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Environmental Protection Department

Operations and Regulatory Affairs Division

LLNL
Experimental Test Site 300

Compliance Monitoring Program for the CERCLA-Closed Pit 6 Landfill

Annual Report for 2003

Authors

Eric Christofferson
Richard G. Blake

Lawrence Livermore National Laboratory
University of California, Livermore, California 94551

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Contents

Figures

Appendices

Tables

LLNL Experimental Test Site 300

Compliance Monitoring Program for the CERCLA-Closed Pit 6 Landfill

Annual Report for 2003

Summary

This combined fourth-quarter and annual report is required by the *Post-Closure Plan for the Pit 6 Landfill Operable Unit, Lawrence Livermore National Laboratory Site 300* (Ferry *et al.* 1998). It summarizes post-closure compliance activities performed at the Pit 6 landfill during 2003, with emphasis on fourth-quarter results. Compliance activities during 2003 included quarterly ground water sampling and chemical analysis, an annual inspection of the capped facility by an independent Professional Engineer (PE), and an elevation survey of the landfill cap to check for any undue subsidence. Three monitoring reports covering the first, second, and third quarters of 2003 have been submitted previously (Christofferson *et al.* 2003a, 2003b, Christofferson and Taffet 2003). The third-quarter report (Christofferson and Taffet 2003) contains a photocopy of the PE's annual inspection report and the elevation survey results. The PE reported the closed landfill to be in good condition, and the elevation survey showed no undue subsidence of the landfill cover that could affect its integrity.

No new release of any constituent of concern (COC) from Pit 6 is indicated by the chemical analyses performed on ground water samples during 2003. COCs that were released prior to pit closure continued to be detected in ground water samples at low concentrations. These COCs include tritium, perchlorate, trichloroethene (TCE), tetrachloroethene (PCE), and cis-1,2-dichloroethene (cis-1,2-DCE). As in the past, bis(2-ethylhexyl)phthalate (DEHP), which is not a designated COC, was detected in one downgradient ground water sample during 2003. As of the fourth quarter of 2003, the contaminant plumes associated with Pit 6 are confined to shallow depths and none has been detected beyond the site boundary.

Introduction

Site 300 is the Lawrence Livermore National Laboratory (LLNL) Experimental Test Facility located in the Altamont Hills approximately 13 km southwest of Tracy, California (**Figure 1**). Site 300 is owned by the United States Department of Energy (DOE) and is operated by the Regents of the University of California. The closed Pit 6 landfill is located within Site 300 near its southern boundary (**Figure 2**). A post-closure plan for the Pit 6 landfill (Ferry *et al.* 1998) was implemented during the second quarter of 1998. Quarterly and annual reports of compliance monitoring activities at Pit 6 are required by the post-closure plan.

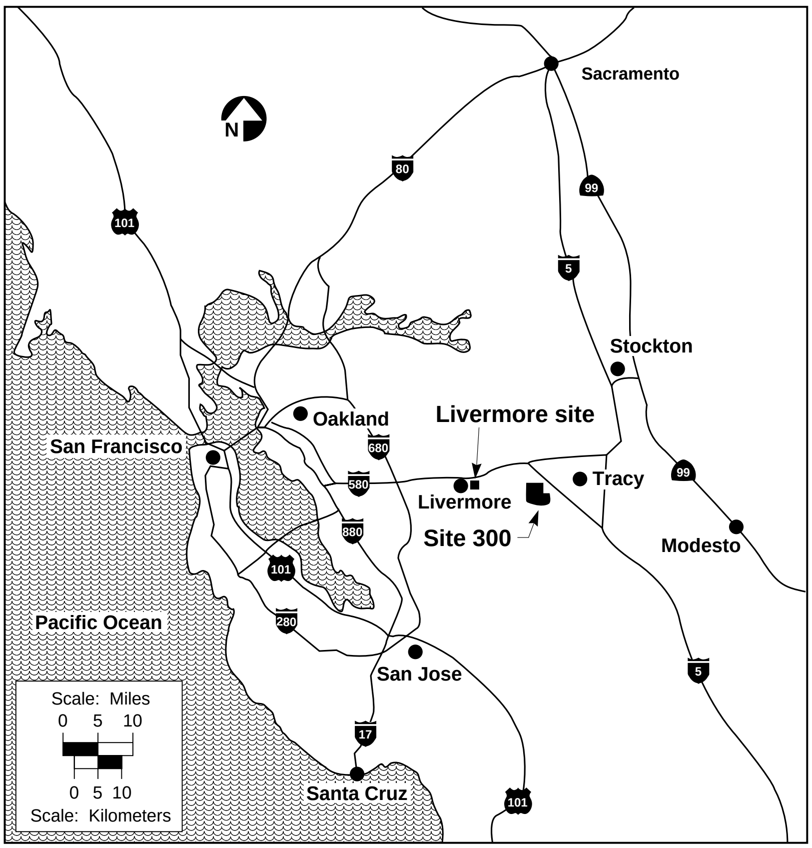

Figure 1. Location of LLNL Site 300.

Post-closure activities at the Pit 6 landfill are being conducted as a removal action under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) as part of the overall remediation of Site 300. Closure of the Pit 6 landfill was completed during the summer of 1997 with the construction of a waterproof cap over the landfill and a surface water drainage system around it. The U.S. Environmental Protection Agency (EPA), the California Department of Toxic Substances Control

(DTSC), and the California Central Valley Regional Water Quality Control Board (CVRWQCB) approved the post-closure monitoring plan in May 1998.

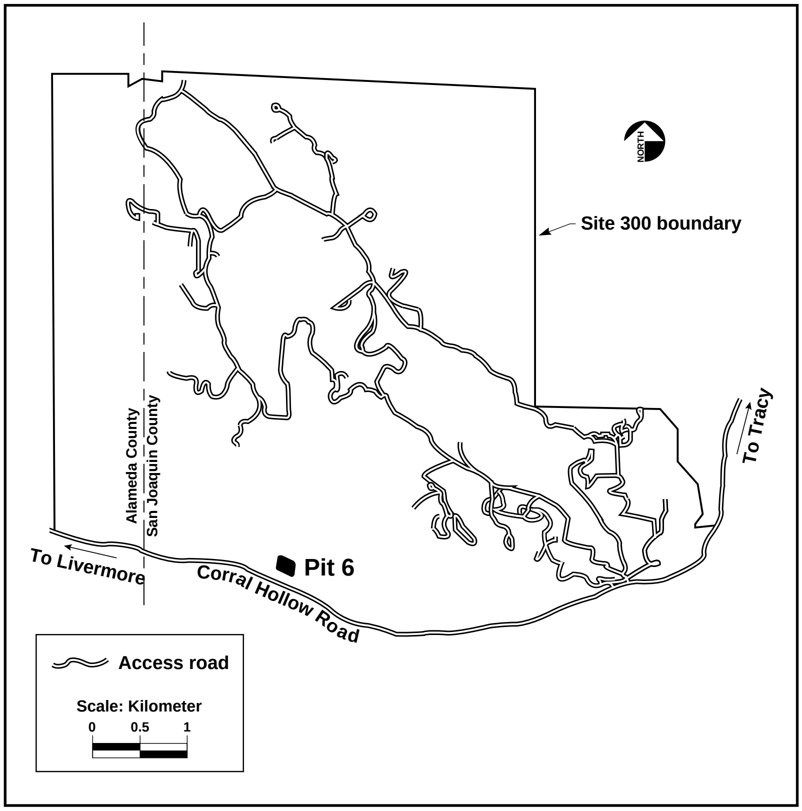

Figure 2. Location of Pit 6 at LLNL Site 300.

The closed Pit 6 landfill covers an area of about 1 hectare (2.5 acres). Its elevation is approximately 215 m (700 ft) above sea level. From 1964 to 1973, approximately 1500 cubic meters (2000 cubic yards) of solid wastes were buried there in nine separate trenches. The Pit 6 disposal trenches were constructed in Quaternary terrace deposits above and north of the Corral Hollow Creek flood plain. Tertiary sedimentary rocks, primarily the Neroly Formation lower blue sandstone unit ($Tnbs_1$), lie beneath the terrace deposits. The trenches were not lined, consistent with historical disposal practices. Three large trenches contain 1300 cubic meters (1700 cubic yards) of solid waste that includes empty drums, glove boxes, lumber, ducting, and capacitors. Six smaller trenches contain 230 cubic meters (300 cubic yards) of biomedical waste, including animal carcasses and animal waste. Minor releases of tritium, several volatile organic compounds (VOCs) (primarily TCE), and perchlorate occurred prior to CERCLA closure in 1997, when a multi-layered cap was constructed over all the trenches and a drainage control system was installed around the cap. The cap and the drainage control system are engineered to keep rain water from contacting the buried waste (Ferry *et al.* 1998). The impermeable cap also prevents any VOCs from degassing to the atmosphere.

Surface runoff from the pit area flows southward toward Corral Hollow Creek. The Carnegie-Corral Hollow Fault zone extends beneath the southern third of Pit 6. The northern limit of the fault zone is shown in **Figure 3**. Ground water flows southeastward to Pit 6, following the inclination (dip) of the underlying sedimentary rocks. The flow direction shifts to east-southeast as it approaches the closed landfill. Depths to the water table range from 10 to 20 m. A trough containing terrace gravel within the fault zone beneath Pit 6 provides a channel for ground water to flow east-southeast, parallel to the Site 300 boundary fence (Webster-Scholten 1994).

Figure 3 shows the locations of the wells that are used to monitor the ground water in the vicinity of the Pit 6 landfill, including upgradient wells, detection wells, and corrective action wells. For well construction details including depth, screened interval, and other completion information, see the closure plan (Ferry *et al.* 1998).

Monitoring program overview

The primary post-closure monitoring activity performed by LLNL at Pit 6 is the quarterly collection of ground water samples for chemical analyses. Field measurements of ground water physical parameters are taken at the times of sample collection. Two ground water monitoring programs have been implemented at the Pit 6 landfill to ensure compliance with regulations. The Detection Monitoring Program (DMP) detects any new release of COCs to ground water from wastes buried in the Pit 6 landfill, while the Corrective Action Monitoring Program (CAMP) monitors the movement and fate of historically released COCs in the ground water. COCs, as defined by Title 23 of the *California Code of Regulations* (CCR), Chapter 15, are waste constituents, reaction products, and hazardous constituents that are reasonably expected to be in or derived from waste buried in the Pit 6 landfill.

Twenty-four COCs, including VOCs and radioisotopes, were identified initially for monitoring (Ferry *et al.* 1998). Perchlorate and nitrate were discovered subsequently in the ground water near Pit 6 during CERCLA site-wide surveys. Perchlorate was added to the COC list, and quarterly monitoring and reporting on it began during the third quarter of 2000. Quarterly reporting of nitrate began with the first quarter report of 2003. Beginning 1 January 2003, the sampling schedule for the CAMP wells changed as described in the *Compliance Monitoring Plan/Contingency Plan for Interim Remedies at Lawrence Livermore National Laboratory Site 300* (Ferry, *et al.* 2002). Since January 2003, an expanded set of CAMP wells (**Figure 3**) is being monitored for tritium activity, VOCs, nitrate, and perchlorate (**Table D-1**).

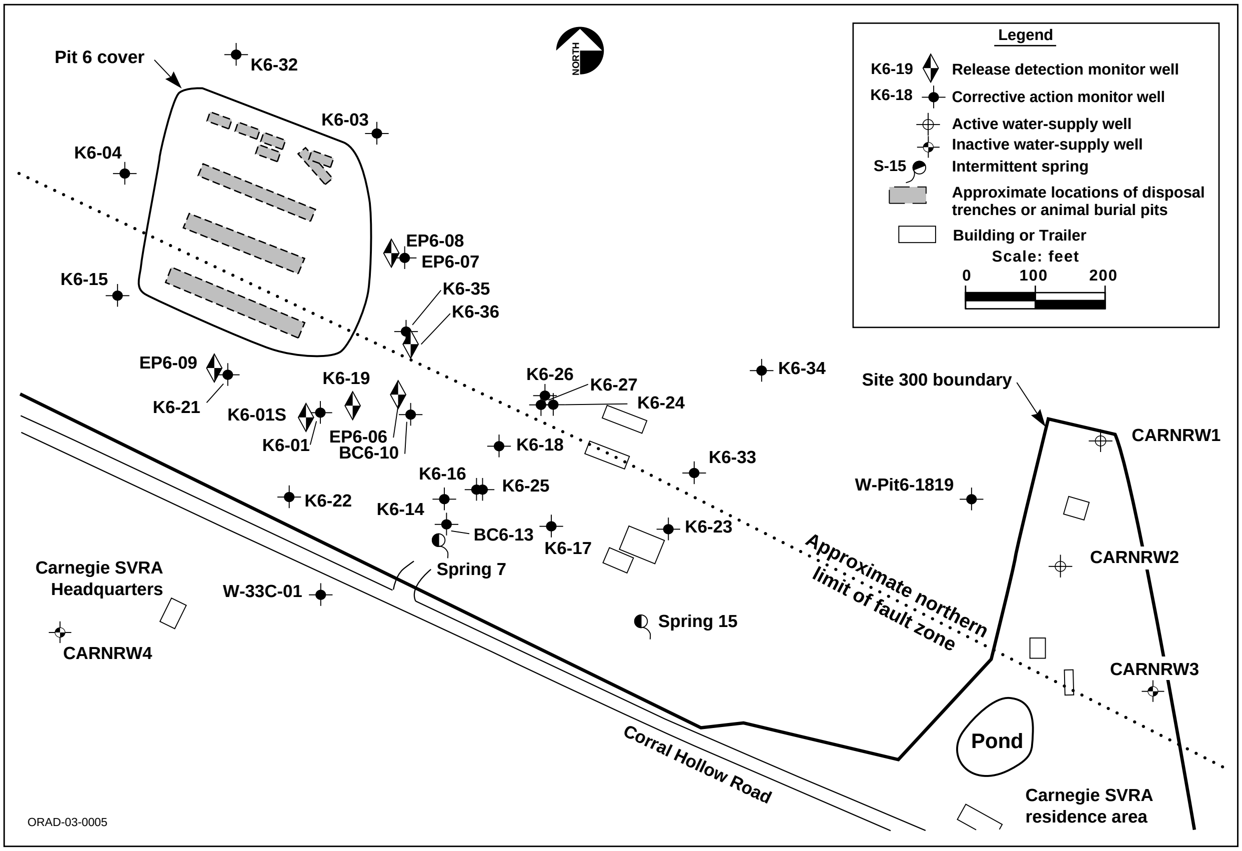

Figure 3. Locations of Pit 6 monitoring wells.

DMP objective. The primary DMP objective is to detect any new release of COCs to ground water. To detect releases in a timely manner, ground water is sampled quarterly from six wells located hydraulically downgradient of Pit 6 along the point of compliance. These wells are identified as EP6-06, EP6-08, EP6-09, K6-01S, K6-19, and K6-36 in **Figure 3**. Ground water samples are sent to state-certified laboratories where they are analyzed quantitatively for the presence (or absence) of COCs (see **Table C-1** for the list of DMP COCs). Gross alpha and gross beta radioactivity measurements are used as surrogates for seven radionuclide COCs other than uranium and tritium. Additional field measurements of ground water general parameters are obtained quarterly at the time of sample collection.

