R. 173.435; they depend on the isotopes included (49 C.F.R. 173)."
Mixed waste	Radioactive waste also containing RCRA-designated hazardous constituents.
Primary and secondary containment	Primary containment is that set of engineered safety features immediately around a radioactive or hazardous material designed to prevent its release; secondary containment is the set of backup features outside the primary containment.
Radioactive waste	Material that contains radionuclides regulated under the Atomic Energy Act of 1954, as amended, and is of negligible economic value given the cost of recovery.
Radioactivity	The properties that certain nuclides have of spontaneously emitting particles, gamma radiation, or x radiation.
Radius of impact	The distance to which a specified peak overpressure will extend. In this EIS/EIR, the level at which it is calculated is 1 psi.
Retention tanks	Tanks in which liquid wastes and other effluents are held pending determination of what, if any, treatment they require before disposal.
Satellite waste accumulation area	The initial point of waste accumulation at waste-generating facilities. Waste is held here for later transfer to the waste management organization.
Transuranic (TRU) waste	Waste containing 100 nCi/g or more of alpha-emitting isotopes of elements above uranium in the periodic table with half-lives of over 20 years.
Tritium	A radioactive isotope of the element hydrogen, with two neutrons and one proton in its nucleus. Common symbols for the isotope are H3 and T.
TRU	*See* Transuranic waste.
Waste Accumulation	An area specifically designed for temporary storage of wastes until they are picked up by the waste management staff. Hazardous and mixed waste may only be stored in these areas for up to 90 days.

Area	Radioactive waste may also be stored in these areas prior to being transferred to Waste Management storage facilities or being shipped offsite.
Waste Generator	Any individual or group of individuals that generate radioactive, mixed, or hazardous wastes at LLNL or SNL, Livermore. Waste generator responsibilities are discussed in section B.3.1.1.
Waste Isolation Pilot Plant (WIPP)	A facility in southeastern New Mexico being developed as the disposal site for transuranic and transuranic mixed waste, not yet approved for operation.
Waste Management Facilities	One or more of the waste management units for LLNL Livermore site, LLNL Site 300, and SNL, Livermore respectively.
Waste Management Staff	Group of individuals whose sole responsibility is to manage wastes generated at the Laboratories (including offsite leased properties) and perform tasks associated with the management of those wastes.

APPENDIX B REFERENCES

13 C.C.R. Chapter 6, 1990, Hazardous Materials.

15 U.S.C. sections 601 et seq., Toxic Substances Control Act.

22 C.C.R. Division 4, ch. 30, sections 66001–67651, California Hazardous Waste Control Act.

22 C.C.R. sections 12000–12901, 14000, California Proposition 65—Safe Drinking Water and Toxic Enforcement Act.

33 U.S.C. sections 1251 et seq., Clean Water Act.

40 C.F.R. subch. 1, 1989, Solid Wastes, July 1, 1989.

42 U.S.C. sections 1857 et seq., Clean Air Act.

42 U.S.C. sections 2011 et seq., Atomic Energy Act of 1954.

42 U.S.C. sections 6901 et seq., Resource Conservation and Recovery Act.

42 U.S.C. sections 7101 et seq., U.S. Department of Energy Organization Act of 1977.

42 U.S.C. sections 9601 et seq., Comprehensive Environmental Response Compensation and Liability Act.

Barnett, J.F., 1992, Interoffice Memorandum, Lawrence Livermore National Laboratory, Livermore, CA, June 25, 1992.

Brekke, David D., 1991, *Sandia National Laboratory Livermore Semiannual Categorical Process Report for the Period of June–November 1990*, Sandia National Laboratories, Livermore, Livermore, CA, June 1991.

California Health and Safety Code section 25100 et seq., California Hazardous Waste Control Act.

California Health and Safety Code section 25244.12, The Hazardous Waste Source Reduction and Management Review Act of 1989.

California Health and Safety Code section 39000 et seq., California Clean Air Act.

California Health and Safety Code, Chapter 6.1, Medical Waste Management Act.

California Water Code sections 13000–13999.16, California Porter-Cologne Water Quality Act.

City of Livermore Municipal Code, Section 13.32.

DOE, 1985, Safety Requirements for the Packaging and Transportation of Hazardous Materials, Hazardous Substances, and Hazardous Wastes, DOE Order 5480.3, U.S. Department of Energy, Washington, D.C., July 9, 1985.

DOE, 1988a, Radioactive Waste Management, DOE Order 5820.2A, U.S. Department of Energy, Washington, D.C., September 26, 1988.

DOE, 1988b, *Nevada Test Site Defense Waste Acceptance Criteria, Certification, and Transfer Requirements*, NVO-325, U.S. Department of Energy, Washington, D.C., October 1988.

DOE, 1989, Hazardous and Radioactive Mixed Waste Program, DOE Order 5400.3, U.S. Department of Energy, Washington, D.C., February 22, 1989.

Garcia, T., 1991, *Tritium Research Laboratory Health Physics Quarterly Report*, Health and Safety Division, Sandia National Laboratories, Livermore, Livermore, CA, January 1991.

Grandfield, C. H., 1989, *Guidelines for Discharges to the Sanitary Sewer System*, Lawrence Livermore National Laboratory, Livermore, CA, August 1989.

Hirabayashi, J. M., 1989, *Guidelines for Waste Accumulation Areas*, Lawrence Livermore National Laboratory, Livermore, CA, March 1989.

Huss, J., 1987, *Preparation Guide for Generators of Hazardous Chemicals and Radioactive Waste at LLNL*, Lawrence Livermore National Laboratory, Livermore, CA, March 1987.

Knezovich, J. P. and J. L. Daniels, 1991, *Biodegradation of High-Explosive Wastes*, Lawrence Livermore National Laboratory, Livermore, CA, February 1991.

LLNL, 1988a, *Decontamination and Waste Treatment Facility Project Status Report*, Lawrence Livermore National Laboratory, Livermore, CA, December 1988.

LLNL, 1988b, *Facility Safety Procedures, Radioactive and Hazardous Waste Treatment and Storage Facilities: Buildings 693, 883 and the 612 Complex*, Lawrence Livermore National Laboratory, Livermore, CA, December 1988.

LLNL, 1988c, *The New Hazardous Waste Management Requisition System*, Lawrence Livermore National Laboratory, Livermore, CA, May–June 1988.

LLNL, 1989a, *Contingency Plan for Waste Accumulation Area Building 233,* Lawrence Livermore National Laboratory, Livermore, CA, November 1989.

LLNL, 1989b, *Hazardous Waste Facility Permit, Modification O, Lawrence Livermore National Laboratory - Site 300*, Lawrence Livermore National Laboratory, Livermore, CA, November 1989.

LLNL, 1989c, *Hazardous Waste Management Plan*, Lawrence Livermore National Laboratory, Livermore, CA, September 1989.

LLNL, 1989d, *Low-Level, Mixed, and Hazardous Waste Certification Program Plan*, Lawrence Livermore National Laboratory, Livermore, CA, September 1989.

LLNL, 1989e, *Remedial Investigation of the High Explosives Burn Pit Facility, Building 829 Complex, Lawrence Livermore National Laboratory Site 300*, Lawrence Livermore National Laboratory, Livermore, CA, August 1989.

LLNL, 1990a, *Air Toxics Inventory Plan (AB2588), Iron Horse Thermal Treatment Enclosure, Site 300, Tracy, California*, Lawrence Livermore National Laboratory, Livermore, CA, September 1990.

LLNL, 1990d, *Firing Table Debris Waste Management Procedures*, Site 300 Safety and Operational Manual, Lawrence Livermore National Laboratory, Livermore, CA, September 1990.

LLNL, 1990e, *FY90 Update Lawrence Livermore National Laboratory Waste anagement Plan Per DOE Order #5820.2A,* Lawrence Livermore National Laboratory, Livermore, CA, January 1990.

LLNL, 1990f, *Generation and Characterization of Waste at the Lawrence Livermore National Laboratory,* prepared by Radian Corporation, Lawrence Livermore National Laboratory, Livermore, CA, October 1990.

LLNL, 1990g, *Hazardous Waste Management Quality Assurance Plan,* -078-92 Rev. 3, Lawrence Livermore National Laboratory, Livermore, CA, November 1990.

LLNL, 1990h, *Health & Safety Manual*, M-010-90, Lawrence Livermore National Laboratory, Livermore, CA, July 1990.

LLNL, 1990i, *TRU Waste Program Certification and Quality Assurance Plan*, Lawrence Livermore National Laboratory, Livermore, CA, June 1990.

LLNL, 1990j, *Waste Minimization Program Plan,* Lawrence Livermore National Laboratory, Livermore, CA, May 1990.

LLNL, 1991a, *1990–1991 Wastewater Discharge Permit Application for the University of California Lawrence Livermore National Laboratory Site*, Lawrence Livermore National Laboratory, Livermore, CA.

LLNL, 1991b, *Approval for December 18, 1989 Revised RCRA Part A Application EPA ID No. CA2890012584*, written correspondence, Department of Health Services and Environmental Protection Agency to U.S. Department of Energy and Lawrence Livermore National Laboratory, Livermore, CA, March 25, 1991.

LLNL, 1991c, Hazardous Waste Received by HWM January 1, 1990–December 31, 1990, 4 Data Base Files (By Quarter), Lawrence Livermore National Laboratory, Livermore, CA, September 16, 1991.

LLNL, 1991d, *Health Services Department (HSD) Procedure for Handling edical Waste*, Lawrence Livermore National Laboratory, Livermore, CA, April 3, 1991.

LLNL, 1991e, Low-level Waste Received by HWM January 1, 1990–December 31, 1990, Data Base File, Lawrence Livermore National Laboratory, Livermore, CA, September 16, 1991.

LLNL, 1991f, Mixed Waste Received by HWM January 1, 1990–December 31, 1990, Data Base File, Lawrence Livermore National Laboratory, Livermore, CA, September 16, 1991.

LLNL, 1991g, *Nuclear Design Waste Minimization 1990 Progress Report, Nuclear Design Program Assurance Office,* Lawrence Livermore National Laboratory, Livermore, CA, April 1991.

LLNL, 1991h, *Request for Proposal (RFP) B147894 for the Preparation of a Resource Conservation and Recovery Act Part B Application for the Construction of a New High Explosive Open Burn/Open Detonation Facility at Livermore National Laboratory Site 300,* Lawrence Livermore National Laboratory, Livermore, CA, ay 1991.

LLNL, 1991i, *Site 300 HE Burn Information for Pit 1 and 3, and the Iron Horse*, Lawrence Livermore National Laboratory, Livermore, CA.

LLNL, 1991j, TRU Waste Received by HWM 1989–1990, 2 Data Base Files, Lawrence Livermore National Laboratory, Livermore, CA, April 4, 1991.

LLNL, 1991k, *Onsite Hazardous Materials Packaging and Transportation Safety Manual*, Draft, Rev. 5, Lawrence Livermore National Laboratory, Livermore, CA, August 1991.

