COMMUNITY GUIDE

LAWRENCE LIVERMORE NATIONAL LABORTAORTY MAIN SITE

SUPERFUND SITE

PREPARED FOR

TRI-VALLEY CARES

LIVERMORE, CALIFORNIA

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This report is part of the Tri-Valley CAREs
Citizens' Monitoring and Technical Assessment Project

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I. INTRODUCTION

The purpose of this report is to familiarize the community members about the status of the Superfund cleanup and some of the program activities that take place at the Lawrence Livermore National Laboratory (LLNL) Main Site Superfund site. The information in this report is based on extensive review of documents obtained from the U.S. Environmental Protection Agency (EPA), the U.S. Department of Energy (DOE), the State of California Department of Toxic Substances Control (DTSC), and the Lawrence Livermore Laboratory Environmental Restoration Division, as well as meetings with the regulatory agencies and meetings with the Community Work Group. It also incorporates information obtained through our role as Technical Assistance Grant recipient as well as other research projects. [1]

This report is organized in the following manner:

- Description of the Superfund process
- Background on the Lawrence Livermore National Laboratory
- Cleanup Activities and Issues
- Site Wide Environmental Impact Statement and Issues
- Key Contacts

[1] This report will serve as our Final Report for the Citizens' Monitoring and Technical Assessment Fund project.

II. 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 contained 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 National Priorities List (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 (RI)

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 1×10^{-4} (one person per 10,000 population) to 1×10^{-6} (one person per 1,000,000 population) incremental lifetime cancer risk (ILCR). Risk below 1×10^{-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 1×10^{-6}, 300,001 per 1,000,000 people would develop cancer. For non-cancer 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. [2]

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.

[2] 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 (ROD)

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 approve 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 National Contingency Plan 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 Applicable or Relevant or Appropriate Requirements (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 effect 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. BACKGROUND OF LAWRENCE LIVERMORE NATIONAL LABORATORY (LLNL)

The Main Site at LLNL encompasses 800 acres, or about one square mile. It is bordered on the west by Greenville Road, on the south by East Ave., on the West by Vasco Road and on the North by Patterson Pass Road. The site is 3 miles east of downtown Livermore, and approximately 40 miles east of San Francisco. The population within a 50 mile radius is approximately 4 million people. The Site is surrounded by residential dwellings to the west, and commercial and industrial development and agricultural lands nearby.

LLNL is a Department of Energy (DOE) research facility operated by the University of California. In 1942, it was first used by the Navy as an aircraft maintenance facility. In 1950, the property was transferred to the Atomic Energy Commission (AEC), a predecessor of the DOE. The site was established in 1952 by Edward Teller and E.O. Lawrence to develop the hydrogen bomb, thus becoming the United States' second nuclear weapons design center (after Los Alamos National Laboratory).

Historically, the site is used for the fabrication**,** development, and testing of new weapons at the Nevada Test Site. In 1952, the University if California began management of the site under contract with the AEC. Since 1950, it has been used for the design of nuclear weapons, as well as processing and testing of high explosives materials and components. Livermore lab supported the work of Los Alamos National Lab (LANL) in adding earth-penetrating capability to the B61 nuclear bomb in 1996. The lab is currently involved in the re-design of several warheads, specifically, the W87 to increase its accuracy and in one of three new design options for the W76 and W88 submarine-launched nuclear weapons. Livermore lab has also been named the lead lab for two new "modifications" of the W80, a nuclear warhead that sits atop cruise missiles. LLNL is studying the possibility of developing a new deep earth-penetrating "mini-nuke" and various other new weapons concepts.

Existing facilities include a plutonium facility, and a tritium **(**radioactive hydrogen used in the hydrogen bomb) facility. The main site houses up to 1540 pounds of plutonium and 500 hundred pounds of uranium 235. Recently, DOE has proposed to double the quantity of plutonium allowed at LLNL at any given time.

Along with the use of radioactive substances, over the years LLNL has used many chemicals that were inadvertently or carelessly released to the environment. These include fuel hydrocarbons (mostly gasoline), metals, tritium, PCBs and volatile organic compounds (VOCs), most often trichloroethene (TCE). Plutonium has also been released to the environment from on-site activities, and although it is not currently a chemical of concern (COC) at the site, there have been detections of plutonium in surrounding areas, most notably in Big Trees Park. 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. Currently, there is an investigation spearheaded by Tri-Valley CAREs and the Alameda County Health Department to better understand how wide spread plutonium contamination is in residential areas. Tritium gas was released through normal operations and accidentally. Tritium is not only concern because of direct exposure, but since Livermore has a large agricultural sector, it is important to keep it out of the food supply.

LLNL is also known for developing laser technology. The National Ignition Facility (NIF) is intended to produce, for the first time in a laboratory setting, conditions of matter close to those that exist in detonating nuclear weapons. To accomplish this, it would focus 192 laser beams, with 45 times more energy than any previous laser system, on a tiny capsule of nuclear fuel. If NIF achieves its ultimate goal, the lasers will compress the nuclear fuel unit until it "ignites" to release about fifteen times more energy than was added.

NIF was justified on the basis that it was essential for the Stockpile Stewardship Program, a program designed to maintain the viability of the U.S. nuclear stockpile (without testing). It has been criticized by Tri-Valley CAREs and others as violating the terms and spirit of the Comprehensive Test Ban Treaty and the 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. That said, NIF is an attractive tool for recruiting scientists to the Lab. Recently, DOE determined that plutonium would be used in experiments at NIF further ensconcing the mega-laser as a nuclear weapons research tool.

Other work performed at the facility includes: Researching non-proliferation, arms control and treaty verification technology, Conducting research on fusion energy, the environment, and biomedicine. Additionally, LLNL is planning to develop a Bio-safety facility on LLNL property. This facility (known as BSL-3) is also controversial because it would allow LLNL to experiment with a broad range of biological agents including live anthrax, bubonic plague, botulism and genetically modified lethal bio-warfare agents. Aside from its inherent ability to take steps toward weaponizing these agents, if inadequately managed, it could endanger the workforce and the surrounding community. The facility also represents a new direction and program for DOE and LLNL: one that is not within the existing “culture “ of LLNL, and one where there is not the ongoing training and knowledge necessary to operate it safely and securely.

IV. SUPERFUND ACTIVITIES AT LLNL

As a result of its work designing nuclear weapons, LLNL conducts experiments with extremely hazardous substances, including weapons grade plutonium (Pu), enriched uranium (U_{235}), tritium and other radioactive substances, as well as hazardous wastes. In operating the facility over fifty years, LLNL has had 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 were done by the Navy.

This plume contains Freon 113, trichloroethene (TCE), trichloroethane (TCA), DCE, and DCA. Also found in groundwater were benzene, toluene, carbon tetrachloride, chromium and tritium (radioactive hydrogen) in excess of drinking water standards established under the Safe Drinking Water Act. These and other pollutants also exist in the soils at numerous locations on site. Groundwater plumes contaminated with volatile organic compounds stretch beneath 85% of the site.

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. This would mean at least 64 additional cancers for Livermore alone. The risk to someone drilling a well near the LLNL boundary would have been two times higher; two cancers per 1,000.

As a result, in 1987 the Environmental Protection Agency (EPA) named the main site to the Superfund list, primarily because of numerous volatile organic compounds (VOCs) found in a one-half mile groundwater plume emanating from the site and heading westward towards Livermore's municipal drinking water wells. 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.

