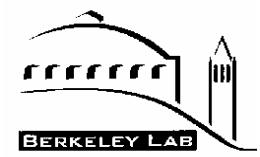

E.O. Lawrence Berkeley National Laboratory
University of California
Environmental Restoration Program

United States Department of Energy

Groundwater Monitoring and Management Plan

for the

Lawrence Berkeley National Laboratory

ENVIRONMENTAL RESTORATION PROGRAM

September 2006

Note: The Groundwater Monitoring and Management Plan for the Lawrence Berkeley National Laboratory Environmental Restoration Program, dated September 2006, was approved by the Department of Toxic Substances Control as final.

Groundwater Monitoring and Management Plan

for the

Lawrence Berkeley National Laboratory

ENVIRONMENTAL RESTORATION PROGRAM

A Joint Effort of
Environment, Health and Safety Division and
Earth Sciences Division
Lawrence Berkeley National Laboratory
University of California
Berkeley, CA 94720

September 2006

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LIST OF ABBREVIATIONS

AOC	Areas of Concern
Berkeley Lab	Lawrence Berkeley National Laboratory
CAP	Corrective Action Program
CVOCs	Chlorinated Volatile Organic Compounds
CMS	Corrective Measures Study
CMI	Corrective Measures Implementation
COC	Chemical of Concern
DCA	Dichloroethane
DCE	Dichloroethene
DO	Dissolved Oxygen
DOE	United States Department of Energy
DTSC	Cal/EPA Department of Toxic Substances Control
ERA	Ecological Risk Assessment
ERP	Environmental Restoration Program
ESG	Environmental Services Group
FY	Fiscal Year
GMMP	Groundwater Monitoring and Management Plan
HHRA	Human Health Risk Assessment
HI	Hazard Index
HRC	Hydrogen Release Compound
IC	Institutional Control
ICM	Interim Corrective Measure
ILCR	Incremental Lifetime Cancer Risk
LLRW	Low Level Radioactive Waste
MCL	Maximum Contaminant Level
MCS	Media Cleanup Standard
MNA	Monitored natural Attenuation
NFA	No Further Action
NFI	No Further Investigation
NTLF	National Tritium Labelling Facility
OEHHA	Office of Environmental Health Hazard Assessment
OSHA	Occupational Safety and Health Administration
PAHs	Polynuclear Aromatic Hydrocarbons
PCBs	Polychlorinated biphenyls
PCE	Tetrachloroethene
PRG	Preliminary Remediation Goal
RCRA	Resource Conservation and Recovery Act
RFA	RCRA Facility Assessment
RFI	RCRA Facility investigation
SMP	Soil Management Plan
SWMU	Solid Waste Management Unit
SVOCs	Semi-volatile Organic Compounds
TCA	Trichloroethane

TCE	Trichloroethene
TSCA	Toxic Substances Control Act
UCL	Upper Confidence Limit
USEPA	United States Environmental Protection Agency
UST	Underground Storage Tank
VOCs	Volatile Organic Compounds
Water Board	Regional Water Quality Control Board

SECTION 1
INTRODUCTION

1.1 PURPOSE AND ORGANIZATION

This Groundwater Monitoring and Management Plan (GMMP) describes the monitoring requirements and management controls required for compliance with the Ernest Orlando Lawrence Berkeley National Laboratory (Berkeley Lab) Resource Conservation and Recovery Act (RCRA) Part B Permit. These requirements and controls are based on the corrective measures recommended in Berkeley Lab's RCRA Corrective Measures Study (CMS) Report (Berkeley Lab, 2005a), which was approved by the California Environmental Protection Agency Department of Toxic Substances Control (DTSC) on October 20, 2005. These approved measures will reduce or eliminate the potentially adverse effects to human health or the environment caused by historic releases of chemicals to soil and groundwater at Berkeley Lab. Preparation and implementation of the GMMP is part of the Corrective Measures Implementation (CMI) phase of the RCRA Corrective Action Program (CAP).

In addition, the GMMP addresses groundwater monitoring requirements derived from policies of the California Regional Water Quality Control Board-San Francisco Bay Region (Water Board) and requirements specified by the United States Department of Energy (DOE) for monitoring and managing tritium-contaminated groundwater at Berkeley Lab. The GMMP contains the following elements:

- A description of the lateral and vertical extent of groundwater contamination for each groundwater contamination plume.
- A description of groundwater monitoring requirements including the methods and locations used to 1) monitor compliance with media cleanup standards within areas of groundwater contamination; 2) monitor for downgradient plume migration; and 3) monitor to ensure groundwater contamination does not migrate past the site perimeter.
- A description of specific surface water monitoring requirements
- A description of Berkeley Lab management controls that will be used to reduce potential risks from exposures associated with contaminated groundwater and reduce the potential for any environmental impacts.

Section 1 of this plan provides background information pertaining to cleanup of non-radionuclide chemical contamination under the RCRA CAP and radionuclide contamination under Department of Energy (DOE) oversight. Section 2 provides descriptions of the extent of groundwater contamination, the cleanup measures that have been or will be applied, and groundwater and surface water monitoring requirements. Section 3 describes Berkeley Lab groundwater management controls.

