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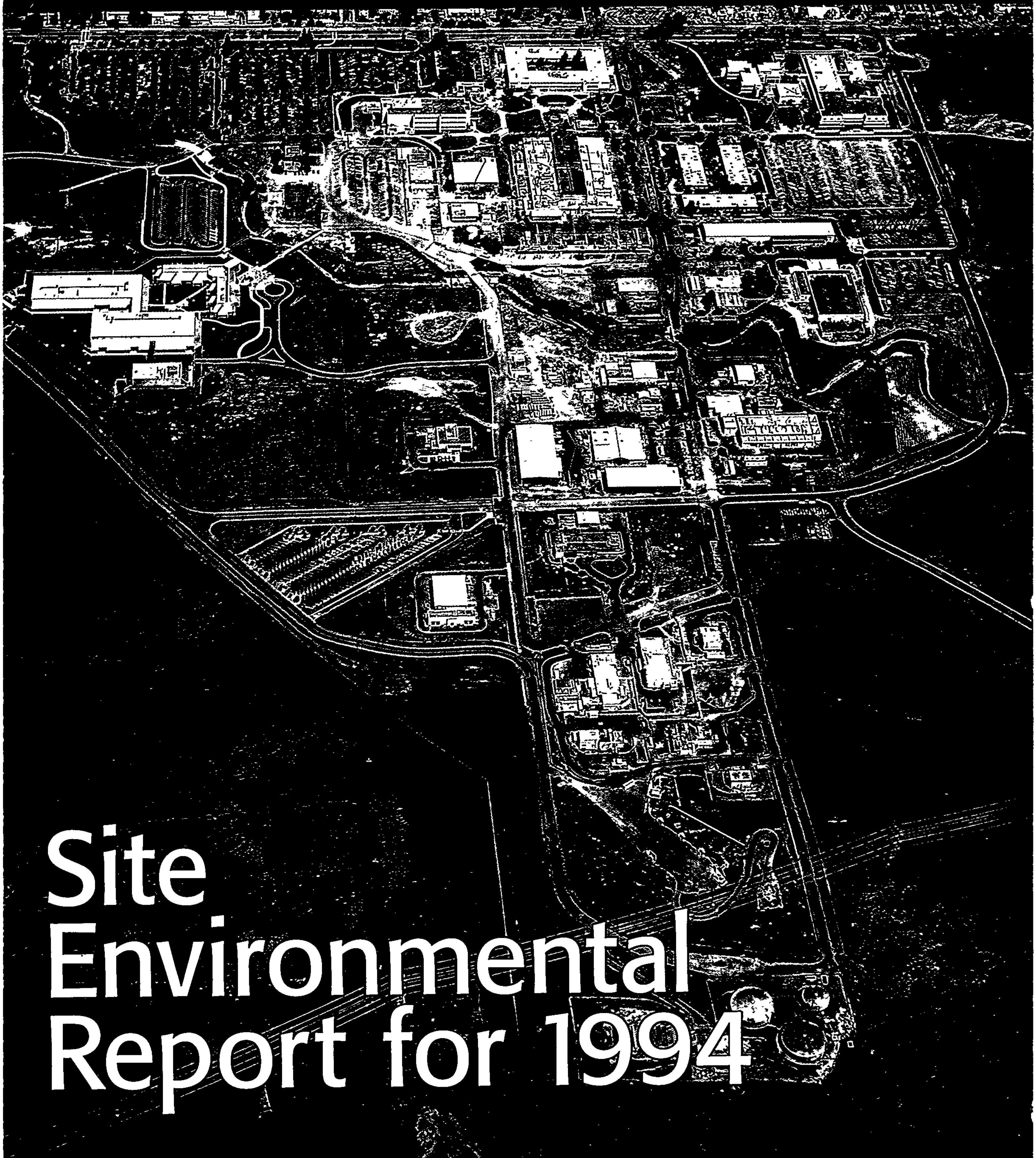
Livermore, California



Site Environmental Report for 1994

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The U.S. Department of Energy (DOE) Order 5400.1, *General Environmental Protection Programs,* establishes requirements for environmental protection programs at DOE sites, including Sandia National Laboratories (SNL). These programs ensure that DOE operations comply with Federal, State, and local environmental laws and regulations, as well as DOE orders and policies. To comply with DOE Order 5400.1, SNL/California has prepared the *Environmental Protection Implementation Plan.* This document provides the framework for SNL/California to implement the DOE's environmental protection goals and to comply with environmental regulations.

To verify effective protection of the environment, SNL/California maintains extensive effluent monitoring and environmental surveillance programs. These programs collect the information necessary to assess how effective pollution control measures are and to characterize the site's impact on the environment. The monitoring program routinely measures the levels of pollutants and radioactive material around the Sandia site and surrounding area. Much of the off-site environmental monitoring data in this report were collected by Lawrence Livermore National Laboratory (LLNL), which monitors outlying areas for both facilities. The SNL/California *Environmental Monitoring Plan* identifies the operations and emissions at the site and describes the effluent monitoring and environmental surveillance programs and activities. These programs and activities are in place to protect the public and the environment. The plan describes exposure pathways (potential routes of human exposure to pollutants), sampling and analysis procedures, radiation dose assessment methods, and quality assurance activities.

The SNL/California Environmental Protection and Environmental Operations departments are responsible for all environmental programs and activities, including reporting requirements. Environmental staff maintain various documents describing specific program areas. These documents are referenced in this report, as appropriate.

The SNL/California Environmental Operations Department prepares the *Site Environmental Report* annually, as required by the DOE and other regulatory agencies. It describes the results of SNL/California's environmental protection activities during the calendar year. It also summarizes environmental monitoring data and highlights major environmental programs. Overall, it evaluates SNL/California's environmental management performance and documents the site's regulatory compliance status.

Most importantly, the *Site Environmental Report* serves the needs of the public. It is a key element in our communication with the local community. For this reason, the report contains two summary chapters: Chapter 1, "Executive Summary," and Chapter 3, "Compliance Summary," which highlight and interpret environmental findings and regulatory compliance for the year. These summaries are written for the layperson and use a minimum of technical terminology. However, we have also included an extensive glossary in the back of the report. It defines acronyms, abbreviations, and technical terms. It also describes radiological nomenclature and conversion information for units used in the report.

The body of the report is a comprehensive description of environmental activities. It provides substantial background information and covers all major environmental programs at SNL/California.

Since 1990, SNL/California has cooperated with the State of California to provide additional independent environmental surveillance around the DOE sites in Livermore. This effort (referred to as the "Agreement in Principle") allows the State Department of Health Services to independently monitor the environment around SNL/California and LLNL. The purpose of this agreement is to provide local citizens added assurance that their health and their environment are being protected adequately. If you have questions or concerns about the content of this report, contact the following agency:

California Department of Health Services
Environmental Management Branch
601 North Seventh St.
Sacramento, CA 95814
Phone: (916) 323–3447

In October 1992, the DOE adopted a public participation policy, which commits to providing the public an opportunity to become involved in the decision-making process for environmental restoration and waste management activities. To implement this program, SNL/California has developed a formal public participation program. This program will help keep the local community members informed of matters that affect them. It will help the DOE address public values and concerns. As a good corporate citizen, SNL/California has a long-standing policy of openness with the local community, which includes public meetings, site tours, and informational bulletins. Our formal public participation program will further foster cooperation with our neighbors.

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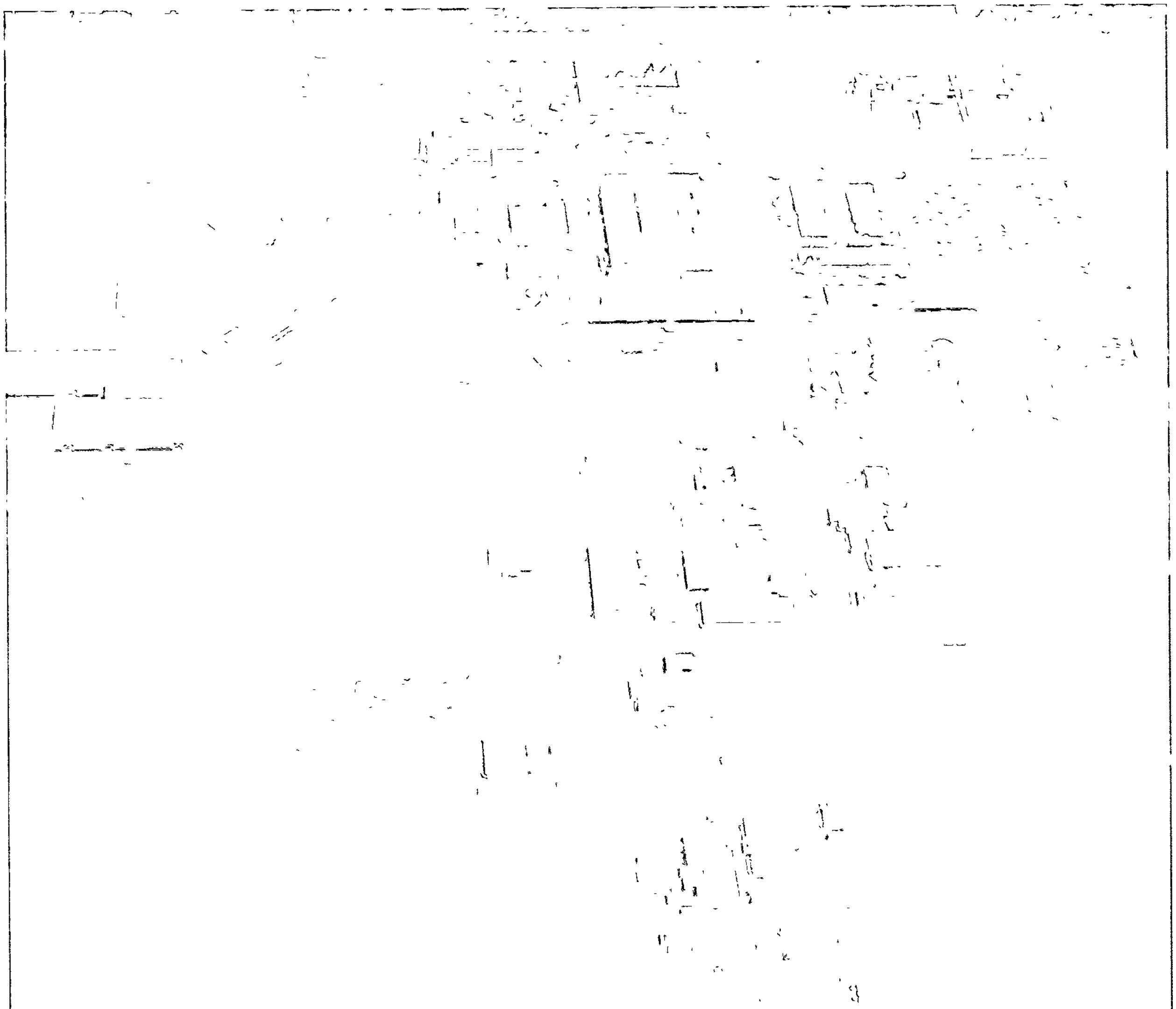


Tritium Research
Air Monitoring
Sewer Monitoring
Water Monitoring
Storm Water Monitoring
Soil Monitoring
Vegetation and Foodstuff Monitoring
External Radiation Monitoring
Radiation Impact to the Public
Compliance with Regulations
Environmental Monitoring Plan

Sandia National Laboratories (SNL) is committed to conducting its operations in an environmentally safe and sound manner. It is mandatory that activities at SNL/California comply with all applicable environmental statutes, regulations, and standards. Moreover, SNL/California continuously strives to reduce risks to employees, the public, and the environment to the lowest levels reasonably possible.

To help verify effective protection of public safety and preservation of the environment, SNL/California maintains an extensive, ongoing environmental monitoring program. This program monitors all significant airborne and liquid effluents and the environment at the SNL/California site perimeter. Lawrence Livermore National Laboratory (LLNL) performs off-site environmental monitoring for both sites. These monitoring efforts ensure that emission controls are effective in preventing contamination of the environment.

As part of SNL/California's Environmental Monitoring Program, an environmental surveillance system measures the possible presence of radioactive and hazardous materials in ambient air, surface water, groundwater, sewage, soil, vegetation, and locally-produced foodstuffs. The program also includes an extensive environmental dosimetry program, which measures external radiation levels around the Livermore site and nearby vicinity.

Each year, the results of the Environmental Monitoring Program are published in this report, the *Site Environmental Report.* This executive summary focuses on impacts to the environment and estimated radiation doses to the public from site emissions. Chapter 3, "Compliance Summary," reviews the site's various environmental protection activities and compliance status with applicable environmental regulations.

The effluent monitoring and environmental surveillance results for 1994 show that SNL/California operations had no harmful effects on the environment or the public. A summary of the monitoring findings is provided below.

Tritium Research

SNL/California no longer supports any nuclear facilities at its site. Tritium (a form of radioactive hydrogen; see Chapter 5) has been the only radionuclide discharged to the environment in measurable quantities from SNL/California site operations for the past several years. This tritium originated from activities in the Tritium Research Laboratory. However, SNL/California completed tritium-related research in 1993 and is now in the final stages of cleaning up the Tritium Research Laboratory for other, non-nuclear laboratory operations.

The transition of the facility includes removal and, whenever possible, reallocation of excess equipment to other Department of Energy (DOE) sites. This process is scheduled to be completed by the summer of 1995. Efforts currently are under way to clean up residual tritium and characterize the radiological condition of the facility.

SNL/California removed the last of the tritium inventory on October 18, 1994. On November 10, 1994, the DOE reclassified the Tritium Research Laboratory as a "Non-nuclear, Low Hazard Facility," which means that it carries no radiological risk to people or the environment.

Air Monitoring

Ambient air is the primary potential exposure pathway to the public from radionuclides emitted from SNL/California operations. Samples of ambient air are collected at the site perimeter and around the Livermore Valley.

During 1994, airborne contaminant concentrations measured at the Livermore site perimeter* and nearby vicinity complied with all applicable air quality standards. The only radionuclide emitted to the atmosphere by SNL/California that requires routine air monitoring is tritium. The highest annual average tritium concentration in air measured at the Livermore site perimeter was approximately 65.2 pCi/m^3 (2.4 Bq/m^3).** This level represents 0.06% of the DOE derived concentration guide—the allowable radionuclide air concentration established by the DOE for protection of the public (see Appendix D, Table D-1). The highest annual average tritium concentration measured in air off-site in the Livermore Valley, was approximately 1.26 pCi/m^3 (4.7×10^{-2} Bq/m^3).

For several years, SNL/California has had no operations that release uranium. However, because of previous work, SNL/California continues to monitor the air for uranium concentrations and reports the data. In 1994, the highest annual average uranium concentration (^{238}U) in air was approximately 6.18×10^{-5} µg/m^3. This represents 0.02% of the DOE derived concentration guide. These concentrations are normal, expected levels from background sources.

Both SNL/California and LLNL discharge small quantities of tritium to the atmosphere as a result of routine operations. Consequently, the tritium measured in ambient air can be attributed to operations at both sites and to natural background sources.

SEWER MONITORING

The sanitary sewer effluent from the SNL/California site is monitored continuously and is sampled weekly and monthly to ensure compliance with Federal, State and local wastewater discharge limits. Moreover, SNL/California strives to minimize liquid effluent to the lowest levels possible.

In 1994, all liquid effluent from the SNL/California sanitary sewer outfall complied with the site outfall discharge limits for regulated metals, radionuclides, and Environmental Protection Agency (EPA) priority organic pollutants. A wastewater sample collected at the site outfall on February 28, 1994, was slightly above the discharge limit for oil and grease. A wastewater sample collected at the site outfall on March 7, 1994, was slightly above the discharge limit for total dissolved solids. However, these concentrations did not adversely affect operations at the Livermore Water Reclamation Plant, according to plant staff.

SNL/California also has a special monitoring program for "categorical processes" subject to EPA wastewater pretreatment standards (Title 40 CFR, Part 433).[1] In 1994, all the liquid effluents from these processes complied with pretreatment discharge standards (for metals and organic pollutants), except one. A wastewater sample collected at the Electroplating Laboratory on April 25, 1994, showed a nickel concentration above the categorical discharge limit. The total volume discharged in this batch was less than 500 gallons. The incident was reported to the Livermore Water Reclamation Plant. It did not cause SNL/California to exceed any permit limits at the site sanitary sewer outfall, nor did it disrupt the operations at the Livermore Water Reclamation Plant. These events are discussed in greater detail in Chapter 4, "Environmental Monitoring."

The DOE and the State of California have established allowable limits—as

* *In this report, the "Livermore site perimeter" refers to both LLNL and SNL/California.*

** *The picocurie (pCi) is a commonly used English unit for measuring levels of environmental radiation. The becquerel (Bq) is a commonly used SI unit (International System of Units) for measuring radiation. These units are defined in the glossary.*

monthly average concentrations and annual totals—for discharging radionuclides into a public sewer system (see Appendix B).[2] These limits were derived to protect the public and the environment. In 1994, the only radionuclide discharged to the sanitary sewer system in detectable amounts was tritium. Tritium concentrations did not exceed the monthly average concentration limit on any occasion. In 1994, the annual average concentration of tritium in the sanitary sewer effluent was 0.1% of the DOE monthly control limit. As a result of routine operations, SNL/California discharged a total of 0.059 Ci (2.2×10^3 MBq) tritium in 1994. This amount is only 1.2% of the total annual limit.

WATER MONITORING

All major surface-water bodies near the site (except the San Antonio Reservoir) are monitored routinely for tritium activity. The highest annual average tritium concentration observed off-site in water in 1994, 71.9 pCi/L (2.7 Bq/L), was 0.4% of the California Environmental Protection Agency's (Cal/EPA) drinking water standard for tritium in public drinking water (20,000 pCi/L).[3] Furthermore, all surface water samples collected in 1994 had tritium levels much lower than the drinking water standard.

Groundwater samples are collected from monitoring wells at the Livermore Water Reclamation Plant. Tritium concentrations in wells downgradient of the plant were slightly higher than other groundwater samples. Even though these wells monitor an aquifer not used as a drinking water source, the tritium levels were still well below the State drinking water standard. The elevated values are due to the Livermore Water Reclamation Plant's past practice of discharging the plant effluent to the Arroyo Las Positas. This practice was discontinued several years ago, and the tritium concentrations have decreased since that time. Now, the tritium levels in the environment are primarily attributable to emissions from both SNL/California and LLNL, as well as to natural background.

Rainwater samples are collected at locations near the SNL/California site and in the Livermore Valley. The highest annual average tritium concentration measured in rainfall in 1994 was 540 pCi/L (20.0 Bq/L) at the LLNL Visitors' Center. This value represents 3% of the drinking water standard.

STORM WATER MONITORING

A State-issued industrial activity storm water permit and a City of Livermore ordinance require SNL/California to eliminate non-storm water discharges and reduce pollutant discharge to the storm drain system to the maximum extent practicable. To comply with these requirements, SNL/California conducts a variety of sampling, monitoring, and inspection activities throughout the year. Storm water runoff is sampled and visually inspected during the wet months. Storm drain outfalls also are inspected during dry weather to make sure that no water is flowing in the storm drain system. The site is inspected annually to further ensure that on-site outdoor activities minimize the amount of pollutants left on the ground, which can be washed into storm water runoff.

In 1994, at least one grab sample was collected from ten of the eleven sampling locations. Samples could not be collected at the Arroyo Seco as it enters the site because not enough runoff could be collected in the sample bottles. Sampling technicians make every effort to collect samples within the first thirty minutes of a storm, or as soon as possible thereafter. All required visual monitoring and sampling were done in 1994.

SOIL MONITORING

Surface soil and arroyo sediment samples are collected throughout the Livermore Valley and are analyzed for radionuclides.

In 1994, the concentration of ^{238}U in surface soils was within historical background levels and was consistent with levels observed in previous years. Tritium concentrations in arroyo samples collected near the Livermore site were lower than the concentrations noted for surface waters in the Livermore Valley, indicating that tritium is not accumulating in the arroyo sediments.

VEGETATION AND FOODSTUFF MONITORING

Samples of vegetation and locally-produced agricultural products were collected in and around the Livermore Valley in 1994. Tritium is the only radionuclide of concern in the terrestrial food pathway from operations at the Livermore site. Tritium is measured in local vegetation and wine. Honey and goat milk are no longer sampled because local production and consumption are decreasing in the area (hence, risk is low).

Wine samples produced in the Livermore Valley showed tritium levels slightly above levels detected in samples from more distant areas. However, these levels of tritium do not represent a health concern. Although the government has not established safety standards for tritium in vegetation nor wine, the levels of tritium observed in each of these media were below the concentration limits permissible for tritium in public drinking water.

EXTERNAL RADIATION MONITORING

SNL/California and LLNL conduct an extensive program to measure external radiation doses at the Livermore site perimeter and throughout the Livermore Valley.

In 1994, the average annual dose equivalent from external radiation measured at the Livermore site perimeter was 68.4 mrem (0.68 mSv). This level was lower than the background radiation dose measured off-site: 73.2 mrem (0.73 mSv). These measurements demonstrate that no measurable external dose was due to direct radiation from Livermore site operations during 1994. That is, if a person had resided at the site fence line 24 hours a day, every day in 1994, he or she would not have received any measurable dose of external radiation above the natural background level.

RADIATION IMPACT TO THE PUBLIC

Small amounts of tritium released from SNL/California operations can be transported through the environment to off-site locations, resulting in potential radiation exposures to the public. Each year, in addition to measuring external radiation doses, the radiation impact from site operations is evaluated and made available to the public in this report. Potential radiation doses are calculated for a hypothetical individual who resides off-site and receives the maximum exposure from all exposure routes. This comprehensive dose assessment includes all radiological emission sources and all significant environmental exposure pathways. The methods and models used to do this assessment are approved by the DOE and the EPA.

The only measurable radionuclide discharged to the atmosphere from SNL/California in 1994 was tritium. Routine operations discharged 95 Ci (3.5×10^6 MBq) of tritium to the atmosphere. The amount of tritium released from SNL/California in 1994 was the lowest on record since the Tritium Research Laboratory became fully operational. (Before Sandia operated the Tritium Research Laboratory, no tritium was emitted from site operations.) Figure 1-1 shows the total annual tritium discharges from SNL/California during 1987–94. The chart shows a general downward trend in tritium emissions over the past eight years. This performance clearly demonstrates SNL/California's conformance

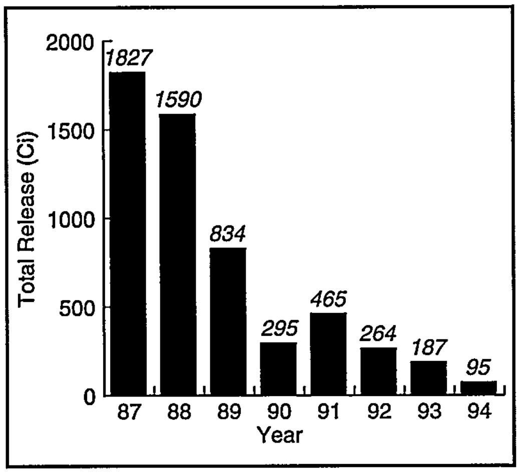


Figure 1-1. Annual airborne tritium discharges from SNL/California, 1987–94.

with the DOE's policy to keep emissions as low as reasonably achievable (ALARA). Note that tritium emissions from 1990 to 1994 decreased primarily because of the phaseout of tritium operations at the Tritium Research Laboratory. SNL/California conducted no tritium experiments in 1994.

The maximum potential radiation dose to a resident in an unrestricted (i.e., publicly accessible) area resulting from SNL/California operations in 1994 was 0.013 mrem (1.3×10^{-4} mSv) effective dose equivalent. This dose was calculated for the point of maximum off-site exposure and represents the cumulative exposure from all significant exposure pathways (inhalation, air submersion, ingestion, and ground-surface irradiation). This level is 0.013% of the DOE allowable limit for protection of the public (100 mrem effective dose equivalent from all sources and all pathways).[3] Furthermore, the methods and parameters used to calculate this dose were very conservative—the dose was calculated for the closest off-site resident, located approximately 1 km northeast of the Tritium Research Laboratory. A major portion of the food consumed by the hypothetical individual was assumed to have been grown locally. The individual was assumed to reside at this location continuously throughout the year. In addition, all the tritium released was assumed to be the most hazardous form, tritium oxide (HTO). Consequently, no one actually receives this dose; it is simply an upper-bound estimate. To put this dose of 0.013 mrem in perspective, it is approximately 28,000 times less than the background radiation dose received in one year by a typical resident of the United States (see Fig. 1-2).

Chapter 5, "Environmental Impacts," contains a much more detailed discussion of potential off-site radiation impacts. For more information about the methods and assumptions used to assess these impacts, see Appendix C. Appendix D summarizes the radiation protection regulations for the public.

COMPLIANCE WITH REGULATIONS

SNL/California expends considerable effort to make sure that site operations comply with all applicable Federal, State,

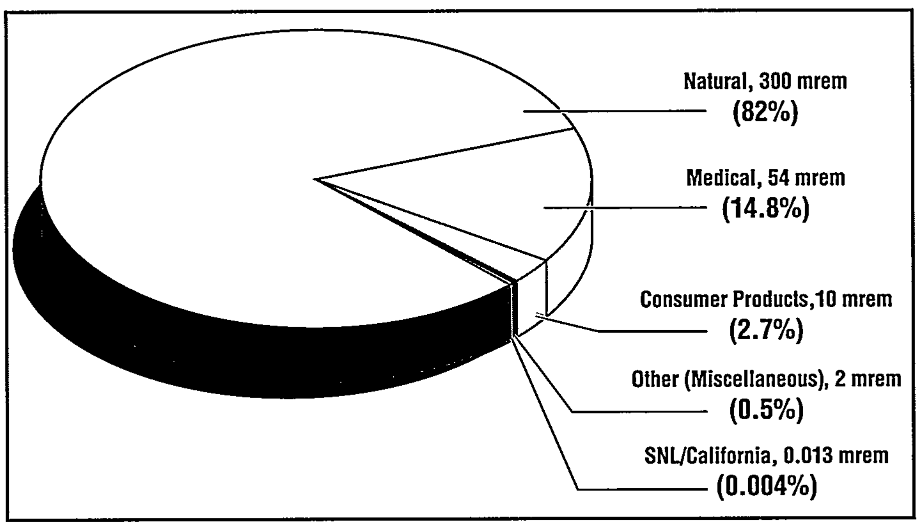


Figure 1-2. Typical radiation doses received by the general public and the maximum contribution from SNL/California.

and local regulations. The environmental monitoring data demonstrate that all emissions to the environment from SNL/California in 1994 were well within regulatory standards (except for three wastewater discharge limit exceedances—see Chapter 4). For details of SNL/California's compliance record, see Chapter 3. It summarizes SNL/California's compliance with applicable environmental statutes and regulations for 1994 and discusses current issues related to environmental management. It also provides an update of SNL/California's response to the environment, safety, and health findings of the DOE Tiger Team assessment conducted between April 30 and May 18, 1990.

ENVIRONMENTAL MONITORING PLAN

SNL/California prepared the *Environmental Monitoring Plan,* in accordance with DOE guidelines.[4] The plan serves as a guidance document for the Environmental Monitoring Program at SNL/California. When read in conjunction with the *Site Environmental Report* (which provides the results of the program for the current year), it provides a comprehensive overview of Sandia's Environmental Monitoring Program.

The *Environmental Monitoring Plan* contains a comprehensive review of environmental monitoring at SNL/California, including administrative structure, pathway analysis, effluent monitoring, sampling of environmental media, laboratory procedures, dose calculations, meteorological monitoring, and quality assurance. It details the operations of each of these areas and documents the rationale behind the diverse monitoring methods. In addition to documenting the monitoring system, the plan provides an in-depth review of the adequacy and scientific defensibility of SNL/California's monitoring program.

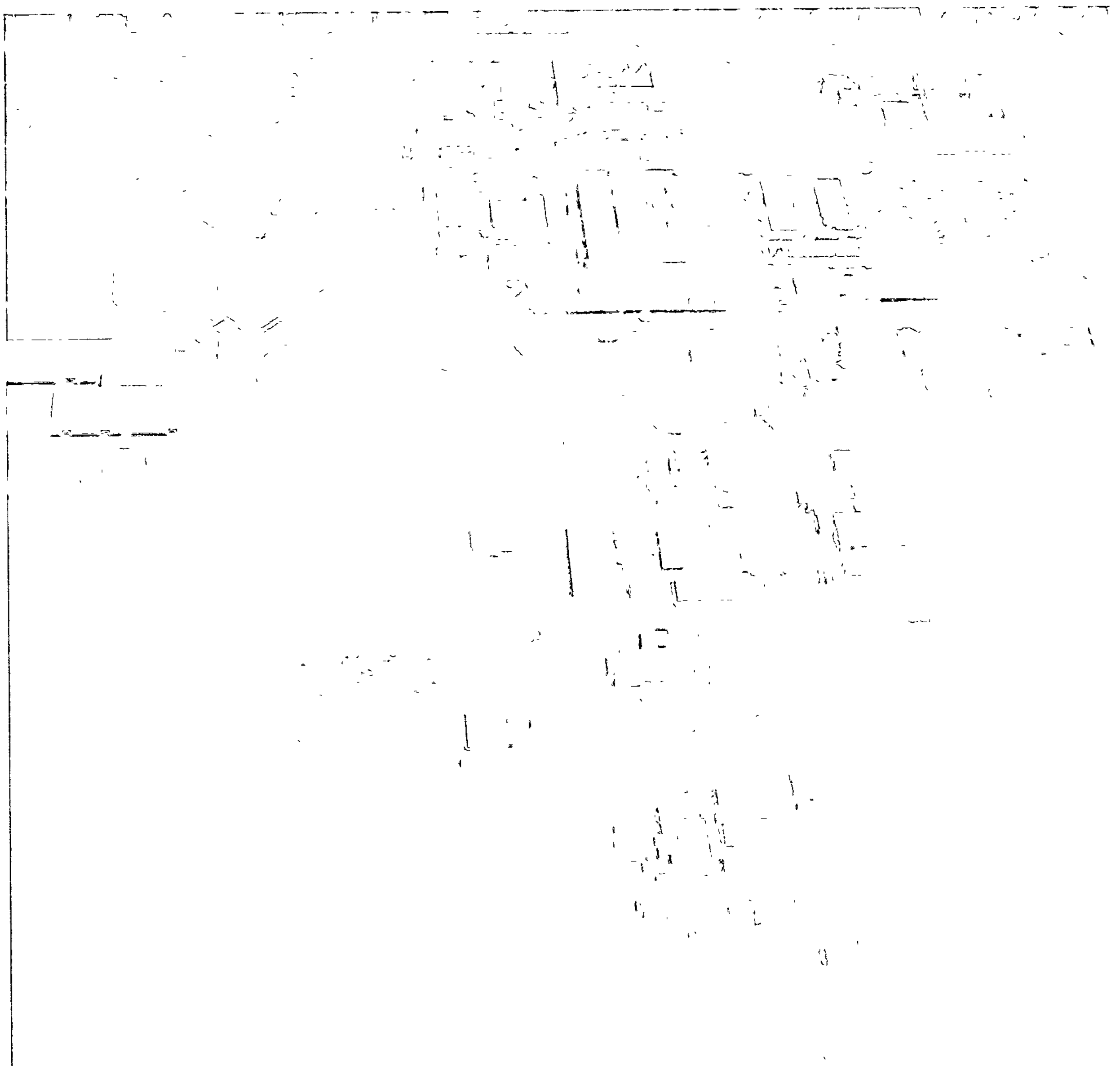
REFERENCES

1. U.S. EPA, Title 40 CFR, Part 433, *Metal Finishing Point Source Category* (July 1994).

2. U.S. DOE, Order 5400.5, *Radiation Protection of the Public and the Environment* (June 5, 1990).

3. State of *California, California Code of Regulations,* Title 22, Sections 64400 et seq, "California Domestic Water Quality and Monitoring" (1995).

4. R. C. Holland, *Environmental Monitoring Plan,* Sandia National Laboratories/California, SAND94-8011 (February 1994).



ENVIRONMENT, SAFETY, AND HEALTH ORGANIZATION
SELF-ASSESSMENT PROGRAM
SNL/CALIFORNIA ENVIRONMENT, SAFETY, AND HEALTH ORGANIZATION
ENVIRONMENTAL PROTECTION DEPARTMENT
ENVIRONMENTAL OPERATIONS DEPARTMENT
SITE DESCRIPTION
LABORATORY SETTING
ANNUAL SITE ENVIRONMENTAL REPORT

Sandia National Laboratories (SNL) is a prime contractor to the Department of Energy (DOE), engaged in research and development in the national interest. On October 1, 1993, Martin Marietta Corporation assumed the contract to manage and operate SNL, which had been managed by AT&T since 1949. On March 15, 1995, Martin Marietta Corporation merged with Lockheed Corporation to form Lockheed Martin Corporation.

SNL consists of facilities in New Mexico, California, Nevada, and Hawaii. As one of the United States' multipurpose national laboratories, SNL develops solutions to a wide range of problems facing the country. With the end of the Cold War, SNL's traditional national security mission has expanded to include advanced military technology, energy and environmental research, arms control/nonproliferation, and advanced manufacturing technology. In addition, Sandia is pursuing the transfer of commercially viable technology to the private sector to strengthen our nation's economic competitiveness in world markets.

Operations at SNL's California facility comprise three broad programmatic areas:

Defense: This program involves national security work, both nuclear and nonnuclear. Defense activities encompass stewardship of the nuclear weapons stockpile and proliferation management of weapons of mass destruction ("management" in this case means prevention, detection, and if needed, response).

Environmentally Driven Initiatives: This multifunctional program addresses a broad range of initiatives centered on combustion science and technology. Areas of emphasis include energy resources for a cleaner environment, environmental remediation and pollution prevention, and minimizing the environmental impact of transportation.

Integrated Manufacturing Technologies: This program uses the systems and technology at the site to enhance the nation's economic competitiveness. Our aim is to be an agile manufacturing test bed for low-cost prototypes and development, as needed by the DOE and U.S. industries. This program serves as a focus for partnerships with U.S. companies to develop joint manufacturing solutions.

SNL/California incorporates the highest regard for environment, safety, and health (ES&H) into every experiment and all site operations. SNL/California operates under the scope of Federal, State, and local regulatory authorities and has obtained all appropriate operating permits. Sandia is committed to operating in full compliance with the letter and spirit of applicable environmental laws, regulations, and standards. Furthermore, SNL/California strives to go beyond compliance with legal requirements by making every effort practical to reduce impacts to the environment to levels as low as reasonably achievable.

ENVIRONMENT, SAFETY, AND HEALTH ORGANIZATION

SNL has established a corporate-level ES&H organization. The SNL President has overall responsibility for ES&H. He is advised by the SNL Quality and Leadership Council regarding ES&H issues. Together, they are ultimately responsible for establishing and communicating a corporate culture that considers the protection and preservation of the environment and the safety and health of its personnel, contractors, visitors, and the public, to be critical to Sandia's success.

SNL/California has an ES&H organization to carry out the corporate ES&H

vision. Its structure is shown in Fig. 2-1. This organization implements ES&H programs and ensures compliance with regulations specific to the California site.

To help assure that ES&H commitments are fulfilled, SNL/California has established a site ES&H Council and a Management Assurance Department. The site ES&H Council ensures top-level management involvement in developing and monitoring ES&H goals. It establishes, promotes, and communicates a culture that recognizes ES&H as a top priority at the California site. The site ES&H Council also provides leadership and consistency of approach in the SNL/California ES&H program. It provides a mechanism for organizational communication—both horizontally and vertically.

The Management Assurance Department provides oversight of management-related ES&H activities and provides direct ES&H assurance information to the SNL/California vice president. The department ensures uniform implementation of corporate ES&H management processes through the use of organizational ES&H coordinators. Additionally, the department conducts internal audits and self-assessments of the SNL/California's ES&H management processes.

SELF-ASSESSMENT PROGRAM

SNL is developing a comprehensive system for assessing ES&H status and for tracking progress toward achieving ES&H goals. The SNL ES&H Self-Assessment Program consists of three key subprograms: Appraisal, Performance Indicators, and Operating Experience Evaluation.

The ES&H Appraisal Program establishes an internal appraisal hierarchy consisting of independent assessments, management surveillance, and organizational inspection activities. At SNL/California, senior management has established the Laboratory Assessment Program for conducting site-wide independent ES&H assessments. The Management Assurance Department coordinates training for SNL/California employees and managers involved in performing self-assessments.

The ES&H Performance Indicator Program establishes a set of quantitative measures for the DOE to use in evaluating and tracking SNL's ES&H performance.

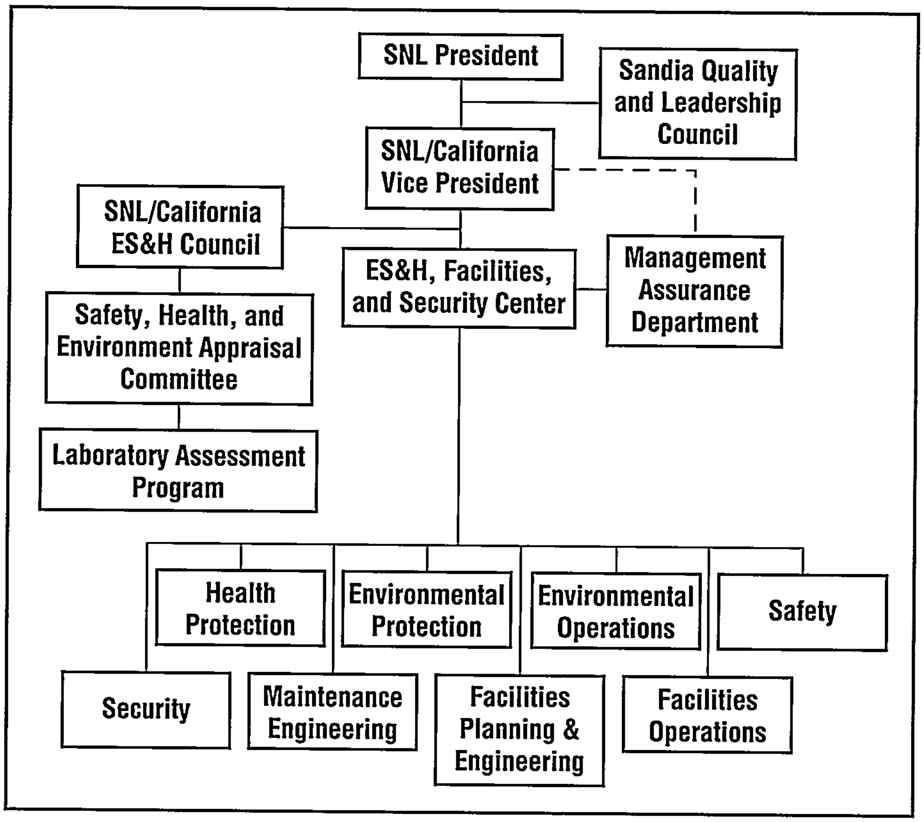


Figure 2-1. Organizational structure of environment, safety, and health at SNL/California.

The ES&H Operating Experience Evaluation Program documents incidents and lessons learned from these incidents. This information is distributed to employees to heighten their awareness of ES&H principles.

In addition, SNL/California's ES&H and Facilities Quality Assurance Group coordinates quality assurance/technical assessments within SNL/California's ES&H organization.

SNL/California Environment, Safety, and Health Organization

The organization responsible for ES&H at SNL/California is the ES&H, Facilities, and Security Center. An important part of the center's mission is to ensure the health and safety of SNL/California employees and the general public, and to protect the environment. This mission is fulfilled by helping SNL/California employees understand and comply with DOE orders and their legal responsibilities under Federal, State, and local laws and regulations. The ES&H, Facilities, and Security Center has four departments involved in ensuring workplace safety and protection of the environment: Health Protection, Safety, Environmental Protection, and Environmental Operations. An ES&H and facilities quality assurance group reports directly to the center director and is functionally independent of the departments within the center.

The original Environmental Protection Department was restructured in 1994. SNL/California's environmental programs now are divided between two departments: the Environmental Protection Department and the Environmental Operations Department. The mission of these departments is to ensure that operations at SNL/California are conducted in an environmentally responsible manner and in compliance with applicable laws and regulations. They contribute their expertise and services to guide and support other SNL/California departments in achieving their missions and goals. They are directly responsible for this report and the activities described herein. Therefore, their specific responsibilities are described below.

Environmental Protection Department

The Environmental Protection Department has a variety of programs to properly manage (minimize and dispose of) hazardous waste and to assess and remediate potentially contaminated areas. To fulfill its mission, the department has groups responsible for public participation, waste management, pollution prevention, environmental restoration, and asbestos management (Fig. 2-2). The following sections briefly describe the activities of these groups.

Public Participation

The Public Participation Group is responsible for implementing a public participation program that supports both of the environmental departments at SNL/California. This group has developed a public participation plan, which was approved by the DOE.[1] Twice each year, the group publishes a public newsletter, which contains information about SNL/California's environmental activities.

Waste Management

The Waste Management Group is responsible for managing radioactive, mixed, medical, energetic, and hazardous wastes. Waste management activities include the collection, on-site transport, storage, treatment, packaging, and shipment of wastes in accordance with DOE-, EPA- and State-specified regulations and requirements. The group also manages the following Waste Management Program activities: training, permitting, reporting, interfacing with regulators through the DOE, program planning, recordkeeping, and budgeting.

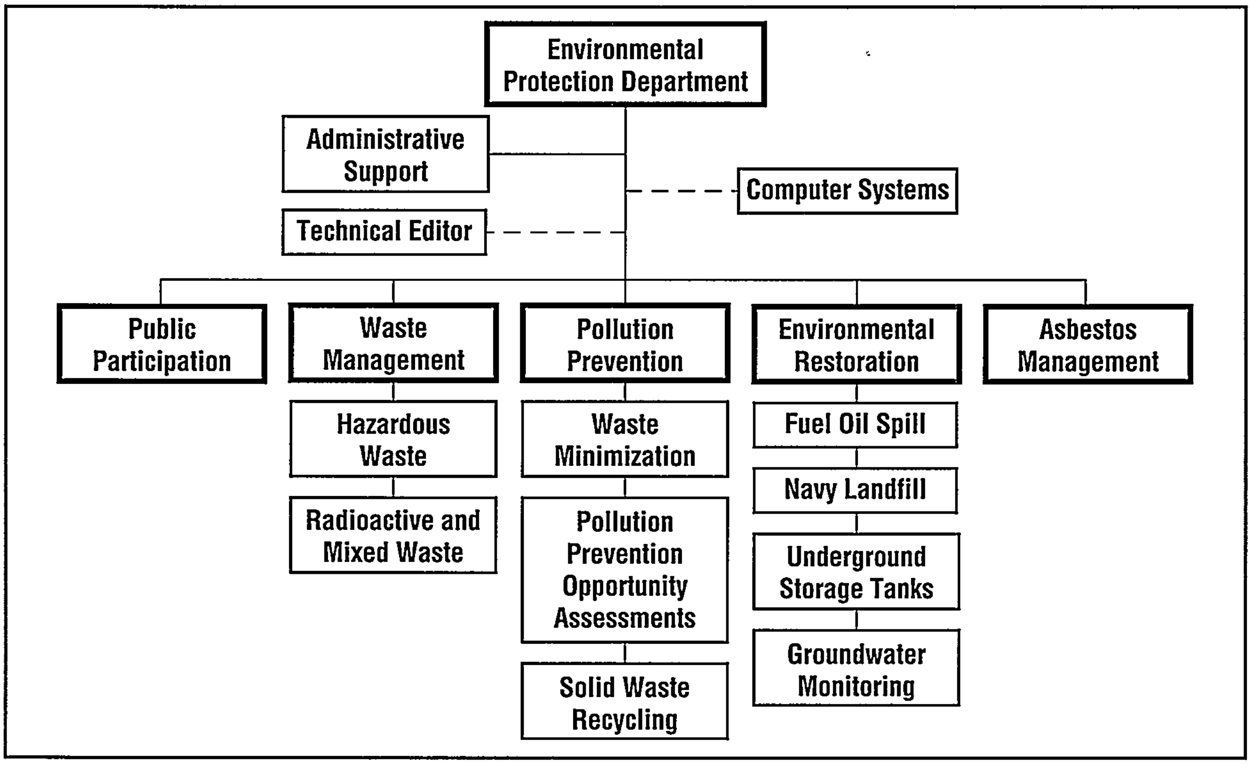


Figure 2-2. Organizational structure of the Environmental Protection Department.

The Waste Management Group is responsible for operations conducted in the Hazardous Waste Storage Facility, the Tritiated Waste Storage Facility, and the Radioactive and Mixed Waste Storage Facility. In addition, the group manages the permitting of three on-site treatment facilities that are regulated under "permit-by-rule" (two waste compactors and a fluorescent light tube crusher).

Pollution Prevention

The Pollution Prevention Group is responsible for promoting pollution prevention and source reduction of all wastes in all site activities. Responsibilities include:

- gathering process information,
- evaluating processes and performing pollution prevention opportunity assessments,
- fostering employee awareness of pollution prevention and source reduction issues and technologies, and
- developing and maintaining site recycling programs.

The Pollution Prevention Group also is responsible for preparing reports to the DOE and to Federal, State, and local regulators. SNL/California has a waste minimization/pollution prevention coordinator to manage these efforts.

Environmental Restoration

The Environmental Restoration Group is responsible for assessing the extent of historical contamination of SNL/California sites and managing any necessary restoration efforts. This group also is responsible for characterizing groundwater flow and groundwater monitoring.

Asbestos Management

The Asbestos Management Group is responsible for SNL/California's program to protect employees and the public from the health effects of asbestos. SNL manages asbestos in place and removes it only if its presence and condition create a potential health hazard or if modifications or maintenance require that the asbestos be disturbed.

Environmental Operations Department

The Environmental Operations Department maintains a variety of programs to monitor the environmental impacts of site emissions and to preserve the quality of the environment. To fulfill its mission, the department has groups responsible for environmental surveillance, air quality, chemical information management, environmental planning, and wastewater/storm water management (Fig. 2-3). The following sections briefly describe the activities of these groups.

Environmental Surveillance

The Environmental Surveillance Group at SNL/California assesses potential impacts to the public and the environment from site operations. The group is responsible for ensuring that SNL/California complies with Federal, State, and local regulations and DOE orders governing protection of the environment. Specifically, environmental surveillance personnel maintain a meteorological monitoring system, an air tritium monitoring system, and a direct radiation monitoring system, to ensure SNL/California's compliance with the National Emission Standards for Hazardous Air Pollutants (NESHAPs) Rule for Radionuclides, under the Federal Clean Air Act (CAA), and DOE orders. The group uses these systems to monitor the general environment of SNL/California and nearby vicinity to verify that emission controls are effective in preserving the local

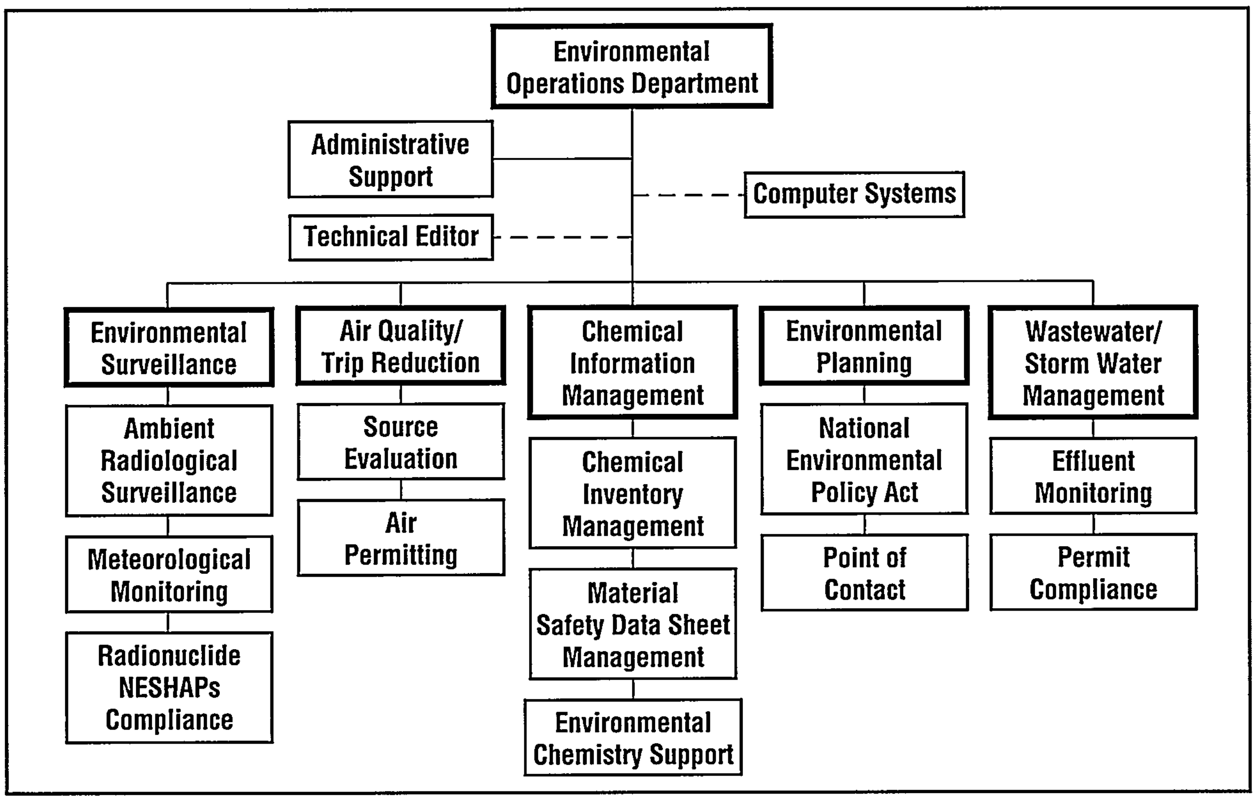


Figure 2-3. Organizational structure of the Environmental Operations Department.

environs. The group also prepares numerous reports and other documents to demonstrate compliance.

Air Quality/Trip Reduction

The Air Quality Group manages a program to facilitate site compliance with regulations governing air emissions to the environment. The Air Quality Compliance Program maintains the site air emissions inventory and evaluates Sandia operations that are potential sources of air pollutants. In 1994, the Bay Area Air Quality Management District implemented a trip reduction regulation, which requires employers in the Bay Area with more than 100 employees to reduce air pollution by reducing vehicle trips to and from the work site. In response to this regulation, SNL/California established a Trip Reduction Program to promote clean air commute modes for employees.

Chemical Information Management

The Chemical Information Management Group is responsible for providing consultation for chemical analysis and data review and for maintaining the site-wide Chemical Information System/Material Safety Data Sheet system. This system is a UNIX-based relational database containing comprehensive information for tracking chemicals used at SNL/California. It includes a site-wide chemical inventory, potential personnel exposure data, and approximately 40,000 Material Safety Data Sheets (which can be used by anyone at SNL/California). The system soon will include hazardous waste tracking information.

Environmental Planning

The Environmental Planning Group is responsible for implementing the National Environmental Policy Act (NEPA) at the SNL/California site. This responsibility involves evaluating proposed projects, activities, and programs for potential environmental and human impacts. Key environmental concerns include potential air emissions (through vents or stacks on buildings), water effluents (storm water or sanitary sewer outfall), human exposure to hazardous substances, and waste generation and minimization.

In addition, the Environmental Planning Group acts as the point of contact for the ES&H Interdisciplinary Team, which comprises representatives from each of the primary disciplines within ES&H, and when appropriate, facilities and security programs. The Interdisciplinary Team is responsible for helping SNL/California's project teams consider ES&H, facility, and security issues as they plan and implement new projects or change ongoing projects. By reviewing proposed projects early in the planning stages, the Interdisciplinary Team helps make sure they begin on time.

Wastewater/Storm Water Management

The Wastewater/Storm Water Management Group is responsible for ensuring that SNL/California complies with all Federal, State, and local regulations and DOE orders regarding the quality of wastewater and storm water discharges. The group monitors these discharges both visually and through sampling and analysis. The group ensures that SNL/California site activities do not impact the quality of surface waters in the vicinity or in the San Francisco Bay. The group verifies that wastewater and storm water discharges are in compliance with established standards and requirements. The group prepares numerous reports, permit applications, and other documents to demonstrate compliance with various environmental regulations and DOE orders.

SITE DESCRIPTION

This section provides an overview of the SNL/California site, physical environment, and ecological characteristics of the area.

Laboratory Facility

The SNL/California site covers 1.7 km^2 (413 acres), which includes 213 acres of developed areas. In 1986 and 1987, the DOE acquired 228 acres to provide a security buffer zone between developed areas and the Laboratory.

The site facilities comprise approximately 74,400 m^2 (801,000 $ft.^2$) of building floor space. Of this, about 31% is office and drafting areas, 48% is light laboratories and shops, and 3% is heavy laboratories (e.g., high-pressure test facilities and explosives chambers). The remaining 18% is classified as miscellaneous usage, such as computer rooms and library space.

SNL/California is a multiprogram laboratory involved in a broad range of research and development. Facilities are designed for small-scale scientific and applied engineering research. The site has neither production nor large-scale manufacturing operations.

Emissions and Water Supply

In general, potential radiological emissions from normal operations at SNL/California comprise small amounts of tritium. However, tritium-related research ceased at SNL/California in 1993. SNL/California has sources of uranium, principally depleted uranium, but uranium materials have not been machined on site for several years. Therefore, site operations do not emit uranium isotopes. Nonradiological emissions include nitrogen oxides (NO_x), particulates, and precursor organic compounds.

The site's water supply normally comes from the Hetch Hetchy Aqueduct, which is supplemented occasionally by water from the Zone 7 Flood Control and Water Conservation District. Sandia's sanitary sewer effluent merges with the Lawrence Livermore National Laboratory (LLNL) sewer system, and the combined waste stream discharges to the City of Livermore sanitary sewer system at the northwest corner of the LLNL site. The sanitary sewer effluent from the SNL/California site (and from the rest of the Livermore area) is processed at the Livermore Water Reclamation Plant. After treatment, the wastewater is transported via pipeline to the San Francisco Bay. A portion of the treated effluent is reclaimed and used for local irrigation.

LABORATORY SETTING

SNL/California is located next to the City of Livermore (population approximately 58,000), in eastern Alameda County, 65 km (40 miles) east of San Francisco (Fig. 2-4). The operating area is surrounded on all sides by DOE-owned land, which serves as a buffer zone. The site lies at the western base of the Altamont Hills. To the north is LLNL, and further north is an expanding business park and commercial development. The property to the south and east of the site comprises agricultural and low-density residential areas. Although principally residential, the area to the west encompasses a wide range of uses, to include a business park, grazing lands, vineyards, and other small agricultural and industrial developments.

Topography

The Livermore Valley is an irregularly shaped lowland in the Diablo Range of the California Coastal Mountain Range. The valley is approximately 26 km (16 miles) long (east to west) and averages about 11 km (7 miles) wide. The valley floor slopes gently downward to the west at about 10 m/km (50 ft./mile). The elevation is approximately 200 m (660 ft.) at the eastern boundary of the valley and 90 m (295 ft.) at the southwest corner.

The topography of the California site is generally characterized by relatively flat areas at the northern portion of the site, hills to the south, and steep banks along the Arroyo Seco.

Geology and Hydrology

The Livermore Valley overlies a complex geologic region where ancient arroyos

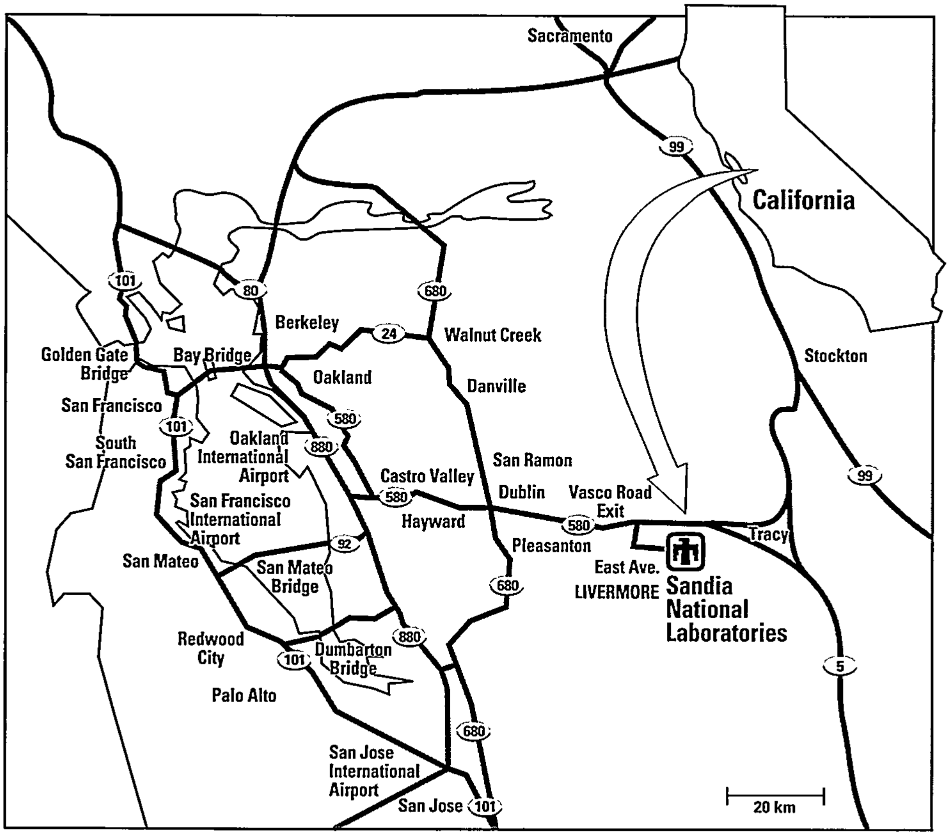


Figure 2-4. SNL/California in a regional setting.

have deposited a heterogeneous mixture of sand, silt, clay, and gravel. These alluvial deposits create layers of higher and lower permeability overlying the older Livermore formation. The groundwater of the Livermore Valley can be found in the more permeable layers, which lie between 5 and 33 m (17 and 110 ft.) below the surface (Fig. 2-5). Groundwater in the Livermore Valley generally flows in a westerly direction. The groundwater movement underlying the SNL/California site is strongly influenced by the Las Positas Fault Zone. North of the fault, movement is generally westerly. South of the fault, the movement is less distinct, but appears to be radial from a groundwater mound. Investigations of groundwater movement in this area are in progress.

Located in west-central California, the site is in a seismic region. The major faults are San Andreas, Hayward, Calaveras, and Greenville. The closest major faults are Calaveras—about 11 miles west of the site, and Greenville—about 2 miles east of the site. A small, locally active fault, the Las Positas Fault, runs through the southern portion of the site. Intermittent streams (arroyos) flowing northwest carry surface drainage into the Alameda Creek near Sunol, which continues west to the San Francisco Bay. The Arroyo Seco crosses the site from the southeast to the northwest. Storm water runoff from the hills to the southeast flows into the arroyo during the rainy season. The arroyo is dry the rest of the year. The SNL/California site storm sewer system also channels storm water into the Arroyo Seco. This system is the main pathway for the site's surface drainage.

Climate and Meteorology

The climate of the Livermore Valley consists of mild, rainy winters and warm, dry summers. The mean annual temperature is 12.5°C (55°F), with extremes ranging from 0° to 38°C (32° to 100°F). Rain falls primarily between October and April. Precipitation at the SNL/California site for calendar year 1994 was 33.3 cm (13.1 in.). The prevailing winds blow from the west and southwest from April to September (Fig. 2-6). The winds are variable during the rest of the year. Specific meteorological measurements for 1994 are summarized in Chapter 4, "Environmental Monitoring Program."

Vegetation

Vegetation on the developed areas of the site consists of plants suitable for general landscaping. The undeveloped land, which mainly comprises the DOE security buffer zone, is dominated by non-native grasses, such as slender oat and ripgut brome. Much of this zone is under cultivation to provide erosion control and fire protection.

The Arroyo Seco supports diverse vegetation. There are several large sycamore, valley oak, and red willow trees, as well as patches of cattail and rush at the eastern segment of the arroyo. The central portion of the arroyo hosts a few canyon live oak and almond trees, and annual grasses.

