Community Guide

to the

Lawrence Livermore National Laboratory

Main Site

Superfund Cleanup

and related topics

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I. Introduction

Lawrence Livermore National Lab (LLNL) was founded in 1952 by Edward Teller and E.O. Lawrence to develop the hydrogen bomb, thus becoming the United States' second nuclear weapons design lab after Los Alamos National Laboratory in New Mexico. Prior to this, the land was used by the Navy as an aircraft maintenance facility.

The main site stretches over one square mile; located on the eastern edge of the City of Livermore. Homes, apartments, little league fields and more are built up to the fence line. There are approximately 50,000 people living within 2 miles of the main site, and 7 million within a 50-mile radius. The site is 3 miles east of downtown Livermore and 40 miles east of San Francisco. The Lab's environmental documents consider the communities within a 50 mile radius of LLNL as the affected study area for environmental impacts.

Decades of nuclear weapons work have heavily contaminated the air, soil and groundwater on and around the site. Since the 1960's, LLNL has released approximately one million curies of radiation into the environment. Rainfall at the Lab has been found to contain tritium concentrations seven times higher than the state and federal maximum standard for drinking water. A 1995 California Department of Health Services investigation found Livermore children and young adults have six times the incidence of malignant melanoma and elevated levels of brain cancers. In 1987, the Lab was placed on the Environmental Protection Agency's (EPA), "Superfund" list, a list of the most contaminated sites in the nation. As of 2011, the date of the last estimate from LLNL, cleanup will not be completed until the year 2080 at a remaining cost of one billion dollars.[1]

Livermore Lab is actually composed of two geographically disparate locations. The "main site" is the primary laboratory complex in the City of Livermore. The second location, known as "Site 300", is Livermore Lab's high explosives testing range in the nearby city of Tracy. Both sites have soil and groundwater are heavily contaminated with toxic and radioactive materials. This community guide provides an overview of the history and current issues affecting the Livermore Lab main site only. For issues relating to the Site 300 area see the Tri-Valley Communities Against a Radioactive Environment (Tri-Valley CAREs) companion community guide.

The purpose of this report is to familiarize the community and interested members of the public with the current status of the Superfund cleanup and the Lab's ongoing activities that have the potential to cause significant contamination and hazardous health conditions.

This Guide is based upon an extensive review of documents obtained from the U.S. EPA, the U.S. Department of Energy (DOE), the State of California Department of Toxic Substances Control (DTSC), and the Livermore Laboratory

[1] Communication with Phil Wong, Remedial Site Manager at Livermore Lab, October 21, 2011.

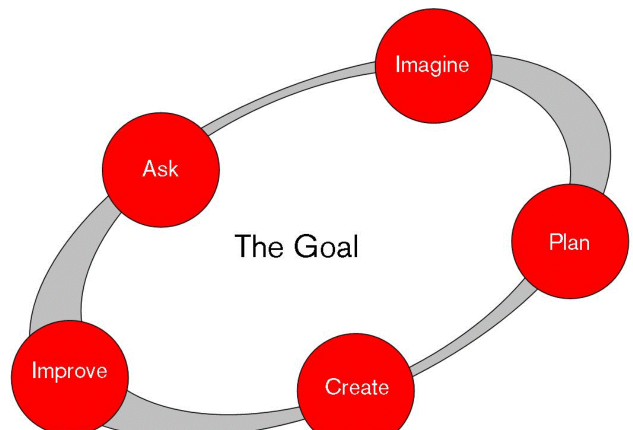
Environmental Restoration Division, as well as information gathered during Tri-Valley CAREs meetings with regulatory agencies and the Lab's Community Work Group established to oversee the Superfund cleanup.

Tri-Valley CAREs is a community group based in Livermore, California. We have been actively involved in monitoring the activities of LLNL for over thirty years. Founded in 1983, the group comprises more than 5,000 active members from across the community, including retired Lab employees, artists, teachers, biologists, lawyers and engineers. In 1989, as a result of Tri-Valley CAREs effective oversight of the Superfund cleanup, Tri-Valley CARES became the first community group in EPA Region 9 to win a Technical Assistance Grant (TAG), which provided financial resources to continue and expand its Superfund community involvement efforts. To this day, Tri-Valley CAREs continues its active oversight of the Superfund cleanup. As will be described in this guide, Tri-Valley CAREs participation has resulted in more stringent cleanup standards, significantly enhanced community access to information and analysis, enhanced opportunities for effective public participation and markedly improved cleanup designs and outcomes.

Funding for Tri-Valley CAREs work on this guide and in the cleanup process has been generously provided by the San Francisco Foundation and the Citizen's Monitoring and Technical Assistance Project.

II. Description of the Superfund Process

The Comprehensive Environmental Response, Compensation, and Liability Act, or CERCLA, was enacted in 1980 and is commonly referred to as the Superfund. Actions taken under CERCLA (Superfund) deal with sites where there have been past releases of hazardous substances. Other laws such as the Resource Conservation and Recovery Act, or RCRA, regulate the day-to-day management, transportation and disposal of hazardous wastes. At some Superfund sites, usually active sites with ongoing operations, these laws and regulations overlap. It is then up to the regulatory agencies to determine which set of regulations is most appropriate to use.



Superfund was amended in 1986 by the Superfund Amendments and Reauthorization Act (SARA). Among other things, SARA introduced Section 117(e) "Grants for Technical Assistance," which is a source of funding for much of the research that is relied upon in this report.

The National Oil and Hazardous Substance Contingency Plan, usually shortened to the National Contingency Plan (NCP), provides the regulatory and procedural framework for implementing the cleanup responsibilities established under CERCLA. The Superfund process involves the following steps:

Step 1: National Priorities List (NPL)

After initial site discovery, a site is inspected and rated in terms of potential endangerment to public health. If a site scores high enough, it is placed on the NPL and becomes a Superfund site.

Step 2: Remedial Investigation and Feasibility Study (RI/FS)

After a site is placed on the NPL, the Remedial Investigation and Feasibility Study (RI/FS) are each prepared. This stage is known as the RI/FS process.

a) Remedial Investigation

The RI includes a detailed characterization of the site and a human health risk assessment. The site characterization identifies chemicals of concern, describes the geology and hydrology of the site, describes the ecosystem at the site (including sensitive animal and plant species), and describes how chemicals of concern are situated. This risk assessment addresses how humans or ecological receptors can possibly be exposed to the identified chemicals, and estimates the health and ecological risks.

The risk assessment defines the level of risk that may be posed to residents and/or workers in the contaminated area, based on sometimes very complicated risk assessment techniques. Human health risks must be below a certain level for the EPA to accept the remediation strategy. Acceptable risk for potential cancer causing agents lies within the range of 1 x 10-4 (one person per 10,000 population) to 1 x 10-6 (one person per 1,000,000 population) incremental lifetime cancer risk (ILCR). Risk below 1 x 10-6 is considered de minimus (negligible), and thus is considered acceptable. In the United States, a cancer incidence of 3,000 persons per a 10,000 population is expected (or 300,000 per 1,000,000), without exposure to additional contamination. At an ILCR level of 1x10-4, 3,001 people in a population of 10,000 would develop cancer; at a level of 1 x 10-6, 300,001 per 1,000,000 people would develop cancer. For noncancer health risks, acceptable levels of risk are based on a hazard index (HI). Any HI of 1.0 or above presents an unacceptable health risk.

b) Ecological Assessment

Concurrent with the development of the RI, an ecological assessment is prepared. Rather than focusing on public health, the ecological assessment focuses on how chemicals at the site will affect sensitive “ecological receptors” (i.e., plants and animals potentially present at the site that could be exposed to chemical contaminants). The ecological assessment surveys the site for receptors that are classified as threatened, endangered, rare, or have some special status, or specific sensitivity to contaminants present at the site. It also evaluates whether there any observable effects as a result of the contamination and evaluates cleanup options for the site. The methods for performing ecological risk assessments are in their early stages of development. Often, we don't know what species are present, and we rely on information about what levels of contaminants pose a potential threat based on old data or data extrapolated from information about other similar species.

c) Feasibility Study

The FS evaluates cleanup options. The FS usually includes an estimate of costs, an analysis of various technologies, and an estimate of cleanup time. Cleanup standards are also set forth. For any given site, these standards, in general, are called ARARs (Applicable or Relevant and Appropriate Requirements). ARARs encompass all federal, state and local laws, regulations, and regulatory guidance that must be adhered to during cleanup. Often, the FS is the first report that specifically identifies the clean-up plan for the site. The FS does evaluate ecological effects of various remedies. There are usually several drafts that are available for regulatory and public comment.