LLNL, 1991l, *Commercial/Industrial Waste Generation Survey,* Lawrence Livermore National Laboratory, Livermore, CA.

LLNL, 1991m, *Mixed Waste Storage Available*, Lawrence Livermore National Laboratory, Livermore, CA, December 16, 1991.

LLNL, 1991n, *Waste Minimization and Pollution Prevention Awareness Plan*, Lawrence Livermore National Laboratory, Livermore, CA, May 13, 1991.

LLNL, 1992a, *Firing Table Waste Inventory*, Lawrence Livermore National Laboratory, CA, June 25, 1992.

LLNL, 1992b, Resource Conservation and Recovery Act Part B Permit Application, Hazardous Waste Treatment and

Storage Facilities, EPA ID Number CA2890012584, Lawrence Livermore National Laboratory, Livermore, CA, January 2, 1992.

SNL, Livermore, 1989a, *Hazardous Waste Operation Plan*, Sandia National Laboratories, Livermore, Livermore, CA, February 1989.

SNL, Livermore, 1989b, *Implementation Plan for DOE Order 5820.2A, Radioactive Waste Management*, Sandia National Laboratories, Livermore, Livermore, CA, April 1989.

SNL, Livermore, 1989c, *SNLL Onsite Hazardous Waste Acceptance Criteria*, Hazards Control Bulletin, HCB-8, Sandia National Laboratories, Livermore, Livermore, CA, March 1989.

SNL, Livermore, 1990b, *Hazardous Material Sampling and Analysis Plan,* Sandia National Laboratories, Livermore, Livermore, CA, March 1990.

SNL, Livermore, 1990c, *Spill Prevention Control and Countermeasure Plan*, Sandia National Laboratories, Livermore, Livermore, CA, February 1990.

SNL, Livermore, 1991b, *Environmental Safety & Health Manual*, Sandia National Laboratories, Livermore, Livermore, CA, February 1991.

SNL, Livermore, 1991c, *Guidelines for Hazardous Waste Generators*, Sandia National Laboratories, Livermore, Livermore, CA, May 1991.

SNL, Livermore, 1991d, *Guidelines for Storage of Hazardous Waste*, Sandia National Laboratories, Livermore, Livermore, CA, May 1991.

SNL, Livermore, 1991e, *Hazardous Waste Management Facility Contingency Plan*, Revised 1991, Sandia National Laboratories, Livermore, Livermore, CA, ay 1991.

SNL, Livermore, 1991f, *Low-Level Radioactive Waste Quality Assurance Plan*, Sandia National Laboratories, Livermore, Livermore, CA, May 1991.

SNL, Livermore, 1991g, *Low-Level Radioactive Waste Certification Program Plan*, Sandia National Laboratories, Livermore, Livermore, CA, May 1991.

SNL, Livermore, 1991h, *Mixed Waste and Low-Level Waste Information, 1990 and 1991 Data*, Sandia National Laboratories, Livermore, Livermore, CA, July 9, 1991.

SNL, Livermore, 1991i, *Site Specific Plan*, Sandia National Laboratories, Livermore, Livermore, CA, September 1991.

SNL, Livermore, 1991j, *Tritium Research Facility Environment, Safety and Health Enhancement Project, Fiscal Year 1992 Budget*, Sandia National Laboratories, Livermore, Livermore, CA, 1991.

SNL, Livermore, 1991k, *Wastewater Discharge Program, Environmental Protection Division.* Sandia National Laboratories, Livermore, Livermore, CA, January 1991.

SNL, Livermore, 1991l, *Waste Description and Amounts by Building, April 1991,* Sandia National Laboratories, Livermore, Livermore, CA, updated November 1991.

SNL, Livermore, 1991m, *Waste Reduction Report FY90*, Draft, Sandia National Laboratories, Livermore, Livermore, CA, March 1991.

SNL, Livermore, 1991n, *Hazardous Waste Operation Plan*, Sandia National Laboratories, Livermore, Livermore, CA, August 1991.

SNL, Livermore, 1991o, *Waste Minimization and Pollution Prevention Awareness Plan*, Sandia National Laboratories, Livermore, Livermore, CA, December 31, 1991.

SNL, Livermore, 1991p, *Source Reduction Evaluation Review and Plan*, Sandia National Laboratories, Livermore, Livermore, CA, September 1, 1991.

SNL, Livermore, 1991q, *Hazardous Waste Management Performance Report*, Sandia National Laboratories, Livermore, Livermore, CA, September, 1991.

SNL, Livermore, 1992a, *Area 8 Incinerator Safe Operating Procedures*, Sandia National Laboratories, Livermore, Livermore, CA, April 1992.

SNL, Livermore, 1992b, *Incinerator Part B Application*, Sandia National Laboratories, Livermore, Livermore, CA, April 1992.

UC, 1987, *Final Environmental Impact Report for the University of California Contract with the Department of Energy for Operation and Management of Lawrence Livermore National Laboratory,* University of California, Livermore, CA, July 1987.

Yano, Gordon, 1991, "White Paper Recycling Plan Targeted to Start April 8," *Newsline*, Volume 16, No. 18, Lawrence Livermore National Laboratory, Livermore, CA, March 1991.

APPENDIX C ENVIRONMENT, SAFETY, AND HEALTH

The purpose of this appendix is to discuss the environment, safety, and health programs at Lawrence Livermore National Laboratory (LLNL), including LLNL Site 300, and Sandia National Laboratories, Livermore (SNL, Livermore). Figure C-1 illustrates how Appendix C relates to other appendices and the EIS/EIR. Of particular importance is the support this appendix provides to discussions of waste management (Appendix B), accident analysis (Appendix D), and the related parts of Sections 4 and 5 of the EIS/EIR. This appendix is organized according to the following major sections:

Section C.1 discusses the regulatory requirements for environment, safety, and health programs with which the Laboratories must comply. Section C.2 discusses the organizations of LLNL and SNL, Livermore that deal with environment, safety, and health responsibilities. Section C.3 discusses occupational exposures to radiation, toxic materials, and other industrial hazards arising from the normal operations of facilities. Section C.4 evaluates the impact of releases of radioactive and toxic materials from normal plant operations. The impact of exposures arising from contamination situations are currently being remediated under the Environmental Restoration Program (see section 4.17). The potential impact to members of the general public from hypothetical accidents is discussed in Appendix D. Section C.5 discusses the methods and protocols used by the Laboratories to assure the quality of these programs.

The line management of LLNL and SNL, Livermore are responsible for providing safe working conditions for workers at LLNL and SNL, Livermore and for limiting exposure of the general public in the vicinity to hazardous and radioactive materials. They are assisted in meeting these responsibilities by the Hazards Control Department, the Environmental Protection Department, and the Health Services Department at LLNL, and by the Center for Environment, Safety, and Health and Facilities Management at SNL, Livermore.

C.1 REGULATORY REQUIREMENTS

The primary guidance for the operation of LLNL and SNL, Livermore is provided by DOE orders. DOE orders and other DOE directives are technically equivalent to regulations developed by other regulatory agencies to implement federal laws at private facilities. TableC-1 provides a summary of these laws and regulations and the agencies responsible for their implementation.

Table C-1 Representative Listing of Federal, State, and Local Regulatory Requirements Affecting Environment, Safety, and Health

Laws, Regulations and Requirements	Responsible Agencies
National Environmental Policy Act of 1969 (42 U.S.C. sections 4321 et seq.)	Council on Environmental Quality
Resource Conservation and Recovery Act (42 U.S.C. sections 6901 et. seq.)	U.S. Environmental Protection Agency
Comprehensive Environmental Response Compensation and Liability Act/Superfund Amendments and Reauthorization Act (42 U.S.C. 9601 et. seq.)	U.S. Environmental Protection Agency
Clean Air Act (42 U.S.C. sections 7401 et seq.)	U.S. Environmental Protection Agency

Clean Water Act (33 U.S.C. sections 1251 et seq.)	U.S. Environmental Protection Agency
Safe Drinking Water Act (42 U.S.C. sections 300 et seq.)	U.S. Environmental Protection Agency
Toxic Substance Control Act (15 U.S.C. sections 2601 et seq.)	U.S. Environmental Protection Agency
Noise Control Act of 1972 (42 U.S.C. sections 4901 et seq.)	U.S. Environmental Protection Agency
Occupational Safety and Health Act of 1970 (29 U.S.C. 651 et seq.)	U.S. Department of Labor
California Porter-Cologne Water Quality Act (Water code sections 13000–13999.16)	California Environmental Protection Agency (Water Resources Control Board and Regional Water Quality Control Boards)
California Clean Air Act (Health and Safety Code sections 39000 et seq.)	California Environmental Protection Agency (Air Resources Board)
Air Toxics "Hot Spots" Information and Assessments Act (Health and Safety Code sections 44300 et seq.)	California Environmental Protection Agency (Air Resources Board)
California Safe Drinking Water and Toxic Enforcement Act (Health and Safety Code sections 25249.5 et seq.)*	California Environmental Protection Agency
California Hazardous Waste Control Act (Health and Safety Code sections 25100 et seq.)	California Environmental Protection Agency
City of Livermore Sewage Discharge Regulations	City of Livermore, CA, (Livermore Water Reclamation Plant)
DOE Order 5480.1B "Environment, Safety, and Health Program for Department of Energy Operations"	U.S. Department of Energy
DOE Order 5400.1 "General Environmental Protection Program"	U.S. Department of Energy
DOE Order 5480.4 "Environmental Protection, Safety, and Health Protection Standards"	U.S. Department of Energy
DOE Order 5000.3A "Occurrence Reporting and Processing of Operating Information"	U.S. Department of Energy
DOE Order 5400.2A "Environmental Compliance Issue Coordination"	U.S. Department of Energy
DOE Order 5482.1B "Environment, Safety, and Health Appraisal Program"	U.S. Department of Energy
DOE Order 5484.1 "Environment, Safety, and Health Protection Information Reporting Requirements"	U.S. Department of Energy
DOE Order 5483.1A "Occupational Safety and Health Program for Government-Owned, Contractor-Operated Facilities"	U.S. Department of Energy
DOE Order 5480.11 "Radiation Protection for Occupation Workers"	U.S. Department of Energy

DOE Order 5400.5 "Radiation Protection of the Public and the Environment"	U.S. Department of Energy
DOE Order 5480.10 "Contractor Industrial Hygiene Program"	U.S. Department of Energy
DOE Order 5480.19 "Conduct of Operations Requirements for DOE Facilities"	U.S. Department of Energy
DOE Order 5480.8 "Contractor Occupational Medicine Program"	U.S. Department of Energy
DOE Order 5700.6C "Quality Assurance"	U.S. Department of Energy