Pesticides, polychlorinated biphenyls (PCBs), several fluorocarbons (Freons), phenolics, and phthalates were not initially designated as COCs, because they were detected historically in fewer than 2% of the ground water samples analyzed. However, we continue DMP monitoring annually for the presence of these chemicals using EPA method 625 for the extractable organic compounds and EPA method 8080 for PCBs.

To detect potential releases from Pit 6, quarterly COC measurements are compared with statistically determined limits of concentration, called statistical limits, or SLs (see **Appendix C**, **Table C-1**, for the list of COCs and their respective SLs). If a COC measurement exceeds an SL, the measurement is investigated further to determine its validity. A simple data validation method is employed that is consistent with state regulations. Two independent ground water samples, called retest samples, are obtained at least one week apart from the associated monitoring well and analyzed for the suspect COC. If the COC is present in either sample at a concentration that exceeds the SL, then the initial analysis is deemed to be validated and it is reported as statistically significant evidence of a release. If neither retest sample measurement exceeds the SL, then the initial exceedance is not confirmed, and a release report is not made. Any further investigation of a COC is at the discretion of the Site 300 Remedial Project Managers (RPMs) and is conducted by LLNL under CERCLA.

CAMP objectives. The primary CAMP objectives are to: (1) evaluate the effectiveness of the corrective action, (2) evaluate natural attenuation of the ground water VOC and tritium plumes, (3) monitor perchlorate and nitrate in ground water, and (4) evaluate the need for implementing contingency actions. To accomplish the CAMP objectives, ground water measurements from all of the monitoring wells shown in **Figure 3** are evaluated on a quarterly basis.

Several VOCs, tritium, and perchlorate were released to ground water from Pit 6 prior to its closure. The VOCs, primarily the solvents PCE and TCE, have been described and evaluated previously in the *Final Site-Wide Remedial Investigation Report, Lawrence Livermore National Laboratory Site 300* (Webster-Scholten 1994), the *Final Feasibility Study for the Pit 6 Operable Unit, Lawrence Livermore National Laboratory Site 300* (Devany *et al.* 1994), the *Addendum to the Pit 6 Engineering Evaluation/Cost Analysis, Lawrence Livermore National Laboratory, Site 300* (Berry 1996), the *Final Site-Wide Feasibility Study for Lawrence Livermore National Laboratory Site 300* (Ferry *et al.* 1999), and the *Interim Site-Wide Record of Decision for Lawrence Livermore National Laboratory Site 300* (DOE 2001).

Tritium activity is above the background activity of 3.7 Bq/L (100 pCi/L) in the ground water downgradient from Pit 6, suggesting that a localized tritium release occurred prior to pit closure (Ferry *et al.* 1998). Monitored natural attenuation is the interim remedial action selected for the tritium plume.

Additional post-closure activities for Pit 6 include: (1) inspection of the landfill by LLNL technical staff following major storms; (2) an annual comprehensive inspection of the landfill by an independent state-certified Professional Engineer (PE); (3) an annual pit cap elevation survey; (4) repairs as necessary to maintain the integrity of the landfill, its water diversion system, and its network of monitoring wells; and (5) preparation of reports. Reports of post-closure activities are provided quarterly to the participating regulatory agencies for their information and use.

Detection monitoring program summary for 2003

No new release of COCs from Pit 6 is indicated by the DMP ground water data collected during 2003. COCs that were released prior to pit closure, including three VOCs, perchlorate, and tritium, continued to be detected in the ground water at low concentrations.

Samples of ground water were obtained quarterly from all of the six detection monitoring wells during 2003, except from well K6-36, which was dry during the third and fourth quarters. Ground water samples were analyzed quarterly by California-certified laboratories for the COCs specified in the post-closure monitoring plan (see **Appendix C, Table C-1** for a list of COCs). The quarterly COC measurements for the DMP wells are contained in **Appendix A**, **Table A-1**. Quarterly field measurements of ground water parameters and measurements of total dissolved solids (TDS) for year 2003 are contained in **Appendix A**, **Table A-2**, for the DMP wells. In addition to COCs, ground water samples were analyzed during the second quarter of 2003 for the presence of any of seven PCBs. None was detected. Additional analyses were also made during the first and second quarters using EPA method 625 to detect the presence of any of 86 extractable organic compounds. Of these 86 compounds, only one was detected in one ground water sample. DEHP was detected at a concentration of 10 µg/L in the first quarter ground water sample from well EP6-06, but it was not detected in any of the second quarter samples.

VOC concentrations are generally low and slowly decreasing in the ground water adjacent to Pit 6. **Figure 4** shows an exponentially decreasing TCE concentration since 1988 in the ground water sampled at DMP well K6-19. This trend of decreasing concentrations strongly suggests that the primary release of TCE from Pit 6 to the ground water occurred prior to the initial TCE measurements of ground water from well K6-19 in 1988. Our continued measurements do not indicate that any VOCs have been released to ground water from Pit 6 since its closure in 1998.

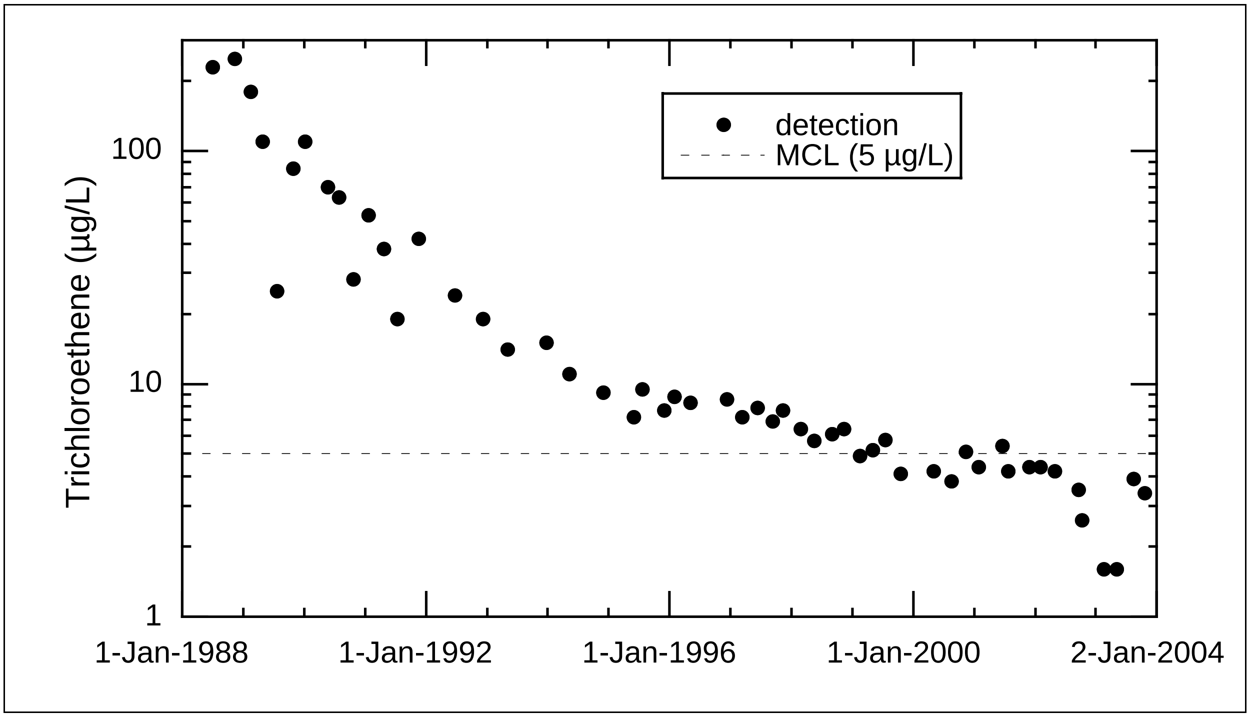

Figure 4. History of TCE (µg/L) in ground water at Pit 6 DMP well K6-19.

In 1998, we reported that our detections of the VOC 1,2-DCA represented statistically significant evidence of a post-closure release of 1,2-DCA from Pit 6 (Galles 1998). During the fall of 1998, ground water was pumped from well EP6-09 and VOCs were removed from it by air-sparging. The results of this pumping test and remedial action were a sharp decrease in TCE concentration in the ground water at well EP6-09 from 15 µg/L to 2 µg/L and a decrease of 1,2-DCA concentration to below its analytical detection limit. Subsequently, TCE concentrations in the ground water have rebounded to around the MCL of 5 µg/L (**Figure 5**), while 1,2-DCA remains below its detection limit of 0.5 µg/L (**Figure 6**). During 2003, only two ground water samples, both from well EP6-09, showed TCE concentrations slightly above the MCL of 5 µg/L. These samples were obtained during the first and third quarters (5.3 µg/L and 5.5 µg/L TCE, respectively) (**Figure 5**). For a more detailed account and map of the Pit 6 TCE plume, see the CAMP summary following.

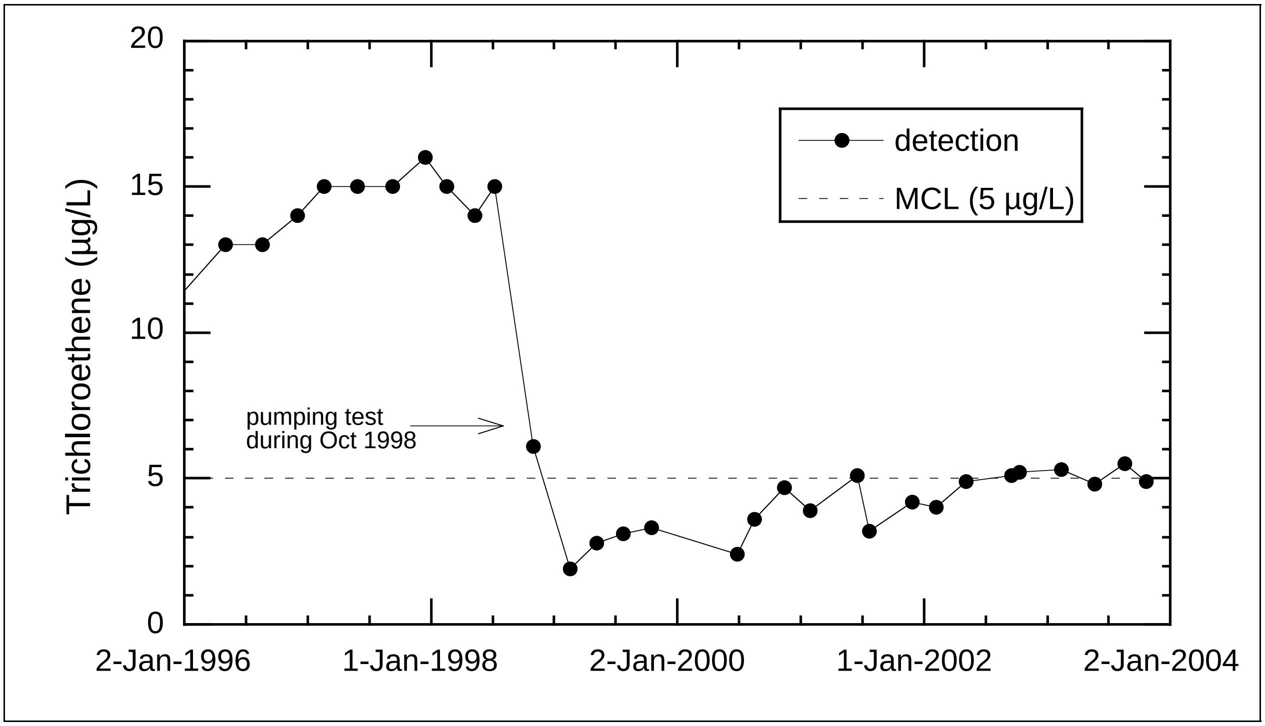

Figure 5. History of TCE (µg/L) in ground water at Pit 6 DMP well EP6-09.

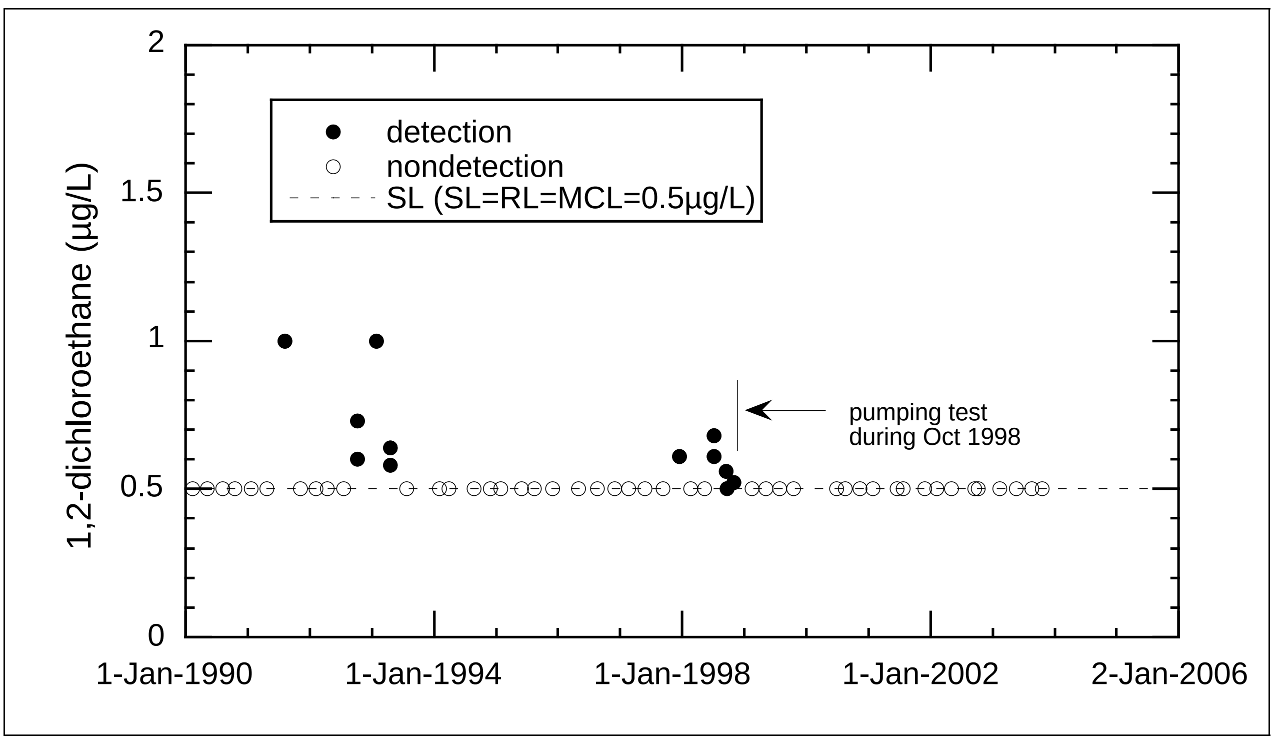

Figure 6. History of 1,2-DCA (µg/L) in ground water at Pit 6 DMP well EP6-09.

