4.11 WATER

This section provides an overview of surface water and groundwater at the Livermore Site and Site 300. Additionally, this section describes water use and floodplains at these sites. Wastewater is discussed in Section 4.14.4. A discussion of existing contamination in the groundwater at and adjacent to the sites is included in Section 4.17.

4.11.1 Surface Water

Livermore Site

Surface drainage and natural surface infiltration at the Livermore Site are generally good, but drainage decreases locally with increasing clay content in surface soils. Surface flow may occur intermittently from October to April, during the valley's wet season. Only intermittent streams flow into the eastern Livermore Valley from the surrounding uplands and low hills, where they merge on the valley floor. The four major intermittent streams that drain into the eastern Livermore Valley are Arroyo Mocho, Arroyo Seco, Arroyo Las Positas, and Altamont Creek (Figure 4.11.1–1). Arroyo Seco and Arroyo Las Positas pass through the Livermore Site, while Altamont Creek and Arroyo Mocho flow offsite to the north and southwest, respectively. Recharge to sediments underlying the Livermore Valley is primarily from the arroyos that originate in the eastern foothills and flow across the valley. When surface flow occurs in these channels, water infiltrates into the underlying alluvium and eventually percolates to the aquifers within the Livermore Valley (LLNL 1992a).

The headwaters of the Arroyo Seco drainage are in the hills southeast of the Livermore Site. Arroyo Seco has a drainage length of approximately 12 miles and a watershed area of approximately 8,960 acres upstream of SNL/CA. The Arroyo Seco flows through SNL/CA before crossing over the southwest corner of the Livermore Site and continuing southwesterly. Flow only occurs in the arroyo during rainfall because discharge to the stream is from storm runoff only. The channel is well defined in the section that passes directly through the Livermore Site and is dry for at least 6 months of the year. In fact, during dry years, it may flow only 10 to 15 days per year in the vicinity of the Livermore Site vicinity (LLNL 2002cc).

Arroyo Las Positas is an intermittent stream that drains from the hills directly east of the Livermore Site with a watershed area of approximately 3,300 acres. This channel enters the Livermore Site from the east, is diverted along a storm ditch around the northern edge of the site, and exits the site at the northwest corner. Discharge from the onsite Drainage Retention Basin (DRB), discussed below, keeps the arroyo flowing perennially. Additionally, water from springs and runoff in the nearby hills feed into Arroyo Las Positas (LLNL 2002cc). Flow has increased in the arroyo over the past several years, due to treated groundwater discharges. A desilting project is currently underway to restore 100-year flood capacity to the arroyo (Water KPT 2002).

Before 1992, it was determined that stormwater was infiltrating and dispersing contaminated groundwater in the area of what is currently the DRB. Therefore, the DRB was constructed with a liner in 1992 to prevent this infiltration of stormwater. The DRB collects about one-fourth of the surface water runoff from the site and a portion of the Arroyo Las Positas drainage. When full, the DRB discharges north to a culvert that leads to Arroyo Las Positas. During wet weather, the majority of the discharge from the DRB is stormwater, but a substantial amount of the flow is discharged from groundwater treatment facilities (LLNL 2002cc).

Nearly all of the surface water runoff at the Livermore Site is discharged into Arroyo Las Positas; only surface runoff along the southern boundary and storm drains in the southwest corner of the Livermore Site drain into Arroyo Seco. Regional drainage flows through the southwestern part of the Livermore Valley into the San Francisco Bay through Alameda Creek.

Other natural and man-made water bodies present in the eastern Livermore Valley are shown in Figure 4.11.1–1. There are more than 27 ponds located in and around the eastern Livermore Valley. The majority of the small ponds are used for private water storage for livestock watering; some have other uses, such as ornamental. The Patterson Reservoir is located 0.8 mile northeast of the Livermore Site. This reservoir covers 3.23 acres and contains about 100 acre-feet. The South Bay Aqueduct is an open canal that circles the Livermore Valley and delivers drinking water to the south San Francisco Bay Area, as well as to the Livermore Site.

LLNL performs semi-annual monitoring of reservoirs and ponds, the Livermore Site swimming pool, the DRB, rainfall, tap water, stormwater runoff, and receiving waters, in accordance with DOE O 450.1 *Environmental Protection Program*, and DOE O 5400.5, *Radiation Protection of the Public and the Environment*. Samples are analyzed for gross alpha, gross beta, and tritium concentrations. EPA-established maximum contaminant levels (MCLs) for drinking water are used as a benchmark at which a sample exceeding this level would be a potential cause for concern. Surface water and drinking water sampling locations are shown in Figure 4.11.1–2.

The median activity for tritium in surface and drinking waters was estimated from calculated values to be below the laboratory's minimum detectable activities.[1] Sampling location PALM demonstrated the highest tritium activity offsite, however, the value was still less than 1 percent of the MCL. Median activities for gross alpha and gross beta radiation were both less than 5 percent of their respective MCLs. Since 1988, water in the Livermore Site swimming pool demonstrated the highest tritium activities because it is closest to tritium sources within the site. However, the tritium activity measured in the pool in 2002 was less than minimum detectable activity (LLNL 2003l).

Site 300

Surface water at Site 300 consists of seasonal runoff, springs, and natural and man-made ponds (Figure 4.11.1–3). There are no perennial streams at or near Site 300 (LLNL 2003l). The canyons that dissect the hills and ridges at Site 300 drain into intermittent streams. The majority of the intermittent streams within the site drain south to Corral Hollow Creek, also intermittent, which runs along the southern boundary of Site 300 toward the east into the San Joaquin Valley. Elk Ravine, a major drainage channel for most of Site 300, extends from the northwest portion of the site to the east-central area and drains the center of the site into Corral Hollow Creek. Some of the canyons in the northeast section of Site 300 drain to the north and east toward the city of Tracy in the San Joaquin Valley (LLNL 1992a). Downstream of the GSA, Corral Hollow Creek has flow from a groundwater treatment facility.

[1] At a level this low, the counting error associated with the measurements is nearly equal to or greater than the calculated value.

Naturally occurring springs are shown by the presence of flowing water or wet soils where the water table is close to the surface and the presence of distinct hydrophytic vegetation (cattails, willow). There are at least 22 springs at Site 300. Most of the springs have very low flow rates and are recognized only by small marshy areas, pools of water, or vegetation (LLNL 2003l).

Eight surface water bodies are present at Site 300. Several areas of surface water discharge are present onsite near cooling towers. These runoff areas have the same characteristics as natural springs because they contain running water and support hydrophytic vegetation. A sewage oxidation pond and a sewage percolation pond are located in the southeast corner of the site in the GSA, and two lined class II explosives process water surface impoundments are located a mile to the west. Three wetlands were created from past cooling tower discharges at Buildings 827, 851, and 865. These wetlands are currently irrigated with potable water (LLNL 2003l).

4.11.2 Stormwater

Livermore Site

LLNL monitors two storm events per rainy season at the Livermore Site for radioactive and nonradioactive constituents in accordance with waste discharge requirements (WDR 95-174), NPDES Permit No. CA0030023, issued in 1995 by the San Francisco Bay Regional Water Quality Control Board (RWQCB) (RWQCB 1982). This permit requires the collection of two samples each wet season at effluent locations identified as ASW and WPDC, and at influent locations identified as ALPE, ALPO, ASS2, ASSE, and GRNE on Figure 4.11.2–1. Samples from locations CDB and CDB2 characterize runoff from the southeastern portion of the Livermore Site, and samples from CDBX characterizes water leaving the DRB. Storm sampling and analyses are performed for gross alpha, gross beta, plutonium, and tritium. The samples are also analyzed for nonradioactive parameters including several pesticides and metals, hardness, pH, total suspended solids (TSS), chemical oxygen demand, and oil and grease (LLNL 2003l). LLNL also meets the stormwater compliance monitoring requirements of the statewide General NPDES Permit for Stormwater Discharges Associated with Construction Activity (Order 99-08-DWQ, NPDES Permit No. CAS 000002) (SWRCB 1999) for projects that disturb one or more acres of land (LLNL 2002cc).

