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Groundwater Investigation and Remediation

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During 2003, groundwater investigations and remediations under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) continued at both the Livermore site and Site 300. LLNL samples and analyzes groundwater from areas of known or suspected contamination. Portions of the two sites where soil or groundwater contains or may contain chemicals of concern are actively investigated to define the hydrogeology and nature and extent of the contamination and its source. Where necessary, remediation strategies are developed and evaluated in preparation for a CERCLA removal action or through the feasibility study process. An approved remedy for each area is developed in consultation with the regulatory agencies and the community.

This chapter reviews the distribution of contaminants in groundwater and the progress LLNL has made in removing contaminants from groundwater and from the unsaturated zone (soil vapor) at the Livermore site and Site 300. The sites are similar in that the contamination is, for the most part, confined to the site. The sites differ in that Site 300, with an area of 30.3 km^2 (11.8 mi^2), is much larger than the Livermore site and has been divided into eight operable units based on the nature and extent of contamination, and topographic and hydrologic considerations. The Livermore site at 3.08 km^2 (1.3 m^2) is effectively one operable unit.

Livermore Site Ground Water Project

Initial releases of hazardous materials occurred at the Livermore site in the mid-to-late 1940s when the site was the Livermore Naval Air Station (Thorpe et al. 1990). There is also evidence that localized spills, leaking tanks and impoundments, and landfills contributed volatile organic compounds (VOCs), fuel hydrocarbons, metals, and tritium to the groundwater and unsaturated sediment in the post-Navy era. The Livermore site was placed on the U.S. Environmental Protection Agency National Priorities List in 1987.

An analysis of all environmental media showed that groundwater and unsaturated sediment are the only media that require remediation (Thorpe et al. 1990). The identified compounds that currently exist in groundwater at various locations beneath the site at concentrations above drinking water standards, or maximum contaminant levels (MCLs), are trichloroethylene (TCE), perchloroethylene (PCE), 1,1-dichloroethylene, chloroform, 1, 2-dichloroethylene, 1,1-dichloroethane, 1,2-dichloroethane, trichlorotrifluoroethane (Freon 113), trichlorofluoromethane (Freon 11), and carbon tetrachloride.

Physiographic Setting

The general topography of the Livermore site is described in Chapter 1. The Livermore Valley groundwater system is a sequence of semiconfined aquifers in which groundwater moves downslope from the valley uplands toward the east-west axis of the valley. It then flows generally westward toward the southwest portion of the basin. From there, groundwater has historically flowed south into the Sunol Valley Groundwater Basin.

The largest quantities of groundwater are pumped from the central and western portions of the Livermore Valley, where the valley fill sediment is thickest. These sediments make up two aquifers: the Livermore Formation and its overlying alluvium. The Livermore Formation averages about 1000 m in thickness and occupies an area of approximately 250 km^2. The alluvium, which is about 100 m thick, is the principal water-producing formation within the valley.

Hydrogeology of the Livermore Site

Sediment types at the Livermore site are grouped into four categories—clay, silt, sand, and gravel—based on the dominant particle type. Groundwater flow beneath the site is primarily in alluvial sand bodies, gravel lenses, and channels, bounded by the less permeable clay and silt. The alluvial sediments have been mapped into nine hydrostratigraphic units (HSUs) beneath the Livermore site, using data collected over the years. HSUs can be defined as sedimentary sequences whose permeable layers show evidence of hydraulic connection. The HSUs of concern beneath the Livermore site are the Quaternary alluvial deposits of the upper member of the Livermore Formation (see **Figure 7-1**). HSUs 1B, 2, 3A, 3B, 4, and 5 contain contaminants that are primarily solvents (Blake et al. 1995; Hoffman et al. 1998).

Remediation Activities and Monitoring Results

In 2003, the Livermore site Ground Water Project (GWP) treated more than 1060 million liters of groundwater and removed approximately 90 kg of VOCs (**Table 7-1**). The GWP also brought new treatment facilities on line, installed wells, conducted hydraulic tests, developed groundwater models, published required documents, and maintained close contact with regulatory agencies and the community.

LLNL removes contaminants from groundwater and from the unsaturated zone (soil vapor) at the Livermore site through a system of 28 treatment facilities located throughout the 6 HSUs containing contaminants of concern. Extraction wells are used to extract groundwater for each facility, which is then treated to remove VOCs. Treatment usually consists of removing VOCs with an air-stripping system, after which any VOCs present in the stripper's effluent air are removed with granular activated carbon filters.

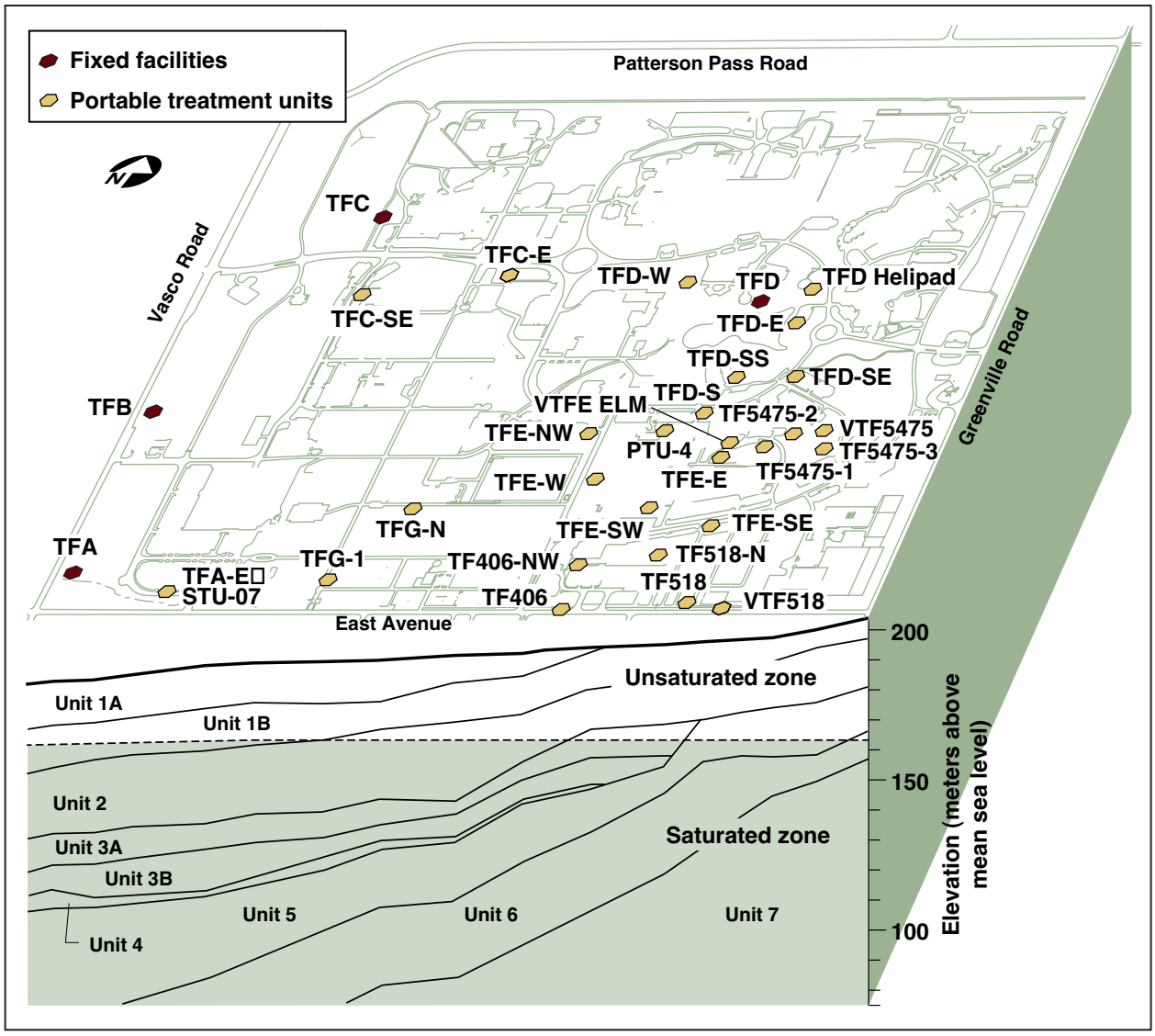

Figure 7-1. Map and cross section of the Livermore site showing hydrostratigraphic units and the locations of the treatment facilities