1.2 RCRA CORRECTIVE ACTION PROGRAM

Berkeley Lab's RCRA Hazardous Waste Facility Permit required that Berkeley Lab investigate and address the historical non-radionuclide chemical releases in accordance with the RCRA CAP requirements. The Permit is issued and enforced by the DTSC, including the activities required under the RCRA CAP. The primary components of the RCRA CAP are:

- RCRA Facility Assessment (RFA)
- RCRA Facility Investigation (RFI)
- Corrective Measures Study (CMS)
- Corrective Measures Implementation (CMI).

The RFA, which was completed in 1992, and the RFI, which was completed in 2000, comprised the investigation phase of the CAP. The purpose of the RFA was to identify known and potential past releases of hazardous waste and hazardous constituents to the environment from Solid Waste Management Units (SWMUs) and Areas of Concern (AOCs) at Berkeley Lab. SWMUs, AOCs, and other areas of known or potential release of contaminants are collectively referred to as "units" in this report.

SWMUs identified at Berkeley Lab included above-ground and underground waste storage tanks, sumps, scrap yards, plating shops, the former hazardous waste handling facility, waste accumulation areas, hazardous waste storage areas, and waste treatment units. AOCs identified at Berkeley Lab primarily included chemical product storage tanks (e.g., fuel tanks), transformers, and hazardous materials storage areas.

Results of the RFA are provided in the *RCRA Facility Assessment at the Lawrence Berkeley Laboratory* (Berkeley Lab, 1992). The RFA found that hazardous waste or hazardous

constituents had been released to soil and groundwater. Based on these findings, DTSC concluded that an RFI was required to characterize areas at the site where releases had occurred.

The RFI, which was conducted between October 1992 and September 2000, included identification of the source and nature of the contaminants that had been released to the environment, and characterization of the magnitude and extent of those releases. The RFI was divided into three phases. The *RCRA Facility Investigation Phase I Progress Report* (Berkeley Lab, 1994a) and the *RCRA Facility Investigation Phase II Progress Report* (Berkeley Lab, 1995) provided results for the first two phases of the RFI. The *RCRA Facility Investigation* (*RFI) Report*, which described the results of the final phase, was submitted to the DTSC on September 29, 2000 (Berkeley Lab, 2000).

As described in the RFI reports, the principal chemical contaminants in the groundwater at Berkeley Lab are chlorinated Volatile Organic Compounds (CVOCs). The CVOCs include primarily tetrachloroethene (PCE), trichloroethene (TCE), carbon tetrachloride, 1,1-dichloroethene (1,1-DCE), *cis*-1,2-dichloroethene (*cis*-1,2-DCE), 1,1,1-trichloroethane (TCA), and 1,1-dichloroethane (DCA). Most of these CVOCs are solvents (and their degradation products) that were used as degreasers for cleaning equipment at Berkeley Lab. Other contaminants that were detected in groundwater include petroleum hydrocarbons (mainly associated with former underground storage tank [UST] sites) and metals (mainly associated with plating shops); and to a much lesser extent semi-volatile organic compounds (SVOCs), polynuclear aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs) and pesticides.

During the RFI, Berkeley Lab implemented a screening process to determine which groundwater units posed a potential risk to human health and/or to beneficial uses of groundwater. The screening process consisted of a comparison between the maximum concentration of each chemical detected in groundwater at each unit to the Maximum Contaminant Levels (MCLs) for drinking water from both the United States Environmental Protection Agency (USEPA) and the California Environmental Protection Agency (Cal/EPA). Concentrations of naturally occurring inorganic elements were also compared to Berkeley Lab background levels for groundwater (Berkeley Lab, 2002a). Based on results of the RFI, the DTSC determined that chemicals detected in the groundwater (and soil) at Berkeley Lab posed a potential

threat to human health and the environment, and required that a CMS be conducted. As the initial step in the CMS, Berkeley Lab completed both an Ecological and a Human Health Risk Assessment (ERA and HHRA) (Berkeley Lab 2002b, 2003a).

The ERA concluded that no hazards exist to plants or animals from exposure to chemicals in soil, groundwater, or surface water at Berkeley Lab. The HHRA generated estimates of risk to humans for each unit based on an industrial-type institutional use scenario for Berkeley Lab. This scenario represents the current use, and the reasonable and likely future use for the facility.

The HHRA concluded that seven groundwater units posed a potential risk to the health of institutional workers. These seven units are:

- Building 51/64 Groundwater Solvent Plume (AOC 9-13)
- Building 51L Groundwater Solvent Plume
- Building 71 Groundwater Solvent Plume, Building 71B lobe (AOC 1-9)
- Building 7 Lobe of the Old Town Groundwater Solvent Plume (AOC 2-4)
- Building 52 Lobe of the Old Town Groundwater Solvent Plume(AOC 10-5)
- Building 25A Lobe of the Old Town Groundwater Solvent Plume (AOC 10-5)
- Support Services Area (Building 69A Area of Groundwater Contamination).

In addition, four groundwater units were identified that did not pose potential risks to the health of institutional workers but did contain Chemicals of Concern (COCs) at concentrations exceeding MCLs, therefore posing a potential threat to beneficial uses of groundwater. These four units are:

- Solvents in Groundwater South of Building 76 (AOC 4-5)
- Support Services Area (Building 75/75A Area of Groundwater Contamination)
- Support Services Area (Building 77 Area of Groundwater Contamination)
- Benzene Detected in Wells East of Building 75A.

