# STATE OF THE SUPERFUND CLEANUP

## Hazardous and Radioactive Pollution Issues at Lawrence Livermore National Laboratory Site 300

Prepared by

Peter Strauss
PM STRAUSS & ASSOCIATES

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A Tri-Valley CAREs Report

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**About the author:** Peter Strauss is an environmental scientist and has served as Tri-Valley CAREs' Technical Advisor since 1991 on the Superfund cleanup of the Livermore Lab Main Site in Livermore and its Site 300 high explosives testing range near Tracy. His responsibilities include providing detailed analysis of soil and groundwater contaminants and their migration through the environment at both locations.


**About Tri-Valley CAREs:** The nonprofit was founded in 1983 as a nuclear weapons watchdog organization. Tri-Valley CAREs' mission includes achieving a comprehensive cleanup of leaking toxic and radioactive wastes at Livermore Lab and preventing further contamination. Tri-Valley CAREs was the first group in EPA Region IX to win a Technical Assistance Grant (in 1989). The group's program involves affected community members in Superfund cleanup decision-making. Tri-Valley CAREs conducts outreach and produces materials in English and Spanish. Visit us at www.trivalleycares.org or at our offices in Livermore and Tracy, CA.


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## STATE OF THE SUPERFUND CLEANUP

### Introduction

The purpose of this report is to familiarize the community members with the status of the Superfund cleanup at Site 300, managed by Lawrence Livermore National Laboratory (LLNL). 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 National Laboratory Environmental Restoration Division, as well as meetings with the regulatory agencies and the Department of Energy. It also incorporates information obtained through our role as Technical Assistance Grant recipient and other funded research projects.

LLNL was founded in 1952 by Edward Teller and E.O. Lawrence to develop the hydrogen bomb, thus becoming the United States' second nuclear weapons design lab after Los Alamos National Laboratory in New Mexico. The Site 300 Superfund site is LLNL's high explosives testing range near the City of Tracy. It tests all the components of a nuclear weapon, except those that are "fissile" . That is, in nuclear reactions, fissile material is capable of sustaining a chain reaction. By definition, fissile material can sustain a chain reaction with neutrons of thermal energy. Site 300 has soil and groundwater that are contaminated with toxic and radioactive materials. Cleanup of both is projected to last until the end of the 21st century.

This summary highlights some of the progress and issues involved in cleaning up Site 300. Site 300 is Livermore Lab's high explosives testing facility. It is located in the Eastern Altamont Hills 17 miles east of Livermore and about 10 miles west of downtown Tracy. It encompasses 11 square miles along Corral Hollow Road. Over the years, Tracy has expanded and a major residential development is proposed near Site 300. 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. The lower HSUs make up the regional groundwater system.

Since it was founded in 1955, Site 300 operations have included open-air blasts with high explosives and radioactive materials used in nuclear weapons. Site 300 activities have polluted soil, surface water, springs and regional groundwater aquifers with chemical and radioactive wastes including solvents, dioxins, furans, PCBs, perchlorate, high explosive compounds, metals, and radionuclides (namely tritium and depleted uranium). An off-site groundwater plume contaminated with solvents has migrated from Site 300 and traveled under Corral Hollow Road and the nearby Corral Hollow Creek.

Releases to the environment occurred from a variety of spills, leaking pipes, leaching from unlined landfills and pits, high explosive test detonations, and disposal of waste fluids in lagoons and dry wells (sumps). Current operations at Site 300 include contained detonations, open-air blasts, explosive and hazardous waste burning, and radioactive and hazardous waste storage. Prevailing winds blow contamination into the Central Valley, and, particularly, toward Tracy and surrounding communities.

In 1990, because of the magnitude of this contamination, Site 300 was added to the federal Superfund site. LLNL recently acknowledged that it is uncertain when cleanup at Site 300 will be completed, if ever. The contamination is widespread and complex, and Livermore Lab estimates that its cleanup at Site 300 will cost around $1.8 billion.

To better manage the cleanup, Site 300 was divided into nine Operable Units (OUs). These are:

- General Services Area (GSA) (OU 1)
- Building 834 (OU 2).
- Pit 6 Landfill (OU 3).
- High Explosives (HE) Process Area (OU 4).
- Building 850/Pit 7 Complex (OU 5).
- Building 854 (OU 6).
- Building 832 Canyon (OU 7).
- Site-Wide (OU 8) including Buildings and Pits that have not been characterized or don't pose a risk.
- Building 812 (OU 9).