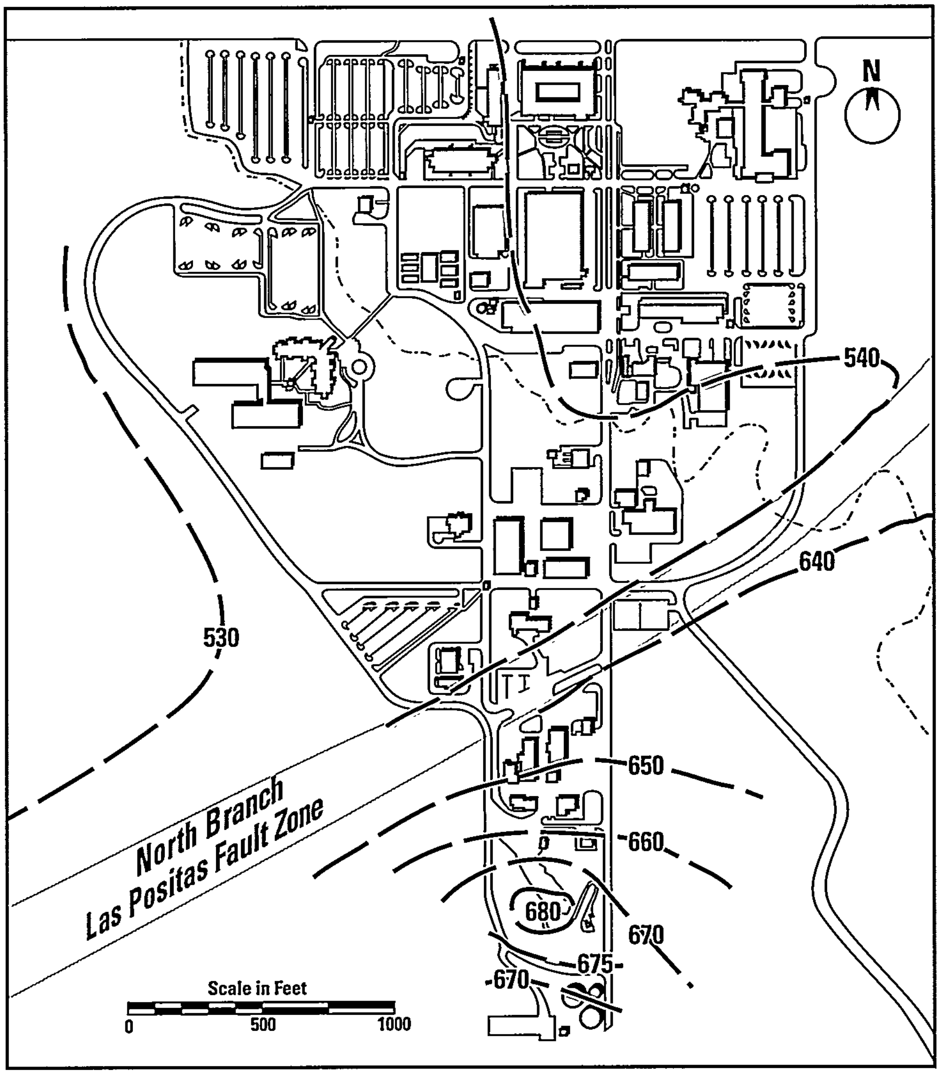


Figure 2-5. Ground contours at SNL/California.

Wildlife

Wildlife is sparse on the SNL/California site. In 1991, a biological survey identified three species of amphibians and reptiles, 31 species of birds, and ten species of mammals. There are no perennial streams or permanent bodies of water at SNL/California to support fish. Wildlife live in the undeveloped grassland and along the arroyo. Representative species include the fence lizard, black-tailed hare, California ground squirrel, red fox, and western meadowlark.

ANNUAL SITE ENVIRONMENTAL REPORT

This *Site Environmental Report* documents all SNL/California's significant environmental activities throughout the year. These include effluent and environmental monitoring, environmental restoration, and protection activities. This report also evaluates SNL/California's compliance with applicable environmental requirements. It is prepared according to the requirements of DOE Orders 5484.1 and 5400.1.[2,3]

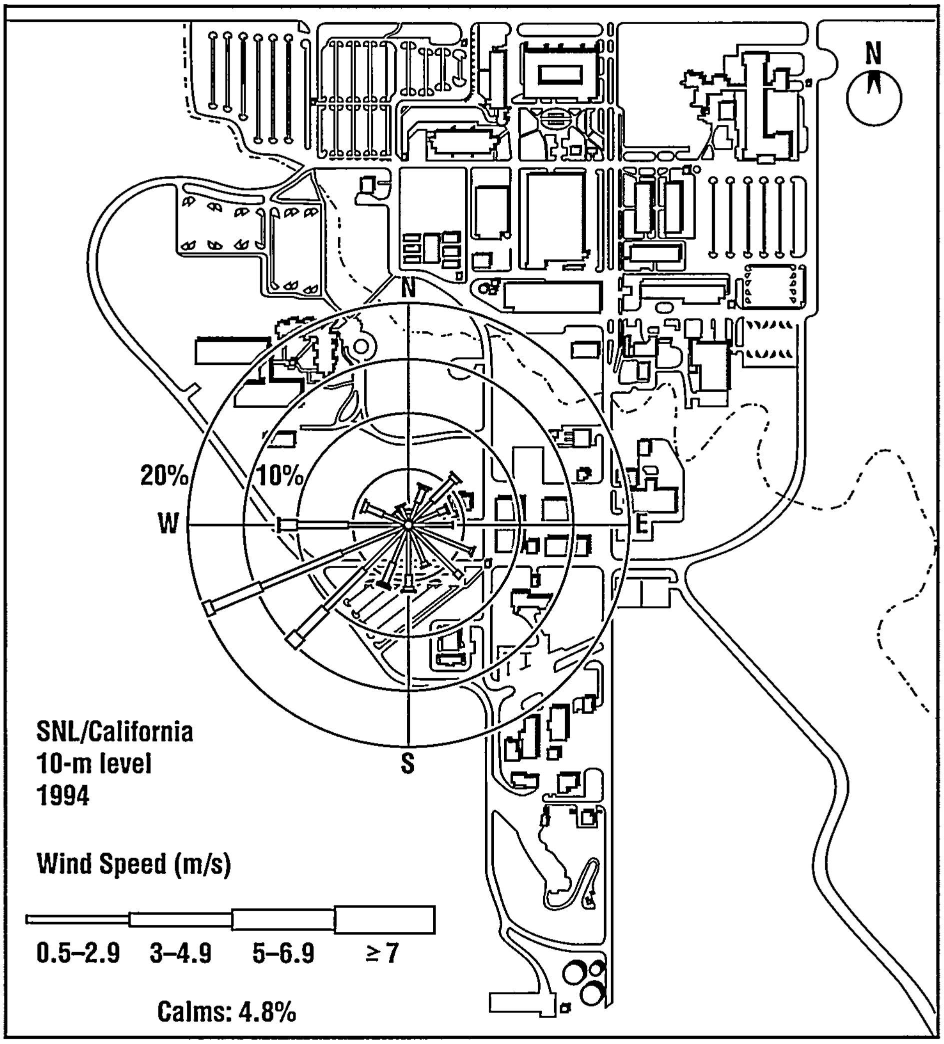


Figure 2-6. Wind rose showing the average annual wind direction and speed during 1994.

Appendix A contains laboratory procedures. Appendix B summarizes applicable regulations governing wastewater discharges to the publicly-owned treatment works. Radiological doses are calculated at the point of maximum credible public exposure, according to EPA-approved methods and incorporating conservative model input and exposure parameters. Appendix C presents the methods, assumptions, and calculations used to assess the routine radiological impacts from SNL/California operations. These measurements are compared to DOE and Federal standards in Appendix D.

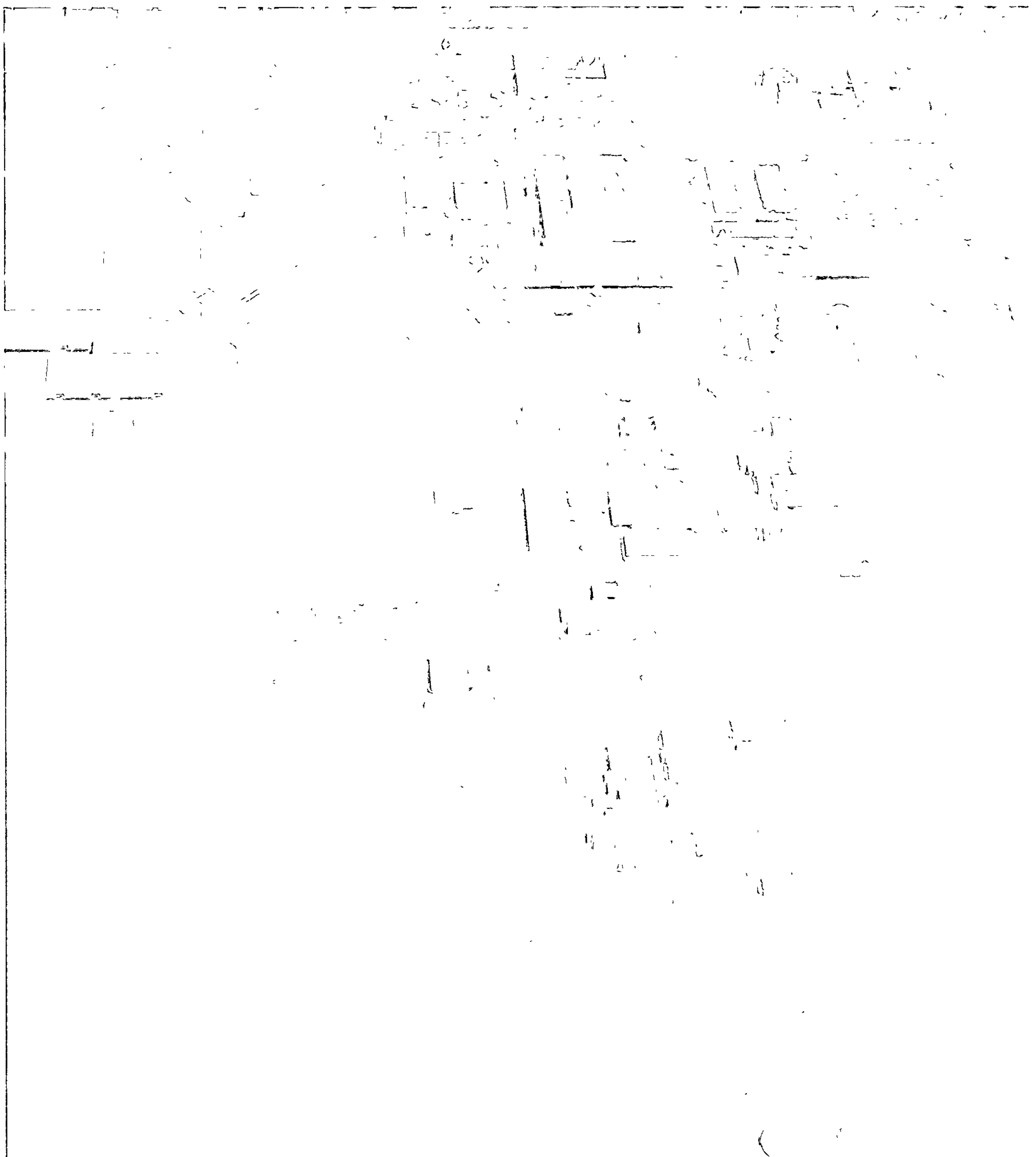
An extensive glossary at the end of this report defines commonly used acronyms and abbreviations, as well as other technical terms used in the body of the report. The International System of Units (SI) or metric system of measurements has been used, where feasible. A section on "Units of Measure" is included in the glossary as additional information about the system of units and quantities.

REFERENCES

1. U.S. DOE, SNL/California, *Public Participation Plan* (September 1994).

2. U.S. DOE, Order 5484.1, Chapter I, "Environmental Protection, Safety, and Health Protection Information Reporting Requirements" (June 29, 1990).

3. U.S. DOE, Order 5400.1, *General Environmental Protection Program* (June 29, 1990).



Environmental Monitoring
Environmental Programs Status
Other Issues and Actions
Environmental Permits

In accordance with DOE policy, SNL complies with all applicable Federal, State, and local environmental laws and requirements. In addition to meeting specific limits, SNL is obligated to keep emissions to the environment as low as reasonably achievable (ALARA). Several Federal, State, and local government agencies are responsible for enforcing and overseeing environmental regulations at SNL/California. The principal agencies include the U.S. EPA, the Cal/EPA, the Department of Health Services, the Department of Toxic Substances Control, the Regional Water Quality Control Board, the Bay Area Air Quality Management District, and the City of Livermore Water Reclamation Plant. Table 3-1 summarizes the major Federal environmental statutes that apply to SNL/California operations. State and local authorities also impose a variety of environmental regulations.

This chapter summarizes SNL/California's environmental management performance and documents the site's compliance with these environmental statutes and regulations in 1994. It also discusses current environmental management programs. The compliance activities at SNL/California are administered by the Environmental Protection and Environmental Operations departments.

ENVIRONMENTAL MONITORING

The environmental monitoring data collected in 1994 demonstrate that operations at SNL/California had no harmful effects on the environment or the public. SNL/California's emissions to the atmosphere during the year complied with all applicable Federal, State, and local environmental laws and standards.

The only detectable radionuclide discharged to the atmosphere was tritium from the Tritium Research Laboratory. Because tritium research has been phased out at SNL/California, the total amount of tritium released by SNL/California in 1994 was the lowest amount since the Tritium Research Laboratory became fully operational. A total of 95 Ci (3.5×10^6 MBq) tritium was discharged to the atmosphere. Of this amount, 91 Ci (3.4×10^6 MBq) was in the form of tritium oxide (HTO or T_2O) and the remaining 4 Ci (0.1×10^6 MBq) was in the form of elemental tritium gas (HT or T_2). Based on these emissions, the potential off-site radiological impact from SNL/California operations was assessed, incorporating all emission sources and all exposure pathways. The assessment was performed using EPA-approved methods and computer codes.

In 1994, the maximum potential dose at a publicly accessible location was 0.013 mrem (1.3×10^{-4} mSv) effective dose equivalent. This small dose is 0.013% of the DOE radiation protection standard, and about 28,000 times less than the background radiation dose received in one year by a typical resident of the United States. Chapter 5 and Appendix C describe the radiological impact assessment in more detail. Appendix D summarizes the laws governing radiation protection of the public.

Tritium is the only radionuclide discharged to the sanitary sewer in measurable amounts. During 1994, SNL/California discharged a total of 0.059 Ci (2.2×10^3 MBq) tritium as a part of routine operations. The DOE has established a control limit of 0.01 µCi/mL of tritium in wastewater discharged to a community sewer system. The average tritium concentration in SNL/California's sanitary sewer effluent was less than 1.3×10^{-5} µCi/mL, which is 0.1% of the DOE control limit. Appendix B summarizes the regulations for wastewater discharge.

The Environmental Operations Department at SNL/California maintains an environmental surveillance program to verify the effectiveness of emission control procedures and to directly measure any effects on the environment. This surveillance program routinely examines environmental media at the site boundary and in the vicinity. Sampling includes ambient air, surface water, groundwater, sewage, soil, vegetation, and locally produced foodstuffs. An extensive network of environmental dosimeters is also used to measure external radiation levels. The environmental surveillance data collected during 1994 demonstrate compliance with EPA and DOE standards.

ENVIRONMENTAL PROGRAMS STATUS

Table 3-1 briefly summarizes the major environmental regulations that apply to SNL/California. They are described in detail below.

Resource Conservation and Recovery Act and California's Hazardous Waste Control Law

Hazardous waste management activities at SNL/California include handling, packaging, and storing energetic, radioactive, mixed, and nonradioactive hazardous waste. SNL/California incinerated small quantities of explosives on-site until October 1989. No other form of hazardous waste disposal has been used at the SNL/California site. The only treatment done on-site is waste compaction to reduce volume, encapsulation of some low-level radioactive waste streams, and consolidation/commingling of various low-volume waste streams at the Hazardous Waste Storage Facility. SNL/California does not generate transuranic or high-level radioactive wastes. Except for liquids generated from scintillation counting (which are sent off-site for incineration), mixed waste is stored on site. Beginning in 1995, existing inventories of mixed waste and any mixed waste produced in the future will be shipped to SNL/New Mexico for management, pursuant to SNL/New Mexico's Federal Facility Compliance Act *Site Treatment Plan,* which is now in draft form (see additional discussion on page 3-3). SNL/California has an active Waste Minimization and Pollution Prevention Awareness Program.

Chemical Waste Program

During 1994, compliance-related activities in hazardous waste management included the following:

- The Cal/EPA determined that SNL/California's incinerator, used for disposing of energetic material, should be permitted under Part B, Subpart O, of the Resource Conservation and Recovery Act (RCRA). After careful re-evaluation, SNL/California decided to discontinue on-site waste incineration. Energetic materials now are shipped off-site to DOE or commercial facilities for disposal. A draft closure plan has been prepared and sent to the DOE. This plan will be forwarded to the Cal/EPA early in 1995.
- The Cal/EPA granted SNL/California a Part B permit for operations at the Hazardous Waste Storage Facility. It is effective from January 4, 1993, to January 4, 2003. This permit allows SNL/California to store hazardous and mixed waste and to conduct limited treatment activities.
- DOE Headquarters lifted the moratorium prohibiting shipment of hazardous waste generated in radioactive material areas at SNL/California. SNL/California had demonstrated adequate controls to prevent contamination of chemical waste by radioactive materials.
- SNL/California and the Cal/EPA reached a settlement on the Cal/EPA audits conducted in 1993. These audits had resulted in the Cal/EPA issuance of a Final Stipulation and Order in February 1994, which required corrective actions and imposed a fine for the alleged violations. SNL/California completed the corrective actions in March 1994. The Cal/EPA provided written acknowledgment of completion in April 1994.

- The Cal/EPA audited the SNL/California waste management program on August 16 and 17, 1994. No violations were found.
- The Pollution Prevention Opportunity Assessment Program received additional funding in 1994 to complete an assessment of the waste management operations.

Low-Level Radioactive Waste Program

The low-level radioactive waste management activities at SNL/California include handling, packaging, and storing radioactive waste. The majority of work completed in 1994 involved preparing shipments of low-level radioactive waste to the Nevada Test Site. Much of this waste was generated during the cleanup and transition of the Tritium Research Laboratory. Major accomplishments for 1994 are discussed below:

- In February 1994, the DOE Nevada Operations Office gave SNL/California approval to ship additional waste to the Nevada Test Site. This shipment supported SNL/California's goal to reduce the site's tritium inventory to less than 4.0 g by May 1994.
- In April 1994, SNL/California shipped 30 m^3 low-level radioactive waste to the Nevada Test Site. The majority of this waste was generated during cleanup and transition activities at the Tritium Research Laboratory. This shipment reduced SNL/California's tritium inventory to less than 4.0 g. It complied with all EPA and DOE regulations.
- In October 1994, SNL/California successfully shipped 29 m^3 low-level radioactive waste to the Nevada Test Site. Most of this waste was generated during cleanup and transition activities at the Tritium Research Laboratory. This shipment reduced SNL/California's tritium inventory to less than 0.1 g. It complied with all EPA and DOE regulations. Following this shipment, the DOE formally reclassified the Tritium Research Laboratory as a "Non-nuclear, Low Hazard Facility."
- In November 1994, the DOE Nevada Operations Office audited the SNL/California low-level radioactive waste management program for recertification. This audit included follow-up surveillance by the Nevada Operations Office in February 1995. The outcome of this audit was favorable; all corrective actions and approval to ship waste to the Nevada Test Site are being formalized.
- In November 1994, SNL/California shipped a 29,000-kg (64,000-lb.) vertical lathe with internal contamination to the Nevada Test Site for disposal. This shipment complied with all EPA and DOE regulations.

Mixed Waste Program

The Mixed Waste Program at SNL/California has taken major steps to ensure compliance with the Federal Facilities Compliance Act. SNL management has decided to consolidate all cost and liability by managing all mixed waste at the SNL/New Mexico site, in accordance with the SNL/New Mexico *Site Treatment Plan,* which is now in draft form awaiting DOE approval. SNL/California began planning in 1994 for the transfer of all mixed waste that is in storage and that may be generated in the future to SNL/New Mexico.*

Following the transfer of all inventoried mixed waste to SNL/New Mexico, scheduled to be completed in March 1995, SNL/California will no longer be subject to the requirements of the Federal Facilities Compliance Act.

* *Liquid scintillation counting fluids will continue to be shipped to an off-site commercial disposal facility.*

Comprehensive Environmental Response, Compensation, and Liability Act

The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) is Federal legislation. It establishes a program for cleaning up contaminated areas in the environment. Two SNL/California restoration sites are affected by the Act: the Fuel Oil Spill and the Navy Landfill. SNL/California is cleaning up or assessing these sites under the authority of the Regional Water Quality Control Board. This activity is funded by the DOE Environmental Restoration and Waste Management Program. Although assessment and remediation activities are formally regulated under RCRA and are being done under State direction, they conform to DOE methods specified in Order 5400.4.[1]

Pursuant to Regional Water Quality Control Board Orders 88-142 and 89-184,[2,3] SNL/California was involved in three assessments during 1994: the Fuel Oil Spill, the Navy Landfill, and Miscellaneous Sites. These are described below.

Fuel Oil Spill

As a result of an accidental puncture of an underground fuel transfer line in 1975, approximately 229,000 L (59,500 gallons) of #2 diesel fuel were released into the soil from a reserve fuel tank. Bench-scale tests of various remediation technologies were conducted during 1993. Analysis of the test results indicated *in situ* bioremediation to be the most effective and feasible cleanup method. Using a computer code developed at Los Alamos National Laboratory and monitoring well data, Los Alamos experts prepared a three-dimensional model characterizing the spill area. Argonne National Laboratory conducted additional bench-scale studies at the University of Notre Dame, to establish nutrient and oxygen levels and to identify degradation products. SNL/California completed three groundwater wells downgradient of the spill site to monitor and control the spread of the contaminated groundwater.

After heavy rainfall in the spring of 1993, the groundwater at the Fuel Oil Spill site rose about 3.6 m (12 ft.). Diesel and BTEX (benzene, toluene, ethylbenzene, and xylene) contamination were noted during the second-quarter groundwater sampling. As a result, the Regional Water Quality Control Board directed SNL/California to implement an interim remedial measure—a groundwater treatment system. SNL/California completed the work plan and system design in December 1993. Equipment installation, including carbon filtration beds and a free product separator, began in December 1993. The associated pumps, tanks, and piping were installed in January 1994, and the interim remedial measure commenced.

The interim remedial measure limits the flow of contaminated water away from the Fuel Oil Spill site. In so doing, SNL/California pumps and treats the groundwater and then discharges it to the sanitary sewer or uses it in landscape watering, pursuant to the Regional Water Quality Control Board's approval. From February to April 1994, SNL/California drilled 24 boreholes for a pilot study. These boreholes are used for monitoring instrumentation, injection/withdrawal, and geophysical characterization. In September 1994, the Environmental Protection Department installed seven tensiometers and one down-hole barometer at the site. In addition, an infiltration gallery was constructed 1.2 m (4 ft.) below the surface. Environmental Protection set up a small landfarm to bioremediate contaminated soil from the boreholes and other equipment installation activities. SNL/California installed equipment for the pilot study—including mixing tanks, compressors, and data collection system—in the summer and fall of 1994. The pilot study is scheduled to begin in June 1995.

Navy Landfill

An inactive landfill, used by the U.S. Navy and LLNL in the 1940s and 1950s, is located on the SNL/California site. Records show that no hazardous materials were disposed of at this site. SNL/California installed monitoring wells and implemented a sampling program for both water and soil to verify that no hazardous materials nor contamination exist at the site. SNL/California completed and submitted to the Regional Water Quality Control Board a *Solid Waste Water Quality Assessment Test Report* (March 1990) and a follow-on *Final Additional Field Investigation Report* (March 1994).[4,5] In response, the Board issued a *Recommendation for Closure* in November 1994.[6] SNL/California is preparing a closure plan, to be completed in the summer of 1995 and submitted to the Board for review and approval.

Miscellaneous Sites

Under the direction of the Regional Water Quality Control Board, SNL/California assessed areas suspected of being contaminated from past operations. In 1993, SNL/California analyzed soil from sites identified during DOE's 1988 Environmental Survey. None of these sites were found to be contaminated. SNL/California sent a report documenting these findings to the Regional Water Quality Control Board.[7] One of the miscellaneous sites—the "burn pit"—was incorporated in the Navy Landfill closure. Neither cleanup nor further action is required at any of these sites. The Regional Water Quality Control Board approved the "no further action" closure on April 27, 1994.

Superfund Amendments and Reauthorization Act Title III; Emergency Planning and Community Right-to-Know Act

The Emergency Planning and Community Right-to-Know Act (EPCRA)—also known as the Superfund Amendments and Reauthorization Act (SARA) of 1986, Title III—requires reporting of toxic chemical usage and releases. The purpose of this provision is to make information about potential environmental releases of toxic chemicals available to the public. In accordance with the requirements of the Act, SNL/California submits reports annually to the EPA, the State of California, and the LLNL Fire Department. In 1994, SNL/California had two substances that were reportable under Sections 311 and 312: No. 2 fuel oil (fire hazard) and liquid nitrogen (asphyxiator, compressed gas, and cryogenic). In 1994, SNL/California had no reportable substances under Section 313, Toxic Release Inventory.

Clean Water Act/Safe Drinking Water Act

Wastewater Discharge

SNL/California maintains one Wastewater Discharge Permit issued by the City of Livermore. This permit regulates SNL/California's sanitary and industrial effluent, which is discharged to the City's sewer system, and enforces the requirements of the Federal Clean Water Act (CWA).

In 1994, all sanitary sewer effluent from SNL/California complied with the site outfall discharge limits for regulated metals, radionuclides, and EPA priority organic pollutants. On two occasions, the sanitary sewer effluent slightly exceeded the site's discharge limits: once for oil and grease and once for total dissolved solids.

Wastewater samples collected at the site outfall on February 28, 1994, showed an oil and grease concentration of 110 mg/L. The discharge limit for oil and grease is 100 mg/L. Therefore, the concentration of oil and grease in the site sewer effluent on this date was slightly greater than the discharge limit. SNL/California notified the Livermore Water Reclamation Plant, as required by the Wastewater Discharge Permit. However, the plant staff indicated that these concentrations did not adversely affect plant operations.

Wastewater samples collected at the site outfall on May 7, 1994, showed a total dissolved solids concentration of 480 mg/L. The discharge limit is an incremental limit of 325 mg/L greater than the concentration of the incoming water. The total dissolved solids level of the incoming water during this period was 46 mg/L. Therefore, the concentration of total dissolved solids in the site sewer effluent on this date was slightly greater than the discharge limit. SNL/California notified the Livermore Water Reclamation Plant, as required by the Wastewater Discharge Permit. Again, the plant staff indicated that these concentrations did not adversely affect plant operations.

Chapter 4, "Environmental Monitoring Program," details all SNL/California's wastewater monitoring activities in 1994, including the sampling results.

SNL/California operates two metal finishing categorical processes subject to the EPA's pretreatment standards for point sources (Title 40 CFR parts 403 and 433).[8,9] These two processes, the Electroplating Laboratory and the Printed Wiring Facility, require special sampling of the wastewater they generate. In 1994, all the liquid effluents from these processes complied with pretreatment discharge standards (for metals and organic pollutants), except for one parameter on one occasion. A wastewater sample collected at the Electroplating Laboratory on April 25, 1994, showed a nickel concentration of 5.0 mg/L (the discharge limit for nickel is 2.38 mg/L). The total volume discharged in this batch was less than 500 gallons. SNL/California notified the Livermore Water Reclamation Plant, as required by SNL/California's Wastewater Discharge Permit. This incident did not cause the site to exceed any permit limits at the sanitary sewer outfall, nor did it disrupt plant operations, according to the plant staff. All other liquid discharges from these processes complied with permit conditions for the entire year.

Industrial Storm Water Discharge

SNL/California holds a Notice of Intent with the State of California Water Resources Control Board and must comply with the California General Industrial Activities National Pollutant Discharge Elimination System (NPDES) Storm Water Permit.[10] This permit complies with Federal permitting requirements for industrial storm water discharges. It requires SNL/California to implement a comprehensive storm water management program. SNL/California's program is designed to eliminate illicit discharges and connections to the storm drain system. The permit also requires SNL/California to implement a storm water pollution prevention plan and a storm water monitoring plan.[11,12]

In 1994, SNL/California identified sources of potential non-storm water discharges, implemented the *Storm Water Pollution Prevention Plan,* and conducted all monitoring activities required by the plan. The site complied with all requirements for storm water discharge from an industrial activity during 1994.

Drinking Water

The drinking water for the SNL/California site is supplied by the San Francisco Water District through the Hetch Hetchy Aqueduct. The San Francisco Water District is responsible for monitoring the quality of the incoming water. SNL/California neither treats nor samples the drinking water. LLNL maintains the drinking water distribution system for both sites. Maintenance includes water quality screening analyses.

Clean Air Act/Air Quality Regulations

In 1994, SNL/California complied with applicable laws, regulations, and guidelines governing radiological and nonradiological emissions to the atmosphere.

Several operations at SNL/California are subject to the rules and regulations administered by the Bay Area Air Quality

Management District because they emit, or have the potential to emit, air contaminants.[13] The District and the California Air Resources Board are responsible for setting regulations and providing guidance to attain and maintain EPA and State of California air quality standards. In 1994, the District inspected SNL/California twice, found the site to be in compliance with air standards each time, and issued no violations.

Tables 3-2 and 3-3 list the permitted sources and exemptions granted to SNL/California. During 1994, SNL/California complied with all the conditions specified in its air discharge permits.

In 1994, SNL/California also fully complied with the new Bay Area Air Quality Management District Regulation 13, Rule 1, which requires large employers in the San Francisco Bay Area to reduce the number of single-occupancy vehicle trips to the work site. In October 1994, SNL/California completed a required transportation survey of all employees. The response rate was 96.8%. The vehicle-to-employee ratio was 0.77, which achieves SNL/California's performance objective for 1997.

The Transportation Program at SNL/California also received an honorable mention award for its participation in the Bay Area Air Quality Management District's "Spare the Air" campaign. This campaign is designed to limit the amount of air emissions to the environment on days when pollution levels are approaching unhealthful levels. SNL/California was recognized as one of the top 14 companies of the 420 participants in the Bay Area.

NESHAPs Compliance for Radionuclides

The EPA regulates airborne emissions of radionuclides through the Clean Air Act (CAA), National Emission Standards for Hazardous Air Pollutants (NESHAPs).[14] On December 15, 1989, the EPA revised its NESHAPs Rule for Radionuclides—Title 40 CFR, Part 61 (Subpart H applies to DOE facilities). It establishes radiation protection standards for protection of the public, monitoring requirements, and annual reporting of radionuclide air emissions. The EPA has established 10 mrem/yr. as the allowable limit of radiation dose received by the public from air emissions. In 1994, the maximum dose from SNL/California's air pathway was 0.013 mrem (1.3×10^{-4} mSv), or 0.13% of the CAA limit.

Each year, SNL/California evaluates site air emissions for compliance with the NESHAPs Rule for Radionuclides.[14] This evaluation consists of a site-wide survey of all uses of radionuclides and the potential for airborne release. In 1994, the survey identified two facilities with the potential to emit airborne radioactive contaminants: the Tritium Research Laboratory and the Radioactive Waste Management Facility. SNL/California monitors airborne emissions from both facilities.

The gaseous emissions from the Tritium Research Laboratory always have been carefully monitored. In 1991, the stack monitoring system was upgraded to ensure full compliance with the emission monitoring and testing procedures of Section 61.93(b) of the NESHAPs Rule.[14] Each year, as required by the Rule, SNL/California calculates the radiological dose from these emissions, using the EPA-specified computer code (CAP-88). The input parameters and results of this calculation are presented in Chapter 5, "Environmental Impacts." Based on this calculation, SNL/California has determined that its operations involving radionuclides comply with the monitoring and radiological dose requirements of the NESHAPs.

National Environmental Policy Act Compliance

The National Environmental Policy Act (NEPA) requires SNL/California to consider environmental issues in the review of every proposed project on-site.

Because Sandia is a Federal government contractor and receives Federal funds, all proposed projects, programs, and activities must be reviewed for their potential impacts. The DOE has implemented official regulations and orders to guide its facilities in the NEPA process. The DOE Albuquerque Operations Office directs SNL/California NEPA activities.

A site-wide NEPA document, the *Environmental Impact Statement and Environmental Impact Report for Continued Operation of Lawrence Livermore National Laboratory and Sandia National Laboratories, Livermore,* was published in August 1992.[15] The Secretary of Energy approved the document in a Record of Decision on January 20, 1993. The *Environmental Impact Statement* discusses SNL/California's existing and proposed (for the subsequent five to ten years) mission and projects from an environmental perspective. Each existing and proposed project was determined to have a less-than-significant environmental impact to the site and the surrounding area. Therefore, no additional mitigation is required beyond what Sandia does as a part of normal operations.

Chapter 6, "Environmental Program Information," provides more information about SNL/California's NEPA activities in 1994.

Other Environmental Statutes

In 1994, SNL/California had no significant activities governed by the following regulations:

- Toxic Substances Control Act,
- Federal Insecticide, Fungicide, and Rodenticide Act,
- Endangered Species Act,
- National Historic Preservation Act,
- Floodplain Management (Executive Order 11988), or
- Protection of Wetlands (Executive Order 11990).

SNL/California maintains compliance with the regulations listed above through internally generated procedures and review of DOE orders. No lawsuits pertaining to any environmental regulation are on file against SNL/California.

OTHER ISSUES AND ACTIONS

Audits and Inspections

Operations at SNL/California are routinely subjected to internal inspections as part of a self-assessment program. In addition to this internal scrutiny, external regulatory agencies audited or inspected SNL/California in 1994. Table 3-4 lists these audits and inspections by date. The table also cites the purpose and the regulatory agency performing the inspection or audit.

DOE Headquarters audited SNL/California in 1990 (also known as the Tiger Team Assessment). The DOE Headquarters audit in February (see Table 3-4) was a follow-up inspection. These two audits and the associated findings are described briefly below.

DOE Routine Environmental Audit

The DOE's Office of Environment, Safety and Health (EH) established a program in the Office of Environmental Audit (called EH-24) to assess DOE facilities for environmental compliance. The goal of this program is to enhance environmental protection and to minimize risks to the public.

EH-24 audited SNL/California February 22 – March 4, 1994. The objectives of the audit were to:

- evaluate the adequacy of management systems at SNL/California;
- ensure compliance with Federal, State, local and DOE environmental requirements; and
- evaluate proactive management practices.

This comprehensive audit addressed all areas of environmental management, including in-depth reviews of the NEPA and inactive waste sites programs.

The audit report identified nine minor findings. Eight were in the area of environmental management systems, and one was in a technical discipline. The audit team cited a lack of formality as a common thread in seven of the nine findings. However, the audit team was very pleased with the overall environmental management system at SNL/California. Furthermore, the audit findings indicated no serious conditions nor significant deficiencies at SNL/California.

The following is a synopsis of the audit report:

- Commitment to, and ownership of, environmental protection responsibilities pervades SNL/California;
- Environmental protection programs are well designed and implemented, and are effectively managed at SNL/California;
- Some elements of formalized environmental programs have deficiencies;
- Strong internal and external communications have engendered both widespread environmental awareness and strong stakeholder relationships; and
- Line managers and staff have accepted and internalized their responsibility for environmental management.

DOE Tiger Team Assessment

In a 1990 initiative to strengthen safety, environmental protection, and waste management throughout the DOE Complex, DOE Headquarters established inspection teams of ES&H experts—commonly referred to as "Tiger Teams." The Tiger Teams provided an independent assessment of the ES&H programs at DOE facilities. The mission of a Tiger Team was to evaluate a DOE site's compliance with environmental and safety requirements, permit agreements, DOE orders, and best management practices. The Tiger Teams were an integral part of DOE's overall plan to ensure full accountability in the areas of ES&H and compliance with regulatory commitments.

Between April 30 and May 18, 1990, a DOE Tiger Team assessed the ES&H programs at SNL/California. The assessment resulted in 286 key findings, root causes, findings, and concerns. The Environmental Subteam identified a total of 41 findings, three of which were considered key findings. The Environmental Subteam found that environmental and waste management programs at SNL/California were generally in compliance with regulatory requirements, but they had some weaknesses. The key environmental findings were:

- SNL/California had no formalized environmental policies, quality assurance programs to implement environmental protection programs, or procedures to ensure that the environmental compliance program was being carried out effectively and in compliance with all requirements.
- The NEPA Compliance Program was inadequate.
- SNL/California was not in conformance with DOE Order 5400.4 requirements[1] and the Regional Water Quality Control Board Site Cleanup Order No. 89-184[4] for certain remedial response activities associated with inactive waste sites and releases at SNL/California.

SNL/California has made substantial progress towards improving the areas of weakness identified by the Tiger Team. Much effort has focused on strengthening the management oversight and formality of operations relating to ES&H programs. Some of the major improvements are listed below:

- SNL has restructured and expanded its ES&H organization to increase ES&H services.
- A company-wide quality initiative, which includes ES&H, was initiated.

- A Conduct of Operations/Quality Assurance Program has been created to implement DOE Order 5480.19, *Conduct of Operation,*[16] and DOE Order 5700.6C, *Quality Assurance.*[17] The DOE issued these orders to establish and maintain plans and actions to assure quality achievement in DOE programs.
- A formal Quality Assurance Program has been established in SNL/California's ES&H, Facilities, and Security Center.
- A site-wide self-assessment program has been implemented at SNL/California.
- SNL/California has completed its *Environmental Monitoring Plan,* which documents all aspects of the monitoring program.[18]

Figure 3-1 summarizes the status of planned actions scheduled for completion during calendar year 1994. As shown in the chart, 221 planned actions (owned by SNL/California) were due for completion by December 31, 1994. Of these, 129 were completed, officially closed and verified by the DOE Kirtland Area Office; 17 were completed (but not yet verified by DOE); 52 are in progress and on schedule (the completion schedule for these has been renegotiated); and 23 are behind schedule.

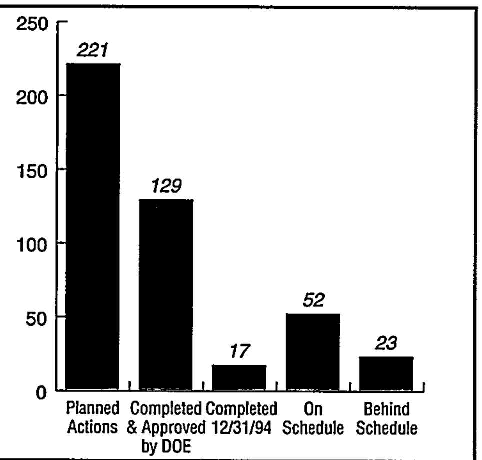


Figure 3-1. Status of SNL/California's Action Plan in response to the DOE Tiger Team findings.

Occurrence Reports

DOE Order 5000.3B, *Occurrence Reporting and Processing of Operations Information,*[19] requires that occurrences be consistently reported to assure that both the DOE and SNL management are kept informed of all events that could:

- affect the health and safety of the public;
- seriously impact the intended purpose of DOE facilities;
- have a noticeable adverse effect on the environment; or
- endanger the health and safety of workers.

The SNL/California Occurrence Reporting System has established a formal process for investigating and notifying the DOE of unusual events at the site. The goals of SNL/California's Occurrence Reporting System are to ensure the following:

- timely identification, categorization, notification, and reporting to SNL and DOE management;
- timely evaluation and implementation of corrective actions, including root cause analyses to identify appropriate corrective actions; and
- dissemination of lessons learned to prevent occurrence of similar events.

Table 3-5 lists all the environment-related events reported through Sandia's Occurrence Reporting System in 1994. SNL/California provides background information for each event reported, including date, type of occurrence, and a brief description.

State Oversight Program

On September 6, 1990, the DOE signed an Agreement in Principle with the State of California to provide California's citizens independent assurance that DOE sites are fulfilling their commitments to health, safety, and the environment. The Environmental Management Branch of the Department of Health Services is the lead agency for the State of California. Long-standing DOE policy states that sites will comply with all applicable environmental statutes and regulations. The Agreement in Principle is a cooperative effort between the State and DOE facilities to help ensure protection of the public and the environment. The DOE has agreed to provide the State access to its facilities, comprehensive monitoring data, and funding to support the Agreement in Principle. The State has an implementation plan for independent monitoring and oversight of DOE sites, including SNL. During 1994, the Agreement in Principle staff reviewed SNL/California environmental programs and monitoring data. In addition, the State independently sampled wastewater effluents, groundwater, and direct radiation levels around the SNL/California site. Members of the public are encouraged to contact the California Department of Health Services (see Preface for address) regarding the information or conclusions drawn in this *Site Environmental Report.*

ENVIRONMENTAL PERMITS

Table 3-6 identifies the environmental permits held by SNL/California in 1994 and the regulatory agencies responsible for enforcing the respective regulations and permit conditions.

Hazardous Waste Permits

The Cal/EPA issued a final RCRA "Part B" permit on December 4, 1992, for SNL/California to operate the Hazardous Waste Storage Facility. The permit is effective from January 4, 1993, to January 4, 2003.

SNL/California did not use its small on-site incinerator in 1994. The incinerator has an air permit issued by the Bay Area Air Quality Management District. SNL/California has used the incinerator in the past to destroy energetic materials, classified documents, and medical wastes. A RCRA hazardous waste Part B permit application with Subpart O exemption for operation of the incinerator was submitted in September 1991 to the EPA and the Cal/EPA. See page 3-2 for additional information regarding the permit application.

As provided by the 1984 Hazardous and Solid Waste Amendments to RCRA, the Cal/EPA conducted a facility assessment in April 1991 and issued a report in September 1991. The Cal/EPA revised this report and reissued it in March 1992.[20] It identified three "solid waste management units" at SNL/California: the Fuel Oil Spill, the Navy Landfill, and Miscellaneous Sites. However, because these units were being assessed and remediated as part of the Regional Water Quality Control Board Order, no corrective action under the RCRA Program was required.

SNL/California conducts all waste handling operations according to the most recent State and Federal regulations. Chapter 6, "Environmental Program Information," contains more information about SNL/California's Hazardous Waste Program.

Air Quality Permits

To comply with the NESHAPs Rule for Radionuclides,[14] SNL/California must obtain EPA approval before starting construction on new sources that may emit radionuclides to the air, or before modifying existing sources. SNL/California has received written approval for operating the low-level tritium evaporator at the Tritium Research Laboratory.

In 1994, SNL/California had Bay Area Air Quality Management District permits for 32 sources of air pollutants, such as boilers, the incinerator, vapor degreasers, a paint spray booth, and various abatement devices (see Table 3-2.) Bay Area Air Quality Management District permits are renewed annually. Table 3-3 lists sources officially exempt from District permitting.

Wastewater Discharge Permit

SNL/California holds one Wastewater Discharge Permit issued by the Livermore Water Reclamation Plant. This permit regulates SNL/California's sanitary and industrial liquid effluent, which is discharged into the City's sewer system. It is renewed annually. It contains discharge limits for the site sanitary sewer outfall and for processes subject to EPA pretreatment standards. The permit also contains liquid effluent monitoring and reporting requirements. For more details, see Appendix B, which summarizes the conditions of SNL/California's Wastewater Discharge Permit.

Groundwater Discharge Permit

SNL/California holds one Groundwater Discharge Permit issued by the Livermore Water Reclamation Plant. This permit regulates the discharge to the sanitary sewer system of water captured by the aquifer protection wells at the Fuel Oil Spill site. SNL/California treats the water before discharging it to the sewer system. The permit contains discharge limits and monitoring and reporting requirements for the chemical constituents of concern.

National Pollutant Discharge Elimination System Storm Water Discharge Permit

SNL/California holds a Notice of Intent with the State Water Resources Control Board to comply with the California General Industrial Activities NPDES Storm Water Permit.[10] This permit allows SNL/California to comply with Federal storm water permitting requirements. It requires SNL/California to manage the quality of its storm water runoff that is discharged into the City's storm drain system. It is renewed every five years.

The permit also requires SNL/California to implement a comprehensive Storm Water Management Program. Sandia's program is designed to identify and eliminate non-storm water discharges to the storm drain system, implement a storm water pollution prevention plan, and establish a storm water monitoring plan. Although the State Water Resources Control Board administers the storm water permit, the Regional Water Quality Control Board administers the program at Federal facilities, such as SNL/California.

In response to Federal CWA permitting requirements for municipal storm water discharges, the City of Livermore has adopted ordinances that control storm water discharges to the City's storm drain system. The Livermore Water Reclamation Plant enforces the City's storm water control ordinances.

REFERENCES

1. U.S. DOE, Order 5400.4, CERCLA (October 6, 1989).

2. State of California, San Francisco Bay Region, Regional Water Quality Control Board, Order 88-142 (September 21, 1988).

3. State of California, San Francisco Bay Region, Regional Water Quality Control Board, Order 89-184 (December 13, 1989).

4. U.S. DOE, Sandia National Laboratories/California, *Navy Landfill Solid Waste Water Quality Assessment Test Proposal* (March 1989).

5. U.S. DOE, Sandia National Laboratories/California, *Final Additional Field Investigation Report* (March 1994).

6. State of California, San Francisco Bay Region, Regional Water Quality Control Board, *Recommendation for Closure* (November 1994).

7. U.S. DOE, *Reconnaissance Investigation Report for Sandia National Laboratories, Livermore Miscellaneous Sites,* DOE/AL Environmental Restoration Program (August 1992).

8. U.S. EPA, Title 40 CFR, Part 403, *Federal Wastewater Pretreatment Standards* (July 1994).

9. U.S. EPA, Title 40 CFR, Part 433, *Metal Finishing Point Source Category* (July 1994).

10. State of California, "NPDES General Permit for Storm Water Discharge Associated with Industrial Activities," State Water Resources Control Board (September 17, 1992).

11. EOA, Inc., *Storm Water Pollution Prevention Plan,* for Sandia National Laboratories/California (January 1994).

12. U.S. DOE, Sandia National Laboratories/California, *Storm Water Management Plan* (January 1994).

13. State of California, Bay Area Air Quality Management District, *Rules and Regulations* (issued January 1980; as revised).

14. U.S. EPA, Title 40 CFR, Part 61, NESHAPs (December 15, 1989).

15. U.S. DOE and University of California, *Environmental Impact Statement and Environmental Impact Report for Continued Operation of Lawrence Livermore National Laboratory and Sandia National Laboratories, Livermore,* DOE/EIS-0157 (August 1992).

16. U.S. DOE, Order 5480.19, *Conduct of Operations* (September 1986).

17. U.S. DOE, Order 5700.6C, *Quality Assurance* (August 1992).

18. R. C. Holland, *Environmental Monitoring Plan,* Sandia National Laboratories/California, SAND94-8011 (February 1994).

19. U.S. DOE, Order 5000.3B, *Occurrence Reporting and Processing of Operations Information* (May 1990).

20. State of California, Environmental Protection Agency, *RCRA Facility Assessment Report* (March 1992).

Table 3-1. Major Federal Environmental Regulations Applicable to SNL/California.

Legislation	Description
Resource Conservation and Recovery Act **(RCRA)**	RCRA regulates hazardous, nonhazardous, and medical waste. It also regulates underground storage tanks containing hazardous substances and petroleum products.
Comprehensive Environmental Response, Compensation, and Liability Act **(CERCLA)** Superfund Amendments and Reauthorization Act **(SARA)**	CERCLA and SARA establish liability, compensation, cleanup, and emergency response for hazardous substances released to the environment.
Emergency Planning and Community Right-to-Know Act **(EPCRA)**	EPCRA (SARA Title III) requires that hazardous substances used on site be reported to State and local governments and to the general public.
Clean Water Act **(CWA)** National Pollutant Discharge Elimination System **(NPDES)**	Through the NPDES, the CWA regulates liquid discharges for both wastewater and storm water discharges from industrial activities.
Clean Air Act **(CAA)** National Emission Standards for Hazardous Air Pollutants **(NESHAPs)**	The CAA and NESHAPs set air quality standards for hazardous air emissions, such as radionuclides and benzene.
Toxic Substances Control Act **(TSCA)**	The TSCA controls the use and exposure of new industrial chemicals. It also regulates the use and disposal of polychlorinated biphenyls (PCBs).
National Environmental Policy Act **(NEPA)**	NEPA establishes criteria for evaluating potential environmental impacts of Federal activities and alternatives.

Table 3-2. SNL/California Bay Area Air Quality Management District Permitted Sources.

Source #	Description	Location	Permit Condition
6 & 7	Boilers #1 & 2	B. 907, Combustion Research Facility	Space heat only; Sulfur content of fuel shall not exceed 0.5% by weight
12	Incinerator (BAYCO reclamation furnace multiple chamber)	Area 8	None
16	Paint Spray Booth	B. 913, Room 130	None
20	Cold Cleaner	B. 913, So. Shed	Solvent usage shall not exceed 5 gal./yr.
21	Cold Cleaner	B. 963, East Shed, Car Mechanics	Solvent usage shall not exceed 15 gal./yr.
22	Boiler	B. 916 NW	Space heat only; sulfur content of fuel shall not exceed 0.5% by weight
23 & 24	Boilers 1 & 2	B. 9137	Space heat only; sulfur content of fuel shall not exceed 0.5% by weight
25	Boiler	B. 912 SW	Space heat only; sulfur content of fuel shall not exceed 0.5% by weight
26 & 27	Boilers 1 & 2	B. 968	Space heat only; sulfur content of fuel shall not exceed 0.5% by weight
28 & 29	Boilers 1 & 2	B. 910	Space heat only; sulfur content of fuel shall not exceed 0.5% by weight
32	Gasoline Dispensing Facility	B. 963	None
33	Vapor degreaser	B. 910, Rm. 310B	Shall not exceed 100 gal./yr. AP-20
34	Vapor degreaser	B. 910, Rm. 310F	Shall not exceed 100 gal./yr. 1,1,1-trichloro-ethane
35	Cold parts cleaner with solvent recovery still	B. 910, Rm. 310F	Shall not exceed 100 gal./yr. methylene chloride
36	Ultrasonic cleaner with vapor recovery still	B. 910, Penthouse	Shall not exceed 150 gal./yr. 1,1,1-trichloro-ethane
37	Tritium Research Laboratory abated by Gas Purification System (A-37) and Vacuum Effluent Recovery System (A-38)	B. 968	SNL shall maintain the Gas Purification System and the Vacuum Effluent Recovery System in good operating condition
38	Tritium wastewater evaporator	B. 968	Same as above
55	Decontamination sink	B. 961	None
56 (A-56)	Waste compactor abated by HEPA filter	B. 961	Waste compactor shall be vented through a HEPA filter during operation
60	Drum crusher	B. 961	Organic liquid shall not accumulate near the crusher

Continued

Table 3-2. SNL/California Bay Area Air Quality Management District Permitted Sources (concluded).

Source #	Description	Location	Permit Condition
77	Hexavalent Chromium Plating Bath	B. 913, Rm. 115	Net throughput not to exceed 46,000 amp-hrs. in any 12-month period
79	Wipe cleaning operations	B. 913, Rm. 124B	Shall not exceed 207.2 lb./yr. solvents
81 & 82	Boiler 2	B. 940	Shall burn only natural gas, except during times of natural gas curtailment
84	Vapor degreaser	B. 913, Rm. 119	Shall not exceed 18 gal./yr. solvent
85	Ammonia-based etchant	B. 910, Rm. 310	Ammonium hydroxide usage shall not exceed 150 gal./yr.
87	Portable abrasive blaster	B. 963	Visible emissions shall not exceed Ringlemann 0.5; shall not use more than 10,000 lb./yr. blasting material
90	Waste handling station	B. 968	Annual process weight shall not exceed 15.5 tons

Table 3-3. Bay Area Air Quality Management District Exemptions Held by SNL/California in 1994.

Source #	Description	Location
9	Machine Shop (abated by baghouse)	Bldg. 913, Rm. 119
30	Diesel fuel dispensing tank	Bldg. 907
31	Diesel fuel dispensing tank	Bldg. 963
39	Potassium-gold-cyanide plating operation	Bldg. 913, Rm. 118
40	Ultrasonic cleaner	Bldg. 961
41	Vapor-phase reflow soldering unit	Bldg. 910, Rm. 310B
42	Traveling furnace	Bldg. 910, Rm. 308F
43	Wipe-cleaning operation	Bldg. 916, Rm. 108F
44	Plastics Laboratory oven	Bldg. 913, Rm. 124B
45	Photo developing operations	Bldg. 913, Rm. 156
46	Low-pressure flat flame burner (abated by Venturi scrubber)	Bldg. 916, Rm. 153
48	AB Dick Offset Printing Press	Bldg. 911, Rm. 110
50	Explosive Test Cell	Bldg. 974
51	Explosive Test Cell	Bldg. 974
52	Trio-tech centrifuge	Bldg. 974
53	Spin Facility	Bldg. 978
57	Foams Development Laboratory	Bldg. 913, Rm. 124A
58	Walk-in oven	Bldg. 913, South Shed
59	Vacuum oven	Bldg. 913, South Shed
61	Laser Chemistry Laboratory	Bldg. 916, Rm. 156
62	Chemical Dynamics Laboratory	Bldg. 906, Rm. 118
63	Cluster Chemistry Laboratory	Bldg. 916, Rm. 158
64	Wipe-cleaning operation, Cluster Chemistry Laboratory	Bldg. 916, Rm. 158
65	Gas-phase Materials Synthesis Laboratory	Bldg. 906, Rm. 101
66	Hybrid Microcircuit Laboratory, ammonia-based etching	Bldg. 910, Rm. 308
67	Hybrid Microcircuit Laboratory, micro pen printer	Bldg. 910, Rm. 308
68	Hybrid Microcircuit Laboratory, screen printer	Bldg. 910, Rm. 308
69	Hybrid Microcircuit Laboratory, dispatch oven	Bldg. 910, Rm. 308
70	Hybrid Microcircuit Laboratory, infrared oven	Bldg. 910, Rm. 308
71	Ultrafast Phenomena Laboratory	Bldg. 905, Rm. 120
73	Chemical Kinetics Laboratory, mixing operation	Bldg. 906, Rm. 103
74	Macromolecular Chemistry Laboratory, VWR oven	Bldg. 941, Rm. 1132
76	Inorganic Synthesis and Vacuum Analytical Laboratory	Bldg. 941, Rm. 1135
83	Instapack foam machine	Bldg. 928
89	Abrasive blaster	Bldg. 969
91	Abrasive blaster	Bldg. 906
92	Burner Engineering Research Laboratory	Bldg. 906, Rm. 130

Table 3-4. Environmental Audits of SNL/California in 1994.

Date	Regulatory Authority	Purpose
2/14–2/18	DOE/Albuquerque, Kirtland Area Office	ES&H oversight visit—safety inspections
2/15–2/18	DOE/Albuquerque Operations Office	Emergency Management Appraisal
2/22–3/4	DOE/Headquarters	EH-24 Environmental Programs audit
4/19–4/22	DOE/Albuquerque Operations Office	Waste Moratorium Phase II Appraisal for implementation of radioactive material management area procedures
6/13	Livermore Water Reclamation Plant	Wastewater inspection
7/7–7/15	DOE/Albuquerque, Kirtland Area Office	ES&H oversight visit—safety inspections
8/17–8/18	California EPA	Evaluate compliance with State hazardous waste laws and permits
8/26 and 8/30	Bay Area Air Quality Management District	Air emission source inspection
9/26–9/30	DOE/Albuquerque Operations Office	Health physics and industrial hygiene appraisal
10/11	Livermore Water Reclamation Plant	Wastewater inspection
11/7–11/11	DOE/Albuquerque, Kirtland Area Office	ES&H oversight visit—implementation of ES&H safety programs
11/14–11/15	DOE/Nevada Operations Office	Appraisal of SNL/California's *Low-level Radioactive Waste Management Plan* and compliance with NVO-325, Rev. 1

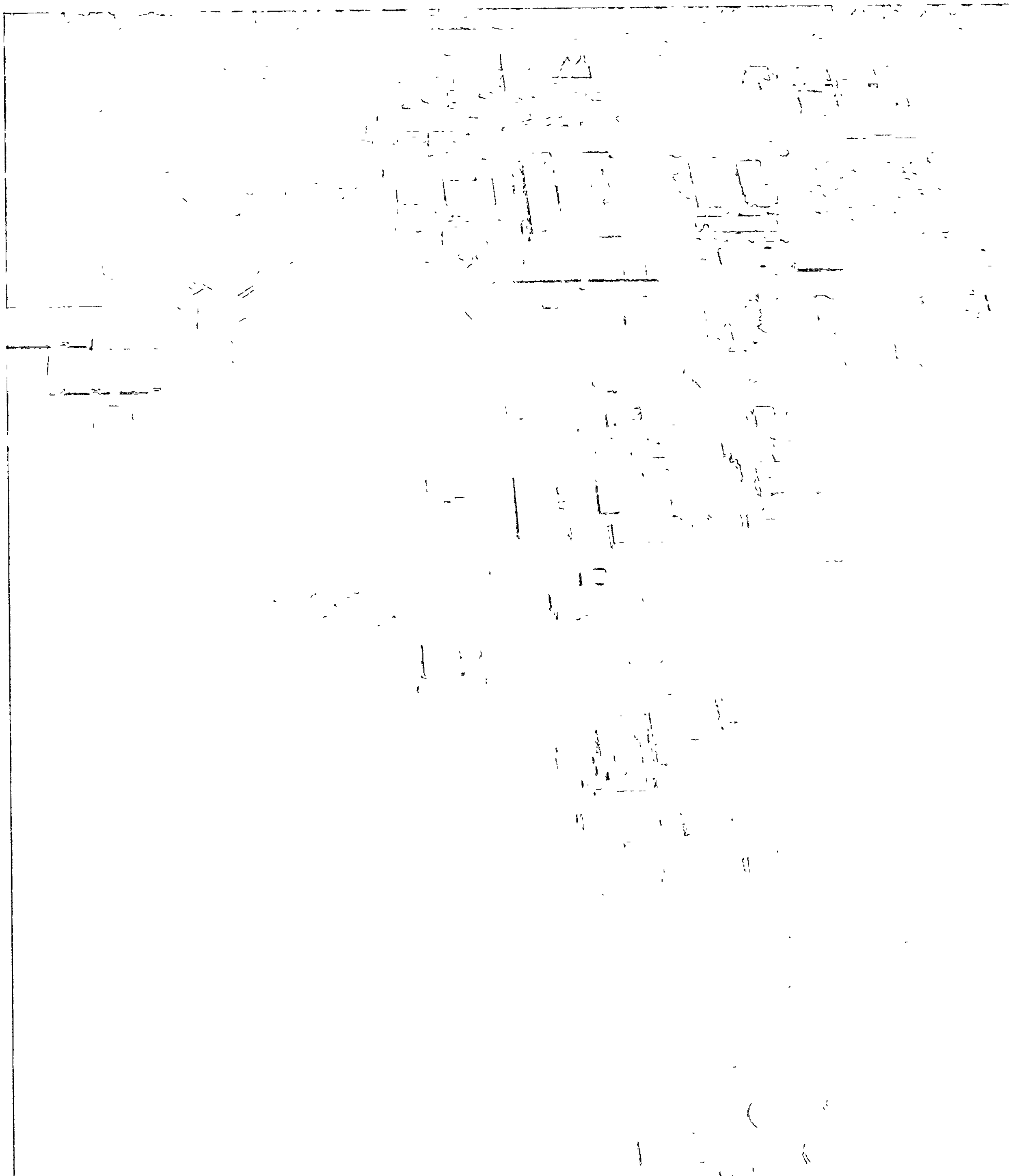
Table 3-5. Environment-related Occurrence Reports.

Report No.	Date	Subject	Occurrence Category	Description of Occurrence
ALO-KO SNL-CASITE-1994-0002	3/24/94	Exceedance of wastewater discharge permit limit for oil and grease	Off-normal	The sewer outfall grab sample collected on 2/28 showed an oil and grease concentration of 110 mg/L, which is above the limit of 100 mg/L. This concentration was a result of workers washing several pieces of heavy equipment at an outdoor washdown pad. Procedures have been established and personnel have been trained to avoid similar occurrences. The final occurrence report was issued in April 1994.
ALO-KO SNL-CASITE-1994-0003	4/19/94	Exceedance of wastewater discharge permit limit for total dissolved solids	Off-normal	The SNL/California sanitary sewer outfall composite sample collected on 3/7 showed a total dissolved solids concentration of 480 mg/L. This concentration was greater than the incremental limit of 325 mg/L above the concentration of the incoming water (which had a total dissolved solids concentration of 46 mg/L). The exceedance was not noted until about 1-1/2 months after it occurred. Therefore, its cause could not be determined. SNL/California has since changed the data and archiving review process to avoid similar occurrences in the future. The final occurrence report was issued in May 1994.
ALO-KO SNL-CASITE-1994-0005	5/13/94	Exceedance of categorical pretreatment standard for nickel	Off-normal	The categorical process grab sample collected on 4/6 showed a nickel concentration of 4.2 mg/L, which is greater than the allowable discharge limit of 2.38 mg/L. The wastewater was treated, and another grab sample was collected and analyzed by Sandia's in-house laboratory. This analysis showed a nickel concentration of 0.88 mg/L. However, a confirmatory sample, which had been sent to an off-site certified contract laboratory for analysis, showed a nickel concentration of 5.0 mg/L. The contract laboratory confirmed this result by reanalysis. Faulty equipment caused the inaccurate in-house result. To ensure accuracy, SNL/California now sends all categorical process wastewater samples to a State-certified contract laboratory for analysis. This incident did not cause SNL/California to exceed any permit limits at the sanitary sewer outfall, nor did it disrupt operations at the Livermore Water Reclamation Plant. The final occurrence report was issued in June 1994.

Table 3-6. SNL/California Environmental Permits in 1994.

