

# *LAWRENCE LIVERMORE NATL LAB, MAIN SITE (USDOE)*

## Site Information:

**Site Name:** LAWRENCE LIVERMORE NATL LAB, MAIN SITE (USDOE)  
**Address:** LIVERMORE, CA

**EPA ID:** CA2890012584  
**EPA Region:** 09

## Record of Decision (ROD):

**ROD Date:** 08/05/1992  
**Operable Unit:** 01  
**ROD ID:** EPA/ROD/R09-92/081

**Media:** Sediment, Ground Water

**Contaminant:** VOCs, Other Organics, Metals, Radioactive Materials

**Abstract:** SITE HISTORY/DESCRIPTION: The 800-acre Lawrence Livermore National Lab (LLNL) (USDOE) site is a multidisciplinary research facility located in Livermore, California. The site is owned by the Department of Energy (DOE) and operated by the Regents of the University of California. Land use in the area is predominantly industrial with an urban area to the west and agricultural lands to the east of the LLNL facility. Wetlands at the site consist of three small areas associated with culverts that channel runoff from the surrounding area into Arroyo Las Positas at the northern perimeter of the site. About 10,000 people use the ground water, which is blended from several downtown Livermore municipal wells, as their primary drinking water supply. The LLNL site was converted from agricultural and cattle ranch land by the Navy in 1942, who used the site until 1946 as a training facility and for aircraft assembly and maintenance. Solvents, degreasers, and paints were routinely used. Between 1946 and 1950, the site was used as a naval reserve command training center, and in 1951, the Atomic Energy Commission (AEC) began using the property as a weapons design and physics research laboratory. In 1977, DOE took over responsibility of the site. Investigations for suspected ground water contamination at LLNL were prompted by the state beginning in 1984, when perchloroethylene was discovered in the domestic supply well of a nearby property. LLNL began supplying bottled water to local residents whose domestic wells had been affected by solvents

migrating from the LLNL facility. Between 1985 and 1987, the LLNL continued the ground water investigations, which revealed that releases of hazardous materials had occurred at the LLNL site during the 1940's. Also in the post-Navy era, localized spills, leaking tanks, surface impoundments, and landfills contributed VOC, FHC, metal, and tritium contamination to ground water and unsaturated sediments. Prior to 1985, LLNL conducted two significant removal actions. From 1982 to 1983, four former pits in the Taxi Strip Area in eastern LLNL were excavated and backfilled; in 1984, a former landfill was also excavated and backfilled. This ROD addresses a final remedy for the contaminated sediment and ground water at the LLNL site. An additional potential source of hazardous materials, the Trailer 5475 East Taxi Strip Area, has been identified and is being investigated. If additional public health or environmental risks from this or other sources are identified, this ROD may be augmented to address any additional necessary actions. The primary contaminants of concern affecting the sediment and ground water are VOCs, including benzene, PCE, TCE, and toluene; other organics, including pesticides; metals, including lead and chromium; and radioactive materials.

**PERFORMANCE STANDARDS OR GOALS:** Chemical-specific sediment and ground water cleanup goals are the more stringent SDWA MCLs and State MCLs and include benzene 1 ug/l; PCE 5 ug/l; TCE 5 ug/l; lead 15 ug/l; total chromium 50 ug/l; total trihalomethanes 100 ug/l; and carbon tetrachloride 0.5 ug/l. Unsaturated sediment will be remediated only if it would result in levels above an MCL if allowed to migrate into the ground water. Unsaturated zone remediation will be complete when modeling shows that contaminants will no longer migrate and cause ground water to exceed MCL. The discharge limits for these chemicals will also be met if effluent waters from the remedial treatment are discharged to ditches or arroyos onsite.

**INSTITUTIONAL CONTROLS:** Not provided.

**Remedy:** SELECTED REMEDIAL ACTION: The selected remedial action for this site includes using vacuuminduced venting to extract contaminants in vapor form from the onsite unsaturated sediment and treating using catalytic oxidation and/or activated carbon; pumping water at 24 initial locations to contain and remediate the ground water plume using both existing and new extraction wells; constructing seven onsite facilities (labelled A to G) to treat the extracted ground water; designing each treatment system specifically to treat the specific combinations of contaminants, including: ultraviolet/oxidation to treat VOCs at facilities A, B, E, and F; air stripping to treat the chloroform and carbon tetrachloride at facilities C, D, and G; ion exchange at facility D to remove chromium; and granular activated carbon at treatment facility F to remove lead; controlling air emissions from the treatment processes at all facilities using granular activated carbon; recharging or reusing the treated water onsite; and monitoring ground water. The estimated present worth cost for this remedial action is \$104,100,000, which includes an annual O&M cost of \$21,585,000 for 50 years.

**Text:** Full-text ROD document follows on next page.

Text:

U.S. Department Of Energy

San Francisco Operations Office, Oakland, California 94612

Lawrence Livermore National Laboratory  
University of California Livermore, California 94551

UCRL-AR-109105

Record of Decision  
for the Lawrence Livermore  
National Laboratory  
Livermore Site

July 15, 1992

Environmental Protection Department  
Environmental Restoration Division

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#### 1. The Declaration

##### 1.1. Site Name and Location

The Lawrence Livermore National Laboratory (LLNL) Livermore site, located at 7000 East Avenue, Livermore, California, is a research and development facility owned by the U.S. Department of Energy (DOE) and operated by the University of California. LLNL was placed on the U.S. Environmental Protection Agency's (EPA) National Priorities List (NPL) in 1987. Currently, about 10,000 people use ground water blended from several downtown Livermore municipal supply wells as their primary drinking water supply. Contaminants from LLNL are currently about 1.6 miles from these supply wells. U.S. EPA, in conjunction with the California Department of Toxic Substances Control (DTSC) and the California Regional Water Quality Control Board (RWQCB), oversees LLNL's investigations and cleanup activities in accordance with Section 120 of the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), as amended.

## 1.2. Statement of Basis and Purpose

This decision document presents the selected remedial actions for the LLNL Livermore site, in Livermore, California, which were chosen in accordance with CERCLA, as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA), and, to the extent practicable, the National Oil and Hazardous Substances Pollution Contingency Plan (NCP). This decision document is based on the administrative record for this site.

The U.S. EPA, the RWQCB, and the DTSC of the California Environmental Protection Agency, formerly the California Department of Health Services (DHS), concur with the selected remedies.

## 1.3. Assessment of Site

The identified compounds of concern, if not addressed by the selected remedies or other considered measures, may present a potential risk to public health as discussed in the Proposed Remedial Action Plan (PRAP) for the site.

## 1.4. Description of the Selected Remedy

The Feasibility Study (FS) evaluated many potential remedies for the LLNL site. Those remedies were divided into two general groups, according to whether the chemical contaminants are in ground water or in unsaturated sediment (i.e., sediment above the water table where pore spaces are only partially filled with water). Three alternatives were evaluated for the ground water plume, and two remedies were evaluated for the unsaturated zone (i.e., the interval above the water table where pore spaces are only partially filled with water).

The selected remedy for ground water is Remedial Alternative No. 1 from the FS, which includes:

- . Pumping water at 18 initial locations to contain and remediate the ground water plume. Water will be pumped from one or more wells at each of these locations using existing monitor and extraction wells, along with new extraction wells. The initial well locations will be chosen to prevent any contaminants, primarily volatile organic compounds (VOCs), from escaping from the current plume area in concentrations above their Maximum Contaminant Levels (MCLs). To enable more rapid remediation, wells will also be placed in all areas with higher concentrations [i.e., greater than about 100 parts per billion (ppb) VOCs or fuel hydrocarbons (FHCs)]. The initial 18 locations will be augmented when field data indicate that new pumping locations will speed the cleanup.

- . Constructing about seven onsite facilities (A to G) to treat the extracted ground water. Each treatment system would be designed to treat the specific combination of compounds in the associated extraction wells.
- . Using ultraviolet (UV)/oxidation-based remediation technology to treat VOCs at Treatment Facilities A, B, and E, and FHCs and VOCs at Treatment Facility F. Treatment Facilities C, D, and G would use air-stripping-based technology, which is more effective on the higher concentrations of specific compounds in the area of those facilities (chloroform, carbon tetrachloride, Freon 113, and 1,1,1-trichloroethane). Treatment Facility D will employ ion exchange to remove chromium, and Treatment Facility F will use granular activated carbon (GAC) to remove lead, if necessary.

The selected remedy for treating the unsaturated zone is Remedial Alternative No. 1 from the FS. This alternative includes using a process called vacuum-induced venting to extract the contaminants in vapor form from the unsaturated sediments, and treating the vapors by catalytic oxidation and activated carbon.

The selected remedies address the principal concerns at the LLNL site by removing contaminants in ground water and soil vapor and treating them at the surface to levels protective of human health and the environment.

This Record of Decision (ROD) applies to all known contaminants in ground water and unsaturated sediment originating from activities at the LLNL site. An additional potential source of hazardous materials (i.e., the Trailer 5475/East Taxi Strip Area) was identified after completion of the PRAP on the LLNL site. If future investigations identify additional public health or environmental risks from this or other potential sources, this ROD may be augmented through CERCLA/SARA and the NCP to address any additional action.

## 1.5 Statutory Determinations

The selected remedies are protective of human health and the environment, comply with Federal and State requirements that are legally applicable or relevant and appropriate to the remedial action, and are cost-effective. The remedies utilize permanent solutions and alternative treatment technology; to the maximum extent practicable, and satisfy the statutory preference for remedies that employ treatment that reduces toxicity, mobility, or volume as a principal element. Because these remedies may result in hazardous materials remaining onsite above health-based levels until cleanup is complete, a review will be conducted within 5 years after commencement of remediation to assure that the remedies continue to provide adequate protection of human health and the environment.

## 2. Decision Summary

### 2.1. Site Name, Location, and Description

LLNL is a multidisciplinary research facility owned by DOE and operated and managed by the Regents of the University of California under contract with DOE. LLNL is located at 7000 East Avenue in southeastern Alameda County, approximately 3 miles east of the downtown area of Livermore, California (Fig. 1). The LLNL site, including the adjacent buffer zone, comprises approximately 800 acres (Fig. 2). The site is heavily developed with large-scale experimental research and support facilities. About 223 storage tanks exist onsite, 46 of which are underground tanks that currently store hazardous materials. A stormwater drainage retention basin roughly 800 feet by 300 feet in size is situated near the center of LLNL. This basin was

recently lined to prevent infiltration of ponded surface water.

The LLNL site land surface slopes approximately 1% to the northwest. Hills of the Diablo Range flank the site to the south and east. The site is underlain by several hundred feet of complexly interbedded alluvial and lacustrine sediments.

Ground water beneath the site is partly within the Spring and Mocho I hydrologic subbasins (DWR, 1974). Depth to ground water at the site varies from about 120 feet in the southeast corner to about 25 feet in the northwest corner. Ground water about 2 miles west of LLNL is used for municipal supply in downtown Livermore. Ground water about 1,000 feet south of East Avenue and about 1,000 feet west of Vasco Road and south of East Avenue is used for domestic and agricultural irrigation. Two intermittent streams, the Arroyo Seco and the Arroyo Las Positas, traverse the area (Fig. 2) and recharge the ground water system during wet periods.

Land immediately north of the LLNL site is zoned for industrial use. To the west, the land use is zoned for high-density urban use. Sandia National Laboratories (SNL), Livermore are located south of the site (Fig. 2) in an area zoned for industrial development. The area east of LLNL is zoned for agriculture and is currently used as pasture land [LLNL Remedial Investigation (RI), Thorpe et al., 1990].

As reported in the Draft Environmental Impact Statement and Environmental Impact Report for LLNL and Sandia National Laboratories, Livermore (DOE and University of California, 1992), no threatened or endangered species are present at the LLNL Livermore site. Wetlands are very limited at the Livermore site and consist of three small areas associated with culverts that channel runoff from the surrounding area into Arroyo Las Positas at the northern perimeter of the site (DOE and University of California, 1992).

## 2.2. Site History and Summary of Enforcement Activities

### 2.2.1. Site History

The LLNL site was converted from agricultural and cattle ranch land by the U.S. Navy in 1942. The Navy used the site until 1946 as a flight training base and for aircraft assembly, repair, and overhaul. Solvents, paints, and degreasers were routinely used during this period. Between 1946 and 1950, the Navy housed the Reserve Training Command at the site. In 1950, the Navy allowed occupation of the site by the Atomic Energy Commission (AEC), which formally received transfer of the property in 1951. Under the AEC, the site became a weapons design and basic physics research laboratory. In 1952, the site was established as a separate part of the University of California Radiation Laboratory. Responsibility for the site was transferred from AEC to the Energy, Research, and Development Administration in 1975. In 1977, responsibility for LLNL was transferred to the DOE, which is currently responsible for the site. In addition to weapons research, LLNL programs have been established in biomedicine, energy, lasers, magnetic fusion energy, and environmental sciences. Details of the site history and the

use, storage and disposal of hazardous materials are presented in the Remedial Investigation (RI) (Thorpe et al., 1990).

### 2.2.2. Summary of Enforcement Activities

The LLNL site was in operation prior to the enactment of the Resource Conservation and Recovery Act of 1976.

The first regulatory order for the LLNL ground water problem was a

compliance order issued in 1984 by the California Department of Health Services (DHS) (now the Department of Toxic Substances Control of the California Environmental Protection Agency). This order required LLNL to investigate ground water quality and to supply bottled water to local residents whose domestic wells had been affected by solvents migrating in ground water from LLNL. At the time this order was issued, the ground water investigation was already underway, and bottled water had been supplied to those local residents since December 1983. All private wells affected by the solvents were permanently sealed by LLNL between 1985 and 1989. In 1985, the RWQCB issued Waste Discharge Requirements to define the vertical and lateral extent of ground water contamination, and to allow discharge of ground water during the investigation. Between 1986 and 1991, the RWQCB issued four Waste Discharge Orders and two Site Cleanup Orders for the LLNL site. Currently, two RWQCB Orders are in effect at LLNL. Order No. 88-075 allows discharge of treated water from pilot Treatment Facility A to a recharge basin south of East Avenue. Order No. 91-091 allows discharge of treated ground water from LLNL treatment facilities to ditches and arroyos, and recharge of treated ground water via infiltration trenches and recharge wells.

Between 1985 and 1987, the RWQCB was the lead regulatory agency for the LLNL ground water investigation. In 1987, LLNL was added to the National Priorities List, as amended. In November 1988, DOE, U.S. EPA, DTSC, and RWQCB signed a Federal Facility Agreement (FFA), which named DOE as the overall lead agency and the U.S. EPA as the lead regulatory agency.

LLNL conducted two significant removal actions prior to 1985. Four former pits in the Taxi Strip Area in eastern LLNL were excavated and backfilled in the winter of 1982-83 under the oversight of the RWQCB. In 1984, a former landfill was excavated and backfilled with oversight by the DHS.

In May 1990, LLNL issued the CERCLA Remedial Investigations Report for the LLNL Livermore Site (RI) (Thorpe et al., 1990). In December 1990, the CERCLA Feasibility Study for the LLNL Livermore Site (FS) (Isherwood et al., 1990) was issued, and, in October 1991, the Proposed Remedial Action Plan for the LLNL Livermore Site (PRAP) (Dresen et al., 1991) was submitted. The Notices of Availability for the PRAP were published in three local newspapers on October 18, 1991, and again on November 19 and 20, 1991, when the comment period on the PRAP was extended. These documents, and all other documents that are the basis for selecting the cleanup remedies for the LLNL site, are contained in the Administrative Record for LLNL, which is located at the LLNL Visitors Center. The LLNL Visitors Center can be accessed from the Greenville Road (east) entrance to LLNL.

## 2.3. Highlights of Community Participation

### 2.3.1. Background

The LLNL ground water problem was brought to the attention of the local community in December 1983, when perchloroethylene (PCE) was first discovered in the domestic supply well of a former rental property northeast of the intersection of Vasco Road and East Avenue. LLNL's immediate action was to sample private wells and deliver bottled water to nearby residents whose wells had been affected. LLNL periodically surveyed these households, located south, southwest and west of LLNL, to ensure that residents were receiving bottled water to meet their water needs, and that the water was arriving in a timely manner. Subsequently, LLNL provided free municipal (City of Livermore) water hookups to the affected households. LLNL also began a regular private well sampling program. In all cases, testing results were (and continue to be) shared with the residents either through telephone calls, personal visits, or follow-up letters that include written sampling results.

In May 1988, LLNL and DOE held a general information meeting for the community on the ground water investigation with key Ground Water Project staff. In addition, LLNL and DOE have responded and continue to respond to requests from the public for information.

LLNL staff conducted interviews between April and July of 1988 with approximately 45 individuals, groups, and agencies to investigate their concerns and information needs regarding the Livermore site cleanup. The results of these interviews formed the basis for the Community Relations Plan that LLNL issued in May 1989. Copies of this plan were made available to the public, and placed in the information repositories located at the Livermore Public Library and at the LLNL Visitors Center.

The specific objectives of the LLNL Livermore Site Community Relations Program are to:

- . Continue providing interested members of the community with timely information about technical activities and findings.
- ù Provide ongoing opportunities for two-way communication between the LLNL Ground Water Project and the community.
- . Establish effective communication with local elected and administrative officials.
- . Remain alert to the community's needs and concerns about the Ground Water Project and other LLNL activities.