LLNL has developed a set of site-specific water quality guidelines to gain a better understanding of the stormwater quality at LLNL. These guidelines were developed using historic site-specific monitoring data. Federal, state, and local criteria were also considered in developing LLNL's site-specific guidelines.

The Federal criteria used to establish LLNL's site-specific guidelines are EPA ambient water quality criteria (AWQC) and benchmark values that EPA established to determine if stormwater discharged from any facility warrants further monitoring. As such, these benchmark levels represent target concentrations for a facility to achieve through implementation of pollution-prevention measures (65 FR 210). EPA drinking water MCLs were also used to develop LLNL's guidelines. State and local criteria used are those listed in the San Francisco Bay Water Quality Control Plan for the Livermore Site, and the Sacramento/San Joaquin River Basins Water Quality Control Plan for Site 300, and the Water Quality Control Plan for the California Regional Water Quality Control Board. If a measured concentration is higher than the comparison guideline, but the value is the same or higher at the influent locations, the source is assumed to be unrelated to LLNL operations; therefore, further analysis is not warranted (LLNL 2002f).

Radionuclides in Stormwater

In response to elevated tritium levels in stormwater runoff, additional tritium investigations began in 1998 to identify potential sources of tritium. In 2001, tritium was detected at 838 picocuries per liter in the main Arroyo Las Positas channel. High levels were found at location 3726, downgradient of Building 343 (see Figure 4.11.2–1). The source of elevated tritium was related to a transportainer containing materials exposed to tritium. Sampling of surface runoff directly downgradient from the transportainer near Building 343 found tritium concentrations as high as 1.1 million picocuries per liter in April 2000. Samples collected later that same day contained tritium levels less than 800 picocuries per liter, which is 4 percent of the tritium drinking water standard. Continued monitoring of both surface runoff near Building 343 and sampling in the storm channels has demonstrated a rapid decrease in measured tritium activities since the transportainer was removed in August 2000. Subsequent monitoring of this network demonstrated that tritium activities in the north-south storm drain near Building 343 had returned to near-background levels by December 2000 (LLNL 2002cc).

Tritium activities at effluent locations were less than 1 percent of the MCL. No gross alpha, gross beta, or tritium activities were above the LLNL site-specific thresholds in 2002 (Table 4.11.2–1). Radioactivity in the stormwater samples collected during 2002 had medians around background levels (LLNL 2003l).

TABLE 4.11.2–1.—*Drinking Water Maximum Contaminant Levels and Livermore Site-Specific Threshold Comparison Guidelines for Radioactive Stormwater Constituents*

Parameter	EPA Drinking Water MCL (pCi/L)	LLNL Comparison Guideline [a] (pCi/L)
Tritium	20,000	973
Gross alpha	15	9.19
Gross beta	50	13

Sources: LLNL 2002f, EPA 2003a.
[a] Site-specific value calculated from historical data and studies.
EPA = Environmental Protection Agency; MCL = maximum contaminant levels; pCi/L = picocuries per liter.

Rainwater is collected and analyzed for tritium activities in support of DOE O 450.1 and DOE O 5400.5. Rainfall in the Livermore area has exhibited elevated tritium levels in the past, primarily from atmospheric emissions of tritiated water from stacks at LLNL's Tritium Facility (Building 331) and from the former Tritium Research Laboratory at SNL/CA. Operations at LLNL were significantly reduced after 1991, when the administrative limit for the LLNL Tritium Research Laboratory was lowered from 300 grams to 5 grams; in 1999, it was raised to 30 grams. Operations at the SNL/CA, Livermore Tritium Research Laboratory, ceased in October 1994. The reduced measurements of tritium in rain reflect the reduction of emissions from the facilities; however, the median tritium activity measured in rainfall at the Livermore Site increased from 53.2 picocuries per liter in 2001 to 83.8 picocuries per liter in 2002 (LLNL 2003l). This is most likely attributed to a slight increase of total measured atmospheric emissions of tritiated water from the Tritium Facility at the Livermore Site from 18.3 picocuries per liter in 2001 to 32.4 picocuries per liter in 2002. All offsite routine rainfall samples measured during 2002 showed tritium activities less than 0.3 percent of the tritium MCL of 20,000 picocuries per liter for stormwater (LLNL 2003l).

LLNL began analyzing stormwater runoff for plutonium in 1998. Samples were analyzed from Arroyo Seco and Arroyo Las Positas effluent locations identified as ASW and WPDC in Figure 4.11.2-1. Plutonium concentrations were below the minimum detection limit of 0.1 picocuries per liter in both liquid and sediment samples for 2002 runoff.

Nonradioactive Contaminants in Stormwater

Sample results for nonradioactive contaminants were evaluated against the site-specific threshold comparison criteria shown in Table 4.11.2–2. All contaminants listed in the table are those that exceed the comparison criteria. The constituents of greatest concern are those exceeding comparison criteria at effluent points and whose concentrations are lower in influent than in effluent (LLNL 2002cc).

Single point chronic algae toxicity testing with freshwater algae (*Selenastrum capricornutum*) was performed in early 2001 as a followup to investigate toxicity problems. Stormwater runoff samples continued to demonstrate an inhibitory effect on growth and survival of green algae through 2002. This Livermore Site annual stormwater monitoring report suggested that the source of this toxicity was upstream of Arroyo Las Positas, most likely from an herbicide called diuron (LLNL 2003l). A Western Area Power Administration electrical transfer station was identified as the likely source of diuron, having just received a calculated application of 40 kilograms of herbicide per 2.5 acres. In 2002, the maximum diuron concentration was measured at 0.29 milligrams per liter, down from 5.3 milligrams per liter in 2001 (LLNL 2002f).

Elevated nitrate levels were found in stormwater flowing onsite. Potential upstream sources include a small vineyard and cattle ranches (LLNL 2003l).

The total hardness of stormwater flowing on the Livermore Site is often relatively low (20 to 100 milligrams per liter) in the Arroyo Seco and occasionally low in Arroyo Las Positas. Metals toxicity is dependent on total hardness of the water; the harder the water, the lower the toxicity. Total hardness and metals values were not at toxic levels in either arroyo. The discharge from groundwater treatment systems at the Livermore Site actually serves to increase total hardness and thus reduces the potential for metal toxicity in stormwater runoff. Relationships between total hardness and metals toxicity will continue to be evaluated at the Livermore Site (LLNL 2002f).

Drainage Retention Basin

The DRB receives treated groundwater from Treatment Facilities D and E and from related portable treatment units. Stormwater runoff dominates wet weather flows through the DRB, but discharges from the treatment facilities now constitute a substantial portion of the total flow in the basin (LLNL 2002cc).

LLNL established the DRB monitoring program to comply with regulatory requirements. In addition to establishing a sampling and analysis plan, management action levels for specific constituents were established to aid in characterizing water quality before its release. These action levels were established based on recommendations made in the *Drainage Retention Basin Management Plan* and are quantitative water quality management objectives (LLNL 2002cc). When these action levels are exceeded, further evaluation is initiated to aid in determining possible causes and immediate remedies. Detailed descriptions of subsequent actions can be found in the site annual environmental reports that are published every year.