Category	Regulation/Authority	Permit Status
Waste Management	Title 40 CFR 264 (RCRA), EPA; Title 22 CCR, Division 4.5, Cal/EPA	Part B permit effective until January 4, 2003.
Air Quality	Bay Area Air Quality Management District	Bay Area Air Quality Management District permits for 32 air emission sources. Permits renewed annually. (See Table 3-2.)
Air Quality	Title 40 CFR 61 (National Emission Standards for Hazardous Air Pollutants), EPA	Issued by the EPA (Title 40 CFR 61, Subpart H) to operate a low-level tritium evaporator at the Tritium Research Laboratory.
Wastewater Discharge	City Ordinance, City of Livermore	Permit for the site sanitary and industrial wastewater discharge. Permit renewed annually.
Storm Water Discharge	Clean Water Act (Title 40 CFR 122–124), EPA, National Pollutant Discharge Elimination System, State Water Resources Control Board	SNL/California has a Notice of Intent on file with the State Water Resources Control Board. As a result, Sandia is covered by the State's National Pollutant Discharge Elimination System General Permit for Discharge of Storm Water Associated with Industrial Activities. Permit renewed every five years.
Groundwater Discharge	City Ordinance, City of Livermore	Permit for discharging treated groundwater to the sanitary sewer. Permit renewed annually.

4 — Environmental Monitoring Program



Effluent Monitoring Results
Meteorological Monitoring Results
Environmental Surveillance Results

The Environmental Operations Department at SNL/California (in conjunction with LLNL) maintains effluent monitoring and environmental surveillance programs. The purpose of these programs is to assess and control potential impacts, if any, to the public and the environment from operations at SNL/California. The department monitors all significant liquid and airborne effluents, making sure SNL/California continually complies with environmental protection laws and standards. Monitoring activities verify the effectiveness of emission control measures by routinely examining environmental media, such as ambient air, surface water, groundwater, soil, arroyo sediments, storm water runoff, sewage, vegetation, and wine, for radionuclides and hazardous chemicals that may be emitted from site operations. An extensive environmental dosimeter network also measures external radiation levels. SNL/California's environmental monitoring activities (joint with LLNL) ensure that all significant exposure pathways are monitored. Table 4-1 shows the types and number of samples collected, the collection frequency, and the parameters measured.

This chapter discusses the results of SNL/California and LLNL's joint monitoring and surveillance activities. The data are interpreted and evaluated according to applicable standards. Appendix A describes the laboratory analyses done on the samples.

EFFLUENT MONITORING RESULTS

Airborne Effluents

The only detectable radionuclide discharged to the atmosphere from SNL/California is tritium from the Tritium Research Laboratory.[1] In 1994, a total of 95 Ci (3.5×10^6 MBq) tritium was discharged. Of this amount, 91 Ci (3.4×10^6 MBq) was in the form of tritium oxide (HTO or T_2O), and the remaining 4 Ci (0.1×10^6 MBq) was in the form of elemental tritium gas (HT or T_2). Based on these stack emissions, SNL/California calculated potential off-site radiological doses to the public, including the maximum possible dose, using EPA-approved assessment models. Chapter 5, "Environmental Impacts," presents the methods and results of this assessment. Figure 4-1 shows the tritium releases for both SNL/California and LLNL for the last ten years.

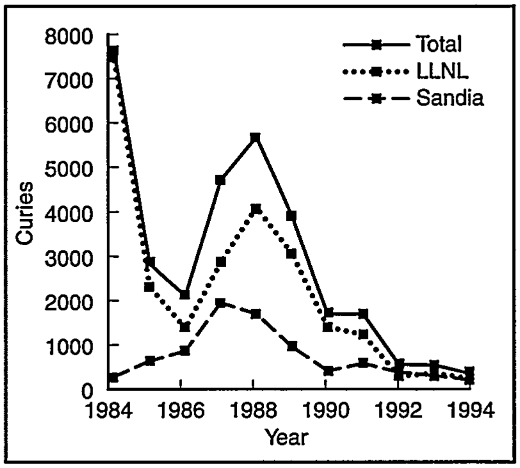


Figure 4-1. Tritium releases from both SNL/California and LLNL since 1984.

The Bay Area Air Quality Management District regulates air emissions of nonradiological pollutants by issuing operating permits. These permits set operating conditions or limitations on sources (equipment or operations) that may emit pollutants to the air. SNL/California has no sources that require routine emission monitoring for nonradiological pollutants. Table 3-2 (in Chapter 3) lists the air discharge permits held by SNL/California in 1994.

Liquid Effluents

SNL/California's Wastewater Control Program ensures that liquid effluents generated by SNL/California operations comply with applicable regulations. Wastewater discharge limits are imposed by the DOE,[2] the City of Livermore

(Appendix B), and other State and Federal agencies. Frequency, methods of sample collection, and parameters for which to analyze are specified in Federal regulations or by SNL/California's wastewater discharge permit. SNL/California continually strives to reduce pollutants in liquid effluents to the lowest levels possible.

In 1982, the EPA National Pretreatment Program provisions of the Clean Water Act (CWA) established liquid effluent monitoring requirements for specific pollutants.[3] Accordingly, SNL/California's Wastewater Control Program emphasizes controlling effluents at the source. SNL/California imposes strict administrative and engineering controls to prevent contaminated liquid discharge to the sanitary sewer system.

Wastewater from SNL/California operations is collected and analyzed before it is released to the sanitary sewer. This analysis allows SNL/California personnel to verify that contaminant levels are acceptable before they allow the water to be released to the sanitary sewer. Almost always, the contaminant concentrations are less than the discharge limits and often are less than detection limits. SNL/California soon will be able to treat wastewater with contaminant concentrations greater than internal site limits, but less than hazardous waste limits. This capability will allow SNL/California to further reduce the already low risk of contaminants entering the sanitary sewer. In addition to monitoring at the source, SNL/California extensively monitors the sanitary sewer effluent as it leaves the site (see pg. 4-4).

Liquid effluent discharges are analyzed according to applicable regulations governing discharges to a publicly-owned treatment works. These regulations include:

- DOE Order 5400.5, which regulates radionuclide discharges to public sewer systems,[2]
- EPA Categorical Pretreatment Standards,[3] and
- City of Livermore wastewater discharge limits (Appendix B).

Liquid Effluent Control Systems Description

SNL/California controls at the generating source potentially contaminated liquid effluents. These effluents are routed to liquid effluent control systems (LECS). LECS consist of large, monitored holding tanks, which collect wastewater, allowing it to be analyzed before being released to the sanitary sewer. By retaining the wastewater at the point of generation, SNL/California can ensure it is within allowable limits before discharging it and can prevent accidental releases to the sanitary sewer system.

LECS Locations

Figure 4-2 shows the locations of all the LECS at the SNL/California site:

- Bldg. 968—all floor drains and laboratory sinks in the Tritium Research Laboratory are routed to two 2,500-gallon tanks.
- Bldg. 913—process wastewater from the central and southern portions of Bldg. 913 and from laboratories in Bldg. 916 is routed to a LECS consisting of three 5,000-gallon tanks.
- Bldg. 910—process wastewater is routed from the Printed Wiring Laboratory to a LECS consisting of one 5,000-gallon tank.
- Bldg. 961—water from decontamination operations is routed to a LECS consisting of one 2,000-gallon tank.
- Bldg. 906—process wastewater is routed to a LECS consisting of two 5,000-gallon tanks.
- Bldg. 941—process wastewater is routed to a LECS consisting of two 5,000-gallon tanks.

Methods

To assure that a representative sample is collected, the contents of the tanks are agitated by recirculation or air bubbling before they are sampled.

Analyses

To ensure compliance with the SNL/California wastewater permit requirements, a grab sample of the LECS contents is collected before the water is discharged to the sanitary sewer. A State-certified commercial laboratory analyzes the samples for parameters associated with the process generating the wastewater (see Table 4-2).

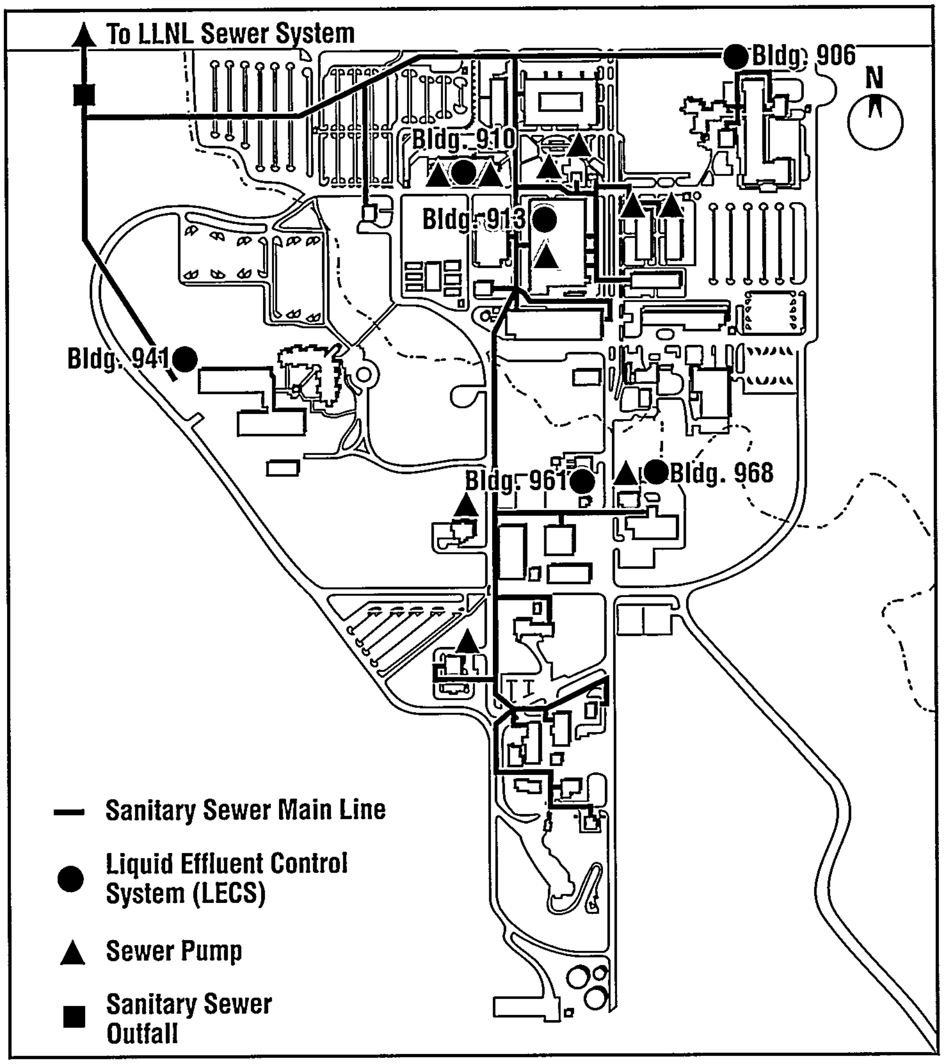


Figure 4-2. SNL/California sanitary sewer outfall and Liquid Effluent Control System locations.

Federal Categorical Processes

Locations

SNL/California operates two "categorical processes," which are subject to the Federal Pretreatment Standards (Title 40 CFR, Part 433): the Electroplating Laboratory in Bldg. 913 and the Printed Wiring Laboratory in Bldg. 910.[4]

Semiannually, SNL/California conducts special sampling procedures for these facilities' wastewater.

Analyses

To comply with the requirements of the Federal Pretreatment Standards, SNL/California collects grab samples of the wastewater from these processes semiannually. A State-certified commercial laboratory analyzes the samples for pH, arsenic, cyanide, cadmium, chromium, copper, lead, mercury, nickel, silver, zinc, and toxic organic compounds. The toxic organic compound analysis covers all EPA priority organic pollutants.

Results

Table 4-3 presents the data for the semiannual monitoring samples. The 1994 data indicate that the wastewater met all pretreatment standards, except one. A wastewater sample collected at the Electroplating Laboratory on April 25, 1994, showed a nickel concentration of 5.0 mg/L (the discharge limit for nickel is 2.38 mg/L). The total volume discharged in this batch was less than 500 gallons. SNL/California notified the Livermore

Water Reclamation Plant, as required by SNL/California's Wastewater Discharge Permit. This incident did not cause SNL/California to exceed any permit limits at the site sanitary sewer outfall, nor did it disrupt operations at the Livermore Water Reclamation Plant, according to plant staff. All other liquid discharges from these processes complied with permit conditions for the entire year. These data are reported in the SNL/California *Categorical Process Report,* which is submitted to the Livermore Water Reclamation Plant semiannually.[5]

Sewer Outfall Monitoring

Sandia monitors its sanitary sewer effluent before it exits the site and joins the sanitary sewer flow from LLNL. Monitoring comprises continuous, grab, and flow-proportional composite sampling.

Locations

Samples are collected at the monitoring station at the site sewer outfall. Figure 4-2 shows the site's sanitary sewer system and the location of the sanitary sewer monitoring station at the SNL/California site.

Methods

SNL/California uses real-time instruments to continuously monitor the site sewer effluent for flow and pH. Grab samples are taken from the effluent stream before it reaches the automatic samplers and monitors. Flow-proportional samples are collected by an automatic, refrigerated, ISCO in-line sampler. SNL/California retains an archive sample to use if confirmatory analyses are needed.

Analyses

A flow-proportional composite sampler continuously samples the sewer effluent so that SNL/California can continuously monitor its compliance with the discharge limits contained in the site's Wastewater Discharge Permit. Sandia conducts all sampling and analysis in accordance with the provisions of the permit.

SNL/California continuously monitors the liquid effluent at the site sewer outfall for pH and flow. SNL/California collects weekly composite and grab samples and sends them to a State-certified laboratory for analysis. The certified laboratory analyzes the composite samples for regulated metals, oxygen demand, total dissolved and suspended solids, and tritium. It analyzes the grab samples for cyanide, oil and grease. SNL/California collects a sewer outfall grab sample monthly. The State-certified laboratory analyzes the monthly sample for EPA priority organic pollutants (EPA Methods 624, 625, and 608). All the analytical results are tabulated in SNL/California's *Wastewater Discharge Compliance Report,* which is submitted to the Livermore Water Reclamation Plant monthly.[6]

Quality Assurance

SNL/California keeps a portion of each composite sample as an archive sample. This archive sample is analyzed in case the routine composite sample shows unusual concentrations of any parameter of concern. Data from the archive sample analysis are used to validate data from the routine sample. SNL/California collects duplicate samples monthly for all parameters except tritium. SNL/California will implement duplicate sampling for tritium in 1995.

Results

Tables 4-4 through 4-6 present the data for the 1994 sewer effluent monitoring.

In 1994, all liquid effluent from the SNL/California sanitary sewer outfall complied with the site outfall discharge limits for regulated metals, radionuclides, and EPA priority organic pollutants.

The wastewater sample collected on February 28, 1994, showed an oil and grease concentration of 110 mg/L. The discharge limit for oil and grease is 100 mg/L. Therefore, the concentration of oil and grease in the site sewer effluent on this date was slightly greater than the discharge limit. SNL/California notified the Livermore Water Reclamation Plant, as required by the Wastewater Discharge Permit. However, according to plant staff, this concentration did not adversely affect plant operations.

The wastewater sample collected at the site outfall on May 7, 1994, showed a total dissolved solids concentration of 480 mg/L. The discharge limit is an incremental limit of 325 mg/L greater than the concentration of the incoming water. The total dissolved solids concentration of the incoming water during this period was 46 mg/L. Therefore, the site sewer effluent on this date was slightly greater than the limit for total dissolved solids. SNL/California notified the Livermore Water Reclamation Plant, as required by the Wastewater Discharge Permit. However, this concentration did not adversely affect plant operations.

SNL/California performed a Mann-Kendall trend test on the 1994 metals and physical data. Copper, pH, and zinc showed an upward trend. Chemical oxygen demand, and oil and grease showed a downward trend. All other parameters showed no detectable trend. These trends are not a concern because none of the parameters exceed site discharge limits. SNL/California will continue to monitor trends.

The DOE and the State of California have established allowable limits for discharging radionuclides to public sewer systems, including a limit of 1×10^{-2} µCi/mL tritium as a monthly average. In 1994, tritium was the only radionuclide discharged to the sanitary sewer system from SNL/California in measurable amounts. The average concentration of tritium in the sanitary sewer effluent was 1.3×10^{-5} µCi/mL, which was 0.1% of the DOE control limit. A total of 0.059 Ci tritium was discharged in 1994. No tritium samples exceeded the monthly average limit.

METEOROLOGICAL MONITORING RESULTS

Meteorological data are continuously collected at a meteorological monitoring station on the SNL/California site. These data represent the atmospheric conditions at the site. SNL/California uses this information to assess the transport, diffusion, and deposition of materials released to the atmosphere. The 1994 data include wind speed, wind direction, rainfall, relative humidity, and ambient temperature.

Monitoring Methods

Sandia maintains a meteorological tower on the western portion of the site (Fig. 4-3). This location represents the local terrain and is clear of any obstructions to wind-flow patterns. The meteorological monitoring system is part of the Atmospheric Release Advisory Capability, a DOE-operated network of monitoring stations designed to provide information to emergency response personnel. The Atmospheric Release Advisory Capability provides 24-hour access to trained assessors and computer models to evaluate atmospheric dispersion and calculate doses from accidental releases of radioactive or hazardous materials.

The SNL/California tower is equipped with HANDAR model 540 instruments (as required by the Atmospheric Release Advisory Capability system), which measure wind speed, wind direction, and temperature at heights of 10 m and 40 m, every 3 seconds. These data are compiled and stored as 15-minute averages. Rainfall is measured at ground level, and relative humidity is measured at the 10-meter level.

Results

The average 1994 surface wind speed and direction (10-meter tower level) measured at SNL/California are plotted in a wind rose (Fig. 4-4). The wind rose graphically illustrates annual average wind flow patterns. The lines extending from the

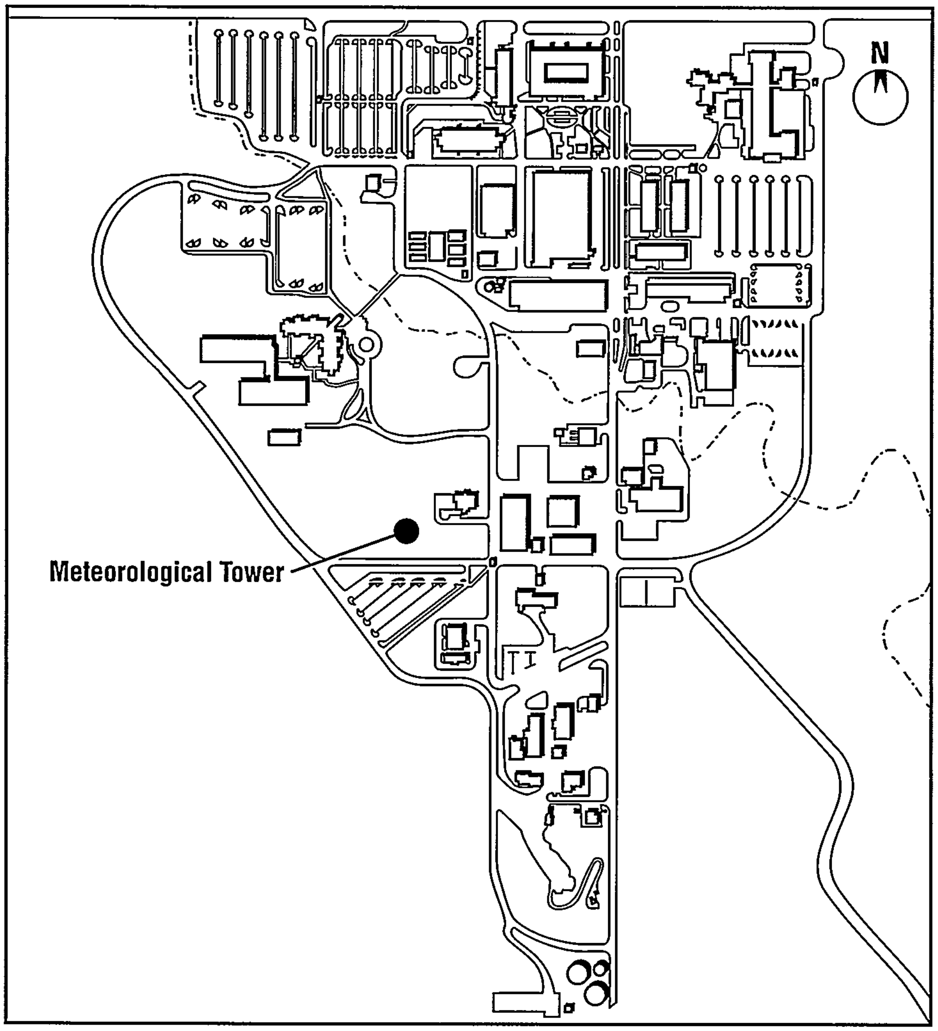


Figure 4-3. Location of the SNL/California meteorological monitoring station.

center of the circle represent the direction from which the wind blows. The length of the lines is proportional to the frequency of the particular wind-speed interval. Each line represents one of the 16 primary compass directions (N, NNE, etc.) and is centered on a 22.5-degree-wide sector. The frequency of calm winds, defined as those less than 0.5 m/s (1.1 mph), was 4.8%, as indicated at the bottom of the figure. Table 4-7 provides the average annual percent frequency of wind direction vs. wind speed. These measurements are based on one-hour averages at the 10-meter tower level.

ENVIRONMENTAL SURVEILLANCE RESULTS

Ambient Air Monitoring

Air is a primary exposure pathway to humans from radionuclides released to the atmosphere. Therefore, environmental air sampling is conducted to evaluate potential doses from inhaled or ingested radionuclides. The inhalation of airborne radionuclides, either directly or from resuspension following deposition, may result in their being absorbed into the body from the lung or GI tract. Skin absorption can also be a significant route of uptake for tritium.

Description

The ambient air monitoring system consists of sampling stations at the site perimeter and throughout the Livermore Valley. This design enables discrimination between radionuclides from site operations and from background sources. If radionuclide concentrations at the perimeter monitoring stations are higher than Valley stations, they are assumed to be due to site emissions. The Valley locations also serve to monitor concentrations of radionuclides at local population centers.

Ambient air is the primary exposure pathway to the public from pollutants emitted from SNL/California operations. The potential emissions of concern are ^{238}U and tritium. ^{238}U is collected as a particulate, and tritium is collected as

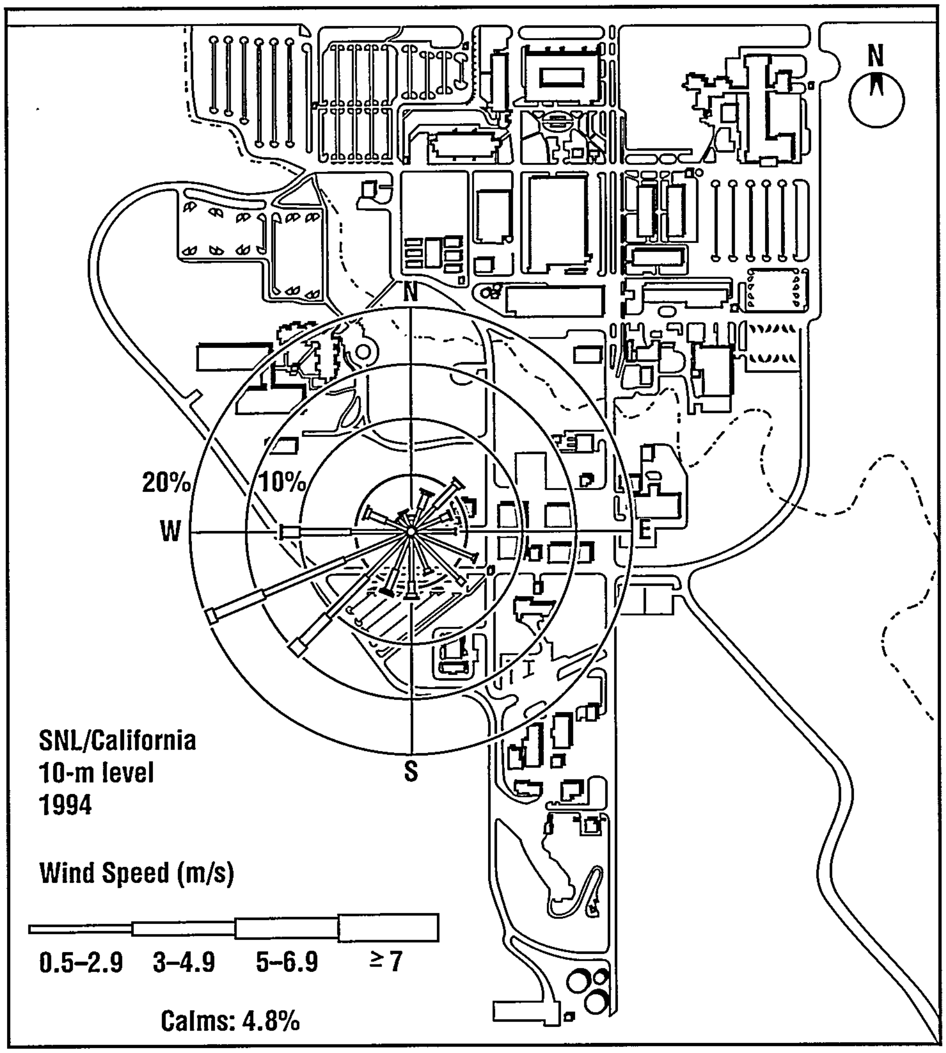


Figure 4-4. Wind rose showing the average annual wind direction and speed during 1994.

tritiated water vapor. More extensive analyses are performed on the air filters in order to monitor the impacts of LLNL operations, which include a greater range of radionuclides. Measurements of gross alpha and gross beta activity are used for screening purposes. The shorter time required for these analyses (as opposed to the radionuclide-specific analyses) provide more immediate indications of a significant increase in the uranium activity. The ratio of the uranium isotopes $^{235}U/^{238}U$ is measured in order to determine the origin of the uranium. The isotopic ratio of uranium used at the SNL/California site is different from that found in nature (uranium is naturally found in soil and in air due to suspension of surface soils). Uranium used at SNL/California is in the form of depleted uranium (uranium that has had most of the ^{235}U removed). Therefore, if the air filters show less ^{235}U than is expected in naturally occurring soils (approximately 0.7%), the source of the uranium is probably site operations.

Locations

The site perimeter (near-field) sampling locations are shown in Fig. 4-5. SNL/California maintains locations ATS-01 through ATS-05. LLNL maintains locations CAFE, SALV, and VET. The off-site (distant) locations, maintained by LLNL (except ATS-07, which is maintained by SNL/California), are shown in Fig. 4-6. LLNL locations XRDS, ZON7, ALTA, LCCY, and FIRE are the locations most pertinent to the SNL/California site. Other LLNL air monitoring locations (not shown) serve primarily to monitor LLNL operations. Table G-4, in the Glossary, lists the sampling location designators.

In 1994, SNL/California implemented a new air tritium sampling network with equipment essentially identical to that used by LLNL.

Methods

High-volume air samplers equipped with Whatman #41 filters with an area of

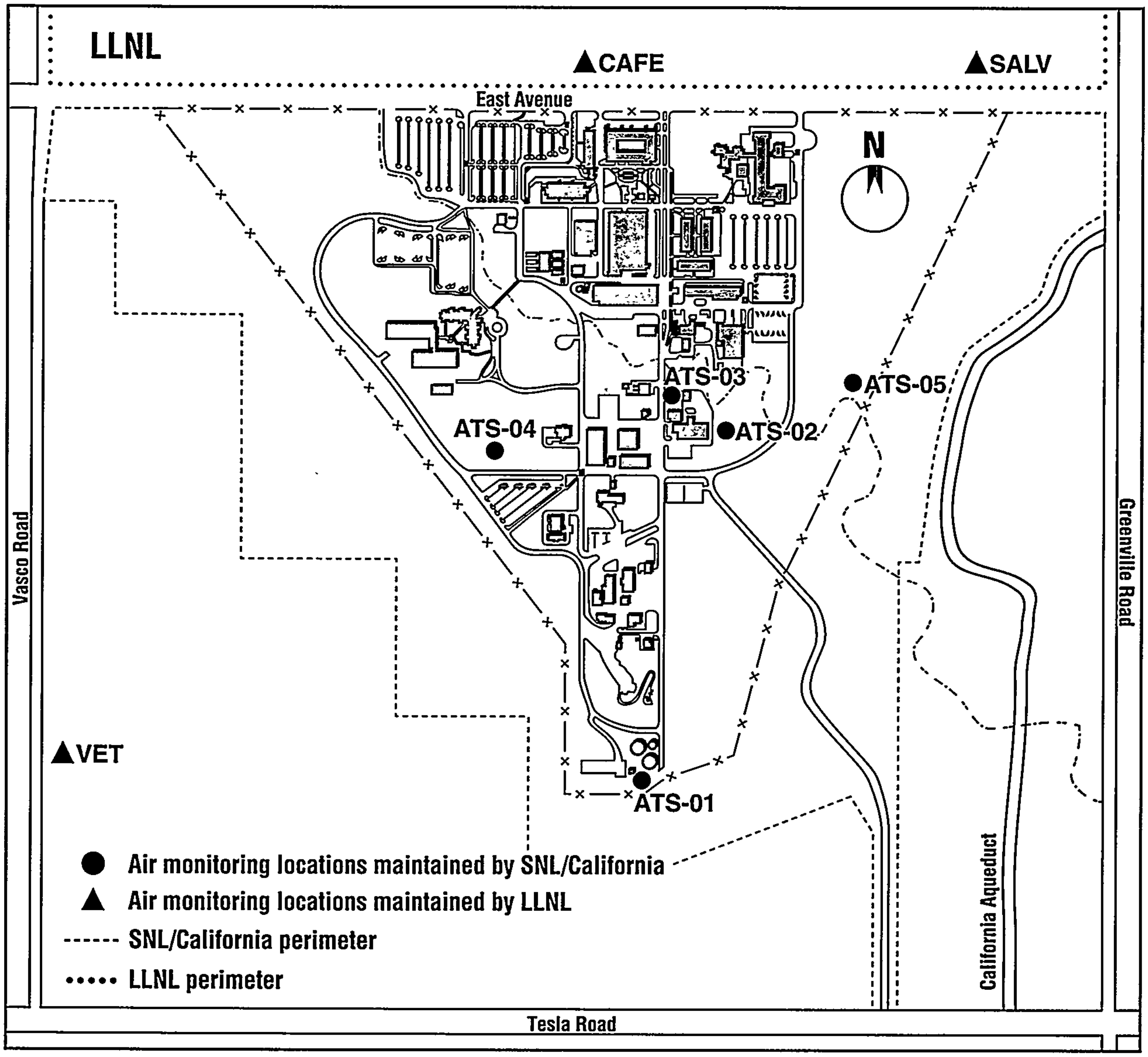


Figure 4-5. SNL/California site perimeter ambient air monitoring locations.

0.052 m² collect air particulates. The filters are a good balance between particulate collection efficiency and the need for an easily dissolved, low-metal-content filter. A mass flow controller maintains the sampler's flow rate at 400 L/min. At the end of the one-week collection period, the flow rate and run time are used to calculate the volume of air sampled. LLNL analyzes monthly composites of the weekly samples from locations CAFE and SALV for ^{235}U, ^{238}U, gross alpha, and gross beta. LLNL analyzes samples from locations VET, XRDS, ZON7, ALTA, LCCY, and FIRE for gross alpha and gross beta emitters.

LLNL collects air tritium samples at locations CAFE, SALV, VET, XRDS, MESQ, MET, VIS, COW, ZON7, ALTA, FIRE, and LCCY. SNL/California collects air tritium samples at all ATS locations. Sampling personnel collect these samples by pumping ambient air through a glass flask containing silica gel at a flow rate of

0.7 L/min. The flow is set to this rate when collection begins, the flow at the end of the two-week collection period is noted, and the average of the two flow rates is used to calculate the total volume of the sample. LLNL collects additional air tritium samples on the LLNL site to assess local impact from specific operations.

Quality Assurance
LLNL uses one high-volume air particulate sampler as a duplicate sampler. This sampler is moved to a different LLNL perimeter location every month and run in parallel with the normal sampler. LLNL analyzes the filter from this sampler for the same parameters as the normal sampler. LLNL also runs one air tritium sampler as a duplicate sampler at LLNL site perimeter locations. This sampler also is moved monthly. SNL/California runs a duplicate sampler at a Sandia-maintained sampling location. This sampler is moved biweekly. Duplicate samplers serve as the basis for determining the precision of the sampling and analytical system.

LLNL and SNL/California assess the accuracy of the analytical system by analyzing reference materials provided by the DOE or the EPA (for air filters), or by analyzing spiked pseudo samples, which have been prepared with standards traceable to the National Institute of Standards and Technology. Blank air filters are processed as a check on possible contamination. Blank silica gel samples are created by bubbling tap water onto a silica gel sampler and then analyzing it for the required constituents. Chapter 8, "Quality Assurance," presents the results from the analysis of quality control samples.

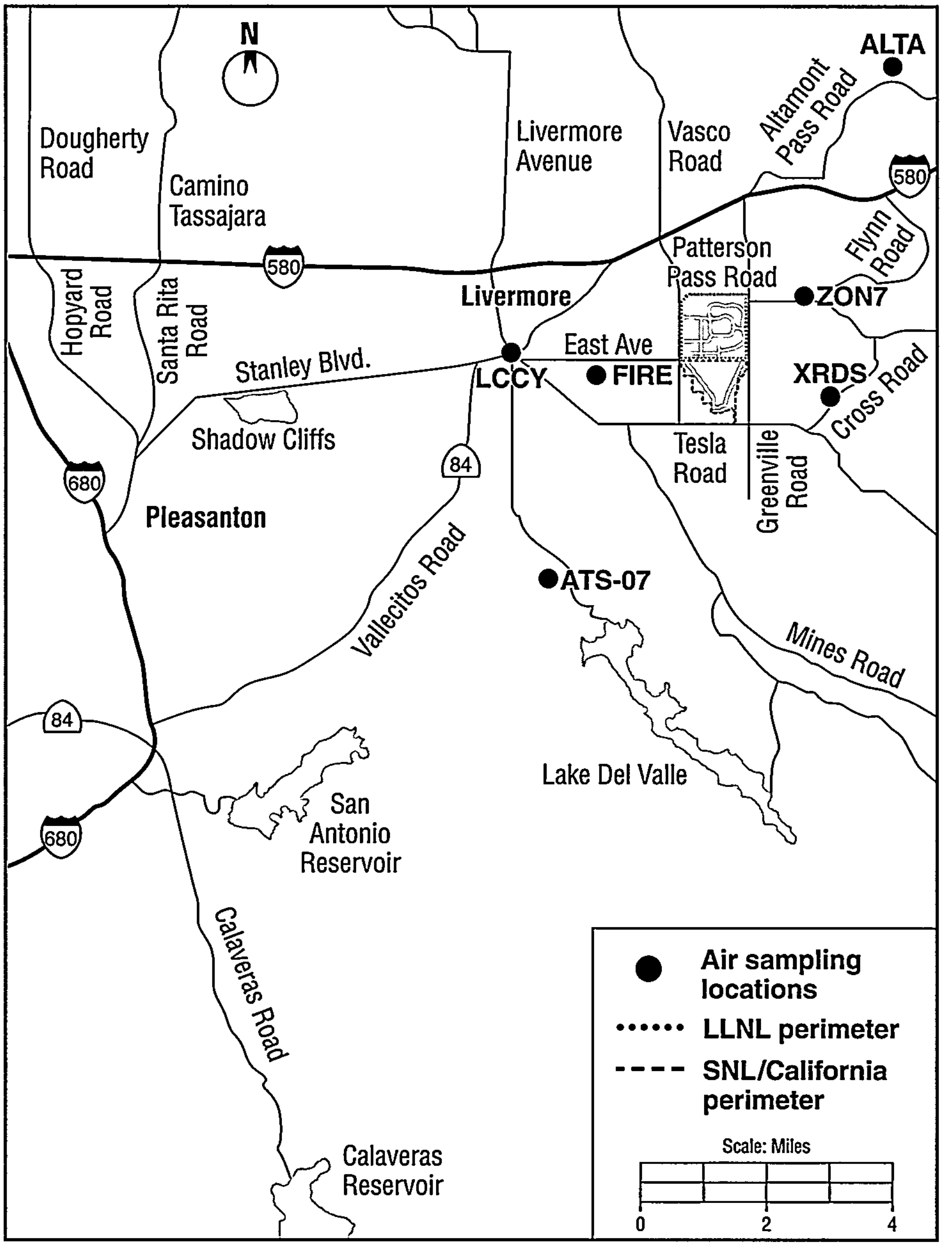


Figure 4-6. Air sampling locations in the Livermore Valley.

Results

Table 4-8 presents the concentrations of uranium in air near the SNL/California site perimeter. The highest annual average ^{238}U concentration in 1994 was 6.18×10^{-5} μg/m^3, which is 0.02% of the DOE's derived concentration guide (see Table D-1 in Appendix D). Figure 4-7 shows the highest annual average uranium concentrations in air at the Livermore site perimeter for 1987–94. Except for the higher concentration in 1988, the uranium concentrations appear to be fairly constant and follow no significant trend. The concentrations detected are within the range to be expected from natural background sources. Although the $^{235}U/^{238}U$ isotopic ratios in Table 4-8 show deviations from the naturally occurring ratio of approximately 0.7%, the deviations are not considered significant. The range of ratios is 0.596–1.20%. These values bracket 0.7%, indicating that differences may be due to measurement error.

Table 4-9 shows the tritium concentrations measured in air at locations sampled by LLNL throughout the Livermore Valley. The highest annual average tritium concentration observed in air off site was 1.26 pCi/m^3 (4.7×10^{-2} Bq/m^3).

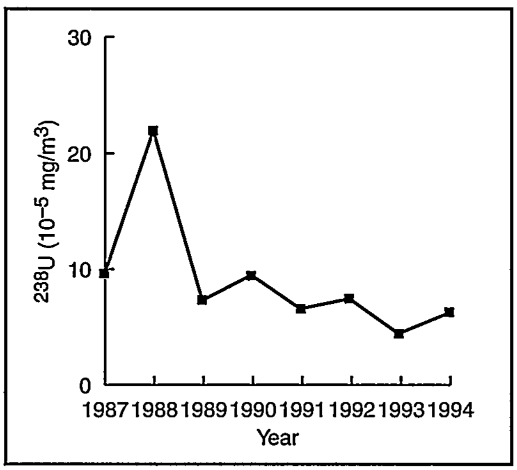


Figure 4-7. Highest annual average uranium concentration in air at the Livermore site perimeter (1987–94).

Table 4-10 shows the tritium concentrations measured in air at locations sampled by LLNL near the SNL/California site perimeter. The highest annual average tritium concentration was 3.67 pCi/m^3 (1.4×10^{-1} Bq/m^3). The DOE allowable limit for tritium in air for protection of the public is 1×10^5 pCi/m^3 (3.7×10^3 Bq/m^3). Figure 4-8 shows the highest annual average values for off-site and on-site tritium concentrations in air for 1987–94 (excluding the SNL/California samplers). The graph clearly shows a decrease in the average tritium concentration in air over the past six years. This corresponds well with the decreased amount of tritium released in recent years (see Fig. 4-1).

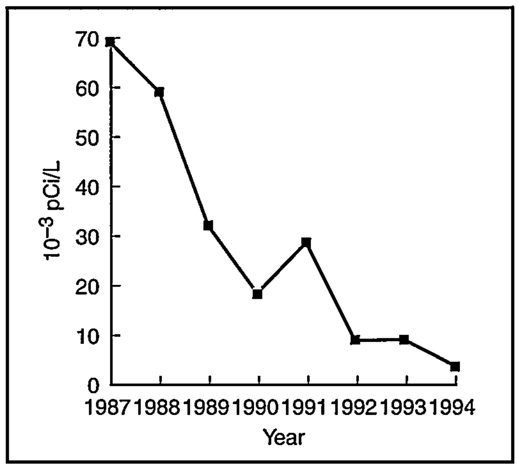


Figure 4-8. Highest annual average tritium concentration in air at the Livermore site perimeter (1987–94).

Table 4-11 shows the tritium concentrations measured in air at locations sampled by SNL/California near the SNL/California site. Location ATS-07 is a background location. The highest annual average tritium concentration observed in air was 65.2 pCi/m^3 (2.4 Bq/m^3), at ATS-03 (see Fig. 4-5). This location is close to the Tritium Research Laboratory.

A statistical comparison of the tritium concentrations in air shows that the concentrations at locations SALV, CAFE, VET, and ZON7 were significantly higher than the concentrations at the other locations. Also, the tritium concentrations at location XRDS were significantly higher than at other Livermore Valley locations (except FIRE), but were lower than the concentrations at CAFE, SALV, VET, and ZON7. The SNL/California locations cannot be compared to the LLNL locations due to differences in the detection limits. However, a statistical comparison of the SNL/California locations shows that tritium concentrations at location ATS-03 were significantly higher than those at other locations. In addition, tritium concentrations at locations ATS-02 and ATS-05 were similar, and higher than those at locations ATS-01, ATS-04, and ATS-07. The tritium concentrations at ATS-01 and ATS-04 were not statistically different than those at the background location (ATS-07). These comparisons indicate that tritium concentrations are statistically higher at the perimeter of the SNL/California and LLNL sites and for a short distance downwind of the sites. However, more distant locations show no significant differences, and the tritium concentrations in air probably represent background values.

SNL/California performed a Mann-Kendall trend test for Sandia-maintained air sampling locations. Locations ATS-01, ATS-02, and ATS-04 showed an upward trend. Location ATS-03 showed a downward trend. Locations ATS-05 and ATS-07 showed no trend. Tritium concentrations probably will show a downward trend or will level off as tritium operations cease at SNL/California and LLNL. Continued trend tests will verify (or negate) this prediction.

The LLNL *Environmental Report* for 1994 contains additional air monitoring data.[7]

Water Sampling

Although there are no direct hydrologic connections between the SNL/California site and local surface bodies of water (except the Arroyo Seco), local surface water bodies could become contaminated due to exchange with pollutants in airborne effluents from site operations or rainout from effluent plumes. The effluent of primary concern in this case is tritium, due to its gaseous nature, and a corresponding high potential for dispersion.

Description

All major bodies of water near SNL/California, except the San Antonio Reservoir, are sampled and analyzed for tritium. In addition, rainwater is collected and analyzed for tritium. Drinking water from the various companies serving the Livermore Valley are also sampled. Monitoring wells near the Livermore Water Reclamation Plant are sampled for tracking any contamination resulting from the plant's past practice of discharging the treated effluent to the arroyo. The sampling wells are used only to monitor groundwater quality near the Livermore Water Reclamation Plant; they are not used as drinking water sources.

In addition, rainwater is collected at several locations near the SNL/California site.

Locations

Figure 4-9 shows the surface water bodies near SNL/California that are sampled. Location ZON7 is the reservoir of the Patterson Pass water treatment facility (1.2 km east of LLNL). Location DUCK is the Springtown pond (an artificial decorative pond 2.6 km northwest of LLNL). Location DEL is Lake Del Valle (a water storage reservoir 8 km south of LLNL). Location SHAD is the Shadow Cliffs Regional Park Recreation Area (a reservoir produced by gravel excavation operations, 11 km west of LLNL). Location CAL is the Calaveras Reservoir (25 km southwest of LLNL). Location POOL is the LLNL swimming pool. Location ALAG is the Arroyo de la Laguna. Locations BELL, GAS, PALM, and TAP are tap water sources, which receive water from different water services. Location ORCH is an orchard on Mines Road.

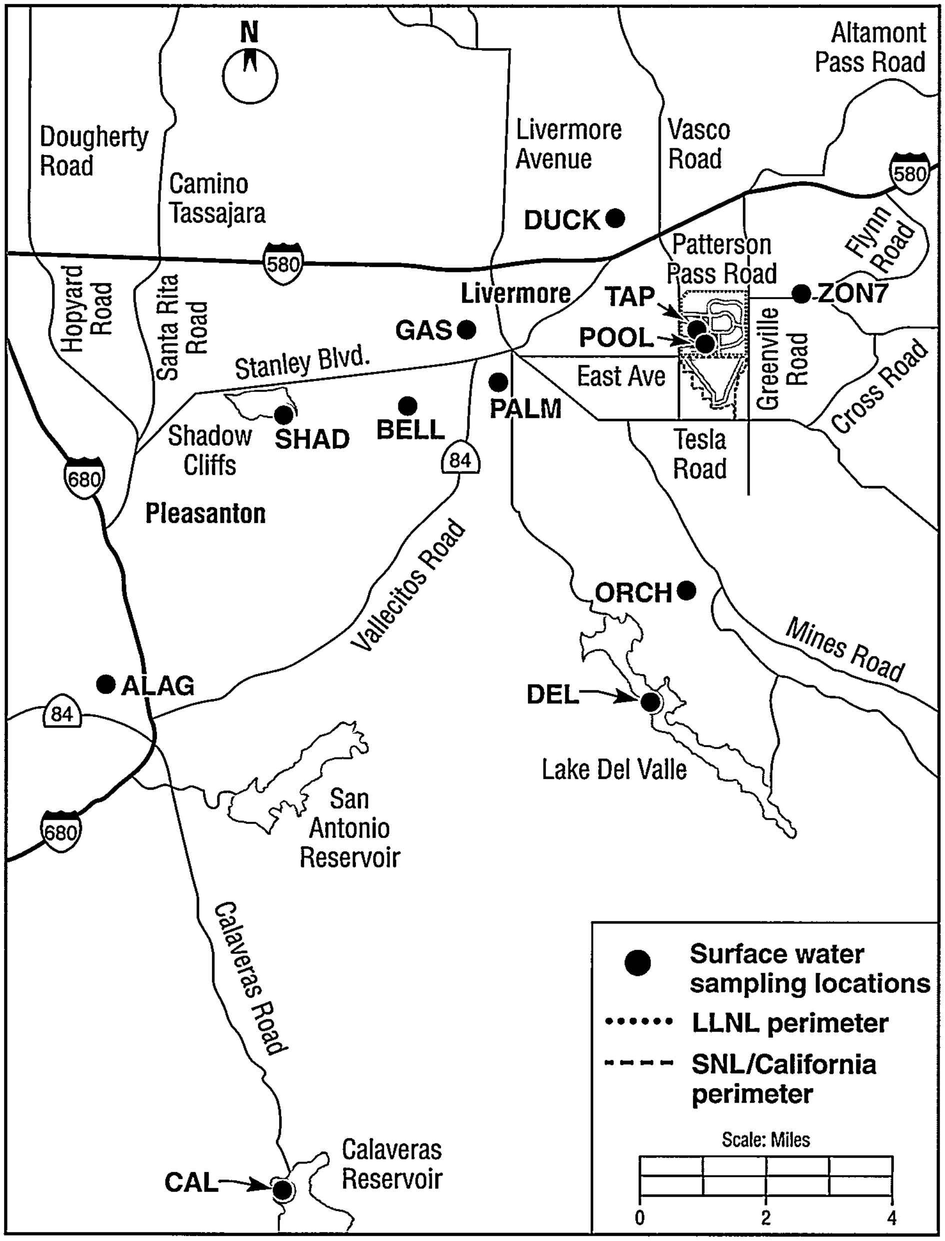


Figure 4-9. Surface water sampling locations in the Livermore Valley.

Rainwater samples are collected in rain gages or open stainless steel buckets during every rainstorm. They are then transferred to argon-flushed glass bottles and delivered to LLNL's Nuclear Chemistry Division.

Quality Assurance

Approximately 10% randomly chosen duplicate samples are collected for the surface water bodies. Random duplicate samples also are collected for rainwater samples if there is enough water for two samples. Laboratory blanks, consisting of "dead" water, are created and processed by LLNL's Nuclear Chemistry Laboratory. The DOE Environmental Monitoring Laboratory and the EPA Environmental Measurements and Standards Laboratory both provide interlaboratory comparison samples for tritium in water. LLNL's Nuclear Chemistry Laboratory analyzes these samples routinely. Chapter 8, "Quality Assurance," presents results from the analysis of quality control samples.

Figure 4-10 shows the rainwater sampling locations. Figure 4-11 shows the Livermore Water Reclamation Plant groundwater sampling locations (wells).

Methods

Surface-water samples are collected quarterly by grab sampling. Samples are collected in argon-flushed glass bottles for tritium analysis.

Results

Table 4-12 contains the tritium concentrations measured in Livermore Valley surface waters. The highest measured value was at the Shadow Cliffs Regional

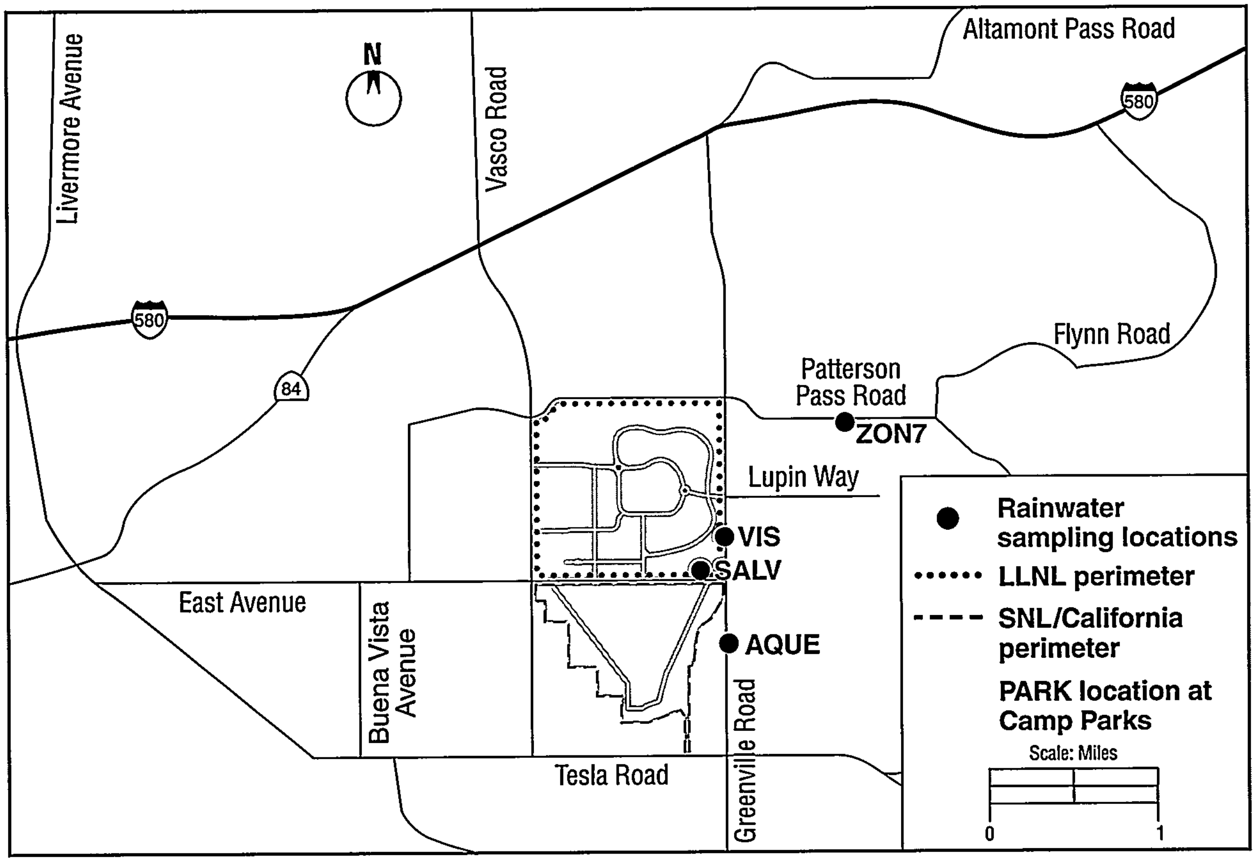


Figure 4-10. Rainwater sampling locations on the SNL/California site and in the Livermore Valley.

Park Recreation Area, at 71.9 pCi/L (2.7 Bq/L); higher concentrations were observed at the LLNL site, but are not considered part of the SNL/California monitoring network. This level represents only 0.4% of the State Department of Health Services drinking water standard for tritium. All surface water samples collected in 1994 were below DOE and State drinking water standards.

Table 4-13 presents the tritium concentrations measured in rainwater. The highest value measured was 540 pCi/L (20.0 Bq/L), at the LLNL salvage yard. This value represents 2.7% of the State drinking water standard for tritium. Figure 4-12 shows the highest annual average tritium concentrations in rainfall for 1987–94. The years 1990 and 1991 had higher concentrations than the earlier years, but levels dropped in 1992 and have remained low through 1994.

Tables 4-14 and 4-15 present the gross alpha and beta concentrations measured in surface water. All measurements in 1994 were below EPA and State Department of Health Services maximum contaminant levels.

Table 4-16 presents the tritium activity measured in monitoring wells near the Livermore Water Reclamation Plant. Since the plant discontinued discharging wastewater to the Arroyo Seco several years ago, the tritium concentrations have been dropping.

Storm Water Runoff

As storm water runs off buildings, material handling areas, parking lots, and other impervious areas on-site, it may pick up various pollutants, such as oil and grease, soil, litter, pesticides, and fertilizer. During dry weather, any non-storm-water discharge eventually evaporates;

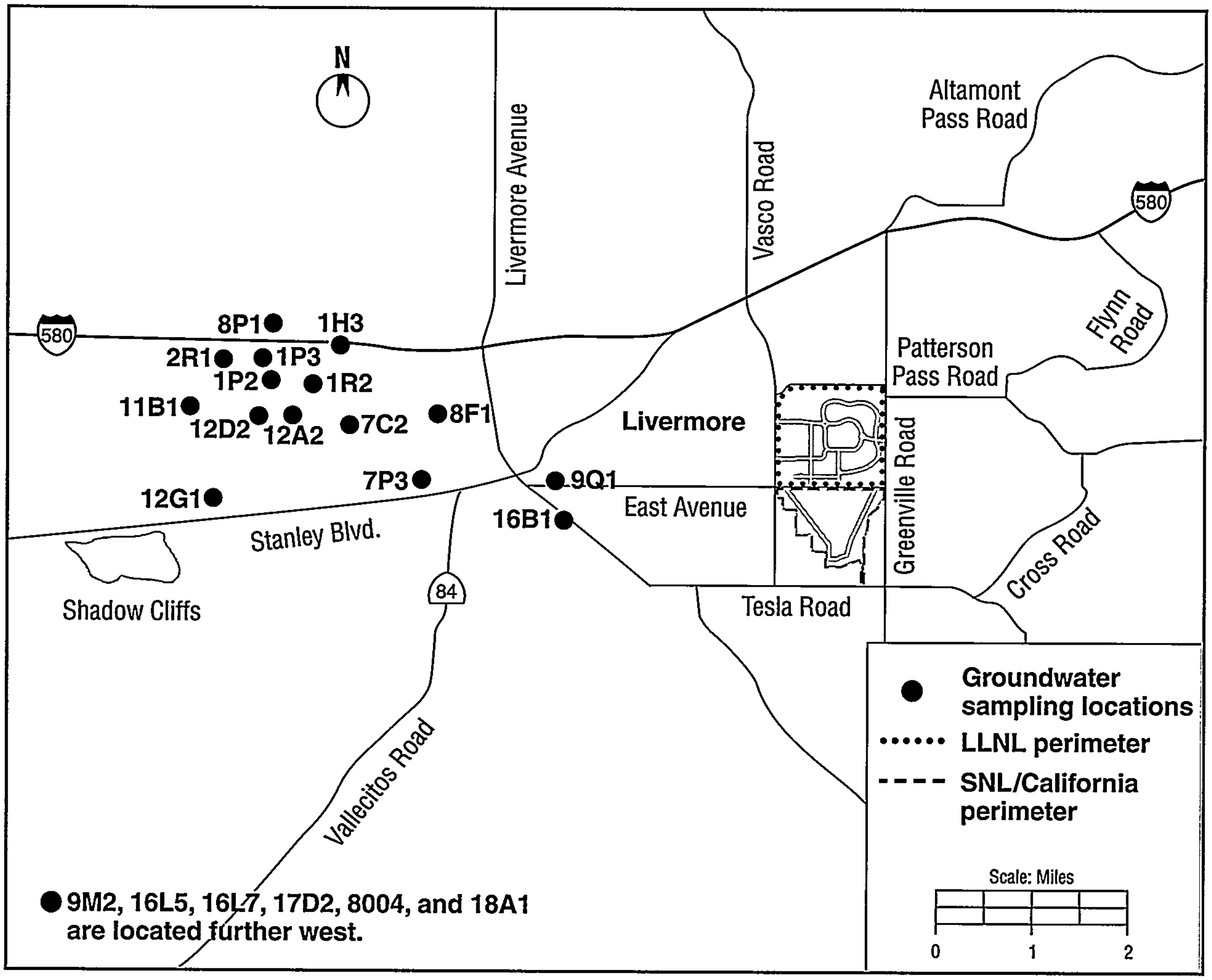


Figure 4-11. Groundwater sampling locations in the Livermore Valley.

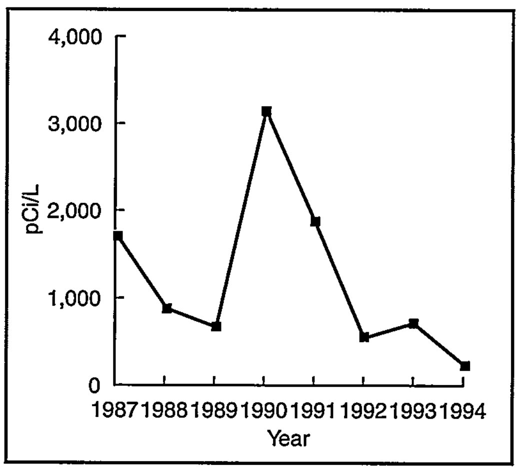


Figure 4-12. Highest annual average tritium concentration in rainfall (1987–94).

however, pollutants left on the ground still may be picked up and transported by runoff in a subsequent rainstorm. The SNL/California storm drain system conveys all runoff to the Arroyo Seco, which discharges into the Alameda Creek and eventually to the San Francisco Bay. The arroyo is also a source for groundwater recharge.

Description

Storm water runoff can transport pollutants on impervious surfaces into surface water bodies. To assess the contribution of site operations to pollutant loading in storm water, SNL/California collects samples of surface runoff at various points in the site's storm drain system.

Locations

Figure 4-13 shows the storm water sampling locations at SNL/California, as follows:

- Location A—maintenance, materials handling and storage, and equipment storage on the west side of the Combustion Research Facility.
- Location B—material handling and equipment transfer for a maintenance area.
- Location C—handling of all incoming materials on site.
- Location D—handling and storage of hazardous materials; raw stock metals, process chemicals, gas bottles storage, and storage sheds; and vehicle fueling, metals, heavy equipment, and sand/aggregate materials storage in the areas surrounding the maintenance yard.
- Location E—primarily indoor research laboratories at the south end of Sandia Drive; outdoor activities include material and light equipment storage and a firing range.
- Location F—material handling area and storage sheds.
- Location G—material handling area and storage sheds; chemical storage shed and loading dock.

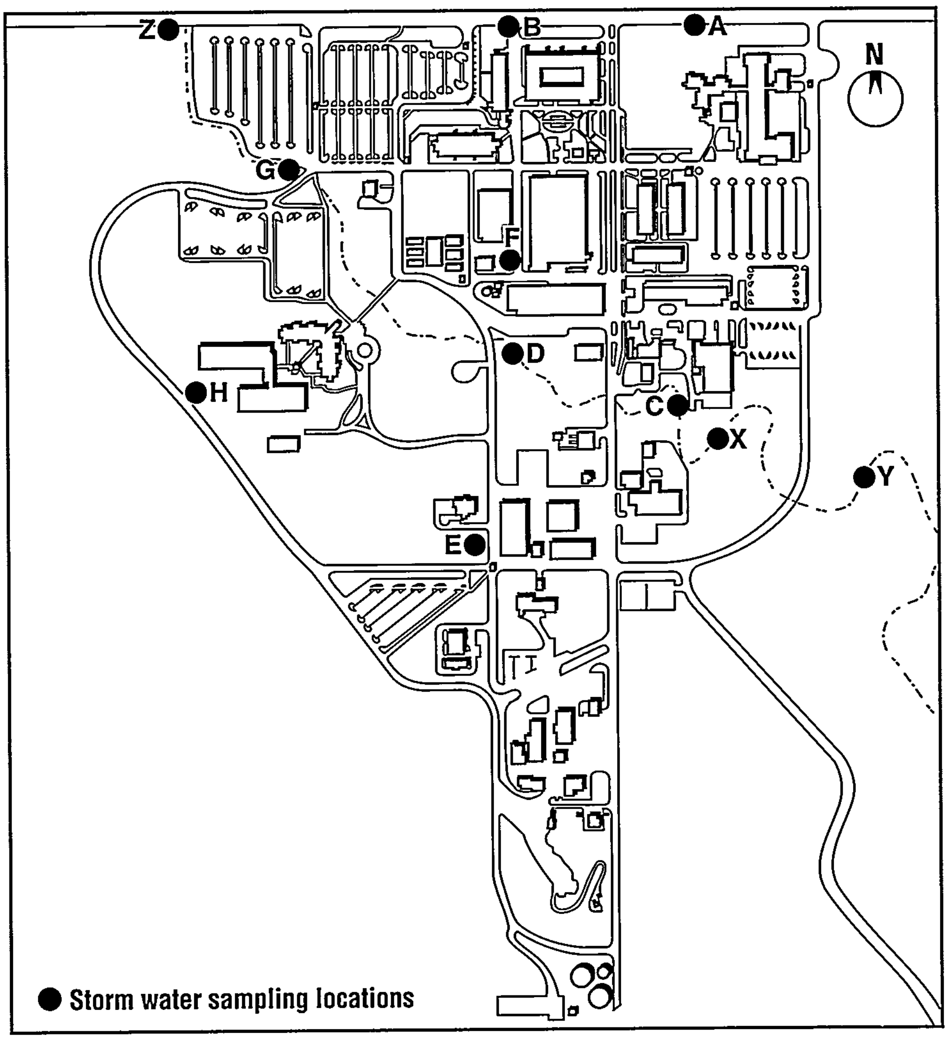


Figure 4-13. Storm water sampling locations on the SNL/California site.