**Figure 1** shows the relative location of each OU along with the contaminants of concern.

## A. Accomplishments[1]

By the end of 2016, 433 million gallons of groundwater had been treated to remove contaminants at Site 300. During 2016, 10 million gallons of groundwater and 81 million cubic feet of soil vapor were treated. VOCs, perchlorate, nitrate, RDX (an explosive), silicon oil, and total uranium were removed. However, almost 99 percent of the contaminant removed was nitrate, while VOCs accounted for only 6.8 kilograms (kg) and all other additional compounds accounted for less than a kilogram. **Table 1** shows the cumulative amount of contaminants removed by Operable Unit through 2016.

[1] 2016 is the latest year that we reviewed cumulative volume of contaminants removed for this report. Although increases in contaminant mass removed have increased, the rate of mass removal has decreased substantially.

**Table 1: OUs and Gross Cumulative Volume of Contaminants Removed (2016)**

| Operable Unit | Volume of Groundwater Treated (thousands of gallons) | Volume of Contaminant Removed from Groundwater (kg) | Volume of Contaminant Removed from Soil (kg)* | Total Mass Removed (kg) |
|---|---|---|---|---|
| GSA | 333,500 | 35 | 78 | 113 |
| B-834 | 1,366 | 47 | 360 | 407 |
| Pit 6 | NA | NA | NA | NA |
| High Explosives Area | 39,424 | 3,493 | NA | 3,493 |
| B-850/Pit 7 | 222 | 42 | NA | 6 |
| B-854 | 22,255 | 4,174 | 14 | 4,188 |
| B-832 | 31,900 | 3,995 | 56 | 4,051 |
| Site-Wide | NA | NA | NA | NA |
| B-812 | NA | NA | NA | NA |
| **Total** | **443,465** | **18,814*** | **508** | **19,222*** |

* These amount may be somewhat misrepresentative because nitrate accounts for approximately 17,000 kg removed from groundwater.

1. <u>GSA</u>

Eastern GSA reduced TCE to below MCLs, and in 2012 the cleanup was declared complete and closed out. The central GSA operates a groundwater treatment system (GWTS) and a soil vapor treatment system (SVTS). The former is an air stripper that then mists the water for vegetation. The latter uses a carbon-based filter known as granulated activated carbon (GAC), to remove solvents from the vapor. Both systems are effective, although the GWTS was inhibited by the drought. Seventeen monitoring wells are installed south of the Site 300 boundary in three water-bearing zones. Historically, Volatile Organic Compound (VOC) concentrations have been reduced by about 272,000 part per billion (ppb) in 1992 to a maximum of 1,360 ppb (at the source) in 2016. In 2016, VOCs were detected south of the boundary in two monitoring wells (83 ppb and 28 ppb respectively).

In 2018, DOE/LLNL submitted a workplan for sampling per- and polyfluoroalkyl substances (PFAS) in groundwater at the Eastern GSA. PFAS belong to a class of highly toxic emerging contaminants that are undergoing increased scrutiny by state and federal regulators. PFAS have been used in an array of consumer products and commercial applications. Decades of heavy use have resulted in contamination of water and soil. PFAS are detected in the blood of 99% of people worldwide. PFAS are very persistent in the environment and bioaccumulate in humans and animals. We do not have enough information to determine why the regulators asked for sampling at this specific site, or the results of the sampling.

2. B-834

Contaminants of concern are VOCs, TBOS/TKEBs (a silicate oil), and nitrate. B-834 has a GWTS and a SVTS. The contaminants have been identified in two HSUs. VOC concentrations have decreased from 1,100,000 ppb in 1988 to 50,000 ppb in 2016. TBOS/TKEBs concentrations have decreased from historic maximum of 7,300,000 ppb to 50 ppb. Nitrate concentrations were 380,000 ppb, in contrast to the 45,000 ppb drinking water standard. An enhanced in-situ (in place) bioremediation study treatability study for VOCs has been ongoing since 2005. Concentrations have decreased by two orders of magnitude. Besides groundwater risks, there is a risk from indoor air exposure, and building occupancy restrictions and monitoring are in place.