All eleven units listed above were included in the CMS Report (Berkeley Lab, 2005a). The CMS Report evaluated methods for cleanup of COCs at each of the seven units that posed potential risks to human health and recommended the measures to be implemented. The primary cleanup methods proposed consisted of combinations of: excavation with offsite disposal of contaminated soil in the source area of the groundwater contamination; soil flushing with

groundwater extraction; monitored natural attenuation (MNA) of groundwater, and enhanced bioremediation of groundwater. The specific corrective measures for each unit were based on site-specific considerations.

1.3 RADIONUCLIDES

Concurrently with the investigation and assessment of chemical releases, Berkeley Lab investigated potential releases of radionuclides from eight units, under the regulatory authority of the DOE. Results of the radiological investigations are provided in the *Summary of Radionuclide Investigations* report (Berkeley Lab, 2003b). As described in that report, the only detected radionuclide contaminant in the groundwater at Berkeley Lab is tritium. The tritium is present in groundwater near Buildings 75 and 71 as a result of past emissions from the former Building 75 National Tritium Labeling Facility (NTLF). Since closure of the NTLF in December 2001, concentrations of tritium in the groundwater have declined to levels below the MCL.

1.4 REGULATORY OVERSIGHT

In July 1993, the DTSC delegated some CAP oversight agency authority and responsibilities at Berkeley Lab to other regulatory agencies. The Water Board was assigned as the lead agency for the technical review of surface water and groundwater impacts.

Radionuclides, including tritium, are not regulated under RCRA and are therefore not included in the CAP. However, radiological contamination at Berkeley Lab has been addressed under the oversight of the DOE.

1.5 PROJECT ORGANIZATION

Berkeley Lab's various divisions manage and operate the laboratory facilities on site. The Environmental Restoration Program (ERP) has been the Berkeley Lab program responsible for investigating and addressing the historical chemical releases under the CAP. The ERP is a joint effort of the Environmental Services Group (ESG) of the Environment, Health and Safety (EH&S) and the Earth Sciences Divisions of LBNL.

The DOE provides funding and oversight of Berkeley Lab operations. The DOE Office of Environmental Management (EM) has been responsible for providing funds for CAP activities at Berkeley Lab. The program is scheduled to be transferred from EM to the DOE Office of Science on October 1, 2006. At that time, the project is scheduled to be in an operation and maintenance (O&M) mode. This will primarily include long-term operation, monitoring, and maintenance of groundwater treatment systems and maintenance and monitoring of the site groundwater well network.

SECTION 2

MONITORING REQUIREMENTS

2.1 GROUNDWATER MONITORING

2.1.1 Previous Groundwater Characterization

Groundwater monitoring wells were installed during the RFA and RFI phases of the CAP with the following four objectives:

1. Determine the source(s) of groundwater contamination and characterize the magnitude and extent of that contamination.
2. Monitor the groundwater quality near the perimeter of the site and downgradient from areas of known contamination.
3. Monitor the groundwater quality at and downgradient from SWMUs and AOCs to determine if releases had occurred.
4. Provide information for evaluating the potential for future migration of contamination in groundwater.

The RFI groundwater monitoring program initially included quarterly sampling of all monitoring wells for volatile organic compound (VOC) analysis, and annual sampling of all monitoring wells for metals. As a result of ongoing characterization work, many new wells were added, and groundwater monitoring requirements changed during the RFI and CMS, leading to submission of five revised monitoring schedule requests, which were approved by the Water Board (Water Board, 1995, 1997, 1999, 2002 and 2005). These requests included monitoring requirements for VOCs, metals, and tritium.

Groundwater characterization results have been documented on a quarterly basis since 1993 in the Berkeley Lab ERP quarterly progress reports. Detailed information on the characterization of the magnitude and extent of groundwater contamination has been provided in the RCRA Facility Investigation Report (Berkeley Lab 2000), the Summary of Radionuclide Investigations (Berkeley Lab 2003b), and the RCRA Corrective Measures Study Report (Berkeley Lab 2005a).

2.1.2 Corrective Measures Implementation (CMI)

Berkeley Lab is currently in the CMI phase of the CAP. The objectives of groundwater monitoring during the CMI are to evaluate the effectiveness of the implemented corrective measures and document the continued stability of groundwater plumes. To accomplish this objective, the following activities are being conducted:

- Monitoring of COC concentrations in groundwater to assess the performance of corrective measures in all areas where Media Cleanup Standards (MCSs) are exceeded.
- Monitoring of COC concentrations in groundwater to assess downgradient plume migration.
- Monitoring COC concentrations to ensure that plumes do not migrate past the site perimeter.
- Monitoring in support of MNA or Enhanced Bioremediation as cleanup methods.

The MCSs applicable at each of the groundwater units were defined in the CMS Report, and are listed in Section 2.1.3 below.