#### 2.3.2. Community Involvement

The LLNL Community Relations Program communicates with the public through six primary methods:

1. Meetings with a Community Work Group (CWG).
2. Distribution of a quarterly newsletter called the Ground Water Project Update and fact sheets.
3. Maintenance of the two information repositories.
4. Support to those responsible for offsite water samples and water level surveys.
5. Setting up tours and responding to general information requests.
6. Meeting with members of the public, including the Technical Advisors hired by a local community group as part of the EPA Technical Assistance Grant (TAG) Program.

Each of these activities is described below.

##### 2.3.2.1. Community Meetings

LLNL established the CWG in 1988 to provide an ongoing forum to advance understanding of technical issues and project decisions, community interests, and the Superfund process throughout the course of the LLNL Ground Water Project. The group is composed of private individuals, representatives of a local community group, and representatives of U.S. EPA, RWQCB, and DTSC. The CWG meets quarterly, and sometimes more often, depending on the status of the technical and regulatory aspects of the

Ground Water Project. LLNL has worked to distribute and explain technical information to the CWG and identify key issues of concern. LLNL has taken steps to respond to those concerns by providing additional information, making changes to certain aspects of the project or, when changes are not possible, by providing the reasons for not taking the proposed action. CWG meetings are open to the public.

A public meeting on the PRAP was held on November 6, 1991, as required by the CERCLA process. About 80 people attended the meeting. The Notice of Availability for the PRAP was published in three local newspapers on October 18, 1991. The public comment period on the PRAP extended from October 18 to December 18, 1991. All comments on the PRAP are addressed in Attachment A, the Responsiveness Summary, to this ROD.

#### 2.3.2.2. Ground Water Update and PRAP Fact Sheet

Distributed on a quarterly basis, the Ground Water Project Update reflects LLNL's desire to regularly inform the community about the Ground Water Project. This multipage fact sheet is distributed to more than 1,800 individuals and organizations. The first edition was published in June 1989.

A fact sheet on the PRAP was distributed in October 1991 prior to the opening of the public comment period on the PRAP. The fact sheet was written specifically to facilitate community understanding of the PRAP.

#### 2.3.2.3. Information Repositories

LLNL established two information repositories in 1989 to provide locations for interested members of the public to review project-related reports. One repository is located at the Livermore Public Library, 1000 South Livermore Avenue, the other is at the LLNL Visitors Center on Greenville Road. The Visitors Center also contains the Administrative Record, which is comprised of all the documents that form the basis for LLNL's final cleanup plan.

#### 2.3.2.4. Support to Offsite Well Monitoring Program

The Ground Water Project arranges sampling times and locations that are convenient to those residents and businesses affected by the offsite well monitoring program. Followup includes mailing a letter that explains the significance of the results.

#### 2.3.2.5. Tours and General Information Requests

Tours have been conducted on request for interested members of the public and for the press. In 1991, tours were conducted of the pilot study treatment units for CWG members and the press. On LLNL Family Day of 1990, special sitewide tours for a number of interested groups were conducted. Requests for general information are handled by community relations staff or appropriate LLNL staff.

#### 2.3.2.6. Contact with Technical Assistance Grant Advisors

A local citizens group hired two technical advisors under a grant approved by U.S. EPA and funded by the DOE as part of the TAG program. The technical advisors have attended CWG meetings and have submitted comments to LLNL regarding project reports. LLNL provided copies of project documents, conducted tours, responded to the advisors' queries, and held an all-day meeting with these advisors in July 1991. LLNL also provided one of the advisors with work space and resources for a week to review project-related documents.

#### 2.3.2.7. Future Community Involvement

DOE and LLNL are committed to maintaining community involvement throughout the cleanup. If desired by the local community, DOE/LLNL will continue to support a CWG. CWG meetings may be used to brief TAG advisors, if desired. Progress of the cleanup will also be reported to the regulatory agencies and the community in Monthly Progress Reports. As required by CERCLA, the Community Relations Plan will be updated after the ROD is signed.

#### 2.4. Scope and Role of Response Actions

The remedial alternatives described in the FS (Isherwood et al., 1990) and the PRAP (Dresen et al., 1991) are summarized in this ROD and address VOCs, FHCs, chromium, and lead in ground water, and FHCs and VOCs in sediment above the water table (the unsaturated zone). In addition, tritium has been detected locally in the soil and ground water, but as described in Section 4.2.1 of the PRAP, tritium at LLNL is self-remediating via natural decay and does not require cleanup. There is no significant way for people to be exposed to the contaminants in the unsaturated zone at LLNL except by migration of the contaminants to the ground water.

This ROD addresses all known ground water and unsaturated zone contamination and any resultant human health and environmental risks, and incorporates the results of LLNL pilot studies. Amendments to this ROD may be made in the future to address significant new or additional contaminants and/or source areas or other unforeseen conditions.

The cleanup objectives for all contaminants originating at LLNL are to:

1. Prevent future human exposure to contaminated ground water and soil.
2. Prevent further migration of contaminants in ground water.
3. Reduce contaminant concentrations in ground water to levels below MCLs, and reduce the contaminant concentrations in treated ground water to levels below State discharge limits (Table 1).
4. Prevent migration in the unsaturated zone of those contaminants that would result in concentrations in ground water above an MCL.
5. Meet all discharge standards of existing permits for treated water, and to treat vapor so that there are no measurable atmospheric releases from treatment systems.

The selected remedial alternatives will achieve these cleanup objectives and address all of the principal concerns at the site by removing the hazardous compounds from the ground water and subsurface soil, when warranted, and treating them at the surface at about seven onsite facilities. Ground water extraction will contain contaminant plumes, stop further migration of contaminants in ground water, and prevent any human exposure to them via water wells. The ground water treatment facilities will use different remediation technologies appropriate for the different influent contaminants and will be designed to reduce contaminant concentrations in the treated ground water to levels below established State discharge standards.

Ground water extraction and treatment will continue until the Federal and State agencies agree that the remediation standards have been met. The target objective is to reduce the concentrations in the ground water after cleanup to levels below MCLs (Table 1).

The ground water remediation standards in Table 1 are the lower of the Federal or State MCLs, and apply to the concentrations remaining in the

ground water after remediation is complete. Ground water cleanup is complete when samples taken anywhere in the plume demonstrate that the remediation standards have been achieved. The discharge limits in Table 1 apply to the effluent water from treatment systems that may be discharged to ditches or arroyos. Although some discharge limits are lower than MCLs, remediation will continue until the remediation standards are met.

Volatile contaminants in the unsaturated zone will be removed by extracting them in vapor, which will be treated onsite. Atmospheric emissions from treatment systems will comply with

Bay Area Quality Management District (BAAQMD) standards. Contaminants in the unsaturated zone will be remediated only if it is predicted that they would result in concentrations above an MCL if allowed to migrate into the ground water. Unsaturated zone remediation will be complete when modeling shows that contaminants will no longer migrate to ground water and create concentrations in the ground water above an MCL.

As part of the additional source investigations that are in progress, evaluations of the transport of VOCs and non-VOCs from the unsaturated zone to the ground water will be conducted. These investigations may identify areas where additional soil and ground water remediation is necessary. Results of these investigations will be summarized in Monthly Progress Reports for review by the regulatory agencies and the public.

Treated ground water will be recharged via wells, the LLNL recharge basin, and local arroyos, and/or used for LLNL landscape irrigation or in LLNL cooling towers, to conserve water resources.

## 2.5. Site Characteristics

Initial releases of hazardous materials occurred at the LLNL site in the mid - to late 1940s when the site was the Livermore Naval Air Station (Thorpe et al., 1990). There is also evidence that localized spills, leaking tanks and impoundments, and landfills contributed VOCs, FHCs, lead, chromium, and tritium to ground water and unsaturated sediment in the post-Navy era. A screening of all environmental media showed that ground water and unsaturated sediment are the only media that require remediation (Thorpe et al., 1990). The identified compounds that exist in ground water at various locations beneath the site at concentrations above drinking water standards are:

1. The VOCs trichloroethylene (TCE), perchloroethylene (PCE), 1,1-dichloroethylene (1,1-DCE), 1,2-dichloroethylene (1,2-DCE), 1,1-dichloroethane (1,1-DCA), 1,2-dichloroethane (1,2-DCA), carbon tetrachloride, and the trihalomethane (THM) chloroform.
2. FHCs (leaded gasoline), including benzene, ethylbenzene, toluene and ethylene dibromide.
3. Chromium and lead.
4. Tritium.

The quality of data for these compounds was considered in the selection of the remedies for the LLNL site in accordance with the LLNL Quality Assurance Project Plan (QAPP, Rice, 1988).

### 2.5.1. VOCs

The VOCs in ground water beneath LLNL occur in relatively low concentrations that underlie about 85% of the LLNL site, over a total area of about 1.4

square miles (Fig. 3). The calculated total volume of undiluted VOCs in ground water is less than 200 gallons. The vertical thickness of the ground water VOC plumes varies from about 30 to 100 feet, and VOCs are seldom found below a depth of about 200 feet. VOCs are relatively mobile in ground water and migrate at a rate of about half the velocity of ground water. TCE and PCE are the predominant VOCs in the study area, and are currently present locally in concentrations up to 4.8 and 1.1 parts per million (ppm) respectively (1992 data). However, the higher concentrations are localized, and total VOC concentrations exceed 1 ppm in ground water from only 10 out of a total of more than 300 wells. The distribution of VOCs in ground water exceeding MCLs is shown in Figure 4. The VOCs and chromium in ground water in the vicinity of the Patterson Pass-Vasco Road intersection appear to originate on private property northwest of the LLNL site as discussed in Iovenitti et al. (1991) and

Hoffman (1991a). This offsite area will be investigated by the potentially responsible parties under RWQCB order. If LLNL is found to be the source of chromium in this area, LLNL will incorporate this area into the remedial design.

Chemical data from boreholes drilled at the locations of suspected VOC releases at LLNL indicate that generally low residual VOC concentrations (less than 100 parts per billion [ppb]) are present in unsaturated sediments. The calculated total volume of undiluted VOCs in the unsaturated zone is less than 100 gallons. Computer modeling indicates that downward movement of VOCs above the water table is not likely to result in ground water VOC concentrations exceeding MCLs for drinking water, except at the Building 518 Area in the southeast corner of the site (Isherwood et al., 1990). The Trailer 5475 Area is also being evaluated for possible cleanup.

In the Building 518 Area, VOCs (predominantly TCE) reach a maximum concentration of about 6 ppm at a depth of 20 feet. These VOCs are believed to have originated from surface spills or leaking drums in the post-Navy era. Recent investigation in the Trailer 5475 Area (also called the East Taxi Strip Area) in eastern LLNL indicate that remediation may be necessary pending additional subsurface investigations and modeling. Total VOC concentrations (predominantly TCE) reach a maximum concentration in unsaturated soil of about 5 ppm in that area. These VOCs originate from former landfills and surface impoundments.

#### 2.5.2. Fuel Hydrocarbons

FHCs occur almost exclusively where a leak of roughly 17,000 gallons of leaded gasoline occurred from a U.S. Navy-era underground fuel tank in the southern part of the site (Fig. 5). Although some gasoline constituents are relatively mobile in ground water, FHCs in ground water have not migrated more than about 500 feet from the leak point due to the very slow ground water movement in the area (Thorpe et al., 1990). Within this area, total FHC concentrations in ground water range from 0.001 to 16 ppm, and benzene concentrations range from less than 0.0001 to about 4 ppm. Ethylene dibromide has been detected in nine Gasoline Spill Area monitor wells above the MCL in concentrations from 0.0001 to 1.3 ppm. FHCs are not present in ground water beneath a depth of about 150 feet.

Prior to withdrawal of fuel vapor by vacuum-induced venting as part of a Gasoline Spill Area pilot study, up to 11,000 ppm total FHCs and 4,800 ppm aromatic hydrocarbons were detected in the unsaturated sediments beneath the former fuel tank. Virtually all FHCs in the unsaturated zone are about 50 feet radially from the leak point.

#### 2.5.3. Metals

Metals above MCLs are present in only a few locations. Chromium in ground water exceeds the MCL in 16 wells scattered in the northwest, central, and southwest parts of the study area and near Arroyo Seco (Fig. 6). The maximum chromium concentration in ground water in the LLNL study area is 160 ppb, in the northwestern corner of the site. Chromium in the LLNL area sediments and ground water appears to have originated naturally and from some LLNL site activities. At LLNL, chromate solutions were used in cooling towers as corrosion inhibitors from approximately 1958 to 1970. Blowdown from the cooling towers was released to the storm drain system, but neither the exact quantity of releases nor the chromium content of the water are known. According to anecdotal information, storm runoff caused the blowdown to flow northerly before infiltrating into the ground near the West Traffic Circle. In addition, naturally occurring chromium deposits have been mined in the hills southeast of LLNL. As described in Section 2.5.1, chromium in ground water northwest of LLNL appears to originate on private property and will be investigated by others (i.e., the potentially responsible parties).

Recent analyses indicate lead is above the 15 ppb remediation standard in only two wells, both in the Gasoline Spill Area, at a maximum concentration of 38 ppb. Lead has a low potential for migration in both the saturated and unsaturated zones because it binds strongly to sediment. This low migration rate and limited extent, indicate that lead at LLNL does not pose a health threat. If, however, lead is found in ground water above the remediation standard, it will be remediated.

#### 2.5.4. Tritium

Tritium in ground water has historically exceeded its MCL (20,000 picocuries per liter [pCi/L]) in only two wells, MW-206 and MW-363, both in the southeast part of the LLNL site. Currently, water from only MW-206 exceeds the tritium MCL (Fig. 6). This tritium was released to the subsurface in former, nearby evaporation ponds, is localized and well defined, and the affected ground water is not used for drinking water. Although tritium migrates at the same rate as ground water, ground water modeling indicates that by the time the affected ground water moves offsite in the absence of active remediation, tritium concentrations would be reduced to concentrations below drinking water standards by natural decay (tritium has a 12.3-year half-life). Therefore, no pathway to humans exists for the observed tritium in ground water. The tritium is effectively self-remediating via natural decay. Ground water will continue to be monitored for tritium to track its distribution and concentrations over the duration of the cleanup.

Recent investigations have identified additional areas where tritium concentrations in unsaturated sediments at LLNL are significantly elevated. These include the Building 514, Eastern Landing Mat Storage, West Traffic Circle, Building 292, and Old Salvage Yard Areas. However, the tritium activity in ground water in these areas is well below the 20,000 pCi/L MCL. The only potentially significant transport pathways to human populations for this tritium are inhalation and skin absorption of tritiated water from direct soil evaporation or from water taken up by plants and released to the air by transpiration from plant leaves. Most of the areas where tritium has been detected are paved with asphalt, thereby limiting potential evaporation from soil and further downward migration by infiltration of rainwater. Elevated tritium levels in transpired water have been measured in isolated areas at LLNL. Screening-level calculations have been performed by LLNL using the standard EPA model AIRDOS-EPA and very conservative assumptions that maximize the calculated dose. These calculations indicate that any potential dose from the measured tritium in soil would not exceed 0.01% of the 10-millirem/year Federal dose standard (Macdonald et al., 1990).

Additional information regarding the distribution, concentration, toxicity, mobility, potential routes of migration, and potential exposed populations of all LLNL compounds of concern can be found in the RI, the Baseline Public Health Assessment (BPHA) (Layton et al., 1990), and Sections 2.1 and 2.6 of this ROD.

## 2.6. Summary of Unremediated Site Risks

As part of the RI report (Thorpe et al., 1990), the BPHA (Layton et al., 1990) was conducted to estimate the potential future health risks if contaminants in ground water and sediments originating from LLNL were not remediated. Evaluation of a no-action scenario is a requirement of the NCP, 40 CFR section 300.430(e)(6), to represent a baseline condition. In addition, a risk assessment was conducted as part of the FS (Isherwood et al., 1990) to estimate the potential public health risks if the concentrations of VOCs in ground water were reduced to their respective MCLs. These and other assessments of potential risks are summarized in the PRAP (Dresen et al., 1991) and below. Details of the risk assessments are contained in the RI and FS.

### 2.6.1. Human Health Risks

The LLNL risk assessment consisted of several steps:

- . Identifying the contaminants of concern (see Section 2.5 of this ROD).
- . Identifying the media through which exposure may occur.
- . Assessing the exposure.
- . Assessing the toxicity of each contaminant.
- . Quantifying the risk.

Each of these is discussed below.

#### 2.6.1.1. Contaminant Identification

##### 2.6.1.1.1. Media of Concern

The primary medium through which public exposure to LLNL contaminants may occur is ground water. Air is also a medium of concern for contaminants that may volatilize from contaminated soil or ground water. The public is not directly exposed to contaminated soils because no offsite surficial soils contain significant concentrations of contaminants originating from LLNL. Contaminated onsite surficial soils were evaluated as a potential medium of concern. However, a screening analysis of the risks resulting from potential onsite exposure to contaminated soils has shown these risks are insignificant (Layton et al., 1990; Hoffman, 1991b; Macdonald et al., 1991). Therefore, surficial soils are not a medium of concern for the LLNL site.

##### 2.6.1.1.2. Contaminants of Concern

A screening analysis was conducted to determine which substances and exposure pathways are potentially important from the perspective of potential adverse health effects. A statistical analysis of thousands of water and soil samples estimated the relative abundance of particular contaminants in the study area (Layton et al., 1990). TCE, PCE, and chloroform account for an estimated 91% of the total amount of VOCs dissolved in the LLNL-area ground water. Of the remaining VOCs, the most hazardous are carbon tetrachloride and 1,1-DCE, which were used to represent the potential adverse effects of the remaining 9% of the VOCs. Nearly 60%

of the mass of the remaining 9% of VOCs is 1,1-DCE. These compounds were used to estimate the public health risks resulting from the offsite migration and domestic use of contaminated ground water. According to the U.S. EPA, PCE, TCE, chloroform, and carbon tetrachloride are classified as B2 carcinogens, which are described as "probable human carcinogens indicated by sufficient evidence in animals and inadequate or no evidence in humans" (U.S. EPA, 1989a). 1,1-DCE is classified as a Class C carcinogen by the U.S. EPA (possible human carcinogen).