TABLE 4.11.2–2.—*Stormwater Quality Parameters Above the Site-Specific Threshold Comparison Guidelines for the Livermore Site in 2002*

Parameter	Location	Influent or Effluent	Result (mg/L)	LLNL Threshold Guideline[a] (mg/L)
Beryllium	ALPO	Influent	0.0018	0.0016
	GRNE	Influent	0.0022	0.0016
	ASS2	Influent	0.0020	0.0016
	ASW	Effluent	0.0019	0.0016
Chemical oxygen demand	ALPO	Influent	259	200
	ASS2	Influent	240	200
Copper	ALPE	Influent	0.015-0.070	0.013
	GRNE	Influent	0.030	0.013
	WPDC	Effluent	0.018	0.013
	ASS2	Influent	0.034-0.060	0.013
	ASW	Effluent	0.028-0.051	0.013
	ALPO	Influent	0.021-0.055	0.013
Diuron	ALPO	Influent	0.29	0.014
	WPDC	Effluent	0.044	0.014
Lead	ALPE	Influent	0.030	0.015
	ALPO	Influent	0.019	0.015
	GRNE	Influent	0.017	0.015
	ASS2	Influent	0.024-0.033	0.015
	ASW	Effluent	0.017-0.028	0.015
Nitrate	GRNE	Influent	11	10
	ASS2	Influent	14	10
	ASW	Effluent	13	10
	GRNE	Influent	19	10
Ortho-phosphate	ALPE	Influent	4.24-5.56	2.5
	ASS2	Influent	5.61	2.5
	ASW	Influent	5.12	2.5
Total suspended solids	ALPE	Influent	1,300	750
	ALPO	Influent	800	750
	ASS2	Influent	800-1,100	750
	ASW	Effluent	980	750
Zinc	ASS2	Influent	0.39	0.35

Source: LLNL 2003l.
[a] not a regulatory limit. Values were established by LLNL to assess stormwater quality.
Note: Influent is stormwater entering the site and effluent is stormwater exiting the site.
mg/L = milligrams per liter.

Stormwater samples are taken from four DRB locations: two influent locations, CDB and CDB2, and two effluent locations, CDBX and WPDC (Figure 4.11.2–1). The DRB is sampled during the first release of the rainy season, from at least one additional storm, and from each dry-season discharge event. Samples are measured for dissolved oxygen saturation, temperature, transparency, nitrate, total dissolved solids, total phosphorus, ammonia nitrogen, chemical oxygen demand, pH, and specific conductance. DRB samples not meeting management action levels are listed in Table 4.11.2–3. Dissolved oxygen levels in 2002 were at or above management action levels of at least 80 percent oxygen saturation for 4 to 12 months. Chemical oxygen demand, total dissolved solids, nitrate, and specific conductance exceeded the management action levels in the 2002 samples. Phosphorus was near management action levels. Sources of nitrate and phosphorus include external sources, stormwater runoff, treated groundwater discharges, and internal sources of nutrient cycling related to algae and plant growth (LLNL 2003l).

TABLE 4.11.2–3.—*Summary of Drainage Retention Basin Samples Exceeding Management Action Levels-2002*

Parameter	Range	Median	Management action level
Dissolved oxygen saturation (%)	31 – 76	59.5	<80%
Temperature (°C)	11.1 – 29	15.4	<15 or >26
Transparency (m)	0.84	N/A	<0.91
Nitrate (as N) (mg/L)	0.9 – 2.3	1.6	>0.2
pH (pH units)	9.04 – 9.21	9.1	not <6.0 nor >9.0
Specific Conductance (µS/cm)	939 – 1,270	1,100	>900
Total Dissolved Solids (TDS) (mg/L)	557 – 820	671	>360
Total phosphorus (as P) (mg/L)	<0.05 – 0.22	0.08	>0.02
Chemical Oxygen Demand (mg/L)	<25 – 81	41.4	>20

Source: LLNL 2003l.
C = Celsius; m = meters; mg/L = milligrams per liter; µS/cm = microsiemens/centimeter.

Site 300

Stormwater at Site 300 and in the vicinity is monitored twice during the wet season in accordance with the statewide General NPDES Permit for Stormwater Discharges Associated with Industrial Activity (WDR 97-03-DWQ, NPDES Permit No. CAS000001, State Water Resources Control Board). The Site 300 stormwater and rainwater sampling network consists of seven stormwater locations and three rainfall locations (Figure 4.11.2–2).

These locations were chosen to best characterize stormwater runoff that would be affected by specific Site 300 activities. Typically, a single storm does not produce runoff at all Site 300 locations because the site receives relatively little rainfall and is largely undeveloped (LLNL 2003l).

LLNL has developed site-specific water quality guidelines for Site 300. These guidelines are shown on Tables 4.11.2-4 and 4.11.2-5.

TABLE 4.11.2–4.—*Site 300 Site-Specific Threshold Comparison Guidelines for Radioactive Drinking Water Stormwater Constituents*

Parameter	MCL (pCi/L)	Comparison Guideline[a] (pCi/L)
Tritium	20,000	85.7
Gross alpha	15	24.3
Gross beta	50	46.8

Source: LLNL 2002f, EPA 2003a.
[a] Site-specific value calculated from historical data and studies.
EPA = Environmental Protection Agency; MCL = maximum contaminant level; pCi/L = picocuries per liter.

TABLE 4.11.2–5.—*Stormwater Quality Parameters Above the Threshold Comparison Guidelines for Site 300 in 2002*

Parameter	Location	Influent or Effluent	Result (mg/L)	LLNL Comparison Guideline[a] (mg/L)
TSS	CARW	Influent	1,800-10,000	1,700
	NLIN	Effluent	4,800	1,700
	GEOCRK	Downstream	14,200	1,700
Chemical oxygen demand	CARW	Influent	393	200
	NLIN	Effluent	289	200
	GEOCRK	Downstream	615	200
Lead	CARW	Influent	0.174	0.015
	NLIN	Effluent	0.065	0.015
	GEOCRK	Downstream	0.237	0.015
Mercury	CARW	Influent	0.0003	0.0002

Source: LLNL 2003l.
[a] not a regulatory limit. Values were established by LLNL to assess stormwater quality.
Note: Influent is stormwater entering the site and effluent is stormwater exiting the site.
mg/L = milligrams per liter; TSS = total suspended solids.

Radionuclides in Stormwater

Tritium levels in all samples were below the minimum detectable activity in Site 300 stormwater during 2002. The maximum values of all gross alpha and gross beta results were 6.76 picocuries per liter and 29.7 picocuries per liter, respectively, approximately 45 percent and 59 percent of the drinking water MCLs (Table 4.11.2–4) (LLNL 2003l). Although these values are higher than those at the Livermore Site, they are not unusual. This area has relatively high natural background gross alpha and gross beta levels in stream flow that are closely associated with suspended sediment from naturally occurring uranium (LLNL 2002cc).

Nonradioactive Contaminants in Stormwater

Specific conductance and TSS were above LLNL comparison guidelines and EPA benchmarks. Most values exceeding benchmark levels at Site 300 are related to high suspended sediment (Table 4.11.2–5). See Figure 4.11.2–2 for stormwater sampling locations. In 2002, TSS was measured at discharge location NLIN at 4,800 milligrams per liter, but this is consistent with the range of historic data at this location. High TSS values were also measured at downstream location GEOCRK and influent location CARW at 14,200 and 1,800 milligrams per liter, respectively. Low TSS concentrations at N883, in addition to lack of flow at sampling locations

NPT6 and NLIN, indicate that LLNL activities were not the direct cause of elevated concentrations at sampling location GEOCRK. Both the GEOCRK and CARW locations are influenced by the larger Corral Hollow watershed, which is dominated by a state off-road motorcycle park and ranching activities (LLNL 2003l). Specific conductance is generally high at the site, most likely due to natural chemical weathering and low annual rainfall (LLNL 2002cc).

Elevated levels of lead and mercury (see Table 4.11.2–5) have been demonstrated in the past to be related to suspended sediment (LLNL 2003l).

Past CERCLA remedial investigations have found dioxin releases related to activities in the vicinity of Building 850. Dioxin cogeners (types of dioxins) have varying degrees of toxicity. The EPA only provides an MCL for the most toxic cogener, to which all other cogeners' maximum contaminant standards are compared. The most toxic cogener, 2,3,7,8-TCDD, was detected at sampling location NLIN at a concentration of 4×10^{-9} milligrams per liter. This concentration was less than the MCL of 3×10^{-8} milligrams per liter. All dioxin cogeners displayed values less than the MCL (LLNL 2003l).