The rationale for, and a detailed description of, CAP compliance monitoring requirements are provided in the *Proposal for Revised Groundwater Monitoring Schedule for the Lawrence Berkeley National Laboratory Environmental Restoration Program* (Berkeley Lab 2005b), which was approved by the Water Board on August 1, 2005 (Water Board, 2005). That document also specifies monitoring requirements to comply with State Water Resources Control Board (SWRCB) policies. To comply with those policies, cleanup to MCLs is the long-term goal for all areas of the site. Therefore in areas where CAP-required MCSs have been achieved but concentrations still exceed MCLs, groundwater monitoring will continue. The proposal also documents monitoring requirements for tritium, which though these are not required under the CAP. To avoid duplication, the *Proposal for Revised Groundwater Monitoring Schedule* is incorporated herein by reference. **Appendix A** contains the figures and tables from the proposal, which list the groundwater monitoring schedule and show the locations of wells required for monitoring.

Monitored Natural Attenuation (MNA) and Enhanced Bioremediation are the approved remedies for several groundwater units. The specific parameters to be monitored, the wells used for monitoring, and the monitoring schedule for these measures are provided in *Monitoring Protocols for Monitored Natural Attenuation and Enhanced Bioremediation for the Lawrence Berkeley National Laboratory Environmental Restoration Program* which is incorporated herein by reference (Berkeley Lab 2005c). The MNA monitoring program will utilize existing monitoring wells to assess whether hydrochemical conditions remain favorable to biodegradation, to determine whether concentration trends for individual CVOCs are consistent with continued natural attenuation, and to evaluate whether corrective action objectives have been met. The hydrochemical parameters to be monitored for this purpose are listed in **Table 1**. These additional monitoring requirements are also summarized where applicable in the following site-specific sections.

2.1.3 Site-Specific Contaminant Extent, Cleanup, and Monitoring Requirements

The following subsections describe each groundwater unit requiring corrective measures under the CAP, and groundwater contamination (tritium) subject to regulation by the DOE. Each plume-specific subsection describes the lateral and vertical extent of groundwater contamination, the corrective measures that have been or will be applied, and monitoring requirements. Maps of the contaminant plumes reflect conditions during the fourth quarter of Fiscal Year 2005 (FY05) (July 1 to September 30, 2005).

Table 1. Analytical Requirements and Significance

Parameter	Trend in Concentration During Natural Biodegradation	Optimum Range in Concentration	Significance
Laboratory Measurements			
CVOCs	Increase in degradation products		Identify parent and degradation (daughter) products. Certain isomers/degradation products provide direct evidence of biodegradation (e.g., cis-1,2-DCE). Used to help assess reductions in contaminant mass.
Methane (CH_4) Ethane (C_2H_6), and Ethene (C_2H_4)	Increases	> 0.5 mg/L	After sulfate has been depleted, carbon dioxide can be used as an electron acceptor for anaerobic biodegradation of organic carbon by methanogenesis, resulting in the production of methane.
Volatile Fatty Acids (VFAs)(1)	Increases	> 0.1 mg/L	Indicates that biodegradation through oxidation has occurred. These acids are added as a primary growth substrate, particularly to induce methanogenic conditions such as in Hydrogen Release Compounds (HRC).
Field or Laboratory Measurements			
Nitrate (NO_3^-)	Decreases	< 1.0 mg/L	After dissolved oxygen (DO) has been depleted, nitrate is used as an electron acceptor for anaerobic biodegradation by denitrifying bacteria.
Nitrite (NO_2^-)	Increases		Produced from nitrate under anaerobic conditions.
Sulfate (SO_4^{2-})	Decreases	< 20 mg/L	After ferrous iron has been depleted used as an electron acceptor for anaerobic biodegradation. Indicator of sulfate reducing bacteria.
Sulfide (H_2S)	Increases	> 1 mg/L	May provide evidence of sulphate reduction.
Field Measurements			
Ferrous Iron (Fe^{2+})	Increases	> 1.0 mg/L	An important trace nutrient for bacterial growth. Indicator of iron reducing bacteria.
Carbon Dioxide (CO_2)	Increases	> 2 times background	Ultimate byproduct of every respiration process except methanogenesis.
Conductivity			Used to help assess representativeness of sample.
Dissolved Oxygen (DO)	Decreases	< 0.5 mg/L	Indicator of aerobic environments; suppresses the reductive dechlorination pathway at higher concentrations.
		> 1.0 mg/L	Vinyl chloride may be oxidized aerobically.
pH		5 < pH < 9	Measurement of suitability of environment to support a wide range of microbial species. pH is also used to help assess representativeness of sample.
		5 > pH > 9	Outside optimal range for reductive pathway.
Temperature		> 20°C	Biochemical process is accelerated. Used to help assess representativeness of sample.

(1) Analysis for VFAs only in areas where HRC is added to the groundwater to enhance bioremediation.