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. Nevertheless, 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 Record of Decision (ROD) was signed in 1992, and full cleanup began in 1995. It and other planning documents first sought to capture the off-site plume and reduce it to MCLs. At the same time, a plan was developed to treat the most heavily contaminated source areas. LLNL proposed, and is partially implementing a plan to pump the contaminated groundwater to the surface, treat it through air strippers, and recharge most of it back to the ground.[3] At certain areas where the contaminant levels were highest, in order to prevent the discharge of treated chemicals to the air or capture and dispose of it in granular activated carbon, LLNL used an ultra-violet (UV)/hydrogen peroxide pretreatment that essentially broke down the VOCs into basic, harmless substances. The original plan contemplated a 53 year clean up time frame.

As active remediation began and as time, experience and knowledge have progressed, LLNL has exceeded expectations about plume capture and mass removal. This is due in part to a much better understanding of the hydrogeology underlying the site and innovations in well-field management that allows LLNL to target source areas.

Hydrogeology

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.

[3] Originally, LLNL constructed a Re-injection basin south of East Ave. In 2003 this was closed because the basin was not sufficiently draining to groundwater.

Figure 1: Relationship of HSUs, Contaminant Levels, and Surface

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 goals. 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.[5] 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 re-injection, 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 chromium[6] 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.[7]

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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.

5 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.

6 Hexavalent chromium is a highly toxic form of chromium. It is the chemical that was the primary contaminant in the movie “Erin Brockovich”.

7 Chromium is treated only during the winter months when it is present in groundwater.

Figure 2: Treatment Facility Areas at LLNL

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.[9] 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.

[9] 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.

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[10]

Treatment Facility Area	Volume of Groundwater Extracted (Mgal)	Volume of VOC Removed from Groundwater (kg)	Volume of VOC Removed from Soil (kg)	Total Mass Removed
TFA	1,191	172		172
TFB	267	63		63
TFC	218	66		66
TFD	550	607	8	615
TFE	198	163	96	259
TFG	30	6		6
TF406	81	10		10
TF518	13	5	187	192
TF5475	1	6	390	396
Total	**2549**	**1097**	**681**	**1778**

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

Figure 4: Total VOC Mass Removed From 1989 – 2004

Major Issues that Could Limit the Effectiveness of the Clean-up

1. Risk Based End State Vision.

While TVC has been informed that DOE's Risk Based End State (RBES) Policy has been put on hold, at least for LLNL, we are very concerned that it will resurface. In late 2003, DOE tasked each site with formulating an "End State" and cleanup strategy based solely on human health risk that would be contrasted to the "Current End State". The implementation of this RBES policy raises grave concerns over cleanup at LLNL and other sites in the U.S. nuclear weapons complex, including:

- ***The RBES abrogates the agreements set forth in ROD for the Livermore Site.***
- ***The RBES plan places pressure on site managers to alter remediation plans on the basis of questionable risk calculations rather than complying with previous commitments.***
- The RBES sets the point of measuring compliance with environmental laws at the Site boundary. Therefore, contaminants will be left to migrate to the fence line and be cleaned up only if the plume crosses the boundary. This will allow contaminants to pollute a much larger area than if the contamination were controlled at the source. This violates a long held principle of environmental cleanup: it takes much more effort to clean up contaminants spread out over a large area than cleaning them up at the source. In fact, during the 1990's, LLNL's own staff endorsed this principle, dubbed "Engineered Plume Collapse" as the strategy that helped it to save time and money during cleanup.
- In one version of the RBES for LLNL, the idea of a containment zone was postulated, whereby the Main Site would become a dedicated zone of polluted groundwater, so long as it did not go beyond the site boundary. While it has been the prevailing policy of the State and EPA that contaminated groundwater should be cleaned to at least drinking water standards, there is a possible exception. A recent modification to this policy is State Water Resources Control Board Resolution 92-49,[11] otherwise know as the "containment zone policy". This policy allows polluters to leave contaminated water in place under certain circumstances. This may have the effect of justifying no action or very little cleanup.

2. Funding Commitments

A basic concern is whether funding commitments are sufficient to ensure long-term cleanup and achievement of project milestones. Nearly every year since 1997 the budget for Main Site cleanup has been reduced. Cutbacks in funds only delay inevitable expenditures, and may make cleanup more costly. Long-term funding for clean up should be a major commitment, and DOE and LLNL should make all attempts to ensure future funding. In addition, as a general principle, while documentation reductions and even lengthening the cleanup schedule *may be* reasonable responses to budgetary restrictions, cleanup standards should not be tampered with unless they are based on sound scientific principles.

3. The Devolution of Environmental Management

As part of DOE's accelerated cleanup program, the Office of Environmental Management is going to transfer its responsibility over each sites to one of two entities: the National Nuclear Security Administration (NNSA) or the Office of Legacy Management. For sites

[11] Policies and Procedures for the Investigation and Cleanup and Abatement Under Section 12204 of the Water Code

that remain active with an ongoing mission, like LLNL, all environmental management responsibility will be transferred to NNSA. Although it makes some sense to require the "polluter" to clean up after itself, the NNSA's mission is building and maintaining the nuclear weapons arsenal within a culture of secrecy. As this bureaucratic shift occurs, there is a risk that the budget for environmental management will become an even lower priority than it is now.

4. Complete Characterization

Even with over 400 monitoring wells, TVC is concerned about characterization in two locations. There are a few areas off property to the west that still have not been fully characterized. The East Traffic Circle was formally a disposal site, as was the East Taxi Strip area. The discovery of the capacitors and drums at the NIF site indicated that this area is a logical extension of the east-side waste disposal area, when miscellaneous Lab and Navy wastes were disposed of without strict regulatory oversight. TVC recommended in the past that DOE continue efforts to characterize this area. In fact, this was where the more recent discovery of PCBs was found (at up to 133 ppm). It seems that whenever construction projects take place in or near this area, something is found. As TVC has long suggested, LLNL needs additional funds for characterization. Information in the Long-term Stewardship document[12] for LLNL supports that position, although it is not apparent that any money is set aside for this. LLNL admits to a low level of confidence in its estimates of the area, volume and mass of contamination for soil and groundwater. Almost all soil is ranked as having a low-level of confidence, and nearly all groundwater is ranked as having a low or medium level of confidence.

5. Complete Cleanup

Wherever possible, TVC recommends that LLNL be cleaned up to a level that allows unrestricted use and avoids the need for long-term stewardship. We also recognize that at a few selected areas this may not be possible due to the nature of the contaminants. Where cleanup to such a level is not practical due to current technical constraints, commitments should be inserted into the final remedy decision detailing the stewardship plan and funding. DOE should develop a program to look for solutions that would minimize or eliminate the need for long-term stewardship. Some contaminants will have to be "stored" in place or at the site for long periods of time. This may be true for many radionuclides and some chemicals. Once decisions are made to leave a contaminant in place, it is difficult to continue research on how the contaminant could be safely treated, thereby avoiding or reducing the need for long-term stewardship measures. DOE should to establish a dedicated program that keeps an eye towards the future and continually looks for solutions to these problems.

[12] DOE, March 15, 2000

8. Relaxing Cleanup standards for TCE and total VOCs

TVC is very concerned that there will be a relaxation of cleanup standards, and that the TCE standard, in particular, may remain the same instead of being strengthened. This issue of relaxing standards for the Main site was first put forward in 1997 in DOE's Ten-Year Plan. The plan assumed that the future regulators will accept a 25 parts ppb standard for total VOCs in the groundwater. This was heightened again when DOE proposed RBES (described above).