* Applies to SNL, Livermore, but not to LLNL

APPENDIX C GLOSSARY

Absolute risk	An expression of excess risk based on the assumption that the excess risk from radiation exposure *adds* to the underlying (baseline) risk by an increment dependent on dose but independent of the underlying natural risk. *See* Relative risk.
Absorbed dose	The mean energy imparted to matter by ionizing radiation per unit mass. The unit of absorbed dose is the rad, which is equal to 100 erg/g.
Accelerator	An apparatus for imparting high velocities to charged particles.
Activity	The number of nuclear transformations occurring in a given quantity of material per unit time. *See* Curie; Radioactivity.
Administrative limit	A limit imposed administratively on the quantity of a radionuclide permitted in a building or part of a building.
AIRDOS	A computer code endorsed by the EPA for predicting radiological doses to members of the public due to airborne releases of radioactive material. It accounts for inhalation, external exposure to direct radiation, and food ingestion pathways.
Alpha, alpha particle	A heavy particle consisting of two neutrons and two protons and thus having a charge of +2; the nucleus of a helium-4 atom.
As low as reasonably achievable (ALARA)	A philosophy of protection that controls and maintains exposures to individuals and to the work force and general public as low as technically and economically feasible below the established limits.
Background radiation	Radiation arising from radioactive material other than that directly under consideration. Background radiation due to cosmic rays and natural radioactivity is always present. There may also be external background radiation from the presence of radioactive substances in building material itself and internal radiation from natural radioactive substances such as potassium-40 in the body.
Best estimate	An estimate made with the numerical inputs that are believed to be representative of the real situation, not biased conservatively.
Beta particle	Charged particle emitted from the nucleus of an atom, with a mass and charge equal in magnitude to that of the electron.
Bioassay	Urinalysis used to monitor the intake of tritium and plutonium in an individual.
Carcinogen	A substance that directly or indirectly causes cancer.
Collective (effective) dose equivalent	The sum of the doses to all exposed groups of people times the number of individuals receiving each dose. For example, if 20 persons receive a dose of 5 rem, 10 a dose of 10 rem, and 5 a dose of 20 rem, the collective dose is (20×5)+(10×10)+(5×20)=100+100+100=300 person-rem.
Committed dose	The time integral of the dose equivalent rate for a specified time period.
Committed Effective Dose Equivalent (CEDE)	"The sum of the committed dose equivalents to various tissues in the body, each multiplied by its weighting factor. It does not include contributions from external dose. Committed dose equivalent is expressed in units of rem (or sievert)" (DOE Order 5480.11, section 8e(8)).
Curie (Ci)	A special unit of activity. One curie equals 37 billion nuclear transformations per second.
Decibel (dB)	A unit measure of a sound pressure ratio. The reference sound pressure is 0.0002 dynes per square centimeter, or the equivalent of 200 micro-bar or 20 Pascal (Pa). This is the smallest sound a human can hear.
Depleted uranium	Uranium from which most of the uranium-235 isotope has been removed.
Dose	A general term denoting the quantity of radiation or energy absorbed. For special purposes, it must be appropriately qualified.
Dose equivalent	"The product of absorbed dose in rads (or gray) in tissue, a quality factor, and other modifying

	factors. Dose equivalent is expressed in units of rem (or sievert)" (DOE Order 5480.11, section 83(2)). The relative biological effectiveness of different kinds of radiation is expressed in the quality factor. (Note: The International Commission on Radiological Protection now uses the term, *radiation weighting factor*, to replace the term, *quality factor*.)
Dosimeter	An instrument or device used to detect and measure accumulated radiation exposure.
Effective Dose Equivalent (EDE)	The dose equivalent from irradiation of an organ or part of the whole body that bears the same risk of cancer as uniform irradiation of the whole body. "The sum over specified tissues of the products of the dose equivalent in a tissue and the weighting factor for that tissue. The effective dose equivalent is expressed in units of rem (or sievert)" (DOE Order 5480.11, section 8e(5)). *(Note: The International Commission on Radiological Protection (ICRP) decided in ICRP Publication 60 to use the term* effective dose *to replace* effective dose commitment.)
Emergency Response Planning Guidelines	Estimates of concentration ranges at which adverse effects can be expected if exposure to a specific chemical last more than 1 hour.
Ergonomic factors	Environmental stresses such as repetitive motion and mental or physical fatigue that can create health concerns when uncontrolled. Ergonomics is also known as human engineering.
Explosives	*See* High explosives.
Exponential notation	A means of expressing large or small numbers in powers of ten. For instance, 4.3×106=4,300,000 and 4.3×10-5 =0.000043. This relationship is also sometimes expressed in the form 4.3E+6=4,300,000 and 4.3E-5=0.000043.
Exposure assessment	The determination of the magnitude, frequency, duration, and route of exposure.
External exposure	Radiation exposure from sources outside the body: cloud passage, material deposited on the ground, and nearby surfaces.
Fission	The splitting of a heavy atomic nucleus into two nuclei of lighter elements, accompanied by the release of energy and generally one or more neutrons. Fission can occur spontaneously or be induced by neutron bombardment.
Gamma radiation	Shortwave-length electromagnetic radiation emitted from the nucleus with typical energies ranging from 10 keV to 9 MeV. Individual gammas considered as particles are also called photons.
Gamma spectroscopy	Analysis of the radionuclides in a sample by measurement of the intensities of the various gammas given off.
Glovebox	A sealed box in which workers, while remaining outside and using gloves attached to and passing through openings in the box, can safely handle and work with radioactive materials, other hazardous materials, and nonhazardous air-sensitive compounds.
Gross alpha	The concentration of all alpha-emitting radionuclides in a sample.
Gross beta	The concentration of all beta-emitting radionuclides in a sample.
Half-life	Time required for a radioactive substance to lose 50 percent of its activity by decay.
Hazard Index (HI)	The ratio between the intake of a chemical and an acceptable health-based reference level. A hazard index of less than 1 indicates a safe level of intake.
Hazardous waste	Any solid, semisolid, liquid, or gaseous waste that is ignitable, corrosive, toxic, or reactive as defined by RCRA and identified or listed in 40 C.F.R. part 261.
Health-conservative scenario	Refers to a scenario in which the highest possible source parameters are used to predict the highest offsite concentrations. Also called the worst-case scenario.
HEPA filter (High Efficiency Particulate Air)	Filter material that captures entrained particles from an air stream, usually with efficiencies in the range of 99.95 percent and above for particle sizes of 0.3 micron. Filter material is usually a paper or fiber sheet that is pleated to increase its surface area.
High explosives (HE)	Chemically energetic materials with the potential to react explosively; nuclear explosives are not included.
Immediately-	Exposure concentrations established by the National Institute for Occupational Safety and

Dangerous-to-Life-or-Health (IDLH) Health/Occupational Safety and Health Administration Standards Completion Program to be used as guidelines for selecting respirator protection for some chemicals. An IDLH condition is one that poses an immediate danger to life or health or that poses an immediate threat of severe exposure to contaminants such as radioactive materials that are likely to have adverse cumulative or delayed effects on health.

Internal exposure Radiation exposure from sources inside the body: from materials ingested, inhaled, or (in the case of tritium) absorbed through the skin.

Inventory The amount of a radioactive or hazardous material present in a building or laboratory.

Low specific activity "'Low Specific Activity material (LSA)' means any of the following:

"(1) Uranium or thorium ores and physical or chemical concentrates of those ores.

"(2) Unirradiated natural or depleted uranium or unirradiated natural thorium.

"(3) Tritium oxide in aqueous solutions provided the concentration does not exceed 5.0 millicuries per milliliter.

"(4) Material in which the radioactivity is essentially uniformly distributed and in which the estimated average concentration of contents does not exceed:

"(i) 0.0001 millicurie per gram of radionuclides for which the A2 quantity* is not more than .05 curie;

"(ii) 0.005 millicurie per gram of radionuclides for which the A2 quantity* is more than .05 curie, but not more than 1 curie; or

"(iii) 0.3 millicurie per gram of radionuclides for which the A2 quantity* is more than 1 curie.

"(5) Objects of nonradioactive materials externally contaminated with radioactive material, provided that the radioactive material is not readily dispersible and the surface contamination, when averaged over an area of 1 square meter, does not exceed 0.0001 millicurie (220,000 disintegrations per minute) per square centimeter of radionuclides for which the A2 quantity* is not more than .05 curie, or 0.001 millicurie (2,200,000 disintegrations per minute) per square centimeter for other radionuclides" (49 C.F.R. section 173.403(n)).

* "'A2 quantities are the maximum activities of radioactive material permitted in the package being transported. These quantities are listed in 49 C.F.R. 173.435; they depend on the isotopes included."

Melanoma A skin cancer characterized by black pigmentation, given to metastasis.

MeV A unit of energy equal to 1.6×10-6 ergs or 1.6×10-13 joules. Short for million electron volts, an electron volt being the energy acquired by an electron when it is accelerated through a potential drop of one volt.

Mutagen A substance that causes genetic or inheritable defects.

Negligible individual risk level A level of average excess risk of fatal health effects attributed to irradiation below which further effort to reduce radiation exposure is unwarranted. The value recommended by the National Council on Radiation Protection (NCRP) is 1 mrem.

Noble gas In this EIS/EIR, neon, argon, krypton, or xenon. With rare exceptions, these gases do not enter into chemical reactions.

Nonionizing radiation Electromagnetic radiation of wavelengths greater than 10-7 m (1000Å), such as laser, thermal, or radio-frequency radiation.

Order of magnitude A factor of ten. When a measurement is made with a result such as 3×107, the exponent of 10 (here 7) is the order of magnitude of that measurement. To say that this result is known to

	within an order of magnitude is to say that the true value lies (in this example) between 3×106 and 3×108.
Person-rem	A unit of collective dose.
pH	The negative logarithm of the concentration of hydrogen ions in a liquid measured in gram equivalents per liter. A pH of 7 is neutral; smaller numbers indicate an acid condition, larger ones a basic condition.
Population exposure	The collective radiation dose received by a population group. *See* Collective dose equivalent.
Pyrotechnic material	A combustible substance such as gunpowder that gives off a display of sparks when burning.
Rad	A unit of absorbed dose equal to 100 erg/g. The equivalent SI unit is the gray, abbreviated Gy; 1 Gy=100 rad.
Radioactivity	The properties that certain nuclides have of spontaneously emitting particles, gamma radiation, or x radiation.
Relative risk	An expression of excess risk based on the assumption that the excess risk from radiation exposure depends on the underlying natural risk.
Rem	The special unit of dose equivalent that expresses the effective dose calculated for all radiation on a common scale. It is the absorbed dose in rads multiplied by certain modifying factors (e.g., the quality factor). The equivalent SI unit is the sievert, abbreviated Sv; 1 Sv=100 rem.
Risk assessment or analysis	Integration of the toxicity and exposure assessment into qualitative and quantitative expressions of risk.
Risk estimator	A number used to convert the measured or calculated effective dose equivalent to estimates of latent fatal cancers that can be attributed to the exposure.
Scenario	A particular chain of hypothetical circumstances that could, in principle, release radioactivity or hazardous chemicals from a storage and handling site, or during a transportation accident.
Screening-level assessment	An assessment of potential health effects used to determine relative risks of various procedures and/or hazards.
Sievert	A unit of dose equivalent equal to 100 rem.
Thermoluminescent detector (TLD)	A dosimeter that operates on the principle that energy absorbed from ionizing radiation raises the molecules of the detector material to a metastable state until they are heated to a temperature high enough to cause the material to return to its normal state accompanied by the emission of light. The amount of light emitted is proportional to the energy absorbed.
Thermonuclear	Related to the fusion process.
Threshold Limit Values/Time-Weighted Average (TLV/TWA)	Guidelines or recommendations that refer to airborne concentrations of potentially hazardous substances. A time-weighted average TLV is an average for a normal 8-hour workday or 40-hour workweek, to which all workers may be repeatedly exposed, day after day, without adverse effect.
Tiger Team	A team set up by the Secretary of Energy in 1989 to assess the environment, safety, and health operations at all DOE facilities to determine whether changes were needed to improve the protection of the environment, safety, and health.
Total detriment	The total number of deleterious effects (fatal and nonfatal cancers, severe hereditary effects, other deleterious effects, and the associated morbidity) that would eventually be experienced by persons exposed to ionizing radiation and by their descendants.
Toxicity assessment	Identification of the types of adverse health effects associated with exposures and the relationship between the magnitude of the exposure and of the adverse effects.
Tritiated water	Water in which one of the hydrogen atoms has been replaced by a tritium atom; sometimes shown as HTO.
Tritium	A radioactive isotope of the element hydrogen, with two neutrons and one proton in its nucleus. Common symbols for the isotope are 3H and T.
Valley fever	A fungal disease of the lungs endemic to the southwest United States characterized in severe cases by high fever and extreme fatigue.