Tritium activity above background occurs within a small volume of shallow ground water that is adjacent to and downgradient (southeast) of Pit 6. As in the past, during 2003, tritium activity exceeded statistical limits in ground water samples from downgradient DMP wells K6-19 and K6-01S (**Table A-1**). The maximum tritium activity measured in a ground water sample from a DMP well during 2003 was 69 Bq/L (well K6-36, second quarter, below the SL of 88 Bq/L), which is less than 10% of the 740 Bq/L MCL for tritium activity in drinking water. (Note that DMP well K6-36 was dry during the third and fourth quarters of 2003.) Tritium activity in the ground water has decreased more than 20% since 1999 when the maximum measured was 93 Bq/L. The decrease can be attributed to dilution, advection, and the natural decay of tritium (12.3-year half-life). Our continued measurements do not indicate that tritium has been released to ground water from Pit 6 since its closure in 1998. For a more detailed account and a map of the Pit 6 tritium plume, see the CAMP summary following.

Perchlorate concentration was above the SL of 4 µg/L in the first quarter ground water sample from well EP6-09 (4.2 µg/L), but was not detected there subsequently during 2003 (**Table A-1**). The first perchlorate exceedence for well EP6-09 (4.4 µg/L) occurred during the third quarter of 2002, which we reported by letter to the Site 300 RPMs to be statistical evidence for a (new) release of perchlorate from Pit 6 (Raber 2002). However, rather than representing a new release from Pit 6, the presence of perchlorate at well EP6-09 may represent a fraction of historically released perchlorate that was drawn to well EP6-09 by extended pumping there during the October 1998 pumping test (Ferry and Holtzapple 2003).

The extractable organic compound, DEHP, which is not a designated COC, was detected in the first quarter routine ground water sample from well EP6-06 at a concentration of 10 µg/L. Subsequently, DEHP was not detected above the RL of 5 µg/L in the routine ground water sample obtained from well EP6-06 during the second quarter of 2003. DEHP has been sporadically detected both upgradient and downgradient of Pit 6 since post-closure monitoring began in 1998. No clear pattern regarding its distribution has emerged. The absence of a pattern has hindered the location of its source or sources in the Pit 6 area. There is no record of DEHP being placed in Pit 6.

Corrective action monitoring program summary for 2003

This section contains a summary evaluation of ground water elevation data and ground water COC data collected quarterly during 2003. The primary COCs for the Pit 6 area are several VOCs and tritium (Ferry *et al.* 1998). Perchlorate and nitrate were subsequently detected in ground water samples from several Pit 6 monitoring wells during site-wide investigations by LLNL. Perchlorate was designated a secondary COC in 2000. Beginning in 2003, nitrate also became a secondary COC, and its occurrence in the ground water is discussed below. Ground water elevations measured during 2003 are listed in **Table B-1**. Detections during 2003 of VOCs, tritium, and perchlorate and nitrate are listed in **Tables B-2, B-3,** and **B-4**, respectively.

Ground water elevations. Figure 7 is a ground water elevation contour map for October 2003. Ground water elevations beneath Pit 6 remain in excess of 5 m (17 ft) below the buried waste trenches. Ground water elevations in wells north of the fault zone fell an average of 1.0 m (3.0 ft) between the third and fourth quarter 2003 measurement dates. The range of decline was -1.68 to –2.04 m (–5.5 to -6.7 ft). Ground water elevations within the fault zone showed little or no decline.

Water elevation measurements of the first water-bearing zone continue to show a typical pattern both quarterly and annually. Ground water elevations in all monitoring wells during 2003 remained below historic highs. North of the approximate limit of the fault zone shown in **Figure 7**, the October 2003 water level elevations average 1.7 m (5.7 ft) lower than the October 2002 elevations, 2.3 m (7.7 ft) lower than the October 2000 elevations, and about 2.7 m (9 ft) lower than the November 1999 elevations. To the south, the October 2003 ground water elevations within the fault zone are about the same as the October 2002 elevations.

Figure 7 is consistent with previous potentiometric surface maps. Within the fault zone to the south, ground water elevations indicate a complex pattern with a hydraulic gradient of approximately 0.03 to the south and southeast, whereas the hydraulic gradient north of the fault zone is 0.007. Flow north of the fault zone is directed to the southeast with a large component of the flow caused by pumping from wells CARNRW1 and CARNRW2. In late November 2000, water elevation monitoring of several key wells between the capped Pit 6 landfill and the water supply wells CARNRW1 and CARNRW2 was initiated. This monitoring continued into 2003. Analysis indicates that the water table elevations of monitor wells north of the fault zone are strongly influenced by pumping from these two water supply wells. Fractures in the $Tnbs_1$ unit play a dominant role in ground water flow. Water table elevations in the wells within the fault zone to the south do not appear to be significantly influenced by pumping from the two water supply wells.

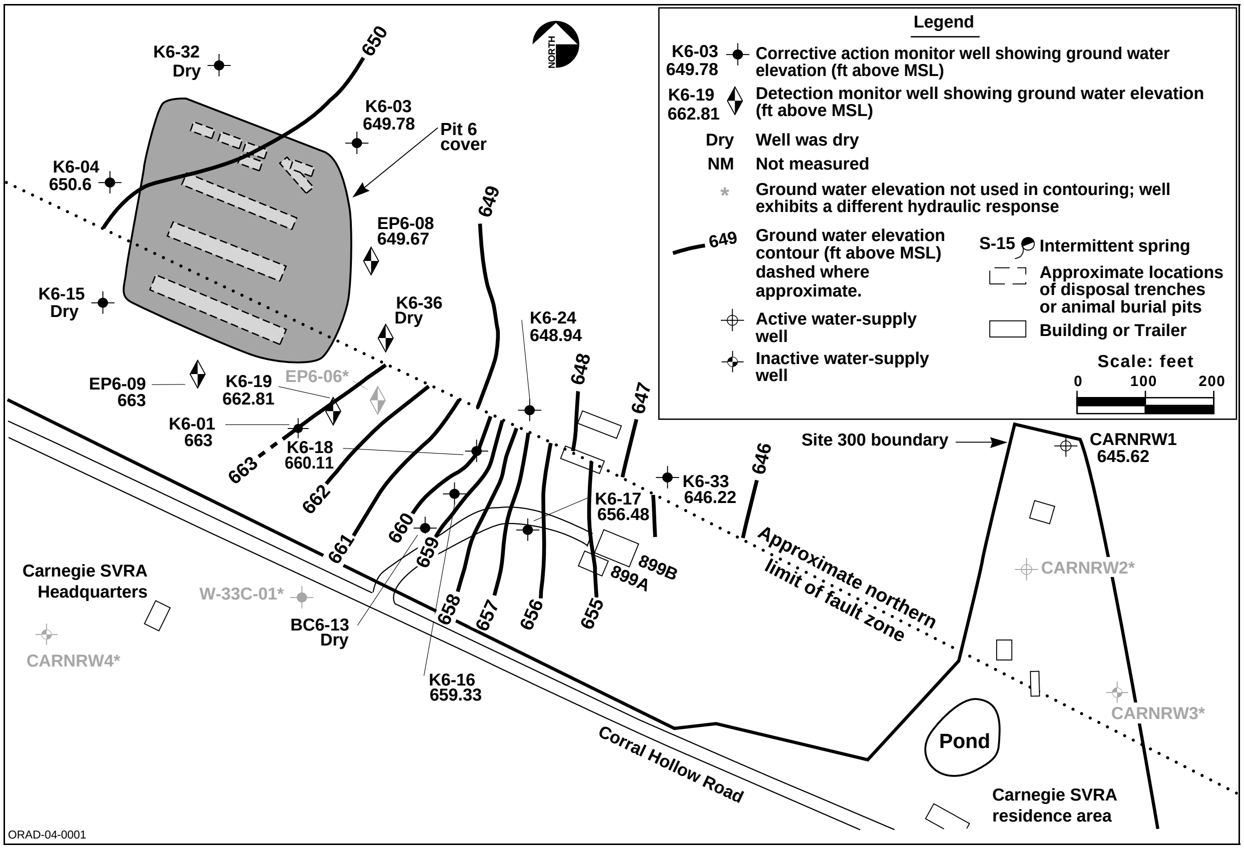

Figure 7. Ground water elevations (ft) for the first water-bearing zone at Site 300 Pit 6, fourth quarter 2003.

Ground water VOC concentrations. Ground water TCE concentrations generally stayed the same during 2003 (**Table B-2**), and were similar to those measured in 2000, 2001, and 2002. The maximum TCE concentration measured during 2003 was 5.5 µg/L in a ground water sample from well EP6-09 in August. For comparison, in 2002, the maximum ground water TCE concentration measured was 5.2 µg/L in a ground water sample from well EP6-09. In 2001, the maximum TCE concentration measured was 5.4 µg/L in a ground water sample from well K6-19. In 2000, the maximum ground water TCE concentration measured was 6.3 µg/L in a ground water sample from well K6-18.

Figure 8 shows the areal distribution of TCE concentrations in ground water for the fourth quarter of 2003. During 2003, TCE was detected in ground water samples from eight wells in the Pit 6 area: EP6-09, K6-16, K6-17, K6-18, and K6-19. These wells define a narrow, elongated TCE plume that originates in the southeast portion of Pit 6. Cis-1,2-DCE was detected during 2003 in ground water samples from well K6-01S. The maximum concentration was 2.5 µg/L in the ground water sample obtained in August 2003 (see **Table B-2**). The presence of cis-1,2-DCE probably represents the natural decomposition of TCE.

PCE was detected during 2003 in ground water samples from wells EP6-08 and K6-36. The maximum concentration was 1.0 µg/L in a ground water sample obtained in February from well EP6-08 (**Table B-2**). The low concentration of PCE has remained relatively constant over time.

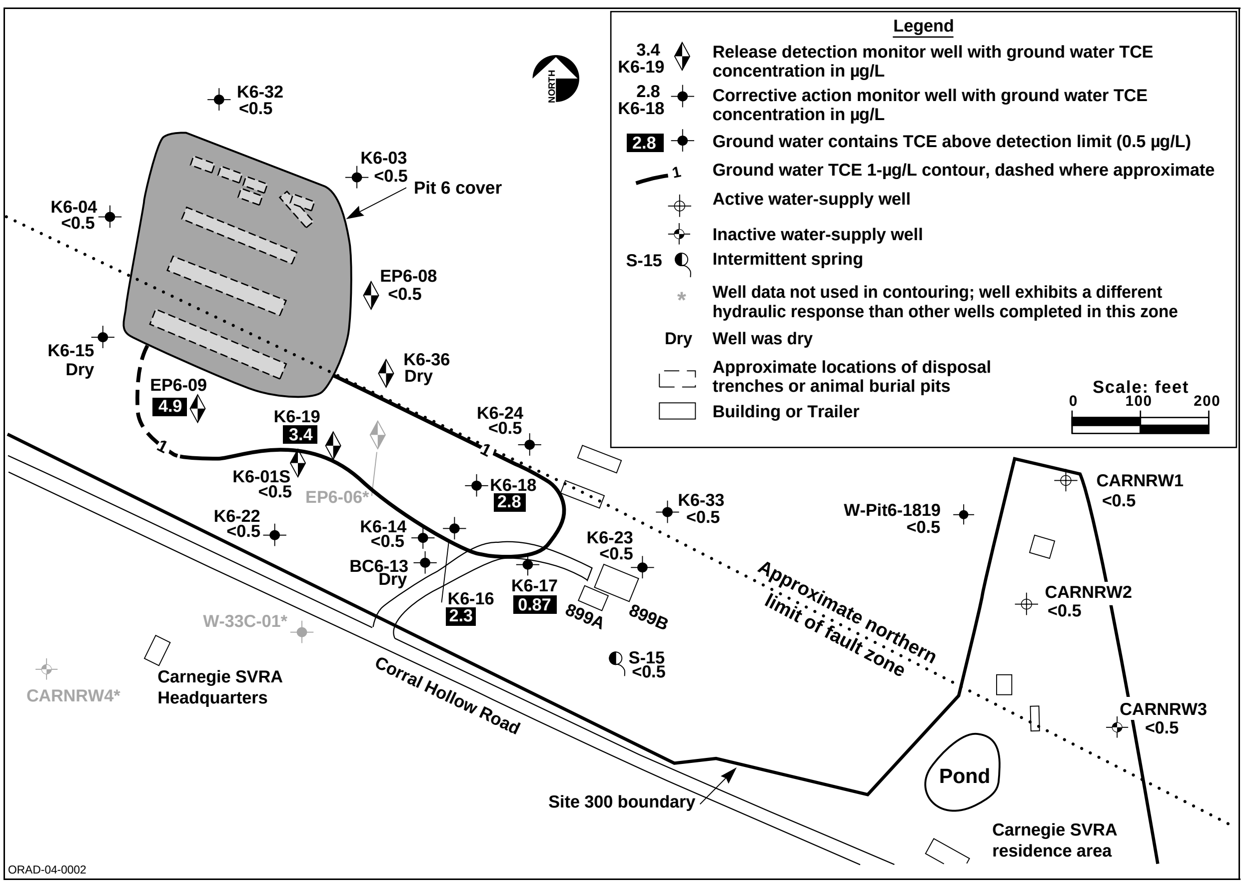

Figure 8. Ground water TCE concentrations (µg/L) in the first water-bearing zone at Site 300 Pit 6, fourth quarter 2003.

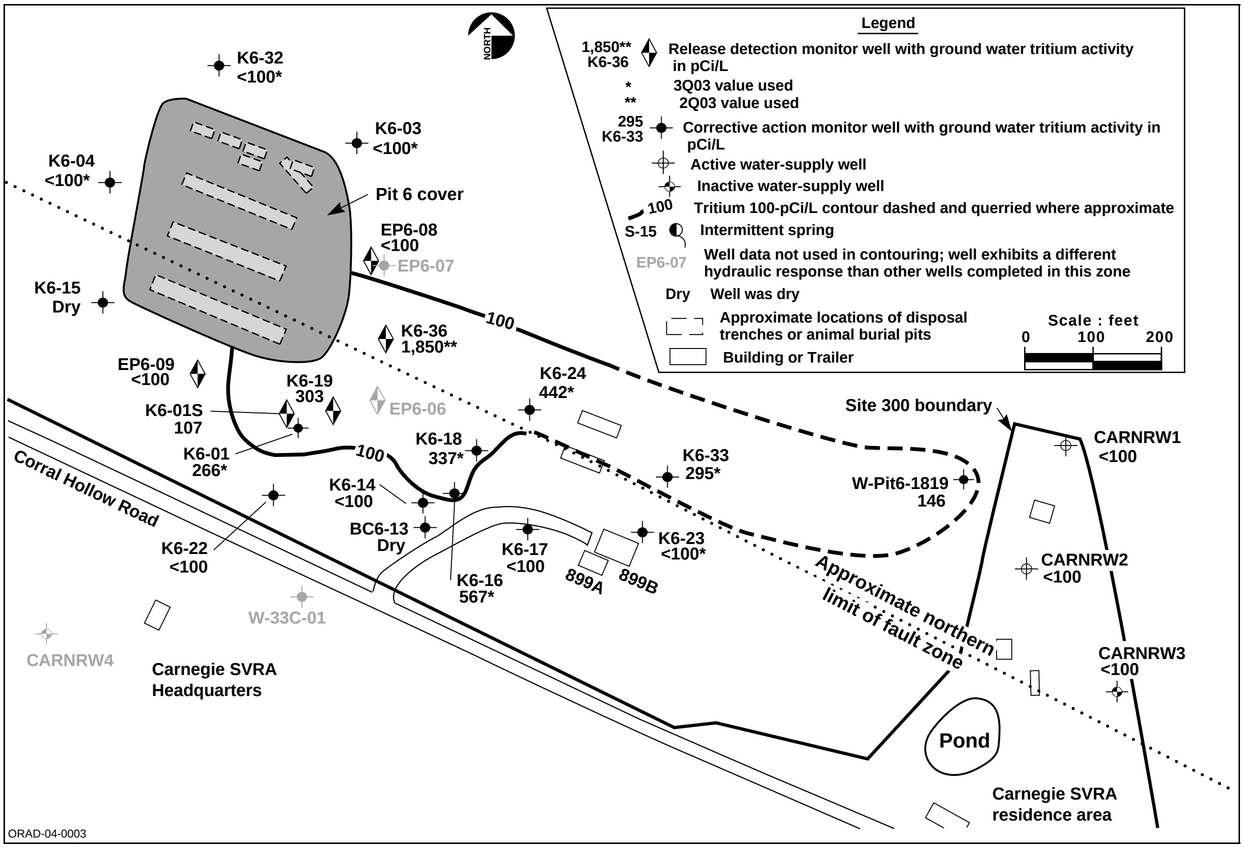

Figure 9. Ground water tritium activities (pCi/L) in the first water-bearing zone at Site 300 Pit 6, fourth quarter 2003.