Step 3: Proposed Plan

After completion of the RI/FS, a proposed plan is presented (sometimes it is referred to as the Remedial Action Plan). This is a relatively short document summarizing the clean-up choice and includes a justification for that choice.
This document may modify the cleanup options designated in the FS. The proposed plan is subject to public comment and a public hearing.

In simple terms, the HI is the relationship between an expected daily intake of a substance and the daily reference dose for a substance. The reference dose is a threshold level of substance intake below which a human population, including sensitive populations such as children, may be chronically exposed without significant adverse health effects. To measure the HI for combined effects of substances, one adds the HI for each substance, with some adjustments.

Step 4: Public Comment and Public Hearing

A public comment period and public hearing follow the release of the proposed plan to the public. The comment period lasts a minimum of 30 days and can be extended by a minimum of 30 days with a timely request. If, based on the public's comments, the proposed plan is significantly altered, additional public comment may be sought on a revised proposed plan. The final remedy selection is made by the lead agency (i.e., the agency or agencies that have ultimate responsibility to ensure that the cleanup process meets all standards and is carried out) and is presented in the Record of Decision (ROD). At federal facility Superfund sites, the remedy selection is a joint decision between the facility manager and the EPA, or, in the case of disagreement, by the EPA only.

Step 5: Record of Decision

The ROD presents the selected remedial action and presents a response to public comments. It specifies clean-up requirements, dates for complying with certain additional actions, and any special conditions. EPA and other agencies with jurisdiction (such as the California State EPA and the DTSC) must be approved in the ROD. No further public hearings are required under CERCLA after the ROD is signed, unless specified in previous agreements, or if there are substantial changes made to the ROD during the clean-up process. The ROD is a legally binding document.

Step 6: Remedial Design

The Remedial Design (RD) specifies the precise design of the technologies that are going to be used and provides precise details where extraction wells, recharge wells and monitoring wells will be located. Once the RD is complete, construction and remedial action begin. At this stage in the process, contingency plans are often developed and discussed in this report. However, there has been discussion among policy makers that contingency plans should be made earlier in the process, and included in the ROD.

Step 7: Source Control Measures and Removal Actions

The NCP allows the lead agency to undertake certain source control measures or removal actions before the formal cleanup process begins to mitigate risks to public health or the environment. Typical removal actions are tank removals or excavation of highly contaminated soil. (In some cases, removal actions may also take place under RCRA under a corrective action plan.) Although allowance of too many actions tends to fragment the cleanup process, if done efficiently and to high standards, further contamination may be substantially reduced. When removal actions are time critical (i.e., contamination presents an immediate risk to human health), they are obviously most important. As discussed in the section on the RI/FS, SARA requires that ARARs be used to set cleanup standards. These ARARs are either based on federal environmental laws or more stringent state laws or accepted guidelines. The Safe Drinking Water Act (SDWA) Maximum Contaminant Levels (MCLs) and Clean Water Act Water Quality Criteria are applied when appropriate.

California State law sometimes requires stricter standards. In most cases, if there is a potable drinking water supply that is potentially affected, the ARARs for groundwater are at least as stringent as the federal MCLs, and California has a non-degradation policy for potential drinking water sources.

There are no federal cleanup levels that are established for soil contamination. Contaminated soil can be ingested, inhaled, may contaminate the groundwater, or all three. Therefore, standards must be set on a site-by-site basis. There is also no standard methodology for determining whether soil contamination will affect the groundwater to the extent that it will exceed the MCLs. At some sites, the potential migration of contaminants from the soil to the groundwater and to air has been modeled to determine whether soils needed remediation. Recently, at many sites contaminated with chlorinated solvents and petroleum hydrocarbons, investigations have also found that vapor from soil or groundwater is diffusing up through soil into basements and homes.

The remediation strategy must satisfy a number of criteria to be accepted by EPA. Among these criteria is Community Acceptance. For community organizations such as Tri-Valley CAREs, this is perhaps its most powerful tool for effecting changes to the cleanup strategy. We recommend that criteria be developed for the Main Site, given the fact that some are already imbedded in the cleanup strategy (e.g., capture the leading edge of the plume), and the fact that remedial action has been occurring for over 10 years. However, community acceptance is not defined in the regulations.

Below is a summary of preliminary community acceptance criteria.

* Complete the cleanup project in a timely manner.
* Cleanup levels should support many uses of the property that are unrestricted by environmental contamination.
* Cleanup levels should be set to the strictest state and federal government levels.
* Remedies that actively destroy contaminants are preferable.
* Radioactive substances should be isolated from the environment.
* Ecosystem protection should be balanced against the cleanup remedies.
* Decisions should not rely on modeling alone.
* Additional site characterization is needed and must be budgeted for over many years.
* DOE should establish a mechanism so that the public is involved in cleanup decisions until the site is cleaned up.
* Cleanup should be given priority over further weapons development.
* Any ongoing activities at LLNL should be designed to prevent releases to the environment.

III. History of Contamination and Remedial Activities at Livermore Lab

LLNL's nuclear weapons design work includes experiments with extremely hazardous and radioactive substances including weapons grade plutonium (Pu), enriched uranium (U235), tritium (tritium is the radioactive hydrogen used in the hydrogen bomb.); as well as hazardous wastes. Plutonium has also been detected in surrounding areas, most notably in Big Trees Park, a children's park near the Lab. Some of the plutonium has made its way to the City of Livermore's water reclamation plant, where the dried sludge was given to residents as a soil amendment decades ago and is currently dispersed in unknown yards and outdoor spaces throughout the community. Tritium gas has also been released in substantial quantities over the years through normal operations and accidental releases. Tritium releases are especially a concern because of Livermore's large agricultural sector; where it can enter the food supply.

Along with the use of radioactive substances, LLNL has used many chemicals that were inadvertently or carelessly released to the environment. These include fuel hydrocarbons (mostly gasoline), metals, PCBs and volatile organic compounds (VOCs); most often trichloroethene (TCE). TCE is an industrial solvent that is known to cause cancer in humans and other noncancer health effects such as impacts to the liver and kidneys, and negative neurological, immunological, reproductive, and developmental impacts.[2]

In operating the facility over the past fifty years, LLNL has had many accidental releases of these substances, as well as extensive groundwater pollution that threatened the City of Livermore's water supply. Releases by the LLNL began in the 1950's: previous releases of solvents and fuel at the site were done by the Navy. LLNL's groundwater plume contains Freon 113, TCE, trichloroethane (TCA), dichloroethane (DCE), and dichloroacetic acid (DCA). Also found in groundwater were benzene, toluene, carbon tetrachloride, chromium and tritium in excess of drinking water standards established under the SDWA. These and other pollutants also exist in the soils at numerous locations on site. Groundwater plumes contaminated with VOCs stretch beneath 85% of the site and beyond to offsite locations.

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[2] EPA Integrated Risk Information System summary on Trichloroethylene: Accessed on 8/3/12 at: www.epa.gov/IRIS/subst/0199.htm

Before cleanup began, EPA's risk assessment estimated that if the groundwater were not cleaned up and reached Livermore's municipal wells, the cancer risk to Livermore from the VOCs alone would have been one cancer for every 1,000 residents. The risk to someone drilling a well near the LLNL boundary would have been two times higher; two cancers per 1,000 residents.

As a result, in 1987 the EPA named the main site to the Superfund list. DOE has entered into agreements with the EPA and state regulators to clean up the groundwater so that it meets drinking water standards and no longer poses the risks described above. This is a long process that is underway with many opportunities for community involvement.