In 2001 EPA reassessed the toxicological profile of trichloroethene (TCE), one of the major contaminants of concern at the Livermore Site. It is expected that if the EPA reassessment holds up, the groundwater standard may be as low as 1 ppb, as opposed to the current standard of 5 ppb.[13] It would be unfortunate indeed if LLNL were to shut down treatment facilities at the source only to find that stricter levels for TCE would be enforced, and the only means would be to go back and recapture the plumes. However, the EPA publishes an annual list of Preliminary Remediation Goals (PRGs), based on the latest scientific evidence of the incremental lifetime cancer risk (ILCR) of one in one million (1×10^{-6}). The PRG for TCE is 1.8 ppb, prior to the development of the Draft Health Assessment. While the EPA recommends that PRGs be used as preliminary screening numbers or initial cleanup goals to determine whether a chemical presents an unacceptable risk, it should be noted that they are based on some conservative exposure assumptions. For example, dermal absorption from bathing is not considered.

9. Long Term Stewardship (LTS)

A working definition of LTS is "the physical controls, institutions, information and other mechanisms needed to ensure protection of people and the environment at sites where DOE has completed plans for cleanup (e.g., landfill closures, remedial actions, removal actions and facility stabilization). The concept of long-term stewardship includes land use controls, monitoring, maintenance and information management".[14]

TVC is concerned about DOE's commitment to implement the necessary plans and activities that this will entail, and maintain steady and necessary levels of funding. LTS activities should include distribution of health information and a health-monitoring plan. DOE (or subsequent federal managers) should implement a systematic process for re-evaluating and if needed, modifying existing LTS activities to ensure that developments in science, technology and performance are incorporated.[15] If contaminants are left in place, DOE should compensate local governments. Even with the best plans, we know that there will be some failures. Some of these failures may require emergency medical response due to sudden events (e.g., explosion), but many may lead to negative health affects due to non-sudden events (e.g., failure to contain seeping groundwater plumes leading to contamination of the water supply). Finally, a reliable, up-to-date record-management facility accessible to the community is required. Because of the long-term nature of contaminants found at many of the sites, DOE should develop a record management system that will always be accessible near the location of the stewardship

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[13] In 2001, EPA conducted a draft Health Assessment of TCE. Although Region IX originally translated this into an acceptable level, it has backed off since the Health Assessment was criticized by the Department of Defense and other PRPs. It is now being assessed by the National Academy of Sciences.

[14] Long-Term Stewardship Study, DOE 2001.

[15] The National Research Council recommended that "DOE should plan for uncertainty and fallibility" of some aspects of the long-tern stewardship program; including developing plans "to maximize follow-through on phased, iterative and adaptive long-term institutional management approaches at sites where contaminants remain".

activities, from a regional access point (such as the state archive or library) and from the National Archive system.

8. Establishing Milestones

While recognizing that cleanup has gone faster than expected in terms of mass removal, TVC has suggested since the development of the Remedial Action Plan that a timetable be established based on performance milestones. These milestones should include the amount of contaminant mass that is removed from the soil and groundwater within an expected time period, regulatory milestones such as achieving cleanup standards, performance trends and achievement of plume control and plume capture. This timetable would then be used to monitor the performance of cleanup, and provide interested parties with some idea how cleanup will progress. The plan does not have a measurable schedule or performance standards which the community can hold it to.

V. SITE WIDE ENVIRONMENTAL IMPACT STATEMENT (SWEIS) FOR LLNL

The Site-wide Environmental Impact Statement for Continued Operation of Lawrence Livermore National Laboratory and Supplemental Stockpile Stewardship and Management Programmatic Environmental Impact Statement (LLNL SWEIS) was prepared pursuant to the National Environmental Policy Act (NEPA) in 2005. It analyzed the potential environmental impacts of continued operation, including near-term proposed projects of LLNL. It analyzed alternatives ranging from reduced activity levels to increased activity levels at both the LLNL main site and Site 300.

The comment period for this document ran through May 27, 2004. Public hearings on the Draft SWEIS were held in April. DOE received over 9,000 comments, mostly criticizing the proposed alternative (i.e., increased activity levels). Tri-Valley CAREs submitted extensive comments (see http://www.trivalleycares.org/TVC_SWEIS_Comment_Final.pdf). Categories covered included contravention of treaties, lack of alternatives covered, poor analysis of cumulative impacts, NIF, BSL-3, increases in plutonium and tritium limits under the preferred alternative, , accident analysis, transportation, Superfund, waste management, activities at Site 300, and the Plutonium Atomic Vapor Laser Isotope Separation system. (This last program, which was extremely controversial, was canceled DOE).

For the purposes of this section of the Community Guide, we will not repeat those comments in full, nor comments related to Site 300 or the Superfund cleanup. Instead we will provide background on a few areas of greatest controversy, followed by a discussion of other issues relevant to the SWEIS.

- Increases in the administrative levels of plutonium
- Increases in the levels of tritium
- Security and Emergency Response at LLNL
- Potential Accidents at LLNL

Increases in Amounts of Plutonium Stored at LLNL

The proposed action would increase the administrative limit for plutonium at LLNL from **1,540 to 3,080 pounds**. Tri-Valley CAREs believes that increasing the storage limit for plutonium at LLNL is dangerous and unnecessary. The LLNL main site is a very compact and crowded 1.3 square mile facility with nearly 10,000 employees and subcontractors on site. Residential neighborhoods are built right up to the LLNL main site fence line. Moreover, The City of Livermore has grown substantially since LLNL was founded in 1952, thereby increasing the risks from a release to a larger and more diverse population. Fires, spills, filter failures, leaks and criticality accidents with radioactive materials have all occurred at LLNL. There have been more than 30 serious, publicly reported accidents involving radioactive materials at LLNL, including plutonium.[16]

Plutonium is a human-made radioactive substance and a potent poison when inhaled or ingested. It is made in nuclear reactors, and one isotope is the primary explosive material in modern nuclear weapons. This is one of the most toxic radionuclides that Lawrence Livermore National Laboratory (LLNL) works with, and when it is introduced to the environment, it is poisonous in very small doses. It has been used at LLNL to design and fabricate nuclear weapons. Even with

[16] See **Table 4** under **Accidents and Accident Analysis**

the cessation of the "Cold War" in the 1990's, LLNL continues to use plutonium for designing, testing and dismantling nuclear weapons.

Bomb makers use Pu^{239} for its ability to rapidly create a chain reaction. This makes it an ideal component for a nuclear weapon, and was first used in the Nagasaki atomic bomb. A modern nuclear warhead contains molded shapes of plutonium (called a "pit") surrounded by a high explosive layer. When the explosive is detonated, it compresses the pit uniformly and rapidly, so that the plutonium implodes to supercritical mass. This causes the fission chain reaction that is known as an atomic bomb. If the pit contains the lighter elements of tritium and deuterium gas, the radiation and temperature from the fission reaction cause the atomic matter to fuse, resulting in a thermonuclear explosion. This is often called the hydrogen bomb.

Pu^{239} has a half-life of 24,000 years, longer than recorded history.[17] Pu^{239} retired from weapons "will remain around for the closest thing to eternity on earth" (American Physical Society spokesperson). In order to approximate the hazardous life of a radionuclide, a general rule of thumb that is used is that a radionuclide's hazardous life is ten times its half-life. So the Pu^{239} in existence today will be hazardous for 240,000 years.