3. Pit 6

Pit 6 is near the southern boundary of Site 300. It was used from 1964 to 1973 to bury waste in nine unlined trenches. Waste included shop waste and animals. It was capped in 1997. The remedy for nitrate and VOCs in groundwater near Pit 6 is monitored natural attenuation (MNA). There are two active water supply wells across Coral Hollow Rd. that provide water for the Carnegie State Vehicular Recreation Area. These wells are monitored on a monthly basis. VOCs in monitoring wells on site had only one occurrence of a well above drinking water standards. Nitrate was also detected in groundwater above MCLs, possibly due to a nearby septic system. This drinking water well is used to fill a pond off-site. The VOCs emanating from Pit 6 need to be carefully monitored. Based on the latest data, these levels meet drinking water standards. Spring 7 in this OU is contaminated by VOCs and poses an inhalation risk.

4. High Explosive Process Area (HEPA)

The HEPA Operable Unit (OU), located near the southern boundary of the site, covers a large area. HEPA was used for chemical formulation, mechanical pressing and machining of explosive detonators. Groundwater contamination is attributed to high explosive discharges into unlined lagoons, as well as a minor source from leaking waste stored at a waste accumulation area. Five groundwater treatment systems (GWTSs) operate at the site, removing VOCs, high explosive (HE) compounds, perchlorate and nitrate. Contaminants were found in the upper three HSUs. All of the wells sampled for VOCs had relatively low detections – none exceeding 50 ppb. HE contaminants and perchlorate have been reduced by over 50% from historic maximums, and nitrate has been reduced by one-third. VOCs were not detected in the off-site water supply well (GALLO1), and VOCs in guard wells remained low and stable. Spring 5 in this OU is contaminated by VOCs and poses an inhalation risk.

5. <u>Building 850/Pit 7 Complex</u>

High explosive experiments were conducted at the B-850 firing table from the 1950s through 2008. It was set in a topographically low area, so that debris from experiments would be contained within the walls of the surrounding hills, as well as reducing air pressure waves. The firing table was used to test detonators for nuclear weapons and armor piercing projectiles. Over 95% of the 22,670 curies of tritium used at Site 300 were used at the B-850 firing table.

Firing tables were covered with gravel to absorb shock. They were rinsed after each experiment to reduce dust. Infiltrating water mobilized chemicals from the gravel to the underlying groundwater and bedrock. Until 1988, the contaminated gravels were removed every 3 months and disposed of in unlined pits to the north, known as the Pit 7 Complex. This complex is a series of pits approximately one-half mile from the northern boundary of the site. (After 1988, gravel from B-850 was transported to the Nevada Test Site.)

This OU is easier to understand if it is subdivided into the B-850 area and the Pit 7 Complex.

<u>B-850</u>

In 2009, at B-850, 27,592 cubic yards of soil containing PCBs, dioxin and furan were scraped from the hillsides and solidified into a 20-foot high monolith. Other contaminants in the soil including depleted uranium (DU), high explosive materials, and metals were also collected. This monolith is inspected after each storm event, and twice per year. It has not shown any signs of deterioration.

Two groundwater HSUs beneath B-850 are primarily contaminated with tritium and perchlorate. There is also some nitrate, HE compounds and DU. There is no aboveground GWTS. During 2016, the following has taken place:

- Tritium degraded from a historical maximum of 566,000 pico curies per liter (pCi/L) to below 20,000 pCi/L in 2016.

- DU has remained stable, and only one well contained groundwater slightly exceeding the 20 pCi/L cleanup standard for uranium.
- At B-850, there was a pilot study begun in 2011 to treat perchlorate by in-situ bioremediation. In the treatment zone there were a number of detections around 40 ppb (the reporting limit is 4 ppb and the California drinking water standard is 6 ppb), although most detections have been reduced to below 6 ppb. In the source area, perchlorate levels ranged from 10 ppb to 65 ppb.
- In July 2019, LLNL completed the RI/FS. The RI/FS posed two alternatives: continued bioremediation or Monitored Natural Attenuation. The former would cost about $10 million and take about 13 years to reach cleanup objectives. MNA would cost two thirds of that but would double the time to reach cleanup goals. The Focused RI/FS process will lead to the selection and subsequent implementation of a cost-effective remedial action to protect human health and the environment. The selected remedy for perchlorate in the Building 850 Area will be incorporated into an amendment to the existing Site-Wide Record of Decision. The final Proposed Plan and Public Meeting is currently scheduled for 2025.
- Nitrate is also being studied for in-situ bioremediation, in the same treatment zone as perchlorate. Concentrations decreased from pre-test 57 parts per million (ppm) to 0.5 ppm. Uranium in this treatment zone was also reduced to approximately 3 pCi/L.
- Groundwater samples for the HE compound RDX is slightly above the MCL (1 ppb).