- Location H—maintenance, materials handling and storage, and equipment storage in areas surrounding the west side of the Integrated Manufacturing Technologies Laboratory.
- Location X—area immediately surrounding the Tritium Research Laboratory.
- Location Y—Arroyo Seco entering the site.
- Location Z—Arroyo Seco exiting the site.

Methods

SNL/California collects samples during two storms that produce runoff sufficient to allow collection of storm water in sample bottles. Grab samples are collected at points in the storm water conveyance system that best represent certain drainage areas and activities. Storm water samples are collected and preserved in accordance with EPA standard methods, which are described in Title 40 CFR, Part 136.[8]

In 1994, storm water runoff was collected directly into sample bottles, when possible. Three of the sampling points are located along the Arroyo Seco, and access to the water sometimes is unsafe during storm conditions. If weather and slope conditions do not allow safe access to the arroyo, the water is collected from above the arroyo with a stainless steel bucket and then is transferred to the sample bottles. In addition to collecting the routine samples, SNL/California personnel conducted a pilot test to collect runoff in the arroyo using an automatic storm water sampler.

Analyses

A State-certified laboratory analyzes storm water samples for conductivity, pH, total suspended solids, and oil and grease, as required by SNL/California's storm water permit requirements. The laboratory also analyzes storm water samples for arsenic, cadmium, chromium, copper, lead, mercury, nickel, silver, zinc, pesticides, volatile organic compounds, semivolatile organic compounds, and tritium. These analyses provide baseline information about pollutants that are discharged with storm water.

Quality Assurance

SNL/California collects approximately 10% duplicate samples and soon will collect a field blank sample to assess potential contamination of future storm water samples. Duplicate and blank sample collection locations are randomly chosen and vary between storms.

Results

Regulatory agencies have not established effluent standards for storm water discharge. SNL/California uses sampling data to optimize storm water pollution prevention activities and to identify trends. Because the Storm Water Monitoring Program is only two years old, SNL/California does not have enough data at each sampling location to perform trend analyses or statistical comparisons between locations. The 1993 and 1994 data will provide a baseline, to which future samples will be compared.

SNL/California's 1994 storm water sampling results successfully identified site conditions and activities that impacted storm water quality. Table 4-17 contains the storm water runoff sampling data. Total suspended solids concentrations ranged from less than the detection limit to greater than 400 mg/L at Location X. Location X represents the area surrounding the Tritium Research Laboratory, which was being landscaped during the time of sampling. Specific conductivity concentrations ranged from 19 µmhos/cm at Location H to 130 µmhos/cm at Location G. Location G also had a high pH reading of 8.9. The high pH at Location G was traced to a concrete structure that was being built at the time of sampling. As a result, SNL/California is implementing best management practices to minimize the amount of pollutant exposure to storm water runoff from construction activities, vehicle and heavy equipment maintenance, materials handling, and building maintenance.

Location G also contained five organic compounds in concentrations ranging from 12 µg/L to 39 µg/L, which are greater than the analytical detection limit. Location C contained one pesticide and one organic compound in concentrations greater than the analytical detection limit (0.04 µg/L and 10 µg/L, respectively). Locations F and H contained one organic compound each in concentrations greater than the analytical detection limit (7 µg/L and 8 µg/L, respectively). Zinc concentrations are consistently greater than the analytical detection limit; they ranged from 0.01 mg/L to 0.46 mg/L (both of these samples were collected at Location H, as shown in Table 4-17). The rest of the metal concentrations were generally less than or equal to the analytical detection limit, except for 0.23 mg/L copper at Location A and 0.94 mg/L nickel at Location E. The organic compounds detected fall into the following categories:

- Phthalates—these chemicals are used in the manufacture of plastics, rubber goods (such as automobile tires) and many other goods; they are common and frequently are found in storm water runoff.
- Fluoranthene, phenanthrene, and pyrene—these chemicals are common constituents of gasoline and motor oil; they are common and frequently are found in storm water runoff from parking, vehicle maintenance, or fueling areas.
- Endrin—this chemical is a common pesticide.
- Trichloroethane—this chemical is used on site as a degreaser.

Monitoring data from sampling locations on site (Locations A–X) are used to determine how effectively best management practices minimize the amount of storm water exposed to pollutants. The storm water runoff at Location Z contained no detectable concentrations of any parameter for which SNL/California analyzed.

Because the storm water sampling program has only been in place for a short time, SNL/California has insufficient data to perform a formal Mann-Kendall trend test. When sufficient data are available, SNL/California will perform tests to denote trends.

Soil/Sediment

Soil is an integrating medium, which can concentrate contaminants released to the atmosphere. Sedimentary material from the arroyos is also an integrating medium, which may concentrate pollutants transported by storm water runoff.

Description

SNL/California collects soil samples from locations near the site perimeter and in the Livermore Valley. Any impacts due to site operations are assumed to be evident by greater concentrations in the near-field samples. Sandia collects arroyo sediments downstream of the site to assess any contamination by site operations.

Locations

Figure 4-14 shows the surface soil sampling locations. Locations VIS and TANK are considered near-field sampling locations. The rest are distant locations. Figure 4-15 shows the arroyo sediment near-field sampling location, ASS2. If air samplers are present, the surface soil samples are taken as closely as possible to these locations. Soil samples are taken from areas not shaded by trees or brush or areas that indicate evidence of human activity, such as construction or agriculture.

Methods

The annual soil and sediment samples are collected by taking cores approximately 10 cm in diameter and 5 cm deep. Five cores are collected from a 1 m^2 area and are composited to make a total

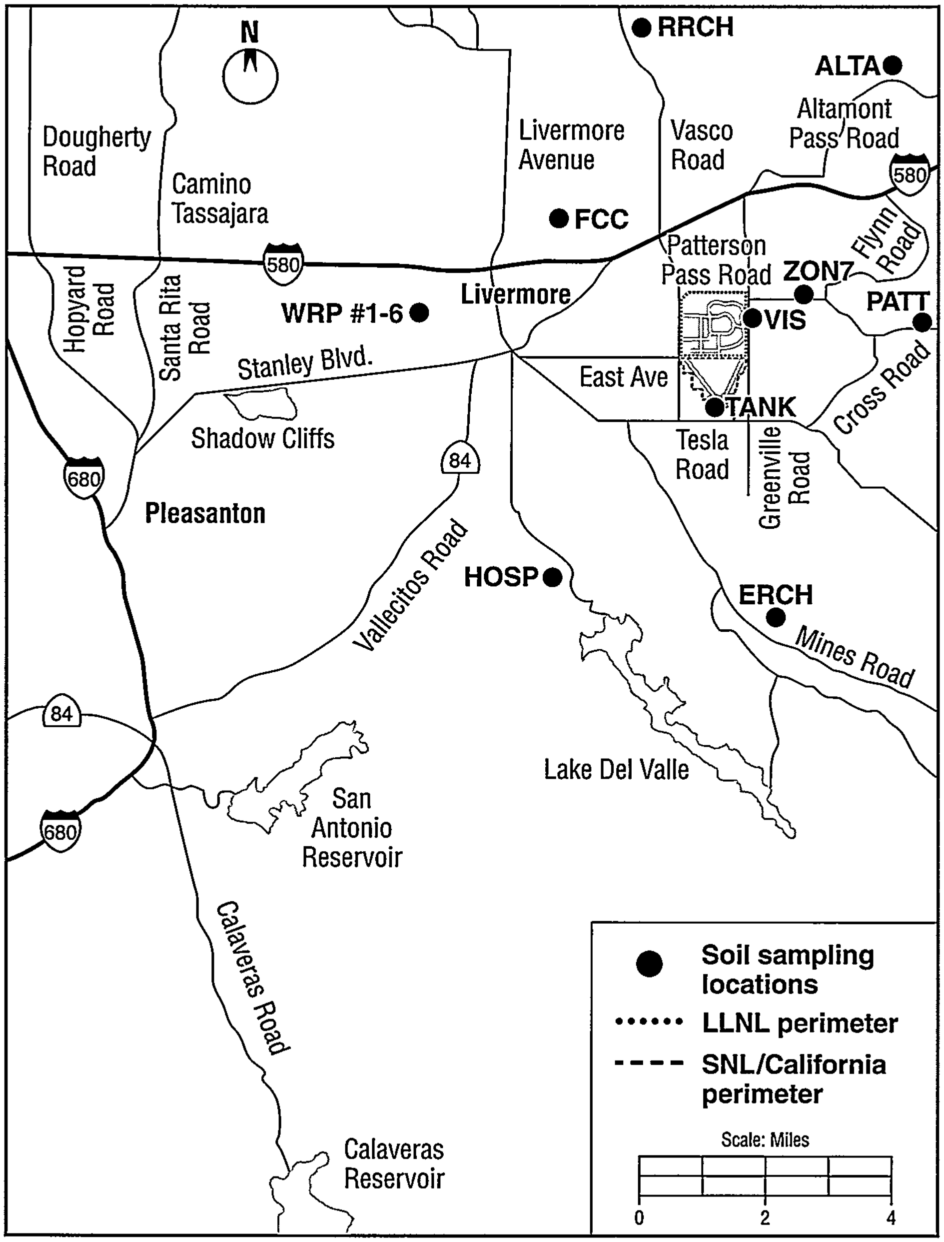


Figure 4-14. Soil sampling locations on the SNL/California site and in the Livermore Valley.

sample of approximately 1 kg. The soil then is delivered to LLNL's Nuclear Chemistry Laboratory, where it is ground and blended. Aliquots are taken for gamma spectroscopy and plutonium analysis. (SNL/California does not use plutonium; therefore, plutonium analyses are not included in this report.) The information of concern to SNL/California is the ^{238}U concentration, which is determined by gamma spectroscopy. Immediately after collection, sediments for tritium analysis are transferred to glass jars, which are then kept in an ice chest until they are delivered to the Nuclear Chemistry Laboratory, where they are frozen until analyzed.

Quality Assurance

Duplicate soil and sediment samples are taken at 10% of the soil sampling sites, chosen at random. These locations are chosen from all the locations sampled by LLNL, and thus may not include duplicates taken from a location near SNL/California.

The DOE Environmental Monitoring Laboratory's interlaboratory comparison soil samples are analyzed twice a year for uranium by LLNL's Nuclear Chemistry Division. The Nuclear Chemistry Division also analyzes reagent-grade sand as blank samples. Results from the analysis of quality control samples are presented and discussed in Chapter 8, "Quality Assurance."

Results

Table 4-18 contains the data for radionuclide concentrations in soil and arroyo sediment samples. Levels of all radionuclides in perimeter samples are similar to those found in off-site samples, indicating no adverse impact due to SNL/California operations.

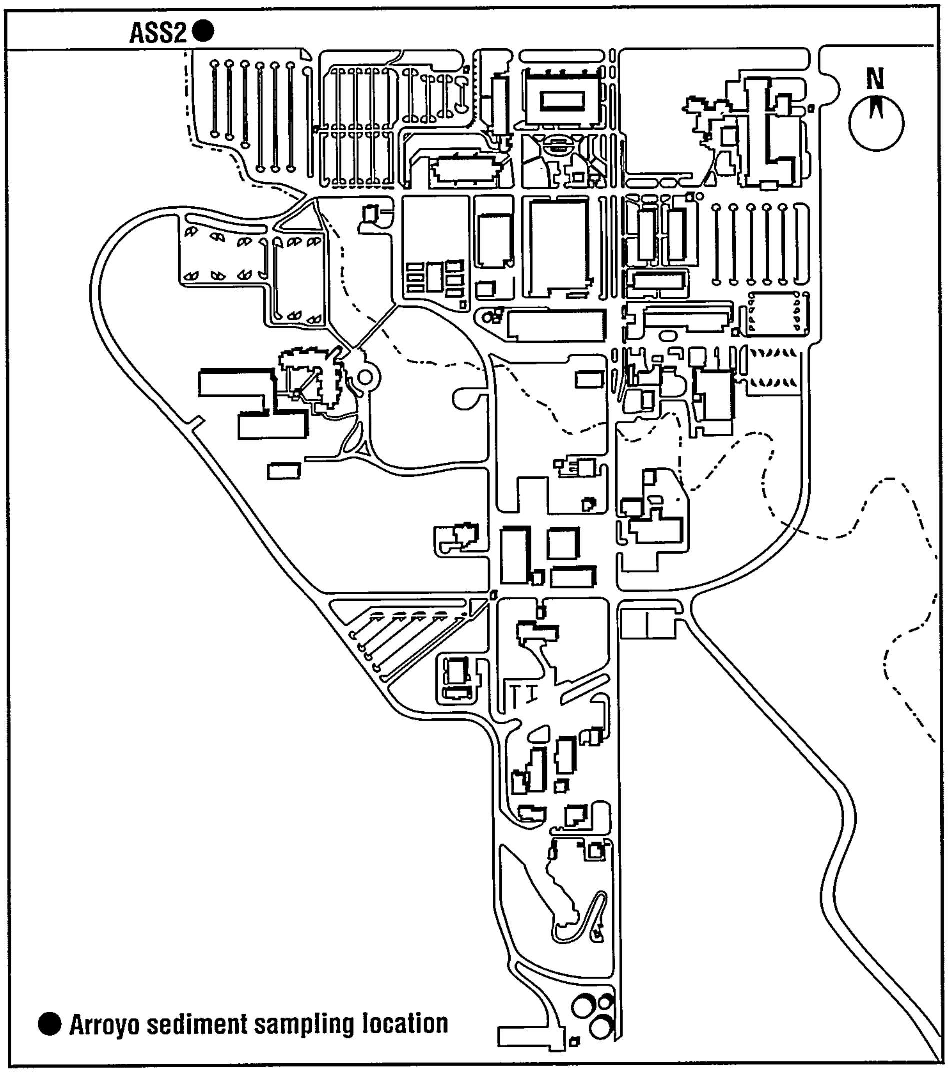


Figure 4-15. Arroyo sediment sampling location on the SNL/California site perimeter.

Vegetation and Foodstuff

Agricultural products can accumulate radionuclides and provide a transport pathway for human ingestion. Vegetation may become tainted with pollutants by direct deposition from the air onto the plants, or by uptake through the roots. The public may also be exposed to pollutants through the consumption of meat from animals fed on contaminated vegetation.

Description

The only agricultural products produced in appreciable quantities near SNL/California are wine and beef. SNL/California samples wine, rather than grapes, to assess the dose to the public at the time of consumption. Wines from nearby vineyards and those in other parts of California are sampled to assess the impact of site operations. Grasses and weeds are sampled due to the lack of production in the area of significant quantities of grains or vegetables. SNL/California does not sample beef because obtaining locally produced beef samples is difficult.

Locations

Figure 4-16 shows the sampling locations for vegetation. Locations AQUE, ZON7, VIS, MET, RAIL, MESQ, and TESW are near-field. Locations FCC, I580, MOD, DAN, PARK, CAL, and PATT are distant. All the Livermore Valley wine locations are considered near-field.

Methods

Vegetation samples consist of grasses or weeds that are green at the time of sampling. They are intended to represent forage for animals in the region. Vegetation samples are collected quarterly. They are put in plastic bags and kept in an ice chest until they are delivered to LLNL's Nuclear Chemistry Laboratory, where they are kept frozen until analyzed.

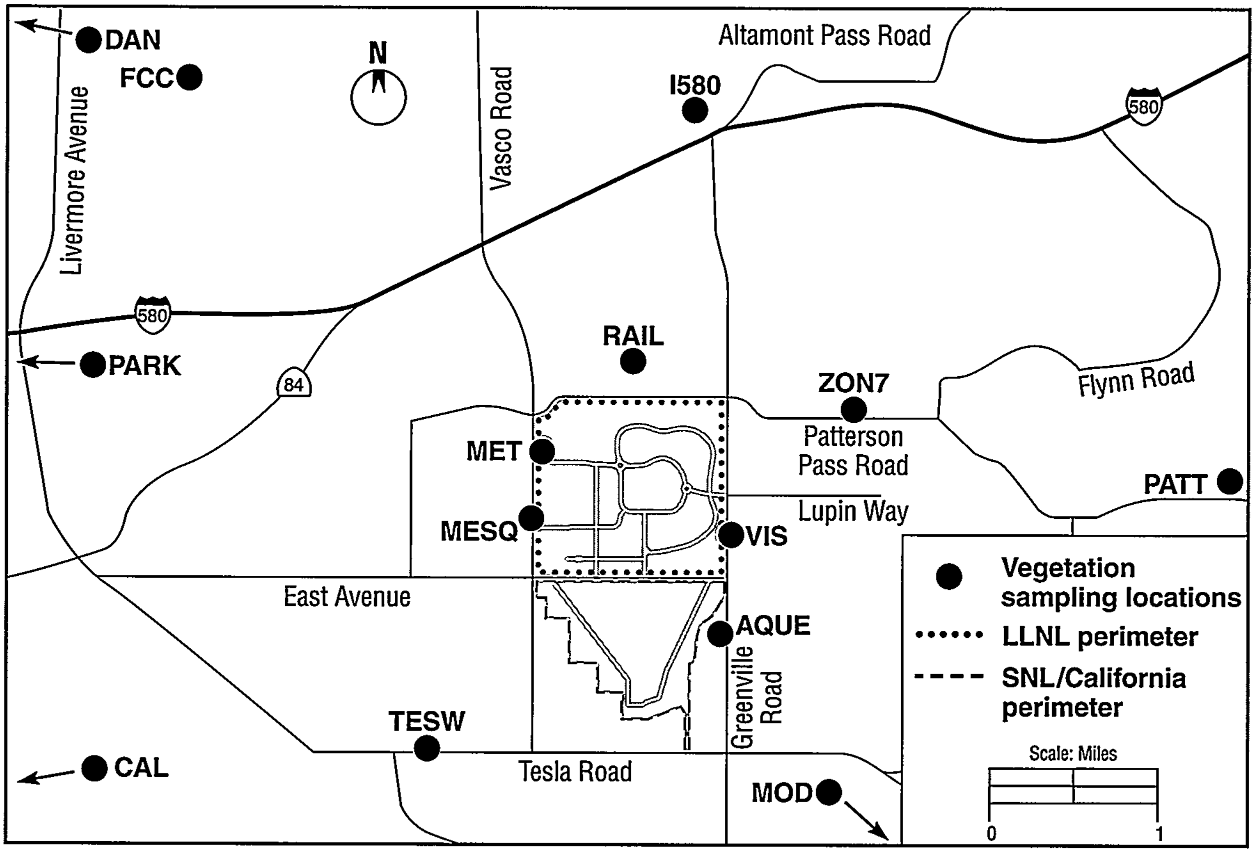


Figure 4-16. Vegetation sampling locations on the SNL/California site perimeter and in the Livermore Valley.

Wine samples are collected annually from local producers. They represent the most recent vintage available for any particular variety; therefore, each year's collection represents a number of vintage years. All samples are analyzed for tritium content. To prevent contamination, wine samples are stored in an argon atmosphere after the original sample containers have been opened.

Quality Assurance

Duplicate samples are collected for approximately 10% of the sampling locations, chosen at random. Wine samples are collected from a number of other California wine producers for comparison. No reference-standard samples for tritium in vegetation or foodstuffs are currently available. Results from the analysis of quality control samples are presented and discussed in Chapter 8, "Quality Assurance."

Results

Table 4-19 contains the tritium data for vegetation collected in 1994. The tritium concentrations remained low, following an initial drop in 1992 from historically higher values. Historical data are shown in Fig. 4-17, which plots the highest annual average tritium concentration in vegetation.

Locations AQUE and VIS show the highest concentrations of tritium. A statistical comparison shows that these locations are significantly higher than the distant locations at a 95% confidence level. Statistical comparisons also show that the perimeter locations were significantly higher than the distant locations (with the exceptions of locations PATT and I580) at a 90% confidence level.

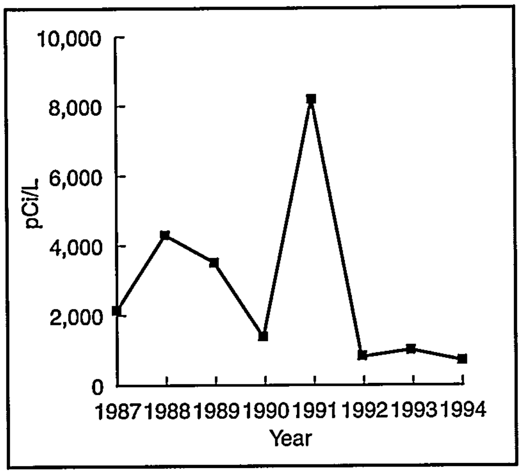


Figure 4-17. Highest annual average tritium concentrations in vegetation (1987–94).

These comparisons indicate that tritium concentrations at or near the SNL/California and LLNL site perimeters are statistically higher than locations more representative of the Livermore Valley; however, the measured values still are quite low. The higher concentrations can be attributed to site operations. The highest concentrations seen in 1994 are lower than those seen in 1993. This drop probably can be attributed to the decrease in tritium inventories (and emissions) at SNL/California and LLNL.

Table 4-20 presents the data for retail wines purchased in 1994. The wines represent several vintage years, and thus are not intended to represent the tritium releases in 1994, but rather to provide an index of public exposure. Both the Livermore Valley wines and the other California wines analyzed showed a decrease in tritium content. Because these wines represent several vintages, the change in tritium content may be a statistical fluctuation or may be due to the wines chosen for sampling.

A statistical comparison of the tritium concentrations in the two types of wines sampled shows that the tritium concentrations in Livermore Valley wines are statistically higher than in the other California wines (at a 95% confidence level).

The levels of tritium observed in foodstuffs produced in the Livermore Valley do not pose a health concern at any consumption rate. No specific safety standards exist for tritium in vegetation or wine. However, the effective dose equivalent was calculated for vegetation (the medium for which a consumption estimate is available). The highest dose calculated was 1.2×10^{-2} mrem, which is 0.012% of the DOE maximum permissible dose to a member of the public.

External Radiation

One of the exposure pathways for population groups living near DOE facilities is external radiation. The only source of external radiation at the SNL/California site is large isotopic radiation sources used for industrial radiography.

Description

Thermoluminescent dosimeters are used to measure the dose rates near SNL/California. Dosimeters are placed at the site perimeter and at more distant locations near the Livermore site. If site operations were contributing significantly to the external radiation dose, the dosimeters at the site perimeter would show a higher dose than those at more distant locations.

Locations

Figure 4-18 shows the locations of the dosimeters at the SNL/California site (near-field). Figure 4-19 shows off-site dosimeter locations (distant).

Methods

LLNL's Environmental Monitoring Group collects the site perimeter and off-site dosimeters quarterly. LLNL's Hazards Control Department processes them. The dosimeters are contained in mylar bags while in the field. The sampling locations have been chosen (per U.S. Nuclear Regulatory Commission)[9] to avoid interference from large objects in the vicinity. LLNL uses Panasonic UD814 dosimeters. Each one contains three elements of thallium-activated calcium sulfate and one

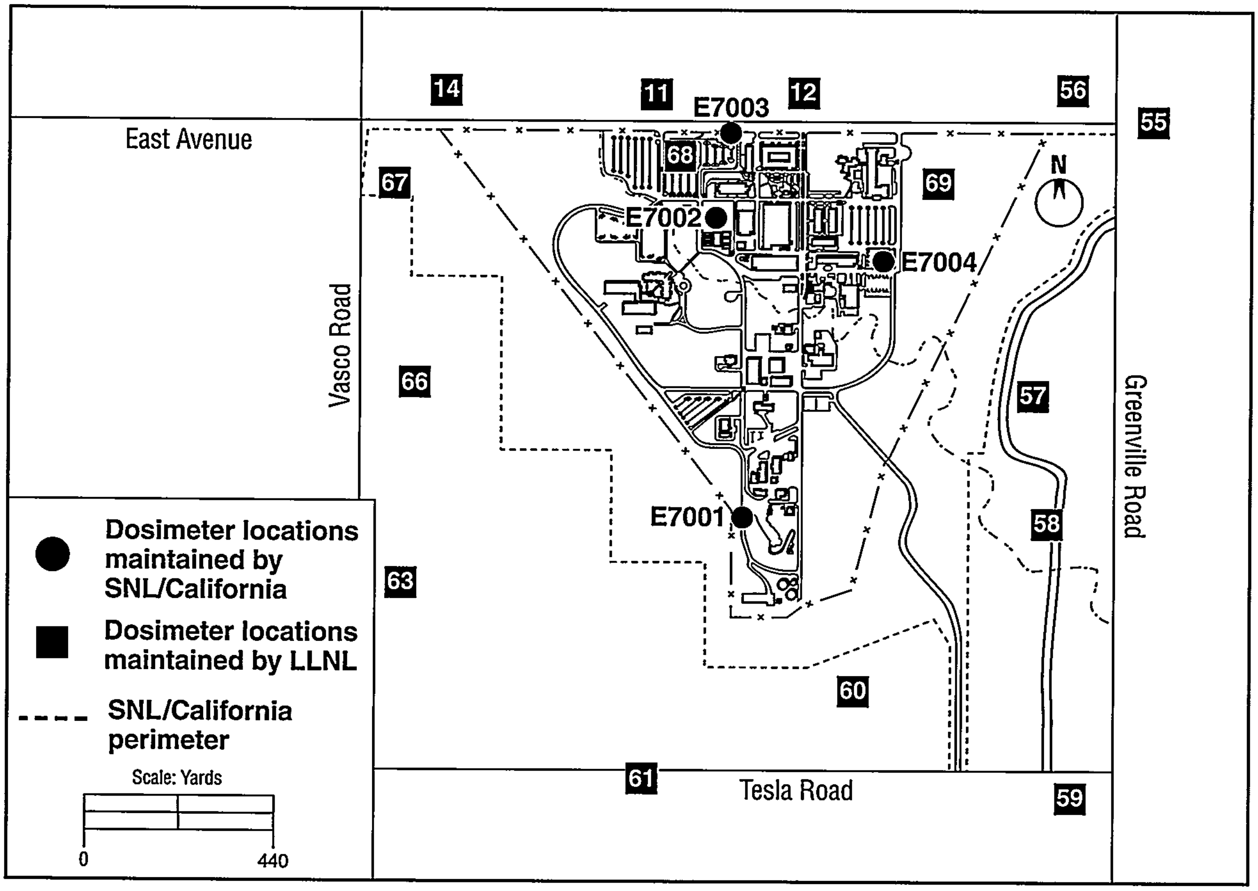


Figure 4-18. Dosimeter locations on the SNL/California site and around the site perimeter.

element of lithium borate.

SNL/California uses Harshaw lithium-fluoride, high sensitivity ribbon dosimeters. SNL/California Environmental Protection Department personnel collect the four on-site dosimeters and send them to SNL/New Mexico for analysis.

Quality Assurance

To be acceptable for placement in the field, all phosphors of the dosimeters must be accurate to ±5% upon calibration. Dosimeters with a known exposure are introduced as blind samples in the processing of the field dosimeters. These are equivalent to spiked pseudo samples for the purposes of establishing the accuracy of the system. Duplicate dosimeter packets are placed at random locations and analyzed along with the routine dosimeters. The dosimeters are calibrated by using a source that is traceable to the National Institute of Standards and Technology. The California Department of Health Services also co-locates dosimeters at some of the monitoring stations to serve as an independent cross check. Exposures to the dosimeters during collection and transit are determined by the use of unexposed dosimeters (referred to as "transit controls"). These are taken on the collection route, carried with field dosimeters during transit to the laboratory, and then read for accumulated dose.

Results

Table 4-21 presents the external radiation data for SNL/California site perimeter monitoring. The annual average external dose at the perimeter was 68.4 mrem (0.68 mSv). Table 4-22 presents the

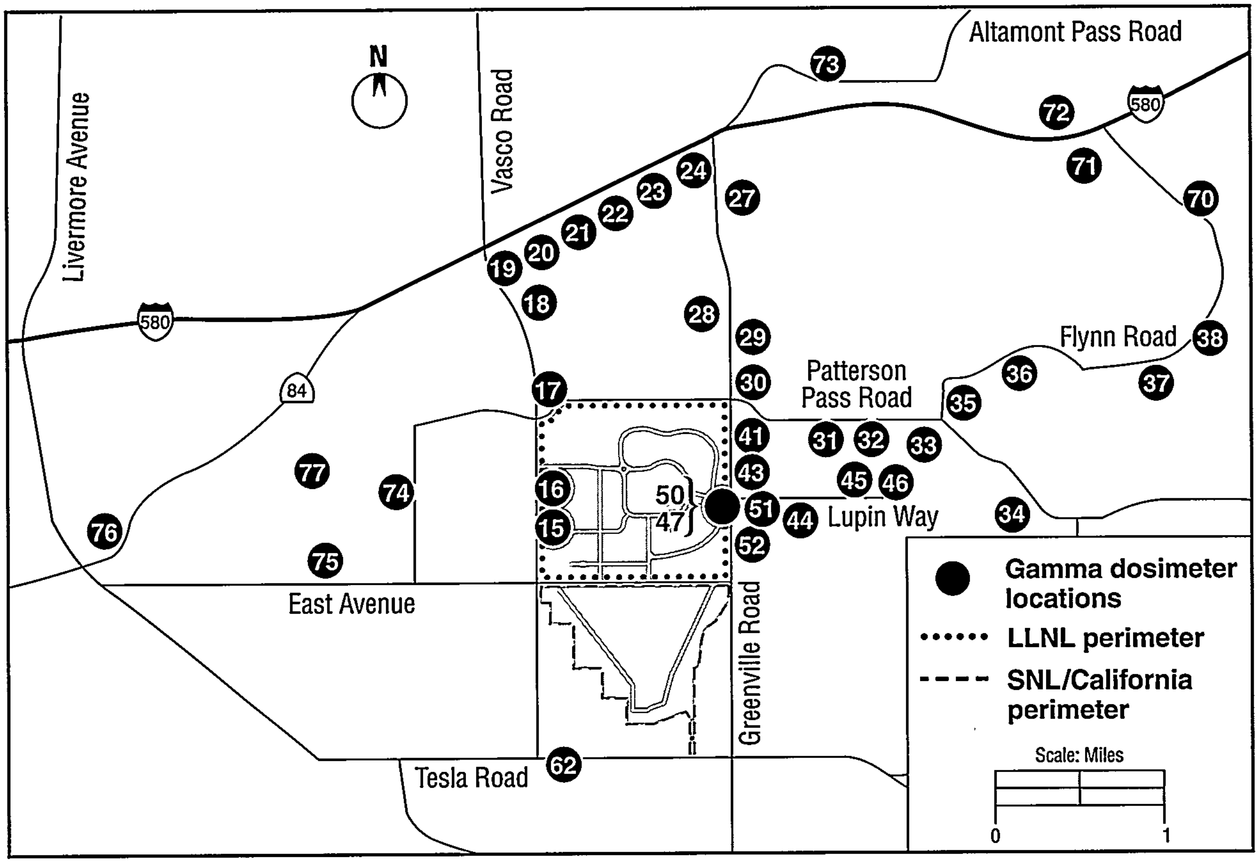


Figure 4-19. Dosimeter locations in the Livermore Valley.

external radiation monitoring data for Livermore Valley locations. The annual average external dose measured for the Livermore Valley locations was 73.2 mrem (0.73 mSv). If operations at SNL/California were producing excess external radiation, the perimeter (near-field) monitoring would show a higher dose than the more distant Livermore Valley monitoring. A Student's t-test comparing the dose at the SNL/California site perimeter and the Livermore Valley showed the dose at the site perimeter to be lower than the dose in the Livermore Valley at a 95% confidence interval. This difference probably is due to variations in the local geology.

SNL/California performed a Mann-Kendall trend test on annual average perimeter doses and valley doses for the years 1989 to 1994. The test showed no significant trends at the 90% confidence level.

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2. U.S. DOE, Order 5400.5, *Radiation Protection of the Public and the Environment* (March 1988).

3. U.S. EPA, Title 40 CFR, Part 403, *Federal Wastewater Pretreatment Standards* (July 1983).

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5. U.S. DOE, Sandia National Laboratories/California, *Categorical Process Report* (January 1995).

6. U.S. DOE, Sandia National Laboratories/California, *Wastewater Discharge Compliance Report* (monthly).

7. R. J. Harrach et al., *Environmental Report* for 1994, Lawrence Livermore National Laboratory, UCRL50027-94 (1995).

8. U.S. EPA, Title 40 CFR, Part 136, *Guidelines Establishing Test Procedures for the Analysis of Pollutants* (1992, latest revision).

9. U.S. Nuclear Regulatory Commission, Regulatory Guide 4.13, *Performance Testing and Process Specifications for Thermoluminescent Dosimetry, Environmental Applications,* Revision 1 (July 1977).

Table 4-1. Environmental Sampling Program Overview.

Medium	No. of Locations[a]	Parameters	Frequency	Requiring Authority	Authority Reported to
Air particulates	17	gross alpha, gross beta, uranium	weekly, monthly	DOE Order 5400.1	DOE
Air tritium	17	tritium	biweekly	DOE Order 5400.1	DOE
Soil	15	uranium, tritium, metals, solvents, pesticides	annually	DOE Order 5400.1	DOE
Groundwater	22	volatile and semivolatile organics, metals, general minerals, diesel, tritium, radium, and uranium	quarterly	RWQCB[b]	RWQCB
Surface water	12	gross alpha, gross beta, tritium	quarterly	DOE Order 5400.1	DOE
Sewer outfall	1	metals, cyanide, BOD, COD, oil and grease, TDS, TSS, pH, tritium, conductivity, pesticides, volatile and semi-volatile organics[c]	sampled continuously or grab; analyzed weekly or monthly	City of Livermore DOE Order 5400.1	City of Livermore, DOE
Stacks	1	tritium	sampled continuously, analyzed weekly	DOE Order 5400.1 Clean Air Act NESHAPs	DOE, EPA
Vegetation and foodstuff	32	tritium	quarterly, monthly	DOE Order 5400.1	DOE
Storm water	10	conductivity, pH, TSS, oil and grease, metals, pesticides, volatile and semivolatile organics, tritium	two storms per sampling location	City of Livermore Municipal Code, Ch. 13.45, DOE Order 5400.1	SWRCB[d] RWQCB, City of Livermore,
External radiation	58	radiation dose	quarterly	DOE Order 5400.1	DOE

[a]These numbers represent all the samples collected by LLNL and SNL/California. Not all the LLNL samples are pertinent to SNL/California; therefore, the number of locations listed in the following tables may differ from these values.
[b]Regional Water Quality Control Board.
[c]BOD = biological oxygen demand, COD = chemical oxygen demand, TDS = total dissolved solids, TSS = total suspended solids.
[d]State Water Resources Control Board.

Table 4-2. LECS Wastewater Analyses.

LECS	Analyses
B. 906	pH, As, Cd, Cr, Cu, Pb, Hg, Ni, Ag, Zn
B. 910	pH, As, Cd, Cr, Cu, Pb, Hg, Ni, Ag, Zn
B. 913	pH, As, Cd, Cr, Cu, Pb, Hg, Ni, Ag, Zn
B. 941	pH, As, Cd, Cr, Cu, Pb, Hg, Ni, Ag, Zn
B. 961	pH, As, Cd, Cr, Cu, Pb, Hg, Ni, Ag, Zn, ^{3}H, ^{238}U
B. 968	pH, ^{3}H

Table 4-3. Semiannual Monitoring Data for the SNL/California Categorical Processes.

Physical and Chemical Parameters	Regulatory Limit[a]	Printed Wiring Lab		Electroplating Lab	
		Dec.–May	June–Nov.	Dec.–May	June–Nov.
Physical Parameters					
Conductivity (μmhos/cm)	N/A	210	94	8300	6800
pH (standard units)	N/A	6.8	7.0	8.0	7.3
Total dissolved solids (mg/L)	N/A	110	<10	5200	5000
Total suspended solids (mg/L)	N/A	<10	<10	50	20
Chemical Parameters (mg/L)					
Biochemical oxygen demand	N/A	13	14	72	21
Chemical oxygen demand	N/A	21	13	430	260
Oil and grease	N/A	<5	<5	<5	5
Arsenic	N/A	<0.005	<0.005	0.010	<0.05
Cyanide	0.65	<0.01	<0.01	0.11	<0.01
Cadmium	0.26	<0.005	<0.005	0.016	0.005
Chromium	1.71	0.23	0.29	0.22	0.58
Copper	2.07	0.12	0.06	1.5	1.7
Lead	0.43	<0.05	<0.05	0.10	<0.05
Mercury	N/A	<0.0005	<0.0005	<0.0005	<0.0005
Nickel	2.38	0.06	0.10	5.0[b]	0.46
Silver	0.24	<0.01	<0.01	<0.01	<0.01
Zinc	1.48	<0.01	<0.01	1.3	0.77
Positively Detected Organic Compounds (μg/L)[c]					
Bis(2-ethylhexyl)phthalate	N/A[d]	<10	<10	110	80
Diethylphthalate	N/A[d]	<5	<5	<5	11
Chloroform	N/A[d]	6	<5	<5	<5

[a]Monthly average limits.

[b]This result exceeds the discharge limit of 2.38 mg/L. The total volume of wastewater discharged in the batch was less than 500 gallons. See page 4-3 for discussion of this result.

[c]Samples also were analyzed for priority pollutants, according to the following EPA methods: 624 (purgeable pollutants), 625 (extractable pollutants), and 608 (organochlorine compounds). Only the compounds that were measured above the analytical detection limit are reported in this table. All other compounds were below detection limits. All the data are reported in the semiannual *Categorical Process Report* for SNL/California.

[d]Organic compounds are regulated as total toxic organics. The limit for total toxic organics is 2130 μg/L.

Table 4-4. Weekly Metals Monitoring Data for the SNL/California Sanitary Sewer Outfall.[a]

	As	Cd	Cr	Cu	Pb	Hg	Ni	Ag	Zn
Date					(mg/L)				
Jan. 3	<0.005	<0.005	<0.01	0.04	<0.05	<0.0005	<0.02	<0.01	0.17
Jan. 10	<0.005	<0.005	<0.01	0.05	<0.05	<0.0005	<0.02	<0.01	0.15
Jan. 17	<0.005	<0.005	<0.01	0.10	<0.05	0.0007	<0.02	<0.01	0.35
Jan. 24	<0.005	<0.005	<0.01	0.15	<0.05	<0.0005	<0.02	0.10	0.34
Jan. 31	<0.005	0.007	0.02	0.11	<0.05	0.0010	<0.02	0.03	0.38
Feb. 7	<0.005	<0.005	0.21	0.11	<0.05	0.0009	<0.02	0.02	0.46
Feb. 14	<0.005	<0.005	<0.01	<0.01	<0.05	<0.0005	<0.02	<0.01	0.09
Feb. 21	<0.005	<0.005	<0.01	0.07	<0.05	<0.0005	<0.02	<0.01	0.29
Feb. 28	<0.005	0.011	0.04	0.17	<0.05	0.0009	<0.02	<0.03	0.77
Mar. 7	<0.005	0.007	0.05	<0.10	<0.05	<0.0005	0.03	0.02	0.85
Mar. 14	0.006	<0.005	0.01	0.05	<0.05	<0.0005	<0.02	<0.01	0.31
Mar. 21	<0.005	<0.005	0.01	0.06	<0.05	<0.0005	<0.02	<0.01	0.19
Mar. 28	<0.005	<0.005	<0.01	0.08	<0.05	<0.0005	<0.02	<0.01	0.32
Apr. 4	<0.005	<0.005	<0.01	0.05	<0.05	<0.0005	<0.02	<0.01	0.20
Apr. 11	<0.005	<0.005	<0.01	0.07	<0.05	<0.0005	<0.02	<0.01	0.31
Apr. 18	<0.005	0.008	<0.01	0.06	<0.05	<0.0005	<0.02	<0.01	0.21
Apr. 25	<0.005	<0.005	<0.01	0.05	<0.05	<0.0005	<0.02	<0.01	0.25
May 2	<0.005	<0.005	0.05	0.06	<0.05	<0.0005	0.03	<0.01	0.22
May 9	<0.005	0.006	<0.01	0.06	<0.05	<0.0005	<0.02	<0.01	0.59
May 16	<0.005	<0.005	<0.01	0.07	<0.05	<0.0005	<0.02	<0.01	0.25
May 23	<0.005	<0.005	<0.01	0.05	<0.05	0.0020	<0.02	<0.01	0.17
May 31	<0.005	<0.005	<0.01	0.06	<0.05	<0.0005	<0.02	<0.01	0.25
June 6	<0.005	<0.005	<0.01	0.06	<0.05	<0.0005	<0.02	<0.01	0.21
June 13	<0.005	<0.005	0.06	0.17	<0.05	0.0070	0.05	0.03	0.55
June 21	<0.005	<0.005	<0.01	0.09	<0.05	0.0006	<0.02	<0.01	0.26
June 27	<0.005	<0.005	<0.01	0.07	<0.05	<0.0005	<0.02	<0.01	0.28
July 5	<0.005	<0.005	<0.01	0.07	<0.05	<0.0005	<0.02	<0.01	0.26
July 11	<0.005	<0.005	<0.01	0.10	<0.05	<0.0005	<0.02	<0.01	0.31
July 18	<0.005	<0.005	<0.01	0.13	<0.05	<0.0005	<0.02	<0.01	0.45
July 25	<0.005	<0.005	<0.01	0.08	<0.05	<0.0005	<0.02	<0.01	0.50

Continued

Table 4-4. Weekly Metals Monitoring Data for the SNL/California Sanitary Sewer Outfall (concluded).

Date	As	Cd	Cr	Cu	Pb	Hg	Ni	Ag	Zn
					(mg/L)				
Aug. 1	<0.005	<0.005	<0.01	0.07	<0.05	<0.0005	<0.02	<0.01	0.53
Aug. 8	<0.005	<0.005	0.01	0.07	<0.05	<0.0050	<0.02	<0.01	0.27
Aug. 15	<0.005	<0.005	<0.01	0.08	<0.05	<0.0005	<0.02	<0.01	0.26
Aug. 22	<0.005	<0.005	0.08	0.13	<0.05	<0.0005	0.05	0.01	0.46
Aug. 29	<0.005	<0.005	<0.01	0.08	<0.05	<0.0005	<0.02	<0.01	0.43
Sept. 6	<0.005	<0.005	0.01	0.06	<0.05	<0.0005	<0.02	<0.01	0.15
Sept. 12	<0.005	<0.005	<0.01	0.09	<0.05	<0.0005	<0.02	<0.01	0.27
Sept. 19	<0.005	<0.005	0.10	0.14	<0.05	<0.0005	<0.02	0.02	0.49
Sept. 26	<0.005	<0.005	<0.01	0.17	<0.05	<0.0005	<0.02	<0.01	0.97
Oct. 3	<0.005	<0.005	0.23	0.14	<0.05	<0.0005	0.08	<0.01	0.56
Oct. 10	<0.005	<0.005	<0.01	0.12	<0.05	<0.0005	<0.02	<0.01	0.60
Oct. 17	<0.005	<0.005	<0.01	0.12	<0.05	<0.0005	<0.02	<0.01	0.32
Oct. 24	<0.005	<0.005	0.05	0.31[b]	<0.05	0.0030	<0.02	0.04	1.10[b]
Oct. 31	<0.005	<0.005	<0.01	0.15	<0.05	<0.0005	<0.02	<0.01	0.64
Nov. 7	<0.005	<0.005	0.06	0.13	<0.05	<0.0005	<0.02	<0.01	0.46
Nov. 14	<0.005	<0.005	<0.01	0.09	<0.05	<0.0005	<0.02	0.02	0.26
Nov. 21	<0.005	<0.005	<0.01	0.07	<0.05	<0.0005	<0.02	<0.01	0.19
Nov. 28	<0.005	<0.005	<0.01	0.12	<0.05	<0.0005	<0.02	<0.01	0.35
Dec. 5	<0.005	<0.005	0.03	0.09	<0.05	<0.0005	<0.02	<0.01	0.34
Dec. 12	<0.005	0.006	0.01	0.19	<0.05	<0.0005	<0.02	0.02	0.65
Dec. 19	<0.005	<0.005	<0.01	0.07	<0.05	<0.0005	<0.02	<0.01	0.62
Median	**<0.005**	**<0.005**	**0.01**	**0.096[c] (0.092)**	**<0.05**	**<0.0005**	**<0.02**	**<0.01**	**0.38[c] (0.37)**
MAD (%)	**2.8**	**20**	**0**	**139[d] (132)**	**0**	**0**	**0**	**0**	**58[d] (47)**
Limit[e]	**0.06**	**0.14**	**0.62**	**1.0**	**0.2**	**0.01**	**0.61**	**0.2**	**3.0**

[a]Samples are collected as a weekly composite.
[b]Outlier.
[c]Average—results include the outliers; results in parentheses do not include the outliers.
[d]Standard deviation from the mean—results include the outliers; results in parentheses do not include the outliers.
[e]Discharge concentration limits, City of Livermore Municipal Code 13.32.

Table 4-5. Weekly Physical Monitoring Data for the SNL/California Sanitary Sewer Outfall.

Date	CN[a]	BOD[b]	COD[b]	O&G[a]	TDS[b]	TSS[b]	pH[a]	^3H[b]
	(mg/L)						(pH units)	(µCi/mL)
Jan. 3	<0.01	83	700	26	370	60	8.1	$<2.61 \times 10^{-5}$
Jan. 10	<0.01	25	99	37	130	20	8.9	$<1.11 \times 10^{-5}$
Jan. 17	<0.01	190	1300[c]	45	230	340	8.3	$<1.69 \times 10^{-5}$
Jan. 24	<0.01	550	640	46	310	370	8.7	$<1.12 \times 10^{-5}$
Jan. 31	<0.01	130	670	27	230	150	8.0	$<1.18 \times 10^{-5}$
Feb. 7	<0.01	400	350	91[c]	260	430	8.3	$<1.21 \times 10^{-5}$
Feb. 14	<0.01	350	600	19	250	180	7.7	$<1.28 \times 10^{-5}$
Feb. 21	<0.01	150	410	43	270	670	7.0	$<1.26 \times 10^{-5}$
Feb. 28	<0.01	410	590	110[c,d]	290	280	8.2	$<1.22 \times 10^{-5}$
Mar. 7	<0.01	650	1110[c]	34	480[c,e]	550	8.3	$<1.27 \times 10^{-5}$
Mar. 14	<0.01	120	260	28	320	150	7.8	$<8.34 \times 10^{-5}$
Mar. 21	<0.01	130	280	24	260	130	8.2	$<1.31 \times 10^{-5}$
Mar. 28	<0.01	52	210	31	180	460	7.8	$<1.32 \times 10^{-5}$
Apr. 4	<0.01	160	83	15	190	80	8.7	$<1.31 \times 10^{-5}$
Apr. 11	<0.01	69	96	30	180	220	8.5	$<1.29 \times 10^{-5}$
Apr. 18	<0.01	240	67	31	130	120	8.2	$<1.33 \times 10^{-5}$
Apr. 25	<0.01	150	210	27	170	110	7.3	$<1.33 \times 10^{-5}$
May 2	<0.01	160	23	8	140	150	8.1	$<1.31 \times 10^{-5}$
May 9	<0.01	200	410	39	370	470	8.1	$<1.30 \times 10^{-5}$
May 16	—[f]	550	290	29	290	180	7.7	$<1.36 \times 10^{-5}$
May 23	<0.01	280	180	50	170	80	6.4[c]	$<9.48 \times 10^{-5}$
May 31	<0.01	340	120	26	190	340	8.1	$<9.11 \times 10^{-5}$
June 6	<0.01	430	1200[c]	22	340	140	8.0	$<1.27 \times 10^{-5}$
June 13	<0.01	130	220	37	190	300	8.9	$<1.18 \times 10^{-5}$
June 21	<0.01	640	240	15	200	190	8.4	$<1.18 \times 10^{-5}$
June 27	<0.01	130	270	42	200	120	8.0	$<1.23 \times 10^{-5}$
July 05	<0.01	170	200	27	300	110	7.3	$<1.23 \times 10^{-5}$
July 11	<0.01	130	170	20	240	100	8.1	$<1.18 \times 10^{-5}$
July 18	<0.01	230	200	24	200	260	8.1	$<1.33 \times 10^{-5}$
July 25	<0.01	130	130	17	220	90	7.0	$<2.01 \times 10^{-5}$

Continued

Table 4-5. Weekly Physical Monitoring Data for the SNL/California Sanitary Sewer Outfall (concluded).

Date	CN[a] (mg/L)	BOD[b] (mg/L)	COD[b] (mg/L)	O&G[a] (mg/L)	TDS[b] (mg/L)	TSS[b] (mg/L)	pH[a] (pH units)	^3H[b] (µCi/mL)
Aug. 1	<0.01	120	91	16	180	70	7.6	$<2.03 \times 10^{-5}$
Aug. 8	<0.01	130	200	15	160	100	7.2	$<1.42 \times 10^{-4}$
Aug. 15	<0.01	180	200	39	230	110	8.3	$<1.36 \times 10^{-4}$
Aug. 22	<0.01	210	260	21	190	240	8.0	$<2.00 \times 10^{-5}$
Aug. 29	<0.01	120	490	20	220	120	7.1	$<1.37 \times 10^{-4}$
Sept. 6	<0.01	–[f]	110	28	180	50	8.6	$<2.03 \times 10^{-5}$
Sept. 12	<0.01	96	280	35	180	170	8.7	$<1.38 \times 10^{-4}$
Sept. 19	<0.01	380	1200[c]	36	200	350	8.5	$<1.38 \times 10^{-4}$
Sept. 26	<0.01	1050[c]	270	26	190	400	7.6	$<3.32 \times 10^{-5}$
Oct. 3	<0.01	–[f]	180	45	280	490	–[g]	$<3.32 \times 10^{-5}$
Oct. 10	<0.01	66	480	29	280	380	–[g]	$<3.32 \times 10^{-5}$
Oct. 17	<0.01	135	120	38	220	130	–[g]	$<2.09 \times 10^{-5}$
Oct. 24	<0.01	600	330	26	250	1100[c]	–[g]	$<2.09 \times 10^{-5}$
Oct. 31	<0.01	410	440	20	160	750[c]	–[g]	$<1.43 \times 10^{-4}$
Nov. 7	<0.01	460	120	36	210	180	–[g]	$<1.41 \times 10^{-5}$
Nov. 14	<0.01	259	100	20	160	120	–[g]	$<2.21 \times 10^{-5}$
Nov. 21	<0.01	208	96	22	140	120	–[g]	$<1.37 \times 10^{-4}$
Nov. 28	<0.01	218	130	59	180	320	–[g]	$<1.37 \times 10^{-4}$
Dec. 5	<0.01	160	120	25	260	140	–[g]	$<2.36 \times 10^{-6}$
Dec. 12	<0.01	305	270	17	240	260	–[g]	$<1.23 \times 10^{-5}$
Dec. 19	0.02	450	190	26	200	360	–[g]	7.32×10^{-6}
Average[h]	**<0.01[i]**	**269 (254)**	**335 (284)**	**32 (29)**	**226 (223)**	**255 (230)**	**8.0 (8.0)**	**<1.33[i] $\times 10^{-5}$**
SDM (%)	**0[j]**	**1.7 (1.7)**	**1.6 (1.6)**	**5 (4)**	**0.7 (0.6)**	**1.8 (1.8)**	**1.8 (0.2)**	**27[j]**
Limit[k]	**0.04**	**–[l]**	**–[l]**	**100**	**325[m]**	**–[l]**	**6 < pH < 9**	**0.01[n]**

[a]Grab sample.
[b]Weekly composite sample.
[c]Outlier.
[d]This concentration slightly exceeds the outfall limit of 100 mg/L. See page 4-4.
[e]This concentration exceeds the discharge limit of 325 mg/L (incremental). See page 4-5.
[f]Data not reported due to laboratory error.
[g]pH samples were not collected after Sept. 26, 1994. The pH value of record is data from the real-time pH probe, not the grab samples.
[h]Results include the outliers; results in parentheses do not include the outliers.
[i]Median.
[j]Median absolute deviation.
[k]Discharge concentration limits, City of Livermore Municipal Code 13.32. Tritium discharge limit is from DOE Order 5400.5.
[l]No specific discharge limit for this parameter.
[m]The discharge limit for TDS is an incremental limit, i.e., 325 mg/L above the concentration of the incoming water.
[n]Limit for tritium is based on an average annual concentration.

Table 4-6. Monthly Organic Priority Pollutant Monitoring Data for the SNL/California Sanitary Sewer Outfall.[a]

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
	(µg/L)											
Chloroform[b]	—	—	—	8.0	8.0	10.0	12.0	5.0	9.0 110.0	14.0	—	19.0
Phenol	—	—	—	—	10.0	—	—	—	18.0	21.0	—	21.0
Diethylphthalate	—	—	—	—	—	25.0	6.0	—	87.0 17.0	7.0	—	—
Benzylbutylphthalate	—	—	—	—	—	—	—	52.0	14.0	—	—	—
Bis(2-ethylhexyl)phthalate	—	—	—	—	—	—	—	10.0	—	—	—	—
Limit (total toxic organics)[c]	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000

[a]This table presents only the organic compounds on the EPA priority pollutant list that were present at concentrations greater than the analytical detection limit. All other compounds were below detection limits. Specific toxic organic compounds are listed in Appendix B. Other, nonregulated compounds (not on the EPA priority pollutant list) were not detected. All monitoring results are reported to the Livermore Water Reclamation Plant monthly.

[b]Chloroform is a common constituent of chlorinated water.

[c]The discharge limit for total toxic organics is the sum of the organic compounds on the EPA priority pollutant list.

Table 4-7. Wind Direction vs. Wind Speed.

	Wind Speed (m/s)					
Direction	**0.0–0.4 (Calm)**	**0.5–2.9**	**3.0–4.9**	**5.0–6.9**	**≥7.0**	**Total**
N	0.3	0.7	0.2	0.2	0.0	1.4
NNE	0.3	1.8	1.2	0.0	0.0	3.3
NE	0.3	3.0	2.1	0.4	0.0	5.7
ENE	0.3	2.5	0.6	0.1	0.0	3.5
E	0.3	3.0	0.1	0.0	0.0	3.5
ESE	0.3	5.8	0.2	0.0	0.0	6.3
SE	0.3	5.9	0.5	0.0	0.0	6.7
SSE	0.3	3.4	0.3	0.0	0.0	4.0
S	0.3	4.1	1.1	0.2	0.0	5.7
SSW	0.3	3.7	1.5	0.2	0.1	5.7
SW	0.3	5.9	4.8	3.0	0.9	14.8
WSW	0.3	6.6	7.7	4.2	1.1	19.8
W	0.3	5.4	4.2	1.7	0.2	11.8
WNW	0.3	2.6	0.8	0.4	0.0	4.2
NW	0.3	1.2	0.1	0.0	0.0	1.6
NNW	0.3	1.1	0.2	0.0	0.0	1.8
Total	**4.8**	**56.7**	**25.7**	**10.5**	**2.3**	**100.0**

Table 4-8. Uranium Concentrations in Air, Measured at the Site Perimeter.

Location[a]	Month	^{238}U (10^{-5} µg/m³)	^{235}U (10^{-7} µg/m³)	$^{235}U/^{238}U$ (10^{-3})
SALV	Jan.	3.17	2.32	7.33
	Feb.	3.44	4.14	12.00
	Mar.	3.56	2.57	7.22
	Apr.	3.06	2.57	8.39
	May	3.44	2.56	7.46
	June	5.35	5.17	9.68
	July	6.32	5.36	8.49
	Aug.	8.11	5.95	7.34
	Sept.	9.58	7.02	7.33
	Oct.	9.78	6.78	6.93
	Nov.	1.71	1.24	7.25
	Dec.	1.23	0.73	5.96
CAFE	Jan.	5.13	3.71	7.24
	Feb.	5.75	4.04	7.03
	Mar.	5.14	3.58	6.97
	Apr.	3.71	2.60	7.00
	May	4.88	3.49	7.15
	June	6.54	5.36	8.20
	July	7.88	6.07	7.70
	Aug.	9.05	6.44	7.11
	Sept.	11.60	8.39	7.24
	Oct.	8.37	5.90	7.04
	Nov.	2.26	1.68	7.46
	Dec.	1.83	1.17	6.42

	Annual Mean ^{238}U Concentrations		
Location	Mean (10^{-5} µg/m³)	SDM (10^{-5} µg/m³)[b]	% of DCG[c]
SALV	5.05	1.02	0.02
CAFE	6.18	0.99	0.02

	Annual Mean ^{235}U Concentrations		
Location	Mean (10^{-7} µg/m³)	SDM (10^{-7} µg/m³)[b]	% of DCG[d]
SALV	4.10	0.93	0.001
CAFE	4.52	0.84	0.001

[a]See Fig. 4-5 for sampling locations.
[b]Standard deviation of the mean.
[c]Derived Concentration Guide (DCG) = 0.3 µg/m³ for ^{238}U activity in air.
[d]DCG = 0.047 µg/m³ for ^{235}U activity in air.

Table 4-9. Tritium Concentrations in Air, Measured in the Livermore Valley (LLNL Samplers).

Month	Sampling Location[a] ZON7	ALTA	LCCY[b]	FIRE	XRDS
	[pCi/m³ ± 2σ (%)]				
January	1.08 ± 30	0.59 ± 46	0.87 ± 33[c]	1.35 ± 36	1.64 ± 25[c]
	1.61 ± 25	0.41 ± 74	0.54 ± 69	0.72 ± 50	0.94 ± 46
February	0.63 ± 52	0.78 ± 57	0.40 ± 78	0.71 ± 43	—[d]
	0.72 ± 55	<0.42	0.44 ± 67	<0.44	<0.49
March	<0.40	<0.37	<0.37	<0.41	<0.50
	0.55 ± 62	0.36 ± 89	0.41 ± 84	0.44 ± 77	<0.34
April	1.50 ± 25	—[d]	0.44 ± 76	<0.38	0.61 ± 57
	1.43 ± 29	0.54 ± 75	0.49 ± 64	0.49 ± 74	0.99 ± 43
May	0.91 ± 48	<0.44		—[d]	<0.35
	0.86 ± 50	<0.33		<0.39	0.47 ± 84
June	1.21 ± 29	—[d]		—[d]	0.79 ± 40
	0.85 ± 41	<0.28		<0.32	<0.29
July	1.41 ± 23	0.45 ± 61		<0.30	0.49 ± 58
	1.35 ± 31	0.38 ± 84		<0.41	0.42 ± 72
	1.06 ± 39	<0.32		<0.34	0.55 ± 57
August	1.30 ± 32	0.40 ± 85		<0.40	<0.29
	1.39 ± 24	0.53 ± 54		<0.31	0.33 ± 72
September	1.18 ± 35	<0.34		<0.38	<0.32
	2.97 ± 15[c]	0.52 ± 65		<0.38	1.63 ± 23[c]
October	2.39 ± 20[c]	0.80 ± 53[c]		0.56 ± 66	2.16 ± 19[c]
	1.29 ± 27	0.54 ± 52		0.65 ± 54	0.64 ± 42
November	0.98 ± 38	0.37 ± 85		0.62 ± 60	0.40 ± 75
	0.69 ± 69	<0.57		<0.38	0.56 ± 71
December	0.77 ± 42	<0.39		0.37 ± 79	0.41 ± 76
	2.79 ± 18[c]	0.83 ± 48[c]		1.30 ± 26	1.64 ± 24[c]
Average[e]	**1.26 (1.05)[f]**	**0.48 (0.44)[f]**	**0.50 (0.44)[f]**	**0.41[g]**	**0.71 (0.61)[f]**
SDM (%)	**32 (32)[f]**	**4 (26)[f]**	**3.7 (13)[f]**	**18[h]**	**31 (7)[f]**
% of DCG[i]	**1×10^{-3}**	**5×10^{-4}**	**5×10^{-4}**	**4×10^{-4}**	**1×10^{-3}**

[a]See Fig. 4-6 for sampling locations.
[b]This location was dropped after April 1994 due to vandalism.
[c]Outlier.
[d]No data.
[e]Livermore Valley overall average = 0.675 pCi/m³.
[f]Data include the outliers. Data in parentheses do not include the outliers.
[g]Median.
[h]Median absolute deviation (%).
[i]DCG = 1×10^5 pCi/m³ (3.7×10^3 Bq/m³).

Table 4-10. Tritium Concentrations in Air, Measured at the Livermore Site Perimeter (LLNL Samplers).