(coccidioidomycosis)	
Volatile organic compound (VOC)	A compound containing carbon and hydrogen in combination with any other element that has a vapor pressure of 1.5 psi absolute (77.6 mm Hg) or greater under storage conditions.
Whole-body radiation	Radiation to the whole body, as opposed to individual organs or parts of the body.

APPENDIX C REFERENCES

29 C.F.R., Part 1910, 1989, Air Contaminants, Occupational Safety and Health Administration, U.S. Department of Labor, January 19, 1989.

40 C.F.R. Part 61, National Emission Standards for Hazardous Air Pollutants.

15 U.S.C. 2601, Toxic Substances Control Act, as amended, 15 U.S.C. sections 2601 et seq.

33 U.S.C. 1251, The Federal Water Pollution Control Act, as amended, 33 U.S.C. sections 1251 et seq.

42 U.S.C. 300, The Safe Drinking Water Act, as amended, 42 U.S.C. sections 300 et seq.

42 U.S.C. 4321, The National Environmental Policy Act of 1969, as amended, 42 U.S.C. sections 4321 et seq.

42 U.S.C. 4901, The Noise Control Act of 1972, as amended, 42 U.S.C. sections 4901 et seq.

42 U.S.C. 6901, The Resource Conservation and Recovery Act of 1976, as amended, Title 42, U.S.C. 6901 et seq.

42 U.S.C. 7401, The Clean Air Act, as amended, 42 U.S.C. sections 7401 et seq.

Acquavella, J. E., G. L. Tietjen, G. S. Wilkinson, C. R. Key, and G. L. Voeltz, 1982, "Malignant Melanoma Incidence at the Los Alamos National Laboratory," *Lancet*, pp. 883–884 (as referenced in Moore, et al., 1984).

Austin, Donald F., and Peggy Reynolds, 1984, *A Case Control Study of Malignant Melanoma Among Lawrence Livermore National Laboratory Employees*, Report No. 3, Lawrence Livermore National Laboratory, Livermore, CA, August 16, 1984.

BEIR V, 1990, *Health Effects of Exposures to Low Levels of Ionizing Radiation*, Committee on the Biological Effects of Ionizing Radiation, Board on Radiation Effects Research, Commission on Life Science, National Research Council, National Academy Press.

Brekke, D. D., 1990, *Site Environmental Report for 1989, Sandia National Laboratory, Livermore*, SAND90-8016, UC-600, Sandia National Laboratories, Livermore, CA and Albuquerque, NM.

CAPCOA, 1991, *Air Toxics "Hot Spots" Program Risk Assessment Guidelines*, AB 2588, Risk Assessment Committee of the California Air Pollution Control Officers Association, January 1991.

DOE, 1980, Construction Safety and Health Program, Order 5480.9, U.S. Department of Energy, Washington, D.C., December 18, 1980.

DOE, 1981, Environmental Protection, Safety, and Health Protection Information Reporting Requirements, Order 5484.1, U.S. Department of Energy, Washington, D.C., February 24, 1981.

DOE, 1982, *Final Environmental Impact Statement*, *Lawrence Livermore National Laboratory and Sandia National Laboratories–Livermore Sites*, DOE/EIS-0028, U.S. Department of Energy, Washington, D.C., July 1982.

DOE, 1983, Occupational Safety and Health Program For Government-Owned, Contractor-Operated Facilities, Order 5483.1A, U.S. Department of Energy, Washington, D.C., June 22, 1983.

DOE, 1984, Environmental Protection, Safety, and Health Protection Standards, Order 5480.4, U.S. Department of Energy, Washington, D.C., May 15, 1984.

DOE, 1985, Contractor Industrial Hygiene Program, Order 5480.10, U.S. Department of Energy, Washington, D.C., June 26, 1985.

DOE, 1986a, Environment, Safety, and Health Program for Department of Energy Operations, Order 5480.1B, U.S. Department of Energy, Washington D.C., September 23, 1986.

DOE, 1986b, Environmental and Health Appraisal Program, Order 5482.1B, U.S. Department of Energy, Washington, D.C., September 23, 1986.

DOE, 1987a, Contractor Occupational Medicine Program, Order 5480.8, U.S. Department of Energy, Washington, D.C., November 16, 1987.

DOE, 1987b, Fire Protection, Order 5480.7, U.S. Department of Energy, Washington, D.C., November 16, 1987.

DOE, 1988a, *External Dose Rate Conversion Factors for Calculation of Doses to the Public*, DOE/EH-0070, U.S. Department of Energy, Washington, D.C.

DOE, 1988b, General Environmental Protection Program, Order 5400.01, U.S. Department of Energy, Washington, D.C., November 9, 1988.

DOE, 1988c, Radiation Protection for Occupational Workers, Order 5480.11, U.S. Department of Energy, Washington, D.C., December 21, 1988.

DOE, 1989a, Environmental Compliance Issue Coordination, Order 5400.2A, U.S. Department of Energy, Washington, D.C., January 31, 1989.

DOE, 1989b, *Toxics Hot Spot Emission Inventory Plan, Sandia National Laboratories, Livermore, California*, U.S. Department of Energy, Albuquerque Operations Office, Albuquerque, NM, August 1989.

DOE, 1990a, Conduct of Operations Requirements for DOE Facilities, Order 5480.19, U.S. Department of Energy, Washington, D.C., July 9, 1990.

DOE, 1990b, *Navy Landfill Solid Waste Water Quality Assessment Test Report*, Draft, U.S. Department of Energy, Albuquerque Operations Office, Environmental Restoration Program, Technical Support Office, Los Alamos National Laboratory, Los Alamos, NM, June 1990.

DOE, 1990c, Occurrence Reporting and Processing of Operations Information, Order 5000.3A, U.S. Department of Energy, Washington, D.C., June 31, 1990.

DOE, 1990d, Radiation Protection of the Public and the Environment, Order 5400.5, U.S. Department of Energy, Washington, D.C., February 8, 1990.

DOE, 1990e, *Tiger Team Assessment of the Lawrence Livermore National Laboratory*, U.S. Department of Energy, Washington, D.C., April 1990.

DOE, 1991, Quality Assurance, Order 5700.6C, U.S. Department of Energy, Washington, D.C., August 21, 1991.

EPA, 1989a, *Exposure Factors Handbook*, Office of Health and Environmental Assessment, EPA/600/6-90/003, U.S. Environmental Protection Agency, Washington, D.C.

EPA, 1989b, *Region IX Risk Assessment Guidance for Superfund Human Health Risk Assessment: U.S. EPA Region IX Recommendations*, Interim Final, U.S. Environmental Protection Agency, San Francisco, CA, December 1989.

EPA, 1989d, *Risk Assessment Methodology, Environmental Impact Statement for NESHAP. Radionuclides*, Volume I, EPA 520/1-89-005, September, 1989.

EPA, 1991, *Health Effects Assessment Summary Tables–1991*, U.S. Environmental Protection Agency, Washington, D.C.

Hiatt, Robert A., and Bruce Fireman, M.A., 1986, "The Possible Effect of Increased Surveillance on the Incidence of Malignant Melanoma," *Preventative Medicine*, Vol. 15.

ICRP 1977, *Problems Involved in Developing an Index of Harm,* Publication 27, International Commission on Radiological Protection, Pergamon Press, New York, May 1977.

ICRP, 1978, *Limits for Intakes of Radionuclides by Workers*, Publication 30, Part 1, Annals of the International Commission on Radiological Protection, Pergamon Press, New York, July 1978.

ICRP, 1988, *Radiation Dose to Patients from Radiopharmaceuticals*, Publication 53, International Commission on Radiological Protection, Pergamon Press, New York, March 1988.

ICRP, 1991, *1990 Recommendations of the ICRP*, Publication 60, International Commission on Radiological Protection, Pergamon Press, New York.

Lamarre, A. L., 1989, *LLNL Site 300 Environmental Investigations Quarterly Report, January–March 1989*, Lawrence Livermore National Laboratory, Livermore, CA.

LLNL, 1987, *Environmental Report for 1986*, Lawrence Livermore National Laboratory, Livermore, CA.

LLNL, 1988, *Environmental Report for 1987*, Lawrence Livermore National Laboratory, Livermore, CA.

LLNL, 1989a, *Internal Dosimetry Program Manual*, Health and Safety Manual, Supplement 33.10, Lawrence Livermore National Laboratory, Livermore, CA.

LLNL, 1989b, *Melanoma Investigation Task Group Status Report*, Lawrence Livermore National Laboratory, Livermore, CA, March 1989.

LLNL, 1990a, *Action Plan in Response to April 1990 Tiger Team Assessment of LLNL, Findings, Responses, and Planned Actions*, Lawrence Livermore National Laboratory, Livermore, CA.

LLNL, 1990b, *Environmental Report for 1989*, UCRL-50027-89, Lawrence Livermore National Laboratory, Livermore, CA.

LLNL, 1990c, *Health and Safety Manual*, Lawrence Livermore National Laboratory, Livermore, CA, January 1990.

LLNL, 1990d, *Health and Safety Manual*, *Chemicals*, M-010-90, Chapter 21, Lawrence Livermore National Laboratory, Livermore, CA, July 1990.

LLNL, 1990e, *Health and Safety Manual*, *Lasers*, M-010-90, Chapter 28, Lawrence Livermore National Laboratory, Livermore, CA, July 1990.

LLNL, 1990f, *Health and Safety Manual*, *Medical Program*, Chapter 5, Lawrence Livermore National Laboratory, Livermore, CA, July 1990.

LLNL, 1990g, *Health and Safety Manual*, *Work Planning and Safety Procedures*, Chapter 2, M-010-90, Lawrence Livermore National Laboratory, Livermore, CA, July 1990.