In 2016, a Five Year Review was prepared for this area. In addition to perchlorate mentioned above, other HE compounds were detected in groundwater during this review. The Five-Year Review also recommended an extraction well at Pit 7 be installed to optimize uranium extraction.

In this OU Spring 8 is contaminated by tritium. In 1972, levels were 770,000 pCi/L. Although tritium activity levels have decreased over the decades, in 2009, the monitoring indicated a potential inhalation risk. Surface water is sampled semi-annually. In 2014, because of drought conditions, surface water was not present.

<u>Pit 7 Complex</u>

The Pit 7 Complex is a series of unlined pits that was filled with gravels from firing tables and other debris. After these pits were filled, they were covered with soil. During some heavy storm events, groundwater levels rose as much as 10 feet, inundating the pits and washing contaminants out. The pits have leaked uranium, tritium (radioactive hydrogen), perchlorate and other contaminants into the groundwater at high concentrations. Historic highs of tritium reached 2,660,000 pCi/L. Maximums in 2016 were 281,000 pCi/L. These levels, while greatly reduced, are still an order of magnitude greater above the federal drinking water standard (20,000 ppb). Because tritium in water is difficult and extremely costly to remove from water, the remedy that addresses tritium most directly is called Monitored Natural Attenuation (MNA). Tritium has a half-life of a little more than 12 years, so this contaminant is allowed to stay in the groundwater while it decays.

In addition to MNA, in 2005, LLNL constructed a series of drains upstream from the pits and diverting runoff into another area (i.e., the Drainage Diversion System). This was intended to mitigate the groundwater level rise, thus hydraulically controlling the migration of tritium. Prior to 2005, for every inch of rainfall, the groundwater level at the pits would rise an average of 5 inches. In 2011, data indicated that it reduced the rise in groundwater by 20%. In 2016, the 2016 Annual Report states that groundwater levels "remained well below the bottoms of the Pit 7 Complex Landfills." However, 2017 and 2018 had higher than normal rainfall, and Drainage Diversion System did not keep all water out of the pits. EPA deferred its long-term protectiveness with respect to this system until DOE completes an engineering evaluation to make the DDS effective or modifies the remedy. In December of 2019, LLNL outlined a workplan to address this problem. DOE proposed to evaluate: DDS capture and diversion; performance of the DDS; and mechanisms for DDS failure. Potential remedies for reducing groundwater recharge to prevent pit inundation include those previously evaluated ibn the 2005 Pit 7 RI/FS, such as:

- In situ stabilization
- Hydraulic barriers (slurry walls)
- Hydraulic Diversion (with additional surface drains or deepening of the DDS)
- Landfill Removal

DOE will also include unnamed new innovative technologies in this list as deemed appropriate. The engineering evaluation will be completed no later than September 2021.

The current remedy also uses a GWTS to extract and treat uranium, and perchlorate. Uranium activities have been reduced to historical highs of 781 pCi/L to 132 pCi/L in 2016. Perchlorate has been reduced from 40 ppb in 2009 to 14 ppb in 2016. Nitrate has been reduced from a historic high of 363 parts per million (ppm) in 2003 to a maximum of 65 ppm in 2016.

6. <u>Building 854</u>

This building complex was used to test the stability of weapon components under various environmental, mechanical and thermal conditions. Contaminants at this site include VOCs, nitrate and perchlorate. The remedy for this site involves 3 GWTSs and one SVTS. VOCs have been reduced from a high of 2,900 ppb to 69 ppb in 2016. Perchlorate was reduced from a maximum of 27 ppb to 15 ppb in 2016. Maximum nitrate in 2016 was 200 ppm. In 2017 an enhanced in-situ bioremediation treatability study will be initiated to reduce perchlorate at this OU.

7. Building 832 Canyon

Much like B-854, B-832 facilities tested stability of weapons components under various conditions. Contaminants were released through leaking pipes and spills. Three GWTSs and 2 SVTS are operated. VOCs are primary contaminants, with perchlorate and nitrate being secondary contaminants. As this area drains south, it has contaminated 5 HSUs. B-830 in this OU has a risk from indoor air exposure and building occupancy restrictions and monitoring are in place. Since remediation began in 2000, in the B-830 source area, VOC concentrations have been reduced from a maximum of 10,000 ppb to a 2016 maximum of 660 ppb in the upper HSU, and 1,900 ppb.