Ground water tritium activity. **Figure 9** shows the areal distribution of tritium activity in ground water for the fourth quarter of 2003. Ground water tritium activities for the year 2003 are listed in **Table B-3**. During 2003, tritium activity was detected in ground water samples from wells K-24, K6-33, K6-36, W-PIT6-1819, and CARNRW2 (all located north of the fault zone), and wells K6-01S, K6-01, K6-16, K6-18, and K6-19 located within the fault zone. During 2003, the maximum tritium activity measured was 68.5 Bq/L (1850 pCi/L; well K6-36), equal to approximately one tenth of the safe limit (MCL) for tritium activity in drinking water. This is slightly lower than the maximum activity measured in 2002 of 73 Bq/L (1970 pCi/L; well K6-36). The highest tritium activity measured to date is 127 Bq/L (3420 pCi/L; well BC6-13; second quarter 2000), which is equal to 17% of the MCL. The first-quarter detection of tritium activity in well CARNRW2 was not confirmed by subsequent retest measurements of ground water samples obtained on 13 March, 7 April, and 16 April 2003, nor was tritium detected in subsequent ground water samples obtained monthly during 2003 from this well.

We installed monitoring well W-Pit 6-1819, located downgradient of well K6-33, to better determine the extent of the tritium plume. The well is a guard well. It is located about 30 m (100 ft) west of the Site 300 boundary with the Carnegie SVRA residence area and about 60 m (200 ft) west of the CARNRW1 and CARNRW2 water-supply wells (**Figure 9**). During 2003, ground water from well W-Pit 6-1819 had tritium activities ranging from <3.8 to 9.7 Bq/L (<104 to 263 pCi/L). These activities are slightly higher than the activities measured there during 2002, following installation of the guard well.

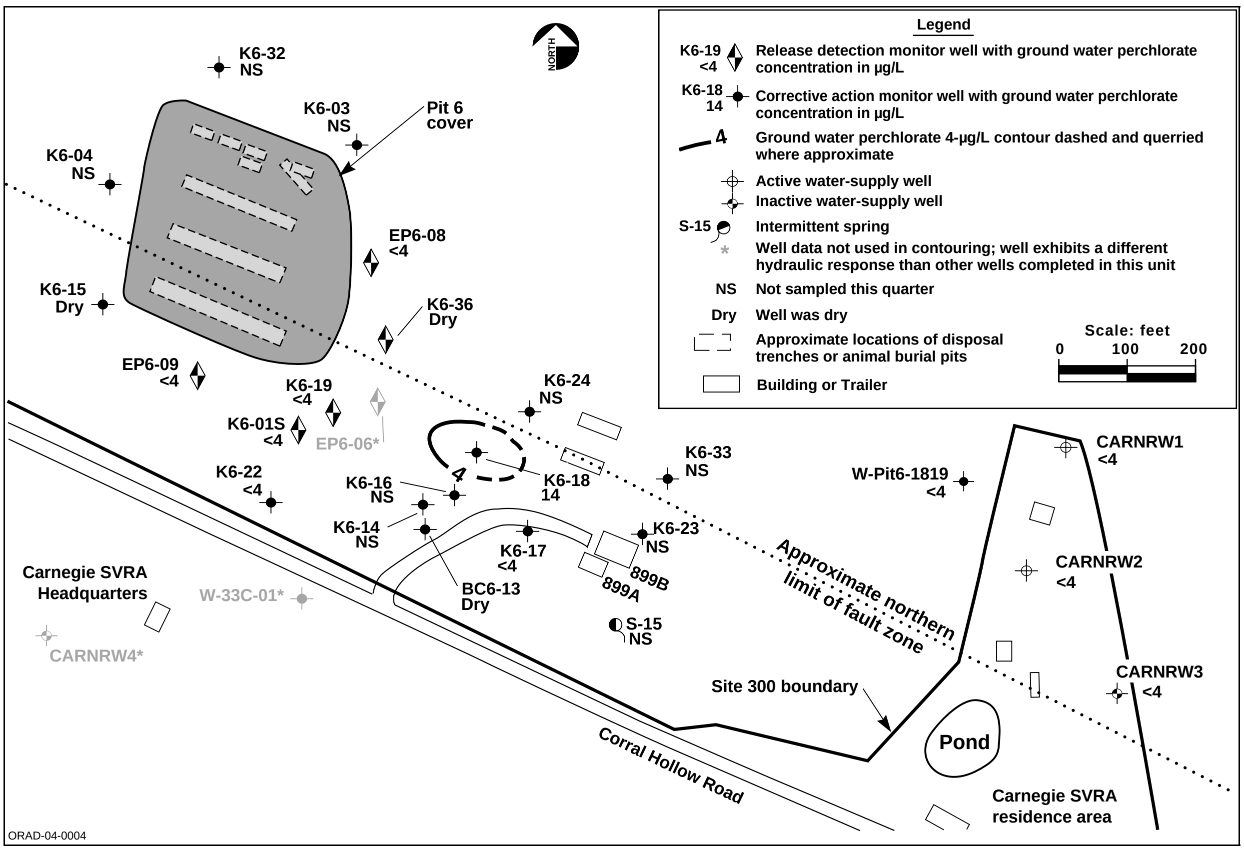

Figure 10. Ground water perchlorate concentrations (µg/L) in the first water-bearing zone at Site 300 Pit 6, fourth quarter 2003.

Ground water perchlorate concentrations. **Figure 10** shows the areal distribution of perchlorate in ground water for the fourth quarter of 2003. The maximum perchlorate concentration measured during 2003 was 14 µg/L in the ground water sampled at well K6-18 in October (**Table B-4**). For comparison, the highest concentration measured in 2002 was 15 µg/L from this same well, K6-18, and in 2001 the maximum perchlorate detected in ground water was 19 µg/L, also in the ground water sampled at well K6-18.

An LLNL CERCLA study of the provenance and distribution of perchlorate at Site 300 is continuing.

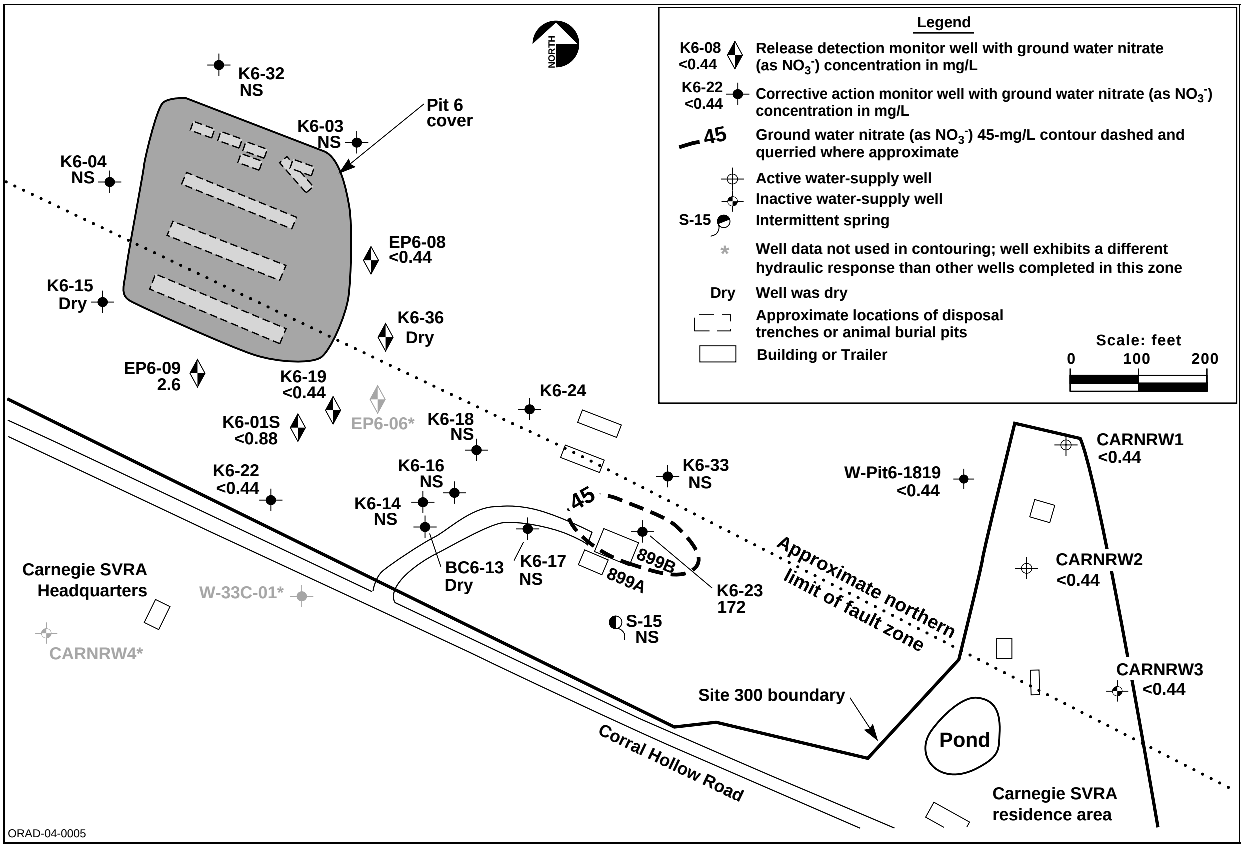

Figure 11. Ground water nitrate concentrations (mg/L) in the first water-bearing zone at Site 300 Pit 6, fourth quarter 2003.

Ground water nitrate concentrations. **Figure 11** shows the areal distribution of nitrate in ground water for the fourth quarter of 2003. Elevated nitrate concentrations, which increased slightly from 159 mg/L to 172 mg/L during 2003, are found only in ground water samples from well K6-23 (**Table B-4**). The nitrate in the ground water sampled at this well is likely related to the nearby septic tank at Building 899B. Ground water from several other wells contained detectable nitrate, but at concentrations below the MCL of 45 mg/L for nitrate in drinking water. An LLNL CERCLA study of the provenance and distribution of nitrate at Site 300 is continuing.

Inspection and maintenance summary for 2003

A required annual Pit 6 inspection was conducted on 25 September 2003, by an independent, state-registered PE. A photocopy of the PE's inspection report is appended to our third quarter report for 2003 (Christofferson and Taffet 2003). The PE reviewed existing documentation regarding the closed landfill and conducted a visual inspection of it. There were no significant findings. The PE found the pit cap to be fully intact. No settlement or subsidence was observed. The drainage system associated with the cap was functioning properly. The PE noted several minor deficiencies and recommended corrective maintenance. Following the PE's recommendations, LLNL removed tumble weeds from the drainage channels.

In September 2003, LLNL surveyors measured the elevations of numerous fixed markers that had been installed on the pit cover in 1998. A comparison of the year 2003 marker elevations with their baseline elevations established in 1998 shows that a maximum subsidence of 0.08 ft occurred during the five-year interval. It is unlikely that this small subsidence has adversely affected the integrity of the pit cover.

LLNL technical personnel inspected Pit 6 twice during 2003 following major storms in February and in November. They reported that conditions there were satisfactory. Both inspections noted the presence of some tumble weeds in the water diversion channels around the Pit 6 cap.

Effectiveness of the corrective action

The corrective action implemented at Pit 6 is discussed in the *Interim Site-Wide Record of Decision for Lawrence Livermore National Laboratory Site 300* (DOE 2001). An impermeable cap was constructed over the landfill in 1997 to prevent any surface water from infiltrating and contacting the buried waste. It was also engineered to prevent volatilization and escape to the atmosphere of organic compounds buried in the landfill. Visual inspections and an elevation survey conducted during 2003 indicate that the cap is sound. Ground water levels continued to fall beneath the closed landfill during 2003 and are in excess of 5 m (17 ft) below the buried waste trenches. No new release of COCs from the closed landfill during 2003 is indicated. Thus, the corrective action taken continues to be effective.

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Abbreviations and acronyms

1,2-DCA	1,2-dichloroethane
Bq	becquerel (international unit of radioactivity equal to 27 pCi)
CAMP	Corrective Action Monitoring Program
CC	control chart (statistical method)
CCR	California Code of Regulations
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
Cis-1,2-DCE	Cis-1,2-dichloroethene
CL	Concentration limit (background concentration of a chemical)
COC	constituent of concern
CVRWQCB	Central Valley Regional Water Quality Control Board
DEHP	di(2-ethylhexyl)phthalate, bis(2-ethylhexyl)phthalate
DMP	Detection Monitoring Program
DOE	U.S. Department of Energy
DTSC	California Department of Toxic Substances Control
EPA	U.S. Environmental Protection Agency
EPD	LLNL Environmental Protection Department
ERD	LLNL Environmental Restoration Division
ft	foot (used as a measure of elevation above MSL)
GWD	ground water depth
GWE	ground water elevation in feet above MSL
km	kilometer
L	liter
LLNL	Lawrence Livermore National Laboratory
m	meter
MCL	maximum contaminant level (for drinking water)
MSL	mean sea level (datum for elevation measurements)
mg	milligram
µg	microgram
nd	none detected
nm	not measured
NS	not sampled
PCB	polychlorinated biphenyl
PCE	perchloroethene, tetrachloroethene
pCi	picocurie (unit of radioactivity)
PE	Professional Engineer
PI	prediction interval (statistical method)
QA	quality assurance
RL	reporting limit (contractual concentration near zero)
RPM	Remedial Project Manager
Site 300	Experimental Test Facility, LLNL
SL	statistically determined concentration limit
SOP	standard operating procedure
TCE	trichloroethene
TDS	total dissolved solids
$Tnbs_1$	Neroly Formation lower blue sandstone unit
VOC	volatile organic compound
yr	year

Appendix A

Tables of Ground Water Measurements

for Detection Monitoring Wells

Table A-1. Pit 6 post-closure monitoring plan constituents of concern (COCs), detection monitoring wells, SLs, MCLs, and quarterly analytical results for 2003.