Much of the contamination at the main site results from poor waste management practices. For example, at the old Taxi Strip area on the eastern side of the site, wastes were dumped into earthen pits. After 1962 the pits were replaced with solar evaporation trays where the radioactive and chemical liquid wastes were allowed to evaporate, and the remaining salts were rolled up in a plastic liner and then placed in 55-gallon drums. Some contaminants were released to the air and ground from evaporation, wind and spillage. In 1982 and 1983, four former pits in this area were excavated and backfilled. In 1984, the East Taxi Strip Circle Landfill was discovered and shortly after excavated and backfilled. This landfill was located near the east boundary of the main site.

The radionuclide-contaminated waste was packaged into drums and transferred to the Waste Management Facility onsite. The state began investigations for suspected groundwater contamination at LLNL in 1984. At that time, perchloroethylene (PCE) was discovered to the west, in a well offsite. A ROD was signed in 1992, and full cleanup began in 1995. Over the years much has been done to capture the office plume and reduce it to the MCL. However, the cleanup process still has a long way to go as is discussed in the next chapter. Cleanup is currently estimated to be completed in the year 2080.

IV. Current Areas of Contamination

The full extent of contamination at LLNL remains uncharacterized and unknown. LLNL is actively engaged in ongoing scientific research, much of which is focused on modernizing the nuclear weapons complex. Nuclear weapons design work continues to result in new emissions of radioactive and toxic contamination into the environment. A full accounting of the contamination will most likely not be possible until nuclear weapons work ceases at the site. This section outlines a few of the most pressing cleanup scenarios that LLNL is grappling with at the time of the publishing of this guide. Likely this will change and shift as time passes but it is a good primer on areas where the public could get involved in the oversight of current cleanup efforts.

A. Offsite Plume

Among the remaining contaminated areas being addressed under Superfund is a significant toxic groundwater plume that has migrated from the Livermore Lab main site into the community aquifer. The off-site contaminant plume has seeped from the Lab in a generally westward flow, and the plume is presently under homes, apartments, the arroyo, a city park and a community swimming pool near Charlotte Way and surrounding neighborhoods.

The major toxic contaminant at the plume's leading edge is a solvent PCE. According to Scorecard.org, PCE is ranked as within the top 10% of the most hazardous compounds to ecosystems and human health.[3] Other portions of the off-site plume contain additional pollutants, including Trichloroethylene, another solvent routinely used for decades in the nuclear weapons programs at Livermore Lab. These solvents affect the central nervous system, liver, kidney and the immune system, and are cancer-causing, among other negative health outcomes. The Lab's contaminated groundwater prompted the State of California to issue a "Determination of Imminent or Substantial Endangerment" in 1984, compelling Livermore Lab to close wells at neighbors' homes along its western perimeter and provide the residents with bottled water. The Lab subsequently acquired some of those properties.

Despite Livermore Lab's efforts to clean up the groundwater contamination by way of a series of groundwater treatment facilities on-site along its western perimeter and a system of off-site extraction wells and underground pipelines, the Lab's off-site pumps and pipeline were insufficient to reach and clean up the leading edge of the contaminated groundwater plume. The Lab has just enough infrastructure out there to keep those pollutants in a "holding pattern" in the area around Big Trees Park and the community swimming pool, but not enough to actually clean it up.

To "solve" this problem,in 2007, Livermore Lab quietly instituted a "pilot project" to pump the PCE-contaminated groundwater and dump it, untreated, into a city sewer line that runs along Charlotte Ave. Tri-Valley CAREs lodged strong objections to the plan pointing out that the sewer system is not a hazardous waste treatment facility and the toxic solvent was neither being isolated nor cleaned up. Rather pumping and dumping untreated water into the sewer system ultimately resulted in a release to the San Francisco Bay. After Tri-Valley CAREs met with the regulatory agencies and voiced these objections, the EPA agreed that dumping the waste into a sewer line was not a "treatment technology," and the Lab withdrew its plan to pump and dump a total of 80 million gallons of PCE-contaminated water. After going back to the drawing board, Livermore Lab decided to build an additional pipeline out to the leading edge of the plume and pump the contaminated water back to an on-site treatment facility for cleaning.

Unfortunately, efforts to clean up contamination often results in new contamination. The construction of the pipeline poses health risks of its own. The construction trenches travel through the area next to Big Trees Park where known plutonium contamination exists in the soil. Construction activities that generate dust have the potential to release radioactively contaminated dust into the air in a populated neighborhood. Tri-Valley CAREs and over 150 residents sought air monitoring for radioactive particles near active construction areas. Despite the Labs ultimate refusal to monitor radioactive air emissions, Tri-Valley CAREs monitored the construction site daily and reported to the Lab, regulators and community whenever dust abatement was inadequate or high levels of radiation were detected. The challenges of the pipeline construction illustrate the ongoing difficulty of safely managing construction sites in known contaminated environment, particularly when surrounded by residential communities.

B. Tritium Contamination

The characterization and cleanup of Tritium or radioactive hydrogen is a major ongoing challenge at the Lab. Because tritium is a gas, it is not captured by HEPA filters, it is only partially captured by other mechanisms, and it diffuses through almost anything. When released into the environment, tritium combines to make water, significantly increasing its biological toxicity. Tritiated water has been shown to induce significant decreases in relative weights of brain, testes, and ovaries, when exposure began at the time of the mother's conception. Lower exposures have been implicated in the induction of behavioral damage. Research conducted at LLNL on the biological effects of tritium revealed that there was

[3] http://scorecard.goodguide.com/chemical-profiles/summary.tcl?edf_substance_id=127-18-4 The Scorecard database was created by the Environmental Defense Fund in 1998.

no level studied below which biological damage could not be found. Operating histories show that it invariably escapes when used under high pressures. The amount of tritium released into the environment from LLNL has always been proportional to the level of tritium activity at the site. Cumulatively, LLNL has released between 750,000 and 1,000,000 curies of tritium into the surrounding environment since 1960. In addition to airborne releases, tritium winds up in waste at LLNL and in releases to sewage, soil, surface and (eventually) ground water. One of the largest and most costly problems regarding the Superfund cleanup at the Main Site is dealing with tritium.

There are several hot spots that are source areas for tritium contamination at LLNL that are undergoing characterization and cleanup. **The first tritium hot spot is Trailer 5475** located in the lower southeast quadrant of LLNL contaminated by aircraft engine maintenance activities and LLNL's old leaky tritiated-water evaporation ponds. This resulted in ground water containing VOCs and tritium above its MCL. To clean up this contamination, Granular Activated Carbon (GAC) was used to remove VOCs from contaminated ground water and soil vapor. The GAC used at Trailer 5475 became contaminated with tritium and VOCs. The GAC system designers at LLNL believed that tritium would preferentially stay in the vapor stream in the vapor extraction system rather than absorb to the carbon and then be re-injected into the subsurface. Operational experience showed the GAC canisters retained tritium. Therefore, mixed VOC/radioactive waste was created, requiring expensive disposal methods. In fact, Lab staff estimated in 2006 that it would cost approximately *$16,000 per 55-gallon drum* to send the mixed waste GAC to an appropriately permitted facility. (Footnote: Resolution of Mixed Waste Management Issues Associated with Operation of Soil Vapor and Ground Water Treatment Facilities at LLNL, Livermore Site, April 2009). Due to the expense of this process, the Lab is exploring other options for treating this mixed radioactive waste and public input is needed!

The **second tritium hot spot is Building 292**, the former Rotating Neutron Target Source Area located in the Northwest quadrant of LLNL. The groundwater under Building 292 was contaminated by tritium from a leaking 1000 gallon underground tank sometime between 1986 and 1989. Additionally, on December 23, 1990, a cold water pipe froze and broke in Building 292 releasing 4000 gal of tritiated water to floor drains connected to the tank. A portion of the water was recovered; an unknown quantity of tritiated water leaked into soils near the tank. (Footnote: Globalsecurity.org http://www.globalsecurity.org/wmd/library/report/enviro/eis-0157/eis0157_417.html) Pine trees in this area absorbed tritiated water and emitted tritium into the air where Lab employees ate lunch. From 1997 through 2004, needles from one particular pine tree with the highest concentrations were collected first monthly and then quarterly; the highest concentration (8800 pCi L-1 [326 Bq L-1]) was observed in September 1997. (Footnote: Historical Doses From Tritate Water and Tritiated Hydrogen Gas Releases to the Atmosphere from LLNL Part 2. LLNL Annual Site-specific Data 1953 — 2003, S. Ring Peterson, May 2005.) The trees ultimately were disposed of. Ongoing community involvement in formulating cleanup strategies and overseeing cleanup activities is needed in this area.