8. Site-Wide OU

The Site-Wide OU is comprised of sites where there have been releases, but LLNL has not found unacceptable risks to health or the environment "at present". This may be due to under-characterization, or there is in fact no unacceptable risk. This OU contains a firing table (B-801) and a nearby landfill (Pit 8, covered in 1974), B-833 (where TCE was released), B-845 firing table and nearby Pit 9 (DU and HE compounds), and B-851 Firing Table (DU releases). At present, only nitrate slightly exceeds drinking water standards at Pit 8. At B-833, TCE has been reduced substantially to 110 ppb. At B-845 and Pit 9, contaminants were all below cleanup levels. At B-851, several monitoring wells were drilled. Soil and rock samples indicated depleted uranium at the surface to 2.5 ft. As a consequence, staff is conducting is conducting a surface-soil gamma radiation survey in several phases. Phase 1 was in a 700-foot radius of B-851. The 700 ft radius was determined because there are special status species and critical habitat in the vicinity. A larger radius would require a Biological Opinion from US Fish and Wildlife Service. Thus, the results are not conclusive.

Additionally, LLNL identified three potential release sites at the B-865 area. VOCs and insulating oil were used at this site and may have been released from tanks, storm drains or a surface impoundment. Although not officially part of this OU, the area overlaps Pits 1 and 2. After characterizing the site, a DOE/LLNL staff are preparing an RI/FS. In July of 2019, the Lab submitted Part 1 of the RI/FS. Analytical data for metals and radionuclides will be presented and evaluated to define any remedial actions necessary to address any threats to humans and the environment in an addendum (Part 2) to this RI/FS document. The addendum RI/FS will be prepared after updated background concentrations are finalized for metals and radionuclides in Site 300 surface and subsurface soil. Part 2 is scheduled for 2022. The final Proposed Plan and Public Meeting is currently scheduled for 2025.

The Part 1 RI/FS found that PCE, Freon 113, and Freon 11 concentrations in groundwater in excess of background should remain within Site 300. Freon

113 in Building 865 groundwater is stable or declining. PCE is the only contaminant consistently detected at concentrations in excess of the MCL in groundwater at Building 865. Statistical analysis was used to estimate the time for all PCE concentrations in groundwater at Building 865 to decline to below its 5 micrograms per liter (μg/L) MCL. Based on the analysis, the maximum concentration of PCE will decline to below 5 μg/L by 2023. Based on estimated current attenuation rates, the estimated cleanup time to the PCE reporting limit of 0.5 μg/L is within 45 years. Based on observed plume behavior, the PCE plume would likely not migrate beyond Site 300 during this time period. Therefore, monitored natural attenuation is recommended for this contaminant.

Additional wells were drilled this year to define the extent of saturation and serve as a guard well for contaminants in groundwater emanating from the Building 865, Pit 8, and OU 5 source areas.

9. Building 812 Firing Table

B-812 and associated buildings were one of the last open-air firing tables used to detonate nuclear weapons experiments with Uranium-238. The area encompasses about 200 acres in the east-central part of Site 300. Four HSUs have been identified in this area, and the upper three had detections of uranium isotopes exceeding the MCL. The hillsides, canyons and groundwater in this area are contaminated, as is a nearby spring.

LLNL has undertaken an extensive soil survey in the Building 812 area to determine the extent of the Uranium-238 contamination, and a soil and biotic sampling effort to determine the radioactive material's deposition depth and uptake in plants and animals. The sampling has taken a long time, and there were many complications. Regulators have concurred that 11 potential release sites were adequately characterized. At two of these sites: the firing table and the gravel pile near the firing table, were deemed to be release sites. In 2017 DOE/LLNL agreed to conduct additional characterization at 10 additional sites. The status of characterization will be decided after this additional work has been completed. The final Proposed Plan and Public Meeting is currently scheduled for 2025.

Related to the work at B-812 and B-851, there is an ongoing study to determine background levels for uranium at Site 300. These background levels will be used in risk assessments at these firing tables. A recent presentation entitled "Update and Proposed next steps for completing a background Data set for LLNL Site 300 soil" established that taking a data set from Mt. Diablo State Park as well as bedrock samples would be used to support a background level of metals at Site 300.