Other contaminants in soil and ground water include benzene at the Gasoline Spill Area, tritium, and inorganic substances, such as chromium, lead, nitrate, sulfate, and manganese. A screening analysis of the transport and fate of benzene indicates that benzene or other gasoline-related contaminants (toluene, xylene isomers, and ethylbenzene) are not likely to reach detectable concentrations west of LLNL. Similarly, tritium continues to undergo radioactive decay with a 12.3-year half-life such that by the time ground water containing elevated levels of tritium would migrate to the western LLNL boundary in the absence of remediation, concentrations would be within background levels. As stated in Section 2.5.4, LLNL plans to monitor tritium in ground water over the life of the cleanup.

As discussed in a letter to the regulatory agencies (Hoffman, 1992), there is strong evidence that the lead in LLNL ground water is naturally occurring. Furthermore, as described in Section 2.5.3, it appears that the migration potential for lead is very low, and its occurrence above the remediation standard is very limited. Several inorganic substances, including chromium, nitrate, sulfate, and manganese, occur in ground water in concentrations exceeding regulatory limits in various monitor wells, sporadically located on site and offsite. Except perhaps for chromium, which has been used in LLNL cooling towers, the observed concentrations appear to reflect background levels of these constituents in ground waters in the Livermore Valley.

#### 2.6.1.1.3. Concentrations of Chemicals of Concern Used in the Risk Assessment

To assess the ground water exposure pathway, migration of the five VOCs of concern (PCE, TCE, chloroform, carbon tetrachloride, and 1,1-DCE) was simulated using the January-September 1988 concentrations as initial conditions. These concentrations range from the various detection limits up to a maximum of 6 ppm for TCE in the Building 518 Area.

#### 2.6.1.2. Exposure Assessment

##### 2.6.1.2.1. Exposure Pathways

The only potential exposure pathway for present and future offsite populations is use of contaminated well waters. For domestic water uses, the potential exposure pathways are ingestion of drinking water, inhalation of volatile substances, and entry through the skin. For irrigation uses, the potential exposure pathways are inhalation of volatilized chemicals from sprinklers, and ingestion of foods from crops or home gardens irrigated with water containing the chemicals of concern. Exposure from contact with surface water runoff or sediment in local arroyos that receive drainage waters from the LLNL site is not a pathway of concern, because no chemicals of concern have been detected in downstream drainage channels near LLNL, and ground water does not discharge to streams near LLNL. The most important offsite exposure pathways with regard to health risk are those that result from domestic well water use from offsite wells (Thorpe et al., 1990).

##### 2.6.1.2.2. Potentially Exposed Population

As described in the BPHA and in Section 2.6.1.1.1 above, there are no significant onsite exposure pathways for LLNL site contaminants. Prior to any soil excavation at LLNL, the existing soil cleanup data are reviewed and maps of known or suspected contamination are consulted to determine whether additional sampling needs to be conducted prior to excavation. If no samples have been previously collected in a given area, preconstruction sampling is performed before excavation begins. If contamination is found, appropriate safety and disposal practices are overseen by the LLNL Hazards Control Department.

The only potentially exposed offsite population consists of residents who use ground water that has migrated from LLNL. In the assessments of risk for the LLNL site, a future residential-use scenario was not considered because it is unlikely that transfer of ownership of the site from DOE would occur in the foreseeable future. No change in ownership of the LLNL Main Site or any portion thereof, or notice pursuant to Section 120 of CERCLA, will relieve DOE of its obligation to clean up contamination resulting from DOE activities, or any future contamination resulting from DOE activities at LLNL. In addition, no change of ownership of the site or any portion thereof will be consummated by DOE without provision for continued maintenance of any containment system, treatment system, monitoring system, or other response action(s) installed or implemented under terms of the LLNL FFA.

#### 2.6.1.2.3. Exposure Point Concentration Estimates

To assess the potential future health risks of the known contaminants in ground water, the movement of VOCs from their current distribution was simulated with a model. A semianalytical model of contaminant transport and fate in ground water was used that considers advection, dispersion, retardation, and degradation. The BPHA contains details on the assumptions and the parameters used in the model.

To address uncertainty inherent in all contaminant migration calculations, two scenarios were investigated, one called "best-estimate" and the other "health-conservative." The health-conservative scenario uses parameter values and assumptions that yield exposures that are very unlikely to be exceeded. U.S. EPA prefers using the most conservative of the health-conservative scenarios (footnote "b," Table 4, Section 2.6.1.4.3) as their estimate of the potential health risk from the LLNL site. The best-estimate simulations use parameter values that are considered to be the most likely or the most representative, based on existing knowledge of the LLNL ground water system and contaminant properties. Best-estimate simulation assumes no human exposure to the ground water until it reaches the currently used municipal supply wells in downtown Livermore because no private wells are currently contaminated and administrative control limits the potential for domestic well installation into a contaminated zone. The administrative control consists of notification by Zone 7, the local water agency, that a proposed new well is in or near the contaminant plume.

#### 2.6.1.2.4. Exposure Frequency and Duration

The exposure period for the offsite public for any exposure pathway of concern was assumed to be a 70-year lifetime. For offsite exposures to contaminated ground water, the fate and transport model was used to calculate maximum 70-year average concentrations in ground water at existing and potential offsite wells. It was assumed that the exposed population uses ground water as its sole source of domestic water for this continuous 70-year period. These and other assumptions were used to estimate the total daily uptake of each chemical of concern in milligrams of chemical per

kilogram body mass per day (mg/kg-day).

#### 2.6.1.3. Toxicity Assessment

##### 2.6.1.3.1. Cancer Potency Factors

Cancer potency factors (CPFs) have been developed by U.S. EPA to estimate excess lifetime cancer risks associated with exposure to potentially carcinogenic chemicals. CPFs, expressed in units of (mg/kg-day)<sup>-1</sup>, are multiplied by the estimated intake of a potential carcinogen, in mg/kg-day, to provide an upper-bound estimate of the excess lifetime cancer risk associated with exposure at that intake level. The term "upper bound" reflects the conservative estimate of the risks calculated from the CPF. Use of this approach makes underestimation of the actual cancer risks highly unlikely. CPFs are derived from the results of human epidemiological studies or chronic animal bioassays to which animal-to-human extrapolation and uncertainty factors have been applied (e.g., to account for the use of animal data to predict the effects on humans).

CPFs for the LLNL chemicals of concern are listed in Table 2. In conformance with EPA methodology, cancer potencies are based on applied, rather than metabolized, doses.

##### 2.6.1.3.2. Reference Doses for Noncarcinogens

Reference doses (RfDs) have been developed by EPA for indicating the potential for adverse health effects from exposure to chemicals exhibiting noncarcinogenic effects. RfDs, which are expressed in units of mg/kg-day, are estimates of lifetime daily exposure levels for humans, including sensitive individuals. Estimated intakes of chemicals from environmental media (e.g., the amount of a chemical ingested from contaminated drinking water) can be compared to the RfD. RfDs are derived from human epidemiological studies or animal studies to which uncertainty factors have been applied (e.g., to account for the use of animal data to predict the effects on humans). These uncertainty factors help ensure that the RfDs will not underestimate the potential for adverse noncarcinogenic effects to occur.

Reference doses for the LLNL chemicals of concern are listed in Table 3.

#### 2.6.1.4. Risk Characterization

##### 2.6.1.4.1. Carcinogenic Risks

The information from the preceding steps was combined to determine if an excess health risk would exist if the site were not remediated. Excess lifetime cancer risks are determined by multiplying the intake level with the CPF. These risks are probabilities that are generally expressed in scientific notation (e.g.,  $1 \times 10^{-6}$  or  $1E-6$ ). An excess lifetime cancer risk of  $1 \times 10^{-6}$  indicates that, as a plausible upper bound, an individual has a one in one million chance of developing cancer as a result of site-related exposure to a carcinogen over a 70-year lifetime under the specific exposure conditions at a site.

Tables A-1 and A-2 in Appendix A summarize the estimated cancer risks for offsite exposure to ground water for both the best-estimate and health-conservative exposure scenarios for PCE, TCE, 1,1-DCE, chloroform, and carbon tetrachloride. Under the best-estimate exposure scenario (Table A-1), the greatest incremental cancer risk is seven in ten million ( $7 \times 10^{-7}$ ), which is associated with a well 2 miles west of the LLNL site that is in the path of the plume containing the highest concentrations of 1,1-DCE.

Under the health-conservative exposure scenario (Table A-2), the incremental cancer risks are on the order of one in one thousand ( $10^{-3}$ ) to one in one million ( $10^{-6}$ ) for all wells. The highest predicted risk, two in one thousand ( $2 \times 10^{-3}$ ), is for a hypothetical well about 250 feet west of the LLNL site. However, no such wells have been constructed to date or are planned for installation prior to cleanup. The most conservative of the health-conservative scenarios (i.e., the one with the  $2 \times 10^{-3}$  incremental risk) is the scenario prescribed by EPA for the LLNL site.

#### 2.6.1.4.2. Potential for Noncarcinogenic Effects

Potential noncarcinogenic effects of a single contaminant in a single medium is expressed as the hazard quotient (HQ) (or the ratio of the estimated intake derived from the contaminant concentration in a given medium to the contaminant's reference dose). By adding the HQs for all contaminants within a medium or across all media to which a given population may be reasonably exposed, the hazard index (HI) can be estimated. If only one compound is involved, then the HQ is equivalent to the HI. If the HI value is greater than 1.0, exposure could result in adverse health effects. The HI provides a useful reference for gauging the potential significance of multiple contaminant exposures within a single medium or across media.

Tables A-3 and A-4 in Appendix A summarize the estimated HQ's for offsite exposure to ground water for both the best-estimate and healthconservative exposure scenarios for the chemicals of concern at LLNL. Under the best-estimate exposure scenario (Table A-3), the greatest HQ is  $1.4 \times 10^{-3}$ , which is for a hypothetical well 2 miles west of the LLNL site in the path of the plume containing the highest concentrations of carbon tetrachloride. Under the health-conservative exposure scenario (Table A-4), the HQ's are on the order of  $10^{-2}$  to  $10^{-1}$  for all wells. The highest predicted HQ (0.8) is for a hypothetical well that is 250 feet west of the LLNL site.

#### 2.6.1.4.3. Combined Carcinogenic Risks and Hazard Indices

The maximum theoretical excess cancer risks for a hypothetical, noremediation scenario, based on the assumption that an individual will use well water for a 70-year (lifetime) period, are presented in Table 4. The maximum additional cancer risk associated with the best-estimate scenario in Table 4 means that the cancer risk from a lifetime exposure to VOCs (PCE, TCE, chloroform, and carbon tetrachloride) in well water derived from a downtown Livermore municipal supply well could be as high as 7 in 10 million ( $7 \times 10^{-7}$ ), using EPA assessment methods. This means that each individual that consumes 2 liters (about 2 quarts) of this water each day for 70 years would increase his or her risk of developing cancer by 7 in 10 million above the normal 1 in 4 cancer risk for Americans (U.S. EPA, 1989a). The HI associated with the bestestimate scenario is far below 1.0, indicating exposure at the predicted concentrations would not produce any adverse health effects from noncarcinogens (see the RI, Thorpe et al., 1990, for details).

Under the health-conservative no-remediation scenario, the maximum additional cancer risk is two in one thousand ( $2 \times 10^{-3}$ ) for a lifetime exposure to contaminants in water from a potential monitor well drilled 250 feet west of LLNL. The HI calculated for this scenario is 1. Because no drinking water wells are likely to be drilled in the area 250 feet west of LLNL, we also calculated the risk based on a lifetime exposure to well water derived from downtown Livermore using the health conservative assumptions. This unlikely scenario results in a maximum additional cancer risk of one in one thousand ( $1 \times 10^{-3}$ ) and an HI of 1. The HI of 1 for the health-conservative scenario indicates that there is some potential for

noncarcinogenic health effects if the very conservative assumptions of the health conservative scenario were ever realized, and if there was an additive effect of all the individual compounds. Both health-conservative risks in Table 4 exceed EPA's one in ten thousand to one in ten million ( $1 \times 10^{-4}$  to  $1 \times 10^{-7}$ ) acceptable risk range for Superfund sites.

#### 2.6.1.4.4. Sources of Uncertainty

Uncertainties are associated with all estimates of cancer and noncancer health hazards. These uncertainties result from incomplete knowledge of many physical and biological processes, such as carcinogenesis. Where specific information is not available, it is necessary to make assumptions and/or use predictive models to compensate for lack of information. The assumptions, models, and calculations are chosen such that the resulting risk and hazard estimates are health-conservative. The specific sources of uncertainty in the risk and hazard estimates presented here are further discussed in the BPHA.

#### 2.6.1.5. Environmental Risks

Currently, there is no potential risk of ecological impacts related to environmental exposure to ground water because no ground water containing contaminants is present at the surface, either onsite or offsite. No perennial streams exist at or near the site and no streams receive flow from ground water. No critical habitats are affected by the ground water and soil contamination. No endangered species or habitats of endangered species are affected by the site contaminants, as described in the FS (Isherwood et al., 1990).

#### 2.6.1.6. Risk Assessment Conclusions

In summary, the identified compounds of concern, if not addressed by implementing the response actions selected in this ROD, may present a potential risk to public health.

### 2.7. Description of Remedial Alternatives

In the FS, three remedial alternatives were assembled for ground water for the LLNL site:

1. Ground water extraction throughout the contaminated area, including source areas, thereby preventing further contaminant migration and enabling the most rapid cleanup. Ground water would be treated at the surface using UV/oxidation or air stripping-based technology with GAC to prevent any measurable air emissions. The treated water would be recharged or used at the LLNL site.
2. Ground water extraction at the downgradient edges of contamination to prevent further contaminant migration. Ground water would be treated at the surface, as for Alternative No. 1, and recharged or used at the LLNL site.
3. Ground water monitoring and treatment at the point of use, if drinking water supply wells should ever contain contaminants from LLNL in concentrations above drinking water standards. Ground water would be treated at the surface as described in No. 1 above.

The remedial alternatives for contaminants in the unsaturated sediment were:

1. Vacuum-induced venting with surface treatment of vapors using GAC, thermal oxidation, or catalytic oxidation.

2. Deferring action to see if contaminants migrate to the ground water, and, if they do, extracting and treating the ground water as described for the ground water remedial alternatives.

A third alternative, excavation and treatment and/or disposal, was also considered for unsaturated sediment. However, this alternative would be applicable only if (1) contaminant concentrations are found in the unsaturated zone that are high enough to cause concentrations above MCLs in the ground water, and (2) they occur at relatively shallow, accessible depths. Currently, no known locations meet these criteria, and this alternative was not considered further. However, excavation, treatment, and/or disposal could be employed in the future if high concentrations of contaminants, treatable perhaps by bioremediation or aeration, are discovered at excavatable depths.

The volume of ground water that contains contaminants above MCLs is much greater than the volume of unsaturated sediment containing contaminants that may impact the ground water in concentrations above MCLs.

The ground water and unsaturated sediment alternatives were developed by considering the nine evaluation criteria prescribed by EPA, as discussed in the FS. The FS discusses the various technologies for treating extracted ground water and vapor and assembles them into treatment options. The preferred treatment options vary from place to place because different parts of the site contain somewhat different combinations of contaminants in ground water and unsaturated sediment.

All the remedial alternatives considered for the LLNL site would include long-term ground water monitoring and reporting, in compliance with CERCLA requirements, until demonstrated achievement of the remedial action objectives. The costs of these activities, which are common to all alternatives for their respective estimated times of operation, were not explicitly addressed in the FS, but were presented in the PRAP to reflect the additional costs of maintaining a remediation program into the distant future. Monitoring activities will be conducted and reviewed periodically to gauge the effectiveness of the remedies. For all alternatives, the costs and implementation times were estimated using the assumptions discussed in the FS. The program operations costs, which were not described in the FS, are summarized in Appendix A of the PRAP (Dresen et al., 1991).

All the treatment options for ground water will reduce the effluent concentration of VOCs, FHCs, chromium, and lead below Applicable or Relevant and Appropriate Requirements (ARARs) (Isherwood et al., 1990). Tables 3-1 and 3-2 in the FS, and Table 1 and Appendix B of this ROD summarize the ARARs for the LLNL site.

As discussed in Section 2.8, Ground Water Alternative No. 1 and Unsaturated Zone Alternative No. 1 meet all ARARs. Ground Water Alternatives 2 and 3 and Unsaturated Zone Alternative 2 do not fully comply with the California non-degradation ARAR.

For treatment options that include disposal of treated ground water or air emissions, the effluent concentrations will be in compliance with RWQCB Waste Discharge Requirements, National Pollutant Discharge Elimination System (NPDES), and BAAQMD standards. Treated ground water will be recharged at the LLNL recharge basin south of East Avenue, in local drainage ditches and arroyos, or in infiltration trenches or recharge wells. Treated water will also be used for onsite landscape irrigation and in LLNL's cooling towers.