2.1.3.1 Building 51/64 Groundwater Solvent Plume

Plume Characterization

The Building 51/64 Groundwater Solvent Plume extends westward from the southeast corner of Building 64 (**Appendix A: Figure 2.4-1**). The principal plume constituents are CVOCs that were used as cleaning solvents, including 1,1,1-TCA, TCE, PCE, and their associated degradation products (e.g., 1,1-DCE, 1,1-DCA, cis-1,2-DCE, and vinyl chloride). The principal source of the solvent plume was likely the Building 51/64 Former Temporary Equipment Storage Area (AOC 9-12), although other sources in the Building 51/64 area may have contributed to the plume. Contaminated soil was excavated from the source area in August 2000. In addition to solvents, PCBs are sporadically detected in groundwater within a small portion of the plume beneath the Building 51 Motor Generator Room. The principal source of the PCBs (Aroclors 1242 and 1248) was electrical equipment in the basement of the motor generator room, although low levels of Aroclor 1260 appear to be derived from a bituminous construction materials beneath the concrete floor. PCB-contaminated soil was excavated from this area from 1996 to 2000, and further removal of PCB-contaminated soil in the vicinity of temporary groundwater sampling point SB51-96-6 was in progress during preparation of this plan.

Maximum concentrations of groundwater COCs detected above MCLs during the fourth quarter of FY05 in the plume source and core area are shown in **Table 2a** in comparison to target risk-based MCSs (the required cleanup level in this area of the plume). PCE, 1,1- DCA, and vinyl chloride exceeded the required cleanup level in the source and core areas. Maximum concentrations of groundwater COCs detected above MCLs during the fourth quarter of FY05 in the downgradient area are shown in **Table 2b** in comparison to MCLs (the required regulatory-based cleanup level in that area of the plume) and the target risk-based MCSs. Six CVOCs exceeded MCLs in the downgradient area during the fourth quarter of FY05. In addition, vinyl chloride exceeded the target risk-based value.

Table 2a. Maximum Concentrations of COCs Exceeding MCLs during the Fourth Quarter of FY05 in the Building 51/64 Groundwater Solvent Plume Source and Core Area

COC	Maximum Concentration Fourth Quarter FY05 (µg/L)	Target Risk-Based Groundwater MCS (µg/L)
TCE	201	1,594
PCE	**393**	343
cis-1,2-DCE	267	98,405
trans-1,2-DCE	48	94,405
1,1-DCE	603	28,873
1,1-DCA	1,750	3,663
1,2-DCA	7.6	1,030
vinyl chloride	**22**	12
PCBs	30	NA

Note: Boldface type indicates that the concentration exceeds the required MCS.
NA: Not Applicable - PCBs do not constitute a risk driver in the Building 51/64 plume so no MCSs were developed.

Table 2b. Maximum Concentrations of COCs Exceeding MCLs during the Fourth Quarter of FY05 in the Building 51/64 Groundwater Solvent Plume Downgradient Area

COC	Maximum Concentration Fourth Quarter FY05 (µg/L)	Regulatory-Based Groundwater MCS (MCL) (µg/L)	Target Risk-Based Groundwater MCS (µg/L)
TCE	**57***	5	1,594
cis-1,2-DCE	**267**	6	98,405
trans-1,2-DCE	**48***	10	94,405
1,1-DCE	**21**	6	28,873
1,1-DCA	**13**	5	3,663
vinyl chloride	**22***	0.5	12

Note: Boldface type indicates that the concentration exceeds the required MCS.
*Based on results from a well within the core area immediately upgradient from the downgradient area.

Corrective Measures

In Situ Soil Flushing and Groundwater Capture in the Source Area

The corrective measure being applied in the source area of the plume is in situ soil flushing. The configuration of the Building 51/64 Groundwater Solvent Plume soil flushing system is shown on **Figure 2.1**. The system consists of an injection trench inside Building 64, and two groundwater collection trenches and a gravel-filled excavation outside the building from which contaminated

groundwater is extracted and treated. Groundwater from three wells (SB64-98-8, SB64-99-5, and SB64-00-1) inside the building and one well (SB64-05-4) outside the southwest corner of the building is also extracted and treated.

Monitored Natural Attenuation in the Downgradient Area

Based on natural attenuation evaluations conducted in the plume area in 1997 and 2003, MNA is being used as the remediation method for this part of the plume.

Sump Effluent Treatment in the Building 51 Motor Generator Room Basement

The Building 51 Motor Generator Room Basement discharge sump collects water from the Building 51 subdrain system. The effluent from the subdrain is captured and treated to prevent the migration of potentially contaminated subdrain water to surface water.

Monitoring Requirements

The Water Board-approved groundwater monitoring schedule and locations of wells for monitoring of VOCs for the Building 51/64 Groundwater Solvent Plume are shown in **Appendix A: Table 2.4-1** and **Appendix A: Figure 2.4-1**, respectively.

The requirements for monitoring parameters in support of MNA are listed in **Table 3**.