## B. Issues

### 1. Funding Commitments

A basic concern is whether funding commitments are sufficient to ensure long-term cleanup and achievement of project milestones. Cutbacks in funds only delay inevitable expenditures and may make cleanup more costly. Long-term funding for cleanup should be a major commitment, and DOE and LLNL should make all attempts to ensure future funding.

### 2. Complete Cleanup

Wherever possible, Tri-Valley CAREs (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.

### 3. Relaxing Policy for Cleanup

Historically, TVC is very concerned that there will be a relaxation of cleanup. This is especially true in 2017 as there is a concerted push to re-evaluate cleanup at major sites. We are concerned that active remediation will shift to passive remediation or that sites will receive waivers from meeting cleanup standards. DOE, because of its massive cleanup around the country is currently searching for new rationales regarding relaxation of current cleanup standards and methods.

### 4. 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".[2] 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. 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 activities (such as the state archive or library) and from the National Archive system.

### 5. California's Drought

Because of limited recharge due to the drought combined with continued groundwater pumping, there were declining ground water levels and yields at many extraction wells. Although we gained significant relief in the drought

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

in the last two rain years, long-term prognosis is that we will continue to experience declining rainfall. This makes the development of the in-situ technologies ever more critical, as well as making sure that all water that is treated above ground be recharged in the aquifer zone or HSU from which it was extracted.

### 6. Remediation of open air firing tables (Building 812)

The Superfund cleanup at Site 300 is entering a new and important phase extending well beyond 2015. Cleanup is starting at one of the last open-air firing tables that had been used often to detonate nuclear weapons experiments with Uranium-238. The area encompasses about 200 acres in the east-central part of Site 300. The firing table is located almost directly over an earthquake fault. The hillsides, canyons and groundwater in this area are contaminated, as is a nearby spring.

In soil samples taken 5 feet below the firing table, total uranium has been measured at a concentration of 22,700 picocuries per gram. For comparison, a DOE report lists the proposed soil cleanup standard for uranium at Building 812 as 3.1 picocuries per gram. This may have been an anomaly, as the sampling method may have detected a piece of DU.

In 2008, LLNL prepared a draft RI/FS for this OU. This document was tabled in order for LLNL to undertake an extensive soil survey in the Building 812 area to determine the extent of the Uranium-238 contamination, and a soil and biotic sampling effort to determine the radioactive material's deposition depth and uptake in plants and animals.  The sampling has taken a long time with many complications. Because of the steep slopes surrounding the firing table, LLNL used a robot to detect radiation for much of the hillsides surrounding the firing table, supplemented by hand-held detectors in areas where the robotic detectors could not access. As mentioned above in the description of B-812, DOE/LLNL have agreed to characterize 10 additional potential release sites.

### 7. The Pit 7 Complex

The "Pit 7 Complex" has leaked uranium, tritium (radioactive hydrogen) and other contaminants into the groundwater at high concentrations. A remedy has been selected at that area, but the remedy allows the most contaminants to be left in place, with others (e.g., uranium) being removed from groundwater. A series of drains and other engineered features have been installed to prevent rainwater from entering the pits and further dispersing the pollutants. Because this remedy has not performed as anticipated, EPA withheld its signature on its long-term protectiveness. DOE, as discussed above, is preparing an engineering evaluation that will include  potential remedies.

### 8. Remediating Perchlorate in Numerous Areas

Perchlorate is used in explosives and is found in several locations throughout the site. Perchlorate was an emerging contaminant approximately 7 years ago, and the remedy for the site did not necessarily involve cleanup of this contaminant. In 2011, after the remedy for B-850 was completed, an in-situ Bioremediation Treatability test began to determine if this technology would remediate perchlorate in the groundwater. We are not sure whether this will be continued, and for how long.,

### 9. Fire Hazard and Controlled Burns

Site 300 normally uses controlled burns to prevent wildfires. In April 2015, LLNL submitted its revised Prescribed Burn/Smoke Management Plan. Objectives include minimizing occurrence of wildfires, managing smoke so that burns conform with CA Air Quality Board and San Joaquin Valley Air Pollution Control District regulations, and managing and protecting biodiversity at Site 300. Burns take place from May through August. Because of the drought and exceedingly dry vegetation, a wildfire can rapidly spread beyond the boundaries of Site 300. Contaminants on the surface, such as depleted uranium and PCBs, could be mobilized by a fire and windstorm, with potential deposition off-site. Heat from controlled burns can turn PCBs and other types of compounds into highly toxic dioxin and furan. Other on-site activities such as drilling new wells, or even routine monitoring could set off a spark that initiates a fire.