The approach for tritium is to keep it in the subsurface as much as possible

where it will decay naturally (i.e., self-remediate) and to minimize its migration. Extraction systems will be designed and operated to prevent tritium from entering a treatment system in concentrations above its MCL. This will be accomplished by monitoring the influent water to the treatment system, both in pipelines and in the well(s). If water containing tritium above the MCL enters a treatment system, the facility will be shut down, and the water containing tritium will be treated by evaporation under existing National Environmental Standards for Hazardous Air Pollutants requirements, or released within allowable limits under the existing permit to the sanitary sewer system. No treated ground water will be recharged back to the subsurface if the tritium level exceeds the MCL.

Treatment options utilizing air stripping will be designed with GAC on the effluent air stream, so there are no measurable VOC air emissions. For those options employing GAC to treat water or air streams, the GAC will be shipped offsite where it will be commercially regenerated to destroy or recycle, if possible, the adsorbed contaminants. Options employing ion exchange for treatment of metals will require offsite recycling or disposal of the ion-exchange resin as a hazardous waste. The expected risk reduction after cleanup is complete is described in Section 2.9.1 of this ROD.

#### 2.7.1. No-Action Alternative

A No-Action Alternative was considered in the FS for the LLNL site to establish a baseline for comparison. Under this alternative, LLNL would cease all characterization and remedial activities. Limited ground water monitoring would continue to track changes in ground water chemistry. The No-Action Alternative is not the same as the Deferred-Action Alternatives discussed in the FS and the PRAP, in that remedial actions may be taken in the future under the Deferred-Action Alternatives. The No-Action Alternatives for ground water and unsaturated sediment do not meet Federal and State standards to protect human health and were not considered viable in the FS and the PRAP.

#### 2.7.2. Ground Water Remedial Alternatives

Two ground water extraction plans that use different arrays of extraction wells form the basis for immediate-action alternatives to remediate ground water. Each extraction plan is discussed subsequently with its remedial alternative.

Costs for the ground water remedial alternatives are summarized in Table 5. In the FS, costs were analyzed using a present worth calculation procedure, as prescribed by EPA. This is the standard procedure for comparing alternatives with costs and revenues beginning, ending, or extending over different periods of time.

##### 2.7.2.1. Ground Water Remedial Alternative No. 1 (The Selected Alternative)

###### 2.7.2.1.1. Ground Water Extraction Plan for Remedial Alternative No. 1- Complete Capture and Source Area Extraction

Under this plan, extraction wells would be strategically placed near contaminant margins to intercept and hydraulically control all ground water originating from LLNL with VOC concentrations exceeding MCLs. In addition, ground water would be extracted from source areas (defined here as those areas with concentrations above about 100 ppb in ground water) to expedite cleanup. This plan would utilize 18 initial extraction locations and about 7 treatment facilities shown conceptually on Figure 7. A plot of the predicted ground water flow patterns using these locations is shown in Figure 8. The flow lines (with arrows on Fig. 8) converge on extraction

locations and show the areas hydraulically captured by the extraction wells. The total rate of ground water removal for this extraction plan is estimated to be about 350 gallons per minute (gpm). Where VOCs and tritium occur together in ground water, the extraction systems will be designed and monitored to minimize tritium migration and to prevent the water influent to any treatment systems from containing tritium in concentrations above the MCL. Therefore, no tritium will be released from treatment systems in concentrations above the MCL.

The 350-gpm sitewide extraction rate is a preliminary estimate used to estimate capture areas, cleanup times and costs relative to other alternatives presented in the PRAP and ROD. This extraction rate and the estimated treatment facility capacities will be analyzed and further refined in the Remedial Design and as part of ongoing work to decrease cleanup times and optimize extraction and recharge rates.

It is estimated that it would take about 50 years to reduce contaminant concentrations to MCLs if only the 18 initial extraction locations are employed. LLNL plans to implement the selected cleanup plan in phases, and evaluate each phase with field data. Additional extraction locations may be used to ensure full hydraulic capture of the plume, and/or to expedite cleanup. If technologically feasible, and if funding permits, LLNL will attempt to achieve cleanup in less than the predicted 50 years. It is estimated that all extraction and treatment facilities under Alternative 1 would be operational in the 1993-94 timeframe, depending on congressional funding. LLNL will make every effort to obtain sufficient funding to fully support the selected cleanup plan. This alternative will comply with all ARARs.

#### 2.7.2.1.2. Treatment Options for Ground Water Remedial Alternative No. 1

Ground Water Containing VOCs (Proposed Treatment Facilities A, B, C, E, and G) (Fig.7). Treatment Facility E could potentially receive ground water containing tritium as well as VOCs.

Treatment Option 1. Granular-Activated Carbon. (GAC) Ground water pumped by extraction wells would pass through beds of activated carbon where VOCs would be removed by GAC. The operating costs of this treatment option are high.

Treatment Option 2. Air Stripping with GAC Treatment of the Vapor. Ground water pumped by extraction wells would pass through an air stripper where VOCs would be removed by transferring them from the water to the air. The vapors from the stripper would pass through GAC to completely remove contaminants. This treatment option is the most economical for ground water containing VOCs.

Treatment Option 3. UV/Oxidation Plus Air Stripping with GAC Filtering of the Vapor. Extracted ground water would be blended with small amounts of hydrogen peroxide and exposed to strong ultraviolet (UV) light, destroying most of the contaminants. LLNL pilot studies have shown that some compounds require secondary treatment by air stripping, which would be added to treat water after it passed through the UV/oxidation unit. The vapors from air stripping would pass through GAC to remove contaminants. This option reduces the amount of waste requiring further treatment or disposal, especially where the majority of the contaminants are readily oxidized by the UV/oxidation process. Costs for this option are moderately high.

Treatment Option 2 or 3 is preferred for Treatment Facilities A, B, C, E, and G, depending on the concentrations and types of the compounds, and the flow rate influent to each treatment facility. Ground Water Containing VOCs

and Chromium (Proposed Treatment Facility D) (Fig. 7)

Treatment Option 1. GAC Plus Ion Exchange. Ground water pumped by extraction wells would pass through GAC beds, which would remove the VOCs. The VOC-free water would then be fed through an ion-exchange resin to extract chromium. The operating costs of this treatment option are high.

Treatment Option 2. Air Stripping with GAC Filtering of the Vapor Phase Plus Ion Exchange. Extracted ground water would pass through an air stripper to remove VOCs. The vapors from the stripper would pass through GAC to remove VOCs from the air. The VOC-free water would flow through an ionexchange resin to extract chromium. This treatment option is preferred because the higher concentrations of TCE, carbon tetrachloride, chloroform, and Freon 113 make this treatment option more economical.

Treatment Option 3. UV/Oxidation Plus Air Stripping and Ion Exchange with GAC Treatment of the Vapor. Extracted ground water would be treated by UV/oxidation, destroying most of the VOCs. Remaining VOCs would be removed from the water by air stripping. The vapors from the air stripper would pass through GAC to completely remove VOCs. The VOC-free water would then flow through an ion-exchange resin to extract chromium. The operating costs of this treatment option are high.

Ground Water Containing FHCs, VOCs, and Lead (Proposed Treatment Facility F) (Fig. 7)

Treatment Option 1. GAC Treatment. Ground water pumped by extraction wells would pass through GAC beds, which remove the FHCs, VOCs, and lead. The operating costs of this treatment option are high.

Treatment Option 2. Air Stripping with GAC Treatment of Both the Vapor and Liquid Phases. Extracted ground water would pass through an air stripper to remove FHCs and VOCs. The vapors from the stripper would passthrough GAC to completely remove FHCs and VOCs. The water would then pass through GAC to extract lead and any remaining FHCs or VOCs. This treatment option is not preferred because the high concentration of FHCs would require frequent carbon regeneration that increases the operating costs of this treatment option substantially.

Treatment Option 3. UV/Oxidation Plus GAC. Extracted ground water would be treated by UV/oxidation, destroying most contaminants. The water would then pass through GAC beds to remove lead and any remaining FHCs or VOCs. This treatment technology is preferred because it can handle the high concentrations of FHCs. It is also the most economical of the treatment options.

Treatment Option 4. Subsurface Bioremediation. Biological treatment would utilize the metabolic destruction of organic compounds by microbes that convert the organic compounds in the ground water to less toxic compounds. Bioremediation of the FHCs in the Gasoline Spill Area is potentially viable. However, the relatively great depth of FHCs at LLNL, which makes providing the correct physical and chemical conditions for the microbes difficult, and the sensitivity of microorganisms to subsurface conditions that are difficult to control, make applicability of subsurface bioremediation at LLNL uncertain. In addition, bioremediation has not yet been proven successful for chlorinated VOCs. Therefore, this treatment option was not considered as an initial remedial action.

2.7.2.2. Ground Water Remedial Alternative No. 2

2.7.2.2.1. Ground Water Extraction Plan for Remedial Alternative No.

## 2-Downgradient Control

Under this plan, extraction wells would be placed along the western boundary of LLNL to intercept and hydraulically control the offsite migration of those VOCs in concentrations exceeding MCLs. In addition, extraction would also occur in the Gasoline Spill Area, where a pilot remediation study is ongoing, and in the adjacent Building 518 Area to prevent migration of FHCs and VOCs to the south of LLNL. This plan would use a total of 10 extraction locations, 1 through 7 and location 9 in and near the western boundary of LLNL and locations 17 and 18 in the southeastern part of LLNL (Fig. 7). Extracted water would be treated at Treatment Facilities A, B, C, and F (Fig. 7). A plot of the predicted ground water flow patterns using the extraction locations for this plan is shown in Figure 9. The rate of ground water extraction for this plan is estimated to be about 200 gpm. This alternative would contain and remediate all known contaminants. It is estimated that it would take more than 90 years to achieve MCLs under this plan and that all extraction and treatment facilities would be operational in 1993.

### 2.7.2.2.2. Treatment Options for Ground Water Remedial Alternative No. 2

This alternative differs from Alternative No. 1 in that fewer initial extraction locations (10 compared to 18 for Alternative No. 1) and treatment facilities (4 compared to 7 for Alternative No. 1) would be employed. The treatment options discussed in Section 2.7.2.1.2 for Treatment Facilities A, B, C, and F would be identical for this alternative.

### 2.7.2.3. Ground Water Remedial Alternative No. 3-Deferred Action

For the Deferred-Action Remedial Alternative, ground water would not be treated until and unless contaminants in concentrations greater than MCLs migrate to a drinking water supply well, such as those operated by the California Water Service Company, located about 2 miles west of LLNL. Under this alternative, treatment would take place at the point of distribution for the affected water-supply system. If contaminants did reach supply wells, probably no sooner than about 200 years, their concentrations would be substantially lower than those currently at LLNL (Thorpe et al., 1990). The ground water would be treated, at a minimum, to conform to the MCLs for each contaminant before it is distributed for human consumption. Selection of an appropriate treatment option would be made at the time that treatment may be necessary because

technology and economics may have changed considerably by then. Currently available options are presented below for comparison.

#### 2.7.2.3.1. Treatment Options for Ground Water Remedial Alternative No. 3

Treatment Option 1. GAC Treatment. Ground water pumped by water supply wells would pass through GAC beds to remove contaminants.

Treatment Option 2. Air Stripping. Ground water pumped by water supply wells would pass through an air stripper. Because only very low concentrations of VOCs may ever occur in water from supply wells (Thorpe et al., 1990), treatment of air emissions would most likely be unnecessary. This treatment option is preferred because concentrations of compounds will be very low and it is the most economical of the treatment options.

Treatment Option 3. UV/Oxidation. Ground water pumped by water supply wells would be treated by UV/oxidation. The concentrations of VOCs are expected to be reduced sufficiently so that secondary treatment would be unnecessary.

#### 2.7.2.4. Comparison of Ground Water Treatment Option Costs

For each extraction and treatment alternative described above, several treatment technology options passed initial screening and were subjected to a detailed evaluation in Section 4 of the FS. For purposes of comparing the treatment technologies in the FS, cost estimates were prepared (see Appendices D, E, and F of the FS) using U.S. EPA's suggested 30 years operating and maintenance period (U.S. EPA, 1989b). A supplemental analysis was conducted for several of the treatment facilities assuming 90 years of operation would be required for Alternative No. 2 to achieve ARARs. This detailed analysis indicates that, in general, for the same length of operation (e.g., 30 years), (1) GAC is about 1.8 times more expensive in present worth for a treatment facility than air stripping and (2) UV/oxidation treatment is 1.3 times as expensive in present worth as air stripping. Alternative No. 3 has a very low present worth, ranging from \$30,000 for air stripping to \$280,000 for GAC, largely because the long timespan prior to possible commencement of treatment reduces the total costs of this alternative in the discounting procedure. This also takes into account the different combinations of contaminants and treatment options at each treatment facility.

In summary, GAC is generally the most costly treatment technology, followed by UV/oxidation, and then by air stripping. However, the costs in the FS do not include the program operations costs in Appendix A of the PRAP. These costs do not significantly affect the relative costs of the treatment options, but they are significant in magnitude when comparing remedial alternatives with different periods of operation.

#### 2.7.3. Unsaturated Zone Alternatives

Costs of remedial alternatives for the unsaturated zone are summarized in Table 6. The remedial alternatives and treatment options are described below.

##### 2.7.3.1. Unsaturated Zone Remedial Alternative No. 1-Vacuum Induced Venting (the Selected Alternative)

Current data indicate that only FHCs in the Gasoline Spill Area, VOCs in the Building 518 Area in the southeastern part of the LLNL site, and possibly VOCs in the vicinity of the Trailer 5475/East Taxi Strip Area in eastern LLNL will need unsaturated zone remediation (Isherwood et al., 1990). FHCs and/or VOCs would be removed from the subsurface by vacuum-induced

venting using extraction wells. Treatment options for the extracted vapor are described in the following section. If vapor extraction were ever considered for any of the localized areas at LLNL where elevated levels of tritium occur in the unsaturated zone, the water portion of the vapor could be (1) released to the atmosphere or (2) separated from the vapor by condensation. For possible tritium air releases from treatment systems, the AIRDOS-EPA computer model would be used to evaluate the potential annual dose to a hypothetical maximally exposed individual. LLNL will shut down any treatment system that emits tritium to the atmosphere at a rate predicted to contribute to an exposure of greater than 10 millirem/year (the Federal standard for clean air).

We estimate that it would take about 10 years to remediate the unsaturated zone under this alternative and that remediation would be underway by late 1992.

#### Treatment Options for Unsaturated Zone Remedial Alternative No. 1

Treatment Option 1. GAC Treatment. Vapors from vent wells would pass through a chamber containing GAC to remove VOCs or FHCs. The treated vapor would be discharged to the atmosphere.

Treatment Option 2. Thermal Oxidation. Vapors from vent wells would pass through a thermal oxidation chamber where the FHC and VOC vapors would be oxidized with the assistance of a heat source such as propane. The VOCs and FHCs would be destroyed and treated air would be discharged to the atmosphere.

Treatment Option 3. Catalytic Oxidation. Vapors from vent wells would be heated and passed through a catalyst, where organic compounds would be converted to harmless oxidation products, such as carbon dioxide and water. The treated air would be discharged to the atmosphere. A catalyst suitable for both VOCs and FHCs has recently been found. The rationale for preferring catalytic oxidation over thermal oxidation for treatment of vapors is presented in Appendix B of the PRAP. If use of catalytic oxidation results in emission of vapors with compounds above regulatory standards, secondary treatment or alternative technologies, such as GAC, will be evaluated and implemented to comply with regulatory standards.

#### 2.7.3.2. Unsaturated Zone Remedial Alternative No. 2-Deferred Action

Under this alternative, all contaminants in the unsaturated zone would be left in place and allowed to degrade, volatilize, or migrate to ground water under natural conditions. Ground water would continue to be monitored according to the requirements of CERCLA. If any contamination of ground water above MCLs occurs, it would either be remediated by ongoing ground water extraction and treatment, or by additional ground water extraction and treatment systems, if necessary.

#### 2.7.3.3. Comparison of Unsaturated Zone Treatment Option Costs

The relative present worth costs for the three vadose zone treatment options are discussed in Section 4 of the FS. In summary, the present value of GAC is about 50% greater than for thermal oxidation, and catalytic oxidation is about 20% less than thermal oxidation.

### 2.8. Summary of the Comparative Analysis of Alternatives

The remedial alternatives and associated treatment options were evaluated against nine EPA criteria in the FS and PRAP. The preferred remedial alternatives for ground water and unsaturated sediment were analyzed in terms of these nine criteria and are summarized in Tables 7 and 8.

#### 2.8.1 Ground Water

Overall Protection of Human Health and the Environment. All the ground water remedial alternatives are equally protective of human health (if institutional controls are in effect for Alternative 3 to prevent new or existing wells from being used) because each is designed to meet the same cleanup criteria. Consequently, the resulting health risks are identical among the alternatives (Isherwood et al., 1990). Since Alternatives 2 and 3 would allow some continued migration of VOCs in ground water, they also allow some degradation of the subsurface environment.

Compliance with ARARs. Ground water Remedial Alternatives No. 1 and No. 2 are designed to achieve all ARARs (Isherwood et al., 1990). However, Alternative No. 2 would allow higher-concentration VOCs in eastern LLNL to migrate across the site, and thus does not fully satisfy the State of California ARAR regarding non-degradation of water resources. Remedial

Alternative No. 3, treat at point-of-use, though estimated to be protective of human health (Isherwood et al., 1990), does not fully satisfy the California non-degradation ARAR.

Long-Term Effectiveness and Permanence. All three remedial alternatives are equally effective in terms of permanence and stability of remediation and reduction in health risks by removing and treating the contaminants.