Of the 28 treatment facilities in operation in 2003, 26 are groundwater treatment facilities and 2 are a vapor treatment facilities (VTFs). A total of 78 groundwater extraction wells and 3 soil vapor extraction wells operated in 2003. Since operations began in 1989, approximately 8471 million liters of groundwater and approximately 1.4 billion m^3 of vapor have been treated, and more than 1554 kg of VOCs have been removed. Table 7-1 shows both the 2003 totals and the cumulative totals of groundwater and soil vapor treated at the facilities and the estimated VOCs removed from the subsurface. A graph of VOC mass removal at the Livermore site since 1989 is presented in Figure 7-2.

Table 7-1. Volatile organic compounds removed from groundwater and soil at the Livermore site

Groundwater treatment facility[a]	Startup date	2003		Cumulative total	
		Water treated (ML)[b]	VOCs removed (kg)	Water treated (ML)	VOCs removed (kg)
TFA	9/89	371.7	8.4	4030	163
TFB	10/90	124.9	5.0	912	59.2
TFC	10/93	121.1	6.6	717	60.5
TFD	9/94	265.0	53.6	1770	553
TFE	11/96	98.4	12.8	642	151
TFG	4/96	21.2	1.2	92.6	4.9
TF406	8/96	51.5	1.4	263	9.0
TF518	1/98	5.3	0.5	42.4	4.8
TF5475	9/98	0.38	0.5	2.65	5.4
Total[c]		1060	90	8471	1011
Vapor treatment facility		**Soil vapor treated ($10^3 m^3$)**	**VOCs removed (kg)**	**Soil vapor treated ($10^3 m^3$)**	**VOCs removed (kg)**
VTF518	9/95	0	0	425	153
VTF5475	1/99	242	33.9	899	340
VTFE ELM	9/03	93.1	50.4	93.1	50.4
Total[c]		335	84	1418	543

a Includes fixed and portable units

b ML = million liters

c Totals rounded to nearest whole number

GWP activities, such as the types of treatment used at the different facilities and total VOC isoconcentration maps for each HSUs, are further described in the *Ground Water Project 2003 Annual Report* (Karachewski et al. 2004).

In 2003, concentrations continued to decrease in most Livermore site VOC plumes. The decline in VOC concentrations is primarily attributed to active remediation and reflects the 90 kg of VOCs removed by the groundwater extraction wells during 2003 (**Table 7-1**). Notable trends and results of VOC analyses of groundwater received from the fourth quarter 2002 to the third quarter 2003 are discussed below.

VOC concentrations on the western margin of the site either declined or remained unchanged during 2003, indicating continued effective hydraulic control of the boundary plumes in the Treatment Facility (TF) A, TFB, and TFC areas. VOC concentrations in the TFA, TFB, and TFC source areas remained unchanged as well. The offsite HSU 1B VOC plumes were below MCLs for all VOCs of concern except at one

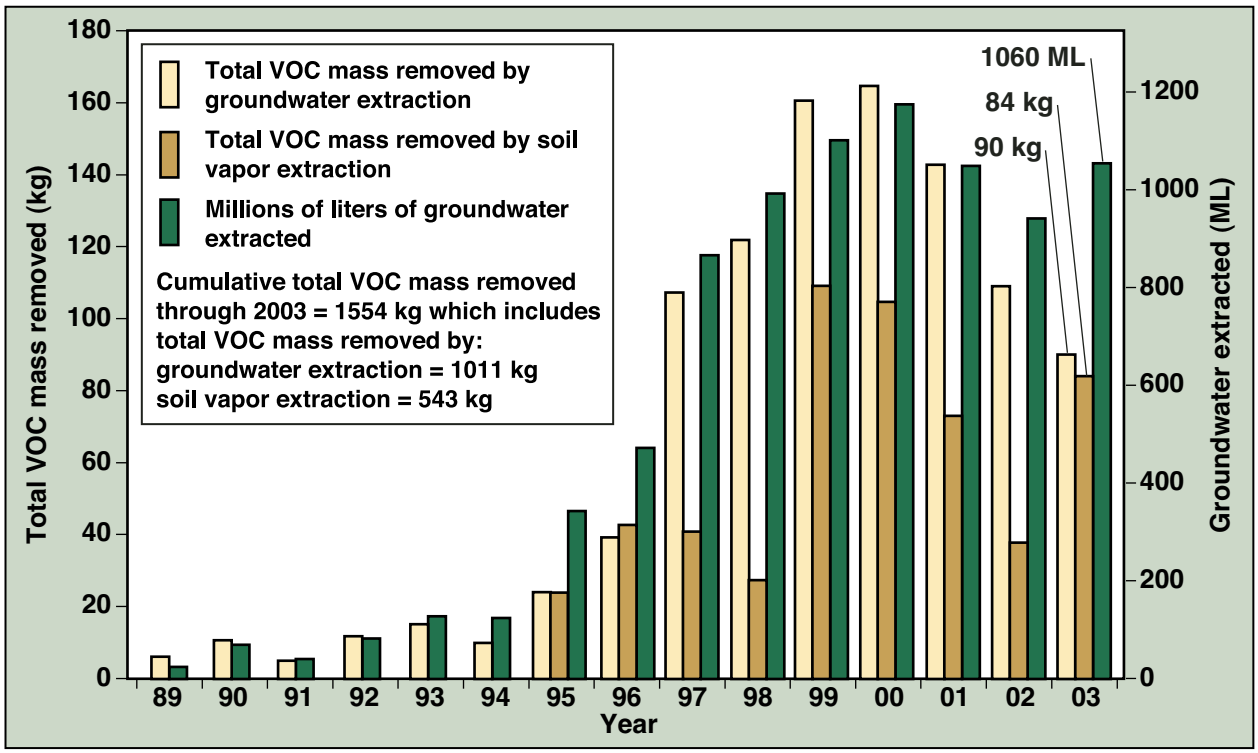

Figure 7-2. Total VOC mass removed and groundwater extracted from the subsurface of the Livermore site, 1989–2003

well where it was slightly above the MCL. PCE was detected at 5.4 µg/L at well W-506 in October 2003. The entire off-site and on-site TFA HSU 2 plume was below 50 µg/L total VOCs for the first time. All offsite TFA HSU 3A wells remained below MCLs for all VOCs of concern.

VOC concentrations in a mobile HSU 2 plume located in the western TFE area continued to decline in 2003. The 100 µg/L total VOC contour within the plume shrank 168 meters toward TFE West extraction well W-305, and total VOCs in well SIP-331-001 in the south-central part of the site declined from 101 µg/L in 2002 to 80 µg/L in 2003. Concentrations further downgradient to the west increased slightly, probably in response to activation of TFG North extraction well W-1807, located at the leading edge of the plume. Total VOC concentrations in the Old Salvage Yard in the southeastern part of the site, also known as the TFE Hotspot source area, remained elevated in 2003 (e.g., 1584 µg/L total VOCs at SIP-ETS-601). Source area cleanup at the TFE Hotspot source area is scheduled to begin in 2005.