### 10. Vapor Intrusion

Vapor intrusion is a concern at Site 300. LLNL staff and the regulators selected 20 buildings that are priority for monitoring, and data from sampling will be included in future Five-Year Reviews

Vapor intrusion begins when a volatile organic compound (VOC) in the soil or groundwater volatilize into soil gas in the subsurface. VOCs, such as trichloroethylene (TCE) migrate upward as gases and potentially enter overlying buildings. Vapors can potentially enter buildings through cracks in basements and foundations, and through conduits (electrical, cable, sewer) and other openings in the building envelope.

The degree to which VOCs volatilize into soil gas depends on variety of factors, including high vapor pressure, low water solubility, and tendency to adsorb to soil particles. Chlorinated solvents such as TCE easily change into soil gas. Migration of vapors in the subsurface is caused by two mechanisms: diffusion and advection. Vapors, emanating from the groundwater source, fill the spaces around the subsurface soil particles (called pore space) above the groundwater table. When the vapor reaches the soil, the vapors have the potential to migrate radially in all directions from the source by diffusion. Diffusion is caused by the random motion of molecules - vapors flow toward the direction of lowest concentration.

Advection in soil gas is caused by movement induced by differences in soil gas pressure. The direction of vapor transport through this mechanism is always toward the direction of lower air pressure. Advection is generally expected to occur in the vicinity of buildings. Air pressure within a building is usually lower (or negative) than the outside. Even small pressure differences may cause advective flow of vapor into the building through cracks and other openings in the building floor or basement walls.

Vapors also can migrate along a preferential pathway, such as a utility corridor or more porous zones of soil or rock, or even beneath asphalt. Sewer lines also a potential conduit for vapors, as well as potential sources of vapors. Vapor concentrations in the soil generally decrease (known as attenuation) as they move away from a  subsurface source.

The vapor intrusion screening level (VISL) methodology being used by DOE/LLNL includes California-specific regulations and methodologies related to trichloroethene (TCE) and tetrachloroethene (PCE).

Indoor air is being sampled during two seasons. Vacuum canisters are used to capture a measured amount of indoor air. This is usually done within 24 hours. A passive sampler such Radiello® samplers can be used for longer time-frames. EPA noted that the advantage of longer-term sampling (i.e., seven days) was that these samplers would reflect the variability of heating, ventilation, and air conditioning (HVAC) operations and the average of conditions over time.

Of highest concern at Site 300 is Building 833, which in the past has indicated very high levels of TCE in indoor air. This building has occupancy controls so that the risks are minimized.

## IV. Community Involvement

At Site 300, the remediation strategy must satisfy a number of criteria to be accepted by EPA.  Among these criteria is Community Acceptance. However, community acceptance is not defined in the regulations. For community organizations such as Tri-Valley CAREs, this a powerful tool for effecting changes to the cleanup strategy.  We developed acceptance criteria for the Site 300 and the Main Site, and we gauge remedial action plans and Records of Decision against these criteria.  Below is a summary of 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 should be designed to prevent releases to the environment.

TVC meets regularly with the regulators and LLNL staff managing environmental cleanup at both sites. This provides us with a heads up on issues that are coming up, as well as providing an exchange where we can discuss technical and policy issues with the regulators. These meetings are extremely helpful for us; however, a wider community exchange is not available on a regular basis.

There are opportunities to get involved at both sites, and aside from listing them, we welcome your suggestions for increasing the level of involvement.

Opportunities include:

- The Superfund law allows public comment during the initial stages of study and the selection of a proposed plan to remediate the area. These are mostly complete. However, there are still areas for which public participation is legally required, including the selection of a remedy for the B-812 firing table at Site 300, the proposed plan to manage mixed waste at the Main Site, and any changes in the remedy. Changes in the remedy may include full implementation of one or more of the technologies that are under experiment at the Main Site.
- The Livermore Lab can conduct public workshops beyond those that are legally mandated.
- Every five years, a mandated Superfund Five-Year Review is compiled with the following general purpose: evaluate the implementation and performance of the selected remedy to determine whether it is protective of human health and the environment. The Five-Year Review identifies issues and/or deficiencies and identifies recommended actions, if necessary. For example, EPA deferred to sign a long-term protectiveness statement for Pit 7 until an engineering evaluation has been completed, and actions were taken to correct deficiencies in the drain system. Public comment is welcome for the Five-Year Reviews, although we do not believe that it is publicized.
- As a fundamental principle, it is important to ensure that cleanup remains a priority, and that, Tracy and surrounding communities are consulted in decision-making.