Reduction in Toxicity, Mobility, and Volume. Remedial Alternatives No. 1 and No. 2 reduce toxicity, mobility, and volume of the compounds. Alternative No. 1 does not allow additional contaminant migration beyond the current extent downgradient. Alternative No. 2 allows VOCs in eastern LLNL to migrate across the site. Remedial Alternative No. 3, deferred action, allows more contaminant mobility than Alternative No. 2 and does not reduce contaminant mobility until and unless contaminants reach domestic or municipal wells in concentrations above an MCL.

An advantage of the UV/oxidation remediation technology (preferred at Treatment Facilities A, B, E, and F) is that TCE, PCE, 1,1-DCE, and FHCs are destroyed in one process, thereby minimizing waste requiring further treatment or disposal. Use of GAC requires regeneration of spent carbon to convert the captured compounds to harmless substances. Ion-exchange resins for metals removal may require disposal as hazardous waste.

Short-Term Effectiveness. All the remedial alternatives would expose workers, the public, and the environment to negligible impacts during installation and operation.

The selected remedial alternative is estimated to achieve the remediation goals in about 50 years compared to 90 years or more for Remedial Alternative No. 2, which employs only four treatment facilities and ten extraction locations. Alternative No. 3 may take about 230 years to achieve remediation goals, and remediation may not begin for 200 years. Each treatment option, combined with the same remedial alternative, would require about the same length of time to achieve the remediation goals. For Alternative No. 1, it is estimated that plume containment and overall hydraulic control will be achieved in 1995. This estimate will be further refined in the Remedial Design.

Implementability. Each of the remedial alternatives and technology options is technically and administratively feasible and supported by available services, materials, and skilled labor. An advantage of the UV/oxidation technology over the GAC technology is that regeneration of the spent carbon is unnecessary. The air-stripping-based and UV/oxidation-based technologies generate substantially less spent carbon than the GAC system for water treatment. UV/oxidation and GAC technologies also have minimal visual impact compared to airstripping towers.

Cost. The present worth of Ground Water Remedial Alternative No.1 (the selected alternative) is estimated to be \$103 million, assuming 50 years of operation. The present worth for 90 years of operation for Remedial Alternative No. 2 is \$99 million. The present worth for Remedial Alternative No. 3 is \$87 million, assuming air stripping is the treatment option used. If Remedial Alternative No. 3 consisted only of monitoring ground water for 100 years, the present worth would be \$12 million.

State Acceptance. The California RWQCB and DTSC accept the selected ground water remedial alternative, Remedial Alternative No. 1. The RWQCB does not accept Ground Water Alternatives No. 2 and No. 3 since they do not fully satisfy the California non-degradation ARAR.

Community Acceptance. The community accepts the general concept of the selected alternative, but desires funding commitments, a detailed implementation schedule, continued opportunity for involvement, and a faster cleanup. Implementation schedules will be included in post-ROD documents called the Remedial Action Implementation Plan and the Remedial Design/Remedial Action reports. LLNL is continually exploring and implementing new methods and techniques that will accomplish the fastest cleanup.

#### 2.8.2. Unsaturated Zone

The remedial alternatives for the unsaturated zone are described below and compared in Table 8 in terms of the EPA evaluation criteria.

Overall Protection of Human Health and the Environment. Unsaturated Zone Remedial Alternative No. 1 is protective of human health and the environment and creates minimal health risks. Remedial Alternative No. 2 has some impact on the subsurface above the water table as contaminants would be allowed to migrate naturally. Estimates indicate natural processes would reduce the concentrations to below MCLs in 90 to 140 years (Isherwood et al., 1990, Appendix G).

Compliance with ARARs. Remedial Alternative No. 1 is designed to achieve ARARs. Alternative No. 2 may allow contaminants to reach the ground water in concentrations exceeding MCLs in a few isolated places (i.e., the Gasoline Spill and Building 518 Areas, and perhaps the East Taxi Strip Area), and therefore does not meet the California non-degradation ARAR.

Long-Term Effectiveness and Permanence. Both of the alternatives are effective in the long run and reduce health risks permanently by removing and treating contaminants.

Reduction in Toxicity, Mobility, and Volume. Remedial Alternative No. 1 results in the immediate removal and complete breakdown of compounds to harmless substances, thereby permanently reducing toxicity, mobility, and volume. Remedial Alternative No. 2 (deferred action) allows VOCs and FHCs to continue to migrate through the unsaturated zone to the ground water. VOCs and FHCs would then be extracted and treated in the ground water at the nearest treatment facility.

Short-Term Effectiveness. Both alternatives would expose workers, the public, and the environment to negligible impacts during installation and operation. Achieving the remediation objectives is estimated to require 10 years for the selected alternative, Alternative No. 1, and 90 years for Alternative No. 2.

Implementability. Both alternatives are technically and administratively feasible and supported by available services, materials, and skilled labor.

Cost. Present worth cost for 10 years of operation for the preferred alternative is \$1.1 million. The preferred alternative utilizes the most cost effective treatment option available for both VOCs and FHCs. The present worth of Alternative No. 2 is \$850,000.

State Acceptance. The California RWQCB and DTSC accept the selected unsaturated zone alternative, Remedial Alternative No. 1. The RWQCB does not accept Unsaturated Zone Alternative No. 2 since it may allow ground water degradation.

Community Acceptance. The community accepts the general concept of the selected unsaturated zone alternative, but desires funding commitments, a

detailed implementation schedule, continued opportunity for involvement, and a faster cleanup. Implementation schedules will be included in post-ROD documents called the Remedial Action Implementation Plan and the Remedial Design/Remedial Action reports. LLNL is continually exploring and implementing new methods and techniques that will accomplish the fastest cleanup.

## 2.9. The Selected Remedies

Based on the requirements of CERCLA, the detailed analysis of the alternatives, and public comments, DOE, LLNL, EPA, the DTSC of the California Environmental Protection Agency, and the California RWQCB have determined that Alternative No. 1 for ground water (pumping and surface treatment by UV/oxidation and air stripping), and Alternative No. 1 for the unsaturated zone (vacuuminduced venting and surface treatment of vapors by catalytic oxidation), are the most appropriate remedies for LLNL.

The selected remedies for this site protect human health and the environment, comply with Federal, State, and local requirements (ARARs), are implementable, and permanently and significantly reduce the toxicity, mobility, and volume of the contaminants.

The goal of this remedial action is to remediate ground water to the ARARs specified in the PRAP and this ROD. Based on information obtained during the RI and on a careful analysis of all remedial alternatives, DOE, LLNL, EPA, DTSC, and the RWQCB believe that the selected remedy will achieve this goal. The approach to be taken to the remediation will involve close monitoring of ground water quality in monitor wells, extracted water quality in extraction wells, and water level elevations near the extraction centers. The extraction well field will be operated dynamically to optimize the cleanup. That is, based on the results from the monitoring plan, individual wells may operate continuously, may be turned off, or may be pumped intermittently. During the course of the remediation, new wells will be installed at appropriate locations and will be operated in the same manner.

To ensure that cleanup levels continue to be maintained, the ground water will be monitored until DOE and the regulatory agencies agree that cleanup is complete.

### 2.9.1. Ground Water

The primary purpose of the selected ground water remedy is to contain VOCs and prevent further downgradient and offsite migration in ground water, and to reduce the concentrations of contaminants in ground water after cleanup to levels below MCLs, the designated cleanup levels. Existing conditions at the site may pose an excess lifetime cancer risk of  $2 \times 10^{-3}$  from ingestion of ground water contaminated with VOCs (primarily TCE) under healthconservative no remediation assumptions. The selected alternative will address all ground water contaminated with VOCs in excess of 5 ppb and will assure that ARARs for individual VOCs, FHCs, lead, chromium, and tritium will be achieved.

The selected ground water remedy involves immediately pumping water at approximately 18 initial locations within the ground water plume (Fig. 7). The total rate of ground water removal for this extraction plan is estimated to be about 350 gpm. Water will be pumped from one or more wells at each of these locations using existing monitor and extraction wells, along with new extraction wells. The well locations will be chosen to prevent any VOCs from escaping from the area in concentrations above their MCLs. To enable more rapid remediation, wells will also be placed in all areas where VOC or FHC concentrations in ground water exceed 100 ppb. Additional extraction

locations may be added to ensure complete hydraulic capture of the plume, and/or to expedite cleanup, if field data indicate additional wells are necessary.

Seven onsite facilities (A to G) will be constructed initially to treat the extracted ground water (Fig. 7). Each treatment facility will be designed to treat a somewhat different combination of compounds. Treatment Facilities A, B, E, and F will use UV/oxidation as the primary treatment technology. Treatment Facilities C, D, and G will use air-stripping as the primary treatment technology. All facilities will use GAC to remove VOCs and FHCs from air streams, and Treatment Facility F will use GAC to remove lead from ground water. Treatment Facility D will use ion exchange to remove chromium from ground water.

The maximum additional cancer risk after remediation is complete is calculated at seven in one hundred million ( $7 \times 10^{-8}$ ) using the best estimate assumptions. This is over 100 times lower than the one in ten thousand to one in ten million ( $1 \times 10^{-4}$  to  $1 \times 10^{-7}$ ) acceptable level of risk specified in the NCP (U.S. EPA, 1990). The HI for this scenario is far less than 1.0, indicating that no adverse health effects from noncarcinogens would occur following the planned remediation. Using health-conservative assumptions that EPA prescribes for assessing site risks, the risk of cancer after remediation, based on a potential monitor well drilled 250 feet west of LLNL, is  $4 \times 10^{-5}$ , and  $3 \times 10^{-5}$  for potential receptor wells in downtown Livermore. Both of these values are within the EPA acceptable risk range. The hazard indices for both healthconservative scenarios are far less than 1 ( $2.7 \times 10^{-2}$  and  $3.1 \times 10^{-2}$ , respectively), indicating no adverse health affects from noncarcinogens after the planned remediation.

#### 2.9.2. Unsaturated Zone

The selected remedy for the unsaturated zone involves using vacuuminduced venting to extract contaminant vapors from the unsaturated sediments and treating the vapors by catalytic oxidation. Use of a catalytic oxidizer provides the flexibility to treat both FHCs and VOCs together and substantially reduces the potential for producing dioxin. The purpose of this response action is to prevent migration of VOCs and FHCs to ground water in concentrations that would impact the ground water in concentrations above MCLs.

Current data indicate that only FHCs in the Gasoline Spill Area, VOCs in the Building 518 Area in the southeastern part of the LLNL site, and possibly VOCs in the vicinity of the East Taxi Strip in eastern LLNL will need unsaturated zone remediation (Isherwood et al., 1990). FHCs and/or VOCs will be removed from the subsurface by vacuum-induced venting using extraction wells.

The selected treatment option for the extracted vapors is catalytic oxidation. In this process, vapors from vent wells will be heated and passed through a catalyst, where organic compounds are converted to harmless oxidation products, including carbon dioxide and water. If use of catalytic oxidation should result in emission of vapors with compounds above regulatory standards, secondary treatment or alternative technologies, such as GAC, will be evaluated and implemented to comply with regulatory standards.

The decision regarding whether an area requires vadose zone cleanup will be based on unsaturated zone modeling and ground water monitoring. If modeling indicates that hazardous materials will impact ground water in concentrations above an MCL, remediation will be implemented. Remediation will continue until in situ concentrations, as verified by soil sampling,

are below those predicted to impact ground water above MCLs. In addition, the ground water near the potential source will be monitored for impacts on ground water quality. Details of the modeling and monitoring will be presented in the Remedial Design.

## 2.10. Statutory Determinations

Section 121 of CERCLA specifies that the selected remedial actions must comply with all Federal and State ARARs, be cost-effective, be protective of human health and the environment, and utilize permanent solutions and alternative treatment technologies or resource recovery technologies to the maximum extent practicable. In addition, the selected remedies should employ treatment that permanently and significantly reduces the volume, toxicity, or mobility of hazardous wastes as their principal element. The selected remedies for ground water and the unsaturated zone are the same as those described in the PRAP and meet these statutory requirements as discussed below.

### 2.10.1. Protection of Human Health and the Environment

The selected remedy for ground water will provide adequate protection of human health and the environment through extraction of contaminated ground water and treatment at the surface to reduce in situ concentrations below MCLs. Discharges to the air will be designed for no measurable contaminant emissions. In addition, further offsite migration of the contaminant plume will be prevented. The selected remedy will reduce exposure to levels within or below EPA's acceptable carcinogenic risk range of  $10^{-4}$  to  $10^{-7}$ , and hazard indices will be far below 1.0 after cleanup.

Vacuum-induced venting of the unsaturated zone will remove subsurface VOCs and FHCs and prevent contaminant migration to ground water. Implementation of the selected remedies will not pose unacceptable short-term risks or impact the adjacent subsurface media, other than some lowering of water levels due to ground water extraction. Lowering of the water table will be mitigated by locally recharging the ground water with treated ground water.

### 2.10.2. Compliance with ARARs

The selected remedies will comply with all Federal and State ARARs, including the to be considered (TBC) criteria in Appendix B. Table 1 and Table B-1 in Appendix B list and describe the ARARs and TBCs that will be attained by each selected remedy.

### 2.10.3. Cost-Effectiveness

The selected remedies provide overall effectiveness proportionate to their costs. Present worth cost estimates for each alternative are presented in Tables 5 and 6. Although the selected remedies cost somewhat more in terms of present worth compared to the other alternatives, they enable more rapid cleanup.

### 2.10.4. Utilization of Permanent Solutions and Alternative Treatment Technologies to the Maximum Extent Practicable

The selected remedies utilize permanent solutions and alternative treatment technologies to the maximum extent practicable. The selected alternatives permanently remove contaminants from ground water and the unsaturated zone by extraction and treatment at the surface using UV/oxidation, air stripping, GAC, and ion exchange for ground water and catalytic oxidation for vapor. Both selected alternatives provide the best balance of tradeoffs among the alternatives, and use treatment technologies that destroy most

contaminants, converting them to harmless compounds.

The selected alternatives will reduce contaminant mobility more than the other alternatives. Although the selected alternatives have a higher present worth cost than the other alternatives, the selected alternatives will accomplish the cleanup objectives in a shorter time period. Therefore, reducing contaminant mobility and expediting cleanup time (short-term effectiveness) were the most important primary balancing criteria in selecting the remedies.

For both selected alternatives, overall protection of human health and the environment and the compliance with ARARs were also decisive factors in remedy selection. Community concerns were included in the decision-making process by addressing community input received at CWG meetings and during the public comment period on the PRAP. The Responsiveness Summary, attached to this ROD, addresses community comments on the remedial alternatives.

#### 2.10.5. Preference for Treatment as a Principal Element

The selected remedial actions satisfy the statutory preference for selecting remedies in which treatment that permanently and significantly reduces the volume, toxicity or mobility of the contaminants is a principal element. The selected remedial action for ground water uses treatment to address the contaminated ground water, which is the principal medium of concern. UV/oxidation-based technology destroys contaminants leaving residual harmless compounds such as carbon dioxide and water. Both UV/oxidation and air stripping-based technologies will achieve a permanent and significant reduction of the toxicity, mobility, or volume of the contaminants. Similarly, for the unsaturated zone, vacuum-induced venting followed by catalytic oxidation of the extracted vapor will destroy VOCs and FHCs after removal from contaminated soil, thereby also meeting this statutory preference.

#### References

California Department of Water Resources (DWR) 1974, Evaluation of Ground Water Resources: Livermore and Sunol Valleys, Bulletin No. 118-2.

Dresen, M. D., W. F. Isherwood, and J. P. Ziafos (1991), Proposed Remedial Action Plan for the Lawrence Livermore National Laboratory Livermore Site, Livermore, California, Lawrence Livermore National Laboratory, Livermore, Calif. (UCRL-AR-105577).

Federal Facility Agreement under CERCLA Section 120 between the United States Environmental Protection Agency, the United States Department of Energy, the California Department of Health Services, and the California Regional Water Quality Control Board, 1988.

Fish, W. (1987), Subsurface Transport of Gasoline-Derived Lead at a Filling Station Contamination Site in Yakima, Washington, Proceedings of the NWWA FOCUS Conference on Northwestern Ground Water Issues, May 5-7, 1987, pp. 557 through 567.

Hoffman, F. (1991a), Possible Sources of Chromium in the Vasco Road - Patterson Pass Road Area, Livermore, California, letter from Fred Hoffman, LLNL Environmental Restoration Division Leader, to John Chesnutt, U.S. EPA Remedial Project Manager, dated August 16, 1991.

Hoffman, F. (1991b), Evaluation of Health Risk from Volatilization of Compounds from the Vadose Zone, letter from Fred Hoffman, LLNL Environmental Restoration Division Leader, to John Chesnutt, U.S. EPA Remedial Project

Manager, dated August 16, 1991.

Hoffman, F. (1992), Results of Lead in Ground Water Analysis, letter from Fred Hoffman, LLNL Environmental Restoration Division Leader, to John Chesnutt, U.S. EPA Remedial Project Manager, dated March 2, 1992.

International Agency for Research on Cancer (IARC) (1982), "Benzene," IARC Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Humans, Suppl. 4 (World Health Organization, IARC, Lyon, France), pp. 8788.

Iovenitti, J. L., J. K. Macdonald, M. D. Dresen, W. F. Isherwood, and J. P. Ziagos (1991), Possible Sources of VOCs in the Vasco Road-Patterson Pass Road Area, Livermore, California, Lawrence Livermore National Laboratory, Livermore, Calif. (UCRL-AR-106898).