	Sampling Location[a]		
	SALV	VET	CAFE
Month		[pCi/m³ ± 2σ (%)]	
January	2.80 ± 17	3.43 ± 14[b]	2.87 ± 13
	2.30 ± 12	2.41 ± 17	4.73 ± 10
February	—[c]	1.76 ± 23	3.26 ± 14
	1.51 ± 24	1.08 ± 31	3.14 ± 14
March	2.15 ± 23	0.99 ± 53	3.61 ± 15
	1.89 ± 13	0.71 ± 53	2.41 ± 14
April	7.54 ± 10	0.81 ± 54	2.56 ± 17
	6.38 ± 10	1.19 ± 36	3.29 ± 13
May	3.38 ± 17	<0.37	0.61 ± 50
	—[c]	—[c]	0.58 ± 62
June	3.57 ± 15	<0.35	0.95 ± 35
	3.21 ± 15	0.45 ± 68	0.80 ± 44
	3.10 ± 15	—[c]	1.14 ± 28
July	2.24 ± 24	<0.37	0.76 ± 54
	1.97 ± 28	<0.34	0.98 ± 43
August	1.54 ± 20	<0.36	1.00 ± 38
	2.89 ± 16	<0.28	1.45 ± 24
September	1.92 ± 27	<0.33	1.30 ± 34
	6.96 ± 9	0.52 ± 67	1.33 ± 32
October	5.52 ± 13	1.53 ± 26	2.92 ± 19
	3.43 ± 14	1.20 ± 28	3.15 ± 14
November	4.72 ± 12	0.91 ± 39	2.56 ± 17
	3.80 ± 15	2.74 ± 19	2.76 ± 15
December	3.06 ± 16	1.34 ± 22	2.21 ± 16
	7.65 ± 8	2.19 ± 18	4.34 ± 10
Mean[d]	**3.67**	**1.13 (1.03)[e]**	**1.49**
SDM (%)	**107**	**94 (72)[e]**	**76**
% of DCG[f]	**4×10^{-3}**	**1×10^{-3}**	**1×10^{-3}**

[a]See Fig. 4-5 for sampling locations.
[b]Outlier.
[c]No data.
[d]Livermore site perimeter overall average = 2.10 pCi/m³.
[e]Data include the outliers. Data in parentheses do not include the outliers.
[f]DCG = 1×10^5 pCi/m³ (3.7×10^3 Bq/m³).

Table 4-11. Tritium Concentrations in Air, Measured at the Livermore Site (SNL/California Samplers).

	Sampling Location[a]					
Date	**ATS-01**	**ATS-02**	**ATS-03**	**ATS-04**	**ATS-05**	**ATS-07**
			[pCi/m³ ± 2σ (%)]			
January	2 ± 50	2 ± 50	26 ± 8	2 ± 50	8 ± 25	—[b]
	2 ± 50	3 ± 33	48 ± 6	3 ± 33	2 ± 50	—[b]
February	<2	<2	38 ± 8	<2	<3	—[b]
March	3 ± 67	3 ± 33	40 ± 8	<3	4 ± 50	—[b]
	<2	2.7 ± 56	36 ± 9	<2	<3	<4
April	<2	10 ± 21	150 ± 4[c]	3.0 ± 67	7.8 ± 35	<4
	5.0 ± 34	10 ± 18	340 ± 2[c]	3.9 ± 49	7.9 ± 23	<4
May	<4	<3	330 ± 2[c]	<4	3.3 ± 54	<4
	<4	<5	120 ± 6[c]	<4	4.3 ± 60	<4
	<3	5.1± 41	57 ± 8	<3	—[d]	<4
June	<3	<3	47 ± 8	<3	5.4 ± 39	<4
	<3	—[d]	36 ± 9	<2	5.6 ± 32	<4
July	<5	—[d]	20 ± 15	<4	4.2 ± 52	<4
	<3	<4	32 ± 12	<4	<3	<4
August	<5	<4	18 ± 19	<3	<4	<4
	<5	<3	62 ± 9	<3	5.5 ± 40	5.1 ± 55
September	<4	3.5 ± 60	26 ± 13	<4	4.3 ± 54	<4
	<4	11 ± 27	37 ± 11	<5	25 ± 16	<5
October	5.7 ± 49	22 ± 18	56 ± 9	4.8 ± 60	29 ± 13	<5
	<5	<4	20 ± 26	<5	<5	<4
November	5.3 ± 79	13 ± 31	8.9 ± 37	10 ± 33	<3	<50
	<4	<4	<3	<3	<5	<30
	<5	3.3 ± 58	<4	<4	<5	<30
December	3.5 ± 51	7.3 ± 30	10 ± 23	3.4 ±62	17 ± 18	<3
Median	**<4**	**<4**	**65.2[e] (31.2)[f]**	**<3.2**	**<5**	**<4**
MAD (%)	**22**	**33**	**138[g] (57)[f]**	**20**	**36**	**0**
% of DCG[h]	**4×10^{-3}**	**4×10^{-3}**	**6×10^{-2}**	**3×10^{-3}**	**5×10^{-3}**	**4×10^{-3}**

[a]See Figs. 4-5 and 4-6 for sampling locations.
[b]Station under construction during this period.
[c]Outlier.
[d]Sample lost due to power outage.
[e]Mean.
[f]Data include the outliers. Data in parentheses do not include the outliers.
[g]SDM (%).
[h]DCG = 1×10^5 pCi/m³ (3.7×10^3 Bq/m³).

Table 4-12. Tritium Concentrations Measured in Livermore Valley Surface Water Samples.

	Sampling Location[a]					
	DEL[b]	ZON7[b]	DUCK[b]	GAS[c]	ALAG[b]	SHAD[b]
Quarter	[pCi/L ± 2σ (%)]					
First	19.2 ± 18	28.4 ± 13	54.8 ± 8	30.7 ± 12	63.9 ± 8	72.2 ± 7
Second	18.8 ± 14	18.3 ± 16	56.1 ± 7	36.0 ± 11	53.0 ± 8	71.7 ± 7
Third	27.1 ± 15	25.1 ± 15	50.5 ± 10	37.7 ± 11	37.3 ± 11	80.6 ± 7
Fourth	17.2 ± 19	20.8 ± 15	39.2 ± 11	11.2 ± 20	48.5 ± 8	63.3 ± 8
Mean	**20.6**	**23.2**	**50.2**	**28.9**	**50.7**	**71.9**
SDM (%)	**22**	**19**	**15**	**42**	**22**	**10**
% of DWS[d]	**0.1**	**0.1**	**0.3**	**0.1**	**0.3**	**0.4**

	Sampling Location[a]					
	CAL[b]	TAP[e]	PALM[c]	ORCH[f]	BELL[c]	POOL[g]
Quarter	[pCi/L ± 2σ (%)]					
First	15.4 ± 21	19.2 ± 18	22.6 ± 15	19.9 ± 19	35.9 ± 11	98.0 ± 55 141 ± 38 128 ± 40
Second	13.6 ± 22	13.7 ± 24	18.0 ± 16	20.3 ± 13	18.0 ± 18	148 ± 41 86.0 ± 54 89.9 ± 53
Third	20.0 ± 18	23.1 ± 16	25.9 ± 15	15.3 ± 22	20.2 ± 15	116 ± 42 99.3 ± 50 130 ± 49
Fourth	17.0 ± 16	20.6 ± 13	20.4 ± 13	12.0 ± 21	20.4 ± 13	141 ± 34 161 ± 33
Mean	**16.5**	**19.2**	**21.7**	**16.9**	**23.6**	**122**
SDM (%)	**16**	**21**	**16**	**24**	**35**	**21**
% of DWS[d]	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.6**

[a]See Fig. 4-9 for sampling locations.
[b]Surface water.
[c]Tap water—Livermore locations.
[d]Drinking water standard (DWS) = 2×10^4 pCi/L (740 Bq/L).
[e]Tap water—LLNL.
[f]Well water.
[g]LLNL swimming pool.

Table 4-13. Tritium in Rain, Measured at the Livermore Site and in the Livermore Valley.

	Sampling Location[a]			
	VIS	SALV	ZON7	AQUE
Date	[pCi/L ± 2σ (%)]			
01/25/94	199 ± 28	342 ± 17	63 ± 81	197 ± 27
03/25/94	213 ± 26	821 ± 9	92 ± 54	—[b]
04/11/94	292 ± 22	259 ± 22	92 ± 64	372 ± 18
04/26/94	195 ± 28	1450 ± 6	199 ± 27	365 ± 16
05/09/94	163 ± 28	320 ± 16	138 ± 33	—[b]
11/07/94	<48	<49	<48	<46
Mean	**185**	**540**	**105**	**245**
SDM	**43**	**95**	**53**	**63**

[a]See Fig. 4-10 for sampling locations.
[b]No data.

Table 4-14. Gross Alpha Activity Measured in Livermore Valley Surface Water Samples.

Quarter	DEL	ZON7	DUCK	GAS	ALAG	SHAD
	Sampling Location[a] [pCi/L ± 2σ]					
First	0.47 ± 0.47	0.80 ± 0.47	0.72 ± 0.30	0.60 ± 0.31	2.56 ± 0.48	1.53 ± 0.52
Second	0.45 ± 0.07	0.52 ± 0.09	2.21 ± 1.64	0.33 ± 0.08	0.69 ± 0.08	0.30 ± 0.07
Third	5.38 ± 1.07	1.97 ± 0.65	0.35 ± 1.60	3.21 ± 0.77	1.29 ± 0.74	8.18 ± 1.39
Fourth	0.50 ± 0.26	2.58 ± 0.31	4.03 ± 1.72	3.40 ± 0.36	−3.26 ± 0.91	3.62 ± 0.41
Mean	**1.70**	**1.47**	**1.83**	**1.88**	**0.32**	**3.41**
SDM (%)	**144**	**66**	**92**	**88**	**784**	**102**

Quarter	CAL	TAP	PALM	ORCH	BELL	POOL
	Sampling Location[a] [pCi/L ± 2σ]					
First	0.59 ± 0.39	1.62 ± 0.37	0.19 ± 0.32	3.58 ± 0.60	−0.08 ± 0.41	0.88 ± 0.55 0.14 ± 0.49 0.41 ± 0.87
Second	0.09 ± 0.05	0.18 ± 0.07	−0.23 ± 0.33	0.19 ± 0.07	0.40 ± −0.07	−0.09 ± 0.06 −0.89 ± 0.41 −1.26 ± 1.90
Third	−0.11 ± 2.22	0.63 ± 0.23	2.11 ± 0.66	7.19 ± 2.11	1.49 ± 0.68	7.67 ± 2.15 2.10 ± 1.95 3.84 ± 1.32
Fourth	0.05 ± 0.18	1.16 ± 0.14	0.9 ± 0.25	4.13 ± 0.55	1.30 ± 0.25	7.98 ± 0.98 −1.02 ± 4.41 0.74 ± 1.00
Mean	**0.16**	**0.90**	**0.74**	**3.77**	**0.78**	**1.71**
SDM (%)	**189**	**70**	**138**	**76**	**95**	**186**

[a]See Fig. 4-9 for sampling locations.

[b]Due to the statistical nature of radiation measurements, negative values are possible. They are included here rather than detection limits ("less than" values) to provide more information than is possible using detection limits.

Table 4-15. Gross Beta Activity Measured in Livermore Valley Surface Water Samples.

Quarter	Sampling Location[a] DEL [pCi/L ± 2σ]	ZON7	DUCK	GAS	ALAG	SHAD
First	3.82 ± 0.33	2.99 ± 0.34	4.11 ± 0.54	2.31 ± 0.30	2.05 ± 0.32	3.22 ± 0.34
Second	42.70 ± 0.50	2.79 ± 0.26	0.45 ± 2.18	4.10 ± 0.28	4.65 ± 0.27	3.01 ± 0.26
Third	4.11 ± 0.60	3.19 ± 0.54	5.30 ± 2.30	2.20 ± 0.46	2.05 ± 0.47	5.32 ± 0.76
Fourth	1.92 ± 0.22	2.90 ± 0.22	8.40 ± 1.25	1.90 ± 0.21	2.12 ± 0.36	3.38 ± 0.30
Mean	**13.14**	**2.97**	**4.56**	**2.63**	**2.72**	**3.62**
SDM (%)	**150**	**6**	**72**	**38**	**47**	**31**

Quarter	Sampling Location[a] CAL [pCi/L ± 2σ]	TAP	PALM	ORCH	BELL	POOL
First	5.82 ± 0.33	3.43 ± 0.31	2.14 ± 0.30	3.25 ± 0.36	2.44 ± 0.30	3.79 ± 0.34 5.70 ± 0.39 3.55 ± 0.72
Second	1.80 ± 0.24	0.84 ± 0.24	2.86 ± 0.63	1.67 ± 0.27	5.79 ± 0.29	4.95 ± 0.27 0.54 ± 0.87 2.97 ± 1.24
Third	1.78 ± 0.48	0.88 ± 0.37	2.08 ± 0.47	6.02 ± 1.28	2.87 ± 0.53	6.35 ± 1.25 4.10 ± 1.38 8.81 ± 1.29
Fourth	0.39 ± 0.20	59.70 ± 0.50	2.16 ± 0.21	2.74 ± 0.43	2.92 ± 0.22	6.43 ± 0.67 7.15 ± 2.01 7.55 ± 1.00
Mean	**2.45**	**16.21**	**2.31**	**3.42**	**3.50**	**5.16**
SDM (%)	**96**	**179**	**16**	**54**	**44**	**44**

[a]See Fig. 4-9 for sampling locations.

Table 4-16. Tritium Activity Measured in Livermore Valley Groundwater Samples.

Well ID[a]	Tritium Activity [pCi/L ± 2σ (%)]	Percent of MCL[b]
1H3	11.5 ± 21	0.1
1P2	94.6 ± 6	0.5
1P3	15.5 ± 19	0.1
1R2	48.5 ± 8	0.2
2R1	96.3 ± 5	0.5
7C2	72.5 ± 6	0.4
7P3	<1.7	0.008
8F1	33.8 ± 10	0.2
8P1	45.7 ± 8	0.2
9M2	23.8 ± 17	0.1
9Q1	30.8 ± 12	0.2
11B1	424.0[c] ± 3	2.1
12A2	94.9 ± 5	0.5
12D2	168.0 ± 4	0.8
12G1	134.0 ± 4	0.7
16B1	20.9 ± 17	0.1
16L5	29.3 ± 14	0.1
16L7	43.9 ± 10	0.2
17D2	<2.4	0.01
8004[d]	30.9 ± 13	0.2
18A1	7.6 ± 45	0.04
Mean	**82.4 (63.8)[e]**	
SDM	**147 (129)[e]**	

[a]See Fig. 4-11 for sampling locations.
[b]Maximum contaminant level (MCL) = 20,000 pCi/L (740 Bq/L).
[c]Outlier.
[d]Replaced well 18A5.
[e]Results include the outlier; results in parentheses do not include the outlier.

Table 4-17. SNL/California Storm Water Sampling Results.

Parameter	Date	Sampling Location[a]				
		A[b]	B[c]	C[b]	D[c]	E[b]
Required Analyses						
Total suspended solids (mg/L)	02/94	10	30	260	50	110
	11/94	<10	160	70	70	160
Conductivity (μmhos/cm)	02/94	36	110	63	48	42
	11/94	31	40	29	41	39
pH (units)	02/94	7.0	7.0	7.1	6.9	7.4
	11/94	7.4	7.1	7.1	7.4	7.0
Oil and grease (mg/L)	02/94	<5	<5	<5	<5	<5
	11/94	<5	<5	<5	<5	<5
Additional Analyses[d]						
Tritium (pCi/L)	02/94	12.1	12.9	12.1	12.9	12.1
	11/94	12.4	12.4	12.4	12.4	12.4
Metals (mg/L):						
Arsenic	02/94	<0.005	<0.005	<0.005	<0.005	<0.005
	11/94	<0.005	<0.005	<0.005	<0.005	<0.005
Cadmium	02/94	<0.005	<0.005	<0.005	<0.005	<0.005
	11/94	<0.005	<0.005	<0.005	<0.005	<0.005
Chromium	02/94	<0.010	<0.010	0.010	<0.010	<0.010
	11/94	<0.010	0.010	<0.010	<0.010	0.020
Copper	02/94	0.230	<0.010	0.010	<0.010	<0.010
	11/94	0.020	0.010	<0.010	0.010	0.020
Lead	02/94	<0.050	<0.050	<0.050	<0.050	<0.050
	11/94	<0.050	<0.050	<0.050	<0.050	<0.050
Mercury	02/94	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
	11/94	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Nickel	02/94	<0.020	<0.020	0.030	<0.020	0.940
	11/94	<0.020	<0.020	<0.020	<0.020	0.040
Silver	02/94	<0.010	<0.010	<0.010	<0.010	<0.010
	11/94	<0.010	<0.010	<0.010	<0.010	<0.010
Zinc	02/94	0.040	0.210	0.140	0.050	<0.010
	11/94	0.120	0.150	0.120	0.100	0.210
Organics (μg/L):						
Bis(2-ethylhexyl)phthalate	11/94	–	–	10.000	–	–
Endrin	11/94	–	–	0.040	–	–

[a]See Fig. 4-13 for sampling locations. No samples were collected at location Y because there was not enough runoff.
[b]This location was sampled on Feb. 10, 1994, and Nov. 9, 1994.
[c]This location was sampled on Feb. 17, 1994, and Nov. 9, 1994.
[d]Additional parameters are analyzed to obtain baseline information about which pollutants are discharged with storm water. Certain chemicals may be eliminated from the suite of chemicals analyzed if they are not detected in storm water discharge after several sample collection periods. Samples were analyzed for priority pollutants according to the following EPA methods: 624 (purgeable pollutants), 625 (extractable pollutants), and 608 (organochlorine compounds). All priority pollutants were below applicable discharge limits.

Continued

Table 4-17. SNL/California Storm Water Sampling Results (concluded).

Parameter	Date	Sampling Location[a]				
		F[e]	G[b]	H[b]	X[b]	Z[f]
Required Analyses						
Total suspended solids (mg/L)	02/94	–	240	30	20	–
	11/94	40	210	<10	430	100
Conductivity (μmhos/cm)	02/94	–	130	28	33	–
	11/94	31	47	19	26	43
pH (units)	02/94	–	8.9	7.0	7.0	–
	11/94	7.0	7.0	7.2	7.6	7.2
Oil and grease (mg/L)	02/94	–	14	<5	<5	–
	11/94	<5	<5	<5	<5	<5
Additional Analyses[d]						
Tritium (pCi/L)	02/94	–	12.1	12.1	12.1	–
	11/94	12.4	12.4	12.4	12.4	12.4
Metals (mg/L):						
Arsenic	02/94	–	<0.005	<0.005	<0.005	–
	11/94	<0.005	<0.005	<0.005	<0.005	<0.005
Cadmium	02/94	–	<0.005	<0.005	<0.005	–
	11/94	<0.005	<0.005	<0.005	<0.005	<0.005
Chromium	02/94	–	<0.010	<0.010	<0.010	–
	11/94	<0.010	0.010	<0.010	0.020	<0.010
Copper	02/94	–	<0.010	0.070	<0.010	–
	11/94	0.010	0.020	<0.010	0.010	0.010
Lead	02/94	–	<0.050	<0.050	<0.050	–
	11/94	<0.050	<0.050	<0.050	<0.050	<0.050
Mercury	02/94	–	0.0005	<0.0005	<0.0005	–
	11/94	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Nickel	02/94	–	<0.020	<0.020	<0.020	–
	11/94	<0.020	<0.020	<0.020	0.030	<0.020
Silver	02/94	–	<0.010	<0.010	<0.010	–
	11/94	<0.010	<0.010	<0.010	<0.010	<0.010
Zinc	02/94	–	0.040	0.460	0.010	–
	11/94	0.250	0.280	0.030	0.100	0.140
Organics (μg/L):						
Benzylbutylphthalate	02/94	–	39.000	–	–	–
Bis(2-ethylhexyl)phthalate	02/94	–	30.000	–	–	–
Diethylphthalate	11/94	7.000	–	–	–	–
Fluoranthene	11/94	–	12.000	–	–	–
Phenanthrene	11/94	–	13.000	–	–	–
Pyrene	11/94	–	12.000	–	–	–
Trichloroethane	11/94	–	–	18.000	–	–

[e]This location was sampled only on Nov. 9, 1994, due to lack of runoff during the February storm.
[f]This location was sampled only on Nov. 9, 1994, because access to the arroyo was unsafe during the February storm.

Table 4-18. Radionuclides Measured in Soil and Arroyo Sediments.

Soil	
Location[a]	**^{238}U**[b] **[µg/dry g ± 2σ (%)]**
ALTA	$9.19 \times 10^{-7} \pm 73$
ERCH	$5.00 \times 10^{-7} \pm 59$
FCC	$<4.50 \times 10^{-7}$
HOSP	$<1.48 \times 10^{-7}$
PATT	$7.36 \times 10^{-7} \pm 84$
RRCH	$<5.69 \times 10^{-7}$
TANK	$<7.33 \times 10^{-7}$
VIS	$8.77 \times 10^{-7} \pm 45$
WRP1	$<5.90 \times 10^{-7}$
WRP2	$11.00 \times 10^{-7} \pm 48$
WRP3	$8.12 \times 10^{-7} \pm 43$
WRP4	$7.20 \times 10^{-7} \pm 77$
WRP5	$11.70 \times 10^{-7} \pm 56$
WRP6	$9.87 \times 10^{-7} \pm 78$
ZON7	$<3.35 \times 10^{-7}$
Median	**7.33×10^{-7}**
MAD (%)[c]	**25**

Arroyo Sediments		
Location[d]	**^{3}H**[b] **(pCi/L)**	**^{238}U** **[µg/dry g ± 2σ (%)]**
ASS2	48.6 ± 89	$<7.50 \times 10^{-7}$

[a]See Fig. 4-14 for sampling locations.
[b]Sampling depth = 0 – 0.5 cm.
[c]Median absolute deviation.
[d]See Fig. 4-15 for sampling location.

Table 4-19. Tritium Concentrations Measured in Livermore Valley Vegetation.

	Sampling Location[a]						
	AQUE	RAIL	MESQ	MET	VIS	PATT	ZON7
Quarter	[pCi/L of moisture content ± 2σ (%)]						
First	399 ± 15	145 ± 42	<48	160 ± 32	272 ± 20	<47	89 ± 55
Second	492 ± 13	141 ± 37	256 ± 25	142 ± 37	318 ± 18	77 ± 65	208 ± 26
Third	624 ± 10	322 ± 17	504 ± 12	513 ± 12	976 ± 7	108 ± 43	333 ± 16
Fourth	1270 ± 6	228 ± 23	82.9 ± 61	163 ± 31	243 ± 23	<46	206 ± 25
Mean	**696**	**209**	**223**	**244**	**811**	**62[b]**	**209**
SDM (%)	**56**	**41**	**94**	**73**	**69**	**25[c]**	**48**
Dose (mrem)	**12×10^{-3}**	**4×10^{-3}**	**4×10^{-3}**	**4×10^{-3}**	**32×10^{-4}**	**1×10^{-3}**	**4×10^{-3}**

	Sampling Location[a]						
	I580	TESW	FCC	MOD	DAN	PARK	CAL
Quarter	[pCi/L of moisture content ± 2σ (%)]						
First	79 ± 62	58 ± 83	<46	<56	<54	71 ± 68	<47
Second	179 ± 41	<48	<48	<56	<46	77 ± 65	<56
Third	515 ± 12	<43	86 ± 52	<45	<43	<45	<43
Fourth	129 ± 38	454 ± 13	<45	<46	<43	<48	<45
Mean	**126**	**53[b]**	**47[b]**	**51[b]**	**45[b]**	**59[b]**	**46[b]**
SDM (%)	**88**	**14[c]**	**4[c]**	**10[c]**	**4[c]**	**22[c]**	**4[c]**
Dose (mrem)	**4×10^{-3}**	**3×10^{-3}**	**0.4×10^{-3}**	**1×10^{-3}**	**1×10^{-3}**	**1×10^{-3}**	**1×10^{-3}**

[a]See Fig. 4-16 for sampling locations.
[b]Median.
[c]Median absolute deviation (%).

Table 4-20. Tritium Concentrations Measured in Retail Wines.[a]

	Area of Production	
Sample	Livermore Valley	California (Non-Livermore Valley)
	[pCi/L ± 2σ (%)]	
1	117 ± 10	11 ± 32
2	84 ± 22	14 ± 75
3	191 ± 10	14 ± 52
4	217[b] ± 10	15 ± 20
5	98 ± 12	18 ± 30
6	74 ± 13	18 ± 74
7	96 ± 10	
8	106 ± 11	
9	144 ± 14	
10	67 ± 17	
11	89 ± 12	
12	59 ± 12	
Mean	**112 (102)[c]**	**15**
SDM (%)	**41 (35)[c]**	**18**

[a]Wines from a variety of vintages were purchased and analyzed in 1994. Twelve samples of Livermore Valley wines and six samples of other California wines were analyzed. The concentrations shown are not decay-corrected to the vintage year.

[b]Outlier.

[c]Results include the outlier; results in parentheses do not include the outlier.

Table 4-21. Quarterly and Annual Environmental Radiation Measurements at Livermore Site Perimeter Locations.

Location[a]	1st. Quarter (mrem)	2nd. Quarter (mrem)	3rd. Quarter (mrem)	4th. Quarter (mrem)	Annual Total
11	15.1	14.9	15.7	17.1	62.8
12	15.4	16.4	15.8	17.4	65.0
14	17.2	18.3	17.1	19.3	71.9
55	16.1	17.3	16.4	19.1	68.9
56	17.4	17.6	18.3	37.7[b]	91.0[b]
57	17.6	18.8	18.3	20.1	74.8
58	17.0	17.7	16.5	18.8	70.0
59	16.3	17.7	16.5	17.2	67.7
60	17.1	18.9	18.6	19.8	74.4
61	15.8	16.4	15.7	16.4	64.3
63	16.9	21.3	17.5	18.9	74.6
66	17.4	18.6	18.3	18.7	73.0
67	16.0	18.4	17.2	18.3	69.9
68	17.1	18.1	17.8	20.0	73.0
69	16.7	17.9	17.4	19.5	71.5
E7001[c]	14.0	13.9	13.3	16.0	57.2
E7002[c]	13.4	15.3	13.3	19.5	61.5
E7003[c]	13.9	14.1	13.9	16.1	58.0
E7004[c]	13.1	12.3	11.8[b]	13.3[b]	50.5
Mean	**16.0**	**17.0**	**16.3 (16.5)[d]**	**19.1 (18.4)[d]**	**68.4 (67.2)[d]**
SDM (%)	**9**	**13**	**12 (10)[d]**	**25 (7)[d]**	**13 (10)[d]**

[a]See Fig. 4-18 for sampling locations.
[b]Outlier.
[c]This monitoring station is managed by SNL/California, and the dosimeters are processed at SNL/New Mexico.
[d]Results include the outliers; results in parentheses do not include the outliers.

Table 4-22. Quarterly and Annual Environmental Radiation Measurements at Livermore Valley Locations.

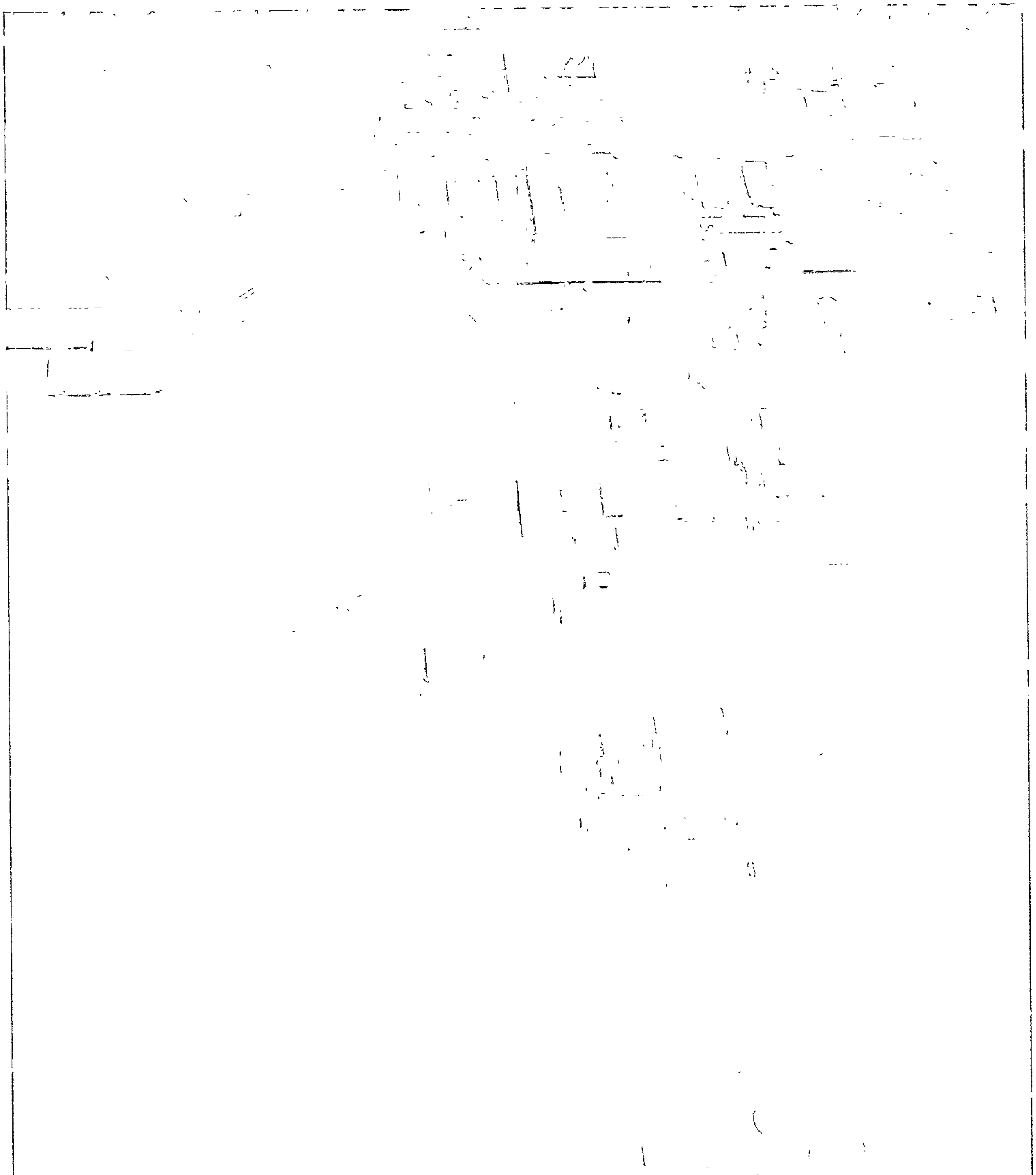
Location[a]	1st. Quarter	2nd. Quarter	3rd. Quarter	4th. Quarter	Annual Total
	(mrem)				
15	17.1	17.2	17.8	18.6	70.7
16	16.6	17.5	—[b]	—[b]	68.2[c]
17	17.5	18.3	17.6	20.1	73.5
18	14.2[d]	14.1	13.7	16.9	58.9
19	16.1	17.0	16.4	17.0	66.5
20	16.9	16.9	16.6	19.0	69.4
21	15.7	16.7	16.4	20.6	69.4
22	18.1	19.6	18.4	21.0	77.1
23	18.0	18.8	18.7	19.8	75.3
24	17.5	19.1	18.7	19.5	74.8
27	18.1	20.8	20.4	20.4	80.7
28	18.9	21.2	20.1	21.1	81.3
29	18.3	19.2	19.8	21.1	78.4
30	—[b]	19.1	20.4	19.6	78.8[c]
31	—[b]	18.6	18.4	19.9	75.9[c]
32	17.4	17.9	18.6	20.1	74.0
33	—[b]	18.8	19.5	20.4	78.3[c]
34	18.9	20.7	19.3	21.2	80.1
35	18.4	19.7	19.4	19.3	76.8
36	18.1	18.8	19.4	19.5	75.8
37	—[b]	19.2	19.3	20.0	78.0[c]
38	18.3	—[b]	—[b]	20.9	78.4[c]
41	17.6	18.3	17.5	19.2	72.6
43	16.8	18.7	18.5	19.6	73.6
44	16.9	20.9	19.5	21.5	78.8
45	16.7	17.2	16.8	19.0	69.7
46	17.1	17.9	17.6	19.3	71.9
47	16.8	17.3	18.3	18.7	71.1
50	16.7	17.0	17.5	18.2	69.4
51	17.3	19.2	18.4	20.1	75.0
52	17.0	17.7	17.1	18.8	70.6
62	15.6	16.7	16.8	18.1	67.2

Continued

Table 4-22. Quarterly and Annual Environmental Radiation Measurements at Livermore Valley Locations (concluded).

Location[a]	1st. Quarter (mrem)	2nd. Quarter (mrem)	3rd. Quarter (mrem)	4th. Quarter (mrem)	Annual Total
70	16.9	18.2	18.0	19.0	72.1
71	—[b]	—[b]	19.6	21.1	81.4[c]
72	19.4	21.4	20.1	22.4	83.3
73	17.1	18.3	18.5	20.6	74.5
74	16.6	16.5	15.8	—[b]	65.2[c]
75	14.3[d]	15.5	14.6	17.2	61.6
76	14.9	14.8	15.2	17.0	61.9
77	16.5	16.5	16.9	17.5	67.4
Mean (mrem)	**17.1 (17.3)[e]**	**18.2**	**18.0**	**19.6**	**73.2**
SDM (%)	**7 (6)[e]**	**11**	**9**	**7**	**8**

[a]See Fig. 4-19 for sampling locations.
[b]No data.
[c]When a dosimeter is missing, the mean value from the available data is used to calculate the annual total.
[d]Outlier.
[e]Results include the outliers; results in parentheses do not include the outliers.



TRITIUM
MODELING THE DISPERSION OF ATMOSPHERIC RELEASES
PERSPECTIVES ON RADIATION EXPOSURES

Radiological impacts from SNL/California's operations are diminishing rapidly. SNL/California has ceased tritium research; as a result, site emissions to the environment have dropped. Furthermore, SNL/California has released no uranium for several years. In the past, Sandia released very small amounts of tritium to the surrounding environment. The public could be exposed to extremely low levels of radiation from these releases.

Each calendar year, SNL/California's environmental staff assesses the impacts from site emissions and reports them to the public in this *Site Environmental Report.* The staff members determine radiological impacts by calculating the radiation dose to a maximally exposed individual and for the total population living within 80 km (50 miles) of the site.

All the significant exposure pathways are sampled as a part of SNL/California's Environmental Monitoring Program. However, any pollutants released are at very low concentrations once dispersed in the environment. As a result, levels often are too low to determine dose to humans directly from environmental measurements.

Furthermore, the origin or source of tritium (the only radionuclide released from SNL/California) found in the environment is difficult to trace. It may be released from SNL/California operations, LLNL operations, world-wide fallout, or it may be produced naturally. Consequently, the public's exposure to tritium directly resulting from SNL/California releases is difficult to measure. Therefore, potential radiation doses are calculated based on facility emissions, i.e., stack monitoring data. This information is entered into EPA-approved environmental transport and exposure pathway computer models to calculate off-site doses. In this report, the *effective dose equivalent* is used to express radiation dose in terms of potential health risk. Appendix C explains radiation dose terminology and the methods and assumptions used in calculating these doses.

The major pathways of radiation exposure from atmospheric releases are inhalation and consumption of locally grown foods.

TRITIUM

Because tritium is the only radionuclide discharged to the environment in measurable amounts from operations conducted at SNL/California, much of the monitoring program is devoted to assessing and controlling its impact. For this reason, this report provides specific information about the dosimetry and environmental behavior of tritium.

Tritium (^3H, commonly designated by T), a radioactive isotope of hydrogen, is a naturally occurring and ubiquitous component of the environment. Tritium is produced in relatively large amounts by interactions of cosmic rays and gases of the upper atmosphere. The world-wide inventory of tritium has been substantially increased by nuclear weapons testing. Tritium has a physical half-life of 12.3 years and decays by emission of a beta particle of very low energy (maximum energy 18 keV and an average energy of 5.7 keV).

At room temperature, tritium combines with gaseous hydrogen (H_2) to form HT. Even more readily, it exchanges with one hydrogen in water vapor to form "tritiated water" (HTO), the most common form of tritium in the environment. Tritiated water is easily absorbed into living organisms, behaving like normal water. For this reason, tritium occurs naturally in all living things.

Tritium generally is considered one of the least toxic of all radioisotopes. Because of the extremely low energy of the beta particle emission, tritium does not pose an external radiation hazard. (The mean range of tritium's beta particle in water is 0.69 μm.) However, tritium taken into the body can cause harm at a cellular level.

Tritium released to the atmosphere can exist in two chemical forms: tritium oxide (i.e., water vapor—HTO or T_2O) or elemental tritium (i.e., gas—HT or T_2). Human absorption and metabolism differ greatly for the two chemical forms of tritium. These two forms also behave differently in the environment.

Tritium oxide is readily absorbed by the body when inhaled or ingested with food or water. Tritium oxide also may be absorbed through the skin. An individual exposed to airborne tritium oxide typically absorbs about half as much tritium through the skin as by inhalation. In this report, all tritium doses from the air pathway have been calculated taking into account both inhalation and skin absorption. In addition, the dosimetry models used for tritium oxide assume that the body would eliminate tritium at the same rate as water.

Elemental tritium is not assimilated by the human body. Of the tritium gas inhaled, only about 0.004% is converted to the oxide form and retained in the body as free water. For this reason, the oxide form of tritium is about 25,000 times more harmful (results in a higher dose) than an equal dose of elemental tritium.

Careful perusal of the environmental monitoring data indicates that the only evidence of impact due to SNL/California (and LLNL) operations is a slight increase in tritium concentrations in the environment. Tritium concentrations in air, rainwater, vegetation, and wine are slightly greater near SNL/California and LLNL than at more distant locations. The tritium concentrations in air have decreased over the past several years, following the trend of decreased tritium effluents released to the air. Because the air pathway is the primary source of tritium for the other environmental media, concentrations of tritium in these environmental media are expected also to show a downward trend during the next few years. The levels of tritium detected are not high enough to be a health concern. The analytical methods are sensitive enough to allow SNL/California to detect even these very small amounts of radioactive materials in the environment.

MODELING THE DISPERSION OF ATMOSPHERIC RELEASES

Radioactive materials discharged to the atmosphere are mixed and dispersed as they are transported by prevailing winds. This dispersal can result in internal exposure to people via inhalation and ingestion. Radionuclides are removed from air by radioactive decay and deposition onto the ground or vegetation. The deposited radionuclides can then move through various pathways to humans. Appendix C contains more information on environmental transport processes.

Computer models developed by the EPA simulate the movement, decay, and deposition of radionuclides to predict the air concentrations at downwind locations. These models also calculate the uptake and transfer of radionuclides through the food chain. This information can be used to estimate radiation doses to individuals residing in specific areas.

SNL/California assesses the radiological impacts of site operations by determining four potential doses to the public:

- external (direct) dose at the site boundary,
- maximally exposed individual dose (all pathways),
- air pathway dose, and
- collective (population) dose.

Figure 5-1 simplistically represents the important exposure pathways.

External Radiation Dose

The external dose is a measure of the radiation field at the site boundary from direct penetrating sources of radiation (primary gamma rays). Thermoluminescent dosimeters are used to measure the external dose at locations around the SNL/California site that permit uncontrolled public access (e.g., fence lines and open areas). Dosimeters also are placed at distant locations to serve as background or *control* measurements. The near-field and far-field dosimeters can be compared to determine if site operations contribute to the external dose rate. That is, the difference in the dose rates between the site perimeter and the background locations represents the external dose due to SNL/California operations.

In 1994, the annual average external dose at the site boundary was 68.4 mrem (0.68 mSv), compared to 72.6 mrem (0.73 mSv) for the Livermore Valley monitoring stations. The Valley result is significantly greater than the perimeter result within the statistical confidence level of the method, indicating that no external dose was measured as a direct result of SNL/California operations in 1994.

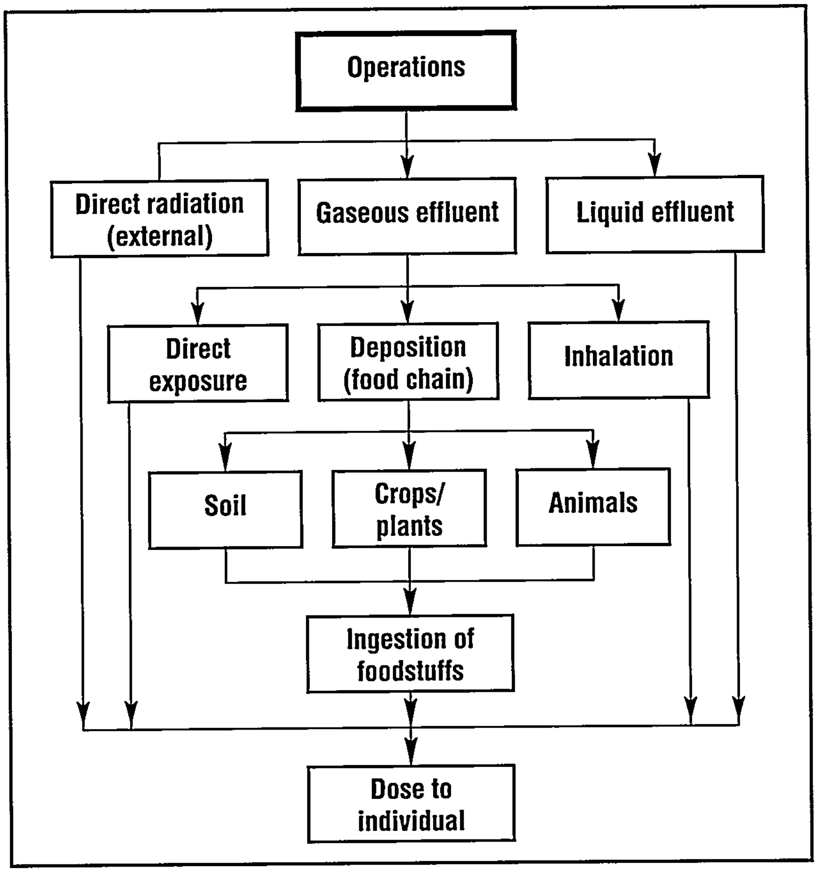


Figure 5-1. Major radiation exposure pathways to humans.

Maximally Exposed Individual Dose

The *maximally exposed individual* is a hypothetical person who lives at an off-site location and has a presumed lifestyle that produces the highest credible radiation dose. The following exposure pathways were included in the calculated dose potentially received by this maximally exposed individual in 1994:

- inhalation of air downwind,
- submersion in the airborne plume, and
- consumption of food and water contaminated by fallout.

The characteristics and assumptions used to calculate this individual's dose maximize the contributions of all realistic environmental pathways of exposure to radionuclides. In reality, these assumptions overestimate the dose (because no one actually lives under the presumed conditions). Thus, this is not an actual dose received by anyone, but an upper-limit estimate.

The dose to the maximally exposed individual from SNL/California operations in 1994 was 0.013 mrem (1.3×10^{-4} mSv) effective dose equivalent (see Tables 5-1 and 5-2). This dose represents the total exposure from all emission sources and all exposure pathways (i.e., inhalation, air submersion, and ingestion).

The current DOE radiation protection limit for the public is 100 mrem/yr. (1 mSv/yr.), which is consistent with the recommendations of the International Commission on Radiological Protection. Thus, the maximum calculated dose was 0.013% of the allowable standard.

Air Pathway Dose (Clean Air Act Standards)

The EPA has established radiation dose limits for protection of the public in the Clean Air Act (CAA)—Title 40 CFR, Part 61, Subpart H, the National Emission Standards for Hazardous Air Pollutants (NESHAPs) Radionuclide Rule. Under the Rule, no member of the public shall receive a radiation dose of more then 10 mrem/yr. from emissions to the atmosphere. To demonstrate compliance with the CAA, SNL/California must calculate the air pathway dose using the CAA Assessment Package, 1988 (CAP88) computer codes. This software contains exposure characteristics and dose factors specified by the EPA.

Because only the air pathway contributes to off-site doses at SNL/California, this dose is the same as the maximally exposed individual dose. Therefore, the 1994 air pathway dose was 0.013 mrem, which is 0.13% of the CAA limit.

Population Dose

The regional population dose from SNL/California operations was estimated by calculating the radiation dose to the total population residing within an 80-km (50-mile) radius of the SNL/California site. Exposure to regional populations can include the following pathways: inhalation, air submersion, and ingestion. The population dose is referred to as the *collective effective dose equivalent.* It is expressed in units of person-rem or person-Sv.

The collective dose for 1994 was 0.7 person-rem (0.007 person-Sv). There are no regulatory limits for collective dose. DOE Order 5400.5 requires an estimate of the collective dose as an additional evaluation of public impact of site operations. This population dose is 4×10^{-5}% of the estimated 1.9×10^{6} person-rem collective effective dose equivalent from natural background radiation (assuming 300 mrem/yr. as a conservative average dose).[1]

PERSPECTIVES ON RADIATION EXPOSURES

This section provides basic information about the sources of radiation exposure and compares various levels of radiation doses. Thus, it is intended to more clearly explain the radiation doses resulting from SNL/California operations. The calculated *maximum* dose from SNL/California operations in 1994 was 0.013 mrem. This dose is extremely small compared to Federal standards and natural background levels of radiation. To compare, note that the national average radiation dose received by the general public from both natural and man-made sources of radiation is approximately 365 mrem/yr. (see Fig. 5-2).

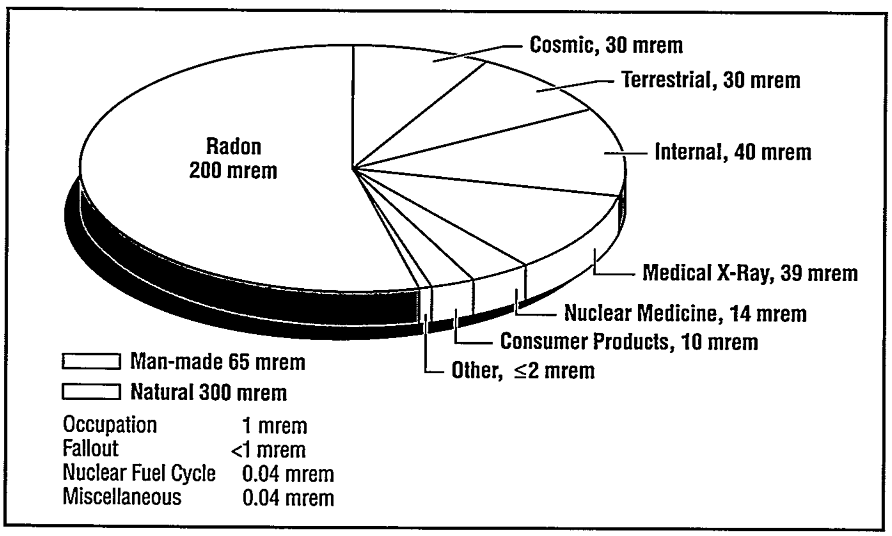


Figure 5-2. Sources of radiation received by a U.S. resident.

Natural Background Radiation

The major source of radiation exposure to the public is attributed to radiation from naturally occurring radioactive materials in the environment, or *background* radiation. This exposure occurs from both external and internal sources, including cosmic radiation from the sun. Recent evidence suggests that as much as two-thirds of a person's background dose come from naturally occurring radon gas, which accumulates in buildings. Radioactive materials also are in the environment as a result of former nuclear weapons testing.

The amount of radiation exposure an individual receives varies according to location and lifestyle. In the Livermore area, background radiation dose is about 200–300 mrem/yr.

Cosmic Radiation

Energetically charged particles from space continuously enter the Earth's atmosphere. These particles, along with secondary particles and photons they create, are referred to as *cosmic radiation.* Because the atmosphere provides a shielding effect, the intensity of this radiation increases with altitude above sea level. The average annual dose to people in the U.S. from cosmic radiation is about 27 mrem.[2] Due to the higher elevation, people living in the Rocky Mountain states receive an annual cosmic radiation dose of 60–80 mrem.

Terrestrial Radiation

Terrestrial radiation refers to radiation emitted from radioactive materials, primarily potassium (^{40}K), isotopes of thorium (Th), and isotopes of uranium (U), in the Earth's rocks and soils. The average annual dose from terrestrial gamma radiation is about 28 mrem, but varies geographically across the U.S.[2] For example, this dose has been measured to be about 63 mrem on the eastern slopes of the Rocky Mountains.

Internal Radiation

Natural radionuclides in the environment enter the body through inhalation and through ingestion of foods, milk, and water. These radionuclides are metabolized in the body similarly to nonradioactive elements, although each element is metabolized differently. Natural radionuclides include isotopes of uranium, thorium, radium, radon, polonium, bismuth, and lead from the ^{238}U and ^{232}Th decay series. In addition, the body contains isotopes of potassium (^{40}K), tritium (^{3}H), rubidium (^{87}Rb), and carbon (^{14}C).

The major contributors to the annual dose equivalent for internal radionuclides are the short-lived decay products of radon (mostly ^{222}Rn), which account for an average dose of about 200 mrem/yr. in the United States. Radon gas, a decay product of the uranium series, accumulates in buildings. Radon levels vary widely according to geographical area.

The average dose from other internal radionuclides is about 39 mrem/yr., which is predominantly attributed to the naturally occurring radioactive isotope of potassium, ^{40}K. A small fraction of all potassium is ^{40}K. Thus, any food containing potassium also contains small amounts of ^{40}K. The concentration of ^{40}K in human tissues is similar in all parts of the world.[2]

Man-made Sources of Radiation

In addition to natural sources, most people are exposed to a number of man-made sources of radiation. The average person in the U.S. receives approximately 65 mrem/yr. from medical procedures (e.g., x-rays) and radioactive materials in consumer products.

Many consumer products contain radioactive materials. For some products, like smoke detectors, the ionizing radiation is required for the functioning of the device. Other products, such as televisions, give off radiation as an incidental by-product. Table 5-3 gives examples of common consumer products containing radioactive materials. The U.S. average annual individual dose from consumer products is about 10 mrem.[2]

Radiation is an important tool of diagnostic medicine and cancer treatment. In general, medical exposures from diagnostic or therapeutic x-rays result from radiation beams directed to specific areas of the body. Thus, all body organs normally are not irradiated uniformly. Nuclear medical examinations may also involve the internal administration of radioactive materials or radionuclides to the patient. The average annual effective dose equivalent for the U.S. population from medical examinations is 53 mrem (about 39 mrem for diagnostic x-rays and 14 mrem for nuclear medical procedures).[3] The actual dose an individual receives depends on the number and type of treatments received each year.[3]

A few other sources of radiation contribute minor doses to people in the United States. The dose to the general public from the nuclear fuel cycle—such as uranium mines, mills, fuel processing plants, nuclear power plants, and transportation—has been estimated at less than 1 mrem/yr.[2]

Small doses to individuals occur as a result of radioactive fallout from: atmospheric nuclear weapons tests, which were conducted before the 1960s; emissions of radioactive materials from other nuclear facilities, such as DOE facilities; and transportation of radioactive materials. The combined dose from these sources contributes less than 1 mrem/yr. to the average person in the U.S.[2]

Table 5-4 lists examples of radiation doses from a variety of sources. This table presents a range of radiation doses to help add perspective to the doses discussed in this report.

REFERENCES

1. U.S. DOE, Order 5400.5, *Radiation Protection of the Public and the Environment* (March 1988).

2. U.S. National Council on Radiological Protection and Measurement, *Ionizing Radiation Exposure of the Population of the United States*, Report #93 (1987).

3. U.S. National Council on Radiological Protection and Measurement, *Exposure of the U.S. Population from Diagnostic Medical Radiation*, Report #96 (1989).

Table 5-1. Dose Summaries.

Pathway	Dose (mrem/yr.)	Organ	Dose (mrem/yr.)
Internal Dose	1.3×10^{-2}	Gonads	1.3×10^{-2}
Ingestion	0.7×10^{-2}	Breast	1.3×10^{-2}
Inhalation	0.6×10^{-2}	Bone marrow	1.3×10^{-2}
		Lungs	1.3×10^{-2}
External	0	Thyroid	1.3×10^{-2}
Air Immersion	0	Bone surface	1.0×10^{-2}
		Remainder	1.5×10^{-2}
Total Effective Dose Equivalent	**1.3×10^{-2}**		

Table 5-2. Effective Dose Equivalent and Individual Lifetime Risk for Critical Receptors.

Direction	Distance (m)	EDE[a] (mrem/yr.)	Risk[b]
NE[c]	1100	1.3×10^{-2}	3.6×10^{-7}
SE	800	6.3×10^{-3}	1.7×10^{-7}
SW	900	6.9×10^{-3}	1.9×10^{-7}
W	1200	8.7×10^{-3}	2.4×10^{-7}

[a]EDE = effective dose equivalent. Individual effective dose equivalent for all pathways.
[b]Individual lifetime risk. The risk to the maximally exposed individual (3.6×10^{-7}) indicates a probability of 1 chance in 2,800,000 of contracting a fatal cancer.
[c]Indicates location of maximally exposed individual (highest off-site radiological dose).

Table 5-3. Examples of Consumer Products Containing Radionuclides.

Product	Radionuclide	Activity
Timepieces[a]	Tritium	5–25 mCi
Aircraft Instruments[a]	Tritium Promethium-147 Radium-226	≤10 Ci ≤0.3 Ci ≤20 μCi
Marine Compasses[a]	Tritium	0.2–2 Ci
Exit Signs[a]	Tritium	2–15 Ci
Voltage Discharge Tubes	Promethium-147	3 μCi
Vacuum Tubes	Natural thorium	0.8–1.2%
Low Voltage Fuses	Promethium-147	3 μCi
Smoke Detectors	Americium-241 Radium-226 Natural uranium	0.1 mCi 0.01–15 μCi 7.5 mg

[a]The radioactive material is used for illumination.

Table 5-4. Comparison of Various Radiation Doses.

Dose Level (mrem)	Source/Description
0.013	Dose to maximally exposed individual from SNL/California operations in 1994.
1	Average daily radiation dose received by a U.S. resident.
5	Cosmic radiation dose to a person on a round-trip airplane flight from New York to Los Angeles.
10	Typical dose from one chest x-ray, using modern equipment.
10	Annual dose limit, set by the EPA under the Clean Air Act, for exposures from airborne emissions from operations of nuclear fuel facilities, including power plants, uranium mines, and DOE facilities.
33	Average yearly dose from cosmic radiation to people in the Livermore area.
66	Average yearly dose to people in the United States from man-made sources of radiation.
60–80	Average yearly dose from cosmic radiation to people in the Rocky Mountain states.
100	Annual limit of radiation dose from DOE facilities to a member of the public (all sources and all pathways).
170	Average yearly dose to an airline flight crew member from cosmic radiation.
300	Average yearly dose received by people in the United States from all sources of natural background radiation.
900	Average dose from a lower-intestinal medical diagnostic x-ray series.
1,000–5,000	EPA Protective Action Guidelines for nuclear accidents.
5,000	The BEIR V report estimated that an acute dose at this level would result in a lifetime excess risk of death from cancer of 0.8 percent.
50,000–100,000	Radiation doses in this range are likely to result in varying degrees of radiation sickness (complete recovery expected).
500,000–600,000	Radiation doses in this range would most likely result in death.

6 — Environmental Program Information

Environmental Restoration Program
Air Quality Management Program
Wastewater/Storm Water Control Programs
Waste Management Programs
Waste Minimization and Pollution Prevention Awareness Program
Chemical Information Management
Toxic Substance Control Act Compliance
National Environmental Policy Act Compliance

ENVIRONMENTAL RESTORATION PROGRAM

CERCLA and SARA mandate cleanup of toxic and hazardous contaminants at closed or inactive waste sites. SNL/California activities related to these laws are being addressed under the DOE Environmental Restoration Program and are directed by the State Regional Water Quality Control Board.

Currently, SNL/California is remediating two sites (Fig. 6-1): the Fuel Oil Spill and the Navy Landfill. A third previously listed site, the Trudell Auto Repair Shop, was cleaned up and officially closed in 1990. No new activities were carried out at this site in 1994. In addition, investigations were completed in 1993 at five sites with suspected contamination (Miscellaneous Sites). The Regional Water Quality Control Board Site Cleanup Order 88-142,[1] issued in September 1988, directs cleanup activities at SNL/California. This Order was modified in 1989 for the Fuel Oil Spill (Order 89-184).[2] The Environmental Protection Department is conducting these restoration activities, as described below.

Fuel Oil Spill

In 1975, as the result of an accidental puncture of an underground transfer line, 59,500 gallons of #2 diesel fuel spilled into the vadose zone from an above-ground reserve fuel tank. SNL/California has monitored the groundwater in this area since 1985. It shows occasional low-level contamination with fuel oil components. Neighboring farmers sometimes use this aquifer as a source of drinking or agricultural water.

SNL/California completed a remedial investigation of the spill site in November 1988. In 1990, SNL/California, Argonne National Laboratory, and Notre Dame University performed several bench-scale tests to determine the most effective means of cleanup. The resulting treatability report indicated that bioremediation would be the most effective of the technologies tested in reducing fuel oil contamination. In 1991, *in situ* bioremediation tests were done. Bioremediation was proven effective, but it proceeds at a slower rate than laboratory tests done in slurry reactors.

In December 1990, Argonne began groundwater flow and contaminant transport modeling to support the pilot bioremediation system design. Using a computer code developed at Los Alamos National Laboratory and monitoring well data, experts at Los Alamos prepared a three-dimensional model characterizing the spill area. Argonne conducted additional bench-scale studies at Notre Dame to establish required nutrient and oxygen levels and to identify degradation products. SNL/California completed three groundwater wells downgradient of the spill site to monitor the spread of the contaminated groundwater.

After heavy rainfall in the spring of 1993, the groundwater at the Fuel Oil Spill site rose about 3.6 m (12 ft.). Diesel and BTEX contamination were noted during the second-quarter groundwater sampling. As a result, the Regional Water Quality Control Board directed SNL/California to implement an Interim Remedial Measure, a groundwater treatment system. Because SNL/California is planning to move the system to a permanent location (to serve as the water treatment system for the Fuel Oil Spill pilot study nutrient injection and withdrawal systems), it has been termed the "Temporary Interim Remedial Measure."

In the fall of 1993, the Regional Water Quality Control Board approved SNL/California's work plans for the Fuel Oil Spill pilot study and the Temporary Interim Remedial Measure. SNL/California completed the Fuel Oil Spill site plan in October 1993 and the Temporary Interim Remedial Measure work plan and system design in December 1993.

SNL/California completed site preparation—including fencing, gates, site

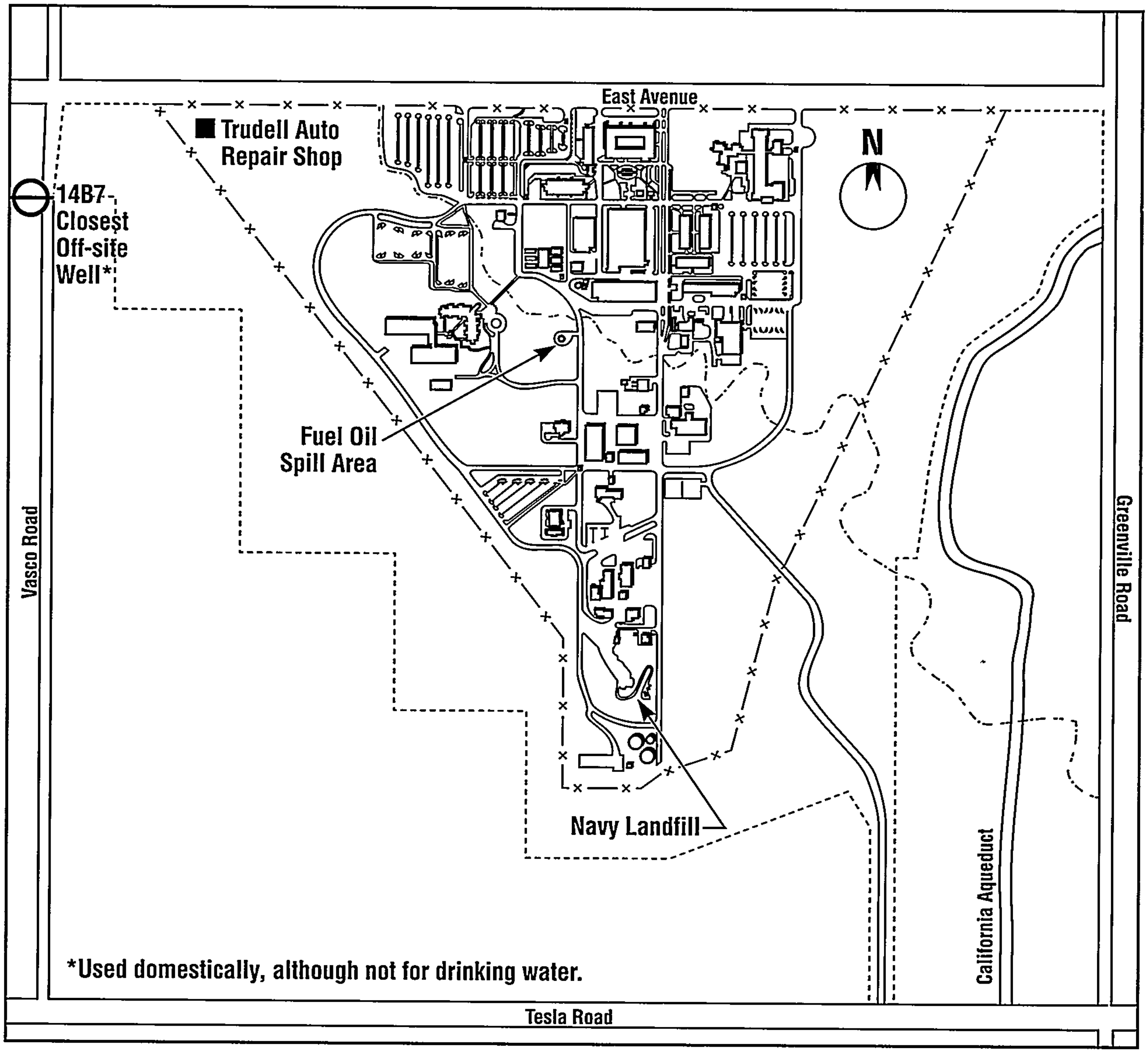


Figure 6-1. SNL/California remediation sites.

grading, gravel, and paving—in December 1993. Using the conceptual design from Argonne National Laboratory, SNL/California installed a free product separator and carbon filtration beds in January 1994. The Temporary Interim Remedial Measure went on-line in early February 1994.