Table 3. Requirements for Monitored Natural Attenuation – Building 51/64 Groundwater Solvent Plume

Well Number	Location	Sampling Frequency	
		Hydrochemical Indicator Parameters[1]	VOCs (EPA Method 8260)
MW71-95-9[2]	Upgradient	Semiannually for one year and then annually	Not required
MW51-96-16	Plume Core	Semiannually for one year and then annually	Semiannually
MW51-96-17	Plume Core	Semiannually for one year and then annually	Annually
MW51-97-13	Downgradient Plume Core	Semiannually for one year and then annually	Annually
MW51-97-12	Crossgradient	Semiannually for one year and then annually	Semiannually
MW51-97-15	Downgradient	not required	Semiannually
MWP-1	Downgradient	not required	Quarterly

(1) The required parameters and analytical methods are provided in Berkeley Lab, 2005c.
(2) Also used as upgradient well for Building 71B lobe

2.1.3.2 Building 51L Groundwater Solvent Plume

The Building 51L Groundwater Solvent Plume is centered near the southwest corner of former Building 51L in the Bevalac Area of Berkeley Lab (**Appendix A: Figure 2.4-2**). A machine/maintenance shop was located in the Building 51L area prior to the 1970's. Solvent drum racks had at various times reportedly been located nearby along the wall of Building 51A, and along the retaining wall located approximately 20 feet west of Building 51L.

Plume Characterization

The principal plume constituents are CVOCs that were used as cleaning solvents, including TCE, PCE, and associated degradation products (e.g., cis-1,2-DCE, trans-1,2-DCE, and vinyl chloride). Based on the results of soil and groundwater sampling, solvent spills that occurred at the location of Building 51L appear to be the primary source for the soil and groundwater contamination.

Maximum concentrations of groundwater COCs detected in the Building 51L Groundwater Solvent Plume above MCLs during the fourth quarter of FY05 are shown in **Table 4** in comparison to target risk-based MCSs (the required cleanup level). Vinyl chloride is the only COC that exceeds the target risk-based MCS.

Table 4. Maximum Concentrations of COCs Exceeding MCLs during the Fourth Quarter of FY05 in the Building 51L Groundwater Solvent Plume

COC	Maximum Concentration Fourth Quarter FY05 (µg/L)	Target Risk-Based Groundwater MCS (µg/L)
TCE	310	1,594
PCE	9.5	343
cis-1,2-DCE	643	98,405
trans-1,2-DCE	70	94,405
1,1-DCE	21	28,873
1,1-DCA	100	3,663
vinyl chloride	**400**	12

Note: Boldface type indicates that the concentration exceeds the required MCS.

Corrective Measures

Rerouting Stormdrain Line

The existing 24-inch stormdrain and catch basin that is located within the plume will be relocated to prevent contaminated groundwater from entering the stormdrain and discharging to North Fork Strawberry Creek.

Soil Excavation with Offsite Disposal

Contaminated soil in the Building 51L Groundwater Solvent Plume Source Area will be excavated and disposed of offsite, which will reduce the impact of soil contaminants on groundwater quality in the plume area. The planned excavation geometry is expected to result in preservation of a sufficient number of existing groundwater monitoring wells to evaluate residual groundwater concentrations. It is anticipated that post-excavation residual COC concentrations in groundwater will be less than the required MCSs (target risk-based levels). However, if groundwater COC concentrations still exceed MCSs, then MNA will be implemented to achieve the required cleanup levels. The specific wells to be included in the program would be specified

only after it was determined that MNA was required, so no MNA monitoring requirements are presented herein.

Monitoring Requirements

The Water Board-approved groundwater monitoring schedule and locations of wells for monitoring of VOCs for the Building 51L Groundwater Solvent Plume are shown in **Appendix A: Table 2.4-2** and **Appendix A: Figure 2.4-2**, respectively.

2.1.3.3. Building 71 Groundwater Solvent Plume (Building 71B Lobe)

The Building 71 complex housed the former Super Heavy Ion Linear Accelerator (Super HILAC) and associated support facilities. The Super HILAC is no longer in operation. Building 71B houses a machine shop.

Plume Characterization

The Building 71B Lobe of the Building 71 Groundwater Solvent Plume extends southwestward from Building 71B (**Appendix A: Figure 2.4-3**). The principal Building 71B lobe constituents are CVOCs that were used as cleaning solvents, including TCE, PCE, and associated degradation products (e.g., cis-1,2-DCE, and vinyl chloride). Based on the results of soil and groundwater sampling, solvent spills that occurred at the location of Building 71B appear to be the primary source for the soil and groundwater contamination. Accessible soil contamination in the source area has been previously excavated.

Maximum concentrations of groundwater COCs detected above MCLs during the fourth quarter of FY05 are shown in **Table 5** in comparison to MCLs (the required regulatory-based cleanup level) and target risk-based MCSs. TCE, PCE, cis-1,2-DCE, and vinyl chloride exceeded the required MCS during the fourth quarter of FY05. Vinyl chloride also exceeded the target risk-based value.

Table 5. Maximum Concentrations of COCs Exceeding MCLs during the Fourth Quarter of FY05 in the Building 71B Lobe of the Building 71 Groundwater Solvent Plume

COC	Maximum Concentration Fourth Quarter FY05 (µg/L)	Regulatory-Based Groundwater MCS (MCL) (µg/L)	Target Risk-Based Groundwater MCS (µg/L)
TCE	**42**	5	1,594
PCE	**249**	5	343
cis-1,2-DCE	**56**	6	98,405
vinyl chloride	**16**	0.5	12

Note: Boldface type indicates that the concentration exceeds the required MCS.

Corrective Measures

In Situ Soil Flushing with HRC in the Source Area

The corrective measure being applied in the source area of the plume is in situ soil flushing combined with injection of Hydrogen Release Compound (HRC). The configuration of the soil flushing system is shown on **Figure 2.2**.