Radiation as emitted by plutonium has been shown to be carcinogenic (i.e., causing cancer), mutagenic (causing mutation of the DNA), and teratogenic (causing malformation and disease to fetuses). Radiation can induce cancer in nearly every tissue or organ of the human body. Cancer induction is a delayed response. It has been long held in the scientific community that although humans are exposed to naturally occurring and induced radiation (e.g., medical exams), there is essentially no safe level of radiation. The severity of the radiation dose depends primarily on the quantity of radiation taken into the body and on the route by which it enters the body.

Pu^{239} primarily emits alpha particles. However, it is associated with Americium 241 (Am^{241}), which primarily emits gamma radiation. Plutonium metal is pyrophoric. That is it ignites in the presence of air. Small particles and shavings from machine work create a fire hazard. However, large metal pieces form an oxide coating on the outside, and no longer ignite on contact. In general, inhaled plutonium is far more hazardous than plutonium that is ingested. Tiny particles can lodge in the lung, where they can remain for a period of 500 days. Of material absorbed into the deep lung, approximately 15% goes to the lymph nodes and eventually to the bloodstream. If deposited in the bone through the bloodstream, it can remain there for up to 200 years.

The National Academy of Sciences began publishing a report on the Biological Effects of Ionizing Radiation (BEIR) in 1972. Each successive report has increased the fatal cancer risk/ low dose relationship. The BEIR V report in 1990 asserted that radiation is almost nine times as dangerous as had been estimated by the BEIR I Report.

Plutonium is primarily used and stored in a heavily guarded facility known as the Superblock. The Superblock contains the plutonium building, the tritium building and support buildings. The Superblock is so named because it is encircled by two security fence, overlooked by a guard tower, has restricted access, some of the structures are reinforced in case of an earthquake, and there are systems built into the facility that provide protection from natural disaster, fire and loss of power. LLNL claims that the Superblock is governed by rules and regulations that are "similar to those used by the Nuclear Regulatory Commission for nuclear reactors".

The Superblock complex consists of several buildings for storing, handling, packaging and machining radioactive materials and metals, including tritium, uranium (U), plutonium (Pu),

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17 A half-life is a measure of time it takes for half the radioactive material to radiate energetic particles and rays and transform to new material. For example the half live of $cesium_{137}$ is 30 years, during which half of it decays to a stable non-radioactive stable nuclide ($barium_{137}$).

curium (Cm), and americium (Am). Plutonium is used or stored at the Plutonium Facility and Central Vault (Building 332). Several support buildings outside of the Superblock also handle plutonium. These support buildings do not have the same degree of protection as the Superblock.

The Plutonium Facility began operation in 1961. Because of its age and the safety infrastructure built into the building, vulnerabilities such as the ventilation system and electrical system must be considered carefully. Although the plutonium facility is not a nuclear reactor, in the nuclear power industry reactors undergo a rigorous review after they have been operating for forty years and design upgrades must be considered. Similarly, the DOE should conduct a rigorous review of the LLNL plutonium facility and recommend significant design upgrades, if warranted.

A single workstation has a mass limit of 2.6 kg (5.7 lbs.) of plutonium in solid form. In certain cases this quantity can be raised to 4.0 kg (8.8 lbs.). Currently, a single laboratory has a plutonium limit of 20-kg (44 lbs.). The proposed action would raise this to **40 kg**. This is called the material-at-risk.

Plutonium contaminated solid wastes are sealed in metal drums, which then are transported to the waste management facilities. Liquid wastes are dried and become a solid waste. Wastewater is transported to a central collection system consisting of two 1,000-gallon retention tanks. Radioactivity is monitored and an alarm sounds if levels are twice background radiation levels. All water below permitted levels (4×10^{-7} μCi/ml) is discharged to the City of Livermore's sanitary sewer. All water exceeding discharge requirements is transferred via tank truck to the waste management facility.

In addition, below is a description of some of the more hazardous operational parameters from normal operations.

Storage

Plutonium is dangerous to store. Plutonium is primarily found in two forms at LLNL: metal or plutonium oxide. There is also ash and residues that contain plutonium, as well as liquid plutonium nitride. Of primary concern is storing it so as not to exceed a critical mass in any one location, whereby there would be enough neutron activity to start a fissionable event (i.e., criticality accident). This why there are strict mass limits for any one workstation. Second, there are always radiation hazards associated with plutonium.

Most plutonium is stored in double containers. Plutonium metal reacts with oxygen to form plutonium oxides. Release of heat and expansion of volume, which may cause failure of the primary storage container, accompany this reaction. To keep the inner surface of the outer container free of contamination, the first can is often wrapped in plastic bags. In 1994 eight cans of ash residues were found pressurized. A 1998 DOE Report indicated that the entire inventory of had to be vented.

LLNL's Protection Strategy

LLNL has three tiers system to protect against releases of plutonium to the environment. The first are confinement barriers that protect workers from contamination. These include the metal cans for storing plutonium, glovebox enclosures, and glovebox exhaust/filtration systems. All gloveboxes are operated under negative pressure so that under normal operations contaminants flows through the ventilation system. The second tier of confinement refers to the room where the primary confinement system is located. Fire rated doors and barrier walls are constructed to withstand a design basis accident. Typically, each room's exhaust is first filtered by a single HEPA filter and is then conducted to a two stage HEPA system. Room pressure is positive but is lower than corridor pressure.

From 1975 and 1985, LLNL routine releases of all radioactivity to the atmosphere were approximately 4,000 Curies (Ci) per year.[18] In 1990, the Department of Energy (DOE) had an inspection team that evaluated each of the facilities Environmental Health and Safety programs. This inspection team was known as the "Tiger Team". At LLNL, it found that there was "measurable offsite plutonium contamination that was found in high-volume air particulate sampling collected during 1988." This could have resulted from wind-blown particulates from on-site soils, stack emissions, or wind-blown particulates from off-site soils.

Exhaust stacks are also monitored to detect plutonium if it passes through the filters. Facilities using plutonium send exhaust through at least two sets of HEPA filters before exhaust air is emitted to the environment. In1980, plutonium was detected leaving the stacks. HEPA filters are employed to capture fine particles in the exhaust of gloveboxes, from room ventilation systems and from air stacks. They are "the last barrier of protection against the release of particulate radioactivity to the environment at our nuclear facilities". The potential failure of the HEPA filters is of serious concern to Tri-Valley CAREs. Aside from failure of the filters due to degradation, there is concern that two filters in series are not sufficient to capture particles that are in the range of 0.1 micron in size.

Releases to Water

Discharge from the sanitary sewer at LLNL flows to the Livermore Water Reclamation Plant (LWRP). LLNL is the largest user, contributing approximately 30 million liters per month. Most storm sewers are also routed to the LWRP, although some are discharged to a holding pond and to Arroyo Seco. Data indicates that plutonium has been released both acutely and chronically. Although most of the plutonium in the sewage is precipitated with sludge, the remaining liquid is discharged to San Francisco Bay. There are no estimates on how much plutonium was released to the Bay. Even if it is a very small amount, there should be some concern about it.

The largest known release of plutonium to the sewer occurred in 1967, and is documented in the section on **Accidents and Accident Analysis**. LLNL estimates that it released 32 mCi, although the source was never definitively established. It has been speculated that some of the release was from holdup in the old sewer lines, and that construction activities caused the release. In late May 1967 monitors detected a permissible release to the sewer although it was 30 to 100 times normal. By early-June, LLNL increased monitoring frequency. On June 6, levels were approximately 1 to 2 thousand times normal.