In March and April 1994, SNL/California drilled ten monitoring boreholes and installed downhole instrumentation, five injection/withdrawal wells, four Zone 1 withdrawal wells, and five geophysical logging boreholes. SNL/California set up a small landfarm (*ex situ* bioremediation) to treat the drill cuttings from the wells and boreholes. The landfarm will reduce the contamination in the soil to less than 50 ppm.

During the summer of 1994, utility hookups were completed, and the data acquisition software was finished and installed. Following these activities, SNL/California installed a subsurface infiltration gallery, seven tensiometers, and a remote barometer at the pilot study site. Multiplexers and data loggers were installed and connected to the computers. The data collection computer system began baseline monitoring for temperature, pressure, and soil moisture. This system comprised 158 information channels collecting data once every minute, 24 hours per day.

In late November 1994, SNL/California completed the construction of the pilot study system. The components of the Temporary Interim Remedial Measure were moved into the pilot study system and were tested. The Final Interim Remedial Measure now is continuously operating. SNL/California will conduct a small-scale, flow-through test in April 1995. The bioremediation pilot study is expected to begin in June 1995.

Navy Landfill

An inactive landfill is located at the southern end of the SNL/California site. It was used by the Navy during and shortly after World War II, and again by LLNL in the 1950s and early 1960s. A survey of historical records and landfill contents indicated that only general construction debris and machine turnings were disposed of at the site. There is no indication of any hazardous materials being buried at this landfill. The landfill measures approximately 11,300 m^2 in area and 68,800 m^3 in volume.

The landfill appeared on the State of California's Solid Waste Water Quality Assessment Test Program list in December 1987. Consequently, the State required a wastewater quality assessment test proposal (equivalent to a remedial investigation plan). SNL/California submitted the proposal in March 1993 and a report in 1994.[3,4]

To characterize the site, SNL/California installed an upgradient well, three downgradient wells, a piezometer, and two lysimeters. Two additional wells were installed in 1993, under the direction of the Regional Water Quality Control Board, to provide additional information about the groundwater at the site. The wells and the lysimeters are sampled quarterly.

Trudell Auto Repair Site

The DOE purchased the Trudell Auto Repair Shop in 1987 to expand SNL/California's security buffer zone. At the time of purchase, the land surrounding the shop was contaminated with oil, lead, and low levels of chlorinated solvents resulting from improper disposal procedures. The contamination at the site was not due to DOE or SNL/California activities. However, SNL/California completely cleaned up the site, and the Regional Water Quality Control Board officially closed it in 1990. As part of post-closure surveillance, SNL/California continues to monitor the groundwater beneath the site.

Miscellaneous Sites

As directed by the Regional Water Quality Control Board, SNL/California assessed areas suspected of being contaminated by past operations. In 1993, SNL/California analyzed soil from sites identified during the DOE's *1988 Environmental Survey.* The results of the analysis showed no contamination above RCRA action levels. SNL/California submitted a report on the sampling and analyses to the Regional Water Quality Control Board.[5] One of the Miscellaneous Sites (the "burn pit") was incorporated in the Navy Landfill closure. On April 27, 1994, the Regional Water Quality Control Board approved closure of the Miscellaneous Sites, with no further action required.

Underground Storage Tank Management

SNL/California complies with Federal and State requirements for underground storage tanks.[6] SNL/California has two regulated underground storage tanks.

One 500-gallon tank was installed in a vault behind Bldg. 964 in 1986 to store diesel fuel for emergency power generators. It is constructed of double-walled fiberglass and is equipped with a Leak Alert™ system (Universal Sensors & Devices), which meets all tank monitoring requirements.[6] The Leak Alert™ system has two sensors—metal-oxide semiconductors—which detect organic vapors. These sensors are connected to a signal panel, which emits both audio and visual alarms.

The second underground storage tank is a 950-gallon steel tank in a containment vault located below grade, north of the Tritium Research Laboratory. This tank stores diesel fuel for the building's emergency generator.

Spill Prevention Control and Countermeasure Plan

The *Spill Prevention Control and Countermeasure Plan* establishes procedures for controlling, and if necessary, remediating oil spills at SNL/California.[7] The plan was prepared in accordance with Title 40 CFR, Part 112.[8] It was approved in December 1992. Site personnel have been trained in spill response procedures.

AIR QUALITY MANAGEMENT PROGRAM

In 1994, SNL/California continued activities to assure site-wide compliance with air quality regulations. These activities are directed toward assuring adequate evaluation of air permit requirements and other applicable regulations. Operations at SNL/California are subject to the rules and regulations of the Bay Area Air Quality Management District, the State Air Resources Board, and the EPA, which have jurisdiction over facilities that emit air contaminants.

SNL/California's Air Quality Management Program identifies and evaluates potential sources of air pollutants, and documents compliance requirements. The Air Quality Group (Environmental Operations Department) maintains the site-wide air emissions source inventory, which provides data on materials, equipment, and operations that are subject to air quality regulations. The Air Quality Group also prepares applications for air permits or exemption requests as needed in conjunction with this inventory.

In 1994, SNL/California operated 32 permitted sources and 37 exempt sources. SNL/California annually reports air emissions from these sources to the Bay Area Air Quality Management District, at the time of permit renewal.

In 1993, the Air Quality Management Program started SNL/California's Employer Trip Reduction Program to help reduce air pollution by reducing automobile trips to the work site. In October 1994, SNL/California completed a employee commute survey, which was required by the Bay Area Air Quality Management District, to determine the number of vehicles arriving at SNL/California each day. The survey results, based on a 96.8% response rate, were used to calculate Sandia's vehicle-to-employee ratio: 0.77 (i.e., 77 vehicles for every 100 employees). This ratio surpasses Sandia's 1994 goal of 0.87 and fully meets all trip reduction goals through 1997.

In 1994, SNL/California also participated in the Bay Area Air Quality Management District's *Spare the Air Campaign,* which is designed to inform the public and employers of days when air pollution is approaching unhealthful levels. On these "spare the air days," the District and participating employers request individuals to curtail or postpone pollution-causing activities. The District recognized SNL/California as one of the top 14 employers out of 420 participating companies in the Bay Area and awarded SNL/California for outstanding efforts in the *Spare the Air Campaign.*

WASTEWATER/STORM WATER CONTROL PROGRAMS

Wastewater Management Program

The primary goal of the Federal CWA is to protect and restore the integrity of the nation's waterways. The CWA establishes the National Pollutant Discharge Elimination System (NPDES), which requires permitting of all point-source liquid effluent discharges. These permits contain specific criteria for discharging liquids to waterways. The State of California has authority to enforce the requirements of the CWA. The Livermore Water Reclamation Plant is responsible for permitting and enforcement of SNL/California's wastewater; the plant has issued SNL/California a permit for discharging wastewater to the municipal sewer system. The permit contains specific pollutant limitations and monitoring requirements.

During the last few years, the government has implemented more stringent regulations governing industrial wastewater discharges to public sewer systems. SNL/California always has maintained a program to control liquid effluents. This program incorporates administrative and engineering controls to prevent contaminated wastewater from being discharged to the municipal sewer system.

In 1994, SNL/California developed the Wastewater Waste Minimization Program to reduce pollutants in wastewater discharge, protect the environment, and ensure compliance with Federal, State, and local regulations. This program involves several stages.

The first step is a wastewater survey designed to collect the information needed to identify wastewater sources on site.

The next step is to develop and implement a drain registration program. This program will track and maintain the information collected during the site survey and will update it.

The final step is to identify and select wastewater minimization opportunities.

SNL/California also has developed an informational brochure, which is being distributed to site personnel. The brochure provides general guidelines to SNL/California personnel about what can and cannot be discharged into the sanitary sewer.

Liquid Effluent Control Systems

The Liquid Effluent Control Systems (LECS) are key elements of SNL/California's wastewater management. The LECS comprise large, monitored, holding tanks, which collect and retain wastewater generated at key facilities. These systems allow SNL/California to analyze the wastewater and verify that its constituents are within acceptable limits before discharging it to the sanitary sewer system. SNL/California has six LECS in operation, at the following locations (see Fig. 4-2 in Chapter 4): Bldg. 913 (Electroplating Laboratory), Bldg. 910 (Printed Wiring Laboratory), Bldg. 961 (Hazardous Waste Facility), Bldg. 968 (Tritium Research Laboratory), Bldg. 906 (Combustion Research Facility), and Bldg. 941 (Integrated Manufacturing Technologies Laboratory).

Sewer Diversion Facility at LLNL

The combined SNL/California and LLNL sewer effluent is discharged to the City of Livermore municipal sewer system at the northwest corner of the LLNL site. To better control effluents and increase protection of the Livermore Water Reclamation Plant, LLNL and SNL/California constructed a sewer diversion facility at LLNL. This system can retain approximately 200,000 gallons of contaminated sewage on-site, if necessary, for further evaluation.

Storm Water Management Program

Amendments to the CWA in 1987 require permits for storm water discharges from municipal storm drain systems and storm water discharges associated with industrial activities. In 1990, the EPA published specific permit requirements. With permitting authority, California's Water

Resources Control Board adopted the General Industrial Activities NPDES Storm Water permit (for storm water discharge) in 1991, which was later amended in 1992. It allows industrial facilities in California* to be in compliance with the Federal storm water permitting requirements by filing a Notice of Intent with the Board. SNL/California has filed a Notice of Intent and must comply with the requirements of the permit. Although the State Water Resources Control Board administers the storm water permit, SNL/California is regulated by the Regional Water Quality Control Board.[9]

In response to the permitting requirement of the Federal CWA for municipal storm water discharges, the City of Livermore adopted ordinances that also require SNL/California to manage storm water discharges to the City's storm drain system. The Livermore Water Reclamation Plant enforces City storm water ordinances.

SNL/California complies with Federal, State, and local storm water requirements through a comprehensive Storm Water Management Program. This program includes the Storm Water Pollution Prevention Program and the Storm Water Monitoring Program.

Storm Water Pollution Prevention Plan

The *Storm Water Pollution Prevention Plan* identifies activities that result in non-storm water discharges to the storm drain system and describes how these discharges are eliminated.[10] It identifies sources and activities that could allow pollutants to be deposited on impervious surfaces and picked up by storm water runoff. It also describes how SNL/California minimizes these pollutant sources discharged with storm water runoff by implementing best management practices.

Because the SNL/California site continually changes, the *Storm Water Pollution Prevention Plan* is a living document. It is updated regularly to reflect these changes.

Storm Water Monitoring Program

The purpose of the Storm Water Monitoring Program is to optimize SNL/California storm water pollution prevention activities. It consists of extensive visual inspection and sampling activities, which include:

- *Dry Weather Visual Inspection*—During dry weather, no water should be flowing in the storm drain system. SNL/California inspects all storm drain outfalls that discharge into the site's two main storm water conveyances (the Arroyo Seco and the drainage channel along East Avenue) for any flow or evidence of past flow (such as sludge or stains) at least twice from May through September.
- *Wet Weather Visual Inspection*—SNL/California also inspects all storm drain outfalls discharging into the site's two main storm water conveyances during storms to see if storm water runoff is picking up pollutants from the site. These inspections are conducted once per month from October through April, during a storm that produces runoff.
- *Storm Water Sampling*—When it has rained enough to produce runoff, SNL/California collects storm water samples from up to eleven sampling locations, during at least two separate storms. Chapter 4 describes each sampling location and the results of Sandia's storm water sampling activities in 1994.
- *Annual Site Inspection*—The annual site inspection ensures that best management practices are effectively implemented. Findings from the site

* *The California General Industrial Activities NPDES Storm Water Permit applies to regulated facilities throughout California, except facilities located in Santa Clara County. The San Francisco Bay Regional Water Quality Control Board has adopted a separate NPDES permit for facilities in Santa Clara County.*

inspection are used to update the *Storm Water Pollution Prevention Plan.*

Storm water monitoring information is used to identify potential sources of pollutants and non-storm water discharges.

In 1994, SNL/California completed all dry season, wet season, and annual site inspections. Storm water samples were collected from all storm water sampling locations (see Fig. 4-13 in Chap. 4), except Location Y, which represents the Arroyo Seco as it enters the site. No water was flowing in the Arroyo upstream of the site.

Because collecting samples in the Arroyo Seco is often dangerous under storm conditions, SNL/California conducted a pilot test using an automatic storm water sampler. The automatic sampler effectively collected storm water samples. However, locating a power supply was a problem. SNL/California personnel are investigating reliable power sources. SNL/California will install automatic samplers at locations D, Y, and Z, as budget allows.

To increase storm water pollution prevention awareness on site, SNL/California has developed a general storm water informational brochure. SNL/California also has developed four best management practices brochures, which target potential storm water pollution from construction activities, vehicle and heavy equipment maintenance, material handling, and building maintenance. These brochures will be used to train site personnel, including contractors and subcontractors, on practices that minimize the site's impact on storm water quality.

WASTE MANAGEMENT PROGRAMS

RCRA, as amended by the Hazardous and Solid Waste Amendments of 1984, requires a comprehensive program for managing hazardous wastes from generation to ultimate disposal. The primary goals of RCRA are to reduce the volume and toxicity of wastes and to minimize the amount of waste requiring land disposal. The California Hazardous Waste Control Law is similar to, but more restrictive than, RCRA. The EPA authorized the State to assume authority for implementation in August 1992. This authority is enforced by Cal/EPA's Department of Toxic Substances Control.

Hazardous waste activities at SNL/California include collection, on-site transportation, consolidation, commingling, treatment, and storage of energetic, radioactive, mixed, and nonradioactive hazardous wastes. SNL/California has not disposed of and does not plan to dispose of hazardous wastes at the site. Small quantities of energetic wastes, medical wastes, and classified film have been incinerated on site in the past. SNL/California maintains an operating procedure, a contingency plan, and a closure plan for its small incinerator. These plans are reviewed and updated as required. SNL/California submitted a RCRA Part B permit application, with Subpart O exemption for operation of the incinerator, to the EPA and the Cal/EPA. However, SNL/California has decided not to use the incinerator in the future and has sent a draft closure plan for the incinerator to the DOE. This plan will be forwarded to the Cal/EPA in early 1995.

In 1989, SNL/California implemented a computerized tracking system for all hazardous, mixed, and radioactive wastes. This system tracks wastes from the point of generation to final disposal. Table 6-1 summarizes the 1994 waste generation rate at SNL/California.

In 1992, SNL/California began to tie the waste management tracking system into the site-wide chemical inventory system. This effort was discontinued in 1993 due to lack of funding. Progress resumed in 1994, and implementation is scheduled for 1996.

Hazardous Waste

Hazardous waste is a material with no further end use, which is not radioactive, but contains constituents that may be harmful to human health or the environment. The EPA and the Cal/EPA regulate wastes identified in RCRA and in the California Hazardous Waste Control Law, respectively.

SNL/California sends all nonradioactive hazardous wastes generated on site to permitted commercial facilities for treatment or disposal. Table 6-2 lists the hazardous waste transportation and disposal companies SNL/California used in 1994. SNL/California shipped an average of approximately 4,600 kg/month chemical waste off-site for disposal in 1994.

Radioactive Waste

SNL/California typically generates very small amounts of radioactive waste, which are sent to the Nevada Test Site for disposal. SNL/California is working with the DOE Nevada Operations Office to revise the waste approval program to include additional, radioactive waste streams. SNL/California shipped three loads of low-level radioactive waste (approximately 112 m^3) to the Nevada Test Site in 1994. Most of the waste was generated by the cleanup and transition of the Tritium Research Laboratory. SNL/California is storing small volumes (less than 7 m^3) of low-level radioactive waste from other research and development activities. No transuranic nor high-level radioactive wastes are generated at the SNL/California site.

Mixed Waste

Mixed waste is a hazardous waste that also contains radionuclides regulated by the Atomic Energy Act. SNL has decided to manage all mixed waste at the SNL/New Mexico site. In 1994, SNL/California began planning to transfer all mixed waste to SNL/New Mexico for management. SNL/California will no longer store mixed waste on site.

WASTE MINIMIZATION AND POLLUTION PREVENTION AWARENESS PROGRAM

SNL/California has supported various waste minimization activities since 1985. These efforts have evolved into the Waste Minimization and Pollution Prevention Awareness Program. The program's principal objective is to maximize all opportunities for eliminating or minimizing waste through source reduction, reuse, and recycling. Waste that cannot be reduced, reused, or recycled is treated through available treatment technology. The program reflects ongoing efforts to integrate pollution prevention and waste minimization into the site's operating philosophy. The increases in waste management costs and the public's interest in environmental issues provide added incentives for an effective program.

SNL/California has implemented a variety of waste minimization techniques. These are supported by employee training programs aimed at reducing waste while meeting the company's requirements for quality, productivity, safety, and environmental compliance.

A key element of the Waste Minimization and Pollution Prevention Awareness Program is the development of baseline information on waste generation. Sandia has established a corporate Pollution Prevention Team to assist in the ongoing evaluation and evolution of the waste minimization program. Its primary functions are to make all SNL employees aware of the program, identify tasks to implement the program, and provide a mechanism for communicating waste minimization issues within the SNL community and to the public. The Pollution Prevention Team is responsible for developing, designing, creating, and overseeing implementation of waste minimization projects. Waste generators are responsible for implementing the program.

SNL/California's waste minimization and pollution prevention efforts demonstrate both the commitment and involvement of SNL/California's management and staff. These efforts include the following:

- Waste Minimization and Pollution Prevention Awareness Program awareness has been incorporated into several required ES&H training courses and is provided at monthly new-hire orientations.
- SNL/California hosts an Earth Day exhibit annually, which includes internal programmatic activities, external regulatory agencies, and commercial representatives.
- The Solvent Substitution Technical Advisory Committee and Chlorofluorocarbon Elimination Working Groups help users find less hazardous or nonhazardous solvents and cleaning agents.
- SNL/California employees substitute safe alternatives for hazardous chemicals whenever possible.
- SNL/California developed and implemented a trip reduction program. The purpose of this program is to reduce air pollution by reducing vehicle trips to the site.
- Waste minimization personnel conduct site-wide waste minimization activities surveys to determine the usage of waste minimization practices around the site.
- Mulching mowers are used to reduce yard waste. In addition, SNL/California is studying a composting process to use yard waste generated on site.
- Toner cartridge recycling began in December 1992; 525 toner cartridges were recycled in 1994, netting a revenue of $933.00. This recycling effort also saved 6 m^3 (210 ft.^{3}) landfill space.
- The SNL/California Materials Management Department, General Stores, stocks environmentally safe products and products containing post-consumer recycled material.
- SNL/California has supported a metal recycling program for several years. The metal recycled in 1994 netted $25,400 in revenue.
- The Property Reapplication and Reclamation Department reassigns excess equipment to internal or external organizations.
- Paper and aluminum cans throughout the site are recycled. In 1994, more than 26,000 kg (58,000 lb.) paper and more than 450 kg (1,000 lb.) cans were collected for recycling.
- Tires from the Maintenance Department are recycled as a part of LLNL's tire recycling program.
- The Waste Management Group recycles hazardous wastes whenever possible. Some examples are batteries, mercury, coolants, petroleum oil, empty drums, and lead. Silver from photochemicals (fixers and developers) is reclaimed whenever possible.
- The Tritium Research Laboratory has reduced its tritium inventory to less than 0.1 g. The Cleanup and Operations Team managed their cleanup efforts well ahead of schedule and under budget. More than $10 million worth of excess equipment was shipped to and reused by other DOE facilities. More than $110,000 in disposal fees and more than 90,000 kg (200,000 lb.) waste were saved.
- The wastes generated by laboratory processes are assessed (through pollution prevention opportunity assessments) to determine if they can be eliminated or reduced.

The Waste Management Group tracks all regulated waste generation information. The Facilities Operations and Property Management departments track and maintain all nonhazardous waste information. The quantities listed in Table 6-3, except for sanitary waste, are based on the manifested shipment database for calendar years 1993 and 1994, respectively. Table 6-4 shows the results of SNL/California's recycling efforts in 1994.

Pollution Prevention Opportunity Assessments

SNL/California conducts "pollution prevention opportunity assessments," under the direction of the DOE. These assessments evaluate material management and waste generation activities of site processes to identify waste minimization opportunities.

During 1994, SNL/California has continued to reduce the amount of waste generated on site through the Pollution Prevention Opportunity Assessment Program.

Five assessments were completed in 1994, for the following facility processes: the Plotting and Digitizing Support Laboratory, the Radiography Laboratory, Solid Office Waste, Waste Management Facilities, and the Scientific Computing Operations Digital Photo Imaging Laboratory. In addition to the five assessments, three reassessments were conducted, for the following facility processes: the Electroplating Laboratory, the Photo Laboratory, and the Printed Circuit Laboratory. SNL/California reassesses processes every 18 to 24 months after the initial assessment. Sandia also tracks process waste generation biannually (after assessment) to help track waste minimization progress. The results of the 1994 assessments and reassessments are summarized below.

Plotting and Digitizing Support Laboratory

The laboratory's main processes consist of a Gerber photo plotter and an AGFA Rapidline 66 film processor. Photo-circuit masters are designed and processed onto film. The photo plotter exposes the master onto film, and the AGFA film processor develops the film. The processor generates most of the hazardous waste in the form of spent developer and fixer. This self-contained unit is fitted with automatic chemical replacement and a rinse water unit.

To minimize waste, this facility could recycle water and could fit the processor with a filtration/recirculation system.

Radiography Laboratory

The Radiography Laboratory performs film radiography or radioscopy (electronic imaging) on weapon and nonweapon components. The majority of hazardous photochemical waste is generated by a DuPont NDT 100 Film Processor. A small amount of radioactive waste also is periodically generated as radioactive sources become obsolete. Steps already instituted to minimize waste include: 1) reducing the volume of photochemicals used in processing by 50%, and 2) using more real-time radiography to reduce the need for film processing.

Office Solid Waste

The purpose of this assessment was to document the amounts and types of nonhazardous waste generated by office staff during a one-week period. Building 922 was used as a representative sample. This building houses the SNL/California ES&H departments (about 80 people) and covers approximately 10,000 ft.^{2}. A waste minimization team sorted all the trash from the building during a one-week period (including paper and aluminum cans in the recycling bins). The trash was categorized as paper, plastic, glass, wet garbage, restroom waste, and miscellaneous materials. The total amount of trash collected during the week was approximately 169 kg (371 lb.). The average daily occupancy of the building was 65 people; thus, each person averaged approximately 5.7 lb. trash per week.

Overall, the results of this assessment show that SNL/California is practicing waste minimization of nonhazardous office waste (especially through paper and aluminum can recycling programs). However, SNL/California could implement additional recycling programs for cardboard and glass.

Waste Storage Facilities

SNL/California's waste management facilities—the Hazardous Waste Storage Facility and the Radioactive and Mixed Waste Storage Facility—generate a secondary stream of hazardous and radioactive waste. This waste is produced during routine collection and processing of waste. The total amount of secondary hazardous waste generated in the waste management facilities from January 1993 to July 1994 was 1160.6 kg. The total amount of secondary radioactive waste generated during the same period was 1528.8 kg (with an activity of 0.070 mCi). No mixed waste was generated.

The following options were proposed for the Hazardous Waste Storage Facility: 1) recycle glass containers; 2) attribute the disposal of empty containers to generators' waste streams; and 3) dispose of empty containers as municipal waste, when possible.

The following options were proposed for the Radioactive and Mixed Waste Storage Facility: 1) open packages in a lay-down area instead of in radiological material management areas (the latter requires the material to be classified as radioactive waste); 2) Package tritium scintillation vials in plastic bags for disposal; 3) use smaller scintillation vials to reduce the amount of waste; 4) reduce the number of radioactive materials management areas; 5) install a hand blow dryer to eliminate paper towel waste; and 6) discontinue using the facility for mixed waste.

Network Operations' Digital Photo Imaging Laboratory

The Network Operations' Digital Photo Imager is a part of the Infrastructure and Networking Research Department. The imager provides slides, prints, and transparencies directly from computer files. Its major volume of waste is generated by two Ilford Digital Photo Imager processors. This process produces approximately 900 kg photochemical waste per year. Due to a shift in mission, this process will no longer be needed in the future. Thus, the waste stream will be eliminated entirely.

Electroplating Laboratory Reassessment

The following waste minimization activities have been accomplished since the initial assessment in 1992:

- The cadmium plating process was replaced with tin-zinc and zinc-nickel alloy processes.
- The Oakite 90 cleaning solution will be replaced as soon as a satisfactory replacement is found.
- The Environmental Operations Department has implemented the Chemical Information System to track all chemicals on site; this system has reduced the amount of chemicals kept in stock around the site.

The Electroplating Laboratory is moving to a new location. With this move, the following process changes and waste minimization activities will be implemented:

- The new processing lines will be modified to improve efficiency and process flow.
- An acid recovery system will be installed to reclaim acids for reuse.
- Laboratory personnel are looking for a system to reclaim alkalines. Alkalines will be neutralized until a system can be found.

Photo Laboratory Reassessment

The following waste minimization activities have been accomplished at the Photo Laboratory:

- A new, smaller Hope/Kodak C-41 Processor, requiring 50% less solution, has been installed.
- The Chemical Information System is being used to track chemicals for this laboratory.
- Two of the four Royal Print Processors have been shut down.

The Photo Laboratory personnel are evaluating digitized processor units.

Printed Circuit Laboratory Reassessment
The following waste minimization activities have been accomplished at the Printed Circuit Laboratory since October 1992:

- The Chemical Information System is tracking all chemicals, thereby minimizing the inventory of chemicals in the laboratory's stock.
- Chemical baths are monitored and adjusted, if possible.
- A permit has been obtained to allow alternate treatment for spent chemical solutions.

The following waste minimization/ process improvements are planned for the future:

- The laboratory personnel are evaluating a system to neutralize spent chemical baths. This system would allow the spent solutions to be disposed of as nonhazardous wastewater.
- The laboratory personnel have begun treating the rinsate and disposing of it to the sanitary sewer. The Environmental Operations Department analyzes the rinsate before it is discharged to the sewer.

Assessments Scheduled for 1995
Three pollution prevention opportunity assessments are scheduled for 1995: the Supercritical Flow Reactor Laboratory, Technical Art operations, and the Flame Chemistry Laboratory. Four reassessments are scheduled for 1995: the Machine Shop, Mechanics Shop, Paint Shop, and Inorganic Solid Waste and Empty Containers <30 Gallons. The Environmental Protection Department will assess additional processes as waste streams are identified.

CHEMICAL INFORMATION MANAGEMENT

The Environmental Operations Department implemented a site-wide Chemical Information System/Material Safety Data Sheet management system in April 1992. This system is designed to help SNL/California more effectively comply with Federal, State and local regulations and DOE orders, and to improve the operating efficiency in chemical work areas. It is a computer database, which tracks chemical containers in facilities by bar-code labels. It has several unique features, including flexible software, which permits SNL/California to customize it for the inventory's special needs. The system provides detailed information on chemical usage on site, thus supporting numerous activities, including:

- Employee Right-to-Know/Material Safety Data Sheet,
- Emergency Planning and Community Right-to-Know Act (EPCRA),
- Waste Minimization,
- Hazardous Materials Management,
- Spill Information and Emergency Preparedness,
- Fire Protection,
- California Proposition 65, and
- General resources for audits, surveys, and information.

In 1992, SNL/California began to tie the waste management tracking system into the site-wide chemical inventory system to form a "cradle-to-grave" process (chemical procurement through waste management). Due to funding constraints, the program was delayed until 1994. Work on the project resumed in 1994, and anticipated implementation is in 1996.

TOXIC SUBSTANCE CONTROL ACT COMPLIANCE

The Toxic Substance Control Act (TSCA) establishes regulations to control the use of and exposure to new industrial chemicals. It identifies toxic substances and regulates their manufacture, use, storage, handling, and disposal. TSCA requires premanufacturing notification and evaluation of new chemicals to assess the health and environmental risks. It also regulates the use, inspection, and disposal of polychlorinated biphenyls (PCBs).

SNL/California removed all PCB transformers in response to a major sitewide electrical upgrade, conducted over the last few years. Most remaining PCB-contaminated electrical equipment (concentrations of 50 to 500 ppm) was removed or retrofitted with non-PCB-contaminated mineral oil. Only a few PCB-contaminated ballast switches and capacitors now remain on-site.

NATIONAL ENVIRONMENTAL POLICY ACT COMPLIANCE

The National Environmental Policy Act (NEPA) is the basic national charter for the protection of the environment. This law requires that SNL/California protect the environment by reviewing each new or changing project for potential environmental impacts. Environmental issues considered include air emissions, water and wastewater issues, waste generation and minimization, and the human environment (workers and the surrounding community). NEPA documents are available to the public and serve as a vehicle for the public to participate in the DOE's decision-making process.

A major SNL/California NEPA document, the site-wide *Environmental Impact Statement,* was published in August 1992.[11] The Secretary of Energy signed the Record of Decision in January 1993, which formally allows the DOE to continue operations at SNL/California. From an environmental perspective, this document discusses the existing and proposed mission and projects of SNL/California for the subsequent five to ten years.

The *Environmental Impact Statement* provides a baseline of environmental information by which Sandia evaluates the potential impacts of each proposed project, activity, and program. It discusses SNL/California's continuing operations to provide routine services to the entire site. Such routine operations include maintenance activities, administrative duties, and temporary office space and support activities.

Each proposed SNL/California project must be evaluated according to the DOE's *NEPA Implementing Procedures* (Title 10 CFR 1021).[12] The DOE Albuquerque Operations Office provides guidance to SNL/California regarding these implementing procedures. Part of the required NEPA documentation for every project is an Environmental Checklist, which is designed for Sandia staff members to describe their projects and identify potential environmental issues. The SNL staff member submits the checklist to the SNL/California NEPA analyst (in the Environmental Operations Department), who reviews the project and recommends an initial NEPA classification for the project. The checklist is then submitted to the DOE Albuquerque Operations Office for review and a NEPA determination. The DOE determines that the project (1) falls under a categorical exclusion, as defined in the implementing procedures, (2) is covered under the site's *Environmental Impact Statement,* or (3) requires further NEPA review and documentation. SNL/California does not make determinations on its own proposed projects.

In 1994, SNL/California formed an interdisciplinary team to participate in the review process for proposed projects' NEPA environmental checklists. This team comprises program representatives from the ES&H, Facilities, and Security Center. The point of contact for ES&H programs, who is also the site's NEPA analyst, leads and coordinates the team. Through this team, SNL/California ensures that ES&H regulatory requirements, site planning, security, and administrative issues are addressed early in the planning stages of a project. The interdisciplinary team review process complements the SNL/California NEPA review process by improving the quality of the NEPA reviews and streamlining interactions with line organizations.

Because the SNL/California site has a site-wide *Environmental Impact Statement,* most of the NEPA evaluations result in either coverage under existing documentation or a request to the DOE for categorical exclusion. In 1994, more than 50 projects were evaluated, and NEPA classifications and/or determinations were made. Most of these projects fell into the following general categories of continuing actions and operations: projects relating to environmental cleanup and technology; global warming; energy and environment; materials research and development; computer modeling and analysis, project management, research, and development; and microelectronics.

SNL/California requested categorical exclusions for support structures, specifically for the siting of temporary trailers; other structures used temporarily, such as offices for auditors, summer teachers, or students; and structures to house equipment and/or infrastructure facilities, such as communications, water, sewer, and gas mains.

In past years, the NEPA Program staff provided NEPA training to 97% of SNL/California's employees. As a continuing effort, a NEPA training module has been incorporated into the ES&H training class for new employees. The goal of the training is to familiarize staff members with NEPA and to show them how using the DOE environmental checklist can help them integrate environmental mitigation into their projects. If a staff member needs additional NEPA training, one- and three-day courses are available for detailed, comprehensive methodology and process training.

Additionally, the NEPA Program staff meets monthly with the SNL/California ES&H coordinators to exchange information on upcoming projects, status of current projects, training requirements, and ways to improve the NEPA process.

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Environmental Impact Report for Continued Operation of Lawrence Livermore National Laboratory and Sandia National Laboratories, Livermore, DOE/EIS-0157 (February 1992).

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Table 6-1. Average Daily Waste Generation Rate at SNL/California.[a]

Waste	Generation Rate (kg/day)
Hazardous chemical	250
Mixed	2.6
Radioactive	88

[a]Based on twenty working days per month.

Table 6-2. SNL/California Waste Transport and Disposal Companies Used in 1994.

Company	Function
Aptus Inc.	Treat
Bethlehem Apparatus	Recycle
BFI	Transport and treat
BROCO, Inc.	Treat
Chemical Waste Mgmt. Co.	Transport
Drew Resources	Transport and treat
Evergreen Environmental Services	Transport
Evergreen Oil, Inc.	Recycle
Kettleman Hills	Landfill
M. P. Environmental	Transport
Norris Industries, Inc.	Treat
Quadrex	Treat
Rollins	Transport and treat
Romic Chemical Co.	Transport, treat and recycle
S. D. Meyers	Transport, treat and recycle
Southern California Chemical	Treat
Thomas Gray	Transport
Trade Waste Incineration	Treat
Trojan Batteries	Transport and recycle

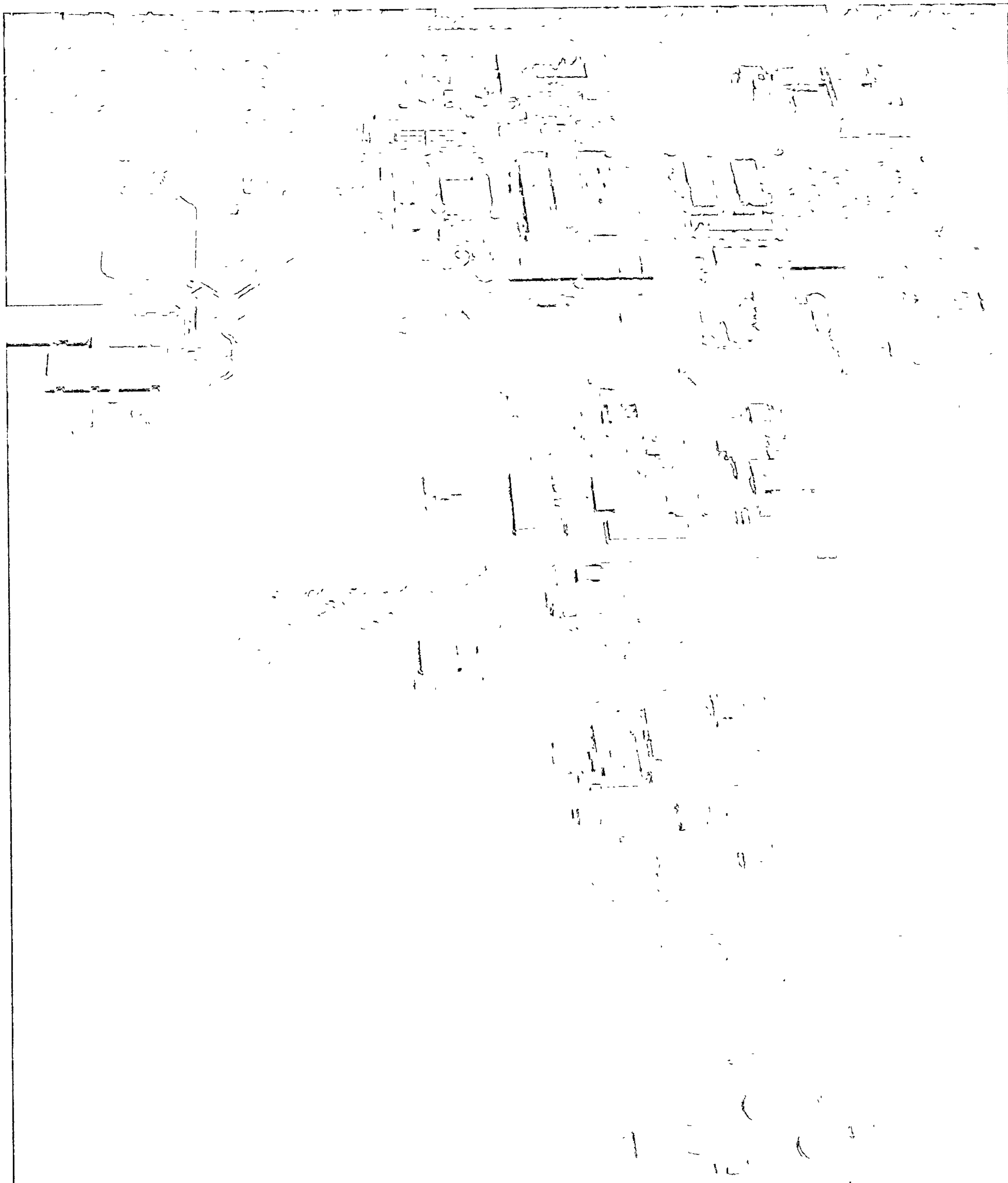
Table 6-3. SNL/California Site Waste Reduction Summary.

Waste Type	Waste Shipped in 1993 (kg)	Waste Shipped in 1994 (kg)	Change
RCRA hazardous waste	22,329	23,069	+3%
California-regulated (non-RCRA) hazardous waste	21,144	14,965	−29%
Low-level mixed waste	234	346	+48%
Low-level radioactive waste	38,187	17,920	−53%
TSCA (PCBs/asbestos)	9,978	18,156	+82%
Biohazardous	102	133	+30%
Sanitary waste[a]	368,000	880,740	+139%

[a]Increase was due to several intensive site-wide cleanup activities.

Table 6-4. SNL/California Site Recycling Activities (Estimated Values).

Material	1991	1992	1993	1994
Office Paper (tons)	3.0	22.47	27.0	29.0
Aluminum (tons)	0.17	0.50	0.44	0.50



GROUNDWATER SAMPLING ANALYTICAL RESULTS

SNL/California issued the *Groundwater Protection Management Program Plan* on September 14, 1990,[1] to assure compliance with applicable Federal, State, and local environmental protection laws and regulations, Executive Orders, and internal department policies. The plan's objective is to document a management program for groundwater protection and remediation. Specifically, it addresses CERCLA, SARA, RCRA, and the Safe Drinking Water Act. The plan includes the following elements, as required by DOE Order 5400.1:[2]

- documentation of the quantity and quality of the groundwater,
- identification of sites that may be contaminated with hazardous substances, and
- a remedial action program, which is directed by the Regional Water Quality Control Board and contained in DOE directives.

SNL/California designed the Groundwater Monitoring Program as a part of the Environmental Restoration Program to monitor the effectiveness of the site's pollution control measures and to make sure that contaminants are not entering domestic water supplies. The groundwater sampling schedule calls for the 29 site-wide monitoring wells to be sampled each quarter, as indicated in Table 7-1. However, persistent drought conditions have generally reduced the number of wells that can be sampled to 12 or 13. Parameters for analysis are selected in accordance with Regional Water Quality Control Board requirements. Selection is based on the history of the area and the need for obtaining data for site-wide groundwater characterization.

The Environmental Restoration Program evaluates SNL/California's inactive waste disposal sites, spill locations, and waste management practices to determine if there is an adverse impact on the environment, and to develop any necessary remedial actions. This program also will support the remediation of groundwater that might become contaminated in the future. The uppermost water-bearing unit, which may be considered a water table aquifer, and the deeper confined/semiconfined aquifers at SNL/California are connected hydrologically to aquifers used for human and livestock drinking water, and for agricultural purposes. However, they are not a water source for these purposes.

SNL/California is conducting a Remedial Investigation/Feasibility Study to fully assess the nature and extent of the release of hazardous substances. This investigation encompasses four tasks:

- Fuel Oil Spill—Assessment and Remediation
- SNL/California Miscellaneous Sites [Arroyo Seco (AS-3, AS-4)]
- Navy Landfill—Assessment and Remediation
- Trudell Auto Repair Station—Assessment and Remediation

SNL/California is conducting the remediation activities according to orders issued by the Regional Water Quality Control Board.[3,4]

GROUNDWATER SAMPLING

The drought conditions in California in 1986–92 were relieved to some extent in 1993–94. Water levels in most of SNL/California's monitoring wells rose in 1993 but were similar or slightly decreased in 1994. As in previous years, many of the wells could not be sampled because they were dry or had extremely low water levels. A hydrogeologist determined the wells' suitability to be sampled by checking water levels and conditions. If sampling was possible, the water was checked for stability of pH, temperature, and specific conductivity before samples were taken. Three purge volumes were removed, when possible. Established quality assurance and quality control procedures were followed. These include chain-of-custody reporting and analyzing trip and equipment blanks to ensure the validity of the data.

LLNL reports data from groundwater monitoring wells installed on SNL/California property as part of the LLNL groundwater investigation project. Results are reported in LLNL's *Monthly Progress Report.* The Regional Water Quality Control Board requires quarterly reports to summarize groundwater-related project activities at SNL/California. Groundwater monitoring requirements have been upgraded and are defined in Board Orders 88-142 and 89-184 and in memoranda from the Board to the DOE.[3,4]

Fuel Oil Spill Site

The Fuel Oil Spill site has 17 monitoring wells. Seven wells (FM-1–FM-7) were installed in 1984 to assess the impact of a 59,000-gallon diesel fuel spill on the subsurface environment. However, persistent drought conditions lowered the water table, requiring the installation of ten deeper wells (FM-8–FM-14, and FDG-1–FDG-3) between 1986 and 1988.

During all four quarters of 1994, 6 of the 17 Fuel Oil Spill monitoring wells had enough water for SNL/California to obtain a sample, according to established procedures. Water levels generally declined in all Fuel Oil Spill monitoring wells each quarter.

Arroyo Seco

In January 1986, four wells were installed at locations along the Arroyo Seco (AS-3 and AS-4 in Fig. 7-1), which traverses the site. Locations of three of the wells (AS-3A, B, and C) were based on primary recharge areas and expected surface runoff points at the SNL/California site. Well AS-3C was installed at a much greater depth to monitor the third aquifer. (Water-bearing zones are numbered consecutively downward from the ground surface.) A fourth well, AS-4, installed upgradient of SNL/California, was intended to function as a background well.

During the first and second quarters of 1994, groundwater samples were obtained from well AS-4 only. By midyear, groundwater elevations had declined so much that samples could not be obtained from any of the four Arroyo Seco wells in the third and fourth quarters.

Navy Landfill

In January 1986, SNL/California installed one well (NLF-1) at the Navy Landfill site, an abandoned landfill used in the 1940s and 1950s for construction debris. SNL/California installed three additional wells (NLF-2–NLF-4) in June 1988 (Fig. 7-1). In an effort to assess the elevated levels of chromium and nitrate observed in groundwater at the Navy Landfill site, SNL/California installed two additional monitoring wells (NLF-5 and NLF-6) in August 1993.

All six Navy Landfill wells contained enough water for sampling during all four quarters of 1994.

Buffer Zone

As part of the expansion of the DOE security buffer zone in 1987, SNL/California acquired property that had been used as a gasoline service station and an auto repair shop. This land, known as the Trudell Auto Repair site, had subsurface contamination from previous activities. Restoration of the Trudell site was completed in August 1990, and the Regional Water Quality Control Board approved site closure in November 1990. Although cleanup of the site is officially complete, SNL/California continues to monitor the area through quarterly sampling of well MW-406 (see Fig. 7-1).

MW-406 did not contain enough water for sampling during 1994.

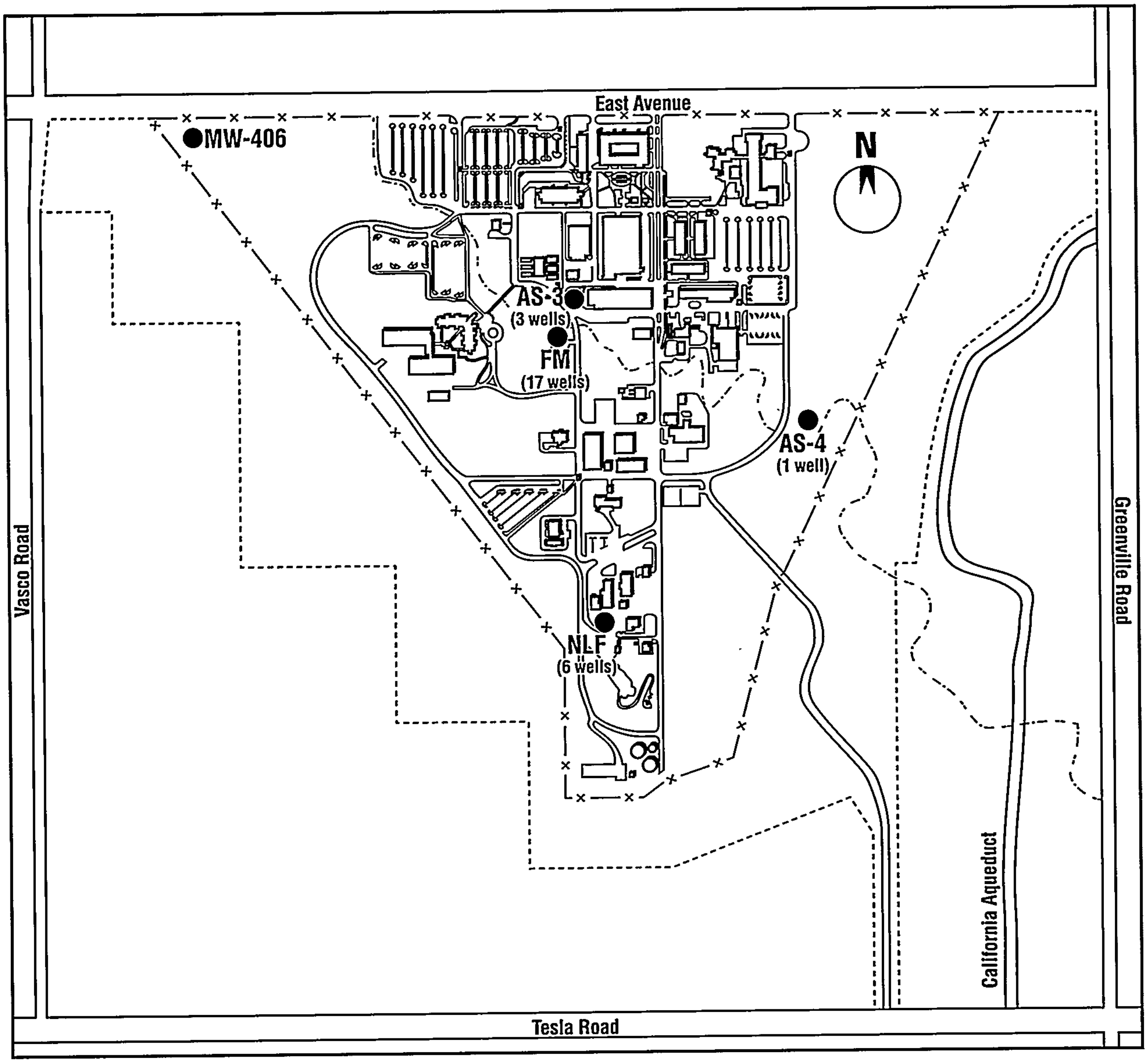


Figure 7-1. Groundwater monitoring well locations on the SNL/California site.

ANALYTICAL RESULTS

Table 7-2 lists the physical, chemical, and radiological parameters of regulatory interest in groundwater from the various SNL/California well locations. They include organic compounds, general chemistry, metals, and radioactivity. Tables 7-3 through 7-5 summarize quarterly sampling data, noting the highest positively detected parameter for each well in 1994.

In 1994, well NLF-6 was the only location in which chloroform or carbon tetrachloride were detected. Chloroform was detected every quarter, in concentrations ranging from 0.79 to 1.1 µg/L, which are considerably less than the Federal maximum contaminant level (100 µg/L). Carbon tetrachloride was detected in well NLF-6 during the first three quarters at levels greater than the State maximum contaminant level (0.5 µg/L). The highest level detected was 2.2 µg/L in the third quarter. SNL/California will continue to monitor both of these analytes.

During the first quarter, methylene chloride was detected in concentrations greater than the Federal maximum contaminant level (5 µg/L) in all wells sampled. This analyte was also detected in the quality assurance/control samples, and was determined to be a result of laboratory contamination.

Throughout three of the four quarters in 1994, diesel was found sporadically in wells around the site. At the Fuel Oil Spill site, six of the seven wells sampled in 1994 showed diesel concentrations between 58 and 130 µg/L. Figure 7-2 shows diesel concentrations in wells at this site from 1989 to 1994. At the Navy Landfill site, three of the six wells sampled this year showed diesel concentrations between 68 and 620 µg/L. Many of the results were "Z-qualified" or "A-qualified" diesel. "Z-qualified" or "A-qualified" means that the detected chromatographic pattern does not match the standard diesel pattern. However, the analytical method used by SNL/California specifies that the detected compound be reported as diesel. Additional analysis has shown that the detected compound could be a phthalate. Phthalates are used commonly in explosives, nail polish, and solid rocket propellants; they also are used in insecticides, coating agents, printing inks, and adhesives. The sporadic occurrence of a qualified diesel may be due to the materials used during sampling (such as labels, pens, bottles). SNL/California will continue to investigate the source of the qualified diesel and will document additional findings in future reports.

Groundwater from all of the monitoring wells showed high concentrations of total dissolved solids. Every well sampled exceeded the secondary drinking water standard (500 mg/L) in at least one quarter. This is a measure of water quality only, and is indicative for this area.

Groundwater from several of the monitoring wells in the Navy Landfill area showed levels of chromium, nickel, and nitrate greater than the maximum contaminant levels. Wells NLF-1, NLF-3, and NLF-4 showed chromium concentrations at half of the State level (0.05 mg/L), although the highest level detected was 0.27 mg/L. Nickel was detected in all Navy Landfill wells except NLF-2 and NLF-5. The nickel concentration in well NLF-1 (0.4 mg/L) exceeded the State level (0.05 mg/L) in the first quarter only. The nickel concentration in well NLF-3 exceeded the State level every quarter, averaging 2.5 mg/L. Nitrates (as nitrogen) were detected regularly in wells NLF-1, NLF-3, and NLF-6 at concentrations up to 56 mg/L,

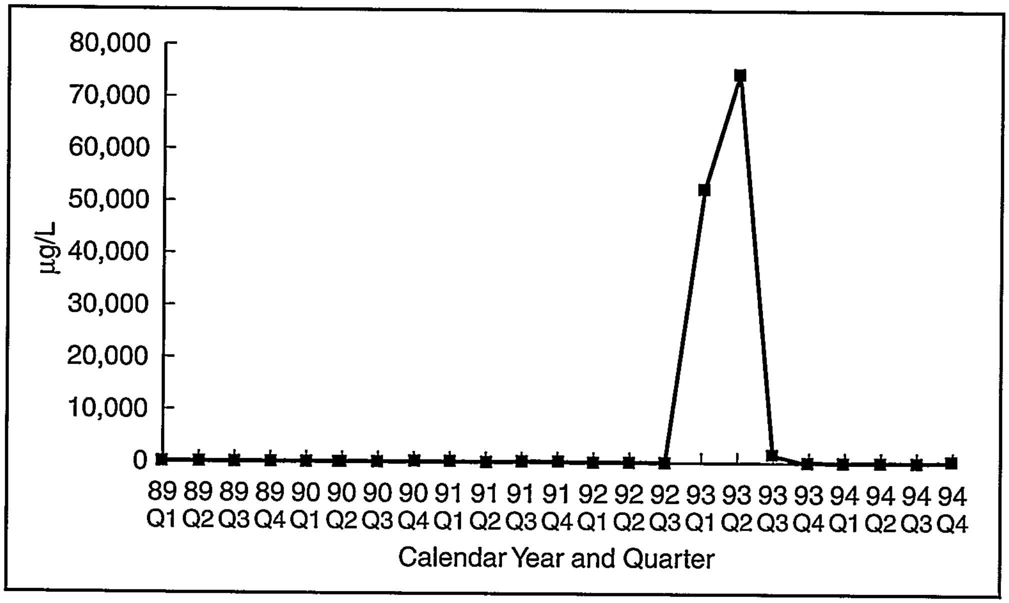


Figure 7-2. Highest positively detected diesel concentration in groundwater from any Fuel Oil Spill monitoring well.

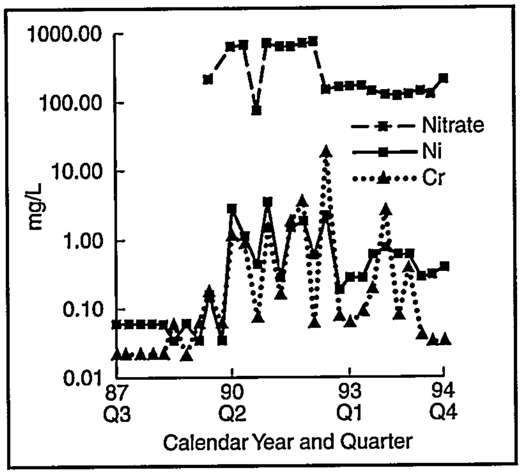


Figure 7-3. Highest detected analyte concentration in groundwater from any Navy Landfill monitoring well.

which is greater than the Federal maximum contaminant level (10 mg/L). Figure 7-3 shows historical trends of these parameters in groundwater at the Navy Landfill site.

Throughout the site, groundwater showed a wide range of aluminum concentrations. Wells FDG-2, FM-11, and NLF-1 were the only wells to exceed the State maximum contaminant level (1 mg/L), with concentrations of 1.2–65 mg/L reported.

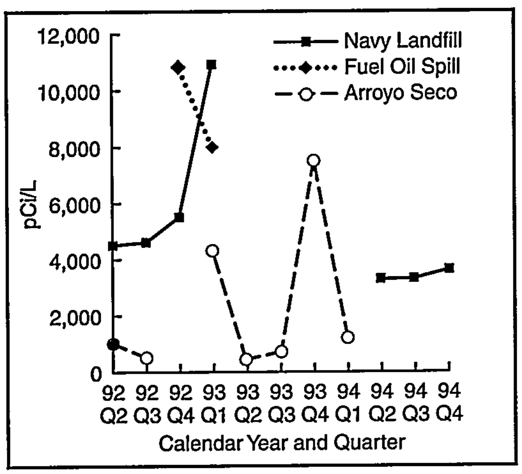


Figure 7-4. Highest tritium activity observed in SNL/California monitoring wells.

Samples were analyzed in 1994 for total uranium, radium-226 and -228, and tritium. The analytes were detected well below State and Federal maximum contaminant levels. Figure 7-4 shows historical tritium monitoring data at the Navy Landfill site, Fuel Oil Spill site, and Arroyo Seco wells.

REFERENCES

1. U.S. DOE, Sandia National Laboratories, Livermore, *Groundwater Protection Management Program Plan* (September 1990).

2. U.S. DOE, Order 5400.1, *General Environmental Protection Program* (November 1988).

3. State of California, San Francisco Bay Region, Regional Water Quality Control Board, Order 88-142 (September 21, 1988).

4. State of California, San Francisco Bay Region, Regional Water Quality Control Board, Order 89-184 (December 13, 1989).

Table 7-1. Sample Analysis Schedule.

Area	Well ID	EPA 601[a]	EPA 602 (BTEX)[b]	EPA 8015 (TPHD)[c]	CCR General Minerals[d]	CCR Metals[e]	RAD[f]	Water Elevation
Fuel Oil Spill	FM-1	X	X	X	X	Y	Y	X
	FM-2	X	X	X	X	Y	Y	X
	FM-3	X	X	X	X	Y	Y	X
	FM-4	X	X	X	X	Y	Y	X
	FM-5	X	X	X	X	Y	Y	X
	FM-6	X	X	X	X	Y	Y	X
	FM-7	X	X	X	X	Y	Y	X
	FM-8	X	X	X	X	Y	Y	X
	FM-9	X	X	X	X	Y	Y	X
	FM-10	X	X	X	X	Y	Y	X
	FM-11	X	X	X	X	Y	Y	X
	FM-12	X	X	X	X	Y	Y	X
	FM-13	X	X	X	X	Y	Y	X
	FM-14	X	X	X	X	Y	Y	X
	FM-15	X	X	X	X	Y	Y	X
	FDG-1	X	X	X	X	Y	Y	X
	FDG-2	X	X	X	X	Y	Y	X
	FDG-3	X	X	X	X	Y	Y	X
Arroyo Seco	AS-3A	X	X	X	Y	Y	Y	X
	AS-3B	X	X	X	Y	Y	Y	X
	AS-3C	X	X	X	Y	Y	Y	X
	AS-4	X	X	X	Y	Y	Y	X
Navy Landfill	NLF-1	X	X	X	X	X	X	X
	NLF-2	X	X	X	X	X	X	X
	NLF-3	X	X	X	X	X	X	X
	NLF-4	X	X	X	X	X	X	X
	NLF-5	X	X	X	X	X	X	X
	NLF-6	X	X	X	X	X	X	X
Buffer Zone	MW-406	X	X	X	Y			X
	MW-11							X

X indicates analysis done every quarter.
Y indicates analysis done every year.
[a]EPA Method 601 applies to halogenated volatile organic compounds.
[b]EPA Method 602 applies to BTEX (benzene, toluene, ethylbenzene, xylenes), which are aromatic volatile organic compounds.
[c]TPHD is diesel, which is analyzed according to EPA Method 8015.
[d]CCR general minerals include aluminum, bicarbonate, carbonate and hydroxide alkalinity, calcium, chloride, copper, manganese, nitrate (as NO_3), pH, sodium, specific conductivity, sulfate, total dissolved solids, total hardness, and zinc (Title 22 CCR 64433). Potassium also is included in the analyses.
[e]CCR metals include antimony, arsenic, barium, beryllium, cadmium, chromium, cobalt, copper, fluoride salts, lead, mercury, nickel, selenium, silver, thallium, vanadium, and zinc. These are listed as Inorganic Persistent and Bioaccumulative Toxic Substances in Title 22 CCR 66261.24(a)(2)(A).
[f]RAD (radioactivity) analyses include tritium, radium, and uranium.

Table 7-2. Water Quality Parameters and Detection Limits for Monitoring Wells.

Parameter	Locations	Limit[a]	Parameter	Locations	Limit[a]
Halogenated Volatile Organics (EPA 601) (μg/L)	All	5.0	**CCR Metals (mg/L)**	All	
			Aluminum		0.2
BTEX (EPA 602) (μg/L)	All		Antimony		0.2
Benzene		0.50	Arsenic		0.005
Toluene		0.50	Barium		0.05
Ethylbenzene		0.50	Beryllium		0.01
Xylenes		0.80	Cadmium		0.05
TPHD (EPA 8015) (μg/L)			Chromium		0.05
Diesel		50	Cobalt		0.05
CCR General Minerals			Copper		0.05
Surfactants (total suspended solids) (mg/L)	All	0.02	Iron		0.1
Specific conductivity (μmhos/cm)	All	1.0	Lead		0.2
pH (units)	All	—[b]	Manganese		0.02
Total dissolved solids (mg/L)	All	10.0	Mercury		0.0005
Hardness (mg/L)			Nickel		0.1
Anions (mg/L)	NLF[c]		Selenium		0.005
Chloride		1.0	Silver		0.05
Nitrate/nitrite		0.1	Thallium		0.2
Sulfate		2.0	Vanadium		0.05
Bicarbonate		5.0	Zinc		0.05
Carbonate		5.0	**Radioactivity (pCi/L)**	All	
Hydroxide		5.0	Total uranium		1.0
Cations (mg/L)	All		Radium-226		0.3
Calcium		0.5	Radium-228		0.3
Magnesium		0.5	Tritium		700
Potassium		1.0			
Sodium		5.0			

[a]Detection limits can vary from sample to sample, depending on items such as matrix interference and instrument sensitivity.
[b]Not applicable.
[c]NLF = Navy Landfill.