Hydrauger Effluent Capture and Treatment

Effluent from several hydraugers used to dewater the slopes for slope stability purposes has been collected, treated, and discharged to the sanitary sewer. Capture and treatment of effluent from these hydraugers will continue until CVOC concentrations are below detectable levels.

Monitoring Requirements

The Water Board-approved groundwater monitoring schedule and locations of wells for monitoring of VOCs for the Building 71 Groundwater Solvent Plume are shown in **Appendix A: Table 2.4-3** and **Appendix A: Figure 2.4-3**, respectively. The requirements for monitoring parameters in support of MNA are listed in **Table 6**.

Table 6. Monitoring Requirements for Enhanced Biodegradation – Building 71B Lobe

Well Number	Location	Sampling Frequency	
		Hydrochemical Indicator Parameters[1]	VOCs (EPA Method 8260)
MW71-95-9[2]	Upgradient	Semiannually for one year and then annually	Not required
MW71B-99-3R	Plume Core	Semiannually for one year and then annually	Quarterly
SB71B-04-1	Downgradient Plume Core	not required	Quarterly
MW90-5	Downgradient	not required	Semiannually

(1) The required parameters and analytical methods are provided in Berkeley Lab, 2005c.
(2) Also used as upgradient well for Building 51/64 lobe

2.1.3.4 Building 7 Lobe of the Building 7 Groundwater Solvent Plume (AOC 2-4)

The Old Town Groundwater Solvent Plume is a broad, multi-lobed groundwater plume, composed primarily of CVOCs, which underlies much of the Old Town area. The geometry and distribution of chemicals in the plume indicate that it consists of three coalescing lobes that were originally discrete plumes derived from distinct sources (**Appendix A: Figure 2.4-4a**).

Plume Characterization

The Building 7 lobe (AOC 2-4) contains significantly higher VOC concentrations than the other two plume lobes, and extends northwestward from the northwest corner of Building 7 to the parking area downslope from Building 58 (**Appendix A: Figure 2.4-4b**).

Leaks and/or overflows of CVOCs (primarily PCE) from an abandoned sump (the Former Building 7 Sump ([AOC 2-5]) that was located north of Building 7 were the source of the contamination. The principal Building 7 lobe constituents are CVOCs that were used as cleaning solvents, including PCE and carbon tetrachloride, and their associated degradation products (e.g., TCE, 1,1-DCE, cis-1,2-DCE, and vinyl chloride). The sump and adjacent highly contaminated soil were excavated in 1995, although residual contaminated soil is still present in the source area.

Maximum concentrations of groundwater COCs detected above MCLs during the fourth quarter of FY05 in the plume source and core areas are shown in **Table 7a** in comparison to the target risk-based MCSs (the required cleanup level). TCE, PCE, and carbon tetrachloride exceeded the required cleanup level in the source and core areas.

Maximum concentrations of groundwater COCs detected above MCLs during the fourth quarter of FY05 in the plume periphery areas are shown in **Table 7b** in comparison to MCLs (the required regulatory-based cleanup level) and target risk-based MCSs. Seven CVOCs exceeded MCLs during the fourth quarter of FY05. No target risk-based values were exceeded.

Table 7a. Maximum Concentrations of COCs Exceeding MCLs during the Fourth Quarter of FY05 in the Source and Core Areas of the Building 7 Lobe of the Old Town Groundwater Solvent Plume

COC	Maximum Concentration Fourth Quarter FY05 (µg/L)	Target Risk-Based Groundwater MCS (µg/L)
TCE	**33,000**	1,594
PCE	**42,000**	343
carbon tetrachloride	**1,900**	27
cis-1,2-DCE	340	98,405
1,1-DCE	340	28,873
1,1-DCA	15	3,663
vinyl chloride	3.6	12

Note: Boldface type indicates that the concentration exceeds the required MCS.

Table 7b. Maximum Concentrations of COCs Exceeding MCLs during the Fourth Quarter of FY05 in the Periphery Area Downgradient of the Building 7 Lobe of the Old Town Groundwater Solvent Plume

COC	Maximum Concentration Fourth Quarter FY05 (µg/L)	Regulatory-Based MCS (MCL) (µg/L)	Target Risk-Based Groundwater MCS (µg/L)
TCE	**140**	5	1,594
PCE	**156**	5	343
carbon tetrachloride	**12**	0.5	27
cis-1,2-DCE	**41**	6	98,405
1,1-DCE	**125**	5	28,873
1,1-DCA	**32**	5	3,663
vinyl chloride	**1.4**	0.5	12

Note: Boldface type indicates that the concentration exceeds the required MCS.

Corrective Measures

Soil Excavation with Offsite Disposal

Contaminated soil in the plume source area will be excavated and disposed of offsite. This measure will reduce the impact of soil contaminants on groundwater quality in the plume area, although it is anticipated that post-excavation residual COC concentrations in groundwater in the source and core areas will likely remain above the required MCSs (target risk-based levels) for some chemicals.

In Situ Soil Flushing in the Source and Core Areas

An additional corrective measure being applied in the source and core areas of the plume is in situ soil flushing. The configuration of the Building 7 Lobe soil flushing system is shown on **Figure 2.3**. The principal components of the system (from east to west) are described below.