HSU 3A total VOC concentrations continued to decline in the TF5475 area in 2003 due to a combination of soil vapor extraction at VTF5475 and regional dewatering of HSU 3A. VOCs also declined in the east-central TFD area in response to pumping at

TFD Southshore. TCE concentrations in well W-361 declined from 1000 µg/L in 2002 to 140 µg/L in 2003. Elsewhere in HSU 3A, concentrations remained largely unchanged during 2003.

In HSU 3B, a significant TCE concentration increase observed near TFD South suggests that VOCs within HSU 3B may be migrating out of the TFD Southeast area toward the TFD South area. TCE in well W-1511 increased from 62 µg/L in 2002 to 750 µg/L in 2003. Hydraulic containment of the HSU 3B source area will be addressed as part of 2004 milestones. Elsewhere in HSU 3B, VOC concentrations remained largely unchanged during 2003.

A significant total VOC concentration increase was also observed in HSU 4 at the TFD Helipad area, where concentrations in well W-1253 increased from 212 µg/L in 2002 to 3403 µg/L in 2003. Hydraulic containment of the HSU 4 source area at the TFD Helipad area will be addressed as part of the 2004 milestones. Elsewhere, concentrations in HSU 4 remained largely unchanged during 2003.

VOC concentrations in HSU 5 continue to slowly decline in the TFE East area due to pumping at extraction well W-566. Total VOC concentrations at downgradient well W-1210 decreased from 56 µg/L in 2002 to 47 µg/L in 2003. VOC concentrations on DOE property administered by Sandia National Laboratories south of East Avenue remained low during 2003, suggesting that the Treatment Facility 406 South facility proposed for 2006 may not be needed to achieve timely cleanup. The highest TCE concentrations were observed in well W-509, which declined from 20 µg/L in 2002 to 15 µg/L in 2003. HSU 5 VOC concentrations in other areas of the Livermore site remained largely unchanged during 2003.

During 2003, tritium activities in groundwater from all wells in the TF5475 area remained below the 741 Bq/L (20,000 pCi/L) MCL and continued to decrease by natural decay. Similarly, tritium activities in the Building 292 area declined below the MCL in 2003.

Groundwater Flow and Transport Modeling

Flow and contaminant transport models are used at the Livermore site to optimize the design and operation of remediation systems; to support ongoing subsurface characterization activities; and to improve our ability to forecast, monitor, and interpret the progress of the remediation program. In 2003, LLNL continued development of the three-dimensional (3-D) basin-scale groundwater flow and transport model initiated in 2002. The model was updated by incorporating remediation system improvements and hydrogeologic information from new wells. LLNL is currently improving the calibration of the 3-D model flow field to simulate the extensive extraction well field and the resultant dewatering observed on the eastern portion of the site. In parallel with the basin-scale model, LLNL developed several local-scale models to evaluate the effectiveness of potential groundwater injection wells to mitigate dewatering, as well as their long-term effect on the remediation system.

In addition to groundwater flow and transport models, LLNL also developed semi-analytical and numerical modeling tools to simulate dual extraction and SVE for remediation of source areas. LLNL utilized these quantitative tools in the design, operation, and performance evaluation of the TFE ELM, Trailer 5475, and TFD Helipad source areas. The semi-analytical models were initially calibrated with the data obtained from SVE tests conducted at these source areas. The models were then used to select extraction well locations and treatment facility design parameters such as optimal vapor extraction flow rates. Currently, LLNL is refining source area remedial modeling capabilities and developing approaches to integrate them with the regional-scale models for determining realistic estimates of cleanup time for the Livermore site.

Site 300 CERCLA Project

Environmental investigations and cleanup activities at Site 300 began in 1981. Site 300 became a CERCLA site in 1990, when it was placed on the National Priorities List. The CERCLA environmental restoration operable units (OUs) are shown in **Figure 7-3**. All characterized contaminant release sites have been assigned to one of eight OUs based on the nature, extent, and sources of contamination, and topographic and hydrologic considerations. The major contaminants of concern for each OU are listed in **Table 7-2**. Background information for LLNL environmental characterization and restoration activities at Site 300 can be found in the *Final Site-Wide Remedial Investigation Report, Lawrence Livermore National Laboratory Site 300* (Webster-Scholten 1994). Key milestone and deliverable due dates for 2003 are listed in **Table 7-3**. All milestone and deliverable due dates were met during 2003.

Geology of Site 300

Site 300 is located in the sparsely populated Altamont Hills, which are part of the Coast Ranges Physiographic Province and separate the Livermore Valley to the west from the San Joaquin Valley to the east. Site 300 stratigraphy is shown in **Figure 7-4**. Rocks exposed in the region are classified into three groups:

- Late Tertiary-Quaternary (0–5 million years ago)—alluvium and semi-lithified sediments, mainly of continental origin
- Early to late Tertiary (5–65 million years ago)—shallow marine and continental sedimentary and volcaniclastic rocks
- Jurassic-Cretaceous (65–180 million years ago)—Great Valley sequence (marine sedimentary rocks and ophiolites) and Franciscan Complex (sheared and variably metamorphosed sedimentary and igneous rocks)