4.11.3 Groundwater

4.11.3.1 *Regional Hydrogeology*

Livermore Site

The majority of Livermore Valley sediments is water bearing and transmits groundwater in varying degrees. In contrast, the uplands generally do not yield groundwater in sufficient quantities to constitute a groundwater resource. The Livermore Valley has been divided into a series of 12 groundwater subbasins based on the locations of faults, topography, and other hydrogeological barriers that affect groundwater occurrence, movement, and quality (Figure 4.11.3.1–1) (LLNL 1992a).

The Livermore Site lies primarily within the Spring and Mocho I subbasins. The water-bearing sediments in the Livermore Valley include late-Pleistocene to Holocene-age alluvial sediments, generally less than 200 feet thick, which overlie Plio-Pleistocene alluvial and lacustrine Livermore Formation sediments, up to 4,000 feet thick. The Livermore Formation consists of beds of gravel, sand, silt, and clay of varying permeabilities. Sandy gravelly layers alternate with fine-grained, relatively impermeable layers, and groundwater can be both confined and semiconfined (LLNL 1992a).

Stream runoff from precipitation, controlled releases from the South Bay Aqueduct, direct rainfall, irrigation, and treated groundwater infiltration recharge the Livermore Valley groundwater basin. In addition, stream channels, ditches, and gravel pits west of the city of Livermore are important sources for shallow, alluvial aquifer recharge. Groundwater is naturally discharged from the basin at Arroyo de la Laguna, located over 11 miles southwest of the Livermore Site. Some minor discharges also occur at springs, including those along Arroyo Las Positas near its confluence with Altamont Creek (LLNL 1992a). Natural recharge occurs primarily along the fringes of the Livermore Valley groundwater basin and through the arroyos during periods of winter flow. Artificial recharge, if needed to maintain groundwater levels, is accomplished by releasing water from Lake Del Valle or from the South Bay Aqueduct into arroyo channels in the east (LLNL 2002cc).

Groundwater generally moves east to west within the Livermore Valley, westward through the Amador Subbasin, eventually terminating in a large groundwater depression near two gravel mining areas located west of the city of Livermore. A former gravel mining company had extracted deep groundwater, causing the large groundwater depression. Current gravel mining is not as deep as in the past, decreasing the need for deep groundwater pumping. Subsequently, the groundwater depression has decreased. At the eastern edge of the Livermore Site, groundwater gradients are relatively steep, but under most of the site and farther to the west, the contours flatten to a gradient of approximately 0.003 foot per foot (LLNL 2002cc).

Pumping of groundwater for agricultural uses has historically accounted for the major withdrawal of groundwater from the Livermore Valley groundwater basin. As the valley has become increasingly urbanized, a shift in groundwater users has caused the amount of pumping for municipal use and gravel quarrying to exceed agricultural withdrawals. Agricultural use, namely vineyards and a few ranches, account for approximately 1,000 acre-feet per year of water in the Livermore Site vicinity. Although agricultural withdrawals are still a major source of drawdown, agriculture is increasingly using more surface water from the state water project than groundwater.

Site 300

Site 300 lies on the eastern flank of the Diablo Range. Most surface runoff and most groundwater flow toward the San Joaquin Valley. Runoff that concentrates in the Elk Ravine and Corral Hollow Creek recharges local bedrock aquifers. The regional groundwater table beneath Site 300 largely occurs within sandstone and conglomerate beds of the Neroly Formation, and groundwater moves through both pores and fractures. A deep confined aquifer (400 to 500 feet deep) is present beneath the southern part of Site 300 within the lower Neroly Formation sandstones. This confined aquifer provides the Site 300 water supply. Pumping tests performed in Site 300 water supply wells affirm the integrity of the aquitard separating the shallow and deeper aquifers within the lower Neroly Formation. In addition to the regional aquifers, local perched aquifers containing small amounts of water occur in some deposits within the Neroly Formation and the marine Tertiary sequence (LLNL 1992a). Because the water quality is generally poor and yields are low, these perched water-bearing zones do not meet the State of California criteria for aquifers that are potential water supplies (LLNL 2002cc).

4.11.3.2 *Local Hydrogeology*

The following section describes the local hydrogeology for the Livermore Site and Site 300.

Water-bearing Units

Livermore Site

Figure 4.11.3.2–1 shows the major water-bearing hydrostratigraphic units beneath the Livermore Site. These water-bearing units include deposits formed during the late Pleistocene to Holocene-age and are composed of shallow, heterogeneous, unconsolidated alluvium and deep fluvial and lacustrine sediments. The permeable sediments, shown as lenses on Figure 4.11.3.2–1, transmit water within each unit, and are separated by clay layers, and may comprise confining layers. A regional confining layer at the top of Unit 6 slopes westward and varies in depth from about 60 feet beneath the eastern edge of the Livermore Site to about 400 feet near the western site boundary (LLNL 2002cc).

Site 300

Two regional aquifers or major water-bearing zones have been identified at Site 300: an upper water table aquifer in the sandstones and conglomerates of the Neroly Formation and a deeper confined aquifer located in Neroly sandstones just above the Neroly/Cierbo Formation contact. Both aquifers have permeable zones layered with lower permeability claystones, siltstones, or tuffs. Many of the sandstones are fine-grained and silty and contain fractures. Groundwater flow is both intergranular and in fractures (LLNL 2003l). In addition to the two regional aquifers, several perched aquifers have been identified, some of which give rise to springs. Extensive perched aquifers are present beneath the Pit 7 area and the Building 834 complex. In addition, shallow Quaternary alluvium and undifferentiated Tertiary nonmarine sediments are locally water bearing, such as under the GSA (see Figure 4.11.3.2–2). These local aquifers are generally unconfined or water table aquifers (LLNL 1992a).

Occurrence and Flow of Groundwater

Livermore Site

Water table depth at the Livermore Site varies from 30 to 130 feet (LLNL 2003l). Figure 4.11.3.2–2 shows approximate water table elevations in 2002. Although water table elevations vary slightly with seasonal and year-to-year differences in natural and artificial recharge and pumping, the patterns shown in Figure 4.11.3.2–3 are generally maintained.

Groundwater at the Livermore Site and vicinity generally flows to the southwest in the northeastern part of the site and to the west in the western portion of the site. This differs from the generally westward regional flow observed in the 1980s. The shift in flow direction is a consequence of groundwater recovery and remediation in the southwest portion of the site and agricultural pumping (LLNL 2002cc). Groundwater from the northern half of the Livermore Site eventually discharges to Arroyo Las Positas near First Street, about 1.5 miles northwest of the site. Groundwater from the southern half of the Livermore Site may flow westward through the mapped gap between the Mocho I and Mocho II subbasins (see Figure 4.11.3.1–1), about 1.5 miles west of the Livermore Site, where it may continue to flow westward toward the municipal well field near central Livermore. The majority of sediments are hydraulically continuous between the Mocho I and Mocho II subbasins. Although the magnitude and direction of groundwater flow in the Mocho I-Mocho II gap are uncertain, it is conservatively assumed that at least some groundwater from the Livermore Site exits the Mocho I subbasin in this area (LLNL 1992a).

The groundwater gradient is steepest near the northeast corner of the Livermore Site and at the southeast corner near the Las Positas Fault (about 0.15 foot per foot) and decreases to between 0.001 and 0.005 foot per foot west of the site. Hydraulic heads in wells at the Livermore Site decrease with increasing depth, indicating downward vertical gradients. The vertical component of the hydraulic gradient reportedly increases in and near the regional confining layer. Vertical gradients are typically lower in the shallow saturated alluvium west of the site, where the confining layer in the Lower Member of the Livermore Formation is deeper, and increase near the eastern margin of the site, where the confining layer is close to the ground surface (LLNL 1992a). Vertical gradients generally range from as high as 0.23 foot per foot (downward) near the eastern margins to less than 0.003 foot per foot (downward) at the western edge of the Livermore Site (LLNL 2003l).