Table 7-3. Highest Positively Detected Parameters in SNL/California Navy Landfill Monitoring Wells.[a]

Parameter[c]	Well[b] NLF-1	Quarter	NLF-2	Quarter	NLF-3	Quarter
Halogenated Volatile Organics (EPA 601) (µg/L)						
Carbon tetrachloride	<0.6	1,2,3,4	<0.6	1,2,3,4	<0.6	1,2,3,4
Chloroform	<0.5	1,2,3,4	<0.5	1,2,3,4	<0.5	1,2,3,4
Methylene chloride	15[d]	1	20[d]	1	15[d]	1
TPHD (EPA 8015) (µg/L)						
Diesel	330[e]	4	68[e]	1	620	2
CCR General Minerals (mg/L)						
Total dissolved solids	1600	1	1100	4	800	1
Hardness						
Anions						
Nitrate (as nitrogen)	56	2,4	<0.1	1,2,3,4	17	4
CCR Metals (mg/L)						
Aluminum	65	1	<0.2	1,2,3,4	<0.2	1,2,3,4
Chromium	0.27	1	<0.05	1,2,3,4	0.034	2
Nickel	0.4	1	<0.1	1,2,3,4	0.3	1
Radioactivity (pCi/L)						
Radium-226	0.2	2	0.36	2	0.08	2
Radium-228	0.33	2	0.86	2	0.89	2
Tritium	3300	3	–88.7	3	596	2

Continued

Table 7-3. Highest Positively Detected Parameters in SNL/California Navy Landfill Monitoring Wells (concluded).[a]

	Well[b]					
Parameter[c]	**NLF-4**	**Quarter**	**NLF-5**	**Quarter**	**NLF-6**	**Quarter**
Halogenated Volatile Organics (EPA 601) (µg/L)						
Carbon tetrachloride	<0.6	1,2,3,4	<0.6	1,2,3,4	2.2	3
Chloroform	<0.5	1,2,3,4	<0.5	1,2,3,4	1.1	2
Methylene chloride	15[d]	1	19[d]	1	16[d]	1
TPHD (EPA 8015) (µg/L)						
Diesel	<50	1,2,3,4	<50	1,2,3,4	<50	1,2,3,4
CCR General Minerals (mg/L)						
Total dissolved solids	530	1	840	2	2000	1
Hardness						
Anions						
Nitrate (as nitrogen)	6.9	4	<0.1	1,2,3,4	50	2
CCR Metals (mg/L)						
Aluminum	<0.2	1,2,3,4	<0.2	1,2,3,4	<0.2	1,2,3,4
Chromium	0.013	3,4	<0.05	1,2,3,4	0.01	3
Nickel	0.027	3,4	<0.1	1,2,3,4	0.028	2
Radioactivity (pCi/L)						
Radium-226	0.10	2	0.16	2	0.37	2
Radium-228	0.59	2	0.83	2	0.42	2
Tritium	154	3,4	−154	2	433	3

[a]All groundwater data are reported to the Regional Water Quality Control Board each quarter.
[b]See Fig. 7-1 for sampling locations.
[c]Unless noted in the table, all other constituents were below detection or regulatory limits.
[d]Analyte was found in all samples collected in the first quarter of 1994.
[e]This is a "Z-qualified" or "A-qualified" diesel, which means that the detected chromatographic pattern does not match the standard diesel pattern; however, the analytical method specifies that the detected compound be reported as diesel.

Table 7-4. Highest Positively Detected Parameters in SNL/California Fuel Oil Spill Monitoring Wells.[a]

Parameter[d]	Well[b,c]							
	FM-11[e]	Quarter	FM-12	Quarter	FM-13[f]	Quarter	FM-14	Quarter
Halogenated Volatile Organics (EPA 601) (μg/L)								
Methylene chloride	23[g]	1	9.5[g]	1	–	–	14[g]	1
TPHD (EPA 8015) (μg/L)								
Diesel	70	2	58[h]	1	70[h]	4	130[h]	4
CCR General Minerals (mg/L)								
Total dissolved solids	570	1	570	1	540	3	650	1
CCR Metals (mg/L)								
Aluminum	6.1	2	0.19	4	0.15	4	<0.2	1,2,3,4
Radioactivity (pCi/L)								
Radium-226	0.68	1	0.43	1	–	–	0.32	1
Radium-228	−0.02	1	0.47	1	–	–	−0.13	1
Tritium	956	1	1160	1	–	–	2200	1

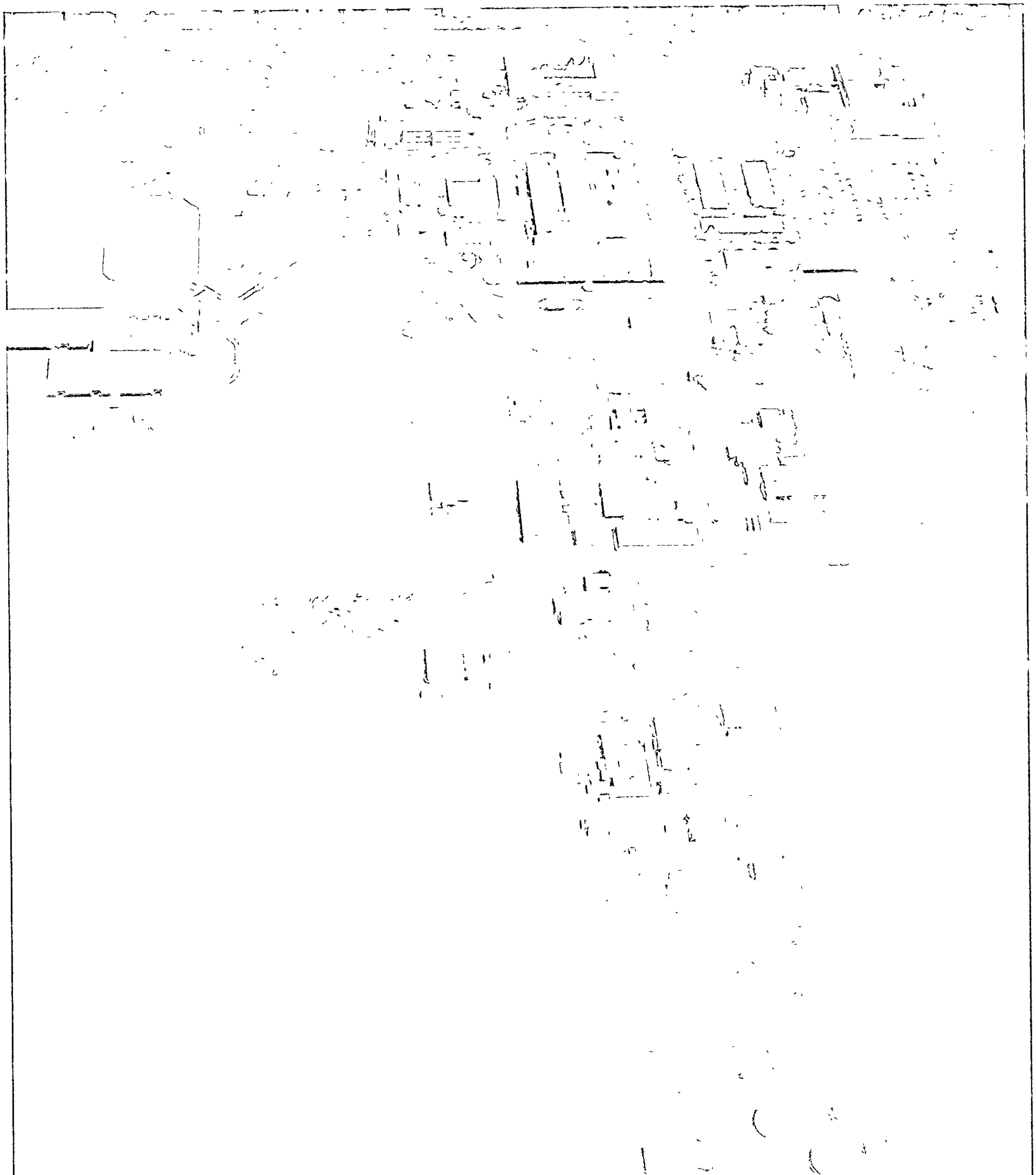
Parameter[d]	Well[b,c]					
	FDG-1	Quarter	FDG-2	Quarter	FDG-3	Quarter
Halogenated Volatile Organics (EPA 601) (μg/L)						
Methylene chloride	18[g]	1	26[g]	1	24[g]	1
TPHD (EPA 8015) (μg/L)						
Diesel	<50	1,2,3,4	96[h]	1	82[h]	1
CCR General Minerals (mg/L)						
Total dissolved solids	530	1	720	1	590	1
CCR Metals (mg/L)						
Aluminum	0.31	1	1.5	2	0.05	2
Radioactivity (pCi/L)						
Radium-226	0.28	1	0.66	1	0.48	1
Radium-228	0.12	1	0.20	1	−0.10	1
Tritium	188	1	546	1	1190	1

[a]All groundwater data are reported to the Regional Water Quality Control Board each quarter.
[b]See Fig. 7-1 for sampling locations.
[c]Wells FM-1 through FM-10 were too dry to be sampled at all during 1994.
[d]Unless noted in the table, all other constituents were below detection or regulatory limits.
[e]Well FM-11 was sampled during the first and second quarters; it was dry the rest of the year.
[f]Well FM-13 was sampled during the third and fourth quarters; it was dry the rest of the year.
[g]This analyte was found in all samples collected in the first quarter of 1994.
[h]This is a "Z-qualified" or "A-qualified" diesel, which means that the detected chromatographic pattern does not match the standard diesel pattern; however, the analytical method specifies that the detected compound be reported as diesel.

Table 7-5. Highest Positively Detected Parameters in SNL/California Arroyo Seco Monitoring Wells.[a]

Parameter[d]	Well[b,c] AS-4[e]	Quarter
Halogenated Volatile Organics (EPA 601) (μg/L)		
Methylene chloride	15[f]	1
TPHD (EPA 8015) (μg/L)		
Diesel	<50	1,2
Radioactivity (pCi/L)		
Radium-226	0.47	1
Radium-228	0.38	1
Tritium	205	1

[a]All groundwater data are reported to the Regional Water Quality Control Board each quarter.
[b]See Fig. 7-1 for sampling locations.
[c]Wells AS-3A, AS-3B, and AS-3C were too dry to be sampled at all during 1994.
[d]Unless noted in the table, all other constituents were below detection or regulatory limits.
[e]Well AS-4 was sampled during the first and second quarters; it was dry the rest of the year.
[f]This analyte was found in all samples collected in the first quarter of 1994.



DATA QUALITY ASSURANCE

DATA INTERPRETATION

MONITORING PERFORMED BY LAWRENCE LIVERMORE NATIONAL LABORATORY

SNL/California maintains an effluent monitoring and environmental surveillance program, as required by DOE Orders 5400.1 and 5400.5.[1,2] These Orders specify quality assurance requirements consistent with DOE Order 5700.6B.[3] The DOE has issued DOE Order 5700.6C,[4] which supersedes DOE Order 5700.6B. The ES&H, Facilities, and Security Center at SNL/California has developed and is implementing a *Quality Assurance Management Plan* consistent with the provisions of DOE requirements.[5] Additional procedures for implementing the plan include the following:

- qualifications and training;
- procedure development and control;
- control of measuring and test equipment, including monitoring and data collection equipment;
- identification and control of samples;
- identification and control of technical data;
- procurement control;
- records management; and
- independent assessment.

Consistent with the requirements of the *Quality Assurance Management Plan,* the Environmental Surveillance Group has developed a *Quality Assurance Project Plan,* which describes how the *Quality Assurance Management Plan* will be implemented.[6] The *Quality Assurance Project Plan* includes quality assurance guidance from other documents, such as Title 40 CFR, Part 58, *Ambient Air Quality Surveillance,*[7] and the EPA's *Quality Assurance Handbook for Air Pollution Measurement Systems.*[8] To meet the most current guidance on quality assurance for environmental projects, the *Quality Assurance Project Plan* follows the guidance and format of the draft *Quality Assurance Requirements for Environmental Programs.*[9] Operating procedures supplement the *Quality Assurance Project Plan* and implementing provisions of the *Quality Assurance Management Plan.* Operating procedures specify requirements for environmental monitoring, LECS monitoring, and process wastewater sampling for compliance with Federal categorical pretreatment regulations.

The Environmental Operations Department incorporates normal data and supervisory reviews into routine operations. SNL/California's upper management performs management assessments, as required in the *Quality Assurance Management Plan.* Assessments identify problems that may keep an organization from achieving required goals or conforming to requirements. Finally, the *Quality Assurance Management Plan* provides for independent technical assessments to verify quality.

DATA QUALITY ASSURANCE

SNL/California assesses the quality of the data collected for the Environmental Operations Department by estimating the precision and accuracy of the data. SNL/California estimates precision by collecting duplicate samples. The data obtained from the duplicate samples is compared to the data obtained from the routine samples. A confidence interval thereby can be calculated. The confidence interval represents the variability that exists in the monitoring system and the range of values around a reported data point, within which the actual value can be expected to lie.

Accuracy is estimated through analysis of samples containing a known amount of the constituent of interest. The result is compared to the known amount, and once again, a confidence interval is calculated. This confidence interval indicates the range of values within which the actual value can be expected to lie. In general, smaller confidence intervals represent more accurate and precise analyses.

The Environmental Operations Department has standardized methods for calculating confidence intervals and has established acceptance criteria for them. These methods and acceptance criteria are described in the procedure, *Data Validation and Verification for the Environmental Monitoring Program.*[10] The acceptance criteria account for the confidence interval enlarging (i.e., the error associated with the analysis becomes greater) as the concentration of a constituent in a sample approaches the detection limit. For this reason, acceptance criteria that may be achievable at relatively high concentrations may not be achievable at very low concentrations. At very low levels, the presence of the constituent of interest may be detected, but not the quantity. To address this phenomenon, the EPA recommends that "practical quantitation limits" be established. The Environmental Operations Department has established practical quantitation limits at ten times the detection limit for each constituent of interest. Therefore, the acceptance limits for precision and accuracy are progressive—the confidence interval can be larger near the detection limit and smaller as the practical quantitation limit is approached.

To facilitate the calculation of confidence intervals for accuracy and precision, the procedures for collecting environmental samples specify three types of quality control samples:

- *Duplicate Samples.* Duplicate samples are collected according to the same methods as the routine samples, and at the same time and location. These samples are used to assess the precision (repeatability) of the sample collection and analysis system.
- *Interlaboratory Comparison Samples.* These are samples prepared by the EPA or the DOE. The participating laboratory analyzes them as normal samples and reports the data to the initiating agency. The agency then informs the laboratory of how close the results were to the known amount in the sample. Thus, the participating laboratory uses these data to assess the accuracy of its measurements.
- *Blank Samples.* Blank samples resemble the routine samples as closely as possible, but lack the constituent of interest. These samples are not used to assess accuracy or precision, but are important for assessing possible contamination of the samples during collection, transportation, and analysis.

Table 8-1 shows the results of the EPA Environmental Radioactivity Laboratory's Intercomparison Studies Program for both SNL/California and LLNL. The LLNL data are presented as ratios. One of LLNL's results for gross alpha in water lies outside the acceptable range of ±3 standard deviations. This analysis was new to the laboratory, and procedures are being modified to correct the error. One of the SNL/California tritium-in-water results lies outside of the acceptable range of ±3 standard deviations. An investigation revealed that this result was due to a change in the liquid scintillation cocktail. SNL/California corrected the problem by recalibrating the scintillation counter. No other data were affected.

Table 8-2 presents data from SNL/California's duplicate sampling. These data represent the precision of the combined sampling and analytical processes. All t-tests between routine and duplicate samples showed no significant difference. However, the 95% confidence interval for total suspended solids in wastewater does not meet the acceptance criteria of having a width of less than 50% of the routine sample average. The 95% confidence interval for tritium in air does not meet the acceptance criteria of bracketing zero (showing a slight negative bias). The ratio of duplicate to routine samples for diethylphthalate in wastewater does not meet the acceptance criteria. SNL/California is investigating these issues.

DATA INTERPRETATION

Once the precision and accuracy of the data have been established, and the acceptance criteria have been met, the data must be interpreted. *Data Analysis for the Environmental Monitoring Program* describes SNL/California's methods for interpreting data.[11] These methods fall into several categories:

- *Determining averages and standard deviations.* Averages and standard deviations are useful as summaries of data collected during the year. The usual methods for calculating averages and standard deviations assume that the data have a "normal" (bell curve) distribution. However, many environmental data do not follow a normal distribution, and the usual methods of calculating averages and standard deviations would be misleading for these data sets. Therefore, all data sets are tested for normality. If the data are found to be not normally distributed, then the average and standard deviation appropriate for a data set with a lognormal distribution are calculated. (Most environmental data follow a lognormal distribution if they are not distributed normally.) Data sets with ten or fewer data points are treated as normally distributed, with no checks of the distribution, because more data points are needed to describe the distribution accurately.
- *Testing for outliers.* SNL/California includes outlying data in the data sets, unless they can be attributed to a specific cause (such as laboratory contamination of the sample). The tables present average and standard deviation values both including and excluding the outliers. SNL/California personnel use box plots (a statistical method) to determine outliers.
- *Comparing data.* If possible, SNL/California personnel compare data collected on or near the SNL/California site and data collected at "background"—or distant—locations. If concentrations on or near the site are observed at a higher concentration than at distant locations, the site may be assumed to be the source of observed hazardous or radioactive materials in the environment. Conversely, if concentrations on or near the site are similar to (or lower than) concentrations at distant locations, the site may be assumed not to be the source of hazardous or radioactive materials in the environment. SNL/California personnel compare concentrations by using t-tests (statistical tests) or by analysis of variance techniques to determine if any observed differences are statistically significant.
- *Determining compliance with standards.* If regulatory standards have been established for hazardous or radioactive material concentrations in an environmental medium, SNL/California compares monitoring results to the standard. Because a single data point is associated with high uncertainty, SNL/California personnel use the confidence interval for precision, as calculated above, for comparison. If the 95% confidence interval around the observed value includes values at or above the regulatory standard, then the standard may have been exceeded. The data are investigated further to confirm, if possible, whether or not the standard was indeed exceeded. If the entire confidence interval is above the regulatory limit, then we assume the standard was exceeded.
- *Determining values below the analytical detection limit.* Most analytical methods cannot state definitively that the concentration of a hazardous or radioactive material is zero. Most analytical methods have a "lower limit of detection," below which material presence cannot be ascertained. This lower detection limit usually is defined as the concentration at which the presence of

the material can be detected with 99% statistical certainty. These values are shown with a "less than" symbol (<) preceding the value. They cannot be used in the normal statistical calculations described above because they represent ranges instead of discrete values. To perform statistical calculations on data sets containing these values, SNL/California personnel use the following methods:

- —If more than one-third of the data set consists of detection limit values, SNL/California reports the median and median absolute deviation of the data set, instead of the average and standard deviation.
- —If less than one-third of the data set consists of detection limit values, SNL/California calculates averages and standard deviations using the detection limit as a normal result. (This method is conservative because it really represents the highest possible value for the data.)

Monitoring Performed by Lawrence Livermore National Laboratory

LLNL conducts much of the off-site environmental monitoring and transmits the results to SNL/California. LLNL has a quality assurance program and procedures for environmental monitoring, documented in the *Environmental Monitoring Section Quality Assurance Plan.*[12] Samples processed outside of LLNL are sent to laboratories that have been State-certified to do the analyses required. Many of the radiological analyses are done by the Nuclear Chemistry Division at LLNL. The Nuclear Chemistry Division has established a quality assurance plan for environmental measurement and has applied to the State for certification.

Table 8-3 presents data from LLNL's duplicate sampling effort. These data represent the precision of the combined sampling and analytical processes. The results for gross alpha in air fall outside the acceptance criteria due to variability in the samples. This variability is due to the very low levels of activity on the sample filters. The results for tritium concentrations in air also are outside the acceptance criteria because of outliers in the data set.

Table 8-4 shows the results of the DOE Environmental Measurements Laboratory's Quality Assessment Program sample analyses performed by LLNL. Because the DOE does only two of these intercomparisons per year, the data are presented as ratios. All data were within the acceptable range.

References

1. U.S. DOE, Order 5400.1, *General Environmental Protection Program* (November 1988).

2. U.S. DOE, Order 5400.5, *Radiation Protection of the Public and the Environment* (March 1988).

3. U.S. DOE, Order 5700.6B, *Quality Assurance* (March 1989).

4. U.S. DOE, Order 5700.6C, *Quality Assurance* (August 1992).

5. U.S. DOE, Sandia National Laboratories/California, *Quality Assurance Management Plan* (1991).

6. R. C. Holland, *Environmental Monitoring Program Quality Assurance Project Plan,* Sandia National Laboratories/California, SAND93-8010 (June 1993).

7. U.S. EPA, Title 40 CFR, Part 58, *Ambient Air Quality Surveillance* (1987).

8. U.S. EPA, *Quality Assurance Handbook for Air Pollution Measurement Systems,* EPA600/9-76-005 (1976).

9. American Society for Quality Control, *Quality Assurance Requirements for Environmental Programs,* ANSI/ASQC E4 (September 1992).

10. U.S. DOE, Sandia National Laboratories/California, *Data Validation and Verification for the Environmental Monitoring Program* (January 1994).

11. U.S. DOE, Sandia National Laboratories/California, *Data Analysis for the Environmental Monitoring Program* (January 1994).

12. L. M. Garcia and R. A. Failor, *Environmental Monitoring Section Quality Assurance Plan*, Lawrence Livermore National Laboratory, UCRL-AR-114318 (1993).

Table 8-1. Quality Assurance Analyses for the Environmental Protection Agency's Environmental Radioactivity Laboratory Intercomparison Studies Program.[a]

			Value Reported (pCi/L ± 1σ)		
Medium	Analysis	Analyzed by	Analytical Result	Known	Normalized deviation from the known value[b]
Water	tritium	SNL/California	3410 ± 130	4936 ± 494	−5.35
		SNL/California	9027 ± 995	9951 ± 995	−0.928
	gross alpha	LLNL	31 ± 4	57 ± 14	0.54[c,d]
	gross beta	LLNL	25 ± 3	23 ± 5	1.09[c]
	tritium	LLNL	4783 ± 23	4936 ± 494	−0.54
		LLNL	8842 ± 38	9951 ± 995	−1.93

[a]All data were provided by LLNL's Nuclear Chemistry Division.
[b]Acceptable deviations are between −2 and 2 (−2 < x < 2).
[c]These LLNL comparisons are ratios, not normalized deviations.
[d]This analysis was new to the laboratory. Procedures are being modified.

Table 8-2. Quality Assurance–Duplicate Sampling, Selected Parameters on SNL/California Collected Samples.

Medium	Analysis	Confidence Interval (95%)[a]	Ratio[b]
Wastewater			
	Biological oxygen demand	—[c]	0.989
	Chemical oxygen demand	36.65/–9.49	—[d]
	Total suspended solids	33.59/–27.83	—[d]
	Total dissolved solids	1.94/–10.50	—[d]
	Specific conductivity	2.75/–0.77	—[d]
	Oil and grease	19.17/–25.04	—[d]
	pH	2.21/–0.46	—[d]
	Chromium	—[c]	0.775
	Copper	3.03/–6.97	—[d]
	Mercury	—[c]	1.420
	Nickel	—[c]	0.800
	Silver	—[c]	1.000
	Zinc	3.85/–5.05	—[d]
	Bis(2-ethylhexyl)phthalate	—[c]	1.000
	Chloroform	—[c]	0.962
	Diethylphthalate	—[c]	20.357
	Phenol	—[c]	0.833
Storm Water Runoff			
	pH	—[c]	1.010
	Specific conductivity	—[c]	0.976
	Total suspended solids	—[c]	0.909
Air			
	Tritium	–1.17/–32.80	—[d]

[a]Only calculated for data sets with more than eight valid data pairs.
[b]Only calculated for data sets with less than eight valid data pairs. The value is the ratio of quality assurance sample/routine sample.
[c]Not calculated–less than eight valid data pairs available.
[d]Not calculated–more than eight valid data pairs available.

Table 8-3. Quality Assurance—Duplicate Sampling, Selected Parameters on LLNL Collected Samples.

Medium	Analysis	Ratio[b]	Regression Analysis[a] Correlation Coefficient	Slope	Y-intercept
Water					
Rainwater	tritium	0.86	—[c]	—[c]	—[c]
Surface and drinking water	tritium	—[d]	0.93	0.908	0.829
Vegetation	tritium	0.76	—[c]	—[c]	—[c]
Air	gross alpha	—[d]	0.09	0.933	-4.26×10^{-8}
	gross beta	—[d]	0.83	0.976	-7.36×10^{-7}
	tritium	—[d]	0.67	1.22	-4.80×10^{-4}

[a]Only calculated for data sets with more than eight valid data pairs.
[b]Only calculated for data sets with less than eight valid data pairs. The value is the ratio of quality assurance sample/routine sample.
[c]Not calculated—less than eight valid data pairs available.
[d]Not calculated—more than eight valid data pairs available.

Table 8-4. Quality Assurance for the Department of Energy's Environmental Measurements Laboratory Quality Assessment Program.[a]

Medium	Analysis	LLNL Value	EML Value	LLNL/EML Ratio[b]
Water	tritium	172 ± 2	187	0.92
	tritium	114 ± 44	113	1.01
Air	uranium	16.6 ± 1.3	15.8	1.05
	uranium	8.3 ± 0.2	9.5	0.88

[a]All data were provided by LLNL's Nuclear Chemistry Division.
[b]Acceptable ratios are between 0.7 and 1.3.

ACRONYMS AND ABBREVIATIONS
TECHNICAL TERMS
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ACRONYMS AND ABBREVIATIONS

ALARA	as low as reasonably achievable
ANSI	American National Standards Institute
ASME	American Society of Mechanical Engineers
BOD	biological oxygen demand
BTEX	benzene, toluene, ethylbenzene, xylenes
CAA	Clean Air Act (Federal)
Cal/EPA	California Environmental Protection Agency
CCR	California Code of Regulations
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CN	conductivity
COD	chemical oxygen demand
CWA	Clean Water Act (Federal)
DCG	Derived Concentration Guide (DOE)
DOE	Department of Energy
DWS	drinking water standard
EDE	effective dose equivalent
EPA	Environmental Protection Agency
EPCRA	Emergency Planning and Community Right-to-Know Act
ES&H	environment, safety, and health
HT or T_2	elemental tritium
HTO or T_2O	tritium oxide (tritiated water)
LECS	Liquid Effluent Control System
LLNL	Lawrence Livermore National Laboratory
MAD	median absolute deviation
NEPA	National Environmental Policy Act
NESHAPs	National Emission Standards for Hazardous Air Pollutants
NPDES	National Pollutant Discharge Elimination System
O&G	oil and grease
PCB	polychlorinated biphenyl
RCRA	Resource Conservation and Recovery Act
SDM	standard deviation of the mean
SI	International System of Units
SNL	Sandia National Laboratories
TDS	total dissolved solids
TSCA	Toxic Substance Control Act
TSS	total suspended solids

TECHNICAL TERMS

accuracy The closeness of the result of a measurement to the true value of the quantity measured.

air particulates Airborne particles. These may include dust, dirt, and pollutants that occur as particles, and any pollutants that may be associated with or carried on the dust or dirt.

aliquot A portion of a sample taken for analysis.

alpha particle A charged particle (identical to the helium nucleus) comprising two protons and two neutrons that are emitted during decay of certain radioactive atoms. Alpha particles are stopped by several centimeters of air or a sheet of paper.

ambient air The surrounding atmosphere, usually the outside air, as it exists around people, plants, and structures. It does not include the air next to emission sources.

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

arroyo An intermittent or seasonal stream.

background radiation Ionizing radiation from natural sources. It may include cosmic radiation; external radiation from naturally occurring radioactivity in the earth (terrestrial radiation), air, and water; internal radiation from naturally occurring radioactive elements in the human body; and radiation from medical diagnostic procedures.

best management practice Any method, process, or procedure developed to prevent and/or reduce pollutants discharged to the environment.

beta particle A charged particle (identical to the electron), which is emitted during decay of certain radioactive atoms. Most beta particles are stopped by ≤0.6 cm of aluminum.

categorical process An industrial process, which discharges wastewater and is regulated under Title 40 CFR, Part 403.

collective effective dose equivalent The sum of the effective dose equivalents of all individuals in an exposed population within a certain radius; expressed in units of person-rem (or person-sievert).

contaminant Any hazardous or radioactive material present in an environmental medium, such as water or vegetation.

controlled area Any Laboratory area to which access is controlled to protect individuals from exposure to radiation and radioactive materials.

cosmic radiation High-energy particulate and electromagnetic radiation that originates outside the earth's atmosphere. Cosmic radiation is part of natural background radiation.

discharge A release into an area not controlled by SNL/California.

dose A term denoting the quantity of radiation energy absorbed.

dose, absorbed The energy imparted to matter by ionizing radiation per unit mass of irradiated material. (The unit of absorbed dose is the rad.)

dose, effective The hypothetical whole-body dose that would give the same risk of cancer mortality and/or serious genetic disorder as a given exposure and that may be limited to just a few organs. The effective dose equivalent is equal to the sum of individual organ doses, each weighted by the degree of risk that the organ dose carries. For example, a 100-mrem dose to the lung, which has a weighting factor of 0.12, gives an effective dose that is equivalent to 12 mrem (100 × 0.12).

dose, equivalent A term used in radiation protection that expresses all types of radiation (alpha, beta, and so on) on a common scale for calculating the effective absorbed dose. It is the product of the absorbed dose in rads and certain modifying factors. (The unit of dose equivalent is the rem.)

dose, maximum boundary The greatest dose commitment, considering all potential routes of exposure from a facility's operation, to a hypothetical individual who is in an uncontrolled area where the highest dose rate occurs. It assumes that the hypothetical individual is present 100% of the time (full occupancy), and it does not take into account shielding (for example, by buildings).

dose, maximum individual The greatest dose commitment, considering all potential routes of exposure from a facility's operation, to an individual at or outside the Laboratory boundary where the highest dose rate occurs. It takes into account shielding and occupancy factors that would apply to a real individual.

dose, population The sum of the radiation doses to individuals of a population. It is expressed in units of person-rem. For example, if 1,000 people each received a radiation dose of 1 rem, their population dose would be 1,000 person-rem.

dosimeter A portable detection device for measuring the total accumulated exposure to ionizing radiation. See also *thermoluminescent dosimeter.*

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

effective dose equivalent Abbreviated EDE; the summation of the products of the dose equivalent received by specified tissues of the body and a tissue-specific weighting factor. This sum is a risk-equivalent value and can be used to estimate the health risk of the exposed individual. The tissue-specific weighting factor represents the fraction of the total health risk resulting from uniform whole-body irradiation that would be contributed by that particular tissue. The EDE includes the committed EDE from internal deposition of radionuclides and the EDE due to penetrating radiation from sources external to the body; it is expressed in units of rem (or sievert).

effluent	A liquid or gaseous waste discharged to the environment.
emission	A gaseous or liquid stream containing one or more contaminants. The verb form, emit, means the act of discharging a contaminant or pollutant into the environment.
environmental remediation	The process of restoring a contaminated area to a noncontaminated or safe condition.
exposure	A measure of the ionization produced in air by x or gamma radiation. (The unit of exposure is the roentgen.)
external radiation	Radiation originating from a source outside the body.
extractable pollutants	Pollutants that can be removed from a contaminated sample by passing water through the sample.
gamma radiation	Short-wavelength electromagnetic radiation of nuclear origin that has no mass or charge. Because of its short wavelength (high energy), gamma radiation can cause ionization. Other electromagnetic radiation (such as microwaves, visible light, and radio waves) have longer wavelengths (lower energy) and cannot cause ionization.
groundwater	A subsurface body of water in the zone of saturation (where soil sediments have become saturated with water).
half-life, radioactive	The time required for the activity of a radioactive substance to decrease to half its value by inherent radioactive decay. After two half-lives, one-fourth of the original activity remains ($1/2 \times 1/2$); after three half-lives, one-eighth ($1/2 \times 1/2 \times 1/2$); and so on.
hazardous waste	Waste exhibiting any of the following characteristics: ignitability, corrosivity, reactivity, or EP-toxicity (yielding toxic constituents in a leaching test). Because of its concentration, quantity, physical, or chemical characteristics, it may: 1) cause or significantly contribute to an increase in mortality rates or cases of serious irreversible illness; or 2) pose a substantial present or potential threat to human health or the environment when improperly treated, stored, transported, disposed of, or handled.
internal radiation	Radiation from a source within the body as a result of deposition of radionuclides in body tissues by processes such as ingestion, inhalation, or implantation. Potassium (^{40}K), a naturally occurring radionuclide, is a major source of internal radiation in living organisms.
lysimeter	A device for sampling soil moisture in the unsaturated zone. See *vadose zone.*
nonattainment area	An area that does not meet the National Ambient Air Quality Standards.
non-storm water	Any water flow that is not entirely composed of rain.

nuclide	A species of atom characterized by what constitutes the nucleus, which is specified by the number of protons, number of neutrons, and energy content; or, alternatively, by the atomic number, mass number, and atomic mass. To be regarded as a distinct nuclide, the atom must be able to exist for a measurable length of time.
organic compound	A chemical whose primary constituents are carbon and hydrogen.
organochloride	An organic compound in which one or more of the hydrogen atoms have been replaced with a chlorine atom.
Part B permit	The second, narrative section submitted by hazardous waste generators in the RCRA permitting process. It details the procedures followed at a facility to protect human health and the environment.
pH	A measure of hydrogen ion concentration in an aqueous solution. Acidic solutions have a pH less than 7, basic solutions have a pH greater than 7, and neutral solutions have a pH of 7.
piezometer	Generally, a small-diameter, nonpumping well used to measure the elevation of the water table or potentiometric surface (an imaginary surface that represents the static head of groundwater and is defined by the level to which water will rise).
pollutant	Any hazardous or radioactive material present in an environmental medium, such as water or vegetation. For storm water, a pollutant is a material that can be mobilized in water, including (but not limited to) litter, soil, oil and grease, pesticides, and fertilizer.
pretreatment	Any process used to reduce a pollutant load before wastewater enters the sewer system.
pretreatment regulations	National wastewater pretreatment regulations (Title 40 CFR, Part 403) adopted by the EPA in compliance with the 1977 amendments to the Clean Water Act, which required that the EPA establish pretreatment standards for existing and new industrial sources.
priority pollutants	A set of organic and inorganic chemicals identified by the EPA as indicators of environmental contamination.
purgeable pollutants	Pollutants that can be removed from a sample by passing nitrogen gas through the sample.
radiation protection standard	Limits on radiation exposure regarded as necessary for protection of public health. These standards are derived based on acceptable levels of risk to individuals.
radiation	Energy emitted from the nucleus of an atom in the form of waves or particles.
radioactivity	The property or characteristic of a nucleus of an atom to spontaneously disintegrate accompanied by the emission of energy in the form of radiation.
radiological	Arising from radiation or radioactive materials.
radionuclide	An unstable nuclide. See *nuclide* and *radioactivity*.

recharge zone	An area of the ground in which surface water migrates to the groundwater.
remediation	See *environmental remediation.*
sanitary sewer system	A system that collects or conveys domestic and industrial wastewater off site. The SNL/California system connects to the LLNL sanitary sewer system, and the combined effluent then connects to the City of Livermore municipal sewer system. The effluent is treated at the Livermore Water Reclamation Plant.
scintillation cocktail	A solution of organic compounds that emits light upon interacting with radiation. For the purposes of this report, it is used primarily for the tritium analysis.
source	Any operation or equipment that produces and/or emits pollutants (e.g., pipe, ditch, well, or stack).
storm drain system	A collection of inlets, catch basins, channels, and trenches, which transport rain from paved areas on the SNL/California site to the Arroyo Seco.
storm water runoff	Rainfall on paved areas that flows over the ground surface.
terrestrial	Pertaining to or deriving from the earth.
terrestrial radiation	Radiation emitted by naturally occurring radionuclides, such as ^{40}K; the natural decay chains ^{235}U, ^{238}U, or ^{232}Th; or cosmic-ray-induced radionuclides in the soil.
thermoluminescent dosimeter	A type of dosimeter. After being exposed to radiation, the material in the dosimeter (lithium fluoride) luminesces upon being heated. The amount of light the material emits is proportional to the amount of radiation (dose) to which it was exposed. See also dosimeter.
tritium	A radionuclide of hydrogen with a half-life of 12.3 years. The very low energy of its radioactivity decay makes it one of the least hazardous radionuclides.
uncontrolled area	An area beyond the boundaries of a controlled area. See *controlled area.*
upgradient	Opposite of the direction of groundwater flow from a designated area of interest. Analogous to upstream.
uranium	A metallic element that is highly toxic and radioactive.
uranium, depleted	Uranium consisting primarily of ^{238}U and having less than 0.72 wt% ^{235}U. Except in rare cases occurring in nature, depleted uranium is man-made.
uranium, total	The amount of uranium in a sample, assuming that the uranium has the isotopic content of uranium in nature (99.27 wt% ^{238}U, 0.72 wt% ^{235}U, and 0.0057 wt% ^{234}U).
vadose zone	The partially saturated or unsaturated region of the ground above the water table that does not yield water to wells.

wind rose A diagram that shows the frequency and intensity of wind from different directions at a particular place.

Zone 7 The common name for the Alameda County Flood Control and Water Conservation District. Zone 7 is the water management agency for the Livermore-Amador Valley with responsibility for water treatment and distribution. Zone 7 is also responsible for management of agricultural and surface water and the groundwater basin.

RADIOLOGICAL UNITS

becquerel (Bq) Unit of radioactive decay equal to one disintegration per second. (SI unit)

curie (Ci) Unit of radioactive decay equal to 2.22×10^{12} disintegrations per minute. (conventional unit)

millirem (mrem) Unit equal to 10^{-3} rem. See *rem.*

person-rem The unit of population dose, which expresses the sum of radiation exposures received by a population. For example, two persons, each with a 0.5-rem exposure, receive 1 person-rem, and 500 people, each with an exposure of 0.002 rem, also receive 1 person-rem.

rad A unit of absorbed dose from ionizing radiation (0.877 rad/R).

rem Stands for roentgen equivalent man; a unit of ionizing radiation, equal to the amount of radiation needed to produce the same biological effect to humans as 1 rad of high-voltage x-rays. It is the product of the absorbed dose (rad), quality factor (Q), distribution factor, and other necessary modifying factors. It describes the effectiveness of various types of radiation in producing biological effects.

roentgen (R) A unit of radiation exposure that expresses exposure in terms of the amount of ionization produced by x or gamma rays in a volume of air. One roentgen (R) is 2.58×10^{-4} coulombs per kilogram of air.

sievert (Sv) A unit of radiation dose equivalent. The Sv is the SI unit equivalent to the rem. It is the product of the absorbed dose (gray), quality factor (Q), distribution factor, and other necessary modifying factors. It describes the effectiveness of various types of radiation to produce biological effects; $1\ Sv = Gy \times Q \times N = 100$ rem.

UNITS OF MEASURE

Throughout this report, an attempt has been made to incorporate the International System of Units—Système Internationale (SI)—or metric system of measurements, with some exceptions. Radiological quantities [activity—curies (Ci), exposure—roentgen (R), and dose—rad and rem] have also been reported in U.S. conventional units because current standards are written in terms of these units. The equivalent SI units are the becquerel (Bq), coulomb per kilogram (C/kg), gray (Gy), and sievert (Sv), respectively.

Table G-1 presents prefixes used in this report to define fractions or multiples of the base units of measurement. Table G-2 lists abbreviations for commonly used units of measure. Table G-3 presents conversion factors for converting from SI units to U.S. conventional units.

Table G-1. Prefixes Used with SI (Metric) Units.

Prefix	Factor	Symbol
mega	1 000 000 or 10^{6}	M
kilo	1 000 or 10^{3}	k
centi	0.01 or 10^{-2}	c
milli	0.001 or 10^{-3}	m
micro	0.000001 or 10^{-6}	µ
nano	0.000000001 or 10^{-9}	n
pico	0.000000000001 or 10^{-12}	p
femto	0.000000000000001 or 10^{-15}	f
atto	0.000000000000000001 or 10^{-18}	a

Table G-2. Abbreviations for Commonly Used Units of Measure.

	Symbol	Name
Radioactivity		
	Ci	Curie
	µCi	microcurie (10^{-6} Ci)
	pCi	picocurie (10^{-12} Ci)
	Bq	becquerel
Volume		
	cm^3	cubic centimeter
	L	liter
	mL	milliliter (10^{-3} L)
	m^3	cubic meter
	ppmv	parts per million volume
	ppb	parts per billion
	µL	microliter (10^{-6} L)
Length		
	km	kilometer (10^{3} m)
	m	meter (m)
	cm	centimeter (10^{-2} m)
	mm	millimeter (10^{-3} m)
	µm	micrometer (10^{-6} m)
Mass		
	kg	kilogram (10^{3} g)
	g	gram
	mg	milligram (10^{-3} g)
	µg	microgram (10^{-6} g)
Time		
	yr	year
	d	day
	h	hour
	min	minute
	s	second

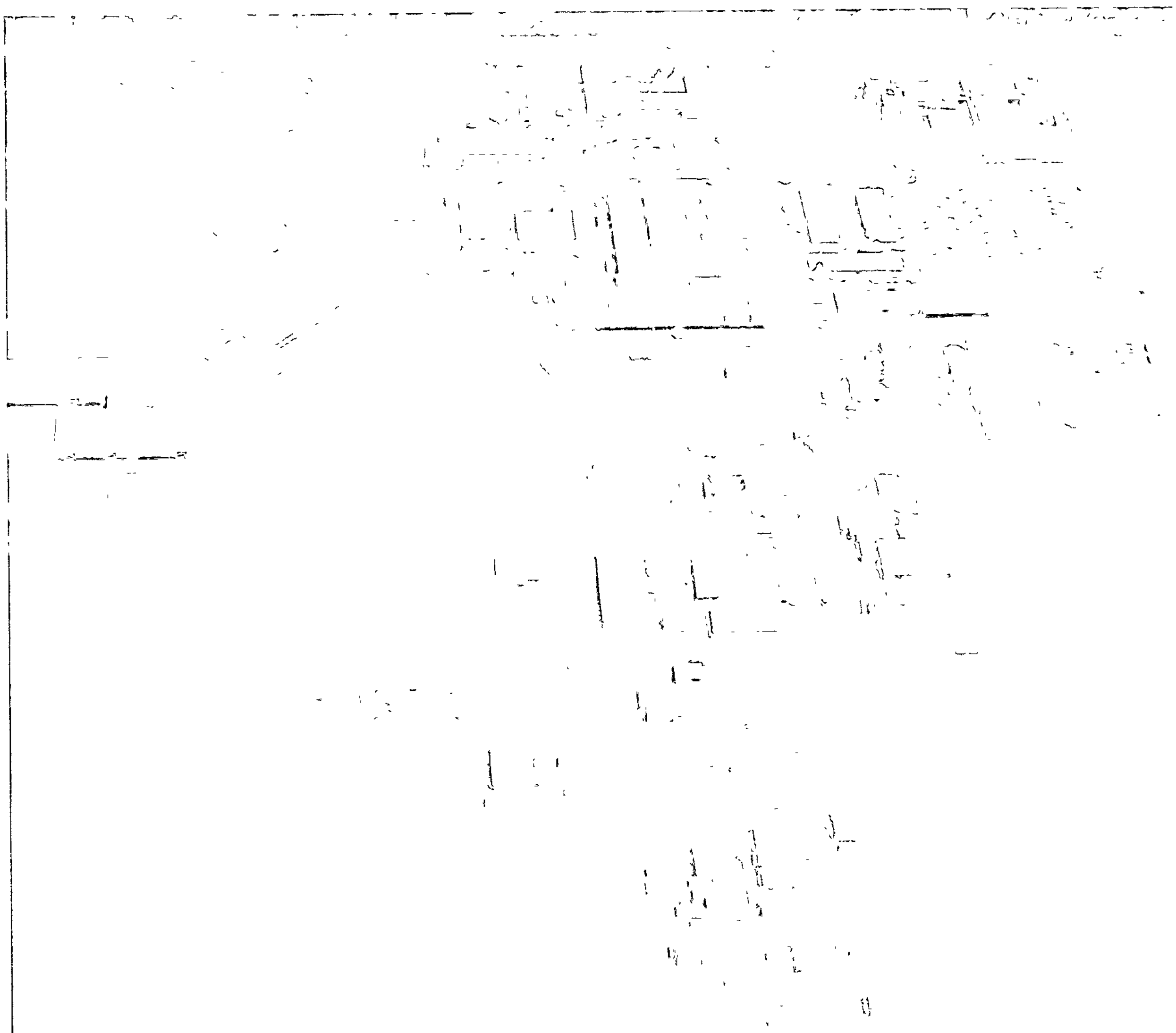
Table G-3. Conversion Factors for Selected SI (Metric) Units.

Multiply SI Unit	By	To Obtain U.S. Conventional Unit
Celsius (°C)	9/5, then add 32	Fahrenheit (°F)
centimeters (cm)	0.39	inches (in.)
cubic meters (m^3)	35	cubic feet ($ft.^3$)
hectares (ha)	2.5	acres
grams (g)	0.035	ounces (oz.)
kilograms (kg)	2.2	pounds (lb.)
kilometers (km)	0.62	miles (mi.)
liters (L)	0.26	gallons (gal.)
meters (m)	3.3	feet (ft.)
micrograms per gram (μg/g)	1	parts per million (ppm)
milligrams per liter (mg/L)	1	parts per million (ppm)
square kilometers (km^2)	0.39	square miles ($mi.^2$)
becquerel (Bq)	2.7×10^{-11}	curie (Ci)
gray (Gy)	100	rad
sievert (Sv)	100	rem

Table G-4. Sampling Location Designators.

Designator	Description
ALAG	Arroyo de la Laguna
ALTA	Residence on Altamont Pass Road
AQUE	Intersection of the California Aqueduct and Greenville Road
AS-3	Arroyo Seco, downgradient wells
AS-4	Arroyo Seco, upgradient well
ASS-2	Arroyo Seco South, outfall from SNL/California
ATS	Ambient air monitoring locations maintained by SNL/California
BELL	Tapwater, Bell Ave., Livermore
CAFE	LLNL south cafeteria
CAL	Calaveras Reservoir
DAN	Danville
DEL	Lake Del Valle
DUCK	Springtown duck pond
ERCH	Escobar ranch
FCC	Federal Communications Commission office
FIRE	Fire station on East Ave., Livermore
FM	Fuel Oil Spill
GAS	Tapwater from gasoline station in downtown Livermore
HOSP	Veteran's Administration Hospital
I580	Interstate 580 overpass over Greenville Road
LCCY	Livermore City Corporation Yard
MESQ	Mesquite Drive in Livermore
MET	LLNL Meteorological Tower
MOD	Ranch in Modesto
MW-406	Monitoring Well #406, old Trudell property
NLF	Navy Landfill
ORCH	Well water from an orchard on Mines Road
PALM	Tapwater, Palm Ave., Livermore
PARK	Camp Parks, Army Reserve Training Center
PATT	Residence on Patterson Pass Road
POOL	LLNL swimming pool
RAIL	Railroad tracks north of LLNL
RRCH	Ralph ranch
SALV	LLNL salvage yard
SHAD	Shadow Cliffs Regional Park Recreation Area
TANK	Water storage tanks on southern portion of the SNL/California site
TAP	LLNL tapwater
TESW	Corner of Tesla Road and Mines Road
VET	Veterinarian's residence/business on Vasco Road
VIS	LLNL visitor's center
WRP	City of Livermore Water Reclamation Plant
XRDS	Residence on Cross Road
ZON7	Patterson Pass water treatment facility of Zone 7 Water District

Appendix A — Laboratory Procedures



Ambient Air
External Radiation
Sanitary Sewer Effluent
Soil/Sediment
Vegetation and Foodstuff
Surface Water
Liquid Effluent Control Systems
Storm Water Runoff
Groundwater

SNL/California uses the Environmental Monitoring Laboratory of LLNL's Nuclear Chemistry Division for the analysis of radionuclides in environmental media (except gross alpha, gross beta, and tritium in groundwater, and gross alpha and gross beta in air particulates, which analyses are done by a commercial laboratory). The Environmental Monitoring Laboratory is obtaining State Department of Health Services accreditation. This process includes extensive documentation and implementation of personnel qualifications, analytical procedures, and quality assurance and quality control programs. The Environmental Monitoring Laboratory issued a quality assurance plan in April 1991. Submittal of the application for accreditation is planned for 1995, pending complete implementation of the quality assurance and quality control programs.

Chemical and physical analyses on LECS samples are done by Environmental Operations Department personnel using equipment owned and maintained by LLNL's Inorganic and Physical Chemistry Department and SNL/California's Environmental Protection Department. These analyses, which are only indicative and not done for compliance purposes, are primarily for the presence of metals. Plans to add total organic carbon analysis are in process.

Analyses of groundwater and gross alpha and gross beta in air particulates is performed by outside commercial laboratories. For a commercial laboratory to be considered for use by SNL/California, it must be accredited by the State Department of Health Services.

Following is a brief synopsis of the analyses done on samples from each of the environmental media.

AMBIENT AIR

Air Particulates

One-half of the filter is submitted to the commercial laboratory for gross alpha and gross beta analyses. After a four-day waiting period (to allow decay of radon daughter products), a 2-in. circle is cut from the filter and placed in a gas-proportional counter for determining gross alpha and beta activity. The other half of the filter is retained and included in a monthly composite sent to the Environmental Monitoring Laboratory for uranium analyses. The filters are ashed, and then dissolved by treatment with HF, $HClO_4$, and HNO_3. The uranium is then purified by ion exchange, and the activity of each of the uranium isotopes is determined by mass spectrometry.

Tritium

LLNL samples—The silica gel is sent to the Environmental Monitoring Laboratory, where it is transferred from the collection flask to a plastic bag. It is thoroughly mixed, and an aliquot is taken for processing. The sample is then freeze-dried. The water removed is counted by liquid scintillation to determine the tritium concentration.

SNL/California samples—The silica gel is sent to a contract laboratory, where it is thoroughly mixed and an aliquot is taken for processing. The moisture on the silica gel is removed by azeotropic distillation with toluene. An aliquot of the distillate is then counted by liquid scintillation to determine the tritium concentration.

EXTERNAL RADIATION

The dosimeters collected by LLNL are processed by LLNL's Hazards Control Department, using automated equipment. The dosimeters are received from the Monitoring Group and stored in a lead shield until they are processed.

The dosimeters collected by SNL/California personnel are processed by the Health Instrumentation Department at SNL/New Mexico. These dosimeters are also stored in a lead shield before processing.

SANITARY SEWER EFFLUENT

Tritium

Sewer samples are distilled in preparation for tritium counting. SNL/California's Health Physics organization does the counting by liquid scintillation.

Other Analyses

The metals and organics samples are sent to a State-certified, commercial laboratory, where they are processed in accordance with EPA protocols. The analyses performed on sanitary sewer effluent samples are EPA method 624 (volatile organics), EPA method 625 (semivolatile organics), EPA method 608 (pesticides), metals (As, Cd, Cr, Cu, Pb, Hg, Ni, Ag, Zn), oil and grease, chemical oxygen demand, biological oxygen demand, cyanide, total dissolved solids, total suspended solids, and pH.

SOIL/SEDIMENT

Tritium in Arroyo Sediment

A portion of the sediment is sent to the Environmental Monitoring Laboratory, where it is freeze-dried. The water removed is then analyzed for tritium activity by liquid scintillation counting.

Surface Soils

The surface soil samples are sent to the Environmental Monitoring Laboratory, where they are analyzed for various radioactive constituents. The only parameter of concern to SNL/California is uranium, which is determined by gamma spectrometry.

VEGETATION AND FOODSTUFF

All vegetation and foodstuff samples are processed by the Environmental Monitoring Laboratory.

Tritium in Vegetation

An aliquot of the vegetation is freeze-dried, and the water removed is analyzed for tritium activity by liquid scintillation counting.

Tritium in Wine

An aliquot of wine is passed through a Peterson furnace to oxidize all the organic matter in the wine to water. This water is then passed through a gas conversion furnace, which converts the water to hydrogen gas. The hydrogen gas is then analyzed for tritium activity by introducing it into an internal gas proportional counter. Alternatively, the wine may be purged with an inert gas and allowed to decay for a period of time. Then the ^3He (the decay product of tritium) is measured by mass spectrometry and used to calculate the tritium concentration.

SURFACE WATER

These samples are processed by the Environmental Monitoring Laboratory.

Low-tritium Water

Water that is expected to have very low tritium content (such as certain surface water and well water) is processed by electrolytically concentrating the tritium content of the water (enriching). The water is then analyzed for tritium activity by liquid scintillation counting.

High-tritium Water

Because this water contains higher levels of tritium, electrolytic enrichment is not necessary. This water is distilled under an argon atmosphere and then is analyzed for tritium content by liquid scintillation.

LIQUID EFFLUENT CONTROL SYSTEMS

Metals

Metals analyses are performed by Inductively Coupled Plasma-Atomic Emission Spectra (ICP-AES) in accordance with internal Environmental Protection Department procedures, which are compatible with applicable EPA procedures.

pH

Analyses are performed in accordance with internal Environmental Protection Department procedures, which are compatible with applicable EPA procedures.

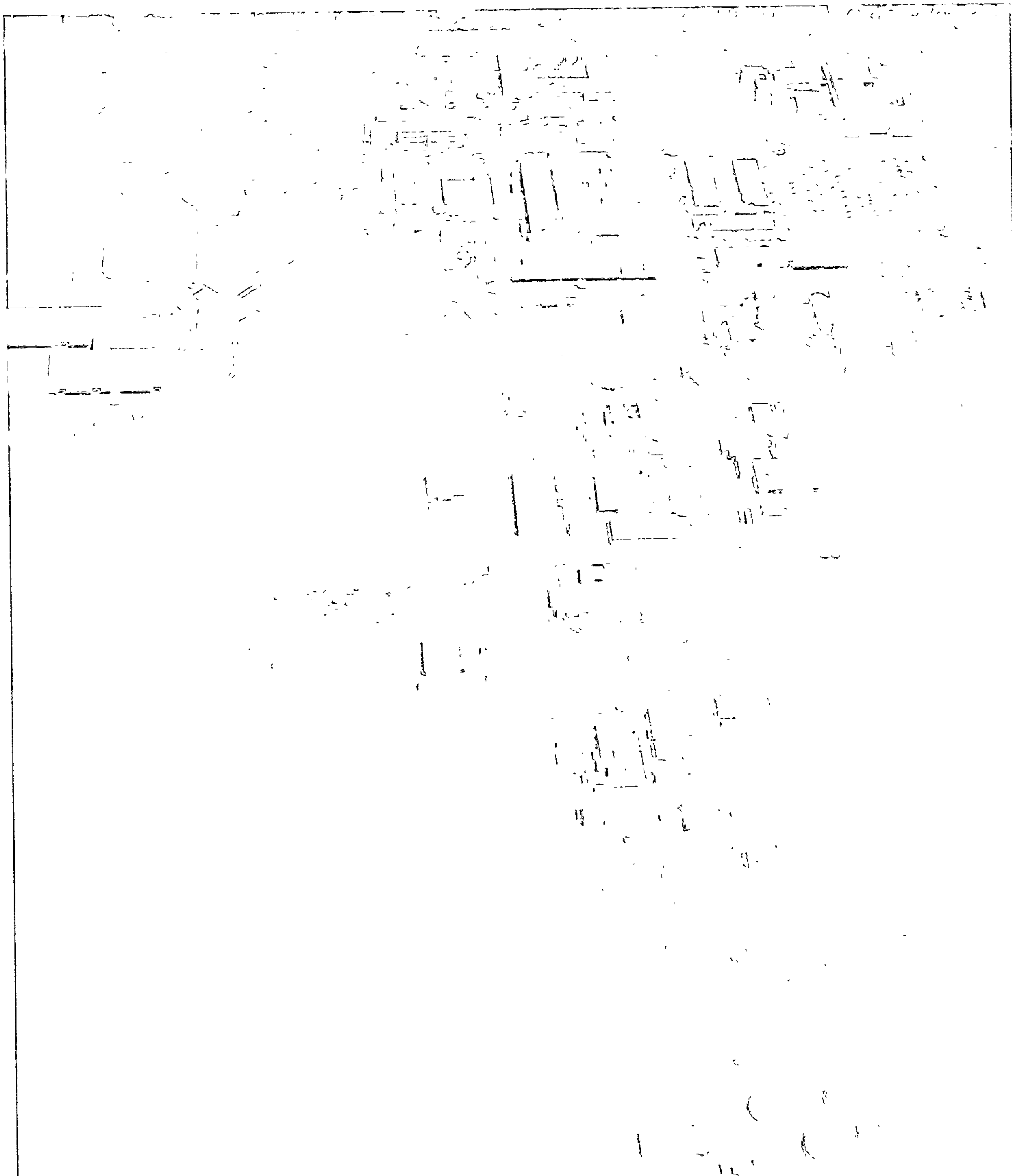
STORM WATER RUNOFF

Samples are sent to a State-certified, commercial laboratory, where they are processed in accordance with EPA protocols. The analyses performed on storm water runoff samples are EPA method 608 (pesticides), EPA method 624 (volatile organics), EPA method 625 (semivolatile organics), metals (As, Cd, Cr, Cu, Pb, Ni, Ag, Zn), pH, total suspended solids, specific conductivity, oil and grease, and tritium.

GROUNDWATER

Groundwater samples are analyzed by a State-certified commercial laboratory. The samples are processed in accordance with EPA protocols. The analyses performed on groundwater samples are EPA method 624 (volatile organics), EPA method 625 (semivolatile organics), CCR Title 22 organics, metals (As, Ba, Be, Cd, Cr, Pb, Se, Ag), gross alpha, gross beta, and tritium.

Appendix B — Wastewater Discharge Regulations



Federal Regulations
State and Local Regulations
Department of Energy Orders

Because the wastewater discharge regulations that apply to SNL/California are extensive, this appendix provides a synopsis of pertinent laws and associated requirements. Three categories of regulations are discussed: Federal regulations, State and local regulations, and DOE orders.

FEDERAL REGULATIONS

The Clean Water Act (CWA) provides the legislative framework for protecting the nation's waterways. Liquid discharges into surface waters and municipal sewer systems from industrial sources are regulated. In accordance with the objectives of the CWA, the EPA has established categorical pretreatment standards for specified classes of industrial dischargers. SNL/California is designated as a "Metal Finishing Point Source Category." Therefore, SNL/California is subject to the pretreatment standards in Title 40 CFR, Parts 403 and 433. These standards are based on available pollution control technology for specific industrial processes.

The Metal Finishing Category covers wastewater discharges from 46 unit operations (Table B-1). SNL/California currently operates two processes subject to the Federal Pretreatment Standards: The Electroplating Laboratory in Bldg. 913 and the Printed Wiring Facility in Bldg. 910.

The major provisions of the Federal Pretreatment Standards applicable to Sandia are the wastewater discharge limitations (Title 40 CFR, Part 433), summarized in Table B-2. The discharge limits apply at the point of discharge from the designated process, before any dilution occurs.

Table B-3 lists the toxic organic compounds that make up the total toxic organic standard for Metal Finishing Categories (Title 40 CFR, Part 433.11). This list is consistent with the City of Livermore's definition of total toxic organics, which includes all EPA priority organic pollutants. The total toxic organic standard is defined as the summation of all quantifiable values greater than 10 µg/L of these compounds. In calculating total toxic organics, the concentrations of specific compounds that were not detected, but which have detection limits greater than 20 µg/L, were assumed to be present at one-half the detection limit.

STATE AND LOCAL REGULATIONS

State of California

The EPA has delegated authority to the State of California to enforce the National Pollutant Discharge Elimination System (NPDES) and Federal Categorical Pretreatment Standards (Title 40 CFR, Part 403). The San Francisco Bay Regional Water Quality Control Board has issued an NPDES permit to the City of Livermore Water Reclamation Plant. In addition, the Federal pretreatment program is administered through the Livermore Water Reclamation Plant with oversight by the Regional Water Quality Control Board. This arrangement ensures a viable pretreatment program and enforcement of all pertinent State and Federal regulations.

Title 22 of the California Code of Regulations (CCR) defines hazardous waste. The criteria for hazardous waste are applicable regardless of waste origin. If wastewater meets the Federal or State criteria of a hazardous waste (and is not otherwise covered under the CWA), it may not be discharged to the sewer system.

City of Livermore

Section 13.32 of the City of Livermore Municipal Code contains the discharge limits for Livermore's sanitary sewer system. These limits are stated in Sandia's Wastewater Discharge Permit, issued annually by the Livermore Water Reclamation Plant, and summarized below.

In general, no facility may discharge any pollutant or wastewater that will interfere with the operation or performance of the publicly-owned treatment works. Users of the publicly-owned treatment works shall not discharge to the sanitary sewer system the following substances:

(a) Any liquids, solids, or gases that by reason of their nature or quantity are, or may be, sufficient either alone or by interaction with other substances to cause fire or explosion or be injurious in any other way to the publicly-owned treatment works or to the operation of the publicly-owned treatment works.

(b) Solid or viscous substances that may cause obstruction to the flow in a sewer or other interference with the operation of the wastewater treatment facilities.

(c) Any wastewater having a pH less than 6 or greater than 9, unless a city permit is obtained. Wastewater having any other corrosive property capable of causing damage or hazard to structures, equipment, and/or personnel of the publicly-owned treatment works is also prohibited.

(d) Any wastewater containing toxic pollutants in sufficient quantity, either singly or by interaction with other pollutants, to injure or interfere with any wastewater treatment process, constitute a hazard to humans or animals, create a toxic effect in the receiving waters of the publicly-owned treatment works, or to exceed the limitations set forth in the categorical pretreatment standard.

(e) Any noxious or malodorous liquids, gases, or solids, which either singly or by interaction with other wastes, are sufficient to create a public nuisance or hazard to life or are sufficient to prevent entry into the sewers for maintenance and repair.

(f) Any substances that may cause the publicly-owned treatment works effluent or any other product of the publicly-owned treatment works, such as residues, sludge, scum, or gases, to be unsuitable for reclamation and reuse or to interfere with the reclamation process.

(g) Any waters or waste that contain more than 100 mg/L freon, extractable fat, oil, or grease.

(h) Any substance that will cause the publicly-owned treatment works to violate its NPDES permit or the receiving water quality standards.

(i) Any wastewater with objectionable color not removed in the treatment process.

(j) Any wastewater having a temperature that will inhibit biological activity in the publicly owned treatment works treatment plant.

(k) Any pollutants, including oxygen-demanding pollutants released at a flow rate and/or pollutant concentration that a user knows or has reason to know will cause interference to the publicly owned treatment works.

(l) Any wastewater containing any radioactive wastes or isotopes of such half-life or concentration as may exceed the limits established by the State or Federal regulatory agency applicable to the publicly owned treatment works user.