LLNL, 1991a, *Air Toxics Risk Screening Document for Lawrence Livermore National Laboratory*, *Plant No. 255*, AB2588, Lawrence Livermore National Laboratory, Livermore, CA, February 1991.

LLNL, 1991b, *Analytical Laboratory Sampling Records—1990*, Database Printout, Lawrence Livermore National Laboratory, Livermore, CA, April 1991.

LLNL, 1991c, *Emergency Response Plan (2/27/90); Release of Tritium to the Environment (1981–1990)*, Lawrence Livermore National Laboratory, Livermore, CA, February 2, 1990.

LLNL, 1991d, *Environmental Report for 1990,* UCRL-50027-90, Lawrence Livermore National Laboratory, Livermore, CA.

LLNL, 1991e, *Essential Features of the LLNL Environmental, Safety, and Health Program*, UCRL-AR-104719, Lawrence Livermore National Laboratory, Livermore, CA.

LLNL, 1991f, *Hazards Control Department Overview*, Lawrence Livermore National Laboratory, Livermore, CA, January 22, 1991.

LLNL, 1991g, *LLNL External Dosimetry Data*, Lawrence Livermore National Laboratory, Livermore, CA.

LLNL, 1991h, *LLNL Organization and Protocol for Contacts*, Interoffice Memorandum, Lawrence Livermore National Laboratory, Livermore, CA, January 17, 1991.

LLNL, 1991i, *LLNL Safety Experience 1990*, Lawrence Livermore National Laboratory, Livermore, CA.

LLNL, 1991j, *Safety Audits (1987–1990)*, Lawrence Livermore National Laboratory, Livermore, CA.

LLNL, 1991k, *Summary of Environmental Inspections/Appraisals, August 1985–July 1989*, Lawrence Livermore National Laboratory, Livermore, CA.

LLNL, 1991l, *Unusual Occurrence Reports, 1986–1990*, Lawrence Livermore National Laboratory, Livermore, CA.

LLNL, 1991m, *Various Environmental Inspections/Audits*, Lawrence Livermore National Laboratory, Livermore, CA, February 1991.

LLNL, 1991n, *Winter 1991 Course Catalog*, Lawrence Livermore National Laboratory, Livermore, CA.

Mansfield, G., 1991, *Internal Dosimetry Program and Data*, Lawrence Livermore National Laboratory, Livermore, CA.

Miller, G., 1985, *Working in Magnetic Fields*, Health and Safety Manual Supplement 26.12, Lawrence Livermore National Laboratory, Livermore, CA, June 1985.

Moore, D., and D. Bennett, 1984,"Mortality Among the Employees of Lawrence Livermore National Laboratory," *Energy and Technology Review*, Lawrence Livermore National Laboratory, Livermore, CA, December 1984, pp. 9–19.

Moore, D., D. Bennett, and M. Mendelssohn, 1984, *Melanoma Among Lawrence Livermore National Laboratory Employees: An Epidemiologic Puzzle*, Lawrence Livermore National Laboratory, Livermore, CA, December 19, 1984.

NCRP, 1979, *Tritium In The Environment*, Report No. 62, National Council on Radiation Protection and Measurements, Bethesda, MD, March 9, 1979.

NCRP, 1987, *Recommendations on Limits For Exposure To Ionizing Radiation*, Report No. 91, National Council on Radiation Protection and Measurements, Bethesda, MD, June 1, 1987.

NCRP, 1988, *Exposure of Populations in the United States and Canada from Natural Background Radiation*, Report No. 94, National Council on Radiation Protection and Measurements, Bethesda, MD.

NCRP, 1989, *Comparative Carcinogenicity of Ionizing Radiation and Chemicals,* Report No. 96, National Council on Radiation Protection and Measurements, Bethesda, MD, March 1, 1989.

NRC, 1991, *Standards for Protection Against Radiation; Final Rule*, 10 C.F.R. Part 20, Federal Register, Volume 56, No. 98, pp. 22360-23747, May 21, 1991.

ORP, 1991, *Occurrence Reporting Processing System*, Printout of on-line data base for LLNL and SNL, Livermore, U.S. Department of Energy.

Radian Corporation, 1990, *Lawrence Livermore National Laboratory RCRA Part B Health Risk Assessment, Phase II—Hazardous Waste Management Units*, UCRL 21223, Lawrence Livermore National Laboratory, Livermore, CA, February 1990.

Reynolds, Peggy, and Donald F. Austin, 1985, "Cancer Incidence Among Employees of the Lawrence Livermore National Laboratory 1969–1980," *The Western Journal of Medicine*, pp. 214–218, February 1985.

Schneider, Jeffrey S., Dan H. Moore, and Richard W. Sagebiel, 1990, "Early Diagnosis of Cutaneous Malignant Melanoma at Lawrence Livermore National Laboratory," *Archives of Dermatology*, Volume 126, June 1990.

Schweickert, G. J., and J. D. Rosen, 1984, *Health and Safety Manual Supplement 10.08, Noise—Its Measurement, Evaluation, and Control*, Lawrence Livermore National Laboratory, Livermore, CA, July 1984.

SNL, Livermore, 1990a, *External Dosimetry Report for 1989*, Sandia National Laboratories, Livermore, Livermore, CA, March 1990.

SNL, Livermore, 1990b, *Ground Water Investigations, Quarterly Report, January to April 1990*, Sandia National Laboratories, Livermore, Livermore, CA, April 1990.

SNL, Livermore, 1990c, *Ground Water Investigations, Quarterly Report, April to June 1990*, Sandia National Laboratories, Livermore, Livermore, CA, July 1990.

SNL, Livermore, 1990d, *Ground Water Investigations, Quarterly Report, July to September 1990*, Sandia National Laboratories, Livermore, Livermore, CA, October 1990.

SNL, Livermore, 1991a, *Airborne and Liquid Radioactive Effluents Released by Sandia National Laboratory, Livermore (1986–1990)*, Sandia National Laboratories, Livermore, Livermore, CA.

SNL, Livermore, 1991b, *Environmental Safety and Health Manual*, MN471001, Sandia National Laboratories, Livermore, Livermore, CA, February 1991.

SNL, Livermore, 1991c, *Environmental Safety and Health Manual, Primer of Environmental Safety & Health Information for Supervisors*, Chapter 2, MN471001, Sandia National Laboratories, Livermore, Livermore, CA, February 1991.

SNL, Livermore, 1991d, *Environmental Safety and Health Manual, Industrial Hygiene*, Chapter 6, MN471001, Sandia National Laboratories, Livermore, Livermore, CA, February 1991.

SNL, Livermore, 1991e, *Ground Water Investigations, Quarterly Report, October to December 1990*, Sandia National Laboratories, Livermore, Livermore, CA, January 1991.

SNL, Livermore, 1991f, *Log of Occupational Injuries and Illnesses,1986, 1987, 1988, 1989*, Sandia National Laboratories, Livermore, Livermore, CA.

SNL, Livermore, 1991g, *Operating Safety Procedure for Radiofrequency/Microwave Safety Program*, Sandia National Laboratories, Livermore, Livermore, CA, 1991.

SNL, Livermore, 1991h, *Quality Assurance Management Plan*, Sandia National Laboratories, Livermore, Livermore, CA.

SNL, Livermore, 1991i, *Quality Assurance Plan*, Sandia National Laboratories, Livermore, Livermore, CA, April 1991.

SNL, Livermore, 1991j, *Standard Program Occupational Exposures to Hazardous Chemicals in Laboratories*, Sandia National Laboratories, Livermore, Livermore, CA.

SNL, Livermore, 1991k, *Tiger Team Action Plan for Sandia National Laboratory, Livermore*, Sandia National Laboratories, Livermore, Livermore, CA, February 8, 1991.

SNL, Livermore, 1991l, *Tiger Team Related Materials and Information, Tiger Team Assessment*, Sandia National Laboratories, Livermore, Livermore, CA, February 1991.

SNL, Livermore, 1991m, *Tritium Research Laboratory Health Physics Report*, Sandia National Laboratories, Livermore, Livermore, CA, January 1991.

SNL, Livermore, 1992, *Unusual Occurrence Reports 1990–1992*, Sandia National Laboratories, Livermore, Livermore, CA.

Taffett, M. J., J. R. Copland, and R. A. Ferry, 1991, *Draft Feasibility Study for Landfill Pit 6*, UCRL-AR-106307, Lawrence Livermore National Laboratory, Livermore, CA.

Thorpe, R. K., W. F. Isherwood, M. D. Dresen, and C. P. Webster-Scholten (eds.), 1990, *CERCLA Remedial Investigations Report for LLNL Livermore Site*, UCAR-10299, Lawrence Livermore National Laboratory, Livermore, CA.

Till, J. E., and H. R. Meyer, 1983, "Radiological Assessment," *A Textbook on Environmental Dose Assessment*, U.S. Nuclear Regulatory Commission, Washington, D.C., September 1983.

UNSCEAR, 1988, *Sources, Effects and Risks of Ionizing Radiation, Annex F, Radiation Carcinogenesis in Man*, United Nations Scientific Committee on the Effects of Atomic Radiation, E.88.IX.7, United Nations, New York.

APPENDIX D ACCIDENT ANALYSIS

This appendix presents, as required by NEPA, the estimated consequences of accidents that could occur at the LLNL Livermore site, LLNL Site 300, and SNL, Livermore. Figure D-1 illustrates the relationship of Appendix D to other EIS/EIR appendices, sections of the document, and DOE requirements.

The scenarios described here are those that define the bounding envelope of accidents—that is, any other reasonably foreseeable accident at the LLNL Livermore site, the LLNL Site 300, or SNL, Livermore would be expected to have smaller consequences. The analyses of accidents are conservative, being based on assumptions that deliberately maximize environmental consequences, with little or no credit taken for existing preventative and mitigating features in each building or operation analyzed or the safety procedures that are mandatory at LLNL and SNL, Livermore.

Three types of accidents are discussed: those with a potential for releases of radioactive material, those with a potential for release of toxic chemicals, and those involving high explosives. For accidents involving radioactive materials and toxic chemicals, the appendix describes how locations or operations were selected for analysis, the computer codes used to estimate consequences, the development of the scenario and assumptions about source terms, the selection of computer modeling and a description of the results, and predicted health effects. For accidents involving high explosives, the appendix discusses the use of high explosives at the sites, the potential accidents associated with these uses, the effects of potential accidents, and measures that can mitigate these accidents.

D.1 APPROACH TO THE ANALYSIS OF POTENTIAL ACCIDENTS

Accident scenarios have been developed to reflect the broad range of accidents that might occur at the LLNL Livermore site, LLNL Site 300, and SNL, Livermore. These scenarios include low-probability, high-consequence accidents and the more probable low-consequence accidents. Where appropriate, the scenarios are specific to particular buildings and operations and for specific transportation situations.