The **third tritium hot spot is Building 419** (or thereabouts). Lab reports refer to this area as "the Building 419/511 area" since no one really knows where the tritium plume source is due to "complex subsurface conditions where uncertainty remains in the hydrogeologic conditions and the nature and extent of contamination." (Footnote: Draft Focused Feasibility Study of Methods to Minimize Mixed Hazardous and Low Level Radioactive Waste from Soil Vapor and Ground Water Treatment Facilities, September 2010.) The 419 building was constructed in the late 1940s by the U.S. Navy for various purposes related to airplane maintenance. Between 1975 and 1989, LLNL used the building for equipment decontamination and hazardous and mixed waste treatment activities. The 419 Facility includes the building itself, two 500-gallon underground storage tanks and associated piping. The 419 building has been demolished but the slab demolition and soil excavation have not been completed. The Lab still must model how the contamination at the site is impacting the groundwater beneath. (Footnote: LLNL Site Remedial Project Managers' Meeting Summary – April 24, 2012) Tritium and gross alpha radioactivity have been detected in soil samples below the structure. Lead and mercury were also detected. (Footnote: Final Closure Plan for Building 419 Volume 1: Final Closure Plan March 2009.)

Proposed cleanup of this area's mixed radioactive and hazardous waste contamination raise similar questions as the cleanup of the Trailer 5475 area. If mixed waste is generated during the cleanup process, it will be expensive and complicated to dispose of. This is another area where community involvement can make a difference in determining the appropriate cleanup method and overseeing the cleanup process.

C. Building 212

The Building 212 area is located in the south-central part of the Livermore Site along the southern boundary. It is contaminated with mercury, low concentrations of plutonium and other radionuclides. The building was originally constructed as a drill hall for Naval Air Station Livermore in 1943 before Livermore Lab was created. Building 212 was later modified for physics experiments using laser accelerators.

During decontamination and demolition of the superstructure in April 2008, free-phase mercury and radioactive contamination were discovered. Elemental (metallic) mercury and all of its compounds are toxic; exposure to excessive levels can permanently damage or fatally injure the brain and kidneys. Elemental mercury can also be absorbed through the skin and cause allergic reactions. The initial cleanup action, which consisted of removing soil along the northeast side of the building slab, identified further uncharacterized contamination in the soil.[4] The Lab estimates the area contaminated with mercury covers 850 square feet to a depth of up to two feet. According to the DOE's *Building 212 Soil Removal Status Report, February 2009*, the extent of the radioactive contamination is low and falls below the regulatory limit for the required cleanup of an industrial site. Therefore, no cleanup of the radioactive material is likely without community input.

V. How the Public Can Influence the Cleanup

Achieving a full and comprehensive cleanup of the environmental impacts of nuclear weapons development was one of Tri-Valley CAREs' founding objectives in 1983, and it remains a top priority today. Tri-Valley CAREs won the first TAG grant in the western United States from EPA in 1989. With that grant, we have contracted with an environmental scientist, Peter Strauss, and have offered testimony and technical comments on every aspect of the Superfund cleanup. Peter Strauss continues to serve as Tri-Valley CAREs primary technical consultant on the Superfund cleanup efforts.

Also, since 1989, Tri-Valley CAREs has participated in the Livermore Lab Main Site Community Work Group to advise the Lab and the regulatory agencies on the Superfund cleanup. Tri-Valley CAREs was the first non-governmental organization to win a national recognition award from EPA for the effectiveness of its work in 2000.

Further, Tri-Valley CAREs maintains an ongoing commitment to involve the directly affected community in Superfund decision-making. To accomplish this, Tri-Valley CAREs hosts community meetings devoted to cleanup issues and produces articles in our newsletter and stand-alone reader-friendly materials to help encourage and empower public participation. Tri-Valley CAREs maintains an archive of cleanup documents and has a reading room in downtown Livermore where the public can drop in and find out more about ongoing cleanup efforts at LLNL.

Whenever major decisions are made on critical cleanup activities, Tri-Valley CAREs makes a public relations push to inform the media, the public and Tri-Valley CAREs membership about the cleanup options and opportunities for public comment. Interested members of the public are given public speaker training and are invited to workshops on how to write letters to the editor and opinion pieces. Members of the public interested in getting more involved should sign up for Tri-Valley CAREs quarterly newsletter online or by mail to find out all upcoming opportunities for public involvement.

[4] LLNL Ground Water Project, 2009 Annual Report http://www-erd.llnl.gov/library/UCRL-AR-126020-09.pdf

<u>SIMPLE TIPS FOR EFFECTIVELY COMMENTING AT A PUBLIC HEARING:</u>

1) INTRODUCE YOURSELF AND EXPLAIN WHY THE TOPIC MATTERS TO YOU,

2) STATE THE PROBLEM i.e. THIS ACTIVITY WILL GENERATE DUST THAT MAY BE CONTAMINATED WITH RADIOACTIVE PARTICLES,

3) IF POSSIBLE, RESEARCH/PROVIDE EVIDENCE TO SUPPORT YOUR COMMENT i.e. RADIOACTIVE SOIL WAS FOUND IN THIS AREA IN STUDY X, AND

4) STATE YOUR SOLUTION i.e. RADIOACTIVE AIR MONITORING IS NEEDED DURING THE CLEANUP AT THIS SITE AND ENHANCED DUST SUPPRESSION IS NEEDED.

VI. Other Environmental Issues

A number of programs at LLNL threaten to introduce additional contamination onto the Lab site itself and into the San Francisco Bay Area more broadly. This section provides a short description of a few of these programs that the community should be aware of.

A. Plutonium and Security

Maintaining the security of nuclear weapons materials at Livermore Lab has long been a challenge for Congress, oversight agencies and the DOE. This is primarily because the proximity of dense residential neighborhoods immediately adjacent to the Lab makes the on-site storage of weapons-usable quantities of nuclear weapons materials too difficult and expensive to protect. This is why in the Fiscal Year 2013 budget request to Congress, Energy Secretary Steven Chu announced a major reduction in Livermore's security budget due to the deinventory of weapons usuable quantities of nuclear materials at LLNL. This was a huge long-fought victory for Tri-Valley CAREs. We have long advocated to deinventory the weapons usable quantities of plutonium at Livermore Lab to protect the surrounding metropolitan area and to constrain LLNL's operation as a full-service nuclear weapons development site.

Unfortunately, immediately following Secretary Chu's announcement that weapons-usable quantities of nuclear materials would be moved offsite, the DOE announced new plans in 2012 to transport whole fission bomb cores on U.S. highways to LLNL about six times per year. These plutonium cores, often called "pits," would travel from the Los Alamos Lab in New Mexico to LLNL.

This raises legal and security dilemmas that the community must be aware of. After October 1, 2012, LLNL operates with a significantly smaller security force based on a security designation called "category III," which means the site will no longer have authorization to handle bomb-usable quantities of fissile material. By definition, whole bomb cores are bomb-usable amounts of plutonium. Some officials have proposed obtaining a "variance" from nuclear safety and security regulations every time that plutonium pits arrive at Livermore Lab - about six times each year. DOE's plan does not openly discuss what it will mean for plutonium safety to enact regular "variances." Moreover, it is not clear that DOE has the legal authority to do so in the absence of any analysis done pursuant to the National Environmental Policy Act.

Tri-Valley CAREs opposes the plan to bring plutonium bomb cores to LLNL and argues that Congress and decision-makers should engage in a fundamental re-thinking of the perceived "need" to increase bomb production in the US. Community members must remain vigilant against ongoing efforts to bring additional weapons nuclear materials to LLNL.