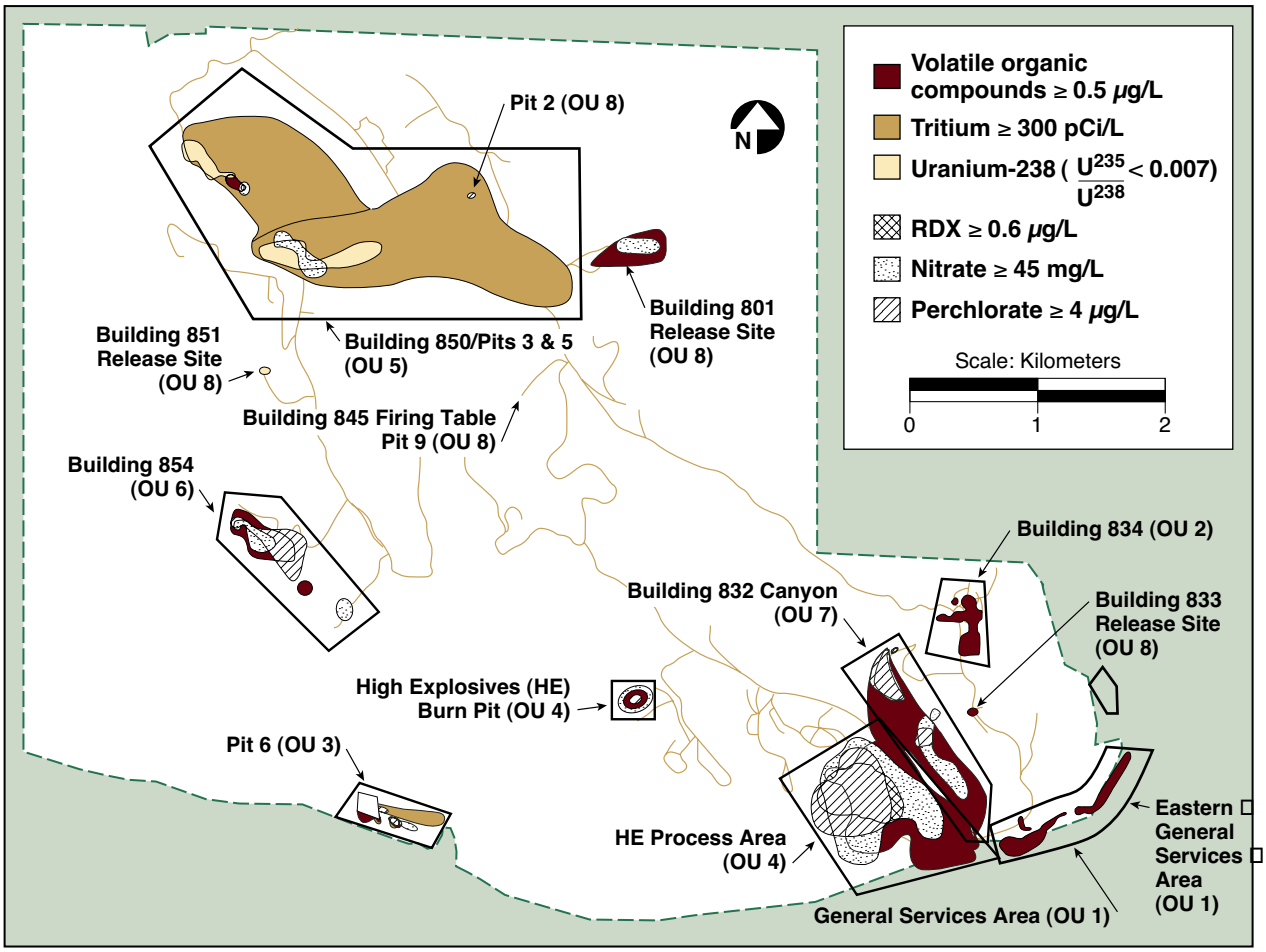

Figure 7-3. Environmental restoration operable units and contaminants of concern

Distinctive blue-gray to brown weathering volcaniclastic sandstone and sandy siltstone, interbedded with light gray weathering tuffaceous claystone and conglomerate, are exposed extensively within Site 300. These rocks are mapped as the late Miocene Neroly Formation (Huey 1948; Dibblee 1980). The Neroly Formation is also present in the subsurface beneath Site 300. It is the principal hydrologic unit within Site 300 and has been the focus of the detailed geologic and hydrogeologic studies conducted during recent years (summarized in the *Final Site-Wide Remedial Investigation Report, Lawrence Livermore National Laboratory Site 300*, [Webster-Scholten 1994]). The complete section of the Neroly Formation is about 150 m thick beneath Site 300.

The floodplain of Corral Hollow Creek lies along the southern boundary of Site 300 and borders portions of the General Services Area (GSA), the High Explosives Process Area, and the area of closed landfill Pit 6. Floodplain alluvium consists dominantly of coarse cobble-bearing terrace gravel derived from sources to the south, with lenses and local coverings of sandy silt and silty clay.

Table 7-2. Major contaminants of concern found in soil, rock, and groundwater at Site 300

Operable Unit (OU)	Contaminant of concern[a]
General Services Area (GSA) (OU1)	VOCs (primarily TCE)
Building 834 Complex (OU2)	VOCs (primarily TCE), organosilicate oil, nitrate
Pit 6 (OU3)	VOCs (primarily TCE), tritium, nitrate, perchlorate
High Explosives Process Area (OU4)	VOCs (primarily TCE), HE (primarily RDX), nitrate, perchlorate
Building 850/Pits 3 & 5 (OU5)	Tritium, depleted uranium, VOCs (primarily TCE), nitrate, perchlorate, metals, PCBs
Building 854 (OU6)	VOCs (primarily TCE), nitrate, perchlorate
Building 832 Canyon (OU7)	VOCs (primarily TCE), nitrate, perchlorate
Site-Wide Operable Unit (OU8)	VOCs (primarily TCE and Freon 113), nitrate, perchlorate, depleted uranium, tritium, metals, RDX, HMX

a See Acronyms and Abbreviations for list of acronyms.

Table 7-3. Calendar year 2003 deliverable and milestone dates for Site 300 environmental restoration activities[a]

Deliverable/Milestone[b]	Due Date
Construct B830-SRC groundwater and soil vapor extraction and treatment facility in the Building 832 Canyon OU	February 28, 2003
Building 854 Draft Interim Remedial Design report	July 1, 2003
Construct B817-SRC groundwater extraction and treatment facility in the HE Process Area OU	September 29, 2003
Install monitor wells for Building 812 and conduct surface soil sampling	September 30, 2003
Complete remedial investigation for the Pit 7 Complex	September 30, 2003
Building 854 Draft Final Interim Remedial Design report	November 14, 2003
Building 854 Final Interim Remedial Design report	December 15, 2003

a Deliverables and milestones are outlined in the Site 300 Federal Facility Agreement and other agreements. See Chapter 2.

b See Acronyms and Abbreviations for list of acronyms.

The bedrock sequence within Site 300 has been slightly deformed into several gentle, low-amplitude folds. The locations and characteristics of these folds, in combination with the regional fault and fracture patterns, locally influence groundwater flow within the site and have therefore been studied in great detail as part of the CERCLA investigations.