Isherwood, W. F., C. H. Hall, and M. D. Dresen (1990), CERCLA Feasibility Study for the LLNL-Livermore Site, Lawrence Livermore National Laboratory, Livermore, Calif. (UCRL-AR-104040). Layton, D. W., J. I. Daniels, and W. F. Isherwood (1990), Baseline Public Health Assessment for CERCLA Investigations at the LLNL Livermore Site, Lawrence Livermore National Laboratory, Livermore, Calif. (UCRL-53953).

Macdonald, J. K., M. D. Dresen, and W. F. Isherwood (Eds.) (1990), LLNL Ground Water Project Monthly Progress Report, October 1990, Lawrence Livermore National Laboratory, Livermore, Calif. (UCAR-10160-90-10).

Rice, D.W., Jr. (1988), Quality Assurance Project Plan, LLNL Ground Water Project, Lawrence Livermore National Laboratory, Livermore, Calif. (UCAR-10219).

Sims, J. M., K. A. Surano, K. C. Lamson, M. G. Brown, and G. M. Gallegos (Eds.) (1990), Environmental Report for 1989, Lawrence Livermore National Laboratory, Livermore, Calif. (UCRL-50027-89).

Thorpe, R. K., W. F. Isherwood, M. D. Dresen, and C. P. WebsterScholten (Eds.) (1990), CERCLA Remedial Investigations Report for the LLNL Livermore Site, Lawrence Livermore National Laboratory, Livermore, Calif. (UCAR10299).

U.S. Department of Energy (DOE) and University of California (1992), Draft Environmental Impact Statement and Environmental Impact Report for Continued Operation of Lawrence Livermore National Laboratory and Sandia National Laboratories, Livermore, University of California, Berkeley, Calif. (SCH-90030847).

U.S. Environmental Protection Agency (EPA) (1988a), Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA (Interim Draft), Office of Emergency and Remedial Response, Washington, D.C. (OSWER Directive 9355.3-01) (October 1988).

U.S. Environmental Protection Agency (EPA) (1988b), CERCLA Compliance with Other Laws Manual, Office of Emergency and Remedial Response, Washington, D.C. (OSWER Directive 9234.1-01).

U.S. Environmental Protection Agency (EPA) (1989a), Risk Assessment Guidance for Superfund, Human Health Evaluation Manual, Part A: Interim Final, EPA/540/1-89/002, Washington, D.C.

U.S. Environmental Protection Agency (EPA) (1989b), Interim Final Guidance on Preparing Superfund Decision Documents, Office of Emergency and Remedial Response, Washington, D.C. (OSWER Directive 9234.1-01) (June 1989).

U.S. Environmental Protection Agency (EPA) (1990), "40 CFR, Part 300, National Hazardous Substances Pollution Contingency Plan, Final Rule," Federal Register, Vol. 55, No. 46, March 8, 1990, p. 8716.

## Appendix A

Tables Summarizing  
Predicted Cancer Risks and  
Hazard Quotients for  
Offsite Exposure

## Appendix B

### LLNL ARARs

This Appendix discusses those standards, requirements, criteria, or limitations under Federal environmental law, and any promulgated standards, requirements, criteria, or limitations under State environmental or facility siting law that are more stringent than those provided under Federal law, that the signatories to LLNL's Federal Facility Agreement consider legally applicable or relevant and appropriate to the LLNL site. In addition, nonpromulgated criteria advisories or guidance that do not meet the definition of Applicable or Relevant and Appropriate Requirements (ARARs), but that may assist in determining what is necessary to be protective, are listed as to be considered (TBC). Some of these apply to remediation activities, such as discharges from treatment facilities, whereas others form the basis for determining when cleanup is complete. Table B-1 is a summary of corresponding ARARs for ground water and the vadose zone. A complete discussion of LLNL ARARs is presented in Section 3 of the Feasibility Study (FS) (Isherwood et al., 1990).

There are three general kinds of ARARs: chemical-specific, location-specific, and action-specific. Chemical-specific ARARs usually result in health- or risk-based concentration limits. The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Compliance with Other Laws Manual (U.S. EPA, 1988b) contains a nonexhaustive list of potential chemicals specific ARARs from which LLNL has drawn to ensure that no ARAR is overlooked.

The chemical-specific concentrations proposed as remedial action objectives for ground water remediation are given for the compounds of concern at LLNL in Table 1 of this document. The standards in the columns of Federal and State drinking water Maximum Contaminant Levels (MCLs) and Federal non-zero Maximum Containment Levels Goals become remedial action objectives for ambient ground water (i.e., ground water left in place after remediation), whereas the discharge limits given in the last column apply to discharges of treated water under LLNL's National Pollution Discharge Elimination System permit. The most stringent concentration limit is the governing ARAR for each chemical of concern.

San Francisco Bay Area Regional Water Quality Control Board's Basin Plan ("Basin Plan") taste and odor objectives are not considered an ARAR because acceptable numerical expressions of these objectives are not available at the present time. There is no methodology for enforcement of these objectives and consequently they have not been enforced by the State. We, therefore, cannot use the Basin Plan's taste and odor objectives to establish a cleanup level for compliance purposes. If in the future a method is established for measurement and achievement of the Basin Plan's taste and odor objectives and achievement of those objectives is determined to be applicable or relevant and appropriate and necessary to ensure that the remedy is protective of human health and the environment, then LLNL will

consider the objectives applicable to the cleanup.

If any additional hazardous substances are found in the ground water environment at levels of concern in the future, standards for those will be requested and agreed upon with the U.S. Environmental Protection Agency and the California Department of Toxic Substances Control.

Resource Conservation Recovery Act (RCRA) Section 3020 bans hazardous disposal by underground injection into or above a source of drinking water unless the reinjection involves treated ground water from a CERCLA response action. This section does not apply if certain conditions are met. At LLNL, proposed injection is a CERCLA response action intended to clean up contamination; the contaminated ground water will be treated to substantially reduce hazardous constituents prior to such injection; and the response action will be sufficient to protect human health and the environment upon completion. LLNL thus meets the conditions for exemption and is not subject to the ban.

Whereas specific ARARs do not appear to exist as cleanup standards for vadose zone sediments, LLNL considers health protection (at a  $10^{-6}$  risk) to be a remedial action objective. Based on results of the Baseline Public Health Assessment (BPHA), ground water constitutes the only significant pathway of exposure from vadose zone contaminants. The BPHA demonstrates that, if ground water concentrations are at MCLs or below, the health risk is well below  $10^{-6}$ .

Unsaturated sediment cleanup concentrations will be based on the mobility of specific contaminants in the sediment at the LLNL site. We have examined the potential for hazardous substances in the sediments of the unsaturated zone to migrate to ground water (Appendix G of the FS). The preliminary results of our investigation indicate that the potential for affecting the ground water depends on the mass, concentration, and distribution of contaminants in the vadose zone.

For the areas of greatest potential concern at LLNL, we conclude that the dominant transport mechanism for migration to the ground water is vapor diffusion. The model illustrated in Appendix G of the FS provides a basis for deciding which, if any, areas at LLNL may warrant vadose zone remediation.

Based on the findings of the BPHA section of the Remedial Investigation (RI) (Thorpe et al., 1990) that no surficial soils at LLNL constitute a potential health threat, we have no cleanup standards for surficial soils.

Location-specific ARARs are restrictions placed on the concentration of chemicals or conduct of operations based on the location of a site. Potential location-specific ARARs include the protection of:

- . Wetlands.
- . Floodplains.
- . Historic landmarks.
- . Coastal zones.
- . Coastal barriers.
- . Rare and endangered species.
- . Cultural resources.

The LLNL site contains no floodplains, historic landmarks, coastal zones, or coastal barriers. As stated in the Livermore Site Environmental Impact Report (EIR) (DOE and University of California, 1992), three small wetlands exist at the culverts that channel runoff into Arroyo Las Positas at the northern perimeter of the site. A review of the LLNL site for rare and endangered species was performed as part of the site EIR, and none have been found. No contemplated action will have an impact beyond those discussed in Section 5 of the FS. LLNL does not believe that significant cultural resources will be impacted, because (1) there is no source of water on the site to sustain early cultures, and (2) virtually the entire site has been subject to intense development over the last 50 years. No excavation is contemplated that would disturb sites to depths greater than they may have already been disturbed.

California's Alquist-Priolo Special Studies Zones Act of 1972 (California Public Resource Code, Section 2621, et seq.) provides constraints on the building of residences within 50 feet of an active fault. RCRA 40 CFR Section 264.18(a) prohibits new treatment, storage, or disposal facilities within 200 feet of a Holocene fault. There are no active faults within 200 feet of LLNL, and construction of residences is not permitted onsite; therefore, these two requirements are not ARARs. All treatment facilities will comply with local construction codes as applied by LLNL's Plant Engineering Department.

Action-specific ARARs are usually technology- or activity-based limitations on actions taken with respect to hazardous wastes. These requirements are triggered by the particular remedial activities that are selected to accomplish a remedy. Since there are usually several alternative actions for any remedial site, different requirements can be triggered. Action-specific ARARs may indicate or influence how a selective alternative is implemented.

The ARARs for the LLNL Livermore site are summarized in Table B-1.

# ***LAWRENCE LIVERMORE NATL LAB, MAIN SITE (USDOE)***

## **Site Information:**

**Site Name:** LAWRENCE LIVERMORE NATL LAB, MAIN SITE (USDOE)  
**Address:** LIVERMORE, CA  
**EPA ID:** CA2890012584  
**EPA Region:** 09

## **Record of Decision (ROD) - Explanation of Significant Differences (ESD):**

**ROD Date:** 08/23/1993  
**Operable Unit:** 01  
**ROD ID:** EPA/ESD/R09-93/127  
**Text:** Full-text ROD document follows on next page.

**PB95-963121**  
**EPA/ESD/R09-93/127**  
**March 1995**

**EPA Superfund**  
**Explanation of Significant Difference**  
**for the Record of Decision**

**Lawrence Livermore National**  
**Laboratory, Livermore, CA**  
**8/23/1993**



**Explanation  
of Significant Difference  
for the  
Change to Granular Activated Carbon  
for Treatment of Vapor at Treatment Facility F,  
Lawrence Livermore National Laboratory,  
Livermore Site**

**June 15, 1993**

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## 1. Introduction

On August 5, 1992, the Record of Decision (ROD) was signed, documenting the final cleanup plan for the Lawrence Livermore National Laboratory (LLNL) Livermore Site in Livermore, California. As required under Section 117(c) of the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), as amended by the Superfund Amendment and Reauthorization Act of 1986 (SARA), and pursuant to 40 C.F.R. Section. 300.435(c)(2)(i) [Fed. Reg. Vol. 55, No. 46 (March 8, 1990)], this Explanation of Significant Difference (ESD) describes a change from the catalytic oxidation technology described in the ROD (DOE, 1992), to granular activated carbon (GAC) for treatment of fuel hydrocarbon (FHC) and volatile organic compound (VOC) vapors at Treatment Facility F (TFF). An ESD is required when significant, but not fundamental, changes are made to the final remedial action plan described in the ROD. This ESD describes information developed during the remedial design process that supports the subject change.

The lead agency for this ESD is the U.S. Environmental Protection Agency (EPA). This ESD includes a brief background of the LLNL Livermore Site, a summary of the remedy selected in the ROD, a description of how the noted change affects the remedy described in the ROD, and an explanation of why EPA and the U.S. Department of Energy (DOE)/LLNL are making this change to the selected remedy presented in the ROD. This document is designed to (1) provide the public with an explanation of the change made to the remedy as described in the ROD, (2) summarize the information that led to the change, and (3) affirm that the revised remedy complies with the statutory requirements of CERCLA Section 121. This ESD was prepared according to the following EPA Guidance Documents: *Guide to Addressing Pre-ROD and Post-ROD Changes* (EPA, 1991) and *Interim Final Guidance on Preparing Superfund Decision Documents* (EPA, 1989).

This ESD and supporting documentation will be placed in the LLNL repositories for interested members of the public to review. One repository is located at the Livermore Public Library, 1000 South Livermore Avenue. Library hours are Monday through Thursday, 10:00 a.m. to 9:00 p.m.; Friday and Saturday, 10:00 a.m. to 5:00 p.m.; and Sunday 1:00 p.m. to 5:00 p.m. The second repository is at the LLNL Visitors Center on Greenville Road. Visitors Center hours are Monday through Friday, 9:00 a.m. to 4:30 p.m.; and Saturday and Sunday 12:00 p.m. to 5:00 p.m. The Visitors Center also contains the Administrative Record, which is comprised of all the documents that form the basis for LLNL's cleanup plan.

DOE/LLNL provided a comment period for the EPA, the California Regional Water Quality Control Board (RWQCB), and the Department of Toxic Substances Control (DTSC) of the California Environmental Protection Agency to comment on this ESD. All comments and responses are presented in this ESD and will be included in the LLNL Administrative Record file. Pursuant to 40 C.F.R. Section 300.435(c)(2)(i), a public comment period is not required for an ESD, and all regulatory agencies overseeing the LLNL Livermore Site agreed that a public comment period was not necessary for this ESD.

## 2. Site Background

This section provides a brief description and history of the LLNL Livermore Site, chemicals of concern in the subsurface, and a summary of the remedy selected in the ROD. Further details can be found in the ROD and in the Administrative Record.

### 2.1. Site Description and History

LLNL is an 800-acre, multidisciplinary research facility owned by the DOE and operated and managed by the Regents of the University of California under contract with DOE. LLNL is located at 7000 East Avenue in southeastern Alameda County, approximately 3 miles east of the downtown area of Livermore, California (Fig. 1). The site is underlain by several hundred feet of complexly interbedded alluvial and lacustrine (lake) sediments. Depth to ground water at the site varies from about 120 ft in the southeast corner to about 25 ft in the northwest corner.

The LLNL site was converted from agricultural and cattle ranch land by the U.S. Navy in 1942. The Navy used the site until 1946 as a flight training base and for aircraft assembly, repair, and overhaul. Solvents, paints, and degreasers were routinely used during this period. Between 1946 and 1950, the Navy housed the Reserve Training Command at the site. In 1950, the Navy allowed occupation of the site by the Atomic Energy Commission (AEC), which formally received transfer of the property in 1951. Under the AEC, the site became a weapons design and basic physics research laboratory. In 1952, the site was established as a separate part of the University of California Radiation Laboratory. Responsibility for the site was transferred from AEC to the Energy, Research, and Development Administration in 1975. In 1977, responsibility for LLNL was transferred to the DOE, which is currently responsible for the site. In addition to weapons research, LLNL programs have been established in biomedicine, energy, lasers, magnetic fusion energy, and environmental sciences. Details of the site history and the use, storage and disposal of hazardous materials are presented in the Remedial Investigation (RI) (Thorpe *et al.*, 1990).

Initial releases of hazardous materials occurred at the LLNL site in the mid- to late 1940s when the site was the Livermore Naval Air Station (Thorpe *et al.*, 1990). There is also evidence that localized spills, leaking tanks and impoundments, and landfills contributed volatile organic compounds (VOCs), FHCs, possibly lead, chromium, and tritium to ground water and unsaturated sediment in the post-Navy era.

In 1987, the LLNL Livermore Site was added to the National Priorities List. In November 1988, DOE, EPA, DTSC, and RWQCB signed a Federal Facility Agreement, which named DOE as the overall lead agency and the U.S. EPA as the lead regulatory agency for cleanup.

### 2.2. Site Characteristics

A screening of all environmental media conducted for the RI (Thorpe *et al.*, 1990) showed that ground water and unsaturated sediment are the only media that require remediation. The identified compounds that exist in ground water at various locations beneath the site in concentrations above drinking water standards are:



- The VOCs trichloroethylene (TCE), perchloroethylene (PCE), 1,1-dichloroethylene (1,1-DCE), 1,2-dichloroethylene (1,2-DCE), 1,1-dichloroethane (1,1-DCA), 1,2-dichloroethane (1,2-DCA), carbon tetrachloride, and chloroform.
- FHCs (leaded gasoline), including benzene, ethylbenzene, toluene, and ethylene dibromide.
- Chromium and possibly lead.
- Tritium.

The VOCs in ground water beneath LLNL, predominantly TCE and PCE, occur in relatively low concentrations that underlie about 85% of the LLNL site and a smaller area offsite, under a total area of about 1.4 square miles. Higher VOC concentrations are localized. Total VOC concentrations exceed 1 part per million (ppm) in ground water from only 10 out of a total of more than 300 wells. The calculated total volume of undiluted VOCs in ground water is less than 200 gal. VOCs are seldom found below a depth of about 200 ft.

FHCs occur almost exclusively where a leak of roughly 17,000 gal of leaded gasoline occurred from a U.S. Navy-era underground fuel tank in the southern part of the site. Total FHC concentrations in ground water range from 0.001 to 16 ppm, and are limited to an area within about 500 ft from the leak point.

Metals above Maximum Contaminant Levels (MCLs) are present in ground water in only a few locations. Chromium in ground water exceeds the MCL (Table 1) in 16 wells scattered in the northwest, central, and southwest parts of the study area and near Arroyo Seco, with a maximum concentration of 160 parts per billion (ppb) in the northwest corner. Lead has exceeded the 15-ppb remediation standard (Table 1) in only two wells in the Gasoline Spill Area in southern LLNL, at a maximum concentration of 38 ppb.

Tritium in ground water exceeds its MCL of 20,000 picocuries per liter (pCi/L) in only one well (MW-206). This occurrence of tritium is localized and well defined. Recent investigations have identified five additional areas where tritium concentrations in unsaturated sediments at LLNL are significantly elevated. However, the tritium activity in ground water in these areas is well below the MCL.