[18] LLNL states that these releases are "insignificant" relative to "established standards and those that result from natural background radiation."

Releases to Sludge and Soil

There have been releases of plutonium that have contaminated soils inside and outside of the boundaries of LLNL. Samples taken in 1993 from three public parks in Livermore revealed higher than expected concentrations of plutonium in soil. One location was Big Trees Park, which is one-half mile west of LLNL's boundary. The average level detected at Big Trees Park was 0.164 pCi/g, which is approximately 33 times the highest predicted background level from the largest weapons-testing fallout (0.005 pCi/g). In Big Trees Park, they found one sample of 1.02 pCi/g, almost 200 times what should be expected. At Sycamore Grove and Sunflower State Park also showed higher than expected levels of plutonium in soil. Soil within LLNL fence line also indicated plutonium concentrations up to 11.5 pCi/g.

Cleanup and Monitoring

Plutonium that was found near the Taxi Strip was cleaned up to industrial standards set by EPA (i.e., 10 pCi/g). Approximately 3,000 cubic yards of contaminated soil was excavated and disposed of at either the Nevada Test Site or one of the Class 1 landfills in California (Casmalia[19] or Kettleman Hills). However, during excavation rainfall was abnormally high, suggesting the possibility that contaminated soil particles were carried away by surface run-off to either drainage ditches or were dissolved and made their way into the groundwater.

Prior to 1971, all monitoring of environmental media (air, soil, and water) was done for general radioactivity (i.e., alpha, beta, and gamma emissions).[20] In 1971, specific elements were monitored. Since 1979, LLNL has routinely sampled air from three remote locations in or near Livermore. These locations include the Tracy Fire Station, the LWRP, and the VA Hospital. Each location showed elevated levels of Pu^{239} and Pu^{240} in each year between 1979 and 1983, after which the levels flattened out.

Increases in Levels of Tritium

The proposed action would produce fusion targets on site and raise the administrative limit for tritium storage at LLNL from 30 grams to 35 grams. Further, it would increase the "at risk" limit (i.e., the amount that could be used in a single room/process at any given time) nearly 10-fold, from 3.5 grams to 30 grams, largely because of planned manufacture of the targets. Tri-Valley CAREs strongly objects to this proposed action and objects that targets would be manufactured in such a heavily populated area.

Tritium is a radioactive form of hydrogen. When released into the environment as a gas, tritium combines to make water, significantly increasing its biological toxicity.[21] 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.[22] Research conducted at LLNL on the biological effects of tritium revealed that there was no level studied below which biological damage could not be found.

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. Operating histories show that it invariably escapes when used under high pressures. The amount of tritium released into the environment

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19 Casmalia was named to the Superfund list in 2001

20 Lindeken et al, Environmental Levels of Radioactivity in Livermore Valley Soils, URCL-74424, 4/16/73.

21 According to the National Academy of Sciences BEIR V report, it is estimated to increase toxicity by 25,000 times.

22 According to the National Academy of Sciences BEIR III report.

from LLNL has always been proportional to the level of tritium activity at the site. Increasing LLNL's tritium activity will mean increased exposures for workers and the public. The SWEIS indicates that radiation exposures will go up due to the proposed action. Tri-Valley CAREs has cataloged many discharges of tritium in the past from LLNL. Cumulatively, LLNL has released between 750,000 and 1,000,000 curies of tritium into the surrounding environment since 1960. The levels of tritium have been found to be elevated in rainwater on site at LLNL and in the directly surrounding community, in the wine grapes grown in the valley and in the biomass of other plants locally. In 1989, when LLNL sampled Livermore Valley wines it found that the tritium concentration in our valley wines was four times greater than the tritium in other California wines.

In 1965 and 1973, about 650,000 curies of tritium were released through the stacks of the tritium facility (Building 331) at the LLNL main site. A sampling of annual tritium releases to the environment from 1986 – 1994, as reported by LLNL, is shown on **Table 2**.

The accidental releases documented at LLNL have been the result of many factors, ranging from equipment failure to employee error. There is nothing to suggest that increases in tritium use at LLNL will not result in similar future accidents. In 1991, a DOE Report of the Task Group on Operation of DOE Tritium Facilities listed the accidents occurring between 1986 and 1991, as shown in **Table 3**.

In 1990, in part due to concerns voiced by Tri-Valley CAREs regarding LLNL's tritium contamination, Livermore Lab substantially reduced its tritium use and inventory. In 1991, LLNL stopped filling the test bomb components with tritium on site. Tritium activities at LLNL declined, as did the releases. There is a direct correlation between the decreases in tritium activity and the amounts released to the environment.

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 Site 300 and the Main Site is dealing with tritium.

Table 2: Annual Releases of Tritium from Normal and Accidental Operations 1986 – 1994

Year	Curies Released
1986	1,128
1987	2,634
1988	3,978
1989	2,949
1990	1,283
1991	1,000
1992	177
1993	137
1994	137

Table 3: Accidental Releases of Tritium 1986 - 1991

Date	**Curies Released**	**Cause**
12/15/86	125	failed pump and cryogenic vessel breach
4/14/87	198	equipment failure and operator error
1/19/88	145	unknown cause or stack monitor malfunction
1/25/88	138	unknown cause or stack monitor malfunction
5/15/88	653	unexpected presence of tritium in gases being vented
8/1/88	120	unknown cause or stack monitor malfunction
2/28/89	112	unknown cause or stack monitor malfunction
8/22/89	329	improper pressure relief of container
10/31/89	112	mistaken belief a palladium bed contained only deuterium and (non-radioactive) hydrogen
4/2/91	144	improper preparation of a reservoir

<u>Security and Emergency Response</u>

The SWEIS does not provide sufficient analysis and information necessary to evaluate the adequacy of security and emergency response There is little information on how the Superblock (Buildings 332 and 331) will be guarded in case of internal fire, biological release from bio-terrorism facility and/or other security-related scenarios. Additionally, there are several buildings (e.g., NIF, Building 239) outside the Superblock that will have sufficient quantities of these radioactive materials where security is not certain. We are very concerned that security systems and personnel are not adequate to prevent intentional releases. DOE stated that it continuously evaluates security measures at LLNL and provides improvements as necessary. Yet details concerning security are classified and beyond the scope of the SWEIS.

The entire LLNL complex in Livermore has approximately 150 security personnel. Of these, approximately 50 have received SWAT-like training. Security personnel are not trained to deal with bomb threats; they rely on Alameda County Bomb Unit for support. They are also not trained to for radiological accidents.

Moreover, there has been pattern of security deficiencies at LLNL that have been investigated and reported over the last several years by the DOE Office of the Inspector General, the General Accounting Office and other agencies which raise great concern. Most recently, in order to manage potential risks, DOE developed a design basis threat (DBT), a classified document that identifies the potential size and capabilities of terrorist forces. DOE's DBT is based on an intelligence community assessment. DOE replaced the 1999 DBT in May 2003 to better reflect the current and projected terrorist threats. There is no indication that the SWEIS has been updated to account for a 2003 Design Basis Threat (DBT).

DOE was criticized in April and May, 2004 by some members of Congress and reported by the General Accountability Office (GAO) for its criteria for determining the severity of radiological, chemical, and biological sabotage. For example, the criterion used for protection against radiological sabotage is based on acute radiation dosages received by individuals. This does not capture the damage that a major radiological dispersal at a DOE site might cause. A worst-case analysis at one DOE site showed that a radiological dispersal could result in measurable increases in cancer mortality over a period of decades after such an event. Moreover, releases at the site could also have environmental consequences requiring hundreds of millions to billions of dollars to clean up. Contamination could also affect habitability for tens of miles from the site, possibly affecting hundreds of thousands of residents for many years.