B. Biowarfare Agent Research at Livermore Lab

DOE operates a bio-warfare agent research facility (called a Biosafety Level-3, or BSL-3) in a 1,500 square foot portable building near the center of LLNL. A designation of BSL-3 is used for "facilities in which work is done with indigenous or exotic agents which may cause serious or potentially lethal disease as a result of exposure by inhalation.

The LLNL BSL-3 may handle up to 100 liters of concentrated, dangerous biological weapon agents such as live anthrax, Q fever and bubonic plague at any one time. In total the BSL-3 may handle up to 25,000 discrete samples of potentially-fatal pathogens. DOE's documents report that researchers in the BSL-3 may genetically modify bio-warfare agents in the facility, possibly creating novel diseases. The facility is equipped to perform tests on small-animal using bioagents and biotoxins in which up to 100 rodents (mice, rats, and guinea pigs) at a time would be exposed to aerosolized pathogenic material.

The DOE's analysis of the potential health and environmental consequences of a terrorist attack on the facility discloses that a suicidal plane crash could breach the facility's containment. In the event of a rupture of the bio-facility, whether by terrorist attack, a disgruntled employee or severe earthquake, the entire Bay Area would be at risk. During the summer months, the winds move across Livermore and the metropolitan East Bay to San Francisco. Under those conditions, a moderate containment breach and release involving live anthrax could cause more than 7,000 deaths. In the winter months, the prevailing winds are toward I-580 and Tracy, putting the Central Valley at risk.

The operation of this facility has already resulted in serious safety violations. In September 2005, an LLNL shipping accident resulted in the exposure of several individuals to anthrax. The anthrax release occurred during a three-stage shipment of approximately 6,400 anthrax samples from LLNL to laboratories in Florida and Virginia. LLNL later acknowledged that an unauthorized individual gained access to LLNL's biological research facilities and improperly packaged the anthrax shipping containers. When the containers were opened offsite, the anthrax had been released in the packaging, resulting in multiple exposures to the individuals who opened the packages. After reviewing the incident, the Centers for Disease Control found twenty-nine regulatory violations, including numerous safety and security deficiencies. LLNL was subsequently fined $450,000 for these incidents.

Tri-Valley CAREs opposes the continued operation of a BSL-3 facility at LLNL for a number of reasons. Most importantly, numerous studies show that the BSL-3 poses a variety of safety and security risks to the local community and the entire Bay Area. Moreover, Tri-Valley CAREs argues that advanced biowarfare agent research should not be performed inside secret nuclear weapons labs because it raises questions as to whether the research is offensive or defensive in nature. Offensive biological weapons research is banned by the Biological Weapons Convention. It is important that community members be aware of the existence of the BSL-3 and consider the risks of living in its proximity.

C. National Ignition Facility

The National Ignition Facility (NIF) is a facility that was built in the 1990's in order to produce, for the first time in a laboratory setting, conditions of matter close to those that exist in detonating nuclear weapons. This would give the government the opportunity to test nuclear weapons in a controlled laboratory setting. NIF's initial cost estimate, according to the 1994-1999 LLNL Institutional Plan, was $677 million. In 1999, a General Accounting Office (GAO) investigation estimated NIF's construction and related research and development costs at $4 Billion. NIF has not achieved its goal and its costs rise annually, possibly to an amount double the 1999 GAO estimate. Instead the facility is plagued with technical roadblocks and is many billion dollars over budget. It is an environmental hazard and an economic black hole.

What NIF does: NIF focuses 192 laser beams, with 45 times more energy than any previous laser system, on a tiny capsule of nuclear fuel. NIF's ultimate goal is to compress the nuclear fuel until it "ignites" to release about fifteen times more energy than was added. To do this work, the NIF building is enormous; approximately the size of three football fields. Although NIF's mission and design has morphed somewhat over the years, the initial goal and most of the infrastructure remain.

Why NIF was designed: NIF's enormous cost was justified on the basis that it was essential for the Stockpile Stewardship Program, a US nuclear weapons program designed to maintain the viability of the U.S. nuclear stockpile (without open air testing). Therefore, NIF is, first and foremost, a weapons project. NIF has military applications in the design of the fusion component of nuclear weapons and in simulations of the effects of nuclear blast on military hardware. It is these capabilities that are the driving force behind the Lab's desire for NIF. Dr. Vic Reis, DOE Former Assistant Secretary for Defense Programs and a strong NIF advocate, described it this way to Congress: "The whole idea of lasers is for understanding the physics of (nuclear weapons) secondaries, but also more particularly, for maintaining that cadre of scientists who both understand the fusion process and all the things that go along with that..."

NIF Undermines International Anti-Nuclear Weapons Agreements: NIF has been criticized by Tri-Valley CAREs and others as violating the terms and spirit of the Comprehensive Test Ban Treaty and the Nuclear Non-Proliferation Treaty because of its supposed ability to achieve and test nuclear explosion-like conditions. Experiments on the NIF and at LLNL, in conjunction with its supercomputers, are intended to enable US weaponeers to upgrade the nuclear weapons codes, the complex software at the heart of designing new and more sophisticated nuclear weaponry. Data developed on the NIF and other DOE fusion facilities could lead to the development of pure fusion bombs.

NIF's Design Changes Pose Serious Health Risks: NIF's danger to the health and safety of local residents became most apparent in 2005 when LLNL announced plans to use plutonium, other fissile materials (such as uranium 235), fissionable materials (such as thorium 232), and lithium hydride in nuclear weapons research experiments at NIF. These uses of the NIF will increase the toxicity and volume of the waste stream, make radioactive releases more likely and create decontamination complications. Moreover, in 2011, DOE announced operational changes at NIF that would increase the maximum tritium inventory from .05 g to .8 grams (a 16 fold increase), increase the maximum per shot "blast" yield from 45 Mega Joules (MJ) to 120 MJ (over 2.5 times more blast yield), and increase the maximum beryllium inventory from 20 grams to 1 kg, (a 50 fold increase). Additionally NIF will create "skyshine" which involves NIF-produced neutrons "scattering off the atmosphere to the public." All of these increases pose potentially significant threats of increased exposure to radiation and toxins to workers, the public and the environment. Tri-Valley CAREs strongly objected to these design and operational changes to NIF. LLNL has approved many of these modifications to NIF and has the authority to implement them at any time without public notification.

D. Decontamination and Waste Treatment Facility

In 2003, Livermore Lab began operating a new hazardous and radioactive waste treatment complex called the Decontamination and Waste Treatment Facility (DWTF) to treat hazardous, transuranic, and mixed radioactive wastes generated by Lab operations. This waste treatment facility complex is located just north of the NIF, near Greenville Road, and includes a dozen buildings and storage pads.

The DWTF enables Livermore Lab to store up to 808,000 gallons of hazardous and radioactive mixed waste on-site at any given time. Further, LLNL is allowed to treat about 300,000 pounds of solid and 400,000 gallons of liquid hazardous and radioactive mixed waste each year of operation. Livermore Lab also generates "purely" radioactive wastes that are not counted in the numbers listed above because they are regulated by the Dept. of Energy, and not by the state and are not treated in this facility.

Typical waste streams at the mixed waste facility complex include radioactive acidic rinse waters, radioactive halogenated solvents, scrap metals with transuranic waste (elements that are heavier than uranium, often including plutonium), and highly dissolved solids from cleanup of chemical spills and leaky drums. The complex includes a Solidification Unit, Shredding Unit, Centrifuge Unit, Freezer Unit, Roll-Off Bin, Tank Farm, Reactive Waste Processing, Pressure Reactor, Water Reactor, Amalgamation Reactor and Uranium Bleaching Unit.

Tri-Valley CAREs objected to the approval of the mixed waste facility complex because of Livermore Lab's history of accidents and releases involving radioactive waste. In fact, Tri-Valley CAREs archives documentation of dozens of accidents involving hazardous or radioactive wastes, including an underground tank leak sending radioactive tritium into the soil and groundwater; two workers who were contaminated with tritium while packaging radioactive wastes; three workers contaminated during a filter shredding operation, including one who received internal contamination; twenty five workers who had to be evacuated when a waste bulking operation resulted in reddish fumes filling the room; and fourteen hazardous releases above wastewater permit levels to the City's sewage treatment plant over a one year period, among others. Moreover, in 2009, an explosion of uranium hydride occurred after internal containment was breached in the facility. The status of the cleanup is unknown. Tri-Valley CAREs continues to monitor the operations of this facility because of the magnitude of the risk that the facility poses in the case of accidents or other releases.