				Quarter			
COC (units)	**Well**	**SL**	**MCL**	**First**	**Second**	**Third**	**Fourth**
Metals (µg/L)							
Beryllium	EP6-06	0.2	4	< 0.2	< 0.2	< 0.2	< 0.2
	EP6-08	0.2		< 0.2	< 0.2	< 0.2	–[(a)]
	EP6-09	0.2		< 0.2	< 0.2	< 0.2	< 0.2
	K6-01S	0.2		< 0.2	< 0.2	< 0.2	< 0.2
	K6-19	0.2		< 0.2	< 0.2	< 0.2	< 0.2
	K6-36	0.2		< 0.2	< 0.2	dry	dry
Mercury	EP6-06	0.2	2	< 0.2	< 0.2	< 0.2	< 0.2
	EP6-08	0.2		< 0.2	< 0.2	< 0.2	–[(a)]
	EP6-09	0.2		< 0.2	–[(a)]	< 0.2	< 0.2
	K6-01S	0.2		< 0.2	< 0.2	< 0.2	< 0.2
	K6-19	0.2		< 0.2	< 0.2	< 0.2	< 0.2
	K6-36	0.2		< 0.2	< 0.2	dry	dry
Radioactivity (Bq/L)							
Tritium	EP6-06	3.7	740	– 1.6	– 0.2	– 1.3	– 0.2
	EP6-08	3.7		– 3.0	– 0.02	1.3	0.7
	EP6-09	3.7		1.1	– 1.6	1.8	0.6
	K6-01S	3.7		3.8	3.2	6.7	4.0
	K6-19	3.7		9.4	9.9	11	11
	K6-36	88		59	69	dry	dry
Uranium (total)	EP6-06	0.13	0.74	0.02	0.05	0.02	0.03
	EP6-08	0.06		0.04	0.04	0.04	–[(a)]
	EP6-09	0.14		0.08	0.08	0.08	0.08
	K6-01S	1.00		0.12	0.14	0.14	0.16
	K6-19	0.27		0.10	0.11	0.10	0.11
	K6-36	0.05		0.04[(b)]	0.02	dry	dry
Gross alpha	EP6-06	0.29	0.56	0.19	0.01	0.01	0.02
	EP6-08	0.15		0.001	– 0.02	0.05	– 0.03
	EP6-09	0.18		0.04	0.05	0.03	0.06
	K6-01S	0.95		– 0.05	0.11	0.23	0.03
	K6-19	0.34		0.03	0.07	0.14	– 0.01
	K6-36	0.07		– 0.06	– 0.01	dry	dry
Gross beta	EP6-06	0.79	1.85	0.32	0.32	0.36	0.26
	EP6-08	0.79		0.30	0.37	0.37	0.48
	EP6-09	0.79		0.34	0.41	0.40	0.41
	K6-01S	2.13		0.59	0.64	0.19	0.55
	K6-19	0.79		0.31	0.36	0.30	0.39
	K6-36	0.97		0.42	0.65	dry	dry
Volatile organic compounds (µg/L, EPA method 601 or 624)							
Benzene	EP6-06	0.5	1	< 0.5	< 0.5	< 0.5	< 0.5
	EP6-08	0.5		< 0.5	< 0.5	< 0.5	< 0.5
	EP6-09	0.5		< 0.5	< 0.5	< 0.5	< 0.5
	K6-01S	0.5		< 0.5	< 0.5	< 0.5	< 0.5
	K6-19	0.5		< 0.5	< 0.5	< 0.5	< 0.5
	K6-36	0.5		< 0.5	< 0.5	dry	dry

Continued

Table A-1. Pit 6 post-closure monitoring plan constituents of concern (COCs), detection monitoring wells, SLs, MCLs, and quarterly analytical results for 2003.

				Quarter			
COC (units)	**Well**	**SL**	**MCL**	**First**	**Second**	**Third**	**Fourth**
Carbon disulfide	EP6-06	5	none	< 1	< 1	< 1	< 1
	EP6-08	5		< 1	< 1	< 1	< 1
	EP6-09	5		< 1	< 1	< 1	< 1
	K6-01S	5		< 1	< 1	< 1	< 1
	K6-19	5		< 1	< 1	< 1	< 1
	K6-36	5		< 1	< 1	dry	dry
Chloroform	EP6-06	0.5	100	< 0.5	< 0.5	< 0.5	< 0.5
	EP6-08	1.0		< 0.5	< 0.5	< 0.5	< 0.5
	EP6-09	0.5		< 0.5	< 0.5	< 0.5	< 0.5
	K6-01S	0.5		< 0.5	< 0.5	< 0.5	< 0.5
	K6-19	1.5		< 0.5	< 0.5	< 0.5	< 0.5
	K6-36	0.5		< 0.5	< 0.5	dry	dry
1,2-dichloroethane	EP6-06	0.5	0.5	< 0.5	< 0.5	< 0.5	< 0.5
	EP6-08	0.5		< 0.5	< 0.5	< 0.5	< 0.5
	EP6-09	0.5		< 0.5	< 0.5	< 0.5	< 0.5
	K6-01S	0.5		< 0.5	< 0.5	< 0.5	< 0.5
	K6-19	0.5		< 0.5	< 0.5	< 0.5	< 0.5
	K6-36	0.5		< 0.5	< 0.5	dry	dry
Cis-1,2-dichloroethene	EP6-06	0.5	6	< 0.5	< 0.5	< 0.5	< 0.5
	EP6-08	0.5		< 0.5	< 0.5	< 0.5	< 0.5
	EP6-09	0.5		< 0.5	< 0.5	< 0.5	< 0.5
	K6-01S	7.0		< 0.5	2.3	2.5	2.2
	K6-19	0.5		< 0.5	< 0.5	< 0.5	< 0.5
	K6-36	0.5		< 0.5	< 0.5	dry	dry
Ethyl benzene	EP6-06	0.5	700	< 0.5	< 0.5	< 0.5	< 0.5
	EP6-08	0.5		< 0.5	< 0.5	< 0.5	< 0.5
	EP6-09	0.5		< 0.5	< 0.5	< 0.5	< 0.5
	K6-01S	0.5		< 0.5	< 0.5	< 0.5	< 0.5
	K6-19	0.5		< 0.5	< 0.5	< 0.5	< 0.5
	K6-36	0.5		< 0.5	< 0.5	dry	dry
Methylene chloride	EP6-06	1	5	< 1	< 1	< 1	< 1
	EP6-08	1		< 1	< 1	< 1	< 1
	EP6-09	1		< 1	< 1	< 1	< 1
	K6-01S	1		< 1	< 1	< 1	< 1
	K6-19	1		< 1	< 1	< 1	< 1
	K6-36	1		< 1	< 1	dry	dry
Tetrachloroethene (PCE)	EP6-06	0.5	5	< 0.5	< 0.5	< 0.5	< 0.5
	EP6-08	1.6		1.0	0.76	0.53	< 0.5
	EP6-09	0.5		< 0.5	< 0.5	< 0.5	< 0.5
	K6-01S	0.5		< 0.5	< 0.5	< 0.5	< 0.5
	K6-19	0.5		< 0.5	< 0.5	< 0.5	< 0.5
	K6-36	1.0		< 0.5	0.52	dry	dry

Continued

Table A-1. Pit 6 post-closure monitoring plan constituents of concern (COCs), detection monitoring wells, SLs, MCLs, and quarterly analytical results for 2003.

				Quarter			
COC (units)	**Well**	**SL**	**MCL**	**First**	**Second**	**Third**	**Fourth**
Toluene	EP6-06	0.5	150	< 0.5	< 0.5	< 0.5	< 0.5
	EP6-08	0.5		< 0.5	< 0.5	< 0.5	< 0.5
	EP6-09	0.5		< 0.5	< 0.5	< 0.5	< 0.5
	K6-01S	0.5		< 0.5	< 0.5	< 0.5	< 0.5
	K6-19	0.5		< 0.5	< 0.5	< 0.5	< 0.5
	K6-36	0.5		< 0.5	< 0.5	dry	dry
1,1,1-trichloroethane	EP6-06	0.5	200	< 0.5	< 0.5	< 0.5	< 0.5
	EP6-08	0.5		< 0.5	< 0.5	< 0.5	< 0.5
	EP6-09	0.5		< 0.5	< 0.5	< 0.5	< 0.5
	K6-01S	0.5		< 0.5	< 0.5	< 0.5	< 0.5
	K6-19	0.5		< 0.5	< 0.5	< 0.5	< 0.5
	K6-36	0.5		< 0.5	< 0.5	dry	dry
Trichloroethene (TCE)	EP6-06	0.5	5	< 0.5	< 0.5	< 0.5	< 0.5
	EP6-08	0.5		< 0.5	< 0.5	< 0.5	< 0.5
	EP6-09	17		5.3	4.8	5.5	4.9
	K6-01S	1.5		< 0.5	< 0.5	< 0.5	< 0.5
	K6-19	13		1.6	1.6	3.9	3.4
	K6-36	2.1		0.8	0.88	dry	dry
Xylenes (total)	EP6-06	1	1750	< 1	< 1	< 1	< 1
	EP6-08	1		< 1	< 1	< 1	< 1
	EP6-09	1		< 1	< 1	< 1	< 1
	K6-01S	1		< 1	< 1	< 1	< 1
	K6-19	1		< 1	< 1	< 1	< 1
	K6-36	1		< 1	< 1	dry	dry
Perchlorate (µg/L)[(c)]	EP6-06	4.7	4 [(d)]	< 3	< 4	< 4	< 4
	EP6-08	4		< 3	< 4	< 4	< 4
	EP6-09	4		4.2	< 4	< 4	< 4
	K6-01S	4		< 3	< 4	< 4	< 4
	K6-19	27.5		< 3	< 4	< 4	< 4
	K6-36	14.4		< 3	5.8	dry	dry

(a) Insufficient ground water for required sample volume (well went dry).

(b) Higher of 2 retest results for total uranium.

(c) Perchlorate SLs equal the analytical RLs for EP6-08, EP6-09, and K6-01S ground water samples. The fourth quarter RLfor perchlorate was 4 µg/L, as shown in the SL column.

(d) California state action level.

Concluded

Table A-2. Pit 6 detection monitoring quarterly ground water physical parameters for 2003.

			Parameters				
Detection well		**Date sampled**	**GWE (a) (ft)**	**Temp. (°C)**	**pH (pH units)**	**Sp. cond. (µmho/cm)**	**TDS(b) (mg/L)**
EP6-06	1	13-Feb-03	661.6	19.5	7.56	1372	875
	2	8-May-03	660.9	20.9	7.43	1328	920
	3	30-Jul-03	659.5	24.1	7.54	1345	850
	4	20-Oct-03	660.7	21.6	7.47	1369	860
EP6-08	1	18-Feb-03	660.9	22.2	7.56	1082	717
	2	23-May-03	658.0	25.7	7.64	1078	693
	3	12-Sep-03	652.6	23.1	7.66	1134	767
	4	22-Oct-03	649.6	24.5	7.27	1511	710
EP6-09	1	14-Feb-03	663.1	21.0	7.60	1442	925
	2	22-May-03	663.0	22.5	7.64	1415	915
	3	20-Aug-03	663.1	24.4	7.64	1449	930
	4	22-Oct-03	663.0	23.9	7.69	1442	935
K6-01S	1	14-Feb-03	663.0	22.1	7.12	3138	2260
	2	7-May-03	663.0	22.0	7.07	3145	2340
	3	20-Aug-03	663.0	24.4	7.09	3149	2340
	4	21-Oct-03	663.0	22.8	7.07	3152	2220
K6-19	1	18-Feb-03	663.0	21.9	7.47	1208	740
	2	7-May-03	663.0	23.0	7.34	1173	755
	3	19-Aug-03	662.8	23.7	7.31	1186	767
	4	21-Oct-03	662.8	22.8	8.01	1153	717
K6-36	1	18-Feb-03	660.5	22.3	7.71	1084	713
	2	22-May-03	656.7	23.6	7.70	1042	693
	3	25-Aug-03	dry	–	–	–	–
	4	21-Oct-03	dry	–	–	–	–

(a) Ground water elevation (water table elevation in feet above mean sea level [MSL]).

(b) Total dissolved solids.

Appendix B

Tables of Ground Water Measurements

for Corrective Action Monitoring Wells

Table B-1. Pit 6 ground water elevations during 2003.

Well	Date sampled	Elevation (ft)	Well	Date sampled	Elevation (ft)
BC6-10	01/02/03	661.6	EP6-08	01/02/03	660.3
BC6-10	02/04/03	661.6	EP6-08	02/04/03	660.2
BC6-10	03/06/03	661.8	EP6-08	02/18/03	660.9
BC6-10	04/09/03	661.4	EP6-08	03/06/03	660.4
BC6-10	07/21/03	661.6	EP6-08	04/09/03	660.5
BC6-10	10/02/03	661.0	EP6-08	05/23/03	658.0
BC6-13	01/02/03	dry	EP6-08	07/21/03	652.4
BC6-13	02/04/03	dry	EP6-08	08/25/03	651.5
BC6-13	03/06/03	dry	EP6-08	10/02/03	649.7
BC6-13	04/09/03	dry	EP6-08	10/22/03	649.6
BC6-13	07/01/03	dry	EP6-08	12/16/03	654.9
BC6-13	10/02/03	dry	EP6-09	01/02/03	663.1
CARNRW1	01/02/03	656.4	EP6-09	02/04/03	663.1
CARNRW1	02/04/03	656.9	EP6-09	02/14/03	663.1
CARNRW1	03/06/03	650.2	EP6-09	03/06/03	663.1
CARNRW1	04/09/03	656.6	EP6-09	04/07/03	663.1
CARNRW1	07/22/03	649.3	EP6-09	05/22/03	663.0
CARNRW1	10/02/03	645.6	EP6-09	07/21/03	663.1
CARNRW3	01/02/03	672.2	EP6-09	08/20/03	663.1
CARNRW3	02/04/03	671.9	EP6-09	10/02/03	662.9
CARNRW3	03/06/03	671.9	EP6-09	10/22/03	663.0
CARNRW3	04/09/03	672.0	K6-01	01/02/03	663.3
CARNRW3	07/21/03	668.7	K6-01	02/04/03	663.1
CARNRW3	10/02/03	666.7	K6-01	03/06/03	663.2
CARNRW4	01/02/03	645.1	K6-01	04/07/03	663.2
CARNRW4	02/04/03	591.8	K6-01	07/21/03	663.2
CARNRW4	03/06/03	645.3	K6-01	10/02/03	663.0
CARNRW4	04/09/03	644.8	K6-01S	01/02/03	663.1
CARNRW4	07/21/03	643.0	K6-01S	02/04/03	663.0
CARNRW4	10/02/03	639.1	K6-01S	02/14/03	663.0
EP6-06	01/02/03	660.8	K6-01S	03/06/03	663.0
EP6-06	02/04/03	661.5	K6-01S	04/02/03	663.0
EP6-06	02/13/03	661.6	K6-01S	04/02/03	663.0
EP6-06	03/06/03	657.6	K6-01S	04/09/03	663.0
EP6-06	04/09/03	660.1	K6-01S	05/07/03	663.0
EP6-06	05/08/03	660.9	K6-01S	07/21/03	663.1
EP6-06	07/21/03	659.4	K6-01S	08/20/03	663.0
EP6-06	07/30/03	659.5	K6-01S	10/02/03	663.0
EP6-06	10/02/03	659.8	K6-01S	10/21/03	663.0
EP6-06	10/20/03	660.7	K6-03	01/02/03	660.5
EP6-07	01/02/03	660.5	K6-03	02/04/03	660.5
EP6-07	02/04/03	660.4	K6-03	02/20/03	661.4
EP6-07	03/06/03	661.1	K6-03	03/06/03	660.7
EP6-07	04/09/03	660.7	K6-03	04/07/03	660.5
EP6-07	07/21/03	652.7	K6-03	04/07/03	660.5
EP6-07	10/02/03	649.8	K6-03	04/16/03	660.3

Continued >

Continued

Table B-1. Pit 6 ground water elevations during 2003.