Accidents and Accident Analysis

Tri-Valley CAREs has concluded that accidental releases of radioactive materials, particularly plutonium, are of great concern and that proposed increases in plutonium amounts at the Lab, as well as increases in the "Material - at - Risk" levels are accidents waiting to happen. Furthermore, the accident analysis in the SWEIS is deficient, and considerably underestimates the consequences of a major accident to the public and the workers. As indicated above, plutonium is a highly radioactive, toxic material used in nuclear weapons. There are numerous potential release mechanisms that could allow plutonium to escape to the environment. These include the following:[23]

- Earthquake, causing a breach in containment facilities.*
- Internal fire, spreading plutonium inside and outside LLNL*
- Loss of power that could cause certain safety features to fail, thus causing a release.*
- External chemical spills, or release of toxic gas, which in turn could cause personnel to lose capacity to protect themselves or the public.
- Spill of plutonium powder or liquid. *
- Internal flood, causing a washout of contaminants to the environment.
- Corrosion of piping/ducting, leading to a release to the air inside or outside the facility.
- Foundry accident where water is mixed with molten plutonium, leading to a steam or hydrogen explosion.
- Disposing of plutonium liquids or wastes on-site and allowing environmental factors such as wind and rain to have it migrate to the air or water. *
- Solvent explosion in glove box, leading to an internal or external release. *

[23] This list was compiled based on the following criteria: 1) It was identified in DOE's Vulnerability Analysis of LLNL as having a greater than one in one million chance of occurring in any single year or is a scenario for which security officers are trained; 2) it has occurred at LLNL; or, 3) it has occurred at another DOE facility. Those marked with an asterisk (*) are release mechanisms that have occurred at LLNL.

- Internal/external transportation accident
- Over/under pressurization of gloveboxes, leading to release through the ventilation system. *
- Break in, or loss of glove, exposing worker to radiation, and changing pressure in glove box. *
- Degradation of glovebox seals.*
- Failure to use approved procedures. *
- Failure of storage containers, leading to internal and external releases. *
- Release of fine particles to LLNL sewer system, which discharges to Livermore's Municipal Wastewater Treatment Facility. *
- Break in the sewer line leading to contamination of soil, groundwater or surface water. *
- Leakage from HEPA filters. *
- Degradation of HEPA filter seals, leading to external emissions.
- Ignition of pyrophoric plutonium, associated with machine turnings, metal castings and the plutonium "skulls". In 1969, a major fire occurred at Rocky Flats when a briquette of machine turnings was stored on combustible shielding material. LLNL deals with all of these types of materials on a smaller scale than Rocky Flats.
- Inadvertent mixing of ignitable compounds with plutonium. In 1964, a major explosion at Rocky Flats occurred when an operator mistakenly thought that carbon tetrachloride would be an extinguishing agent for burning plutonium machine turnings.
- Criticality accident, which is the worst case release mechanism. A criticality accident is a runaway nuclear chain reaction, beginning with an intense flash and followed by a release of radiation. *
- Terrorist activity, including biological weapons attack, truck bomb, or an improvised nuclear device using material at LLNL.

Throughout LLNL's operating history there have been releases of plutonium that have exposed workers and the public. The Defense Nuclear Facilities Safety Board (DNFSB) is an independent federal agency established by Congress in 1988. The Board's mandate under the Atomic Energy Act is to provide safety oversight of the nuclear weapons complex operated by the Department of Energy (DOE). Its staff has evaluated LLNL a number of times and the results of its evaluations have been very critical of LLNL's operations. For example, DNFSB Chairman John Conway wrote in 1997 that the number of infractions at Building 332 "raise questions as to whether DOE-OAK is staffed with the technical capabilities necessary to provide guidance" and that "neither DOE-OAK nor LLNL management appears to recognize or fully appreciate all of the problems of hazardous work control" The DNFSB also criticized vulnerabilities at Building 332 from single-point failures. That is, one system could lead to a failure of the built-in safety systems. In its letter of April 11, 2002, the DNFSB stated "The main issue outlined in the Board's letter of December 21, 1999, to DOE was the vulnerability of the Building 332 EPS [emergency power system] to single point failures that would trigger the subsequent loss of one or more of the four separate downstream safety-class systems requiring emergency power. The staff observed that single-point failures still exist in the present EPS, including the example explicitly cited in the Board's previous letter. Furthermore, it appeared that the laboratory has made few tangible attempts to remedy system vulnerabilities associated with single-point failures." The letter concluded that "LLNL [has] a fundamental lack of understanding of system vulnerabilities in the Building 332 EPS." The SWEIS fails to acknowledge the DNFSB's series of negative reports, and LLNL has not taken sufficient corrective action to remedy criticisms in the reports.[24]

An incident in October 2003 provides but one example of the lack of training, and adherence to procedures necessary for storing, handling and experimenting with highly dangerous materials. Twelve workers were potentially exposed when a portion of the power for Building 332 was contaminated because of multiple failures at a glove box. Plutonium in the glovebox should have been sealed; yet, workers eight years ago had decided not to replace the seals on the glovebox. Because the vent system did not maintain negative pressure during the power outage, there was a leak. Other safety systems failed, validating DNFSB's criticism. Many of the tritium accidents at LLNL have also been attributed to human error and/or management or training failures. There has been a longstanding pattern of these accidents involving numerous radioactive and hazardous materials. Taken together, these have caused us to question the training and safety of the Livermore Lab. It further supports TVC's belief that taking on additional plutonium and raising the plutonium and tritium material at risk limits are a mistake.

Table 4 is a list of releases that were reported at LLNL through 1998. These include both internal and external releases. This list does not include management mistakes, human errors, violations of procedures, and potential problems that <u>could</u> have led to releases; nor does it include releases of tritium from B-331.

24 For further reference, see http://www.dnfsb.gov/pub_docs/llnl/index.html.

Table 4: Accidents and Accidental Releases of Radioactive Materials at LLNL[25]