E. Ongoing Funding Advocacy Needed

LLNL's public relations machine continually spins out press releases and articles that depict LLNL as an institution that is dominated by civilian science. The budget that is released by the DOE each year and approved by Congress provides a radically different picture of what is funded in the day to day operations at LLNL. Although the Lab positively contributes to civilian scientific endeavors, the vast majority of the Lab's budget directly funds nuclear weapons related projects. In fact the weapons portion of the Lab's budget hovers just under 90% of the total budget each year. This is in stark contrast to the amount of money that is designated for cleanup of the contamination on the Lab grounds. In recent years the budget request for cleanup of the main site has stagnated at less than 1% of the Lab's annual budget. For example, the fiscal year 2011 budget request for cleanup was 11.3 million, less than 1% of the Lab's 1.2 billion annual budget. Moreover, nearly every year since 1997, the cleanup budget is threatened by cuts while the weapons budget is increased by Congress. Cutbacks in cleanup funding only delay inevitable expenditures and increase cleanup costs.

Tri-Valley CAREs travels to Washington annually to lobby to restore the cleanup budget and reduce the weapons budget. Tri-Valley CAREs also visits DOE headquarters to pressure them to request sufficient funds for cleanup. Once the budget request has been submitted to Congress, Tri-Valley CAREs visits key congressional offices and committees and provides a firsthand account as to why the cleanup funds are so essential.

Tri-Valley CAREs has had many victories in restoring cleanup funds threatened by budget cuts over the years. One notable example occurred in 2008 when the cleanup budget was cut in half and critical facilities needed to stop the offsite migration of contamination were shut down. A huge, toxic, off-site groundwater plume emanating from the Lab was allowed to migrate further from the Lab. Tri-Valley CAREs sent a delegation to Washington DC to lobby the DOE, the Office of Management and Budget and Congress for restoration of the funds. These efforts were successful to get the funds restored. However, despite the restored funds, LLNL refused to apply the funds to cleanup. Tri-Valley CAREs then sought the help of the EPA. In 2009, EPA fined the Lab $105,000 and threatened additional weekly fines if the noncompliance continued. In the end the critical facilities were put back online. The lesson learned is that the cleanup budget would most likely be slowly eviscerated without constant community oversight and vigilance.

VII. Key Contacts

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List of Acronyms and Glossary

AEC Atomic Energy Commission
ARAR Applicable or relevant and appropriate requirements
Absorption The incorporation of one substance into or through another of a different state (e.g., liquids in solids, gases in liquids). Unless it is certain that absorption is occurring, as opposed to adsorption, the term sorption should be used.
Adsorption Physical adhesion of vapor or dissolved matter to the surface of a solid. The term also refers to a method of treating wastes in which activated carbon removes organic matter from wastewater. Unless it is certain that adsorption is occurring, as opposed to absorption, the term sorption should be used.
Advection The process where liquids are transported at the velocity of the fluid. It is the primary transport mechanism for groundwater.
Aeration The act of exposing a substance to air, usually for the purpose oxidizing or volatilizing the substance.
Aerobic Living or occurring only in the presence of oxygen.
Air-stripping A treatment process that removes or "strips" VOCs from contaminated groundwater as air is forced through the water, causing the compounds to evaporate. Sometimes the vapor that is emitted is captured by a filtering system, usually granular activated charcoal.
Alluvium Unconsolidated clay, silt, sand or gravel deposited during relatively recent geological time by a stream or other water body.
Anaerobic Not capable of living in the presence of free oxygen
Aquifer An underground rock formation composed of permeable materials such as sand, soil, or gravel that can store groundwater and supply it to wells and springs.
Aquitard A bed of almost impermeable material that retards, but does not prevent the movement of groundwater to or from an adjacent aquifer.
Aromatic Of, relating to, or containing the six-carbon ring typical of the benzene series and related organic groups.
BTEX Benzene, toluene, ethyl benzene, and xylene. These are aromatic volatile organic compounds commonly found with gasoline and other petroleum fuels.
Bedrock A general term for the rock that underlies the soil and water table. It may hold some water either because it is fractured or is porous.
Biodegradation Decomposition by natural biological processes
Bioremediation Processes that use living organisms (usually naturally occurring) such as plants, bacteria, yeast, and fungi to break down hazardous substances into less toxic or nontoxic substances.
CAL/EPA California Environmental Protection Agency
CERCLA Comprehensive Environmental Response, Compensation and Liability Act of 1980, commonly referred to as the Superfund.
COCs Chemicals of Concern
Capillary fringe The zone immediately above the water table, where rocks and soil are saturated, but at pressure that is less than atmospheric. Water is held in this zone by capillary forces and cannot be removed by a well.
Carbon adsorption A treatment system that removes contaminants from groundwater or vapor as the fluid is forced through tanks containing activated carbon.
Ci An abbreviation for Curie, a measure of radioactivity. A Curie is defined as the amount of radiation emitted in one second by one gram of pure radium. It is 3.7x1010 disintegrations per second.
Confining layer A geologic formation characterized by low permeability that inhibits the flow of water.

Contaminant A chemical that degrades the natural quality of a substance or media.
DCE Dichloroethene
DNAPL Dense non-aqueous phase liquids. One of a group of organic substances that are relatively insoluble in water and more dense than water. DNAPLs tend to sink vertically through sand and gravel aquifers to the underlying layer.
DoD Department of Defense
DOE Department of Energy
DTSC California Department of Toxic Substances Control
Dispersion Mechanical mixing of a dissolved chemical as it flows through a solution. Dispersion causes chemicals to spread away from the straight-line pathway into a wider path. Temperature, pressure, and chemical forces in the aquifer drive the process. Diffusion is a special case of dispersion.
Disposal The final placement of toxic or other wastes. Disposal may be accomplished through the use of approved secure landfills, surface impoundment, land farming, deep well injection, ocean dumping.
EE/CA Engineering Evaluation/Cost Analysis
EPA Environmental Protection Agency
ESD Explanation of Significant Difference
Exposure pathway The route of contaminants from the source of contamination to potential contact through a medium (air, soil, surface water, or groundwater) to a human or environmental receptor.
Ex-situ Moved from its original place, not in-place. See definition of in-situ.
FFA Federal Facilities Agreement
FS Feasibility Study
GAC Granular Activated Charcoal. A highly porous form of carbon with very even and large pore volume, often made from coconut shells. The high porous structure of activated carbon provides a very large surface area for absorption.
gpd gallons per day
gpm gallons per minute
Groundwater The water in the area of the subsurface that is saturated. That is, the pores between such materials as sand, soil, or gravel are filled with water.
HI hazard index
HRS Hazard Ranking System
HSU Hydrostratigraphic Unit
Halogenated organic A compound containing molecules of chlorine, bromine, iodine, and/or compound fluorine. Many herbicides, pesticides, and degreasing agents are made from halogenated organic compounds.
Hazardous waste Defined by federal and state law as exhibiting either of the following characteristics: ignitability, corrosivity, reactivity, or toxicity
Heavy metal A reference to a group of metals including arsenic, chromium, copper, lead, mercury, silver, and zinc
Henry's Law Henry's Law is a measure of the extent that a chemical separates between water and air. The higher the Henry's Law constant, the more likely substances will volatize rather than remaining in water.
Heterogeneous Non-uniform in grain size, structure, or composition.
Homogeneous Uniform in grain size and structure.
Hydraulic head Head is the energy of a body of water produced by elevation, at a given pressure and temperature. It is a measure of potential energy of a body of water.
Hydrocarbon An organic compound containing only hydrogen and carbon, often occurring in petroleum, natural gas, and coal.
Hydrogeology The study of groundwater, including its origin, occurrence, movement, and quality.