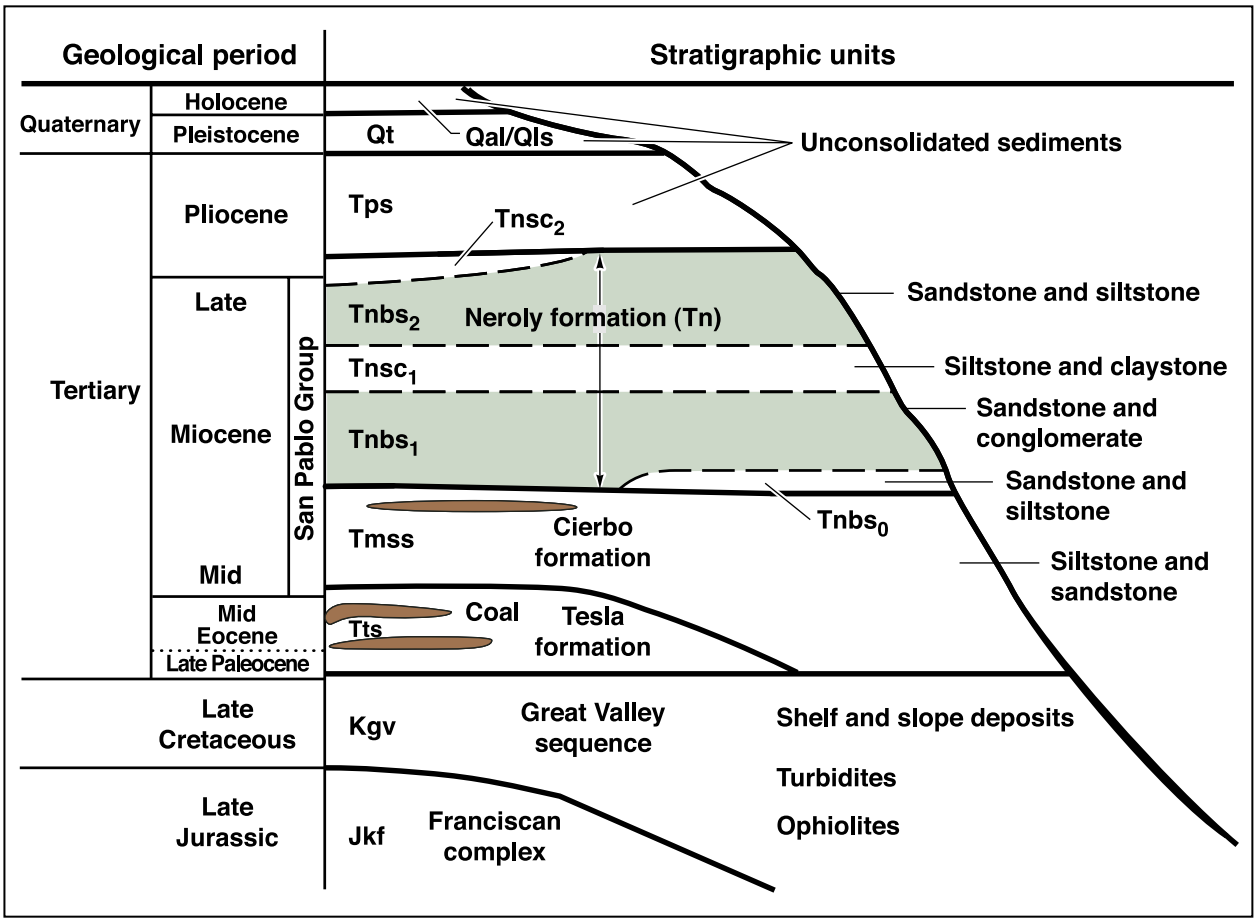

Figure 7-4. Site 300 stratigraphy

Hydrogeology of Site 300

Site 300 is semiarid, with an average annual rainfall of 27 cm. The site is underlain by gently dipping sedimentary bedrock dissected by steep ravines. The bedrock consists of interbedded conglomerates, sandstones, siltstones, and claystones (see **Figure 7-4**). Groundwater primarily occurs in the Neroly Formation upper and lower blue sandstone units ($Tnbs_2$ and $Tnbs_1$) and in the underlying Cierbo Formation (Tmss). Saturated conditions also exist in two units that occur at the base of the Neroly Formation in the Building 854 and Pits 3 and 5 areas, respectively ($Tnsc_0$ and $Tnbs_0$). Groundwater can also be present in permeable Quaternary alluvium valley fill (Qal) during the winter rainy season.

Some groundwater is present as perched water-bearing zones beneath hilltops. The perched water-bearing zones primarily occur in the unconsolidated sediments of the Miocene-age nonmarine unit (Tps) in the Building 833 and Building 834 areas and in

the High Explosives Process Area. An extensive perched water-bearing zone also occurs in $Tnbs_0$ sandstones in the northwestern portion of the East and West Firing Area. Fine-grained siltstone and claystone interbeds in $Tnbs_1$ and Tmss act as aquitards, confining layers, or perching horizons. Portions of the bedrock section at Site 300 are abundantly fractured, and thus much of the groundwater flow occurs in fractures as well as in pores. Bedrock-hosted groundwater is typically present under confined conditions in the southern half of the site but is often unconfined elsewhere. **Figure 7-5** is a map of the potentiometric surface for the first continuous water-bearing zone at Site 300, which principally occurs in the Neroly lower blue sandstone aquifer ($Tnbs_1$) and $Tnbs_0$.

Recharge occurs where saturated alluvial valley fill is in contact with underlying permeable bedrock, and where bedrock strata crop out. Local recharge occurs on hilltops, creating the perched waterbearing zones in the Building 832, Building 834, Building 854, and Building 829/High Explosives Burn Pit areas. Low rainfall and high evapotranspiration rates, steep topography, and intervening aquitards generally preclude direct vertical recharge to the deeper bedrock aquifers.

Groundwater flow in the bedrock follows the inclination, or dip, of the rock layers. The tectonic forces that uplifted the Altamont Hills faulted, gently folded, and tilted the once-horizontal sedimentary strata. A major structure, the east-west trending Patterson anticline, occupies a central location within the site. North of the anticline, bedrock generally dips east-northeast. South of the anticline, bedrock dips south-southeast.

The Cierbo Formation (Tmss) is saturated beneath Doall Ravine, the Building 851 and Building 854 areas, and the southern part of the East Firing Area. The Tmss unit is unsaturated or does not otherwise yield water to wells in other parts of the East and West Firing Areas. The thickness of the Cierbo Formation is not well known because most boreholes are not deep enough to completely penetrate this formation. Some of the deeper wells in the GSA penetrate the uppermost Tmss. The continuity of saturation in the Tmss between the north-west and southeast areas of Site 300 is undetermined. Groundwater in the Tmss occurs under unconfined to artesian conditions.

The Tps unit is the youngest bedrock unit identified at Site 300 and is generally present only on hilltops. Where present, groundwater is typically perched, discontinuous, and ephemeral. The exception to this condition exists in the High Explosives Process Area, where the extent of saturation in Tps sediments is significant. Groundwater in the Tps unit is generally unconfined, although water under confined conditions does occur locally.

Quaternary alluvium (Qal) is present as valley fill in ravines throughout Site 300 but is perennially saturated only in the Corral Hollow Creek stream channel, in Doall Ravine, and in southern Elk Ravine in the vicinity of Building 812. Qal in the Pits 3 and 5 area is only saturated during rainy seasons and for extended periods of higher than normal rainfall. Saturated Quaternary terrace alluvium deposits (Qt) are present at Pit 6, in the GSA, and in the Building 832 Canyon area; some of these groundwater occurrences are ephemeral. Small quantities of groundwater are present in some local landslide (Qls) deposits.