### **2.3. Remedies Selected in the ROD**

The selected remedies for ground water and the unsaturated zone as described in the ROD are summarized below.

#### **2.3.1. Ground Water**

The selected ground water remedy involves initial pumping of water from a minimum of 24 locations within the ground water plume (Fig. 2). The total rate of ground water removed under this extraction plan is estimated to be about 350 gpm. Water will be pumped from one or more wells at each of the locations using existing monitor and extraction wells, along with new extraction wells. The initial well locations will be located near plume margins to prevent any VOCs from escaping from the area in concentrations above their MCLs (Table 1). To enable more

**Table 1. Remediation standards and State discharge limits for compounds of concern in ground water at the LLNL site (from the Record of Decision).**

Constituent	Concentration limit for drinking water <sup>a</sup>			Discharge limit <sup>b</sup> for treated water (ppb)
	Federal MCL (ppb)	California MCL (ppb)	Pre-remediation concentration range at LLNL, March 1990– March 1991 (ppb)	
PCE	5	5	<0.1-1,050	4
TCE	5	5	<0.1-4,800	5
1,1-DCE	7	6	<0.5-370	5
cis-1,2-DCE	70	6	<0.5-24	5 (total 1,2-DCE)
trans-1,2-DCE	100	10	<0.5-1	5
1,1-DCA	—	5	<0.5-60	5
1,2-DCA	5	0.5	<0.1-190	5
Carbon tetrachloride	5	0.5	<0.1-91	5
Total THM <sup>c</sup>	100 <sup>c</sup>	100 <sup>c</sup>	<0.5-270	5
Benzene	5	1.0	<0.1-4,600	0.7
Ethyl benzene	700	680	<0.2-610	5
Toluene	1,000	—	<0.5-4,200	5
Xylenes (total)	10,000	1,750 <sup>d</sup>	<0.5-3,700	5
Ethylene dibromide	0.05	0.02	<0.1-51	0.02
Total VOCs	—	—	up to 5,808	5
Chromium <sup>+3</sup>	50 (total Cr) <sup>e</sup>	50 (total Cr)	<5-150 (total Cr)	50 (total Cr)
Chromium <sup>+6</sup>	50 (total Cr) <sup>e</sup>	50 (total Cr)	<10-140	11
Lead	15 <sup>f</sup>	50	<2-10	5.6
Tritium <sup>g</sup>	20,000 pCi/L	20,000 pCi/L	<200-33,100	(h)

<sup>a</sup> Human receptor. The more stringent concentration limits on this part of the table are shown in a larger typeface to illustrate that LLNL will comply with the most stringent requirements.

<sup>b</sup> From National Pollutant Discharge Elimination System (NPDES) Permit No. CA0029289 (revised 8/1/90) and RWQCB Order No. 91-091. Of the LLNL compounds of concern, VOC specific State discharge limits exist in RWQCB Order No. 91-091 only for PCE (4 ppb), benzene (0.7 ppb), and ethylene dibromide (0.02 ppb). Other VOCs listed in this table are included in the 5 ppb total VOC limit. Discharge limits for metals differ slightly according to discharge location.

<sup>c</sup> Total trihalomethanes (THMs); includes chloroform, bromoform, chlorodibromomethane, and bromodichloromethane (California Drinking Water Requirement).

<sup>d</sup> MCL is for either a single isomer or the sum of the ortho, meta, and para isomers.

<sup>e</sup> National Interim Primary Drinking Water Regulation for total chromium is presently 50 ppb, but will increase to 100 ppb in July 1992. No MCLs exist for Cr<sup>+3</sup> or Cr<sup>+6</sup>.

<sup>f</sup> National Primary Drinking Water Regulation Enforceable Action Level (Federal Register, volume 56, number 110, June 7, 1991, p. 26460).

<sup>g</sup> The RI shows that ground water in the one well that currently exceeds the tritium MCL will be naturally remediated long before it migrates offsite.

<sup>h</sup> There is currently no NPDES discharge limit for tritium. LLNL will use the MCL for tritium as the discharge limit.



rapid remediation, wells will also be placed in all areas where VOC or FHC concentrations in ground water exceed 100 ppb. Additional extraction locations may be added to ensure complete hydraulic capture of the plume, and/or to expedite cleanup, if field data and/or modeling indicate additional wells are necessary.

Seven onsite facilities (A to G) are planned to treat the extracted ground water (Fig. 2). Each treatment facility will be designed to treat a somewhat different combination of compounds. Treatment Facilities A, B, E, and F will use UV/oxidation as the primary treatment technology. Treatment Facilities C, D, and G will use air-stripping as the primary treatment technology. All facilities will use GAC to remove VOCs and FHCs from air streams, and, if necessary, TFF will use GAC to remove lead from ground water. Treatment Facility D and possibly Treatment Facility C will use ion exchange to remove chromium from ground water.

The selected alternative addresses all ground water containing VOCs in excess of MCLs and will assure that Applicable or Relevant and Appropriate Requirements for individual VOCs, FHCs, lead, chromium, and tritium will be achieved.

### 2.3.2. *Unsaturated Zone*

The selected remedy described in the ROD for the unsaturated zone is vacuum-induced venting to extract contaminant vapors from the unsaturated sediments and treating the vapors by catalytic oxidation. In this process, vapors from vent wells are heated and passed through a catalyst, where organic compounds are converted to harmless oxidation products, including carbon dioxide and water. As described in the ROD, if use of catalytic oxidation would result in emission of vapors with compounds above regulatory standards, secondary treatment or alternative technologies, such as GAC, would be evaluated and implemented to comply with regulatory standards.

## 3. Description of Significant Change to the Selected Remedy

This ESD changes one portion of the ROD. To the extent that this ESD differs from the ROD, it supersedes the ROD.

The treatment technology for treating VOC and FHC vapor at TFF was changed from catalytic oxidation to GAC, as described below. Table 2 presents the chronology of events regarding the change from catalytic oxidation to GAC from the time the ROD was signed to the present. Included in Table 2 are teleconferences, report submittals, and agreements reached with the regulatory agencies.

Characterization of the Gasoline Spill Area in the southern part of the LLNL site has been underway since 1983, and vadose zone pilot remediation by vacuum extraction has been underway since 1988. For the pilot remediation, extracted FHC vapors from the subsurface were oxidized with a permitted propane-fired burner or thermal oxidizer. VOCs (low concentrations of TCE and 1,2-DCA) are also present in the ground water containing FHCs.

At the time the RI (Thorpe *et al.*, 1990) and Feasibility Study (Isherwood *et al.*, 1990) were being prepared, long-term plans called for the construction of TFF in the Gasoline Spill Area to treat free-phase gasoline; FHCs and VOCs in ground water; and FHCs in the vadose zone. However, LLNL Environmental Restoration staff had concerns that thermal treatment of

**Table 2. Chronology of events regarding change to granular activated carbon (GAC) from catalytic oxidation for Treatment Facility F.**

Date	Event
August 5, 1992	Record of Decision (ROD) is signed incorporating catalytic oxidation as the method to treat VOC and FHC vapors from unsaturated sediments.
October 22, 1992	LLNL Engineering Group determines that there are insufficient resources to perform the EPA-required catalytic oxidation treatability studies prior to beginning the Dynamic Stripping Demonstration Project (Aines <i>et al.</i> , 1992). In addition, with the availability of onsite steam GAC regeneration, use of GAC is determined to be more cost-effective than catalytic oxidation.
October 23, 1992	Teleconference between Bella Dixon of Doe and Michael Gill of EPA. The potential for a ROD amendment to implement the change is discussed.
October 27, 1992	Preliminary Draft Final Remedial Action Implementation Plan (RAIP) sent to DOE for review with change to GAC included.
November 3, 1992	Change to GAC is discussed with EPA and DTSC during regulatory teleconference.
November 6, 1992	Draft Final RAIP is sent to regulators including the change to GAC.
December 2, 1992	It is agreed at a meeting with DOE, LLNL, EPA, DTSC, and the RWQCB that a ROD amendment is not necessary and that an Explanation of Significant Difference (ESD) is the most appropriate way to implement the change to GAC.
December 10, 1992	Comments on Draft Final RAIP received from regulators. Mention of ESD in the RAIP is recommended.
December 14, 1992	RAIP and ESD discussed during teleconference with regulatory agencies.
January 6, 1993	RAIP is issued, including mention of an ESD to explain change from catalytic oxidation to GAC.
January 21, 1993	It was agreed that the Draft ESD would be due on February 23 to the regulatory agencies during a regulatory teleconference.

halogenated VOCs with FHCs could produce dioxins in the effluent of the thermal oxidizer. This concern was voiced during the conceptual design phase of TFF, circa 1991.

Thermal oxidation of aromatic compounds, such as benzene, in the presence of chlorinated VOCs, such as TCE, can produce tetrachlorodibenzo-para-dioxin (TCDD). However, it has been demonstrated that a recently developed catalyst efficiently destroys FHCs and halogenated VOCs including dichlorobenzene (a surrogate for dioxin) (Lester, 1989). The oxidation of the halogenated compounds also produces minor amounts of hydrogen chloride (HCl) and hydrogen bromide (HBr), which can be removed by a caustic scrubber. The lower temperature of a catalytic oxidizer (700EF versus 1,800EF for the thermal oxidizer) makes caustic scrubbing much easier. In addition, one-third of the supplemental fuel is required for a catalytic oxidizer compared to the thermal oxidizer. As described in the Proposed Remedial Action Plan (Dresen *et al.*, 1991) use of a catalytic oxidizer would provide the flexibility to treat both FHCs and VOCs together, and would substantially reduce the potential for producing dioxin compared to thermal oxidation.

The GAC vapor treatment option, however, has no risk of producing TCDD. GAC is an effective treatment alternative for FHC vapor and is considered Best Available Control Technology (BACT) by the Bay Area Air Quality Management District (BAAQMD). At TFF, vapors are induced into the treatment system from the subsurface by a liquid ring vacuum pump capable of 400 cubic feet per minute. The liquid ring pump exhausts to a demister, which collects water. The vapor stream is passed through one of two 750-lb GAC canisters where FHCs, such as benzene, are sorbed. The treated vapors pass a continuous-reading FHC sensor prior to discharge to the atmosphere. Valves direct the vapor flow to the second GAC canister while the first is being regenerated after a prescribed time that is based on GAC loading rate, or when breakthrough is detected by a sensor linked to a control system. The first canister is flushed with steam to heat the carbon, and to desorb and remove the FHCs. The steam and FHCs are removed from the canister and condensed with a plate-type heat exchanger, which is cooled by clean process water. The condensed steam (water) and FHCs are collected in a separation tank. Level switches within the separation tank activate pumps for discharge to separate collection tanks for light (lighter than water, such as benzene) and heavy (heavier than water, such as TCE) compounds. Details of the remedial design will be addressed in a later design document that will be subject to regulatory review.

The cost of using GAC for vapor treatment at TFF is estimated to be about half of the original catalytic oxidation cost estimate. Table 3 presents the original catalytic oxidation cost estimate, a revised estimate for catalytic oxidation after receiving comments from EPA, and the estimated cost for vapor treatment by GAC with onsite regeneration. The increase in engineering cost of catalytic oxidation is due to the additional engineering requirements for treatability and start-up tests required by the EPA. Overall, the costs for catalytic oxidation increased by approximately 45% due to this treatability testing and reporting. There are no treatability studies required for the GAC treatment option. Therefore, the cost of GAC is far less than catalytic oxidation, and the use of GAC enables TFF to start operation ahead of the scheduled March 1993 date in the Remedial Action Implementation Plan (Dresen *et al.*, 1993).

All appropriate and relevant regulatory requirements, including air emission limits and monitoring requirements, disposal of secondary wastes, and any other substantive requirements that apply to the treatment will be followed during operation of the treatment facility. The

BAAQMD discharge limits for TFF are 6 ppm<sub>v/v</sub> for the vapor treatment system and 10 ppm<sub>v/v</sub> for the ground water treatment system.

In summary, the change from catalytic oxidation to GAC for treatment of vapor at TFF eliminates the possibility of dioxin production, is more cost-effective with current onsite GAC regeneration equipment, and enables earlier operation of TFF.

**Table 3. Comparison of estimated costs for catalytic oxidation and granular activated carbon (GAC).**

Component	Original catalytic oxidation unit with scrubber	Original catalytic oxidation unit and EPA requirements	GAC w/onsite regeneration
Purchase	\$250,000	\$250,000	\$140,000
Engineering	25,000	70,000	25,000
Treatability <sup>a</sup>	0	80,000	0
Activation	60,000	60,000	40,000
Start up testing <sup>b</sup>	20,000	80,000	20,000
Utility connections	80,000	80,000	0
Reporting	10,000	20,000	10,000
Air permitting	20,000	20,000	10,000
Dioxin analysis (treatability and start-up)	5,000	20,000	0
FHC and VOC analyses	2,000	4,000	2,000
<b>Totals</b>	<b>\$472,000</b>	<b>\$684,000</b>	<b>\$247,000</b>
<b>Percent change over original catalytic oxidation estimate</b>		<b>45</b>	<b>-48</b>

<sup>a</sup>Includes treatability work plan, quality assurance plan, and detailed performance testing at manufacturer's facility (varying operating parameters such as residence time and reactor temperature).

<sup>b</sup>Includes detailed performance testing of installed unit.

## 4. Regulatory Agency Comments and Responses

### 4.1 Responses to Department of Toxic Substances Control Comments

Comment 1: *Both the thermal oxidation and catalytic oxidation systems can treat both VOCs and FHCs. The ESD does not indicate that the GAC system can treat FHC. How can the GAC system be justified if it cannot treat the compounds which will be in the vapor waste stream?*

The GAC vapor treatment system is an effective treatment alternative for FHCs and is in fact considered BACT by the BAAQMD for this purpose. Changes have been made in paragraph 6 in Section 3 of the Draft Final ESD to make it clear that GAC successfully treats FHCs.

Comment 2: Page 9, Third Paragraph, Fifth Sentence: *What is the purpose of the VOC sensor? What type of sensor is used? How often is it monitored? How will FHCs be monitored?*

The FHC (rather than VOC) sensor ensures that hydrocarbon concentrations in the treated vapor effluent are below the BAAQMD discharge limits. The BAAQMD discharge limits for TFF are 6 ppm<sub>v/v</sub> for the vapor treatment system and 10 ppm<sub>v/v</sub> for the ground water treatment system. The sensor is a Sierra Monitor Model No. 4100-31, solid state FHC sensor calibrated with representative vapor samples for weathered gasoline. It is continuously monitored by the control system. The BAAQMD will provide feedback on the appropriateness of this sensor. VOCs are not monitored because VOC concentrations in extracted vapor are extremely low compared to FHCs, and FHCs would break through the GAC long before VOCs. Paragraph 6 in Section 3 of the Draft Final ESD has been modified to indicate that an FHC rather than VOC sensor is used.

Comment 3: Page 9, Third Paragraph, Sixth Sentence: *How is it possible for a distribution control system to detect chemical breakthrough in the GAC cansiters?*

The control system operates electronically and continuously monitors the voltage signals from the above-mentioned FHC sensor and various other monitoring devices. The voltage signals are processed by a preprogrammed logic circuit capable of triggering certain controls, such as pneumatically operated diverter valves that direct the vapor flow into either of the GAC vessels.

The text in Paragraph 6 in Section 3 has been modified to indicate that “breakthrough is detected by a sensor linked to a control system.”

Comment 4: Page 9, Third Paragraph, Sixth Sentence: *Is the first canister flushed with stream (sic) as the vapor stream from the subsurface is being passed through it? How is the second canister treated to desorb and remove the VOCs?*

The TFF GAC vapor treatment system consists of two vessels, each containing 750 lb of GAC, which are alternated between vapor treatment and steam regeneration. While one vessel is treating the extracted vapor stream, the other is being regenerated with steam. The text in Paragraph 6 of Section 3 has been modified to make it clear that flow is directed to the second GAC canister while the first is being regenerated.

Comment 5: Page 9, Third Paragraph, Last Sentence: *How are the FHCs which may have been collected in the separation tank removed from the waste stream.*

The regeneration waste stream is first condensed into liquid in a plate heat exchanger, and then routed through a product separator that removes both free-phase FHCs (lighter than water) and VOCs (heavier than water). The product separator is a relatively stagnant tank that allows gravitational separation of hydrophobic compounds, which are removed from above and below the aqueous portion of the fluid. The water effluent from the separator, which contains dissolved concentrations of FHCs and VOCs, is routed into the ground water treatment system influent.

Free-phase VOCs and FHCs are collected in 55-gal drums and disposed by the LLNL Hazardous Waste Management Division according to regulatory standards.

## 4.2 Responses to Regional Water Quality Control Board Comments

Comment 1: *The change from catalytic oxidation to granular activated carbon (GAC) units to treat the vapors from Treatment Facility F is acceptable to the agency.*

Comment noted.

Comment 2: *The description of the GAC vapor treatment system on page 9 does not specify that the unit will also treat the fuel hydrocarbon vapors from Treatment Facility F. Please address this issue.*

See response to DTSC Comment No. 1.