Hydrous This technology adds oxygen in parallel with steam. When injection is
Pyrolysis/Oxidation halted, the steam condenses and contaminated groundwater returns to the heated zone, where it mixes with oxygen rich condensed steam. This enhances natural biodegradation of certain materials by providing nutrients to microorganisms that thrive at high temperatures (called thermopiles).
ILCR Incremental lifetime cancer risk
Impermeable Not capable of spreading or diffusing through the openings or interstices of a medium.
Incineration A treatment technology that involves the burning of certain types of solid, liquid, or gaseous materials under controlled conditions to destroy hazardous waste.
Inorganic compound A compound that generally does not contain carbon atoms, although carbonate and bicarbonate compounds are notable exceptions. Examples of inorganic compounds include various acids, potassium hydroxide, and metals.
In situ In its original place, unexcavated, or unmoved
Institutional controls A legal or institutional measure that subjects a property owner to limit activities at or access to a particular property. Fences, posting or warning signs, and zoning and deed restrictions are examples of institutional controls.
Isotope One of two or more atoms of the same element that have the same number of protons but different number of neutrons. For example, hydrogen has 1 proton, no neutrons; deuterium has 1 proton, 1 neutron; tritium has 1 proton, two neutrons. They are all isotopes of hydrogen.
LLNL Lawrence Livermore National Laboratory
Landfill A land disposal site where the waste is spread in layers, compacted and sometimes covered.
MCL maximum contaminant level established by the Safe Drinking Water Act.
mg/L micrograms per liter (equal to parts per billion, or ppb)
mg/kg micrograms per kilogram (equal to parts per billion, or ppb)
mg/L milligrams per liter (equal to parts per million, or ppm)
mg/kg milligrams per kilogram (equal to parts per million, or ppm)
Medium A specific environment--air, water, or soil- which is the subject of regulatory concern and activities.
Migration pathway A potential path or route of contaminants from the source of contamination to contact with human populations or the environment.
Mixed waste A radioactive waste contaminated with hazardous waste.
Monitoring well A well drilled for the purpose of sampling groundwater to determine the characteristics of the water and the presence or absence of contaminants.
NCP National Contingency Plan
NPDES National Pollution Discharge Elimination System
NPL National Priority List. The EPA's list of high priority sites in the country subject to the Superfund program.
Natural attenuation An approach to cleanup that uses natural processes to contain the spread of contamination and reduce the concentrations of pollutants in soil and groundwater. Natural subsurface processes, such as dilution, volatilization, biodegradation, adsorption, and chemical reactions with subsurface materials are included in this definition.
Organic chemical A substance produced by animals or plants that contains mainly carbon, or compound hydrogen, and oxygen.
Ozone A form of oxygen (03) found naturally which provides a protective layer shielding the earth from ultraviolet radiation. Ozone is also used as an oxidizing agent in some treatment technologies.
PAH Polynuclear aromatic hydrocarbon compounds. A chemical compound that contains more

than one benzene ring. They are commonly found in petroleum fuels, coal
products, and tar.
PCB olychlorinated biphenyls. Compounds comprising a biphenyl structure with 1 to 10
chlorine atoms, resulting in 209 different structural configurations (i.e.,
cogeners). As a group, they are persistent chemicals in the environment.
PCE tetrachloroethene
pCi/L Pico curies per liter (one-trillionth of a curie or 10-12)
ppb parts per billion
ppm parts per million
PRG preliminary remediation goal
PRP Potentially Responsible Party
PTU Portable Treatment Unit
Perched aquifer An unconfined aquifer contained by impermeable rock (see aquitard).
Permeability A characteristic that represents a qualitative description of the relative ease with which
rock, soil, or sediment will transmit a fluid (liquid or gas). A high value of
permeability indicates that flow is not significantly retarded by the medium.
Phase A physically distinct and separable form of matter that may be a single
(physical/chemical) compound. For example, water is stable in three phases: solid (ice), liquid, and
vapor. Treatment systems often use phase differences to separate contaminants
from water.
Plume A well defined, usually mobile, area of contamination in groundwater, soil or the air. .
Pump-and-treat A groundwater treatment process that pumps water to the surface and treats it to remove
or destroy the contaminant.
RAO Remedial Action Objective
RCRA Resource Conservation and Recovery Act (1976)
RD Remedial Design
RI/FS Remedial Investigation/Feasibility Study. This is a process that characterizes the extent of
contamination at a site and explores options for remediation. The process is
mandated by CERCLA, but its framework is used for many other sites, besides
those on the NPL.
ROD Record of Decision
RPM Remedial Project Manager
Radioactivity Any element that exhibits spontaneous disintegration of atomic nuclei, emitting alphaparticles,
beta-particles (electrons), or gamma waves (x-rays).
Radioactive waste Any waste containing radionuclides.
Radionuclide An element characterized according to its atomic mass and atomic number that is
radioactive.
Recharge The replacement of water to an aquifer. In some treatment configurations, treated water is
directly pumped into the aquifer.
Removal action A short-term effort designed to stabilize or clean up a hazardous waste site that poses an
immediate threat to human health or the environment.
SARA Superfund Amendments and Reauthorization Act (1986)
SDWA Safe Drinking Water Act
SVE Soil Vapor Extraction
SWAT Solar-Powered Water Activated-Carbon Treatment Units
SWRB State Water Resources Board
Saturated zone The area beneath the surface of the land in which all pore space is filled with water at
greater than atmospheric pressure.
Screened This term, as used in remediation, refers to the area in a monitoring or injection well
that has openings to the subsurface.
Solvent A substance, usually liquid, that is capable of dissolving another substance to form a

solution.
Sorption A term describing adherence of chemical substances to particles. It includes either absorption or adsorption.
Stratigraphy Description of major and minor divisions of surface and subsurface geologic formations.
Surface water All water naturally open to the atmosphere, such as rivers, lakes, reservoirs, streams, and seas.
Superfund The common name used for CERCLA. Sites listed on the NPL are called Superfund sites.
TAG Technical Assistance Grant
TCA Trichloroethane
TCE Trichloroethene
Toxicity A quantification of the degree of danger posed by a substance to animal or plant life. Toxicity is one of the four characteristics that make a substance hazardous, as defined by RCRA.
Toxic substance A poison; a chemical or mixture that may present an unreasonable risk of injury to health or the environment.
Tritium A radioactive isotope of hydrogen. It can be either in vapor or liquid phase.
VOC Volatile organic compound. One of a group of carbon-containing compounds that evaporate readily at room temperature. Examples of VOCs include trichloroethane, trichloroethylene, benzene, toluene, ethylbenzene, and xylene (BTEX).
Vadose zone The area between the surface of the land and the aquifer water table in which the moisture content is less than the saturation point and the pressure is less than atmospheric.
Vapor The gaseous phase of any substance that is liquid or solid at atmospheric temperature and pressures. Steam is an example of a vapor.
Volatile Evaporates readily at normal pressures and temperatures.

VII. Technical Appendices

1. Groundwater at Livermore Lab Main Site

{Note to Peter: I basically wholesale copied this section from the 2005 community guide. I tried to format it but the footnotes and the figures have become buried in antiquity. I did no work to verify whether this information is still correct so please pay special attention to this section and remove outdated information and modify where necessary. Please feel free to add more modern figures and images to make this part reader-friendly. }

Groundwater at the site ranges from 25 feet to 200 feet below ground surface. In 1995, to better understand the sources of contamination and their pathways, LLNL conducted what is referred to as Hydrostratigraphic Analysis. LLNL is underlain by a thick sequence of sediments known as the Upper and Lower Livermore Formations. A layer of clay approximately 20 – 30 feet thick separates these formations. Contaminants at the site are in the Upper Formation. Within the Upper Formation, highly permeable channels carry groundwater, each separated from one another by a layer of non-saturated material that restricts vertical groundwater flow. These channels are known as Hydrostratigraphic Units (HSUs). Sediment layers that have hydraulic communication are grouped together as one HSU.