The following terms are used to define the scenarios:

- A *reasonably foreseeable accident* is an accident with "impacts which have catastrophic consequences, even if their probability of occurrence is low, provided that the analysis of the impacts is supported by credible scientific evidence, is not based on pure conjecture, and is within the rule of reason" (40 C.F.R. section 1502.22). "Credible" means having reasonable grounds for believability, and the "rule of reason" means that the analysis is based on scientifically sound judgment.
- An accident is *bounding* if no reasonably foreseeable accident with greater consequences can be identified. A *bounding envelope* is a set of individual bounding accidents covering the range of probabilities and possible consequences.
- An analysis is *conservative* if the net result of the assumptions entering into it maximizes the environmental consequences of the accident being analyzed.

A deterministic, nonprobabilistic approach was used to develop the accident scenarios, including those scenarios without a specific initiating cause. The wide range of postulated accidents characterizes the range of risks associated with the operation of the LLNL Livermore site, LLNL Site 300, and SNL, Livermore. To keep the analyses of these accidents within the rule of reason, the scenarios use conservative assumptions, such as stable meteorological conditions that reduce the downwind dilution of hazardous-material releases, or ignore the tendency of reactive chemicals to be depleted by reaction; and in addition, the analyses of these accidents do not violate physical principles or take credit for mitigating factors when the initiating circumstances would render those factors inoperable.

Bounding scenarios were developed for specific hazards (i.e., radioactive material, toxic chemicals, or high explosives for an operation in a building or during transportation). The postulated accident scenario for radioactive material, toxic chemicals, or high explosives, can be reasonably evaluated in terms of the effective dose equivalent, specific toxic effects of individual chemicals, or the radius of impact; and from this, the bounding scenario can be determined. In all cases, bounding scenarios are based on the most limiting consideration: radiation exposure, chemical concentration, or peak overpressure.

The radiological exposures are discussed in the individual scenario descriptions reported in section D.2.8, and the health effects from these exposures are presented in section D.2.9. The chemical exposures are discussed in the individual scenario descriptions reported in section D.3.3. The health effects associated with chemical releases are analyzed separately and presented in section D.3.2.4. The consequences of high explosive accidents are addressed in the individual scenario descriptions in section D.4.3.

APPENDIX D GLOSSARY

Activity	The number of nuclear transformations occurring in a given quantity of material per unit time. See Curie; Radioactivity.
Administrative limit	A limit imposed administratively on the quantity of a radionuclide permitted in a building or part of a building.
AIRDOS	A computer code endorsed by the EPA for predicting radiological doses to members of the public due to airborne releases of radioactive material. It accounts for inhalation, external exposure to direct radiation, and food ingestion pathways.
Alpha, alpha particle	A heavy particle consisting of two neutrons and two protons and thus having a charge of +2; the nucleus of a helium-4 atom.
Americium	An artificial radioactive element of atomic number 95. Am-241 is produced by the beta decay of Pu-241.
Atmospheric dispersion, dilution	The greater the spread downwind of airborne material, the greater the spread and the smaller the concentration along the hotline.
Atmospheric stability	The tendency of the atmosphere to slow the rise of a contaminant plume; the more stable the atmosphere, the smaller the cloud rise and the greater the concentration of the contaminant along the hotline.
Background radiation	Radiation arising from radioactive material other than that directly under consideration. Background radiation due to cosmic rays and natural radioactivity is always present. There may also be external background radiation from the presence of radioactive substances in building material itself and internal radiation from natural radioactive substances such as potassium-40 in the body.
Best estimate	An estimate made with the numerical inputs that are believed to be representative of the real situation, not biased conservatively.
Beta particle	Charged particle emitted from the nucleus of an atom, with a mass and charge equal in magnitude to that of the electron.
Bounding	An accident is bounding if no reasonably foreseeable, equally probable accident can be found with greater consequences. A bounding envelope consists of a set of individual bounding accidents that cover the range of probabilities and possible consequences.
Carcinogen	A substance that directly or indirectly causes cancer.
CHARM™	A Gaussian puff model for atmospheric dispersion of gases.
Collective (effective) dose equivalent	The sum of the doses to all exposed groups of people times the number of individuals receiving each dose. For example, if 20 persons receive a dose of 5 rem, 10 a dose of 10 rem, and 5 a dose of 20 rem, the collective dose is (20 x 5) + (10 x 10) + (5 x 20) = 100 + 100 + 100 = 300 person-rem.
Committed dose	The time integral of the dose equivalent rate for a specified time period.
Committed Effective Dose Equivalent (CEDE)	"The sum of the committed dose equivalents to various tissues in the body, each multiplied by its weighting factor. It does not include contributions from external dose. Committed dose equivalent is expressed in units of rem (or sievert)" (DOE Order 5480.11, section 8e(8).
Conservative	Having consequences that are greater than the most likely consequences; using assumptions that tend

	to overestimate consequences, that err on the safe side.
Criticality	The state of a mass of fissionable material when it is sustaining a chain reaction.
Curie (Ci)	A special unit of activity. One curie equals 37 billion nuclear transformations per second.
Default parameters	Inputs to a computer code that are supplied by the code if the operator fails to supply them.
Depletion of the plume	Removal of contaminants from the plume by rain or deposition on the ground.
Design basis accident	A postulated abnormal event that is used to establish the performance requirements of structures, systems, and components necessary to maintain a safe shutdown condition indefinitely, so that the general public and operating staff are not exposed to hazards in excess of appropriate guidelines.
Deterministic	With results determined by input assumptions and data, but without the probability of occurrence.
Dose	A general term denoting the quantity of radiation or energy absorbed. For special purposes, it must be appropriately qualified.
Dose equivalent	"The product of absorbed dose in rads (or gray) in tissue, a quality factor, and other modifying factors. Dose equivalent is expressed in units of rem (or sievert)" (DOE Order 5480.11, section 83(2)). The relative biological effectiveness of different kinds of radiation is expressed in the quality factor. (Note: The International Commission on Radiological Protection (ICRP) now uses the term *radiation weighting factor* to replace the term *quality factor*.)
Effective Dose Equivalent (EDE)	The dose equivalent from irradiation of an organ or part of the whole body that bears the same risk of cancer as uniform irradiation of the whole body. "The sum over specified tissues of the products of the dose equivalent in a tissue and the weighting factor for that tissue. The effective dose equivalent is expressed in units of rem (or sievert)" (DOE Order 5480.11, section 8e(5)). *(Note: The International Commission on Radiological Protection (ICRP) decided in ICRP Publication 60 to use the term* effective dose *to replace the term* effective dose equivalent.)
Enriched uranium	Uranium enriched in the fissile nuclide U-235.
Explosives	*See* High explosives.
Exponential notation	A means of expressing large or small numbers in powers of ten. For instance, 4.3 × 106 = 4,300,000 and 4.3 × 10-5 = 0.000043. This relationship is also sometimes expressed in the form 4.3E+6 = 4,300,000 and 4.3E-5 = 0.000043.
Exposure assessment	The determination of the magnitude, frequency, duration, and route of exposure.
Fission	The splitting of a heavy atomic nucleus into two nuclei of lighter elements, accompanied by the release of energy and generally one or more neutrons. Fission can occur spontaneously or be induced by neutron bombardment.
Fuel-grade plutonium	Plutonium-239 with enough admixture of other plutonium isotopes (such as plutonium-240) that it cannot be used in weapons although it can be used in reactors.
g notation	Accelerations measured relative to the acceleration of gravity at the earth's surface. Thus, 0.1g = 3.2 ft/sec2 or 98.3 cm/sec2.
Gamma spectroscopy	Analysis of the radionuclides in a sample by measurement of the intensities of the various gammas given off.
Gaussian plume	A plume of contaminants is said to be Gaussian when the contaminant concentrations are greatest at the center line and decrease to either side as exp[-(x/s)2/2], where x is the distance from the center line and s is the distance to the point where the concentration is down to 37 percent of the centerline concentration. *See* Standard deviation.

Glovebox	A sealed box in which workers, while remaining outside and using gloves attached to and passing through openings in the box, can safely handle and work with radioactive materials, other hazardous materials, and nonhazardous air-sensitive compounds.
Hazardous waste	Any solid, semisolid, liquid, or gaseous waste that is ignitable, corrosive, toxic, or reactive as defined by RCRA and identified or listed in 40 C.F.R. part 261.
HEPA filter (High Efficiency Particulate Air)	Filter material that captures entrained particles from an air stream, usually with efficiencies in the range of 99.95 percent and above for particle sizes of 0.3 micron. Filter material is usually a paper or fiber sheet that is pleated to increase its surface area.
High explosives	Chemically energetic materials with the potential to react explosively; nuclear explosives are not included.
Immediately-Dangerous-to-Life-or-Health (IDLH)	Immediately dangerous to life or health concentrations (IDLHs) represent the maximum concentration from which, in the event of respirator failure, one could escape within 30 minutes without a respirator and without experiencing any escape-impairing (e.g., severe eye irritation) or irreversible health effects.
Internal exposure	Radiation exposure from sources inside the body: from materials ingested, inhaled, or (in the case of tritium) absorbed through the skin.
Low specific activity	"'Low Specific Activity material (LSA)' means any of the following": "(1) Uranium or thorium ores and physical or chemical concentrates of those ores. "(2) Unirradiated natural or depleted uranium or unirradiated natural thorium. "(3) Tritium oxide in aqueous solutions provided the concentration does not exceed 5.0 millicuries per milliliter. "(4) Material in which the radioactivity is essentially uniformly distributed and in which the estimated average concentration of contents does not exceed: "(i) 0.0001 millicurie per gram of radionuclides for which the A2 quantity* is not more than .05 curie; "(ii) 0.005 millicurie per gram of radionuclides for which the A2 quantity* is more than .05 curie, but not more than 1 curie; or "(iii) 0.3 millicurie per gram of radionuclides for which the A2 quantity* is more than 1 curie. "(5) Objects of nonradioactive materials externally contaminated with radioactive material, provided that the radioactive material is not readily dispersible and the surface contamination, when averaged over an area of 1 square meter, does not exceed 0.0001 millicurie (220,000 disintegrations per minute) per square centimeter of radionuclides for which the A2 quantity* is not more than .05 curie, or 0.001 millicurie (2,200,000 disintegrations per minute) per square centimeter for other radionuclides" (49 C.F.R. section 173.403(n)). * "'A2 quantities' are the maximum activities of radioactive material permitted in the package being transported. These quantities are listed in 49 C.F.R. 173.435; they depend on the isotopes included."
Maximum credible accident	An accident that has the greatest offsite consequence from hazardous material release and that has a frequency of occurrence greater than 10-6 per year, when credit for mitigation is allowed. Such an accident is one of the set of reasonably foreseeable accidents.