## *Figure 1*
## *Site 300 Site Map*

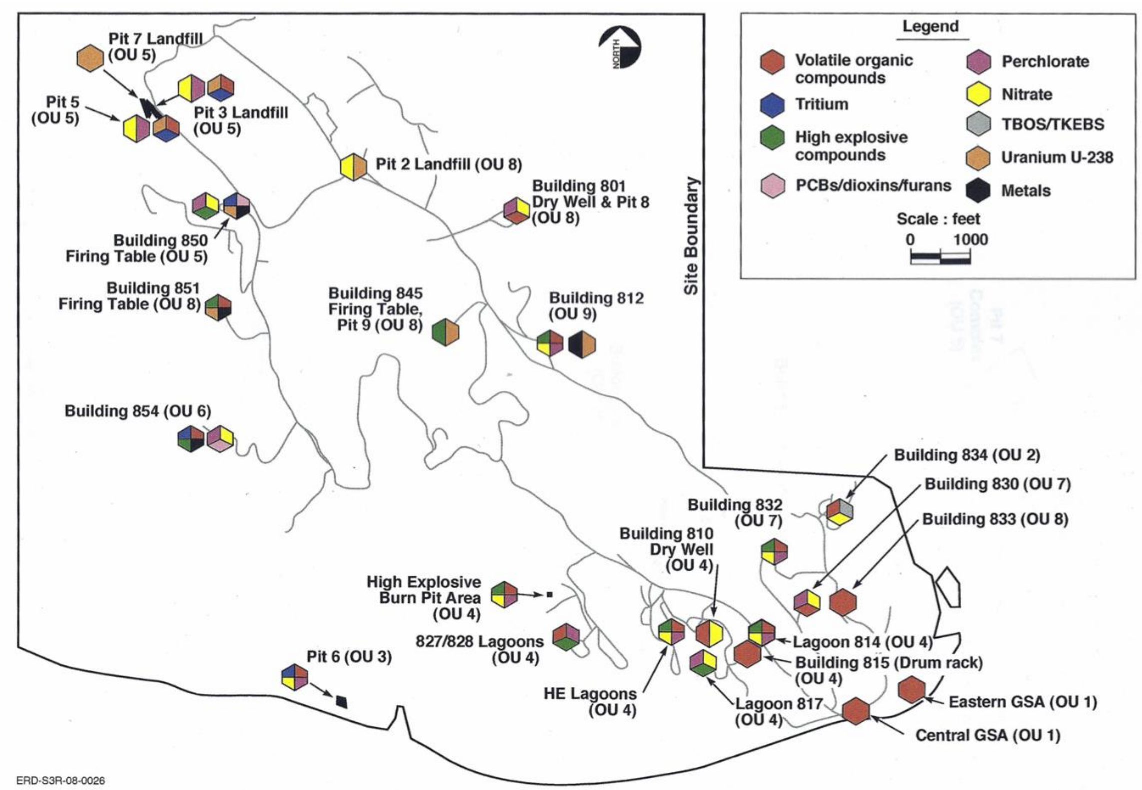


**Figure 1-2. Site 300 release sites and Operable Units (OUs).**

Release sites and contaminants of concern at Site 300 for surface soil, subsurface soil/rock, surface water, and ground water. UCAR 2009

Hydrodynamic (bomb core) test on a firing table at Site 300, 1961. The bright "streaking" effect in the photo is likely from shards of pyrophoric metal, such as Uranium 238, hurtling through the air. U-238 is one of the contaminants of concern in the Site 300 Superfund cleanup. Photo: LLNL

This photo of an open-air blast with radioactive metal was obtained by Tri-Valley CAREs with permission from the Lawrence Livermore National Laboratory archivist.


The photo of an open-air blast with hazardous materials was obtained with permission from the Lawrence Livermore National Lab archivist by Tri-Valley CAREs, 4049 First St., Suite 243, Livermore, CA 94551. Note the size of the buildings in the picture relative to the size of the test blast.

Also above is a photo of the Site 300 sign at the entrance to the site on Corral Hollow Road near Tracy, CA. Note the drums to the right of the sign.