Comment 3: *The brief description of the design and operation of the GAC units does not contain enough detail for the agency to comment on or approve the design as outlined in this document. Our agency has several comments and questions regarding the determination of breakthrough and the disposal of the discharge products from the flushing of the GAC units. However, is it appropriate to address specific design issues of the GAC units within the Explanation of Significant Difference (ESD) document? If design specifications are required in the ESD, then a more complete description of the operation of the GAC units should be included. If not, then a brief description of the GAC's ability to sorb contaminants and the proposal to regenerate the carbon onsite should be sufficient to approve the general technology. The specifics of the design and operation should be proposed to the regulatory agencies in the Remedial Design document.*

As discussed with Elizabeth Adams of the RWQCB, the following sentence has been added to the end of Paragraph 6 in Section 3: "Details of the remedial design will be addressed in a later design document that will be subject to regulatory review."

Comment 4: *This document should state that all appropriate and relevant regulatory requirements, such as air emission limits and monitoring requirements, disposal of secondary wastes generated by the alternate technology and any other substantive requirements that apply to the treatment chain will be followed during operation of the treatment facility.*

Similar language to that suggested in this comment has been added to the end of Section 3 of the Draft Final ESD.

## 4.3 Responses to U.S. Environmental Protection Agency Comments

Comment 1. The ESD needs to be signed by representatives of the U.S. EPA and the U.S. Department of Energy.

Signature blocks for representatives of these agencies have been added to Section 5 of the Draft Final ESD.

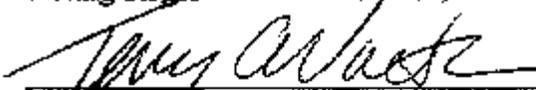
## 5. Statutory Determinations

Considering the new information that has been developed and the change that has been made to the selected remedy, EPA and DOE/LLNL believe that the remedy remains protective of human

health and the environment, complies with Federal and State requirements that were identified in the ROD as applicable or relevant and appropriate to this remedial action, and is cost-effective. In addition, the revised remedy uses permanent solutions and alternative treatment technologies to the maximum extent practical for this site. The change contained herein is significant, but does not fundamentally change the remedy.

  
\_\_\_\_\_  
John Wise  
Acting Regional Administrator, EPA Region IX

8.23.93  
Date

  
\_\_\_\_\_  
Terry A. Vaeth  
Acting Manager, DOE San Francisco  
Operations Office

8/5/93  
Date

## 6. Public Participation Activities

DOE has presented this change to the remedy in the form of an ESD because the change is of a significant, but not fundamental, nature. DOE provided the EPA and State regulatory agencies with a comment period on this ESD. In accordance with Section 117(c) of CERCLA, 42 U.S.C. Section 9617(c), DOE will publish a notice in the local newspaper, which describes this ESD and its availability for review at the LLNL repositories. This ESD and all documents that support the change herein are contained in the Administrative Record for the LLNL site.

## 7. References

- Aines, R., R. Newmark, W. McConachie, K. Udell, D. Rice, A. Ramirez, W. Siegel, M. Buettner, W. Daily, P. Krauter, E. Folsom, A. Boegel, and D. Bishop (1992), *Dynamic Underground Stripping Demonstration Project, Interim Progress Report 1991*, Lawrence Livermore National Laboratory, Livermore, Calif (UCRL-ID-109906).
- Dresen, M.D., J.P. Ziagos, A.J. Boegel, and E.M. Nichols (Eds.) (1993), *Remedial Action Implementation Plan for the LLNL Livermore Site*, Lawrence Livermore National Laboratory, Livermore, Calif. (UCRL-AR- 110532).
- Dresen, M.D., W.F. Isherwood, and J.P. Ziagos (1991), *Proposed Remedial Action Plan for the LLNL Livermore Site*, Lawrence Livermore National Laboratory, Livermore, Calif. (UCRL-AR-105577).
- Isherwood, W.F., C.H. Hall, and M.D. Dresen (Eds.) (1990) *CERCLA Feasibility Study for the LLNL Livermore Site*, Lawrence Livermore National Laboratory, Livermore, Calif. (UCRL-AR-104040).
- Lester, George R. (1989) *Allied Signal Catalytic Destruction of Hazardous Halogenated Organic Compounds*, Air and Waste Management Association, 82nd Annual Meeting and Exposition, June 25-30, 1989, Anaheim, Calif.
- Thorpe, R.K., W.F. Isherwood, M.D. Dresen, and C.P. Webster-Scholten (Eds.) (1990), *CERCLA Remedial Investigations Report for the LLNL Livermore Site*, Lawrence Livermore National Laboratory, Livermore, Calif. (UCAR-10299).
- U.S. Environmental Protection Agency (EPA) (1991), *Guide to Addressing Pre-ROD and Post-ROD Changes*, Office of Solid Waste and Emergency Response, Publication 9355.3-02, April 1991.
- U.S. Environmental Protection Agency (EPA) (1989), *Interim Final Guidance on Preparing Superfund Decision Documents*, Office of Solid Waste and Emergency Response, Directive 9335.3-02.
- U.S. Department of Energy (DOE) (1992), *Record of Decision for the Lawrence Livermore National Laboratory, Livermore Site*, Lawrence Livermore National Laboratory, Livermore, Calif. (UCRL-AR-109105).

# ***LAWRENCE LIVERMORE NATL LAB, MAIN SITE (USDOE)***

## **Site Information:**

**Site Name:** LAWRENCE LIVERMORE NATL LAB, MAIN SITE (USDOE)  
**Address:** LIVERMORE, CA  
**EPA ID:** CA2890012584  
**EPA Region:** 09

## **Record of Decision (ROD) - Explanation of Significant Differences (ESD):**

**ROD Date:** 04/15/1997  
**Operable Unit:** 01  
**ROD ID:** EPA/541/R-97/038  
**Text:** Full-text ROD document follows on next page.

Explanation of Significant Differences  
for Metals Discharge Limits at the  
Lawrence Livermore National Laboratory  
Livermore Site

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April 1997

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UCRL-AR-125927

Explanation of Significant Differences  
for Metals Discharge Limits, LLNL Liv. Site

April 1997

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## 1. Introduction

On August 5, 1992, the Record of Decision (ROD) (Department of Energy [DOE], 1992) was signed, documenting the final cleanup plan for the Lawrence Livermore National Laboratory (LLNL) Livermore Site in Livermore, California. As required under Section 117(c) of the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), as amended by the Superfund Amendment and Reauthorization Act of 1986 (SARA), and pursuant to 40 Code of Federal Regulations (CFR) Section 300.435 (c)(2)(i) (Fed. Reg. Vol. 55, No. 46 [March 8, 1990]), this Explanation of Significant Differences (ESD) describes a change from the National Pollutant Discharge Elimination System (NPDES) Permit No. CA0029289 (Regional Board Waste Discharge Requirements Order No. 91-091) described in the ROD. This ESD describes changes to metals discharge limits approved by the San Francisco Bay Regional Water Quality Control Board (RWQCB) in a letter dated August 15, 1996. With the exception of Treatment Facility A, which will continue to comply with RWQCB Waste Discharge Requirements Order No. 88-075, all ground water treatment facilities, portable treatment units (PTUs), and the Drainage Retention Basin will conform to these new standards when discharging ground water to ditches that lead to the arroyos.

An ESD is required when significant, but not fundamental, changes are made to the final remedial action plan described in the ROD. This ESD was prepared according to EPA guidance (EPA, 1991; 1992).

The lead regulatory agency for this ESD is the U.S. Environmental Protection Agency (EPA). In addition to the EPA, the RWQCB and the California Department of Toxic Substances Control (DTSC) oversee the LLNL Livermore Site cleanup and have commented on this ESD. All regulatory agency comments and DOE/LLNL responses are presented in Section 3.

Pursuant to 40 CFR Section 300.435(c)(2)(i), a public comment period is not required for an ESD, and all regulatory agencies overseeing the Livermore Site cleanup agreed that a public comment period was not necessary for this ESD. A notice will be published in local newspapers (The Independent, Tri-Valley Herald, and Valley Times) that briefly summarizes this ESD.

This ESD will be placed in the LLNL repositories for interested members of the public to review. One repository is located at the Livermore Public Library, 1000 South Livermore Avenue. Library hours are Monday through Thursday, 10:00 a.m. to 9:00 p.m.; Friday, 10:00 a.m. to 6:00 p.m., Saturday, 10:00 a.m. to 5:00 p.m.; and Sunday 1:00 to 5:00 p.m. The second repository is at the LLNL Visitors Center on Greenville Road. Visitor Center hours are Monday through Friday, 1:00 p.m. to 4:00 p.m. The Visitors Center also contains the Administrative Record, which contain all documents that form the basis for the Livermore Site cleanup plan.

The site description and history are described in the Livermore Site Remedial Investigation Report (Thorpe et al., 1990), the Feasibility Study (Isherwood et al., 1990), the ROD (DOE, 1992), and the Remedial Action Implementation Plan (Dresen et al., 1993).

## 2. Description of the Significant Differences and the Basis for the Differences

In March 1996, DOE/LLNL sent a letter to the RWQCB indicating that they did not plan to renew NPDES permit No. CA0029289 when it expired on June 18, 1996. In this letter DOE/LLNL proposed new discharge effluent limits for metals to meet the substantive requirements of the NPDES permit. The proposed discharge limits were discussed with the RWQCB and an agreement was reached to ensure that the new discharge limits are protective of beneficial uses during the wet and dry seasons. It was recognized that during the dry season, the discharge infiltrates near the discharge point and poses minimal threat to aquatic life. However, because the discharged water can infiltrate and recharge a potential drinking water aquifer, Maximum Contaminant Level (MCLs) were chosen as the dry season discharge limits. During the wet season, the effluent flows downstream and may impact aquatic life. Thus, discharge limits set forth in the RWQCB Order No. 94-087 for NPDES permits for treated ground water are chosen for the wet season. As referenced in the LLNL Annual Environmental Reports, the dry season is April 1 through November 30, and the wet season is December 1 through March 31.

Table 1 presents the significant differences between the original and revised metals discharge limits.

## 3. Support Agency Comments

The following responses address EPA comments dated February 20, 1997, DTSC comments dated February 25, 1997, and RWQCB comments dated February 28, 1997 on the Draft ESD, as presented in separate letters to DOE.

### 3.1. EPA Comments and DOE/LLNL Responses

Comment No. 1: Page 1, para 1. The text states: "This ESD describes changes to new metals discharge limits..." The word "new" seems duplicative in this context. We suggest it be removed, since it seems that the word "changes" sufficiently describes the issue.

The word "new" has been deleted.

Comment No. 2: Page 1, paragraph 1, last sentence. "...discharging ground water to ground." Please clarify this sentence. Does "ground" refer to the arroyo or percolation into soil?

The word "ground" refers to all ditches that lead to either Arroyo Los Positas or Arroyo Seco. This word has been replaced with: "...to ditches that lead to the arroyos."

Comment No 3: Table 1. Please clarify what "Not Applicable" means. Does it mean that the discharge limit is zero? Are there no limits for these constituents listed in Order No. 94-087?

In the Dry Season column of Table 1, the "not applicable" footnote denotes that no MCL is established for the individual metal. The "not applicable" footnote in the Wet Season

column denotes that no limit has been established for aquatic life protection. Although DOE/LLNL have no discharge standard for some metals in the Wet or Dry Seasons, quarterly bioassay analyses will indicate harmful metal concentrations. The footnote for the Wet Season (footnote "a") now reads: "No limit is established for aquatic life protection; however, aquatic life is protected by quarterly bioassay analyses." The footnote for the Dry Season has been changed to footnote "b", which now reads: "No MCL is established for the metal."

### 3.2. DTSC Comments and DOE/LLNL Responses

Comment No. 1: Section 2 and Table 1 of the ESD seem to imply that MCL standards apply to ground water, but do not apply to surface water. Table 1 is to [sic] modified such that the discharge standards for hexavalent chromium, nickel and zinc are to be the same for the wet and the dry season.

The discharge standards are protective of beneficial uses. As directed by the RWQCB, MCLs constitute the discharge standard during the dry season because the water recharges to the ground water. Aquatic life protection is the basis for the wet season because the water discharges to the bay. These discharge standards are consistent with the RWQCB NPDES General Waste Discharge Requirements for all San Francisco Bay Region sites remediating ground water containing VOCs.

Comment No. 2: The wet season discharge limit for mercury is to [sic] changed to an enforceable, measurable unit (i.e.  $\mu\text{g/l}$ ). Besides being unenforceable, the use of the 1 gram/day requirement would allow LLNL/DOE to discharge mercury in levels which are neither protective of the human health nor protective of aquatic life. (For example, in January 1996, TFD discharged 160,000 gallons of water. Given the 1 gram/day discharge standard, this water could have been discharged at 51  $\mu\text{g/l}$  mercury).

DOE/LLNL and the RWQCB agree to change the mercury discharge limit to the 2 micrograms per liter MCL, which is more conservative than the 1 gram per day limit in Order No. 94-087.

### 3.3. RWQCB Comments and DOE/LLNL Responses

Comment No. 1: The Explanation of Significant Differences (ESD) should contain the complete listing of all analysis similar to the NPDES permit. Please include the following items in the ESD: the complete listing of the original and revised analysis and sampling points; the original and revised sampling; schedule and the original and revised discharge limits; and finally, include the verification sampling procedure in the event of violations of the discharge limits.

The original and revised analysis, sampling points, and original and revised sampling schedule were not a component of the ROD, and thus do not constitute a significant difference. The following presents where this information has been documented. The complete listing of the original and revised analysis, and the original and revised sampling schedule, are documented in your letter to DOE dated August 15, 1996 (Bessette Rochette, 1996). Sampling points are presented in each self-monitoring report since February 1995, with the exception of the fourth quarter 1996 self-monitoring report because we agreed to only present the sampling point in the 1996 annual report and all future annual reports.

The original and revised metals discharge limits are presented in Table 1 of the ESD. My

verification sampling procedure in the event of discharge limit violations is included in Table 1 of the ESD.

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#### 4. Affirmation of the Statutory Determinations

Considering the new information and the changes that will be made to the proposed remedy, the EPA and DOE believe that the remedy remains protective of human health and the environment, complies with Federal and State requirements identified in the ROD as applicable or relevant and appropriate to this remedial action, and is cost effective. In addition, the revised remedy utilizes permanent solutions and alternative treatment technologies to the maximum extent practical for this site.

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for Metals Discharge Limits, LLNL Liv. Site

#### References

- Bessette Rochette, M. (1996), Letter from the Michael Bessette Rochette, RWQCB Project Manager, to Paul Ko, DOE Project Manager, stating approval of changes to metal discharge limits and sampling frequencies, dated August 15, 1996.
- Dresen, M. D., J. P. Ziagos, A. J. Boegel, and E. M. Nichols (Eds.) (1993), Remedial Action Implementation Plan for the LLNL Livermore Site, Lawrence Livermore National Laboratory, Livermore, Calif. (UCRL-AR-110532)(Page 43 revised September 2, 1993; Table 5 revised July 2, 1996).
- Isherwood, W. R., C. H. Hall and M. D. Dresen (Eds.) (1990), CERCLA Feasibility Study for the LLNL Livermore Site, Lawrence Livermore National Laboratory, Livermore, Calif. (UCRL-AR-104040).
- Thorpe, R. K., W. F. Isherwood, M. D., Dresen, and C. P. Webster-Scholten (Eds.) (1990), CERCLA Remedial Investigation Report for the LLNL Livermore Site, Lawrence Livermore National Laboratory, Livermore, Calif. (UCAR-10299 vols 1-5).
- U.S. Department of Energy (DOE) (1992), Record of Decision for the Lawrence Livermore National Laboratory Livermore Site, Lawrence Livermore National Laboratory, Livermore, Calif. (UCRL-AR-109105).
- U.S. Environmental Protection Agency (EPA) (1991), Guide to Addressing Pre-ROD and Post-ROD Changes, Office of Solid Waste and Emergency Response, Publication 9355.3-02, April 1991.
- U.S. Environmental Protection Agency (EPA) (1992), Preliminary Draft Guidance on Preparing Superfund Decision Documents. Office of Solid Waste and Emergency Response, Directive

9355.3-02, January 1992.

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Table 1. Differences between original and revised metal discharge limits.

	Original	Discharge limit ( $\mu\text{g/L}$ )	
		Revised: Dry season (MCLs) (April 1-November 30)	Revised: Wet season (Order No. 94-087) (December 1-March 31)
Antimony	1,460	6	NA a
Arsenic	20	50	10
Beryllium	0.7	4	NA a
Boron	7,000	NA b	NA a
Cadmium	5	5	2.2
Chromium (hexavalent)	11	NA b	22
Chromium (total)	50	50	NA a
Copper	20	1,300	23.6
Iron	3,000	NA b	NA a
Lead	5.6	15	6.4
Manganese	500	NA b	NA a
Mercury	1	2	2 c
Nickel	7.1	100	320
Selenium	100	50	10
Silver	2.3	100	8.2
Thallium	130	2	NA a
Zinc	58	NA b	220

Notes:

LLNL will notify the Regional Board within 24 hours from initial analytical results indicating that

concentrations exceed the discharge limits. If effluent discharge limits are exceeded, a second effluent

sample and receiving water sample will be collected. If the second sample meets effluent limits, a third

sample will be collected to verify that the second sample is valid. If the second effluent

sample  
exceeds  
the discharge limits, the treatment system will be shut down to determine the cause of the violation.

µg/L = Micrograms per liter.

MCLs = Maximum Contaminant Levels.  
NA = Not applicable.

a No limit is established for aquatic life protection; however, aquatic life is protected by quarterly bioassay analyses.

b No MCL is established for this metal.

c The mercury MCL of 2 µg/L is more conservative than the 1 gram per day limit in Order No. 94-087.

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