Misfire	Failure of an explosive to detonate (completely) when the firing signal is given. Also called a hang-fire.
Mixed fission products	The ensemble of fission products resulting from the fission of a heavy element such as uranium. *See* Fission.
Mixed waste	Radioactive waste also containing RCRA-designated hazardous constituents.
mrem, millirem	1/1000 rem.
Natural uranium	Uranium as it occurs in nature. The natural substance is 99.28 percent uranium-238, 0.72 percent uranium-235, and 0.0055 percent uranium-234. Only the uranium-235 isotope is fissionable by slow neutrons.
Overpressure	In a blast wave, the pressure above ambient. The pressure in the wave rises sharply to the peak overpressure, then falls more slowly to and below ambient.
Packaging	In the NRC regulations governing the transportation of radioactive materials (10 C.F.R. part 71), the term "packaging" is used to mean the shipping container together with its radioactive contents.
Permissible Exposure	Occupational exposure limits enforced by OSHA. May be for short term or 8-hour duration exposure.
Limit (PEL)	
Person-rem	A unit of collective dose.
Plutonium	An artificial, fissile metal of atomic number 94.
Plutonium-239-equivalent activity	A radioactive hazard index factor that relates the radiotoxicity of transuranic nuclides to that of plutonium-239.
Population exposure	The collective radiation dose received by a population group. *See* Collective dose equivalent.
Probabilistic	With results taking into account the probability of occurrence. Probabilistic calculations sometimes combine the results of several deterministic calculations, weighting their results by their probabilities. *See* Deterministic.
Prompt radiation	Gamma or neutron radiation emitted during the fission process is said to be prompt (within microseconds) or delayed (as much as seconds).
Protective (Preventive)	FDA-recommended levels of radiation exposure above which actions should be taken to prevent or reduce the radioactive contamination of human food or animal feeds.
Action Guide	
Radiation source	In context, a small sealed source of ionizing radiation. Sealed sources are generally used to supply a material that has a known radiation intensity or a specific type of radiation and are not easily dispersed or altered chemically under normal use.
Radioactive material	Any material having a specific activity greater than 0.002 microcuries per gram, as defined by 49 C.F.R. part 173.4-3(y).
Radioactive waste	Material that contains radionuclides regulated under the Atomic Energy Act of 1954, as amended, and is of negligible economic value given the cost of recovery.
Radioactivity	The properties that certain nuclides have of spontaneously emitting particles, gamma radiation, or x radiation.

RADTRAN	An NRC-approved code for estimating the radiological impacts of transportation of radioactive materials.
Reasonably foreseeable	An accident whose impacts "have catastrophic accident consequences, even if their probability of occurrence is low, provided that the analysis of the impacts is supported by credible scientific evidence, is not based on pure conjecture, and is within the rule of reason" (10 C.F.R. part 1502.22(b)(4)).
Release fraction	The fraction of the amount of a substance present that is released in an accident.
Rem	The special unit of dose equivalent that expresses the effective dose calculated for all radiation on a common scale. It is the absorbed dose in rads multiplied by certain modifying factors (e.g., the quality factor). The equivalent SI unit is the sievert, abbreviated Sv; 1 Sv = 100 rem.
Resuspension	The process by which material deposited on the ground is again made airborne, such as by wind or vehicle disturbance.
Satellite waste accumulation area	The initial point of waste accumulation at waste-generating facilities. Waste is held here for later transfer to the waste management organization.
Scenario	A particular chain of hypothetical circumstances that could, in principle, release radioactivity or hazardous chemicals from a storage and handling site, or during a transportation accident.
Sealed source	In context, a small source of ionizing radiation. Sealed sources are generally used to supply a material that has a known radiation intensity or a specific type of radiation and are not easily dispersed or altered chemically under normal use.
Source term	In a calculation of contaminant dispersion, the amount of that contaminant assumed available to be dispersed.
Standard deviation	A description used in statistical theory for the average variation of a random quantity. The root-mean-square deviation from an average value.
Threshold Limit Values/Time-Weighted Average (TLV/TWA)	Guidelines or recommendations that refer to airborne concentrations of potentially hazardous substances. A time weighted average TLV is an average for a normal 8-hour workday or 40-hour workweek, to which all workers may be repeatedly exposed, day after day, without adverse effect.
Transuranic (TRU) waste	Waste containing 100 nCi/g or more of alpha-emitting isotopes of elements above uranium in the periodic table with half-lives of over 20 years.
Tritiated water	Water in which one of the hydrogen atoms has been replaced by a tritium atom; sometimes shown as HTO.
Tritium	A radioactive isotope of the element hydrogen, with two neutrons and one proton in its nucleus. Common symbols for the isotope are H3 and T.
TRU	See Transuranic waste.
TRUPACT-II	The package designed to transport contact-handled transuranic waste to the WIPP site. (TRUPACT = Transuranic Package Transporter)
Type A packaging	"A packaging designed to retain the integrity of containment and shielding . . . under normal conditions of transport as demonstrated by" a water spray test, a free-drop test, a compression test, and a penetration test (40 C.F.R. parts 173.403(gg), 173.465).
Type B packaging	An NRC-certified container that must be used for the transport of transuranic waste containing more than 20 curies of plutonium per package. Type B packaging must be able to withstand both normal

	and accident conditions without releasing its radioactive contents. These containers are tested under severe, hypothetical-accident conditions that demonstrate resistance to impact, puncture, fire, and submersion in water (49 C.F.R. part 173).
Uranium	*See* Natural uranium.
Waste Isolation Pilot Plant (WIPP)	A facility in southeastern New Mexico being developed as the disposal site for transuranic and transuranic mixed waste, not yet approved for operation.
Work station waste management unit	*See* Satellite waste accumulation area.

APPENDIX D REFERENCES

10 C.F.R. section 71.73, 1990, Nuclear Regulatory Commission, Subpart F—Package and Special Form Tests, January 1, 1990.

40 C.F.R. section 1502.22, 1988, Chapter V, Council on Environmental Quality, Environmental Impact Statement, July 1, 1988.

40 C.F.R. part 355, App. A, 1989, List of Extremely Hazardous Substances and Their Threshold Planning Quantities.

49 C.F.R. sections 173.53, 173.88, 173.403, 173.435, 173.465, 173.466, 1990, Research and Special Programs Administration, DOT, October 1, 1990.

51 Fed. Reg. No. 6, January 9, 1986.

American Conference of Governmental Industrial Hygienists, 1986, *Documentation of Threshold Limit Values and Biological Exposure Indices*, 5th edition, Cincinnati, OH.

American Industrial Hygiene Association, 1989a, *Emergency Response Planning Guidelines*, AIHA Emergency Response Planning Guideline Committee, Akron, OH March 30, 1989.

American Industrial Hygiene Association, 1989b, *Odor Thresholds for Chemicals with Established Occupational Health Standards*, Akron, OH.

Bauer, W., 1987, *Report of the Technical Review Committee on the Tritium Research Laboratory Incident of August 18, 1987*, Sandia National Laboratories, Livermore, Livermore, CA.

BEIR IV, 1988, *Health Risks of Radon and Other Internally Deposited Alpha-Emitters, Chapter 6*, National Academy Press, Washington, D.C.

Centers for Disease Control, 1990, *Pocket Guide to Chemical Hazards*, U.S. Department of Health and Human Services, National Institute for Occupational Safety and Health, Washington, D.C.

Clayton, G. D. and F. E. Clayton, (eds.), 1981, *Patty's Industrial Hygiene and Toxicology*, Volume 2A, 3rd ed., Wiley, New York.

CRC Press, Inc., 1991, *CRC Handbook of Chemistry and Physics*, 92nd ed., Boca Raton, FL.

DOE, 1988a, *Draft Environmental Impact Statement, Decontamination and Waste Treatment Facility*, DOE/EIS-0133-D, U.S. Department of Energy, Washington, D.C., June 1988.

DOE, 1988b, *Final Environmental Impact Statement, Special Isotope Separation Project*, DOE/EIS-0136, U.S. Department of Energy, Washington, D.C., November 1988.

DOE, 1990a, *Final Supplemental Environmental Impact Statement, Waste Isolation Pilot Plant*, DOE/EIS-0026-FS, Volume 2 of 13, U.S. Department of Energy, Washington, D.C., January 1990.

DOE, 1990b, Order 5400.5, Change 1, Radiation Protection of the Public and the Environment, U. S. Department of Energy, Washington, D.C., February 8, 1990.

DOE, 1990c, Order 5480.11, Change 2, Radiation Protection for Occupational Workers.

DOE, 1991, *Environmental Assessment, Mixed Waste Disposal Operations at the Nevada Test Site*, U.S. Department of

Energy, Nye County, NV, March 1991.

Educational Data Systems, 1991, *Baseline 1990 Census, Lawrence Livermore Laboratories*.

Elder, J. C., J. M. Graf, and J. M. Dewart, 1986, *A Guide to Radiological Accident Considerations for Siting and Design of DOE Non-Reactor Nuclear Facilities*, LA-10294-MS, UC-41, January 1986.

EPA, 1990, *Manual: Protective Action Guides and Protective Actions for Nuclear Incidents*, U.S. Environmental Protection Agency, Washington, D.C., January 1990.

FDA, 1982, *Accidental Radioactive Contamination of Human Food and Animal Feeds; Recommendations for State and Local Agencies*, Food and Drug Administration, October 22, 1982.

Fisher, D. K., 1989, *Hazard Classification Listing of Facilities*, Letter to James T. Davis, July 25, 1989.

Fisher, D. K., 1990, *Request for Information on Radioisotope Inventory*, Letter to Warren W. Warner, September 10, 1990.

Fusion Technology, 1988, Third Topical Meeting on Tritium Technology in Fission/Fusion and Isotopic Applications, May 1-6, 1988, Toronto, Canada, Proceedings Published in Fusion Technology, Volume 14.

Garcia, A. A., 1991, *Plutonium Facility Policy Statement Regarding Operations with Fissile Materials in Building 332*, September 26, 1991.

General Electric Company, 1989, *Nuclides and Isotopes*, 14th Edition, General Electric Company.

Gulden, W., and J. Raeder, 1988, "Safety Aspects of the Next European Torus," *Fusion Technology, 14*, 223, July 1988.

Green, LeRoy, 1991 *TNT Equivalence of LX-10 Explosive*, September 20, 1991.

Hanna, S. R., G. A. Briggs, and R. P. Hosker, 1982 *Handbook on Atmospheric Diffusion*, DOE/TIC-11223, National Oceanic and Atmospheric Administration.

ICRP, 1977, Publication 26, International Commission on Radiological Protection, Pergamon Press, New York.

ICRP, 1979–1982, Publication 30, International Commission on Radiological Protection, Pergamon Press, New York.

ICRP, 1991, *1990 Recommendations of the ICRP*, Publication 60, International Commission on Radiological Protection, Pergamon Press, New York.

Kinney, Gilbert F. and Kenneth J. Graham, 1985, *Explosive Shocks in Air*, Spinger-Verlag, New York.

Klaassen, C. D., M. O. Amdur, and J. Doull (eds.), 1986, *Casarett and Doull's Toxicology: The Basic Science of Poisons*, 3rd ed., Macmillan, New York.

LLNL, 1985, *Hazardous Waste Operation Plan*, Lawrence Livermore National Laboratory, Livermore, CA.

LLNL, 1987, *Safety Analysis Report of the Combined AVLIS Full Scale Demonstration Facility - Building 490, Refurbishment Facility - Building 491, Laser Dye Pump Facility - Building 492,* UCID-20831, Lawrence Livermore National Laboratory, Livermore, CA, May 1, 1987.