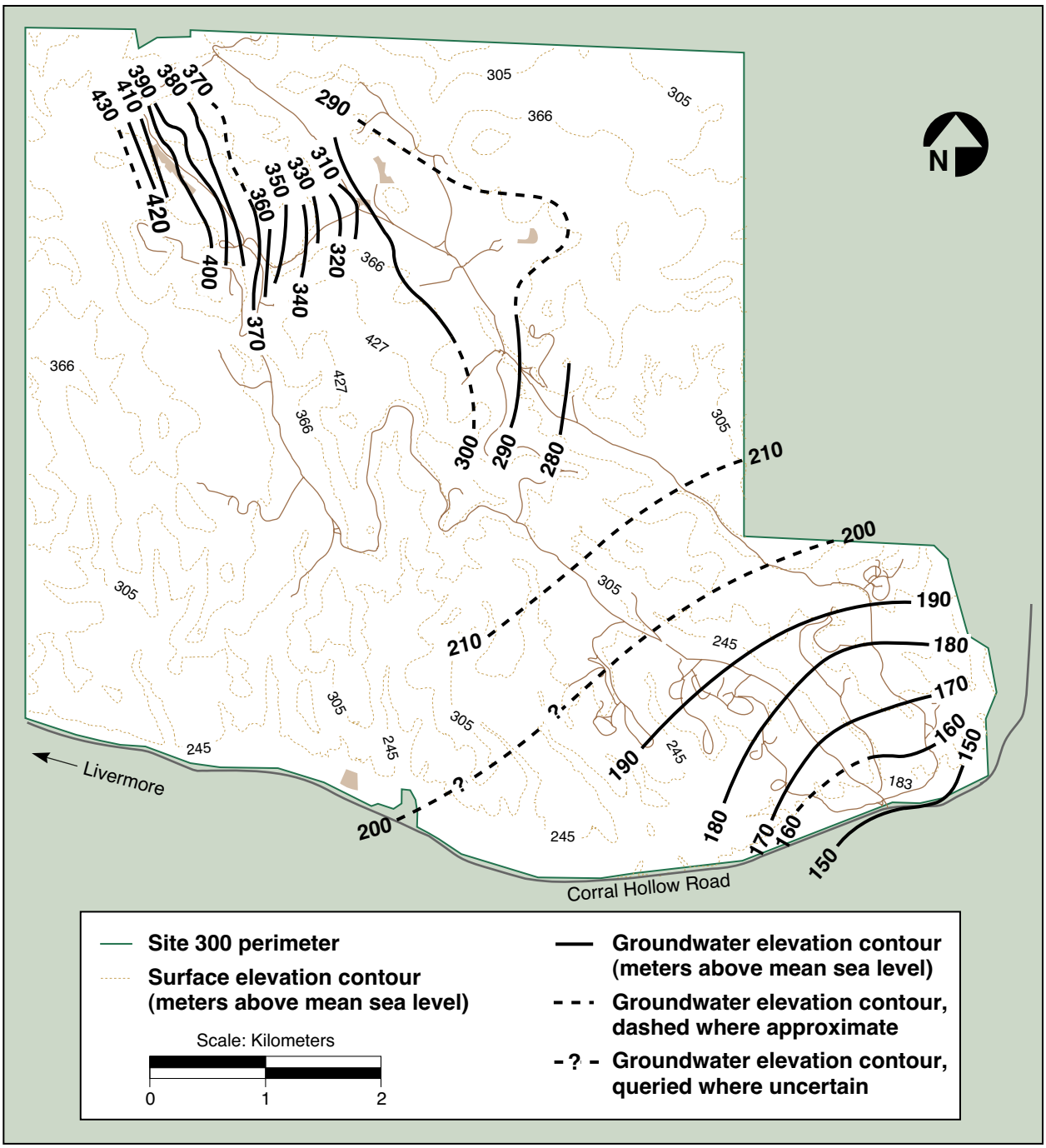

Figure 7-5. Approximate groundwater elevations in the principal continuous water-bearing zone at Site 300

All groundwater contaminant plumes at Site 300 occur in Neroly Formation (Tn) rocks, unnamed Pliocene nonmarine sediments (Tps), or unconsolidated Quaternary sediments (Qal, Qls, or Qt) stratigraphic units. The extent of groundwater contamination at Site 300 is shown in **Figure 7-3**.

Remediation Activities and Monitoring Results

This section presents a summary of monitoring and remediation results for contaminant release sites at Site 300. Detailed monitoring and remediation results for the central GSA, Building 834, High Explosives Process Area, Building 850, Building 854, Pit 6, Building 832 Canyon, and Site-Wide OUs are presented in the *2003 Annual Compliance Monitoring Program (CMP) Report* (Dibley et al. 2004) which is included as an attachment to this SAER report. The eastern GSA treatment system is not included in the CMP report; it operates under a separate National Pollution Elimination System permit and results are presented quarterly (Lamarre 2003a,b,c; Steenhoven 2004). The results of ongoing and planned investigations at the Pit 7 Complex, Building 865, Building 812, and Sandia Test Site are also not a part of the CMP report. Current information for each of these portions of Site 300 is presented at the end of this section.

At Site 300, there are three dedicated (non-potable) groundwater and two soil vapor extraction and treatment facilities at the eastern GSA, central GSA, and Building 834 areas. Due to treatment system modifications and construction activities, the Building 834 treatment facility did not operate during 2003. There are also 10 portable treatment facilities at Site 300, all of which operated during 2003. Thus, 13 treatment facilities that remove VOCs operated during 2003. Twenty-three wells that extract only groundwater, 8 wells that extract only soil vapor and 13 wells that extract both groundwater and soil vapor were pumped and fed into treatment systems during 2003. In 2003, the 23 wells that extract only groundwater and the 13 wells that extract both groundwater and soil vapor yielded about 108.9 million L of groundwater. During the year, the 13 wells that extract both vapor and groundwater and the 8 wells that extract only vapor removed 332,320 m^3 of vapor. In 2003, the Site 300 treatment facilities removed approximately 2.87 kg of VOCs. Since remediation efforts began in 1990, more than 977.2 million L of groundwater and approximately 4.26 million m^3 of vapor have been treated, yielding about 234 kg of removed VOCs. **Table 7-4** summarizes 2003 and cumulative totals of volumes and masses of contaminants removed from groundwater and soil vapor at each Site 300 OU.

The central GSA, eastern GSA, and B830-Distal South (B830-DISS) treatment facilities discharge to surface drainage courses. The B854-Proximal (B854-PRX) solar treatment unit/containerized wetland, B815-Distal (B815-DIS) aqueous phase granular activated carbon, and B830-Proximal North (B830-PRXN) granular activated carbon treatment systems discharge to an infiltration trench. The other seven treatment systems discharge to air by misting.

Table 7-4. Volatile organic compounds removed from groundwater and soil at Site 300

Operable Unit	Startup date	2003		Cumulative total	
		Water treated (ML)[a]	VOCs removed (kg)	Water treated (ML)[a]	VOCs removed (kg)
Eastern GSA	1991	89.3	0.20	895.9	6.39
Central GSA	1993	5.4	0.36	34.56	11.0
Building 834	1995	0	0	0	31.84
High Explosives Process Area	1999	8.4	0.17	18.16	0.26
Building 854	1999	2.8	0.60	15.05	6.74
Pit 6	1998	—[b]	—[b]	0.268	0.0014
Buildings 830 and 832	1999	2.94	0.23	13.12	0.67
Total		108.9	1.56	977.2	56.9
		Soil vapor treated ($10^3 m^3$)	VOCs removed (kg)	Soil vapor treated ($10^3 m^3$)	VOCs (kg)
Central GSA	1994	277.33	1.15	2265.00	67.31
Building 834	1998	0	0	1657.56	108.26
Building 832	1999	54.99	0.16	337.55	1.55
Total		332.32	1.31	4260.11	177.12

a ML = 1 million liters

b Groundwater treatment is not routine at Pit 6. A hydraulic pump test with a portable treatment unit for TCE removal was conducted there in 1998.

The eastern and central GSA contain maintenance and shop facilities and released contaminants to groundwater due to dry well and liquid storage activities. Groundwater influent TCE concentrations to the eastern GSA OU were reduced from 64 µg/L in January 1992 to 2.0 µg/L in December 2003. No longer do any off-site wells in the eastern GSA yield groundwater containing TCE concentrations in excess of the cleanup standard of 5 µg/L. LLNL estimates that 5 to 10 more years of groundwater extraction and treatment will be required to achieve and maintain groundwater VOC concentrations below the cleanup standard at the eastern GSA. TCE concentrations in shallow groundwater beneath the eastern GSA are shown on **Figure 7-6**.

TCE concentrations in the central GSA OU groundwater influent have been reduced from 9400 µg/L in 1993 to 49 µg/L in October 2003. From 1994 through the end of 2003, total VOC concentrations in the central GSA soil vapor extraction influent stream were reduced from 450 mg/L to 1.9 mg/L. VOC concentrations in individual central GSA soil vapor extraction wells have also been significantly reduced. Total VOC concentrations in groundwater beneath the central GSA are shown on Figure 2.1-3 of the *2003 Annual CMP Report.*