Well	Date sampled	Elevation (ft)	Well	Date sampled	Elevation (ft)
K6-03	07/21/03	652.8	K6-19	10/02/03	662.8
K6-03	10/02/03	649.8	K6-19	10/21/03	662.8
K6-04	01/02/03	660.8	K6-21	01/02/03	dry
K6-04	02/04/03	661.1	K6-21	02/04/03	dry
K6-04	02/19/03	660.6	K6-21	03/06/03	dry
K6-04	03/06/03	661.1	K6-21	04/07/03	dry
K6-04	04/07/03	661.1	K6-21	07/01/03	dry
K6-04	07/21/03	653.7	K6-21	10/02/03	dry
K6-04	10/02/03	650.6	K6-22	01/02/03	648.4
K6-14	01/02/03	654.5	K6-22	02/04/03	648.2
K6-14	02/04/03	655.0	K6-22	03/06/03	648.0
K6-14	03/06/03	655.1	K6-22	04/09/03	647.8
K6-14	04/09/03	655.5	K6-22	07/21/03	647.5
K6-14	07/21/03	654.5	K6-22	10/02/03	647.3
K6-14	10/02/03	654.0	K6-23	01/02/03	657.9
K6-15	01/02/03	dry	K6-23	02/04/03	657.7
K6-15	02/04/03	dry	K6-23	03/06/03	657.8
K6-15	03/06/03	dry	K6-23	04/09/03	658.7
K6-15	04/07/03	dry	K6-23	10/02/03	656.8
K6-15	07/01/03	dry	K6-24	01/02/03	659.9
K6-15	10/02/03	dry	K6-24	02/04/03	659.8
K6-16	01/02/03	660.0	K6-24	03/06/03	660.6
K6-16	02/04/03	660.3	K6-24	04/09/03	660.2
K6-16	03/06/03	661.0	K6-24	07/21/03	651.8
K6-16	04/09/03	660.6	K6-24	10/02/03	648.9
K6-16	07/21/03	659.9	K6-25	01/02/03	660.0
K6-16	10/02/03	659.3	K6-25	02/04/03	660.1
K6-17	01/02/03	659.2	K6-25	03/06/03	660.1
K6-17	02/04/03	659.5	K6-25	04/09/03	660.2
K6-17	03/06/03	660.0	K6-25	07/21/03	659.9
K6-17	04/09/03	660.6	K6-25	10/02/03	659.4
K6-17	07/21/03	658.7	K6-26	01/02/03	659.9
K6-17	10/02/03	656.5	K6-26	02/04/03	659.9
K6-18	01/02/03	660.4	K6-26	03/06/03	660.6
K6-18	02/04/03	660.4	K6-26	04/09/03	660.3
K6-18	03/06/03	660.4	K6-26	07/21/03	652.4
K6-18	04/09/03	660.3	K6-26	10/02/03	649.5
K6-18	07/21/03	660.2	K6-27	01/02/03	659.2
K6-18	10/02/03	660.1	K6-27	02/04/03	659.0
K6-19	01/02/03	662.7	K6-27	03/06/03	659.7
K6-19	02/04/03	662.9	K6-27	04/09/03	659.3
K6-19	02/18/03	663.0	K6-27	07/21/03	651.1
K6-19	03/06/03	662.8	K6-27	10/02/03	648.3
K6-19	04/07/03	663.1	K6-32	01/02/03	661.1
K6-19	05/07/03	663.0	K6-32	02/04/03	661.2
K6-19	07/21/03	662.9	K6-32	02/20/03	661.9
K6-19	08/19/03	662.8	K6-32	03/06/03	661.4

Continued >

Continued

Table B-1. Pit 6 ground water elevations during 2003.

Well	Date sampled	Elevation (ft)	Well	Date sampled	Elevation (ft)
K6-32	04/09/03	661.4			
K6-32	07/21/03	654.0			
K6-32	10/02/03	dry			
K6-33	01/02/03	656.8			
K6-33	02/04/03	657.9			
K6-33	03/06/03	657.1			
K6-33	04/09/03	657.4			
K6-33	07/21/03	647.3			
K6-33	10/02/03	646.2			
K6-34	02/04/03	657.8			
K6-34	03/07/03	658.6			
K6-34	04/09/03	657.7			
K6-34	07/21/03	647.6			
K6-34	10/02/03	dry			
K6-35	01/02/03	661.3			
K6-35	02/04/03	661.3			
K6-35	03/06/03	661.5			
K6-35	04/02/03	661.5			
K6-35	07/21/03	653.5			
K6-35	10/02/03	650.7			
K6-36	01/02/03	660.0			
K6-36	02/04/03	659.9			
K6-36	02/18/03	660.5			
K6-36	03/06/03	660.2			
K6-36	04/02/03	660.1			
K6-36	04/02/03	660.1			
K6-36	04/09/03	660.2			
K6-36	05/22/03	656.7			
K6-36	07/21/03	dry			
K6-36	10/02/03	dry			
SPRING15	02/26/03	no access			
SPRING7	03/06/03	dry			
W-33C-01	01/02/03	641.3			
W-33C-01	02/04/03	643.6			
W-33C-01	03/06/03	643.2			
W-33C-01	04/09/03	642.8			
W-33C-01	07/21/03	640.4			
W-33C-01	10/02/03	636.0			

Concluded

Table B-2. Pit 6 volatile organic COCs detected during 2003.

Organic compound	Well	Date sampled	Result (µg/L)
cis-1,2-DCE	K6-01	02/14/03	0.5
cis-1,2-DCE	K6-01	08/06/03	0.5
cis-1,2-DCE	K6-01S	04/02/03	2.2
cis-1,2-DCE	K6-01S	04/09/03	2.3
cis-1,2-DCE	K6-01S	05/07/03	2.3
cis-1,2-DCE	K6-01S	08/20/03	2.5
cis-1,2-DCE	K6-01S	08/20/03	2.5
cis-1,2-DCE	K6-01S	10/21/03	2.2
PCE	EP6-08	02/18/03	1.0
PCE	EP6-08	05/23/03	0.8
PCE	EP6-08	05/23/03	0.8
PCE	EP6-08	08/25/03	0.5
PCE	K6-36	05/22/03	0.5
TCE	EP6-09	02/14/03	5.3
TCE	EP6-09	05/22/03	4.8
TCE	EP6-09	08/20/03	5.5
TCE	EP6-09	10/22/03	4.9
TCE	K6-16	02/19/03	0.6
TCE	K6-16	02/19/03	0.6
TCE	K6-16	07/30/03	2.2
TCE	K6-16	07/30/03	2.3
TCE	K6-17	02/19/03	0.9
TCE	K6-17	05/02/03	1.0
TCE	K6-17	05/02/03	0.9
TCE	K6-17	07/30/03	0.9
TCE	K6-17	10/09/03	0.9
TCE	K6-18	02/26/03	3.2
TCE	K6-18	02/26/03	4.0
TCE	K6-18	07/30/03	2.8
TCE	K6-19	02/18/03	1.6
TCE	K6-19	05/07/03	1.6
TCE	K6-19	08/19/03	3.9
TCE	K6-19	10/21/03	3.4
TCE	K6-19	10/21/03	3.6
TCE	K6-36	02/18/03	0.8
TCE	K6-36	05/22/03	0.9

Table B-3. Pit 6 tritium activities during 2003.

Well	Date sampled	Activity (pCi/L)	Activity (Bq/L)
BC6-10	03/06/03	< 100	< 3.7
BC6-10	08/06/03	< 100	< 3.7
CARNRW1	01/30/03	< 100	< 3.7
CARNRW1	02/27/03	< 100	< 3.7
CARNRW1	03/12/03	< 100	< 3.7
CARNRW1	04/28/03	< 212	< 7.8
CARNRW1	05/15/03	< 100	< 3.7
CARNRW1	06/12/03	< 100	< 3.7
CARNRW1	07/22/03	< 100	< 3.7
CARNRW1	08/13/03	< 100	< 3.7
CARNRW1	09/10/03	< 100	< 3.7
CARNRW1	10/16/03	< 103	< 3.8
CARNRW1	11/13/03	< 100	< 3.7
CARNRW1	12/10/03	< 102	< 3.8
CARNRW2	02/27/03	136	5.0
CARNRW2	03/13/03	< 100	< 3.7
CARNRW2	04/07/03	< 102	< 3.8
CARNRW2	04/16/03	< 102	< 3.8
CARNRW2	04/28/03	< 219	< 8.1
CARNRW2	05/15/03	< 100	< 3.7
CARNRW2	06/12/03	< 100	< 3.7
CARNRW2	07/16/03	< 100	< 3.7
CARNRW2	08/13/03	< 100	< 3.7
CARNRW2	09/10/03	< 100	< 3.7
CARNRW2	10/15/03	< 100	< 3.7
CARNRW2	11/13/03	< 100	< 3.7
CARNRW2	12/10/03	< 100	< 3.7
CARNRW3	05/15/03	< 100	< 3.7
CARNRW3	06/12/03	< 100	< 3.7
CARNRW3	07/22/03	< 100	< 3.7
CARNRW3	08/13/03	< 100	< 3.7
CARNRW3	09/10/03	< 100	< 3.7
CARNRW3	10/15/03	< 100	< 3.7
CARNRW3	11/13/03	< 100	< 3.7
CARNRW3	12/10/03	< 100	< 3.7
CARNRW4	02/27/03	< 100	< 3.7
CARNRW4	05/14/03	< 100	< 3.7
CARNRW4	06/12/03	< 100	< 3.7
CARNRW4	07/16/03	< 100	< 3.7
CARNRW4	08/13/03	< 100	< 3.7
CARNRW4	09/10/03	< 100	< 3.7
CARNRW4	10/15/03	< 100	< 3.7
CARNRW4	11/13/03	< 100	< 3.7

Continued

Table B-3. Pit 6 tritium activities during 2003.

Well	Date sampled	Activity (pCi/L)	Activity (Bq/L)
CARNRW4	12/10/03	< 100	< 3.7
EP6-06	02/13/03	< 108	< 4.0
EP6-06	05/08/03	< 100	< 3.7
EP6-06	07/30/03	< 100	< 3.7
EP6-06	10/21/03	< 100	< 3.7
EP6-07	02/26/03	313	11.6
EP6-07	08/06/03	< 100	< 3.7
EP6-08	02/18/03	< 104	< 3.8
EP6-08	05/23/03	< 100	< 3.7
EP6-08	05/23/03	< 100	< 3.7
EP6-08	09/12/03	< 100	< 3.7
EP6-08	10/22/03	< 100	< 3.7
EP6-09	02/14/03	< 105	< 3.9
EP6-09	05/22/03	< 102	< 3.8
EP6-09	08/20/03	< 100	< 3.7
EP6-09	10/22/03	< 100	< 3.7
K6-01	02/14/03	257	9.5
K6-01	08/06/03	266	9.8
K6-01S	02/14/03	104	3.8
K6-01S	05/07/03	< 100	< 3.7
K6-01S	08/20/03	181	6.7
K6-01S	08/20/03	195	7.2
K6-01S	10/21/03	107	4.0
K6-03	02/20/03	116	4.3
K6-03	04/07/03	< 100	< 3.7
K6-03	04/16/03	< 106	< 3.9
K6-03	08/06/03	< 100	< 3.7
K6-04	02/19/03	< 105	< 3.9
K6-04	02/19/03	< 106	< 3.9
K6-04	08/06/03	< 100	< 3.7
K6-14	02/26/03	< 104	< 3.8
K6-14	07/30/03	< 100	< 3.7
K6-16	02/19/03	654	24.2
K6-16	02/19/03	584	21.6
K6-16	07/30/03	567	21.0
K6-16	07/30/03	524	19.4
K6-17	02/19/03	< 100	< 3.7
K6-17	05/02/03	< 100	< 3.7
K6-17	07/30/03	< 100	< 3.7
K6-17	10/09/03	< 100	< 3.7
K6-18	02/26/03	364	13.5
K6-18	07/30/03	337	12.5
K6-19	02/18/03	253	9.4

Continued

Table B-3. Pit 6 tritium activities during 2003.

Well	Date sampled	Activity (pCi/L)	Activity (Bq/L)
K6-19	05/07/03	268	9.9
K6-19	08/19/03	304	11.2
K6-19	10/21/03	295	10.9
K6-19	10/21/03	303	11.2
K6-22	02/26/03	< 104	< 3.8
K6-22	05/02/03	< 100	< 3.7
K6-22	07/30/03	< 100	< 3.7
K6-22	10/09/03	< 100	< 3.7
K6-23	02/26/03	< 102	< 3.8
K6-23	08/13/03	< 100	< 3.7
K6-24	02/26/03	492	18.2
K6-24	07/30/03	442	16.4
K6-25	03/06/03	< 100	< 3.7
K6-25	08/13/03	< 100	< 3.7
K6-26	02/26/03	< 102	< 3.8
K6-26	08/06/03	< 100	< 3.7
K6-27	02/26/03	< 103	< 3.8
K6-27	08/06/03	< 100	< 3.7
K6-27	08/06/03	< 200	< 7.4
K6-32	02/20/03	< 104	< 3.8
K6-32	08/13/03	< 100	< 3.7
K6-33	02/19/03	460	17.0
K6-33	08/13/03	295	10.9
K6-34	03/07/03	< 100	< 3.7
K6-34	05/23/03	< 104	< 3.8
K6-34	08/13/03	< 100	< 3.7
K6-34	10/09/03	< 100	< 3.7
K6-35	02/26/03	294	10.9
K6-35	08/13/03	388	14.4
K6-35	08/13/03	383	14.2
K6-36	02/18/03	1590	58.8
K6-36	05/22/03	1850	68.5
W-33C-01	03/13/03	< 100	< 3.7
W-33C-01	08/13/03	< 100	< 3.7
W-PIT6-1819	02/26/03	< 104	< 3.8
W-PIT6-1819	06/26/03	123	4.6
W-PIT6-1819	08/13/03	145	5.4
W-PIT6-1819	08/20/03	263	9.7
W-PIT6-1819	10/09/03	146	5.4

Concluded

Table B-4. Pit 6 perchlorate and nitrate concentrations during 2003.