Seven HSUs have been defined at LLNL. HSU 1 and 3 are further subdivided into two parts. HSU 6 and 7 do not appear to be contaminated. LLNL has used hydrostratigraphic analysis to organize these HSUs into operational units relevant to groundwater cleanup, helping it to identify and target contaminant migration plumes. Figure 1 shows the relationship between the HSUs, the surface and contamination.

2. Main Site Superfund Cleanup Wellfield Management

The site is currently divided into nine treatment areas. They are named Treatment Facility A (TFA), TFB, TFC, TFD, TFE, TFG, TF 406, TF 518, and TF Trailer 5475. Advances in technology have greatly helped LLNL to exceed its cleanup goals but still the cleanup has a long road ahead. Because of the development of portable treatment units (PTUs) 4, as concentrations begin to go down, new extraction wells are drilled and the portable units are installed. This decreases work needed to build piping to a fixed facility, and LLNL is better able to target spots with highest concentrations. By 2004, a total of 80 groundwater extraction wells had been installed. In addition to the groundwater treatment facilities, there four areas have soil vapor extraction facilities. These facilities are designated Vapor Treatment Facility (VTF) D Helipad, VTFE Eastern Landing Mat, VTF518 Perched Zone and VTF5474.

Figure 2 provides a diagram of the location of the treatment facilities. Brief descriptions of the Treatment Facilities are described below.

TFA

TFA is located in the southwest quadrant of the Main site. TFA treats water in HSU 1, 2 and 3. TFA is a primary facility that controls the plume that has gone off-site. Chemicals of concern include PCE, TCE, DCE, DCA, TCA, chloroform and Freon 113, all VOCs. Concentrations of PCE in groundwater were highest at this area, measured to 900 ppb in 1988 prior to any remediation. By 2005, these levels have been reduced to 10% of the original, but concentrations of PCE in one well are still almost 20 times the MCL.

Originally, the treated water from TFA and several other facilities were discharged into a Recharge Basin located to the south of East Avenue. Because of problems with reinjection, in 2003, treated water was directly discharged to Arroyo Seco and Arroyo Las Positas. TFA originally used the UV/hydrogen peroxide treatment system described above. In 1997, the system was changed to an air stripper only, largely due to cost considerations and the fact that contaminant concentrations had decreased substantially. TFA also has a solar treatment unit, which is a PTU using solar power.

TFB

TFB is located north of TFA on the western edge of the site. TFB treats HSUs 1 -3. Chemicals of concern include PCE, TCE, DCE, DCA, TCA, chloroform and Freon 113, all VOCs. Hexavalent chromium6 is also present. For the VOCs, TFB uses an air stripper with GAC to capture the off-gas. For chromium, an ion-exchange unit is used. 4 PTUs are skid mounted treatment units housed in a trailer.

In some instances, groundwater is pumped through an air stripper. There are several types of PTUs. The basic PTU pumps at a rate up to 45 gallon per minute (gpm). Another PTU uses GAC to adsorb the contaminant. A third is named a Miniature Treatment Unit and operates at approximately half the flow rate. A fourth is a solar powered PTU (STU), using aqueous-phase GAC at flow rates up to 5 gpm. (Footnote?) LLNL Livermore Site First Quarter 2005 Self-Monitoring Report, May 31 2005. This result occurs in only one extraction well – the rest have lower concentrations. (Footnote) Hexavalent chromium is a highly toxic form of chromium. It is the chemical that was the primary contaminant in the movie “Erin Brockovich”. Chromium is treated only during the winter months when it is present in groundwater.

Figure 2: Treatment Facility Areas at LLNL (Need Figure)

TFC

TFC is located in the northwest quadrant of the Main site. It treats groundwater in HSU 1 and 2. Chemicals of concern include PCE, TCE, DCE, chloroform and Freon 113, all VOCs. Hexavalent chromium is also present. For the VOCs, TFB uses an air stripper with GAC to capture the off-gas. For chromium, an ion-exchange unit is used. Like TFB, it is used during the rainy season. Tests are underway using iron wool to reduce hexavalent chromium to trivalent chromium. Trivalent chromium is not a carcinogen.

TFD

TFD is located in the northeastern corner of the Main site. TFD facilities treat HSUs 2 - 4. Chemicals of concern include PCE, TCE, DCE, DCA, TCA, carbon tetrachloride, chloroform and Freon 113, all VOCs. TFD has 8 separate treatment facilities, including a "dual-phase"8 extraction system near the Helipad. Tests were also done at the helipad to demonstrate electro-osmosis, but apparently these tests were unsuccessful.

TFE

TFE is located in the near the middle to southeast of the Main site. TFE treats HSUs 2 -5. Chemicals of concern include PCE, TCE, DCE, DCA, TCA, carbon tetrachloride, chloroform and Freon 113, all VOCs. Both air stripping and soil vapor extraction are used in this area.

TFG

TFG is located in the southwest quadrant of the Main site. Facilities treat HSUs 1 and 2. Chemicals of concern include PCE, TCE, DCE, DCA, TCA, chloroform, carbon tetrachloride, and Freon 113, all VOCs. Aqueous-phase GAC is used to treat groundwater. A problem arose in 2002 where chloroform was not being adequately captured by the GAC. Samples of effluent had only been taken for TCE, because it was the only contaminant above the MCL in this area. New procedures were implemented to insure that this would not recur.

Treatment Facility 406

Treatment Facility 406 is located in the southern part of the Main site. It treats HSUs 3 – 5.
Chemicals of concern include PCE, TCE, DCE, DCA, TCA, carbon tetrachloride, chloroform and Freon 113, all VOCs. High concentrations of benzene, toluene, and xylene are also present and are being remediated by monitored natural attention. (Footnote) Groundwater is treated by air stripping PTUs and liquid-phase GAC PTUs. Soil vapor extraction has recently been installed to treat a hot spot.

Treatment Facility 518

Treatment Facility 518 is located in the southeastern quadrant of the Main site. It treats groundwater in HSU 4 and 5 with GAC PTU system. Chemicals of concern include PCE, TCE, DCE, DCA, TCA, carbon tetrachloride, chloroform and Freon 113, all VOCs. Soil vapor is also treated in this area.

Treatment Facility Trailer 5475

8 Dual phase extraction refers to a technology that uses a high pressure to extract both groundwater and soil contaminants from one extraction well. For further explanation of this technique as well as others mentioned in this guide, refer to cpeo.org/techtree. (footnote) Monitored Natural Attenuation (MNA) refers to natural breakdown or dispersion of contaminants; monitored to ensure that there is a decrease in concentrations. For VOCs this method is of concern; for fuel hydrocarbons, it has been demonstrated that there is a high degree of biodegradation. (footnote)

Treatment Facility Trailer 5475 is located in the southeastern quadrant of the Main site, above the 518 area. It treats water and vapor in HSU s and 3. Chemicals of concern include VOCs and tritium. Because LLNL did not want to extract water contaminated with tritium, it developed an in-situ catalytic reductive dehalogenation (CRD). CRD uses dissolved hydrogen as a reducing agent, in the presence of a palladium-on-alumina catalyst, to chemically transform compounds such as TCE into environmentally benign ethane. The catalyst, called a reactor, can be placed in an extraction well or above ground. Because of its rapid reaction rates (within several minutes removal efficiencies for most of the chlorinated hydrocarbons are greater than 99%), a treatment unit system can be placed in a dual-screened well, allowing contaminated groundwater to be drawn from one water-bearing zone, treated within the well, and discharged to an adjacent zone.

Because the VOCs and tritium are mixed, an in-well system never brings tritium to the surface. After one reactor was placed in a well, it was discovered that treated water was not separated sufficiently from the contaminated zone. While the system still operates, LLNL installed a second above ground unit and the treated water is re-injected. A diagram of the in-well CRD is provided in **Figure 3**.

Table 1 shows the volume of treated groundwater and soil at each treatment facility area.

Figure 4 provides a chart giving total mass removed per year from 1989 through 2004.

Figure 3: Diagram of In-well CRD Unit

Table 1: Treatment Areas and Volume of Contaminants Removed

Treatment Facility
LLNL Ground Water Project, 2004 Annual Report, UCRL-AR-126020-04, p. SUMM-3

Figure 4: Total VOC Mass Removed From 1989 – 2004