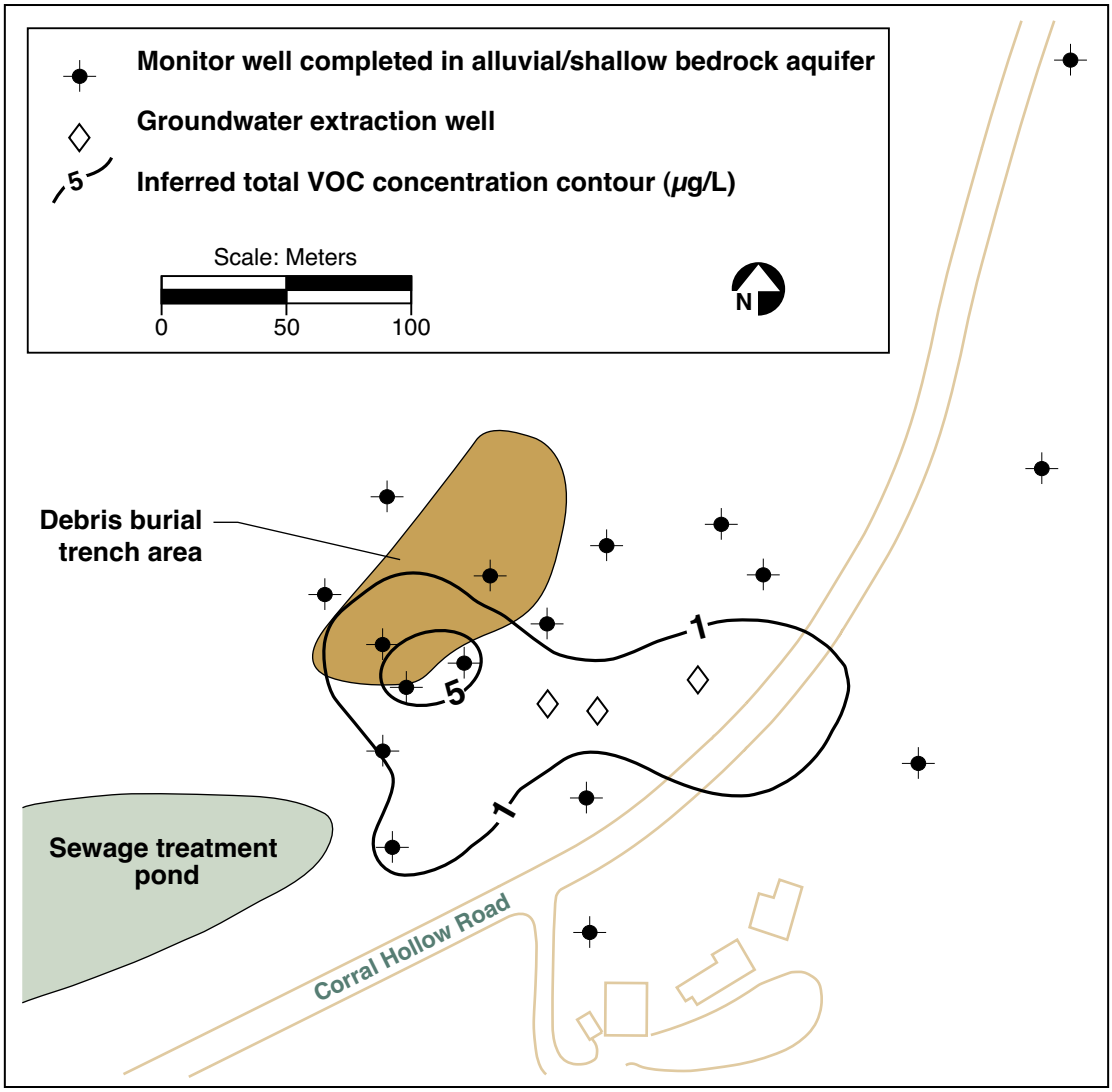

Figure 7-6. Total VOC concentrations in groundwater in the eastern GSA and vicinity (4th quarter 2003)

At Building 834, prototype weapons components were subjected to a variety of environmental stresses including heat and pressure. TCE was used as a heat-exchange fluid and was circulated in piping that leaked. The maximum 2003 total VOC concentration at Building 834 was 200,000 µg/L. Total VOC concentrations in groundwater beneath the Building 834 area are shown on Figure 2.2-3 of the *2003 Annual CMP Report.* Although the Building 834 extraction and treatment system did not operate during 2003 due to treatment facility modifications and construction activities, some VOC mass was destroyed by in situ bioremediation. This mass was not quantified. With the completion of treatment facility upgrades and construction, groundwater and soil vapor extraction and treatment at Building 834 will resume in 2004.

At the High Explosives Process Area OU, where high explosives are pressed and formed, LLNL proceeded to implement the next phase of the remedial strategy by completing construction and beginning operation of the B817-SRC facility. Three other groundwater extraction and treatment systems (B815-SRC, B815-PRX, and B815-DIS) are also operating to reduce contaminant mass in the High Explosives Process Area. Total VOC concentrations in groundwater beneath the High Explosives Process Area are shown on Figure 2.4-3 of the *2003 Annual CMP Report*. Maximum 2003 total VOC concentrations (49 µg/L) were detected in the $Tnbs_2$ aquifer. The total VOC concentrations in source area wells have been reduced by 20 to 40% since remediation began in 1999.

Building 850 is an explosives firing table. During 2003, the maximum detected tritium activity in groundwater at the Building 850 OU was 2880 Bq/L (77,700 pCi/L). Tritium activities in groundwater beneath the Building 850 OU are shown on Figure 2.5-3 of the *2003 Annual CMP Report*. Monitored natural attenuation (MNA) is the selected remedy for the remediation of tritium in groundwater emanating from the Building 850 area. MNA continues to be effective for tritium in that the extent of the 741 Bq/L (20,000 pCi/L) MCL contour continues to diminish and the highest tritium activities continue to be located immediately downgradient of the firing table. The maximum 2003 total uranium activity in groundwater that contains some depleted uranium was 0.426 Bq/L (11.5 pCi/L). Total uranium activity continues to be below the 0.74 Bq/L (20 pCi/L) State MCL.

The Building 854 OU is another site where weapons components were subjected to environmental stresses and where pipes containing TCE leaked. Two groundwater extraction and treatment systems (B854-SRC and B854-PRX) operate in the OU. The 2003 maximum total VOC concentration in groundwater is 200 µg/L, down from a historic maximum detected TCE concentration of 1290 µg/L. Total VOC concentrations in groundwater beneath the Building 850 OU are shown on Figure 2.6-3. of the *2003 Annual CMP Report*.

Pit 6 is a landfill that received waste from 1964 to 1973. The landfill was capped and closed under CERCLA in 1997. MNA is the selected remedy for the remediation of VOCs in groundwater emanating from Pit 6. The maximum 2003 groundwater TCE concentration and tritium activity was 5.5 µg/L. The maximum 2003 groundwater tritium activity was 68.5 Bq/L (1850 pCi/L). Total VOC concentrations and tritium activity in groundwater at Pit 6 are shown on Figures 2.3-3 and 2.3-4, respectively, of the *2003 Annual CMP Report*.

Building 832 Canyon OU facilities were used to test the stability of weapons components under a variety of environmental stresses. Contaminants were released from Buildings 830 and 832 through piping leaks and surface spills. Four groundwater extraction and treatment systems operate in the OU: B832-SRC, B830-SRC, B830-PRXN, and B830-DISS. B832-SRC and B830-SRC extract and treat groundwater and soil vapor. The other two facilities only treat groundwater. The maximum 2003 groundwater TCE concentration was 10,000 µg/L. This maximum concentration occurred in the $Tnsc_{1b}$ hydrostratigraphic unit. The maximum detected 2003 TCE concentration of 3200 µg/L was detected in the Qal hydrostratigraphic unit. Total

2003 VOC concentrations in the$Tnsc_{1b}$ and Qal hydrostratigraphic units at the Building 832 Canyon OU are shown on Figures 2.7-5 and 2.7-4, respectively of the *2003 Annual CMP Report*.

The Site 300 Site-Wide OU is composed of release sites at which no significant groundwater contamination and no unacceptable risk to human health or the environment is present. For this reason, a monitoring-only remedy was selected for these release sites, which include Building 801 Firing Table/Pit 8, Building 833, Building 845 Firing Table/Pit 9, Pit 2, and Building 851 Firing Table. The results of routine monitoring of these sites is included in Section 2.8 and Chapter 3 of the *2003 Annual CMP Report*. No new releases of contaminants from these sites were indicated by the 2003 analytical results.