Well	Date sampled	Perchlorate (µg/L)	Nitrate (mg/L)
BC6-10	03/06/03	< 3	0.75
CARNRW1	01/30/03	< 3	< 0.44
CARNRW1	02/27/03	< 3	< 0.44
CARNRW1	03/12/03	< 3	< 0.44
CARNRW1	04/28/03	< 4	< 0.44
CARNRW1	05/15/03	< 4	< 0.44
CARNRW1	06/12/03	< 4	< 0.44
CARNRW1	07/22/03	< 4	< 0.44
CARNRW1	08/13/03	< 4	< 0.44
CARNRW1	09/10/03	< 4	< 0.44
CARNRW1	10/16/03	< 4	< 0.44
CARNRW1	11/13/03	< 4	< 0.44
CARNRW1	12/10/03	< 4	< 0.44
CARNRW2	02/27/03	< 3	< 0.44
CARNRW2	03/13/03	< 3	< 0.44
CARNRW2	04/28/03	< 4	< 0.44
CARNRW2	05/15/03	< 4	< 0.44
CARNRW2	06/12/03	< 4	< 0.44
CARNRW2	07/16/03	< 4	< 0.44
CARNRW2	08/13/03	< 4	< 0.44
CARNRW2	09/10/03	< 4	< 0.44
CARNRW2	10/15/03	< 4	< 0.44
CARNRW2	11/13/03	< 4	< 0.44
CARNRW2	12/10/03	< 4	< 0.44
CARNRW3	05/15/03	< 4	< 0.44
CARNRW3	06/12/03	< 4	< 0.44
CARNRW3	07/22/03	< 4	< 0.44
CARNRW3	08/13/03	< 4	< 0.44
CARNRW3	09/10/03	< 4	< 0.44
CARNRW3	10/15/03	< 4	< 0.44
CARNRW3	11/13/03	< 4	< 0.44
CARNRW3	12/10/03	< 4	< 0.44
CARNRW4	02/27/03	< 3	8.4
CARNRW4	05/14/03	< 4	2.8
CARNRW4	06/11/03	< 4	1.8
CARNRW4	07/16/03	< 4	< 0.88
CARNRW4	08/13/03	< 4	< 0.88
CARNRW4	09/10/03	< 4	< 0.88
CARNRW4	10/15/03	< 4	< 0.88
CARNRW4	11/13/03	< 4	< 0.44

Continued

Table B-4. Pit 6 perchlorate and nitrate concentrations during 2003.

Well	Date sampled	Perchlorate (µg/L)	Nitrate (mg/L)
CARNRW4	12/10/03	< 4	< 0.44
EP6-06	02/13/03	< 3	0.62
EP6-06	05/08/03	< 4	< 0.44
EP6-06	07/30/03	< 4	< 0.44
EP6-06	10/21/03	< 4	< 0.44
EP6-07	02/26/03	< 3	< 0.44
EP6-08	02/18/03	< 3	3.5
EP6-08	05/23/03	< 4	3.5
EP6-08	05/23/03	< 4	3.5
EP6-08	09/12/03	< 4	5.73
EP6-08	10/22/03	nm[(a)]	< 0.44
EP6-08	12/16/03	< 4	nm
EP6-09	02/14/03	4.2	2.8
EP6-09	05/22/03	< 4	2.7
EP6-09	08/20/03	< 4	2.7
EP6-09	10/22/03	< 4	2.6
K6-01	02/14/03	< 3	< 0.44
K6-01S	02/14/03	< 3	< 0.88
K6-01S	05/07/03	< 4	< 0.88
K6-01S	08/20/03	< 4	< 0.88
K6-01S	08/20/03	< 4	< 0.88
K6-01S	10/21/03	< 4	< 0.88
K6-03	02/20/03	< 3	< 0.44
K6-03	05/22/03	nm	< 0.44
K6-04	02/19/03	< 4	12
K6-04	02/19/03	< 4	12
K6-04	05/23/03	nm	10
K6-14	02/26/03	< 3	0.45
K6-16	02/19/03	< 3	< 2.2
K6-16	02/19/03	< 3	< 2.2
K6-17	02/19/03	< 3	1.9
K6-17	07/30/03	< 4	0.91
K6-18	02/26/03	8	16
K6-18	02/26/03	12	36.3
K6-18	07/30/03	11	nm
K6-18	10/21/03	14	nm
K6-19	02/18/03	< 3	< 0.44
K6-19	05/07/03	< 4	< 0.44
K6-19	08/19/03	< 4	< 0.44
K6-19	10/21/03	< 4	< 0.44

Continued

Table B-4. Pit 6 perchlorate and nitrate concentrations during 2003.

Well	Date sampled	Perchlorate (µg/L)	Nitrate (mg/L)
K6-19	10/21/03	< 4	< 0.44
K6-22	02/26/03	< 3	< 0.88
K6-22	07/30/03	< 4	< 0.44
K6-23	02/26/03	< 15	159
K6-23	08/13/03	nm	162
K6-23	10/21/03	nm	172
K6-24	02/26/03	< 3	< 0.44
K6-25	03/06/03	< 3	< 0.44
K6-26	02/26/03	< 3	< 0.44
K6-27	02/26/03	< 3	< 0.44
K6-32	02/20/03	< 3	< 0.44
K6-32	05/22/03	nm	< 0.44
K6-33	02/19/03	< 3	1.2
K6-34	03/07/03	4.4	< 0.44
K6-34	08/13/03	< 4	< 0.44
K6-35	02/26/03	< 3	< 0.44
K6-36	02/18/03	< 3	1.6
K6-36	05/22/03	5.8	0.59
W-33C-01	03/13/03	< 3	3.2
W-PIT6-1819	02/26/03	< 3	< 0.44
W-PIT6-1819	06/26/03	< 4	< 0.44
W-PIT6-1819	08/13/03	< 4	< 0.44
W-PIT6-1819	08/20/03	< 4	< 0.44
W-PIT6-1819	10/09/03	< 4	< 0.44

(a) nm means not measured this date.

Concluded

Table B-5. Pit 6 monitoring locations, functions, associated monitoring programs, COCs and their sampling frequencies, and fourth quarter of 2003 sampling summary.

Monitoring location	Monitoring function	Monitoring program	COCs[a] (sampling frequency)	Samples obtained	Reason(s), if not completed
K6-17	guard well	CAMP	P (Q), S (SA)	P	
K6-22	guard well	CAMP	P (Q), S (SA)	P	
K6-34	guard well	CAMP	P (Q), S (SA)	P	
W-PIT6-1819	guard well	CAMP	P (Q), S (SA)	PS	
CARNRW1	water supply well	CAMP	P (M), S (M)	PPP-SSS	
CARNRW2	water supply well	CAMP	P (M), S (M)	PPP-SSS	
CARNRW3	water supply well	CAMP	P (M), S (M)	PPP-SSS	
CARNRW4	water supply well	CAMP	P (M), S (M)	PPP-SSS	
SPRING7	plume tracking spring	CAMP	P (SA), S (A)	none	dry
SPRING15	plume tracking spring	CAMP	P (SA), S (A)	none	done 1st and 3rd quarters
BC6-10	plume tracking well	CAMP	P (SA), S (A)	none	done 1st and 3rd quarters
BC6-13 / Spring 7	plume tracking well	CAMP	P (SA), S (A)	none	dry
EP6-07	plume tracking well	CAMP	P (SA), S (A)	none	done 1st and 3rd quarters
K6-01[b]	plume tracking well	CAMP	P (SA), S (A)	PS	
K6-03	plume tracking well	CAMP	P (SA), S (A)	none	done 1st and 3rd quarters
K6-04	plume tracking well	CAMP	P (SA), S (A)	none	done 1st and 3rd quarters
K6-14	plume tracking well	CAMP	P (SA), S (A)	none	done 1st and 3rd quarters
K6-15	plume tracking well	CAMP	P (SA), S (A)	none	done 1st and 3rd quarters
K6-16	plume tracking well	CAMP	P (SA), S (A)	none	done 1st and 3rd quarters
K6-18	plume tracking well	CAMP	P (SA), S (A)	none	done 1st and 3rd quarters
K6-21	plume tracking well	CAMP	P (SA), S (A)	none	done 1st and 3rd quarters
K6-23	plume tracking well	CAMP	P (SA), S (A)	none	done 1st and 3rd quarters
K6-24	plume tracking well	CAMP	P (SA), S (A)	none	done 1st and 3rd quarters
K6-25	plume tracking well	CAMP	P (SA), S (A)	none	done 1st and 3rd quarters
K6-26	plume tracking well	CAMP	P (SA), S (A)	none	done 1st and 3rd quarters
K6-27	plume tracking well	CAMP	P (SA), S (A)	none	done 1st and 3rd quarters
K6-32	plume tracking well	CAMP	P (SA), S (A)	none	done 1st and 3rd quarters
K6-33	plume tracking well	CAMP	P (SA), S (A)	none	done 1st and 3rd quarters
K6-35	plume tracking well	CAMP	P (SA), S (A)	none	done 1st and 3rd quarters
W-33C-01	plume tracking well	CAMP	P (SA), S (A)	none	done 1st and 3rd quarters
EP6-06	release detection well	DMP	All (Q)	All	
EP6-08	release detection well	DMP	All (Q)	All	
EP6-09	release detection well	DMP	All (Q)	All	
K6-01S	release detection well	DMP	All (Q)	All	
K6-19	release detection well	DMP	All (Q)	All	
K6-36	release detection well	DMP	All (Q)	none	dry

(a) P means the primary COCs tritium and VOCs. S means the secondary COCs perchlorate and nitrate. All means all DMP COCs (see **Table C-1** for a list). (M) means sampled monthly. (Q) means sampled quarterly. (SA) means sampled semiannually (done first and third quarters of year). (A) means sampled annually (done first quarter of year).

(b) Whenever well K6-01S is dry, well K6-01 is substituted and is analyzed for all DMP COCs .

Appendix C

Statistical Methods

for Detection Monitoring

Appendix C

Statistical Methods for Detection Monitoring

Monitoring and reporting provisions of the CERCLA closure and post-closure plan for the Pit 6 landfill require the use of statistical methods from the *California Code of Regulations* (CCR), Title 23, Division 3, Chapter 15, Section 2550.7 (Ferry *et al.* 1998).

We use statistically determined limits of concentration (SLs) to detect potential releases of constituents of concern (COCs) to ground water from solid wastes contained in the Pit 6 landfill. We employ two statistical methods, prediction intervals (PIs) and control charts (CCs), to generate SLs. Both methods are sensitive to COC concentration increases. Both methods are cost-effective, requiring only one measurement of a COC per quarter per monitoring well.

We prefer the PI method when COC concentrations in ground water are similar upgradient and downgradient from the monitored unit. We use parametric PI methods when the upgradient COC concentration data are all above the detection limit and the data are approximately normally distributed. We may use parametric methods on log-transformed data, if the transformed data follow a normal distribution. Nonparametric PI methods are more effective when the data cannot be transformed to a normal distribution, or when they contain nondetections.

When the concentration of a COC is spatially variable in the vicinity of a monitored unit, we develop a control chart for each downgradient monitoring well. The control chart compares each new quarterly COC measurement with its concentration history for that well.

Wherever sufficient historical detections exist, we calculate an SL such that any future measurement has approximately a 1-in-100 chance of exceeding the SL, when no change in concentration has actually occurred. This yields a statistical test with a significance level of approximately 0.01. Where historical detections exist, but nondetections constitute part of the data, we set the SL equal to the highest concentration measured. If historical analyses of a COC show all nondetections, then we set the SL equal to the analytical reporting limit (RL). When a routine COC measurement exceeds an SL, we perform two discrete retests. This method of data verification is in accordance with CCR Title 23, Chapter 15, Section 2550.7.

Constituents of Concern

COCs were identified for monitoring in the ground water at the Pit 6 landfill prior to its closure (Ferry *et al.* 1998). COCs, as defined by CCR Title 22, Chapter 15, are waste constituents, their reaction products, or hazardous constituents that are reasonably expected to be in or derived from waste buried in Pit 6. The current COCs for Pit 6 are listed in **Table C-1** below.

Table C-1. Pit 6 COCs, typical analytical reporting limit (RL), concentration limit (CL),[a] and statistical limit (SL) for each of the six detection monitoring wells.

Constituent of concern (COC)	Typical analytical RL (units)	Well EP6-06 CL; SL	Well EP6-08 CL; SL	Well EP6-09 CL; SL	Well K6-01S CL; SL	Well K6-19 CL; SL	Well K6-36 CL; SL
1,1,1-TCA	0.5 µg/L	<RL; RL	<RL; RL	<RL; RL	<RL; RL	<RL; RL	<RL; RL
1,2-DCA	0.5 µg/L	<RL; RL	<RL; RL	<RL; RL	<RL; RL	<RL; RL	<RL; RL
Cis-1,2-DCE	0.5 µg/L	<RL; RL	<RL; RL	<RL; RL	5.4; 7.0	<RL; RL	<RL; RL
Chloroform	0.5 µg/L	<RL; RL	0.1; 1.0	<RL; RL	<RL; RL	0.2; 1.5	<RL; RL
Methylene chloride	0.5 µg/L	<RL; RL	<RL; RL	<RL; RL	<RL; RL	<RL; RL	<RL; RL
PCE	0.5 µg/L	<RL; RL	0.4; 1.6	<RL; RL	<RL; RL	<RL; RL	0.5; 1.0
TCE	0.5 µg/L	<RL; RL	<RL; RL	14; 17	1.1; 1.5	8.2; 13	0.8; 2.1
Benzene	0.5 µg/L	<RL; RL	<RL; RL	<RL; RL	<RL; RL	<RL; RL	<RL; RL
Ethylbenzene	0.5 µg/L	<RL; RL	<RL; RL	<RL; RL	<RL; RL	<RL; RL	<RL; RL
Toluene	0.5 µg/L	<RL; RL	<RL; RL	<RL; RL	<RL; RL	<RL; RL	<RL; RL
Total xylenes	1.0 µg/L	<RL; RL	<RL; RL	<RL; RL	<RL; RL	<RL; RL	<RL; RL
Beryllium	0.5 µg/L	<RL; RL	<RL; RL	<RL; RL	<RL; RL	<RL; RL	<RL; RL
Mercury	0.2 µg/L	<RL; RL	<RL; RL	<RL; RL	<RL; RL	<RL; RL	<RL; RL
Carbon disulfide	5.0 µg/L	<RL; RL	<RL; RL	<RL; RL	<RL; RL	<RL; RL	<RL; RL
Perchlorate	4.0 µg/L	<RL; RL	<RL; RL	<RL; RL	<RL; RL	10.2; 27.5	5.3; 14.4
Tritium	100 pCi/L	RL; RL	<RL; RL	<RL; RL	<RL; RL	<RL; RL	2060; 2390
Uranium (total)	0.5 pCi/L	1.9; 3.6	1.2; 1.5	2.1; 3.7	6.6; 27	3.2; 7.2	0.5; 1.4
Gross alpha [b]	2 pCi/L	2.7; 7.7	0.9; 4.0	1.0; 4.9	7.0; 26	2.0; 9.2	<RL; RL
Gross beta [b]	2 pCi/L	8.6; 21	8.6; 21	8.6; 21	14; 58	8.6; 21	9.8; 26

(a) CL (concentration limit) is equivalent to the background concentration of a COC.

(b) Gross alpha and gross beta are surrogates for ^{125}Sb, ^{137}Cs, ^{60}Co, ^{22}Na, ^{90}Sr, ^{204}Tl, and ^{232}Th.

Chlorinated VOCs (including TCE, PCE, 1,2-DCA, 1,1,1-TCA, methylene chloride, chloroform, benzene, toluene, ethylbenzene, and total xylenes) were detected historically in ground water and/or in soil adjacent to Pit 6. These VOCs are COCs.