LLNL, 1988a, *Radioactive and Hazardous Waste Treatment and Storage Facilities: Buildings 693, 883, and the 612 Complex, Facility Safety Procedure 612,* Lawrence Livermore National Laboratory, Livermore, CA.

LLNL, 1988b, *Shipping, Transferring, and Transporting Explosives*, Health & Safety Manual Supplement 24.05, Revised April 1988, Lawrence Livermore National Laboratory, Livermore, CA.

LLNL, 1989a, *Hazardous Material Business Plan for Alameda County*, Lawrence Livermore National Laboratory, Livermore, CA.

LLNL, 1989b, *Environmental Accidents--Incident Reports 1987, 1988, 1989*, Lawrence Livermore National Laboratory, Livermore, CA.

LLNL, 1989c, *Facility Safety Procedure Building 332, Plutonium Facility*, Lawrence Livermore National Laboratory, Livermore, CA, June 1989.

LLNL, 1989d, Low Level Waste Received by Hazardous Waste Management, 1989-90, Database file, Lawrence Livermore National Laboratory, Livermore, CA.

LLNL, 1989e, *SARA Title III Listing of EHM Chemicals Greater than One Pound*, Lawrence Livermore National Laboratory, Livermore, CA.

LLNL, 1989f, TRU Mixed Waste Received and Managed by Hazardous Waste Management, 1989-90, Database file, Lawrence Livermore National Laboratory, Livermore, CA.

LLNL, 1989g, *Waste Discharge and Chemical Storage Permit Application for 1989-90,* Lawrence Livermore National Laboratory, Livermore, CA.

LLNL, 1990a, *Handbook: Heavy Element Facility (B251)*, Lawrence Livermore National Laboratory, Livermore, CA, April 1990.

LLNL, 1990b, *Hazardous Waste Management Procedure No. 528, Radioactive LSA Shipments to NTS*, Rev. 1, Lawrence Livermore National Laboratory, Livermore, CA, June 13, 1990.

LLNL, 1990c, *Review Draft Safety Analysis Report B332, Plutonium Facility*, UCAR-10211, Rev. 1, Lawrence Livermore National Laboratory, Livermore, CA.

LLNL, 1990d, *Safety Analysis Document for the MOCVD Crystal Growth Facility in Building 166*, Lawrence Livermore National Laboratory, Livermore, CA, July 1990.

LLNL, 1990e, *Shipment Mobility/Accountability Collection, 1990 Outbound Shipments of Hazardous Materials by Aviation Methods (AMI)*, Lawrence Livermore National Laboratory, Livermore, CA.

LLNL, 1990f, *Standard Operating Procedure, Handling Gases, Chemicals and Petroleum Products*, Lawrence Livermore National Laboratory, Livermore, CA.

LLNL, 1990g, *Tiger Team Assessment of the Lawrence Livermore National Laboratory*, Lawrence Livermore National Laboratory, Livermore, CA, April 1990.

LLNL, 1991a, *EPD Incidents from 1987, 1988, 1989*, Lawrence Livermore National Laboratory, Livermore, CA.

LLNL, 1991b, *Operational Safety Procedure No. 166.11, Operation of the Metal Vapor Deposition System in Building 166*, Lawrence Livermore National Laboratory, Livermore, CA.

LLNL, 1991c, *Operational Safety Procedure No. 612.21, Increased TRU Storage Limits for the 612 Complex*, Lawrence Livermore National Laboratory, Livermore, CA.

LLNL, 1991d, *Safety Analysis Document for the Separator Demonstration Facilities Complex*, UCAR-AR-106366, Lawrence Livermore National Laboratory, Livermore, CA, February 1991.

LLNL, 1991e, *Shipment Mobility/Accountability Collection, 1991 Outbound Shipments of Hazardous Materials by*

Aviation Methods (AMI), Lawrence Livermore National Laboratory, Livermore, CA.

LLNL, 1991f, *Summary of Industrial Gas Orders for 1989, 1990, and 1991*, Lawrence Livermore National Laboratory, Livermore, CA.

LLNL, 1991g, *Unusual Occurrence Reports 1987, 1988, 1989, 1990*, Lawrence Livermore National Laboratory, Livermore, CA.

LLNL, 1991h, *Waste Minimization Plans and Activities in the MFD Plating Shop*, UCRL-IDIO6464, Lawrence Livermore National Laboratory, Livermore, CA, February 1991.

McClure, J. D., and A. Tyron-Hopko, 1986, *Radioactive Material (RAM) Transportation Accident/Incident Analysis*, SAND85-1016, TTC-0558, Sandia National Laboratories, Livermore, Livermore, CA, March 1986.

Mishima, J., and L. C. Schwendiman, 1970, *The Amount and Characteristics of Plutonium Made Airborne Under Thermal Stress*, Battelle Northwest Laboratories, Richland, WA, October 1970.

Mishima, J., and L. C. Schwendiman, 1973, *Fractional Airborne Release of Uranium (Representing Plutonium) During the Burning of Contaminated Wastes*, Battelle Northwest Laboratories, Richland, WA, April 1973.

Morse, J. L., and R. C. Weingart, 1989, *High Explosive Application Facility (HEAF), Final Safety Analysis Report*, Lawrence Livermore National Laboratories, Livermore, CA, January 1989.

Napier, B. A., R. A. Peloquin, D. L. Strenge, and J. V. Ramsdell, 1988, *GENII--The Hanford Environmental Radiation Dosimetry Software System, Users Manual*, U.S. Department of Energy, Washington, D.C., December 1988.

NCRP, 1979, *Tritium in the Environment*, Report No. 62, National Council on Radiation Protection and Measurements, March 9, 1979.

National Institute for Occupational Safety and Health, 1974, *Occupational Exposure to Ammonia*, U.S. Department of Health, Education, and Welfare, Public Health Service, Centers for Disease Control.

National Research Council, 1987, *Emergency and Continuous Exposure Guidance Levels for Selected Airborne Contaminants, Vol. 7: Ammonia, Hydrogen Chloride, Lithium Bromide, and Toluene*, National Academy Press, Washington, D.C.

Nuclear Regulatory Commission, 1977a, *Final Environmental Statement on the Transportation of Radioactive Material by Air and Other Modes*, NUREG-0170, Vol. 1 and 2, December 1977.

Nuclear Regulatory Commission, 1977b, *Calculation of Annual Doses to Man from Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10 C.F.R. Part 50, Appendix I*, Regulatory Guide 1.109, Revision 1, U.S. Nuclear Regulatory Commission, Washington, D.C., October 1977.

Nuclear Regulatory Commission, 1979, *Assumptions Used for Evaluating the Potential Radiological Consequences of Accidental Nuclear Criticality in a Plutonium Processing and Fuel Fabrication Plant*, Regulatory Guide 3.35, Revision 1, U.S. Nuclear Regulatory Commission, Washington, D.C., July 1979.

Proctor, N. H., and H. P. Hughes, 1978, *Chemical Hazards in the Workplace*, J. B. Lippincott Co., Philadelphia, PA.

Radian, 1990, *User Manual for CHARM™, Version 6.1*.

RTEC, 1991, *Registry of Toxic Effects of Chemical Substances*, National Institute for Occupational Safety and Health.

Sax, N. I., 1989, *Dangerous Properties of Industrial Materials*, 7th ed., Van Nostrand Reinhold Co., New York.

Selby, J. M., et al., 1975, *Considerations in the Assessment of the Consequences of Effluents from Mixed Oxide Fuel*

Fabrication Plants, Battelle Northwest Laboratories, Richland, WA, June 1975.

Sittig, M., 1985, *Handbook of Toxic and Hazardous Chemicals and Carcinogens*, 2nd ed., Noyes Publications, Park Ridge.

Slade, David H., 1968, *Meteorology and Atomic Energy 1968,* National Technical Information Service, U. S. Department of Commerce, Springfield, VA, July 1968.

SNL, Livermore, 1981, *Tritium Research Laboratory Safety Analysis Report*, SAND81-8234, Sandia National Laboratories, Livermore, Livermore, CA, August 1981.

SNL, Livermore, 1990a, *Hazardous Materials Business Plan*, Sandia National Laboratories, Livermore, Livermore, CA.

SNL, Livermore, 1990b, Chemical Inventory Listing (computer printout), Sandia National Laboratories, Livermore, Livermore, CA.

SNL, Livermore, 1990c, *Tritium Safety Training*, Sandia National Laboratories, Livermore, Livermore, CA, April 23, 1990.

SNL, Livermore, 1991a, *List of Potentially Hazardous Facilities at Sandia National Laboratory, Livermore*, Sandia National Laboratories, Livermore, Livermore, CA.

SNL, Livermore, 1991b, *Process Tritium Water Content*, Sandia National Laboratories, Livermore, Livermore, CA.

SNL, Livermore, 1991c, *Radionuclide Inventory*, Sandia National Laboratories, Livermore, Livermore, CA, February 1991.

SNL, Livermore, 1991d, *Sandia Laboratories Operating Instruction, Radioactive Materials, Use of the Tritium Research Laboratory (TRL)*, Draft #3, OI 6476-L-8480-1, Sandia National Laboratories, Livermore, Livermore, CA, February 18, 1991.

SNL, Livermore, 1991e, *SARA Title III Report*, Sandia National Laboratories, Livermore, Livermore, CA.

SNL, Livermore, 1991f, *Reduction of Site Tritium Inventory Limit*, Draft #5, OI 6476-L-8480-1, Sandia National Laboratories, Livermore, Livermore, CA, November 21, 1991.

SNL, Livermore, 1992, *Tritium Focus Group Meeting, April 8–9, 1992, Identification of Tritium Residues and Shipping Container Requirements*, letter from W. R. Wall to Eric T. Kirk, Sandia National Laboratories, Livermore, Livermore, CA, May 14, 1992.

Stratton, W. R., and D. R. Smith, *A Review of Criticality Accidents*, DOE/NCT-04, Nuclear Criticality Information System, Lawrence Livermore National Laboratory, Livermore, CA, March 1989.

Sutter, S. L., et al, 1981, *Aerosols Generated by Free Fall Spills of Powders and Solutions in Static Air,* Pacific Northwest Laboratory, Richland, WA, January 1981.

Taschner, M., C. Bunnenberg, and W. Gulden, 1991, "Maximum Permissible Amounts of Accidentally Released Tritium Derived From An Environmental Experiment to Meet Dose Limits for Public Exposure," *Fusion Technology, 20, 58*, August 1991.

Toy, A. J., 1991, *Absence of Tritiated Water in Building 331 Inventory,* October 20, 1991.

Turner, J. E., 1986, *Atoms, Radiation, and Radiation Protection,* Pergamon Press, NY.

U.S. Army, 1969, *Structures to Resist the Effects of Accidental Explosions*, TM 5-1300, June 1969.

Zapert, J. G., 1990, *Evaluation of Dense Gas Simulation Models*, EPA Contract No. 68-02-4399.