The following sections describe the current status of investigations under way at three sites that are still under investigation and have not yet reached the Record of Decision for a final remedy to address environmental contamination: Pit 7 Complex, Building 865 and Building 812/Sandia Test Site.

Ongoing and Planned Investigations

Pit 7 Complex

The Pit 7 Complex is composed of four landfills (Pits 3, 4, 5, and 7), that received waste from explosives experiments conducted at Site 300 firing tables. Pits 3 and 5 have released tritium to groundwater. Pits 3, 5, and 7 have released depleted uranium to groundwater. The maximum tritium activity detected in groundwater in 2003 was 17,400 Bq/L (469,000 pCi/L). The maximum detected total uranium activity in groundwater that contained some depleted uranium was 4.55 Bq/L (122.9 pCi/L), 58.2% of this activity is due to added depleted uranium to the natural background uranium activity. Both the tritium and uranium maxima were detected in groundwater samples from $Tnbs_0$ bedrock. Perchlorate, TCE, and nitrate also occur in Pit 7 Complex groundwater at maximum detected concentrations of 14 µg/L, 4.3 µg/L, and 85 mg/L, respectively. **Figure 7-7** presents maps of tritium activities in groundwater in Qal alluvium and in $Tnbs_0$ bedrock.

LLNL completed the remedial investigation of the Pit 7 Complex prior to the September 30, 2003 milestone date (**Table 7-3**). Remedial investigation activities conducted during 2003 included a soil vapor tritium survey to evaluate the tritium activity remaining in the landfills and the adjacent unsaturated zone, and a water budget to define recharge, discharge, and contaminant mobilization mechanisms.

During 2003, LLNL began work on a Remedial Investigation/Feasibility Study for the Pit 7 Complex. The report will present details of the hydrogeology, nature and extent of contamination, and risk assessment and will specify remedial actions that can be applied to address the contamination.

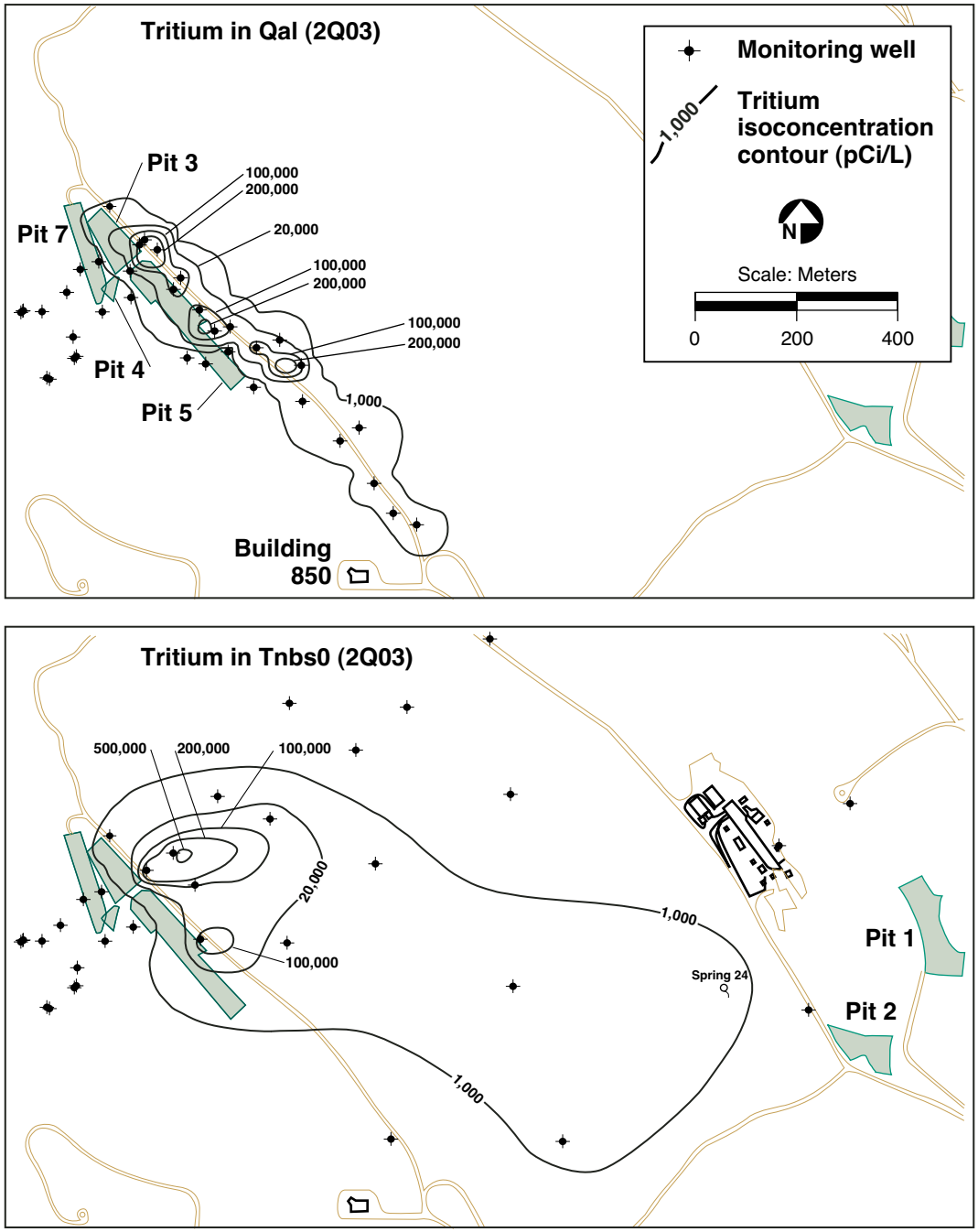

Figure 7-7. Tritium plume in Qal and $Tnbs_0$ (2nd quarter 2003)

Building 865

Building 865 is a former linear accelerator, the Advanced Testing Accelerator. Freon-113 was used as a de-greaser that was subsequently released to groundwater. The maximum Freon-113 concentration detected in groundwater during 2003 was 300 μg/L. The federal and state MCL for Freon-113 in drinking water is 1200 μg/L.

During 2003, LLNL installed five monitoring wells as a part of the remedial investigation of Building 865. LLNL will complete a Characterization Summary report detailing the hydrogeology and nature and extent of contamination emanating from Building 865. This report is currently scheduled for submission to the regulatory agencies by September 30, 2006.

Building 812/Sandia Test Site

Building 812 is an explosives test firing table. A remedial investigation is in process. During 2003, a maximum detected groundwater activity of total uranium, in which some of the uranium was due to addition of depleted uranium, was 1.13 Bq/L (30.5 pCi/L). **Table 7-3** lists a milestone date of September 30, 2003 to complete monitor well installation and surface soil sampling at Builing 812. To meet this milestone, during 2003, 13 monitoring wells were completed at Building 812 and 40 surface samples were collected and submitted for uranium and thorium isotope and metals analyses. LLNL will complete a Characterization Summary report detailing the hydrogeology and nature and extent of contamination emanating from Building 812. This report is currently scheduled for submission to the regulatory agencies by September 30, 2005

The Sandia Test Site was used in the past for several open air explosives experiments. No characterization activities have yet been conducted at the Sandia Test Site. LLNL will complete a Characterization Summary report detailing the hydrogeology and nature and extent of contamination emanating at the site. This report is currently scheduled for submission to the regulatory agencies by September 30, 2006.