Date	Cause
11/8/60	A curium (Cm^{242}) fire occurred in B-251, releasing several Curies. Some Pu^{238} may have been present.
1953 - 1962	Radioactive liquid wastes, including plutonium, were disposed of in unlined pits in the Taxi Strip area
1962 - 1976	Radioactive liquid wastes, including plutonium, were treated in solar evaporation trays at the south end of the Taxi Strip. In 1973, an unknown quantity of plutonium may have been released to soil during a transfer of dry materials from "solar evaporator". LLNL modified evaporation method to reduce wind dispersal. In 1974, LLNL samples around solar evaporation trays confirmed that there were releases to the environment
3/26/63	An explosion and fire involving enriched uranium resulted from a criticality accident at B-261. The explosion was equivalent to approximately 5.19 pounds of TNT. No person received more than 120 mrem.[26] Release of radioactivity was detected in two buildings that are 350 meters away. Approximately 900 Ci were released.
9/13/65	A plutonium fire in B-332 started, involving about 100 grams of wet plutonium in the form of thin plating. A plastic bag containing the plutonium was left over the weekend and it ignited when the bag was handled on Monday. It was reportedly all contained within building. It took 2 1/2 months to cleanup
4/20/67	A spill of radioactive liquid containing plutonium outside B-332 in an outside storage area. A leaking transfer container caused the spill. It began to rain soon afterwards and there were problems containing the plutonium. After the incident, LLNL changed procedures so that waste no longer stored outside B-332.
5/25/67 - 6/15/67	Release of 32 mCi to sewer. In late May, monitors detected a permissible release to the sewer although it was 30 to 100 times normal. By early-June, LLNL increased monitoring frequency. On June 6, levels were approximately 1 to 2 thousand times normal. It was estimated that sludge would contain 2-3 pCi/g of plutonium. In 1975, tests indicated that sludge contained 2.8 pCi/g of Pu^{239}.
6/16/75	An exothermic reaction sprayed contaminated liquids throughout a room in B-332. It was caused by improper addition of reactive chemicals. Decontamination took 3 weeks.
4/8/80	Burst glove box released 0.26 µCi outside B-332 because of "improperly installed HEPA filters." Operations at B-332 stopped until similar glove boxes were inspected.
4/16/80	Flash fire in glove box caused pressure to blow the window out. Plutonium escaped to room in B-332. Caused by leaving ethanol in glovebox, which when heated volatized in the box and finally exploded.
9/82 - 1983	Pits at Taxi strip are excavated. 1500 cubic yards of radioactively contaminated soil removed and disposed at Beatty Nevada. During excavation, rainfall was abnormally high; suggesting that some contaminated soil particles may have been carried away or dissolved and mixed with groundwater.

[25] Based on a report by TVC Technical Advisor Peter Strauss "Playing With Poison,: Plutonium Use at Lawrence Livermore National Laboratory". Information through 1997.

[26] A mrem is a unit of measurement for radiation, adjusted for biologic affects. There is some controversy about using this measurement, as there are many assumptions about the biological affects. See Glossary under Roentgen Equivalent Man.

3/83	Routine handling of drums at B-612 containing curium, americium, and plutonium spilled on to ground and contaminated at least one worker. Event was discovered day after it occurred because contaminated employee wore the same clothes to work that he had worn previous day. Event involved a sequence of procedural and human errors. First, in 1980, the drums were mislabeled, which consequently resulted in their being placed outdoors for three years. Second, in 1983 workers mishandled the drums, which was a violation of safety procedures (i.e., the appearance of leakage did not cause employees to monitor what was leaking). Third, there was a violation of procedures preventing egress from the waste storage area.
2/86	Two workers received internal dose of 1-rem each because of breach in glovebox. This dose was the "allowable" dose over a 50-year period. No respirators were worn. Caused by degradation of gloves.
5/87	LLNL releases approximately 1 mCi of Pu^{239} to sanitary sewer
1990	DOE inspection team identifies of measurable off-site plutonium contamination as determined by high-volume air particulate samples collected during 1988. (LLNL had not investigated or evaluated the cause until identified by DOE.)
6/28/91	X-ray exposure to worker's hand when worker intentionally bypassed safety interlocks in order to x-ray plutonium part.
7/9/91	Monitoring indicates statistically significant increase in plutonium discharge too sanitary sewer. Average went from 0.21 µCi per month during first 7 months of 1990 to 1.25 µCi per month from 8/90 through 5/91. Later report indicates that this increase was probably due to sewer cleaning activities.
10/24/91	Double bag of plutonium powder tore and was spread on floor. Worker received small amount in nasal passage.
10/5/92	While working in glovebox at B-251, worker punctures glove and thumb with curium-244 contaminated material.
10/29/92	Two workers contaminated after can of plutonium oxide is placed in bag. No inhalation occurred.
1994	EPA discovers plutonium in three city parks that are above background. The highest levels occur in Big Trees Park, which is adjacent to Arroyo Seco Elementary School. This park is approximately one-half mile from the LLNL boundary
2/7/96	DOE reported that LLNL couldn't account for 5.5 kilograms (12 pounds) of plutonium in its stockpile. This could be attributed to releases to the environment, quantities that remain bound in the ventilation and sewer systems, theft, or incorrect weighing of the plutonium.
8/5/96	Several basement ducts reported contaminated
12/26/96	Worker's hand is contaminated with radioactive material.
2/3/97	Worker's hand is punctured during glovebox operation.
2/7/97	Complete HEPA filter failure at B-321, releasing depleted uranium.
7/2/97	Personnel contaminated after shredding a HEPA filter at B-513. The HEPA filter was contaminated with over 500 times the limit of curium. Five workers were exposed to doses 3 to 5 times regulatory limits. The DOE issued a Notice of Violation to LLNL, describing "numerous failures by your organization to implement established radiological protection requirements and quality controls necessary to protect workers. These failures occurred multiple times…"
12/11/97	Some HEPA filters show leak rate of 0.04% as opposed to the standard of 0.03%. Filter gaskets could also be source of leaks.

In order to make an informed decision whether to expand or reduce activities at LLNL, it is essential to look at the potential consequences of each alternative. This goes to the heart of NEPA, under which the SWEIS was prepared. The Accident Analysis in the SWEIS, in our opinion, is deficient for a number of reasons, and does not inform the reader or DOE of the full consequences of its actions. The major reasons are articulated below:

The analysis only considers small single-engine aircraft in the airplane crash analysis: An airplane crash is the bounding accident for several of the buildings containing radioactive waste and materials such as plutonium. [27] The analysis excludes commercial jet liners originating from San Jose, Oakland, San Francisco International Airport, Sacramento, and military aircraft originating from Moffett Airfield. These airports are all within 50 miles of LLNL. Thus, the airplane crash scenario assumes that only a small single engine aircraft originating within 20 miles of the site would be involved in an accident.

The analysis only considers latent cancer fatalities (LCF), and does not include other health effects: If any of the accidents were to occur, there would be severe effects that would result, including non-lethal cancers and a number of diseases. Because of the long-lived isotopes (e.g., highly enriched uranium and plutonium) involved in some scenarios, the residual risks of disease from an accident would last centuries, and may in fact outweigh latent cancer effects. The accident analysis considers these effects secondary, and there is no analysis.

The costs from a catastrophic accident are not considered: There is no analysis of the cost of an accident that spreads radiation outside of the Lab. Not only is this vital in weighing the alternatives, it is critical information that should be fully understood before pursuing an action. The Lab is situated in a residential area and is bounded by a rich agricultural region. A major accident could have enormous economic consequences, not only for rebuilding the parts of LLNL that were involved, but cleaning up areas outside the Lab, relocating residents, lost agricultural capability, and monitoring health of affected residents. For comparison sake (there really is no good comparison) the accident at Three Mile Island cost over $1 billion for cleanup, not including the lost cost of the reactor (costing hundreds of million dollars). The accident analysis considers economic effects secondary, and there is no analysis.

The derivation of accident frequencies, except for the small airplane crashes, is not provided: These frequencies are given as a range with no explanation. Accident frequency is so important in measuring the potential consequences of alternatives, that without an explanation, we cannot evaluate whether they are reasonable.

The seismic effects of an earthquake may be understated: The earthquake scenario assumes a 1 g[28] ground surface acceleration (as opposed to 0.6 g used in the Environmental Assessment for the BSL-3 facility). However, a 1991 study by Geomatrix Consultants concluded that acceleration of up to 2.5 g is expected in some structures. Therefore we are concerned that even the g-force number in the SWEIS may underestimate the destruction that may occur at the Livermore Lab.