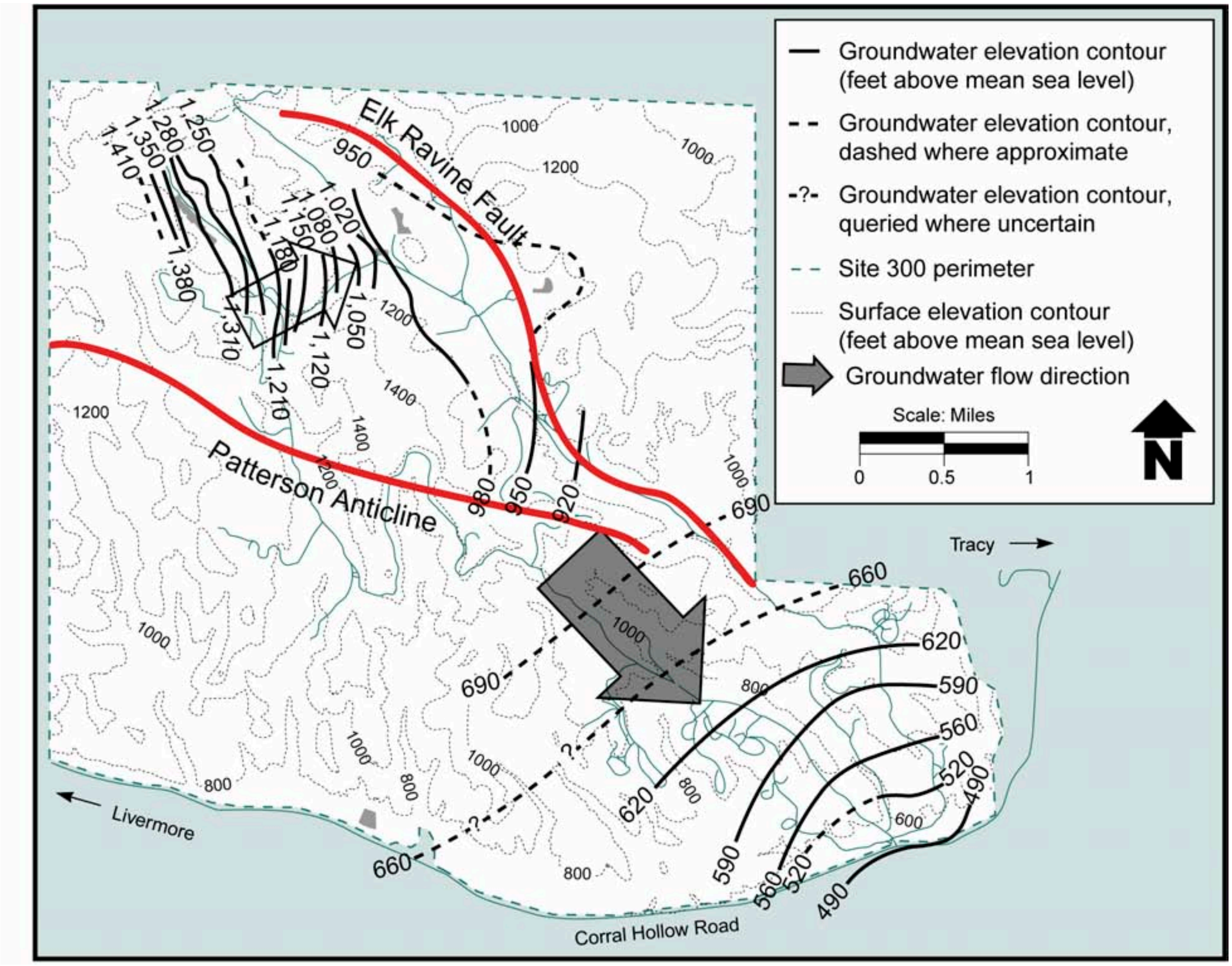
Based on the results of extensive long-term hydraulic testing, the hydraulic conductivity of sediments beneath the site is highly variable, ranging from 3.3 to 52 feet per day (LLNL 2003l). Aquifers in the southwest quadrant of the Livermore Site and the adjacent offsite area have the highest average hydraulic conductivity. There is a greater abundance of coarse-grained deposits in the area, possibly the location of ancient channels of Arroyo Seco. In contrast, the southeast quadrant of the area, including the Livermore Site, has the lowest average hydraulic conductivity and the greatest abundance of fine-grained sediments. Based on pumping tests, the connection between hydrostratigraphic units also appears to be more vertical in the southwest corner and offsite from the Livermore Site (LLNL 2003l).

The estimated groundwater velocities beneath the Livermore Site for the Upper Member of the Livermore Formation, the main water-bearing unit, average 66 feet per year (LLNL 2003l). The wide range in flow rates reflects the broad range of groundwater gradients and lithologies and associated hydraulic conductivities.

Site 300

Site 300 is a large and hydrogeologically complex site where groundwater occurs in both bedrock and alluvial aquifers. Due to steep topography and structural complexity, the geologic units are discontinuous across the site. Consequently, locally unique hydrogeologic conditions govern the occurrence and flow of groundwater and the fate and transport of contaminants. The hydraulic relationships between the northwest and southeast sections of the site have not been well established due to sparse borehole control in the center of the site. Separate groundwater contours for the different hydrogeologic units at Site 300 are shown in Figure 4.11.3.2–4. North of the Patterson Anticline, groundwater occurs under unconfined to confined conditions, primarily within the Neroly and Cierbo bedrock aquifers. General groundwater flow in this area is to the east, and is controlled primarily by the inclination of the rock layers. Perched water-bearing zones also occur within the Quaternary alluvial sands and gravels and in fractured siltstones and claystones. These perched zones are highly discontinuous and variable.

Throughout most of the southeastern portion of Site 300, the lower Neroly bedrock aquifer is a continuous, regional water-bearing zone. Groundwater in this aquifer occurs under confined to flowing artesian conditions. As indicated by the contours in Figure 4.11.3.2–4, groundwater generally flows to the south-southeast in the southern and southeastern parts of the site. Estimated groundwater velocities in the shallow Quaternary alluvial gravels at the GSA range from 1 foot to 10 feet per day (or about 365 to 3,650 feet per year). The estimated groundwater flow rates for bedrock aquifers at Site 300 range from about <0.01 to 1 foot per day (3.6 to 365 feet per year). The wide range of estimated velocities reflects the diverse Site 300 hydrology.



Source: LLNL 2003l.

FIGURE 4.11.3.2–4.—*Approximate Groundwater Surface Elevations and Flow Direction in the Principal Site 300 Water-Bearing Zones*

4.11.3.3 *Background Groundwater Quality*

Livermore Site

Groundwater near the Livermore Site is generally suitable for use as a domestic, municipal, agricultural, and industrial supply; however, use of some shallower groundwater may be limited by its marginal quality. Groundwater less than 300 feet deep is usually unsuitable for domestic use without treatment (LLNL 1992a).

Groundwater in the vicinity of the Livermore Site is mostly a calcium-bicarbonate type, with sodium-chloride waters to the northeast. The maximum concentrations observed for most metals exceed EPA drinking water MCLs; however, the maximum concentrations are usually confined to limited areas. Elevated levels of sodium, hardness, total dissolved solids, specific conductance, and nitrate also exceed EPA water quality standards. High concentrations of boron, chloride, and sulfate limit the use of this groundwater for irrigation. Samples from the Mocho I and Mocho II subbasins (Figure 4.11.3.1–1) have shown that some groundwater is classified as Class II and Class III for irrigation, largely due to high boron concentrations. The high bicarbonate and calcium concentrations may limit the use of this groundwater for livestock. High concentrations of chromium, lead, and manganese may limit the discharge of this groundwater to surface water drainages (LLNL 1992a).