(m) Any wastewater that causes a hazard to human life or creates a public nuisance.

(n) Any waters or wastes containing total dissolved solids increment greater than 325 mg/L, or chloride increment greater than 75 mg/L.

Specifically, SNL/California shall not discharge wastewater containing pollutant concentrations (measured at the site outfall) greater than those listed in Table B-4.

DEPARTMENT OF ENERGY ORDERS

The principal DOE order governing discharges to public sewer systems is DOE Order 5400.5, *Radiation Protection of the Public and the Environment.* The purpose of this order is to establish standards and requirements for DOE operations to protect members of the public and the environment against undue risk from radiation. The DOE orders only address radiation protection, e.g., radionuclide discharges to public sewer systems.

If liquid effluents discharged from DOE operations into sanitary sewer systems contain radionuclides at average monthly concentrations greater than five times the derived concentration guide values for liquids (Chapter III of Order 5400.5) at the point of discharge, then best available control technology shall be implemented.

Tritium is the only radionuclide routinely discharged to the sanitary sewer from operations on the SNL/California site. Applying the discharge limit for tritium, the monthly average tritium concentration in the sanitary sewer effluent from the site may not exceed 0.01 µCi/mL or an annual total of 5 Ci.

Additional DOE Order 5400.5 requirements for controlling radionuclide discharges are listed below:

1. Discharges to public sewers should be coordinated with the operators of the wastewater treatment works.
2. Concentrations shall be controlled so that long-term buildup of radionuclides in solids will not present a handling and disposal problem at sewage disposal plants.
3. If liquid effluents contain concentrations greater than five times the derived concentration guide value, ALARA process considerations are required.
4. Operators should ensure that the total annual discharge of radioactive material to the sanitary sewer system will not cause exposures to members of the general public that will result in doses exceeding a small fraction of the basic annual dose limit.

Table B-1. The 46 EPA-designated Metal-finishing Unit Operations.

1. Electroplating
2. Electroless plating
3. Anodizing
4. Conversion coating
5. Etching (chemical milling)
6. Printed circuit board mfg.
7. Cleaning
8. Machining
9. Grinding
10. Polishing
11. Barrel finishing (tumbling)
12. Burnishing
13. Impact deformation
14. Pressure deformation
15. Shearing
16. Heat treating
17. Thermal cutting
18. Welding
19. Brazing
20. Soldering
21. Flame spraying
22. Sand blasting
23. Other abrasive jet machining
24. Electronic discharge machining
25. Electrochemical machining
26. Electron beam machining
27. Laser beam machining
28. Plasma arc machining
29. Ultrasonic machining
30. Sintering
31. Laminating
32. Hot dip coating
33. Sputtering
34. Vapor plating
35. Thermal infusion
36. Salt bath descaling
37. Solvent degreasing
38. Paint stripping
39. Painting
40. Electrostatic painting
41. Electropainting
42. Vacuum metallizing
43. Assembly
44. Calibration
45. Testing
46. Mechanical plating

Table B-2. Pretreatment Standards for Metal Finishing Category (PSES).[a]

Pollutant	Daily Maximum (mg/L)[b]	Maximum Monthly Average (mg/L)[c]
Cadmium (T)[d]	0.69	0.26
Chromium (T)	2.77	1.71
Copper (T)	3.38	2.07
Lead (T)	0.69	0.43
Nickel (T)	3.98	2.38
Silver (T)	0.43	0.24
Zinc (T)	2.61	1.48
Cyanide (T)	1.20	0.65
Total toxic organics	2.13	–
Cyanide, amenable to chlorination	0.86	0.32

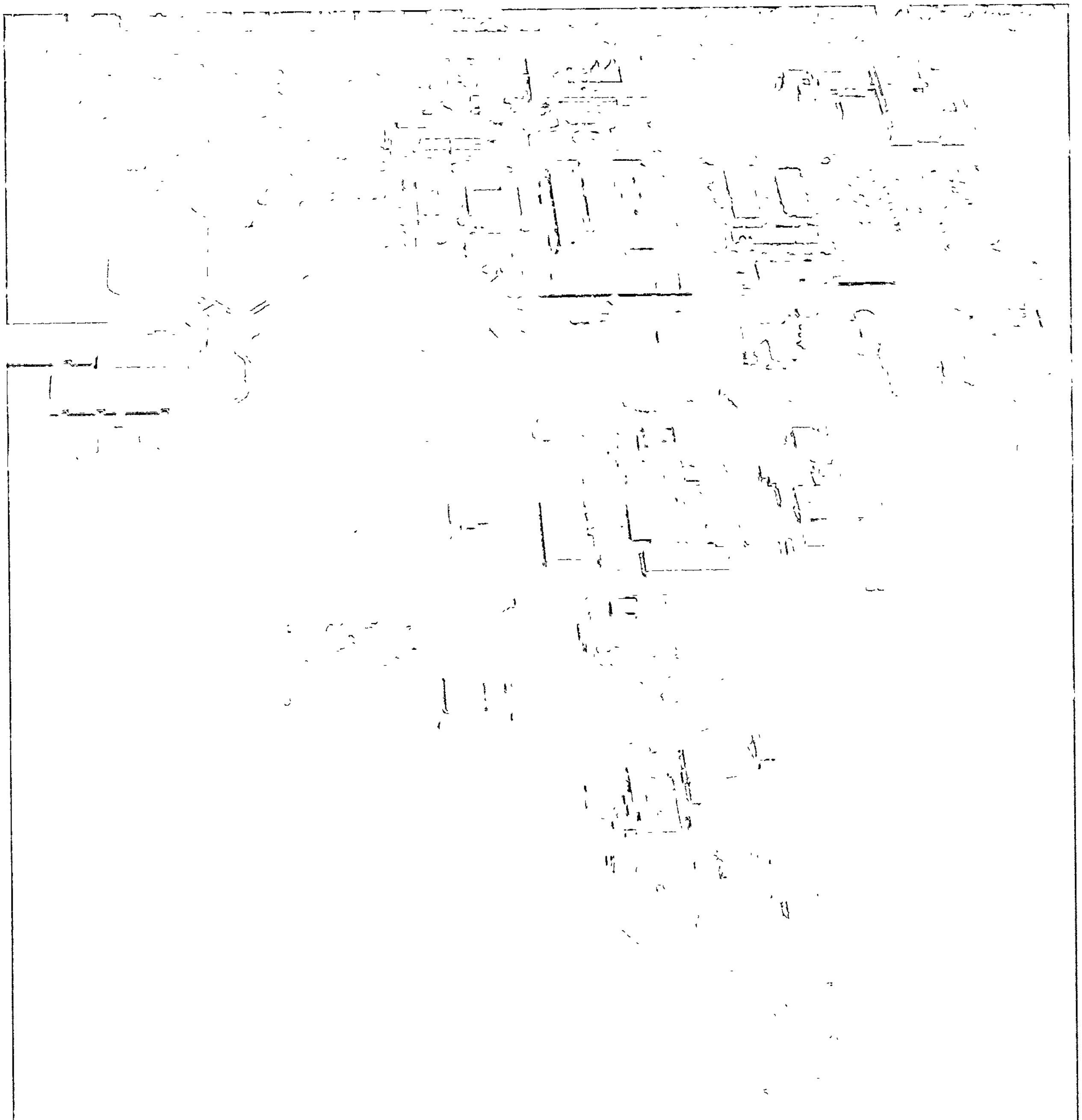
[a]PSES refers to pretreatment standards for existing sources. Pretreatment standards for new sources (PSNS) apply to metal finishing operations that began operation after August 31, 1982. Some of the new source standards are more stringent.
[b]The maximum monthly average is statistically based on 10 samples per month.
[c]The maximum monthly average limit should be applied to batch discharges.
[d]"T" indicates total.

Table B-3. Regulated Toxic Organics.

Acenaphthene
Acrolein
Acrylonitrile
Benzene
Benzidine
Carbon tetrachloride
Chlorobenzene
1,2,4-trichlorobenzene
Hexachlorobenzene
1,2-dichloroethane
1,1,1-trichloroethane
Hexachloroethane
1,1-dichloroethane
1,1,2-trichloroethane
1,1,2,2-tetrachloroethane
Chloroethane
Bis (2-chloroethyl) ether
2-chloroethyl vinyl ether (mixed)
2-chloronaphthalene
2,4,6-trichlorophenol
Parachlorometa cresol
Chloroform (trichloromethane)
2-chlorophenol
1,2-dichlorobenzene
1,3-dichlorobenzene
1,4-dichlorobenzene
N-nitrosodi-n-propylamine
Pentachlorophenol
Phenol
Bis (2-ethylhexyl) phthalate
Butyl benzyl phthalate
Di-n-butyl phthalate
Di-n-octyl phthalate
Diethyl phthalate
Dimethyl phthalate
1,2-benzanthracene (benzo(a)anthracene)
2,4-dichlorophenol
1,2-dichloropropane (1,3-dichloropropene)
2,4-dimethylphenol
2,4-dinitrotoluene
2,6-dinitrotoluene
1,2-diphenylhydrazine (tetrachloromethane)
Ethylbenzene
Fluoranthene
4-chlorophenyl phenyl ether
4-bromophenyl phenyl ether
Bis (2-chloroisopropyl) ether
Bis (2-chloroethoxy) methane
Methylene chloride (dichloromethane)
Methyl chloride (chloromethane)
Methyl bromide (bromomethane)
Bromoform (tribromomethane)
Dichlorobromomethane
Chlorobibromomethane
Hexachlorobutadiene
Hexachlorocyclopentadiene
Isophorone
Naphthalene
Nitrobenzene
2-nitrophenol
4-nitrophenol
2,4-dinitrophenol
4,6-dinitro-o-cresol
N-nitrosodimethylamine
N-nitrosodiphenylamine
Aldrin
Dieldrin
Chlordane
4,4-DDT
4,4-DDE (p,p-DDX)
4,4-DDD (p,p-TDE)
Alpha-endosulfan
Beta-endosulfan
Benso(a)pyrene (3,4-benzopyrene)
3,4-benzofluoranthene
11,12-benzofluoranthene
Chrysene
Acenaphthylene
Anthracene
1,12-benzoperylene
Fluorene
Phenanthrene
1,2,5,6-dibenzanthracene
Indeno (1,2,3-cd) pyrene
Pyrene
Tetrachloroethylene
Toluene
Trichloroethylene
Vinyl chloride (chlorethylene)
3,3-dichlorobenzidine
1,1-dichloroethylene
1,2-trans-dichloroethylene
TCDD
Endosulfan sulfate
Endrin (benzo(b)fluorantheme)
Endrin aldehyde (benzo(k)fluorantheme)
Heptachlor
Heptachlor epoxide (BHB-hexachlorocyclohexane)
Alpha-BHC
Beta-BHC (benzo(ghi)perylene)
Gamma-BHC
Delta-BHC
PCB-polychlorinated biphenyls (dibenzo(a,h)antracene)
PCB-1242 (Arochlor 1242) (2,3-o-phenlene pyrene)
PCB-1254 (Arochlor 1254)
PCB-1221 (Arochlor 1221)
PCB-1232 (Arochlor 1232)
PCB-1248 (Arochlor 1248)
PCB-1260 (Arochlor 1260)
PCB-1016 (Arochlor 1016)
Toxaphene
2,3,7,8-tetrachlorodibenzo-p-dioxin

Table B-4. Specific Pollutant Limitations for Wastewater Discharged to the Livermore Water Reclamation Plant.

Pollutant	Discharge Concentration (mg/L)
Arsenic	0.06
Cadmium	0.14
Copper	1.0
Cyanide	0.04
Lead	0.2
Mercury	0.01
Nickel	0.61
Silver	0.2
Total chromium	0.62
Zinc	3.0
Total toxic organics	1.0



RADIATION DOSE TERMINOLOGY
RADIOLOGICAL DOSE ASSESSMENT
EXPOSURE PATHWAYS
METHODS
ESTIMATING RADIOLOGICAL IMPACT
MODELING PARAMETERS FOR 1994 RADIOLOGICAL DOSE

This appendix explains radiation dose terminology, describes the methods used to calculate radiation doses to the public, and provides the specific models used in the 1994 dose assessment.

RADIATION DOSE TERMINOLOGY

Internal and External Radiation Doses

A person's radiation dose from an external (penetrating) radiation source is received only while the individual is exposed to the source. However, if radioactive material is taken into the body, the dose will continue even after the intake has ceased. The body can intake radioactive materials primarily three ways:

- ingestion of the radioactive material in food or drinking water,
- inhalation of airborne radioactive particulates or vapors, and
- absorption of the radionuclide through the skin.

Following an intake, radioactive material is distributed throughout the body according to how it is metabolized. Consequently, organs will continue to absorb energy emitted by the radionuclides remaining in the body.

The dose rate to organs will diminish over time because of radioactive decay and biological elimination. Because the body rapidly eliminates some materials, like tritium, exposure to radioactivity following intake is brief. Also, some radionuclides decay rapidly (have short half-lives), thereby minimizing exposure.

Absorbed Dose and Dose Equivalent

The absorbed radiation dose is defined as the quantity of radiation energy absorbed by an organ, divided by the organ's mass. The SI unit for absorbed dose is the gray (Gy). An organ receives an absorbed dose of 1 Gy when it absorbs 1 joule (J) of radiation energy per kilogram (kg) of its mass (1 Gy = 1 J/kg). The conventional unit of absorbed dose is the rad (100 rad = 1 Gy).

The measure of absorbed dose is independent of the type of radiation (alpha particles, beta particles, gamma rays, or neutrons). Different types of radiation cause different levels of damage to human tissue, based on the rate of energy deposition.

The dose equivalent takes into account the type of radiation involved in the exposure. The dose equivalent is calculated by multiplying the absorbed dose by a quality factor specific to the type of radiation.

The International Commission on Radiological Protection (ICRP) has recommended specific quality factors for the radiation types most relevant to this report. DOE has adopted these quality factors, which are listed below, in DOE Order 5400.5:

- Gamma rays: 1
- Beta particles, other electrons: 1
- Alpha particles: 20

The committed dose equivalent is the predicted total dose equivalent to a tissue or organ over a 50-year period after a known intake of a radionuclide into the body. Fifty years is the approximate residual life expectancy of a young adult.

The SI unit of dose equivalent and committed dose equivalent is the sievert (Sv). The conventional unit, used in this report, is the rem (100 rem = 1 Sv).

Effective Dose Equivalent

The effective dose equivalent (EDE) combines the dose equivalents received by all organs or tissues into a single weighted sum. The EDE is defined as the sum of all organ dose equivalents after each one has been multiplied by an appropriate weighting factor. The weighting factors were developed by the ICRP. They express the fractional risk of a stochastic health effect associated with the dose equivalent to that organ. DOE adopted the ICRP weighting factors (Wt) in DOE

Order 5400.5. The EPA has accepted these factors for calculating radiation dose for determining compliance with the Clean Air Act (Title 40 CFR, Part 61, Subpart H).

The EDE combines the individual organ or tissue dose equivalents into a single risk-weighted sum. EDEs can be added to determine the total risk from exposure to several radionuclides. When external radiation sources, such as an airborne plume, expose the whole body uniformly, the external EDE is added to the EDE from internal exposures.

The committed effective dose equivalent refers to the total EDE that is accumulated over a 50-year period following a single intake.

Collective Effective Dose Equivalent

Collective dose is the sum of individual doses received by all members of a population. In this report, the average individual EDE is used to calculate the collective dose for the population within a 50-mile radius. The unit of collective EDE is the person-rem or person-sievert (person-Sv).

RADIOLOGICAL DOSE ASSESSMENT

This section presents the methods, assumptions, and calculations used to assess routine radiological exposures from each significant environmental pathway. It covers routine operations involving uniform releases to the environment and is not intended for assessing consequences from accidents.

SNL/California annually assesses radiologic impacts of site operations on the public. This assessment is done in accordance with DOE- and EPA-approved methods. The results are published and made available to the general public each year in the SNL/California *Site Environmental Report*.

The radiological impacts from SNL/California operations are assessed by determining the radiologic dose to members of the public who would receive maximum credible exposures. This assessment involves the following:

- measuring radioactive emissions from SNL/California,
- identifying all relevant exposure pathways,
- evaluating environmental transport and fate of contaminants, and
- estimating human intake and resulting dose.

In most cases, the amount of radioactive material emitted by SNL/California is too small for radiologic doses to be determined from direct measurements of radionuclide concentrations in environmental media. That is, it is not always possible to discriminate between Sandia's contribution to radiation in the environment and natural background sources of radiation. Also, because Sandia is located adjacent to LLNL, the monitoring system cannot always differentiate the emissions from the two sites. Therefore, off-site doses are calculated based on radioactive effluent measurements at the point of discharge from the facility. Environmental transport and exposure pathway computer models are used to estimate radionuclide concentrations in various environmental media at locations accessible to the public. Dosimetric models then are applied to determine human intake and to convert intake to dose.

Radiological doses are expressed in terms of EDE. The method used to calculate EDEs applies the dosimetric parameters recommended by the ICRP in Publications 26 (1977) and 30 (1980).

Doses from the air pathway also are calculated and reported to demonstrate compliance with the Federal Clean Air Act NESHAPs Rule for Radionuclides (Title 40 CFR, Part 61). These doses are calculated using the Clean Air Act Code, which contains models (AIRDOS-EPA and RADRISK) approved by the EPA for calculating atmospheric transport and exposure. Under the Clean Air Act, the

EPA assumes jurisdiction over radionuclides emitted to the atmosphere, i.e., the air pathway. The air pathway dose includes radiological dose from immersion, inhalation, and ingestion, resulting from radionuclides emitted to the atmosphere. Population exposure is converted to radiation dose using dose conversion factors and weighting factors specified by the EPA.

EXPOSURE PATHWAYS

Figure C-1 simplistically represents the important pathways of radioactivity released to the environment. Based on the environmental pathway analysis for SNL/California and the land use characteristics on and around the site, the following doses are calculated:

- external (direct) dose at the site boundary;
- inhalation from the air pathway and submersion from plume passage; and
- ingestion from consumption of locally produced foodstuffs and drinking water.

SNL/California has no operations that discharge liquid effluents to surface water or to the ground. These doses are determined at the point of maximum exposure in uncontrolled areas, i.e., publicly accessible locations. The doses are compared to DOE and EPA radiation protection standards. Each of the doses used to evaluate the radiological impact from SNL/California operations is described briefly below.

External "Fence-Line" Dose

The fence-line dose rate is a measure of the maximum external radiation dose at locations of nearest uncontrolled public access.

The dosimeters measure dose rates from all external radiation sources, including cosmic radiation, radioactivity that occurs naturally in the environment, fallout from nuclear weapons testing, and any contribution from SNL operations. In most cases, the dose rates are a measure of regional background, as shown by comparing the perimeter measurements to those made at off-site locations (in the Livermore Valley). Moreover, these measurements are made at points of maximum exposure and assume an occupancy of 24 hours a day, 365 days a year. No member of the public actually resides at

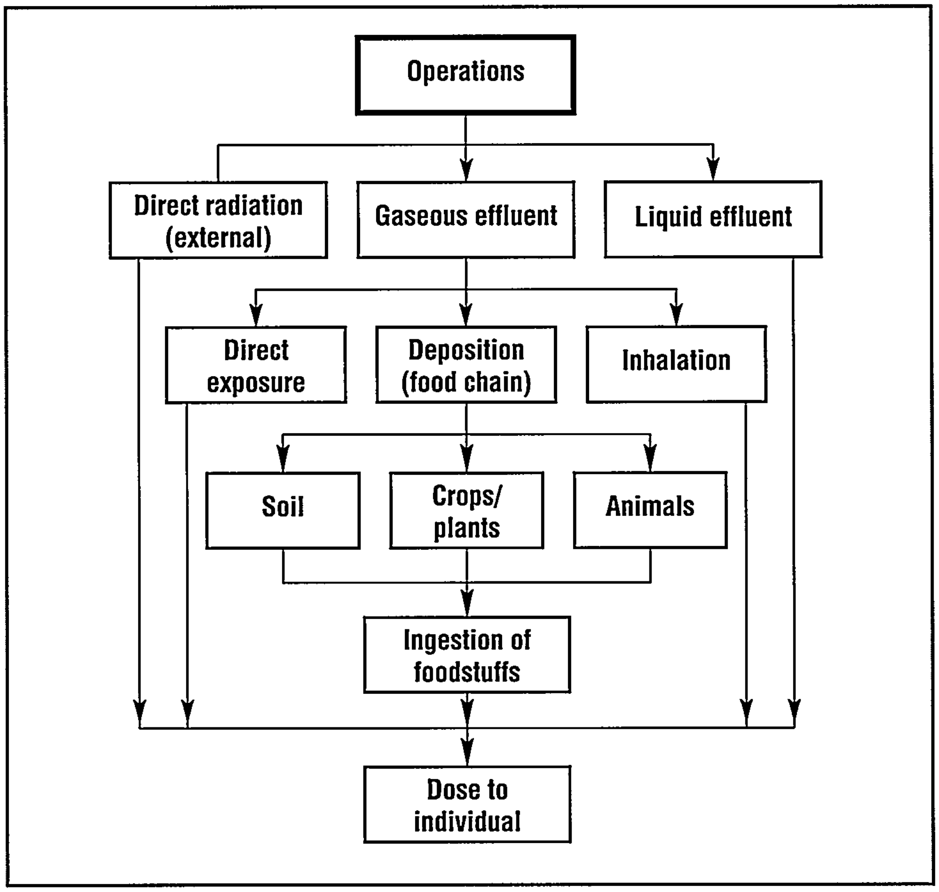


Figure C-1. Major radiation exposure pathways to humans.

these locations for extended periods of time; therefore, these estimates are conservative.

Inhalation/Submersion Dose

Air pathway doses are calculated for each airborne radioactive discharge to the atmosphere. Inhalation/submersion doses are calculated at the site perimeter, at the location of the nearest resident, and at the point of maximum off-site exposure. The amount of radioactivity released by SNL/California is usually too low for radionuclide concentrations in ambient air to be measured accurately and for dose to be determined. Therefore, environmental transport and exposure pathway models are used to calculate potential dose resulting from effluent emissions (measured at the Tritium Research Laboratory stack). The two methods used comply with both DOE standards and NESHAPs.

The atmospheric transport of radioactive materials from SNL/California is calculated based on source term and meteorological conditions. Meteorological factors (wind speed, direction, and atmospheric stability) are measured continuously at a monitoring station on the SNL/California site. Atmospheric observations are collected at two tower levels (10 m and 40 m). Because the 30-m Tritum Research Laboratory stack is being modeled, the corresponding 40-m tower data are used.

Ingestion Dose

Potential doses from ingestion of locally produced foodstuff and surface water are based on actual measurements of radionuclide concentrations in the various media (determined by sample analysis). Conservative exposure data and current ICRP dosimetric factors are used to estimate doses to the individual. Field measurements are used to assess tritium in water, milk, and vegetation (which includes the forage-cow-milk pathway).

METHODS

External Methods

Dose rates from external penetrating radiations (primarily gamma rays) are measured using thermoluminescent dosimeters. These dosimeters provide a direct measure of external radiation exposure rates (expressed in milliroentgens per unit time). The exposure rates are then converted to dose equivalent units (mrem) to compare to appropriate standards.

Annual Inhalation and Submersion Dose Methods

Radioactive materials released to the atmosphere are subject to complex processes, which govern their movement in the environment. Figure C-2 simplistically represents the method used to assess the inhalation/submersion pathway.

Sandia Method

The method used to calculate doses complies with the DOE primary radiation protection standards for the public. Expressed as EDEs, they also comply with the ICRP risk-based system.

Doses are calculated using a computer code based on the Gaussian plume model. This code provides ratios of concentration to release rate (χ/Q) through sixteen, 22.5° compass sectors and at various distances from potential release points. The average annual χ/Q values are calculated using local meteorological data (obtained from sensors on the SNL/California meteorological tower from a height of 40 m). Measurements of wind speed, wind direction, and atmospheric stability are tabulated at 1/4-hour intervals over the calendar year.

Variance in the horizontal wind direction is used to estimate Pasquill-Gifford stability categories, based on the method described by D. H. Slade (1968). Lateral and vertical standard deviations σ_y and σ_z are entered in the computer code as functions of these stability categories and the respective distances. Based on the annual effluent data and the appropriate χ/Q values, the radionuclide concentrations at the site perimeter and at the location of the nearest resident are calculated.

The atmospheric dispersion parameter (χ/Q) is calculated based on the distance from the facility to the receptor location (i.e., site perimeter, nearest resident, and point of maximum ground-level concentration). This process is repeated for each facility that discharges radioactive matter to the atmosphere. Once the code has calculated the dispersion parameter, it multiplies the parameter by the release rate and the standard human inhalation rate, to obtain intake. Dose conversion factors provided by the DOE are used to relate the intake of radioactive material to dose commitment. These dose factors provide estimates of 50-year doses from a chronic one-year intake of radioactivity.

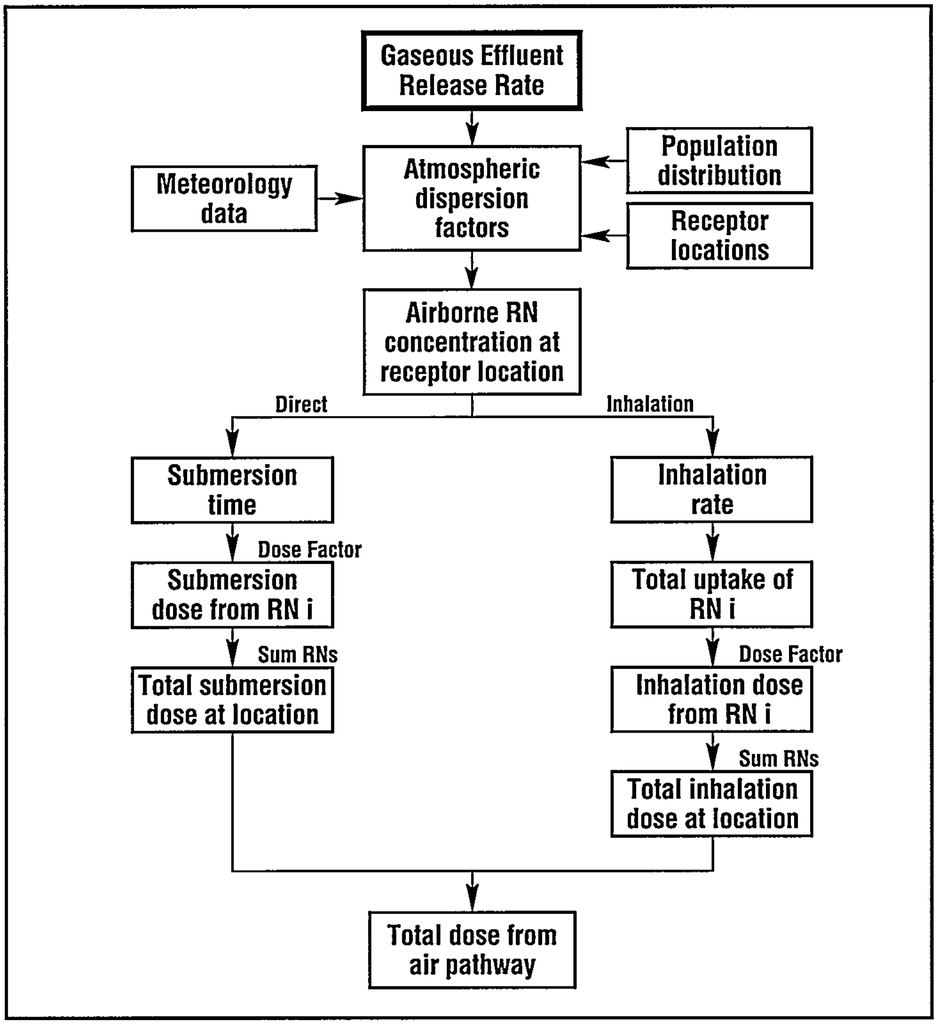


Figure C-2. Dose assessment of air pathway.

Following are the calculations of air pathway dose at the perimeter, the location of the nearest resident, and the point of maximum exposure.

Inhalation and Submersion Dose (D) Calculations (^3H):

$$D_{max} = C \times U \times D,$$

where

C = radionuclide concentration at the receptor,

U = intake rate (the inhalation rate for a maximally exposed adult is 8400 m^3/yr.), and

D = tritium dose conversion factor (9.45×10^{-8} mrem/pCi).

(The tritium dose conversion factor was obtained by multiplying the inhalation dose factor, 6.3×10^{-8} mrem/pCi, by 1.5, to include absorption through the skin).

The radionuclide concentration at the receptor, C, is calculated as follows:

$$C = 3.17 \times 10^4 \text{ Ci/m}^3 (\chi/Q)(Q),$$

where

χ/Q = diffusion parameter (s/m^3), Q = release rate, Ci/yr,

$$3.17 \times 10^4 = \frac{1 \times 10^{12}\ \text{pCi/Ci}}{3.15 \times 10^7\ \text{s/yr}}$$

Assessment Assumptions:

Tritium emissions account for all the off-site dose from SNL/California operations. Tritium exits the site in two major forms: tritium oxide or vapor (HTO or T_2O) and elemental tritium (HT or T_2). Any HTO that enters the body is distributed throughout and is eliminated at the same rate as body water. Only a small fraction of HT is retained. The EDE from exposure to elemental tritium in air is 25,000 times lower than an equal exposure to tritium oxide. For this reason, elemental tritium is excluded from the dose calculations.

Clean Air Act NESHAPs Method

SNL/California is required to calculate and report radiological doses pursuant to NESHAPs (Title 40 CFR, Part 61, subpart H). The EPA dose limits apply only to exposure to members of the public from airborne emissions of radionuclides. This assessment includes exposures from inhalation, air submersion, ingestion, and ground surface irradiation resulting from airborne emissions.

The EPA regulations require that the dose assessment be done using an approved version of the Clean Air Act Code, such as CAP88. SNL/California uses a personal computer version of CAP88, called CAP88-PC, to demonstrate compliance with the NESHAPs Rule for Radionuclides. Human intake is converted to dose using dose conversion and weighting factors specified by the EPA. For this method, the models and parameters used to predict the transport of radionuclides in the environment and to estimate dose meet EPA requirements.

The assessment methodology was developed for the U.S. EPA Office of Radiation Programs by Oak Ridge National Laboratory. Human exposure data are derived from the atmospheric and environmental transport code (Moore, 1979). The dosimetric and health effects database used was developed by the RADRISK computer code (Dunning, 1980). The DARTAB computer code (Begouich, 1981) is used to predict dose (and radiation-induced health effects, if desired) from the human exposure and health effects data.

The CAP88 computer model is used to estimate radiological doses associated with routine emission of radionuclides. This computer model estimates: radionuclide concentrations in air; deposition rates on ground surfaces; ground surface concentrations; intake rates via inhalation of air and ingestion of meat, milk, and fresh vegetables; and radiation doses to humans from airborne releases of radionuclides. An internal library of dose conversion factors combines radionuclide environmental exposure data with dosimetric and health effects data to generate tabulations of the predicted impact (in terms of EDE) of radioactive airborne effluents.

The CAP88-PC model calculates atmospheric dispersion for radionuclides released from stacks or area sources. Radionuclide concentrations in meat, milk, and fresh produce are estimated by coupling the deposition rate output of the atmospheric dispersion models with the NRC Regulatory Guide 1.109 terrestrial food chain models. Radionuclide concentrations for specified distances and directions are calculated for the following exposure pathways:

- immersion in air containing radionuclides;
- exposure to ground surfaces contaminated by deposited radionuclides;
- inhalation of radionuclides in air; and
- ingestion of food in the area.

CAP88-PC uses a modified Gaussian plume dispersion model to calculate annual average radionuclide concentrations for each grid sector. Building wake effects and downwash are not included in the model. The same type of plume rise calculation (buoyant, momentum, or fixed) is used for all sources.

Input into CAP88-PC includes a source term that describes facility-specific parameters and options that control the dispersion model and exposure calculations. Meteorological data are also required as input. The source term includes annual radionuclide release rates and stack height, diameter, heat release rate, and stack gas exit velocity.

Input values for the food chain model are found in *Radionuclides Background Information Document for Final Rules.* All agriculture production parameters are assigned default values.

Environmental Measurements Method

The amount of radioactivity released from SNL/California is very small—often too small to discriminate between it and background radiation sources. Inhalation doses can be calculated based on field measurements of airborne tritium. The EDE for tritium is calculated using the following equation:

$$D(^3H) = C \times U \times DF,$$

where

$D(^3H)$ = effective dose equivalent from inhalation of ^3H, mrem/yr

C = ^3H concentration in air at receptor location, pCi/m^3

U = intake rate (inhalation rate of standard man), 8400 m^3/yr, and

DF = dose conversion factor for ^3H, 9.45×10^{-8} mrem/pCi.

By multiplying U and DF, the final, simplified equation becomes:

$$D(^3H) = C \times 7.94 \times 10^{-4}$$

Ingestion Dose Methods

Potential doses from ingestion of locally produced foodstuff and surface water are estimated by environmental sampling and computer modeling techniques. The dose assessment accounts for each of the significant agricultural products of the Livermore Valley. These include general vegetation and milk. Figure C-3 illustrates the terrestrial food chain pathway analysis. Doses are also calculated for drinking water at each of the eight Livermore Valley water sampling locations. None of these locations are primary sources of drinking water. However, to provide an upper-bound estimate of dose at each location, a hypothetical person is assumed to obtain all his/her drinking water (2 L/day) from that source.

CAP88-PC Computer Method

The CAP88-PC code is used to calculate ingestion doses based on airborne emission data. The doses are calculated from deposition of radionuclides on cropland and pasture. CAP88-PC uses the models from the NRC Regulatory Guide 1.109 to estimate annual doses to man from vegetables, meat, and milk consumption. Dose conversion factors are specified by the EPA.

Environmental Measurements Method

Data from the sampling and analysis of water and foodstuffs are also used to estimate dose.

Annual Dose from Potable Water

Assuming that all water sampled is available as drinking water, the annual whole-body dose for tritium is calculated using the following equation:

$$R_{whole\ body} = C_w U_w D_w,$$

where

C_w = concentration (pCi/L),

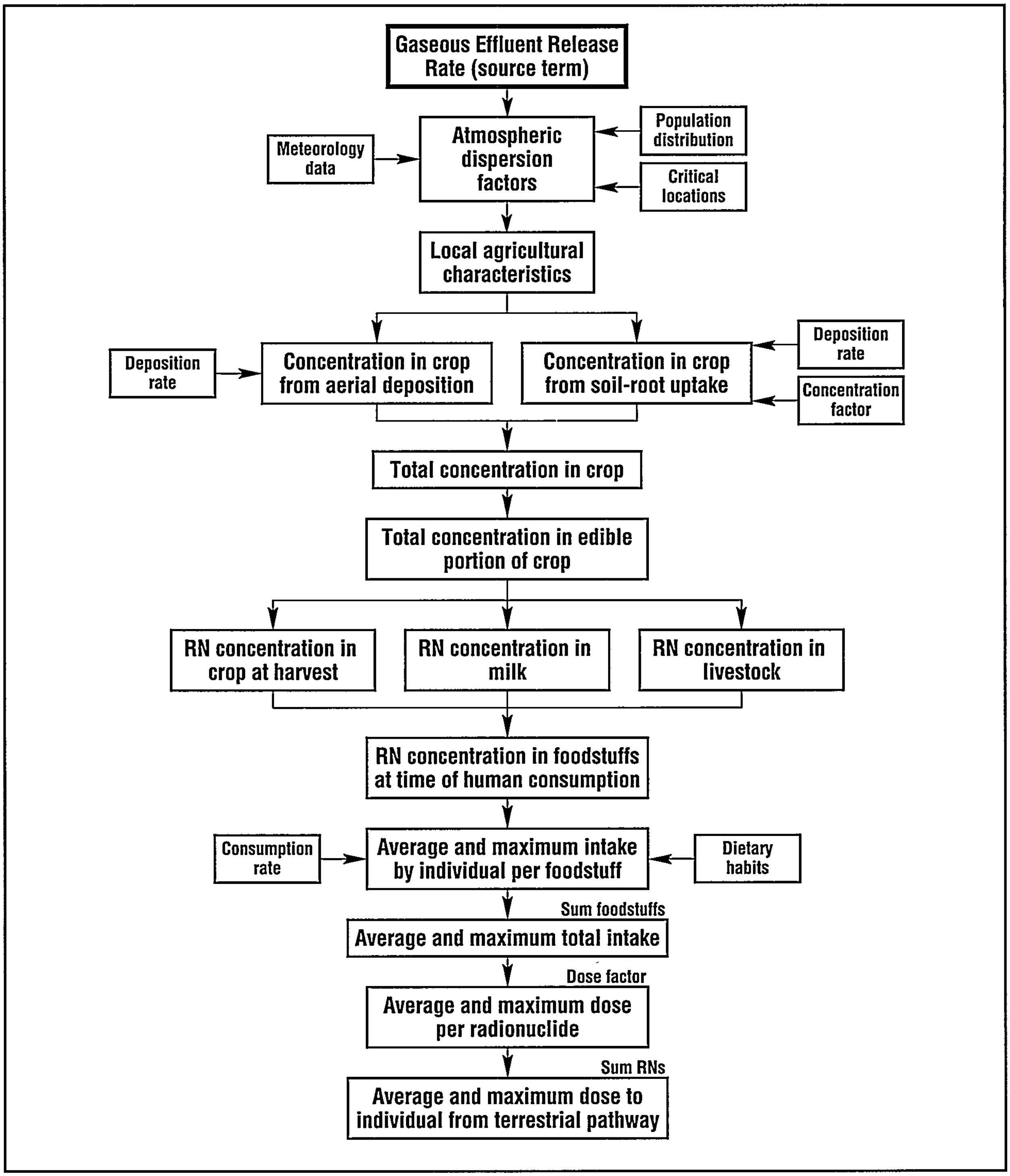


Figure C-3. Dose assessment of terrestrial food chain pathway.

U_w = intake rate (L/yr) = 730 L/yr for maximum exposed individual, and

D_w = dose factor (mrem/pCi) = 6.3×10^{-8} mrem/pCi for the whole-body ingestion pathway for an adult.

$R_{whole\ body}$ is the EDE in mrem from ingestion of 730 L of potable water with concentration C_w.

Annual Dose from Forage-Cow Milk Pathway for Tritium in Vegetation

Assuming that all feed for the cattle was pasture grass, the effective dose equivalent per mCi/mL of HTO for the maximum exposed individual has been calculated using the following equation:

$$D_{whole\ body} = D_{veg} + D_{meat} + D_{milk}$$

Broken down, each of these elements can be expressed as follows.

① $D_{veg^*} = U_{veg} \times C_{veg} \times D_{HTO}$,

*leafy vegetables

where

U_{veg} = intake rate (kg/yr) = 64 kg/yr for maximally exposed individual,

C_{veg} = concentration (pCi/kg)

= $10^9 \frac{\text{pCi/kg}}{\mu\text{Ci/mL}} \times C_{veg}\ \mu\text{Ci/mL}$ (measured),

D_{HTO} = dose factor (mrem/pCi)

= 6.3×10^{-8} mrem/pCi for ^3H for the adult whole-body ingestion pathway.

Thus,

D_{veg} (mrem/yr) = $0.40 \times 10^4\ C_{veg}\ \mu\text{Ci/mL}$ (measured).

② $D_{meat} = U_{meat} \times D_{HTO} \times C_{meat}$,

where

U_{meat} = 110 kg/yr,

D_{HTO} = 6.3×10^{-8} mrem/pCi, and

C_{meat} = $(F_f)(Q_f)(C_{veg}) \exp(-\gamma_i \tau_s)$,

where

F_f = fraction of daily intake of nuclide per kg of animal/fish (pCi/kg in meat per pCi/day ingested by the animal), days/kg,

Q_f = amount of feed consumed (kg/day),

C_{veg} = concentration (pCi/kg),

γ_i = radiological decay constant, day^{-1}, and

τ_s = time between slaughter to consumption (days).

Simplified,

$$C_{meat} = (1.2 \times 10^{-2}\ \text{day/kg})\ (50\ \text{kg/day})\ (C_{veg}\ \mu\text{Ci/mL})\ \left(10^9 \frac{\text{pCi/kg}}{\mu\text{Ci/mL}}\right) \times \exp\left[-1.5 \times 10^{-4}(20)\right]$$

$$= 0.6 \times 10^9 \frac{\text{pCi/kg}}{\mu\text{Ci/mL}} \times C_{veg}\ \mu\text{Ci/mL}$$ (measured).

Thus,

D_{meat} (mrem/yr) = $0.41 \times 10^4\ C_{veg}\ \mu\text{Ci/mL}$ (measured).

③ $D_{milk} = U_{milk} \times D_{HTO} \times C_{milk}$,

where

U_{milk} = 310 L/yr,

D_{HTO} = 6.3×10^{-8} mrem/pCi, and

C_{milk} = $F_m Q_f C_{veg} \exp(-\gamma_i \tau_f)$,

where

F_m = fraction of daily intake of nuclide per liter of milk (pCi/L in milk per pCi/day ingested by the animal), L/day,

Q_f = amount of feed consumed (kg/day),

C_{veg} = concentration (pCi/kg),

γ_i = radiological decay constant, day^{-1},

τ_f = transport time from the feed to milk receptor.

Simplified,

$$C_{milk} = (1.2 \times 10^{-2}\ \text{L/day})\,(50\ \text{kg/day})\,(C_{veg}\ \mu\text{Ci/mL}) \times 10^9 \frac{\text{pCi/kg}}{\mu\text{Ci/mL}} \times \exp[1.5 \times 10^{-4}(2)]$$

$$= 0.5 \times 10^9 \frac{\text{pCi/kg}}{\mu\text{Ci/mL}} \times C_{veg}\ \mu\text{Ci/mL}$$

(measured).

Thus,

D_{milk} (mrem/yr) = $0.97 \times 10^4\ C_{veg}\ \mu$Ci/mL (measured).

Combining all three elements, the final equation becomes:

$D_{whole\ body}$ (mrem/yr) = $0.40 \times 10^4\ C_{veg}\ \mu$Ci/mL (measured)

+ $0.41 \times 10^4\ C_{veg}\ \mu$Ci/mL (measured)

+ $0.97 \times 10^4\ C_{veg}\ \mu$Ci/mL (measured)

= $1.78 \times 10^4\ C_{veg}\ \mu$Ci/mL (measured).

Annual Dose from Milk

The radiation dose (mrem) from tritium in milk is calculated using the annual average HTO concentration in Livermore Valley milk samples collected during the year. The following equation is used:

$$D_{milk} = U_{milk} \times D_{HTO} \times C_{milk},$$

where

U_{milk} = 310 L/yr,

D_{HTO} = 6.3×10^{-8} mrem/pCi, and

C_{milk} = annual average HTO concentration in milk, in pCi/L.

By multiplying U and D, this equation simplifies to:

$$D_{milk} = C_{milk} \times 2 \times 10^{-5}$$

ESTIMATING RADIOLOGICAL IMPACT

Maximally Exposed Individual Dose

The maximally exposed individual dose represents the maximum credible dose to a hypothetical member of the general public. It includes contributions from all potential exposure pathways and is derived using conservative but realistic exposure data and assumptions. The hypothetical person is assumed to reside at the point of highest ground-level, radionuclide air concentration continuously for 24 hours a day, 365 days a year. During this occupancy period, a portion of the person's diet consists of locally produced foodstuffs and drinking water containing the highest measured radionuclide concentration. Rainwater is specifically excluded as a source of drinking water in these calculations. Thus, this dose is not actually received by any individual—it is a conservative estimate (i.e., over-estimate) of the highest possible dose that could be received by a member of the public.

The maximum dose is calculated by summing the doses from all credible exposure pathways. This can be expressed as:

$$D_{max} = D_{external} + D_{inhalation} + D_{ingestion}.$$

Collective Population Dose

The collective population dose is the dose for all people living within a 50-mile (80-km) radius of the site. There are no regulatory limits for population doses. However, DOE Order 5400.5 requires an evaluation of the collective population dose. The population dose is calculated by summing the product of the individual dose and the number of people residing in each sector, for all potential exposure pathways. The collective population dose is referred to as the "collective effective dose equivalent." It is expressed in terms of person-rem (person-Sv).

The EDEs in this report have been calculated according to models and methods consistent with the NRC Regulatory Guide 1.109, *Calculation of Annual Doses to Man from Routine Releases of Reactor Effluent.* The dose and dose-rate conversion factor used in these calculations were obtained from the committed dose equivalent tables for DOE dose calculations. These dose conversion factors are consistent with those specified in ICRP 30.

For population dose, the diffusion parameters and population figures for a sector, *i*, within 80 km of SNL/California are summed over all directions, n.

$$D = 32.17 \times 10^4 \left[\sum_i^n (\chi/Q)_i P_i\right] QUD$$

(person-mrem)

where

$\left[\sum_i^n (\chi/Q)_i P_i\right]$ = Sum of the (χ/Q) for sector, *i*, times the population in sector, *i*, for all regions, n, persons—s/m^3.

Q = release rate, in Ci/yr,

U = inhalation rate, average individual (adult),

D = dose factor, in mrem/pCi, and

P_i = the population of the *i*th sector.

MODELING PARAMETERS FOR 1994 RADIOLOGICAL DOSE ASSESSMENT

Tables C-1–C-7 present the specific modeling input and parameters used in the 1994 dose assessment.

Table C-1. General Description of Radiological Dose Assessment Modeling Parameters.

Parameter	Description
Site	Sandia National Laboratories, Livermore, CA
Facility	Tritium Research Laboratory
Assessment Period	Calendar Year 1994
Model	Clean Air Act Compliance Package—1988 (CAP88-PC)

Table C-2. Source Characteristics.

Parameter (TRL)[a]	Description
Stack Height	30 m
Stack Diameter	1.4 m
Exit Gas Temperature	Ambient
Exit Gas Velocity (momentum plume rise)	1.5 m/s

[a]TRL = Tritium Research Laboratory

Table C-3. Radionuclide Characteristics.

Parameter (TRL)[a]	Description
Radionuclide	Tritium
Total Quantity Discharged (1994)	95 Ci[b]
Half-life	12.3 years

[a]TRL = Tritium Research Laboratory
[b]The source term consisted of 91 Ci HTO and 4 Ci HT. For modeling purposes, all tritium was assumed to be in the oxide form (HTO).

Table C-4. Site Information.

Parameter	Description
Average Temperature	15°C
Annual Precipitation	33.3 cm
Mixing Height	700 m
Average Wind Speed	1.2 m/s

Table C-5. Modeling Parameters.

Description	Value
Human Inhalation Rate (cm^3/hr.)	9.17×10^5
Soil Parameters [effective surface density (kg/m^2, dry weight, assumes 15 cm plow layer)]	2.15×10^2
Buildup Times (year)	
For activity in soil	100
For radionuclides deposited on ground or water	100
Delay Times (day)	
Ingestion of pasture grass by animals	0
Ingestion of stored feed by animals	90
Ingestion of leafy vegetables by man	14
Ingestion of produce by man	14
Transport time from animal feed-milk-man	2
Time from slaughter to consumption	20
Weathering (hour)	
Removal rate constant for physical loss	.0029
Crop Exposure Duration (day)	
Pasture grass	30
Crops/leafy vegetables	60
Agricultural Productivity (kg/m^2)	
Grass-cow-milk-man pathway	0.28
Produce or leafy vegetables for human consumption	0.716
Fallout Interception Fractions	
Vegetables	0.20
Pasture	0.57
Grazing Parameters	
Fraction of year animals graze on pasture	0.40
Fraction of daily feed that is pasture grass when animal grazes on pasture	0.43

Table C-6. Values For Radionuclide-Independent Parameters.

Description	Value
Animal Feed Consumption Factors (kg/day, dry weight)	
Contaminated feed/forage	15.6
Daily Productivity (L/day)	
Milk production of cow	11.0
Meat Animal Slaughter Parameters	
Muscle mass of animal at slaughter (kg)	200
Fraction of herd slaughtered (day)	.00381
Decontamination	
Fraction of radioactivity retained after washing leafy vegetables and produce	.50
Fractions Grown in Garden of Interest	
Produce ingested	1.0
Leafy vegetables ingested	1.0
Ingestion Ratios	
Total within immediate surrounding area—	
Vegetables	0
Meat	0
Milk	0
Minimum ingestion fractions (minimum fractions of food types from outside area are actual fixed values)—	
Vegetables	1.0
Meat	1.0
Milk	1.0
Human Food Use Factors	
Produce ingestion (kg/yr.)	176
Milk ingestion (L/yr.)	112
Meat ingestion (kg/yr.)	85
Leafy vegetable ingestion (kg/yr.)	18

Table C-7. Weather Data.

7A. Harmonic Average Wind Speeds (Wind Towards)

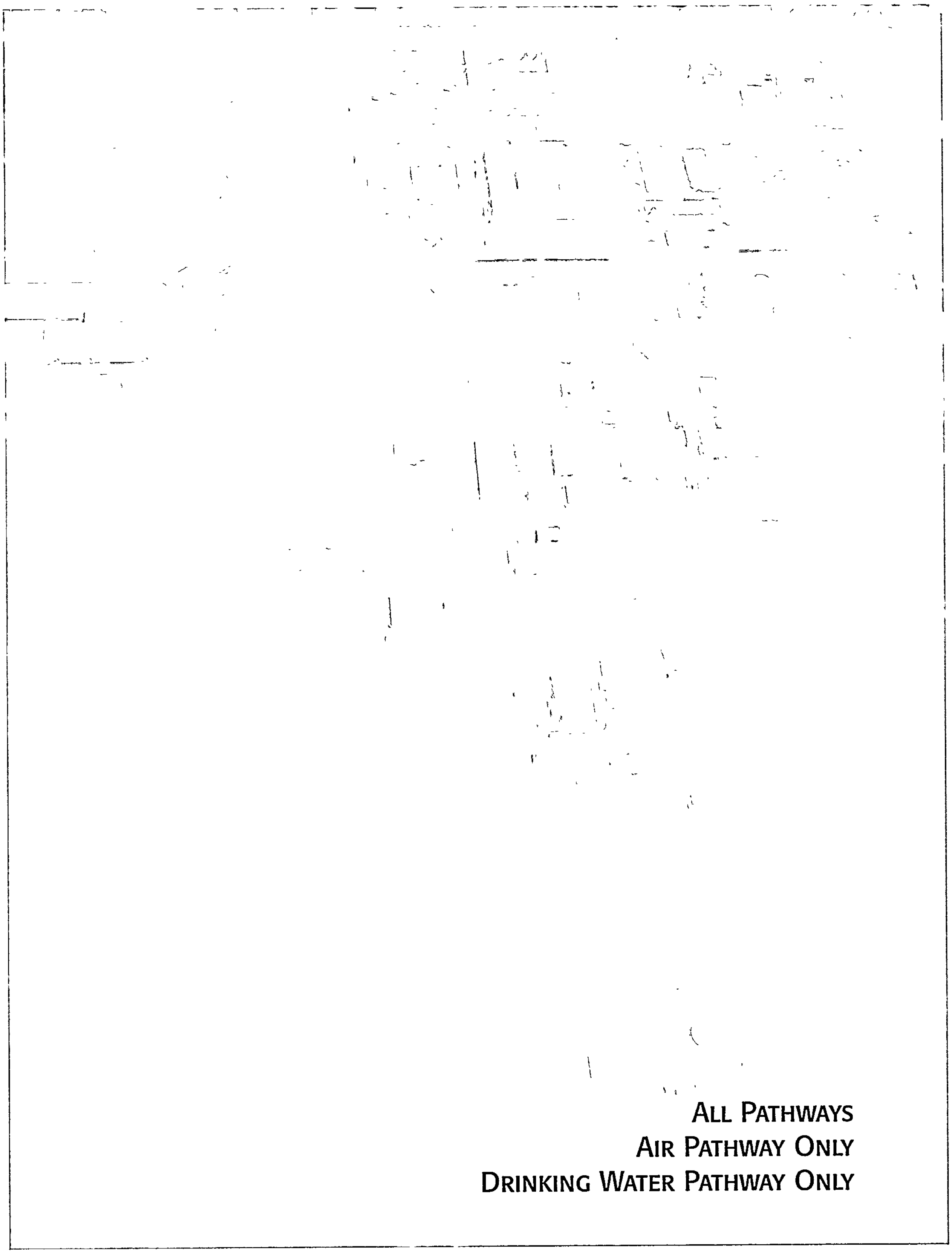
	Pasquill Stability Class							
Direction	A	B	C	D	E	F	G	Wind Frequency
N	0.909	1.032	1.839	2.041	1.730	0.794	0.806	0.043
NNW	0.725	1.582	1.368	1.616	1.429	0.864	0.874	0.040
NW	0.884	1.613	1.846	1.301	1.528	1.081	0.901	0.068
WNW	0.944	1.141	1.119	1.256	1.186	0.878	0.851	0.064
W	0.933	0.822	0.867	0.998	0.816	0.816	0.772	0.038
WSW	0.871	1.215	1.837	1.771	0.851	0.937	0.716	0.036
SW	1.154	1.766	2.382	2.869	1.388	0.984	0.744	0.057
SSW	1.382	2.202	2.521	2.544	1.562	0.866	0.713	0.032
S	1.203	1.527	3.607	3.097	1.132	0.670	0.678	0.026
SSE	1.119	1.574	2.811	2.290	0.596	1.169	0.884	0.016
SE	1.134	1.358	2.040	0.988	1.143	0.910	0.671	0.015
ESE	1.252	1.573	1.952	3.755	1.512	0.844	0.671	0.040
E	1.421	2.438	3.251	3.020	2.127	1.035	0.735	0.118
ENE	1.224	2.293	2.942	3.452	2.346	0.898	0.740	0.199
NE	0.846	1.370	2.062	3.190	2.147	0.903	0.730	0.149
NNE	0.747	0.814	1.491	2.188	2.013	0.880	0.742	0.058

7B. Arithmetic Average Wind Speeds (Wind Towards)

	Pasquill Stability Class						
Direction	A	B	C	D	E	F	G
N	1.038	1.257	2.367	2.486	2.339	0.991	0.942
NNW	0.831	2.133	1.717	2.188	1.916	1.010	1.009
NW	1.146	1.717	1.967	1.671	1.983	1.296	1.093
WNW	1.225	1.700	1.467	1.663	1.554	1.048	1.034
W	1.208	1.133	1.763	1.424	1.076	0.958	0.895
WSW	1.023	1.750	2.378	2.790	1.126	1.341	0.812
SW	1.459	2.159	2.848	3.521	1.554	1.274	0.876
SSW	1.733	2.552	3.147	3.139	1.900	1.060	0.862
S	1.513	2.169	3.898	3.842	1.525	0.920	0.738
SSE	1.411	2.179	3.685	4.113	0.680	1.438	1.079
SE	1.363	1.764	3.030	1.514	1.400	1.225	0.853
ESE	1.534	2.198	3.010	4.480	1.908	0.863	0.689
E	1.785	2.696	3.697	4.195	2.821	1.375	0.883
ENE	1.524	2.654	3.654	4.567	2.979	1.185	0.866
NE	1.086	1.908	3.004	4.423	2.841	1.150	0.844
NNE	0.842	0.957	2.386	2.984	2.657	1.038	0.845

7C. Frequencies of Stability Classes (Wind Towards)

	Pasquill Stability Class						
Direction	**A**	**B**	**C**	**D**	**E**	**F**	**G**
N	0.0345	0.0186	0.0398	0.3289	0.2228	0.0928	0.2626
NNW	0.0458	0.0086	0.0172	0.2378	0.2665	0.1375	0.2865
NW	0.0220	0.0102	0.0051	0.3012	0.3469	0.0931	0.2217
WNW	0.0216	0.0090	0.0108	0.3640	0.3225	0.0865	0.1856
W	0.0360	0.0360	0.0240	0.3213	0.2492	0.1141	0.2192
WSW	0.0707	0.0257	0.0740	0.3698	0.1350	0.1029	0.2219
SW	0.0749	0.0648	0.1640	0.5121	0.0526	0.0385	0.0931
SSW	0.1828	0.1505	0.2796	0.2043	0.0609	0.0358	0.0860
S	0.2687	0.1410	0.2070	0.2115	0.0352	0.0220	0.1145
SSE	0.3869	0.2044	0.0949	0.1168	0.0365	0.0584	0.1022
SE	0.5385	0.1077	0.0769	0.0538	0.0154	0.0615	0.1462
ESE	0.3563	0.1466	0.0862	0.2701	0.0374	0.0230	0.0805
E	0.1413	0.1335	0.1982	0.3592	0.1138	0.0196	0.0343
ENE	0.0360	0.0412	0.1439	0.5496	0.1782	0.0151	0.0360
NE	0.0325	0.0093	0.0372	0.5910	0.2564	0.0279	0.0457
NNE	0.0379	0.0140	0.0279	0.3952	0.3194	0.0778	0.1277
Total	0.0867	0.0538	0.0960	0.4106	0.1928	0.0502	0.1099


ALL PATHWAYS
AIR PATHWAY ONLY
DRINKING WATER PATHWAY ONLY

SNL/California conducts its operations in accordance with applicable Federal, State, and local environmental laws and regulations. In addition, the DOE has established radiation protection standards for the public and the environment, which are contained in DOE Orders pursuant to the Atomic Energy Act.

Radiation protection standards for the public have been established by the DOE to protect public health. Protection of the public is accomplished by limiting radiation doses received by individuals residing in uncontrolled areas (i.e., areas accessible to the public) resulting from DOE operations. In other words, these standards are based on acceptable risk to members of the public.

All Pathways (DOE Order 5400.5)

Environmental protection program requirements for DOE operations are established in DOE Order 5400.1, *General Environmental Protection Program.* Radiation protection standards are provided in DOE Order 5400.5, *Radiation Protection of the Public and the Environment.* Order 5400.5 limits the annual EDE to any member of the public to 100 mrem/year (1 mSv/yr.). This limit is based on the dose to the maximally exposed individual in an uncontrolled area from all emission sources and all exposure pathways. It is consistent with the recommendations of the International Commission on Radiological Protection and the National Council on Radiation Protection and Measurements. The DOE derived concentration guide lists concentrations of radionuclides in water and air that could be continuously consumed or inhaled (365 days/yr.) and not exceed the DOE primary radiation protection standard to the public (100 mrem/yr. effective dose equivalent). Table D-1 contains the derived concentration guide concentrations pertinent to this report.

In addition to these quantitative standards, the overriding DOE policy is that exposures to the public and emissions to the environment shall be maintained as low as reasonably achievable (ALARA).

Air Pathway Only (Clean Air Act, Title 40 CFR, Part 61)

DOE facilities are also required to comply with EPA standards for radiation protection. On December 15, 1989, the EPA issued its final NESHAPs Rule for Radionuclides. This Rule mandates that air emissions from DOE facilities shall not cause any individual in the public to receive in any year an EDE of greater than 10 mrem (0.1 mSv). Table D-2 summarizes the public radiation protection standards that are applicable to DOE facilities.

Drinking Water Pathway Only (Title 40 CFR, Part 141, DOE Order 5400.5)

Radionuclide concentrations in DOE-operated public drinking water supplies shall not cause persons consuming the water to receive an effective dose equivalent greater than 4 mrem (0.04 mSv) in a year. DOE activities shall not cause private or public drinking water systems downstream of the facility discharge to exceed the radiological drinking water limits in Title 40 CFR, Part 141.

Table D-3 lists the State of California (1977) limits for maximum contaminant levels for public drinking water supplies.

Table D-1. DOE Derived Concentration Guide for Protection of the Public.

Nuclide	Concentration in Air (mCi/mL)	Concentration in Air (Bq/mL)	Concentration in Water (mCi/mL)	Concentration in Water (Bq/mL)
^{3}H	1×10^{-7}	4×10^{-3}	2×10^{-3}	74
^{235}U	1×10^{-13}	3.7×10^{-9}	6×10^{-7}	2.2×10^{-2}
^{238}U	1×10^{-13}	3.7×10^{-9}	6×10^{-7}	2.2×10^{-2}

Table D-2. Public Radiation Protection Standards for DOE Facilities.

Exposure[a]	Effective Dose Equivalent[b] (mrem/year)	Effective Dose Equivalent[b] (mSv/year)	Regulation
All pathways[c]	100	1	DOE Order 5400.5
Air pathway only[d]	10	0.1	Federal Clean Air Act

[a]In keeping with DOE policy, exposures shall be kept to as low as reasonably achievable (ALARA) levels.

[b]As defined by the DOE, EDE includes both the EDE from external radiation and the committed EDE from ingestion and inhalation during the calendar year.

[c]These limits are from DOE Order 5400.5 and are consistent with the recommendations of the International Commission on Radiological Protection.

[d]These limits are from the EPA's regulations established under the Clean Air Act, NESHAPs Rule for Radionuclides (Title 40 CFR, Part 61, Subpart H).

Table D-3. California Maximum Contaminant Levels for Public Water Supplies.[a]

Radioactivity	Concentration in Drinking Water
Gross alpha particle activity (including ^{226}Ra but excluding Rn and U)	15 pCi/L or 1.5×10^{-8} µCi/mL or 0.56 Bq/L
Gross beta particle activity	50 pCi/L or 5.0×10^{-8} µCi/mL or 1.85 Bq/L
Tritium	20,000 pCi/L or 2.0×10^{-5} µCi/mL or 740 Bq/L

[a]These limits have been established by the State of California (1977) as safe levels of radionuclides in drinking water consumed by the general public.

NOTES

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