LLNL has ignored the Defense Nuclear Facilities Safety Board's (DNFSB) critique of assumptions used in accident modeling: In April 2004, the DNFSB strongly criticized LLNL's accident analysis. In part, its report states "LLNL is pursuing a new approach to accident analysis in that potentially harmful consequences to the public are mitigated by the structural boundaries of Building 332, which is assumed to reduce the unmitigated release of radioactive materials. In the past, Building 332 relied on a safety-class active ventilation system to ensure that the radioactive materials released during an accident, such as a fire, would be forced through a series of high-efficiency particulate air (HEPA)

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27 A bounding accident is the most severe postulated event that is less than one in one million chance of occurring.

28 A g is used as a measurement of ground acceleration and is a more accurate way than the Richter Scale of estimating the potential damage to structures.

filters before being released to the outside environment. Under LLNL's new approach, it is assumed that the building's leak paths would physically reduce the release of unfiltered contaminated air from the facility." Furthermore, a previous letter on March 25, 2003 stated that the "inadequacies included postulated accident scenarios for which unmitigated consequences had been evaluated to exceed the off-site evaluation guidelines, but for which no safety-class controls had been identified."

There is not a recognition of a pattern of failures of the emergency diesel generators: Buildings 331 (tritium facility) and 332 (plutonium facility) have emergency diesel generators (EDGs) to provide power in the event of an interruption in power supply. These systems would supply pressure for water, ventilation, and actuate other emergency equipment. During the 1990's, the EDGs at B-332 failed routine tests five times. The accident scenarios should not presume that the EDGs will be working, both to run the ventilation system and other emergency equipment. Therefore, all accident scenarios should assume a loss of total power. This affects the fire suppression system, alarms, and security doors. A credible scenario of an unfiltered fire with no power should be analyzed. It is important to note that in October 2003 a plutonium accident resulted in a dozen lab employees potentially being exposed to airborne plutonium because glovebox seals, an emergency generator, an alarm system and negative airflow system all failed simultaneously.

HEPA Filter Failure: HEPA filters are assumed to mitigate most accident scenario releases. However, during a fire, both the filter and the seal are prone to failure, as the filter is made of fiberglass paper and would lose its filtering capability when wet (fire suppression) and would be severely damaged by high temperatures.

Environmental Effects: The SWEIS fails to document and take account of environmental effects in its accident analysis. These effects were considered secondary.

Other Issues Relevant to the SWEIS

1. Using the Precautionary Principle

The SWEIS should incorporate all aspects of the Precautionary Principle into its analysis and decision making process. The Precautionary Principle states that when an activity raises threats of harm to the environment or human health, precautionary measures should be taken even if some cause and effect relationships are not fully established scientifically and that the proponent of an activity, rather than the public, should bear the burden of proof.

2. Analyzing of an Enhanced Civilian Science Program

Ten years ago, Tri-Valley CAREs undertook a study of how LLNL could be converted to an unclassified civilian science lab using DOE's existing budget lines, resulting in a vast reduction in environmental impact and a vast increase in community and worker involvement. The study provided a framework and some very relevant criteria for framing the new civilian science alternative in the SWEIS. The DOE rejected conducting any analysis of the very reasonable alternative of transitioning Livermore Lab in whole or in large part to civilian science purposes.

3. Analyzing Cumulative Impacts of Radioactive Materials

The proposed action signifies a major expansion of programs at LLNL and therefore the SWEIS should make a substantial effort to analyze the cumulative impacts of all programs at LLNL in relation to the burdens that the workers and the community already bear. The SWEIS omits evaluation of the cumulative effects of a number of its proposed actions. For example, the SWEIS should carefully evaluate the releases of plutonium and tritium from the Livermore Lab and how that may affect the health of the community in light of the current proposals to substantially increase the work with plutonium and tritium at LLNL.

4. Analyzing Plutonium Use at the National Ignition Facility

The SWEIS outlines plans to add plutonium, highly-enriched uranium, lithium hydride and other new materials to experiments in the National Ignition Facility (NIF). Some of the planned plutonium experiments will involve fissioning the material. Adding fissile and fissionable material to NIF experiments provides a new utility to its use for nuclear weapons design as well as creating radioactive fission products. Workers and possibly the community would be exposed during operations.

A report by the General Accounting Office (GAO) suggested the reasons for using plutonium at NIF. It stated:[29]

> *Los Alamos National Laboratory officials believe that using plutonium in NIF and achieving robust (repeatable) thermonuclear ignition are key to NIF's value in the area of studying weapons primaries.*

5. Analyzing the BSL-3 Facility and Biological Programs

The SWEIS does discuss in full LLNL's Biology and Biotechnology Research Program (BBRP) and the controversy regarding whether LLNL is the best suited entity for going forward with a higher risk set of programs, such as operating a Bio-Safety Level-3 (BSL-3) facility, in the BBRP. The potential effects of adding yet another facility that uses deadly material is disconcerting. Tri-Valley CAREs maintains the position that BSL-3 level advanced bio-warfare agent research should not be conducted inside LLNL for several reasons. First off, it poses yet another catastrophic hazard to the community. As discussed above, LLNL has a long history of accidental releases of radioactive materials. Second, the Secretary of Energy has publicly spoken out about the security deficiencies at Livermore Lab. The bio-warfare agent storage poses the same kinds of security (e.g., "terror attack" or sabotage) concerns. Moreover, we note that the BSL-3 is planned as a portable building in an area with less security than the Superblock (where the plutonium is stored). Finally, the protection criteria for biological sabotage are based on laboratory safety standards developed by the U.S. Centers for Disease Control and not physical security standards. Therefore, the security risks may be greater. This should have been fully analyzed in the SWEIS.

6. Evaluating Whether Continued Plutonium Research at LLNL is in the National Interest.

LLNL is one of two weapons design laboratories (LANL being the other) that experiments with plutonium, and it is not clear that this research needs to take place at both locations. The Laboratories were set up so that weapons designers could compete against one another in America's pursuit to develop the "best" nuclear weapons. With the demise of the cold war, this competition is no longer important, if ever it was. Maintaining two weapons design laboratories that experiment with extremely hazardous substances is not only an extraordinary expense, but it also increases security and proliferation risks substantially. The SWEIS does not approach this issue and while we believe it should have, we recommend that DOE conduct an independent evaluation.

7. Implement a detailed employee and community health database and uniform radiation data collection system.

As a potential response to the increased dosages that the public will receive from the proposed activity at the Lab, we recommend that DOE begin this effort. [30] It is unclear whether LLNL has compiled a database on employee health and relates that to radiation

[29] GAO-01-677R Follow-up Review of DOE's National Ignition Facility, June 1, 2001

exposure. As some community members have also been exposed, it would be prudent to compile a database to help establish potential links between disease and radiation for the surrounding community.

[30] This recommendation was first made by the Physicians for Social Responsibility concerning employee health, radiation exposure and its links to disease. This report reiterates this recommendation, and has added a community component. See Geiger, Rush et al, Dead Reckoning: A Critical Review of the Department of Energy's Epidemiologic Research, Physicians For Social Responsibility, 1992, p.13.

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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 3.7×10^{10} 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 compound	A compound containing molecules of chlorine, bromine, iodine, and/or 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 Pyrolysis/Oxidation	This technology adds oxygen in parallel with steam. When injection is 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.
μg/L	micrograms per liter (equal to parts per billion, or ppb)
μg/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 or compound	A substance produced by animals or plants that contains mainly carbon, hydrogen, and oxygen.
Ozone	A form of oxygen (0_3) 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 (physical/chemical) A physically distinct and separable form of matter that may be a single 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 alpha-particles, 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.