Site 300

Groundwater quality at Site 300 has a relatively high concentration of total dissolved solids, though variability in natural water quality has been observed. Sodium bicarbonate water is most common in water supply wells. The amount of total dissolved solids ranges from 400 parts per million to 4,000 parts per million in local groundwater. Naturally occurring elements such as barium and uranium in rocks and sediments have contributed to elevated levels (LLNL 2002cc).

4.11.3.4 *Groundwater Contamination*

Livermore Site

Groundwater surveillance monitoring at LLNL complies with DOE O 450.1 and remediation monitoring under CERCLA. The following compounds, mostly volatile organic compounds (VOCs), exist in groundwater at various locations in concentrations above drinking water quality standards: trichloroethylene, perchloroethylene, 1,1-dichloroethylene, chloroform, 1,2-dichloroethylene, 1,1-dichoroethane, 1,2-dichloroethane (1,2-DCA), trichlorotrifluoroethane (Freon 113), trichlorofluoromethane (Freon 11), and carbon tetrachloride (LLNL 2003l). See Section 4.17, Site Contamination and Remediation, for additional water quality information.

To determine the fate and transport of contaminants in each hydrostratigraphic unit, personnel in the Environmental Restoration Division at LLNL use three-dimensional groundwater computer models. Groundwater flow and transport models allow for optimization of well extraction rates, evaluation of potential capture zones of proposed extraction wells, and evaluation of plume migration and hydraulic interference patterns under increased pumping conditions.

In 2002, the Livermore Site Groundwater Project treated more than 248 million gallons of groundwater and removed approximately 146 kilograms of VOCs (LLNL 2003l). LLNL removes contaminants from groundwater at the Livermore Site through a system of 27 treatment facilities located throughout the 6 hydrostratigraphic units containing contaminants of concern (LLNL 2002cc). Since remediation began in 1989, approximately 1,960 million gallons of groundwater have been treated (LLNL 2003l). Contaminated groundwater is pumped from individual wells and sent to a treatment facility. If the treated groundwater meets the discharge limits, it is either discharged to surface drainage channels, including Arroyo Las Positas, or routed to the central DRB. Treated water remains in the DRB until it is released to Arroyo Las Positas by way of a stormwater drainage channel.

Livermore Site treatment facilities use a variety of techniques to remove VOCs from groundwater including granular activated carbon, air strippers, and catalytic reductive dehalogenation (CRD). Air-stripping units replaced ultraviolet/hydrogen peroxide systems that had been in use since 1990. Cumulative VOC mass removed from groundwater and soil vapor extraction through 2002 was 1,380 kilograms (LLNL 2003l). The decrease in size and concentration observed in the Livermore Site VOC plumes is consistent with VOC mass removed since remediation began in 1989. Groundwater is also treated at some facilities for chromium (VI), using an ion-exchange unit during the wet season, December though March (LLNL 2002cc).

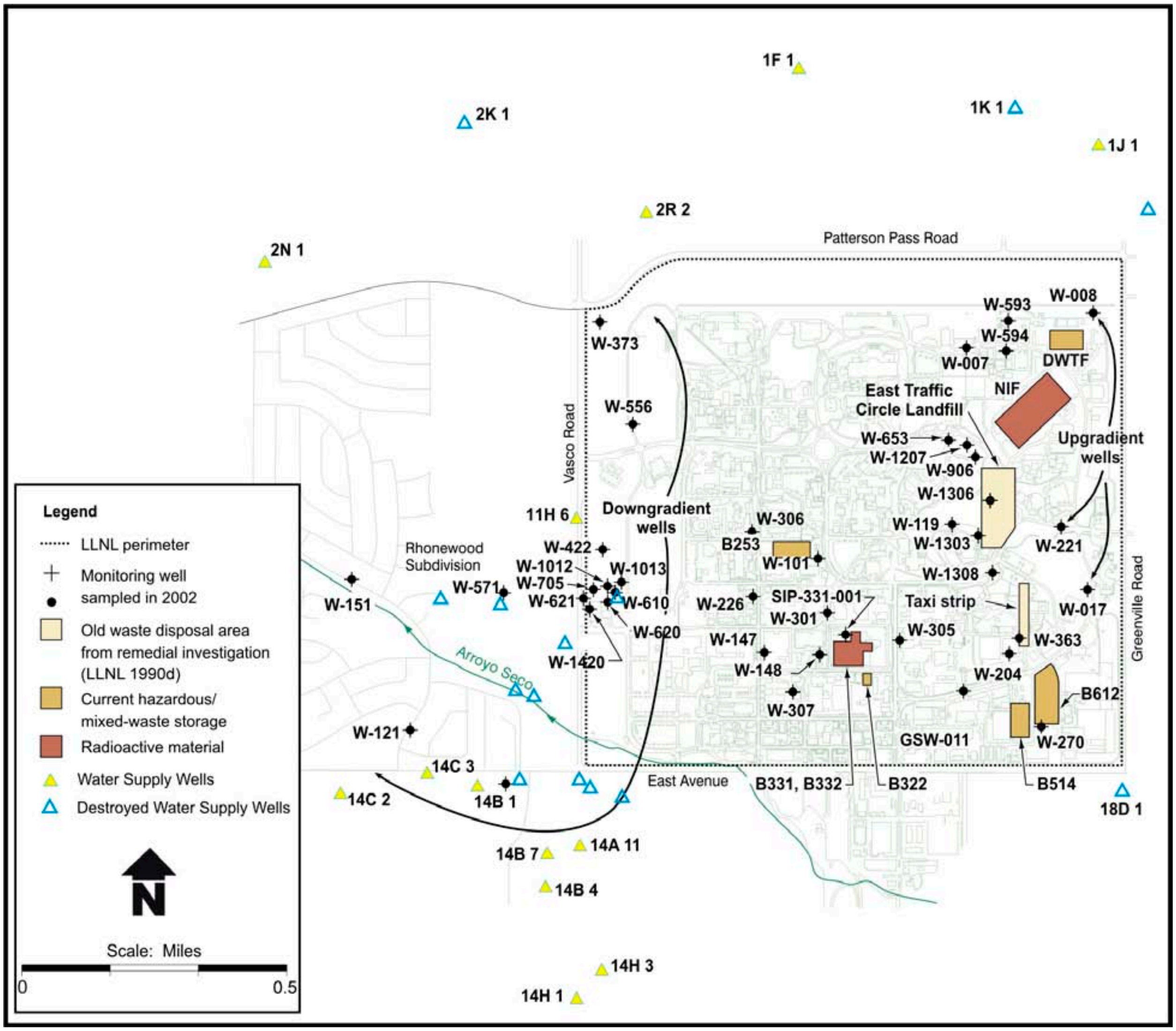
As discussed in the Livermore Site Five-Year Review, from 1996 to 2001, the size and concentrations of VOC plumes had decreased significantly in areas where groundwater extraction and treatment had been implemented (LLNL 1997p). Where groundwater extraction was not occurring, contaminant plumes had migrated, increased in size, or remained unchanged. Along the western margin of the Livermore Site, comprehensive hydraulic containment of all contaminant plumes migrating offsite had been achieved. In the southeastern quadrant, however, total VOC concentrations increased from 521 parts per billion in 2001 to 1,684 parts per billion in 2002. Cleanup in this VOC hot spot is scheduled to begin in 2005. All treatment facilities complied with all permits through 2002 (LLNL 2003l).

Tritiated water is potentially the most mobile groundwater contaminant emanating from the Livermore Site. In August 2002, concentrations of tritium were found at 2,900 ± 300 picocuries per liter (about 15 percent of the MCL) in groundwater from well W-148, downgradient from the Tritium Research Laboratory (Building 331). See Figure 4.11.3.4–1 for Livermore Site groundwater monitoring well locations. Groundwater tritium levels had reduced to approximately 2,600 ± 300 picocuries per liter by December 2002 in all the wells sampled downgradient of Building 331. During 2002, tritium groundwater activities in all wells remained below the MCL and continued to decrease by natural decay (LLNL 2003l).