Beryllium and mercury are COCs because they are listed in the waste disposal records for Pit 6.

Nine radionuclide COCs are associated with waste buried in Pit 6. They are ^{125}Sb, ^{137}Cs, ^{60}Co, ^{22}Na, ^{90}Sr, ^{204}Tl, ^{232}Th, ^{238}U, and tritium. Gross alpha and gross beta radioactivity are used as surrogates for seven of these nuclides, but not for uranium and tritium, which are measured separately (**Table C-1**).

A minor tritium release occurred prior to closure of Pit 6 and is the object of a continuing LLNL CERCLA investigation. The detection monitoring well BC6-12 was destroyed during year 2000, because it was screened across two water-bearing zones and could have provided a conduit for tritium in the shallower zone to contaminate ground water in the deeper zone. Well BC6-12 was replaced by well K6-36, which was constructed adjacent to it. Well K6-36 is screened only in the shallow water-bearing zone. Our calculated COC SLs for replacement well K6-36 are shown **Table C-1**.

A post-closure LLNL CERCLA study detected perchlorate in ground water downgradient of Pit 6. Consequently, perchlorate was added to the COC list and we have calculated SLs for this chemical (**Table C-1**).

Pesticides were not detected over an 18-month period (6 quarterly sampling events) following pit closure and were removed from the COC list.

Phthalates were not designated as COCs, because they were rarely detected prior to pit closure. However, since post-closure monitoring began in 1998, we have detected bis(2-ethylhexyl)phthalate (also known as di[2-ethylhexyl]phthalate, or DEHP) in ground water both upgradient and downgradient from Pit 6.

Table C-2 lists COCs that have indicated statistically significant evidence of release to ground water since post-closure monitoring began in 1998. **Table C-2** also lists the date of our 7-day letter notification to CVRWQCB and the status of any additional investigation of the COC. Note that 1,2-DCA has not been detected since 1998.

Table C-2. Pit 6 COCs showing statistical evidence of post-closure release.

COC	Date of 7-day letter report	Status of release investigation
1,2-DCA	10/13/98[a]	Transferred to ERD[b]
Perchlorate	11/8/02[c]	Retests did not confirm a release

(a) Galles (1998).

(b) LLNL Environmental Restoration Division.

(c) Raber (2002).

Appendix D

Changes in Monitoring Programs or Methods

Appendix D

Changes in Monitoring Programs or Methods

LLNL implemented a compliance monitoring program during the second quarter of 1998 for the CERCLA-closed Pit 6 landfill at Site 300. The program is described in detail in Ferry *et al.* 1998.

During 2000, two new monitoring wells, designated K6-35 and K6-36, replaced monitoring wells BC6-11 and BC6-12, which were destroyed by grouting. Well K6-36, which is screened in the first (shallower) of two water-bearing zones, replaced well BC6-12 for release detection. Well K6-35, screened in the next deeper water-bearing zone, is used for corrective-action assessment.

By request of the CVRWQCB, we added perchlorate to the list of Pit 6 COCs during the third quarter of 2000.

By request of the CVRWQCB, since the third quarter of 2000 we have provided a table of information (**Table B-5)** that lists the Pit 6 CERCLA monitoring wells, their monitoring program assignments, their sampling frequencies, the COCs they monitor, and a reason if they were not sampled during the reported quarter.

During 2001, quarterly tritium monitoring was expanded to include CERCLA well K6-33 and the private, off-site, water supply wells designated CARNRW1 and CARNRW2. During 2002 a new CERCLA guard well was completed downgradient from Pit 6 adjacent to the Site 300 boundary. This well is identified as W-PIT6-1819.

Beginning 1 January 2003, the CAMP sampling schedule and COCs have changed as described in the *Compliance Monitoring Plan/Contingency Plan for Interim Remedies at Lawrence Livermore National Laboratory Site 300* (Ferry, *et al.* 2002). **Table D-1** contains the significant elements of the new monitoring program for Pit 6. Simply stated, an expanded set of CAMP wells and springs will be sampled semiannually for tritium and VOCs, and annually for nitrate and perchlorate, while DMP well monitoring remains essentially unchanged. However, upgradient wells K6-03, K6-04, K6-15, and K6-32, which were formerly sampled quarterly for all the DMP COCs listed in **Table C-1**, are now designated to be CAMP plume-tracking wells and are sampled semiannually for tritium and VOCs and annually for nitrate and perchlorate only.

Beginning in the third quarter of 2003, the sampling and analysis frequency for extractable organic compounds (EPA method 625), which are not designated COCs, was reduced from quarterly to annually.

Table D-1. Pit 6 monitoring locations, monitoring functions, associated monitoring programs, and COCs and their sampling frequencies.

Monitoring location	Monitoring function	Monitoring program	COCs[a] (sampling frequency)
K6-17	guard well	CAMP	P (Q), S (SA)
K6-22	guard well	CAMP	P (Q), S (SA)
K6-34	guard well	CAMP	P (Q), S (SA)
W-PIT6-1819	guard well	CAMP	P (Q), S (SA)
SPRING 7[b]	plume tracking spring	CAMP	P (SA), S (A)
SPRING 15	plume tracking spring	CAMP	P (SA), S (A)
BC6-10	plume tracking well	CAMP	P (SA), S (A)
BC6-13	plume tracking well	CAMP	P (SA), S (A)
EP6-07	plume tracking well	CAMP	P (SA), S (A)
K6-01[c]	plume tracking well	CAMP	P (SA), S (A)
K6-03	plume tracking well	CAMP	P (SA), S (A)
K6-04	plume tracking well	CAMP	P (SA), S (A)
K6-14	plume tracking well	CAMP	P (SA), S (A)
K6-15	plume tracking well	CAMP	P (SA), S (A)
K6-16	plume tracking well	CAMP	P (SA), S (A)
K6-18	plume tracking well	CAMP	P (SA), S (A)
K6-21	plume tracking well	CAMP	P (SA), S (A)
K6-23	plume tracking well	CAMP	P (SA), S (A)
K6-24	plume tracking well	CAMP	P (SA), S (A)
K6-25	plume tracking well	CAMP	P (SA), S (A)
K6-26	plume tracking well	CAMP	P (SA), S (A)
K6-27	plume tracking well	CAMP	P (SA), S (A)
K6-32	plume tracking well	CAMP	P (SA), S (A)
K6-33	plume tracking well	CAMP	P (SA), S (A)
K6-35	plume tracking well	CAMP	P (SA), S (A)
W-33C-01	plume tracking well	CAMP	P (SA), S (A)
EP6-06	release detection well	DMP	All (Q)
EP6-08	release detection well	DMP	All (Q)
EP6-09	release detection well	DMP	All (Q)
K6-01S	release detection well	DMP	All (Q)
K6-19	release detection well	DMP	All (Q)
K6-36	release detection well	DMP	All (Q)
CARNRW1	water supply well	CAMP	P (M), S (M)
CARNRW2	water supply well	CAMP	P (M), S (M)
CARNRW3	water supply well	CAMP	P (M), S (M)
CARNRW4	water supply well	CAMP	P (M), S (M)

(a) P means the primary COCs tritium and VOCs. S means the secondary COCs perchlorate and nitrate. All means all DMP COCs (see **Table C-1** for a list). (M) means sampled monthly. (Q) means sampled quarterly. (SA) means sampled semiannually (done first and third quarters of year). (A) means sampled annually (done first quarter of year).

(b) SPRING 7 is sampled via the adjacent shallow well BC6-13.

(c) Whenever well K6-01S is dry, well K6-01 is substituted and is analyzed for all DMP COCs .

Appendix E

Quality Assurance

Appendix E

Quality Assurance

To ensure data quality, we work within the established Quality Assurance (QA) program of the LLNL Environmental Protection Department (EPD). We use protocols and procedures that cover all aspects of ground water sampling, sample tracking, and data management. These written protocols and procedures are contained in the *LLNL Livermore Site and Site 300 Environmental Restoration Project Standard Operating Procedures (SOPs)* (Dibley and Depue 2002), the *Environmental Monitoring Plan* (Tate *et al.* 1999), and the *EPD Quality Assurance Management Plan* (Merrigan 2001). We use SOPs to minimize inadvertent sample contamination and to maintain sample integrity from the monitoring well to the analytical laboratory. Data management SOPs ensure that all laboratory measurements are received, are accurately recorded, and are properly stored in a computer database and in hardcopy form. Data quality is assessed by the following four methods.

1. Each quarter, a duplicate (collocated) set of ground water samples is collected from one of the Pit 6 monitoring wells. The routine and duplicate sample sets are labeled with different identifier codes. Identical analyses are performed on the routine and duplicate sample sets. Analytical results for the routine and duplicate samples are compared by the analysts responsible for this report. Any significant differences found are investigated in collaboration with a QA chemist. A representative of an analytical laboratory may also be involved during an investigation of suspect data.

2. Each quarter, a set of blank samples is prepared in the field at a randomly chosen Pit 6 detection monitoring well using water of known purity. The field blank samples are submitted to the analytical laboratories together with the routine ground water samples for identical analyses. Field blanks test the cleanliness of sample preparation in the field and sample processing at the analytical laboratory.

3. Each quarter, equipment blanks are prepared and analyzed to ensure that sampling equipment is properly cleaned before use.

4. Each day when samples are collected for volatile organic compound (VOC) analysis, a trip blank (prepared at the analytical laboratory) is carried into the field. It is returned unopened to the analytical laboratory for VOC analysis. If VOCs are detected in a trip blank and in any of the ground water samples collected that day, the VOC results may be discounted and new sampling performed.

Fourth-quarter QA results

The fourth-quarter COC measurements of routine and duplicate ground water samples from DMP well K6-01S are comparable within the uncertainties inherent in the various analytical methods used (**Table E-1**).

Table E-1. Pit 6 analyses of routine, duplicate, and field blank QA samples for fourth quarter 2003.

Date Sampled: 21-Oct-2003

			QA samples		
	EPA		K6-19	K6-19	Pit 6
Constituent	**Method**	**units**	**routine**	**duplicate**	**field blank**
Total dissolved solids (TDS)	E160.1	mg/L	717	740	< 10
Beryllium	E210.2	µg/L	< 0.2	< 0.2	< 0.2
Mercury	E245.2	µg/L	< 0.2	< 0.2	< 0.2
Nitrate (as NO3)	E300.0	mg/L	< 0.44	< 0.44	< 0.44
Perchlorate	E300.0	µg/L	< 4	< 4	< 4
1,1,1-Trichloroethane	E624	µg/L	< 0.5	< 0.5	< 0.5
1,1,2,2-Tetrachloroethane	E624	µg/L	< 0.5	< 0.5	< 0.5
1,1,2-Trichloroethane	E624	µg/L	< 0.5	< 0.5	< 0.5
1,1-Dichloroethane	E624	µg/L	< 0.5	< 0.5	< 0.5
1,1-Dichloroethene	E624	µg/L	< 0.5	< 0.5	< 0.5
1,2-Dichlorobenzene	E624	µg/L	< 0.5	< 0.5	< 0.5
1,2-Dichloroethane	E624	µg/L	< 0.5	< 0.5	< 0.5
1,2-Dichloroethene (total)	E624	µg/L	< 1	< 1	< 1
1,2-Dichloropropane	E624	µg/L	< 0.5	< 0.5	< 0.5
1,3-Dichlorobenzene	E624	µg/L	< 0.5	< 0.5	< 0.5
1,4-Dichlorobenzene	E624	µg/L	< 0.5	< 0.5	< 0.5
2-Butanone	E624	µg/L	< 20	< 20	< 20
2-Chloroethylvinylether	E624	µg/L	< 10	< 10	< 10
2-Hexanone	E624	µg/L	< 20	< 20	< 20
4-Methyl-2-pentanone	E624	µg/L	< 20	< 20	< 20
Acetone	E624	µg/L	< 20	< 20	< 20
Benzene	E624	µg/L	< 0.5	< 0.5	< 0.5
Bromodichloromethane	E624	µg/L	< 0.5	< 0.5	< 0.5
Bromoform	E624	µg/L	< 0.5	< 0.5	< 0.5
Bromomethane	E624	µg/L	< 1	< 1	< 1
Carbon disulfide	E624	µg/L	< 1	< 1	< 1
Carbon tetrachloride	E624	µg/L	< 0.5	< 0.5	< 0.5
Chlorobenzene	E624	µg/L	< 0.5	< 0.5	< 0.5
Chloroethane	E624	µg/L	< 0.5	< 0.5	< 0.5
Chloroform	E624	µg/L	< 0.5	< 0.5	< 0.5
Chloromethane	E624	µg/L	< 0.5	< 0.5	< 0.5
cis-1,2-Dichloroethene	E624	µg/L	< 0.5	< 0.5	< 0.5
cis-1,3-Dichloropropene	E624	µg/L	< 0.5	< 0.5	< 0.5
Dibromochloromethane	E624	µg/L	< 0.5	< 0.5	< 0.5
Dibromomethane	E624	µg/L	< 0.5	< 0.5	< 0.5
Dichlorodifluoromethane	E624	µg/L	< 0.5	< 0.5	< 0.5

Continued

Table E-1. Pit 6 analyses of routine, duplicate, and field blank QA samples for fourth quarter 2003.

Date Sampled: 21-Oct-2003			QA samples		
	EPA		**K6-19**	**K6-19**	**Pit 6**
Constituent	**Method**	**units**	**routine**	**duplicate**	**field blank**
Ethanol	E624	µg/L	< 1000	< 1000	< 1000
Ethylbenzene	E624	µg/L	< 0.5	< 0.5	< 0.5
Freon 113	E624	µg/L	< 0.5	< 0.5	< 0.5
Methylene chloride	E624	µg/L	< 1	< 1	< 1
Naphthalene	E624	µg/L	< 0.5	< 0.5	< 0.5
Styrene	E624	µg/L	< 0.5	< 0.5	< 0.5
Tetrachloroethene	E624	µg/L	< 0.5	< 0.5	< 0.5
Toluene	E624	µg/L	< 0.5	< 0.5	< 0.5
Total xylene isomers	E624	µg/L	< 1	< 1	< 1
trans-1,2-Dichloroethene	E624	µg/L	< 0.5	< 0.5	< 0.5
trans-1,3-Dichloropropene	E624	µg/L	< 0.5	< 0.5	< 0.5
Trichloroethene	E624	µg/L	3.4	3.6	< 0.5
Trichlorofluoromethane	E624	µg/L	< 0.5	< 0.5	< 0.5
Vinyl chloride	E624	µg/L	< 0.5	< 0.5	< 0.5
Tritium	E906	Bq/L	10.9 ± 2.6	11.2 ± 2.6	-0.2 ± 2.2
Gross alpha	E900	Bq/L	-0.007 ± 0.056	0.067 ± 0.048	-0.004 ± 0.007
Gross beta	E900	Bq/L	0.392 ± 0.081	0.321 ± 0.067	-0.002 ± 0.029
Uranium 234 and Uranium 233	AS	Bq/L	0.112 ± 0.010	0.105 ± 0.010	0.001 ± 0.001

Concluded

Operations & Regulatory Affairs Division, Lawrence Livermore National Laboratory
University of California, P.O. Box 808, L-627, Livermore, California 94551