Dissolved chromium has been detected in groundwater samples at the Livermore Site. Groundwater at well W-307, near Building 322, showed a maximum concentration of dissolved chromium of 15 parts per billion, the highest concentration of hexavalent chromium measured in any background well since 1996. Dissolved chromium also has been detected downgradient from the Building 253 catch basin, in wells W-226 and W-306, where concentrations were 10 parts per billion and 40 parts per billion, respectively. No concentrations of either dissolved chromium or hexavalent chromium exceeded the 50 parts per billion total chromium MCL for drinking water (LLNL 2003l).

In 2001, a leaking pipe was discovered connected to a Building 151 mixed-waste retention tank system. It is unknown how long the pipe leaked because it was buried underground. Liquid wastes in this tank system have included various VOCs, trace metals, americium-241, tritium, and various gamma-emitting radioisotopes. Excavations were made around the pipe and soils were analyzed, but no soil contamination was discovered. One upgradient and two downgradient groundwater sampling locations were established to monitor contaminants. VOCs detected in groundwater are being remediated under CERCLA. Concentrations of trace metals, americium, tritium, and gamma-emitting radioisotopes in samples show no indication of being elevated downgradient from Building 151 (LLNL 2002cc).

LLNL currently has in place a storage tank compliance program that is responsible for upgrading and monitoring storage tanks to be certain that they are in compliance with all Federal and state regulations. Information on the storage tank surveillance monitoring program is updated annually and is discussed in detail in the Site Annual Environmental Report.



Source: Hong 2002.

FIGURE 4.11.3.4–1.—*Livermore Site Groundwater Monitoring and Supply Well Locations*

Site 300

The primary contaminants at Site 300 include the solvent trichloroethylene and other VOCs, high explosive compounds, perchlorate, tritium, uranium-238, nitrate, polychlorinated biphenyls (PCBs), silicone-based oil, and metals. In some cases, these compounds have migrated into groundwater as shown on Figure 4.11.3.4–2. Excessive rainfall during the El Niño season (1997 to 1998) contributed to the release of contaminants of concern, mainly tritium in the form of tritiated water, in the Pit 3 and 5 Areas. Because of reduced rainfall since 1998, groundwater elevations have fallen at much of Site 300, thus reducing the potential for releases to occur.

Several groundwater contaminant plumes exist at Site 300 (see Figure 4.11.3.4–2). All contaminant release sites have been assigned to a CERCLA environmental restoration operable unit (OU), based on the nature and extent of contamination and topographic and hydrologic consideration. In the GSA OU, past leaks of solvents from storage areas and buried debris have resulted in three VOC groundwater plumes (LLNL 2002cc). The maximum total VOC concentration in the eastern GSA plume in 2002 was 7.5 parts per billion. VOC plumes in the central GSA had a maximum groundwater concentration of 958 parts per billion. After 8 years of remediation, in 1999, the eastern offsite plume has been restricted to Site 300 property.

VOC and nitrate groundwater plumes are present in the Building 834 OU. The highest VOC concentration of 220,000 parts per billion (predominantly trichloroethylene) occurred in a perched water-bearing zone. This layer has very low hydraulic conductivity, but does yield some groundwater and is hydraulically isolated from the underlying aquifer by more than 295 feet of unsaturated zone. High levels of nitrate; e.g., a maximum 2002 concentration of 280 parts per billion, also occurred in groundwater in the Building 834 OU.

The High Explosives Process Area OU 2002 maximum concentrations of TCE, hexahydro-1,3,5-trinitro-1,3,5-traizine (RDX), nitrate, and perchlorate were 80 parts per billion, 93 parts per billion, 130 parts per billion, and 30 parts per billion, respectively. At Building 854 OU, trichloroethylene, nitrate, and perchlorate plumes had maximum groundwater concentrations of 270 parts per billion, 57 parts per million, and 10 parts per billion, respectively. Building 832 Canyon OU contains groundwater plumes of trichloroethylene, perchlorate, and nitrate at maximum concentrations of 12,000 parts per billion, 11 parts per billion, and 190 parts per million, respectively (LLNL 2003l).

In the past, explosives operations at the Building 850/Pits 3 and 5 OU resulted in releases of tritium and uranium into the groundwater (LLNL 2002cc). In 2002, the maximum tritium activity was approximately 706,000 picocuries per liter in the perched water-bearing zone and 23,700 picocuries per liter in the regional aquifer at the Elk Ravine Fault. Although tritium continues to leach into groundwater, plume activity is decreasing at approximately the radioactive decay rate of tritium (12.3 years). Computer modeling suggests that by the time tritium and depleted uranium in groundwater could reach the Site 300 boundary, both radionuclides would exist at near-background activities. Two smaller depleted uranium plumes had maximum concentrations in 2002 of approximately 118 picocuries per liter and 10.2 picocuries per liter. Both plumes are confined to the perched water-bearing zone. Nitrate and perchlorate maximum concentrations in 2002 were 86 parts per million and 44 parts per billion, respectively.

The Pit 6 OU contains trichloroethylene, perchlorate, and tritium groundwater contaminant plumes with maximum concentrations in 2002 of 5.2 parts per billion, 15 parts per billion, and 1,970 picocuries per liter, respectively (LLNL 2003l). Both tritium and perchlorate plumes are confined to shallow depths in the perched water-bearing zone. No plumes extend beyond the Site 300 boundary. The tritium plume, however, appears to be affected by heavy pumping from offsite Carnegie State Vehicular Recreation Area water supply wells. This plume migration and the associated potential risks are being closely monitored under the CERCLA program. LLNL's CERCLA program is summarized annually in the Site Annual Environmental Report (LLNL 2002cc).

In 2002, 11 treatment facilities treated 24.6 million gallons of groundwater and removed 9.5 kilograms of VOCs. Since remediation efforts began in 1990, more than 226 million gallons of groundwater and 3.93 million cubic meters of vapor have been treated, yielding 231 kilograms of removed VOCs (LLNL 2003l).

For surveillance and compliance monitoring at Site 300, LLNL uses DOE CERCLA wells onsite and private wells and springs offsite. Groundwater samples are measured for organic compounds and general radioactivity at least once a year. Figure 4.11.3.4–3 shows the locations of monitoring wells used for groundwater surveillance. Twelve groundwater-monitoring locations are offsite. Onsite wells monitor a former open-air explosives burn pit, closed landfills, two connected surface water impoundments, and two connected sewer ponds. Two onsite supply wells (well 18 and well 20) are used for surveillance monitoring. Historically, well 18 has shown trace amounts of trichloroethylene. The maximum concentration for 2002 was 0.3 parts per billion, which is equal to 6 percent of the MCL for trichloroethylene. CERCLA studies have not yet determined the source of trichloroethylene in well 18. Well 20 showed no evidence of contamination in 2002 (LLNL 2003l). Trichloroethylene concentrations have decreased below drinking water standards in all offsite wells.

Tritium activity was above background in many of the shallow groundwater surveillance samples obtained during 2002 from Elk Ravine. Tritium, in the form of tritiated water, was released previously near Building 850 and continues to leach into groundwater from vadose zone sources at Building 850. The largest tritiated water plume, which extends eastward more than a mile from a source beneath Building 850, is confined to shallow depths in the Neroly lower blue sandstone unit and overlying alluvium. This confinement is illustrated by comparing the tritium activity of 46,000 picocuries per liter at well NC7-61, which samples the shallowest water-bearing zone, and the tritium activity of 49 picocuries per liter at well NC7-69, which samples the deeper water-bearing zone in this area. Despite past releases, CERCLA modeling studies indicate that tritium concentrations and plume extent are generally diminishing over time.

Natural decay (tritium has a half life of 12.3 years) and slow groundwater velocities (16 – 50 feet per year) will allow released tritiated water to decrease several orders of magnitude below its MCL before it can reach the site boundary and migrate offsite (LLNL 2003l).

The city of Tracy, located northeast of Site 300, uses groundwater from alluvial aquifers in the San Joaquin Valley, which are isolated from contamination at Site 300 by thick claystone layers and a horizontal distance of more than 5 miles. Modeling suggests that contaminants from Site 300 will not affect groundwater used in the Tracy area (LLNL 2000b).

4.11.4 Water Use

Livermore Site

The Livermore Site's primary water source is the San Francisco Hetch Hetchy Aqueduct system. This system obtains its water from a reservoir in the Hetch Hetchy Valley of Yosemite National Park. The secondary or emergency water source is the Alameda County Flood and Water Conservation District, Zone 7. This water is a mixture of groundwater and water from the South Bay Aqueduct of the state water project (LLNL 1992a).

In 2002, 1.2 million gallons per day were derived from the Hetch Hetchy Aqueduct and Zone 7 for use at the Livermore Site. Water is primarily used for industrial cooling processes, sanitary systems, and irrigation at the Livermore Site. Minor amounts of water are used for drinking, manufacturing, washing, system filters, boilers, and a swimming pool (LLNL 1992a).

Livermore Site Vicinity

Water for commercial, residential, and agricultural use near the Livermore Site is derived from private wells, Zone 7, city of Livermore wells, and California Water Service Company (CWSC) wells. CWSC has 13 wells in the Livermore area that produce 1,200 million gallons per year, which is augmented by the purchase of 2,200 million gallons per year from Zone 7 Water Service. CWSC water supply serves approximately 54,000 people in the Livermore area.

Figure 4.11.3.4–1 illustrates water supply well locations in the Livermore vicinity. Ten active domestic supply wells are located within one-half mile of the Livermore Site boundary. Well 11H6 is the closest domestic supply well, located just east of Vasco Road.

Two wells within a half-mile of the Livermore Site are used for irrigation used for agriculture (including lawns and gardens) and industrial supply. Of those, well 14B1 is the closest to the Livermore Site, about 200 feet south of East Avenue. The main agricultural groundwater user in the vicinity was the Wente Brothers Winery located southwest of LLNL. Groundwater for the winery is pumped from Well 14C3 during periods of peak water demand. Ten supply wells have been destroyed since the 1990 inventory near the VOC plume in the southwest corner of the Livermore Site.

Site 300

Site 300 draws drinking water from two onsite groundwater production wells in the southeastern part of Site 300. Therefore, water is subject to the *Safe Drinking Water Act* of 1974 regulations (LLNL 2002cc). The system operates under Water Supply Permit No. 03-10-94-001. The system includes a primary drinking water supply well (well 20) and a backup well (well 18), several holding tanks, and a distribution network. Both are deep, high-production wells that can produce up to 23,700 gallons per hour of potable water (LLNL 2003l). Water production from these wells has declined from a peak of 32.7 million gallons in 1992 to 25 million gallons in 2002. LLNL disinfects well water with chlorine and monitors the quality of this water at the well and throughout the distribution system. In addition, the Hazards Control Department reviews the data to ensure that drinking water standards are met. Site 300 Plant Engineering submits the required reports to the California State Department of Health Services (LLNL 2002cc).

In the near future, it is expected that Site 300 will obtain its drinking water from the Hetch Hetchy Aqueduct system. LLNL will maintain the onsite drinking water wells as a backup supply and will be responsible for the Site 300 Drinking Water Permit requirements.

Figure 4.11.3.4–3 shows the groundwater surveillance sampling locations for Site 300. Well VIE2 is located at a private residence 3.7 miles west of the site and represents a typical potable water supply well in the Altamont Hills. One stock watering well (MUL1) and two stock watering springs (MUL2 and VIE1) are adjacent to Site 300 on the north. Eight wells, CARNRW1, CARNRW2, CDF1, CON1, CON2, GALLO1, STONEHAM1, and W35A-04, are adjacent to the site on the south. Seven of these wells are privately owned and were constructed to supply water for drinking, stock watering, and fire suppression. Well W35A-04 was installed for site monitoring purposes only (LLNL 2003l).

4.11.5 Floodplains

Livermore Site

A floodplain is defined as the valley floor adjacent to a streambed or arroyo channel that may be inundated during high water. Arroyo Las Positas and Arroyo Seco are the only potential sources of flooding onsite. Localized flooding is most likely to occur during the rainy season from October to April. Open ditches and storm drains are designed for a 10-year storm event. Most of the Livermore Site ultimately drains to the north into Arroyo Las Positas, and a small percentage of land in the southwest corner drains southward to Arroyo Seco.

The original course of Arroyo Las Positas was through what is now the Livermore Site. In the 1940s, the U.S. Navy diverted the arroyo to its current location. It now approaches the Livermore Site from the east, runs north along the eastern boundary of the Livermore Site for approximately 1,000 feet, then turns west and flows adjacent to the northern boundary of the Livermore Site until it exits the site in the far northwest corner.

Flood insurance studies were performed by the Federal Emergency Management Agency (FEMA) to determine flood hazards in Alameda County and to identify the approximate limits of the 100-year floodplain. These floodplains were incorporated into Flood Insurance Rate Maps (FEMA 1981, FEMA 1997a, FEMA 1997b). Maps depicting the 100-year and 500-year floodplains for the Livermore Site are presented in Appendix F, Figure F.2.1–1.

Arroyo Las Positas is an intermittent stream that drains approximately 3,300 acres in the northeastern and eastern hills above the Livermore Site. Flow has increased in the arroyo over the past several years, due mostly to discharge from the DRB. The additional flow has improved water quality and habitat value (Water KPT 2002). This arroyo has a maximum predicted 100-year base flood peak flow adjacent to the Livermore Site of 822 cubic feet per second (LLNL 1992a). The 100-year floodplain broadens as it approaches the Livermore Site from the east, from 100 feet wide to approximately 800 feet wide, covering Greenville Road along the northeastern boundary of the Livermore Site. The spreading is due to the shallow channel that cannot contain the 100-year flood. As the arroyo flows westward along the northern boundary of the Livermore Site and approaches the northwest corner of the site, the 100-year flood flow exceeds the channel banks to a width of approximately 120 feet. Storm flow within the northern perimeter channel combines with the western area drainage at the northwest corner of the site. The flow is conveyed to the north, beyond the site, within a drainage easement (the north buffer zone) managed and maintained by LLNL. The 500-year floodplain extends approximately 2,000 feet to the north and is generally bounded by the Western Pacific Railroad right of way (Appendix F, Figure F.2.1–1).

After the FEMA studies were complete, the Arroyo Las Positas Maintenance Project was implemented to protect the Livermore Site from the 100-year flood by ensuring that the arroyo would be capable of handling the 10-year storm event and using the north buffer zone as a floodplain for storm events exceeding the capacity of the arroyo. The maintenance project is permitted under several agencies, including the USFWS, the RWQCB, and USACE nationwide permit. A 2-foot-high berm was constructed along portions of the southern bank of the arroyo to ensure that the 100-year flood event would not inundate the Livermore Site. Maintenance activities undertaken to ensure that the channel can handle the 10-year storm event include a 5-year phased project to desilt the 7,000-linear-foot stretch of arroyo on LLNL property, trimming cattail heights, and conducting bank stabilization/erosion control activities (LLNL 2003l).

Arroyo Seco is an intermittent stream that drains approximately 8,960 acres in the foothills to the southeast of the Livermore Site. The channel is narrow and deeply incised where it is present for about 900 linear feet in the far southwest corner of the Livermore Site. It has a 100-year base flood peak flow of 1,200 cubic feet per second that is contained within the channel at the Livermore Site (LLNL 1992a).

Site 300

Site 300 is primarily on undeveloped land characterized by steep hills and deep ravines. A floodplain analysis was conducted for the 1992 LLNL EIS/EIR for this site to determine the depth and width of inundation due to the 100-year storm event. This analysis is summarized in Appendix F.

Based on the results, there are no 100-year floodplains on Site 300 as the 100-year base flood event is contained within all channels. However, due to the steep slopes and high runoff potential, velocities within these channels could be high during a peak flood event.