Former Building 7 Sump Injection Excavation: The Building 7 Sump remedial excavation was backfilled with gravel and two injection wells were installed within the backfill to allow the injection of treated groundwater.

Building 7 Groundwater Collection Trench: The Building 7 Groundwater Collection Trench is approximately 15 feet northwest of (downgradient from) the former Building 7 sump and intercepts contaminated water flowing from the former sump area. In addition to controlling the migration of contaminated groundwater from the source area, the collection trench currently captures reinjected groundwater flowing eastward from the Building 7 Injection Well System.

Building 7 Injection Well System: Six 24-inch diameter borings (IW7-02-1, through IW7-02-6) form a linear injection array downgradient from the Building 7 Groundwater Collection Trench. Treated groundwater that is injected into the system either flows westward where it is captured by three extraction wells and eastward where it is captured by the Building 7 Groundwater Collection Trench.

Building 53/58 Slope Groundwater Collection Trench and Soil Vapor Extraction System: Eight dual phase (groundwater and soil vapor) extraction wells were installed within the core area of the Building 7 lobe. These wells capture contaminated groundwater migrating westwards towards Building 58.

Building 58 East Groundwater Collection Trench: The Building 58-East Groundwater Collection Trench is located at the southeast corner of Building 58 to control the downgradient migration of the core of the Building 7 lobe, and is complementary to the Building 53/58 Slope Groundwater Collection Trench.

Building 58 West Groundwater Collection Trench: A groundwater collection trench was installed west of Building 58 at the edge of the Building 7 lobe to control downgradient migration.

Building 58 West Subdrain: Water is pumped from a concrete sump that was installed adjacent to an abandoned corrugated metal pipe subdrain west of Building 58. The purpose of the system is to prevent migration of contaminated water to surface water via the drain system.

Monitored Natural Attenuation in the Periphery Areas

Based on a natural attenuation evaluation conducted in the plume area in 1997, and on evaluation of chemical concentration trends, MNA is being used as the remediation method for the periphery area of the plume downgradient (west) of Building 58. MNA may be used in the periphery area north of the plume after concentrations in the core area have been reduced by soil flushing.

Monitoring Requirements

The Water Board-approved groundwater monitoring schedule and locations of wells for monitoring of VOCs for the Building 7 Lobe are shown **in Appendix A: Table 2.4-4** and **Appendix A: Figures 2.4-4a and 2.4-4b**, respectively. The requirements for monitoring parameters in support of MNA for the downgradient periphery area are listed in **Table 8**. MNA requirements for the Building 53 crossgradient lobe area will not be specified until the effects of soil flushing and the additional source area excavation on the magnitude and extent of groundwater contamination have been determined.

Table 8. Requirements for Monitored Natural Attenuation - Building 7 Lobe of the Old Town Groundwater Solvent Plume, Downgradient Area

Well Number	Location	Sampling Frequency	
		Hydrochemical Indicator Parameters(1)	VOCs (EPA Method 8260)
MW 58A-94-14	Downgradient Periphery	Semiannually for one year and then annually	Semiannually
MW58-93-3	Crossgradient Periphery	Semiannually for one year and then annually	Semiannually
MW51-94-15	Downgradient	not required	Annually
MW51-96-3	Downgradient	not required	Annually
SB58-98-6	Downgradient	not required	Annually

(1) The required parameters and analytical methods are provided in Berkeley Lab, 2005c.

2.1.3.5 Building 52 Lobe of the Old Town Groundwater Solvent Plume

Plume Characterization

The Building 52 lobe lies at the northern edge of "Old Town" and extends northwestward from the area east of Building 52 to Building 46 (**Appendix A: Figure 2.4-5**). The distribution

of elevated VOC concentrations in the Building 52 lobe indicates that the source of groundwater contamination was located east of Building 52A. Groundwater and soil sampling conducted in that area indicated that a source of the lobe was likely spills in the vicinity of the paved area east of Building 52A. Contaminated soil was excavated from that area.

Maximum concentrations of groundwater COCs detected in the Building 52 lobe above MCLs during the fourth quarter of FY05 are shown in **Table 9** in comparison to MCLs (the required regulatory-based cleanup level) and the target risk-based MCSs. TCE, PCE, and carbon tetrachloride exceeded the required MCS during the fourth quarter of FY05. Concentrations of all CVOCs were well below target risk-based values.

Table 9. Maximum Concentrations of COCs Exceeding MCLs during the Fourth Quarter of FY05 in the Building 52 Lobe of the Old Town Groundwater Solvent Plume

COC	Maximum Concentration Fourth Quarter FY05 (µg/L)	Regulatory-Based Groundwater MCS (MCL) (µg/L)	Target Risk-Based Groundwater MCS (µg/L)
TCE	**12**	5	1,594
PCE	**25**	5	343
carbon tetrachloride	**4.2**	0.5	27

Note: Boldface type indicates that the concentration exceeds the required MCS.

Corrective Measures

Migration Control at the Building 46 Subdrain

The downgradient migration of the Building 52 lobe is controlled by the Building 46 subdrain, located east of Building 46A. Contaminated groundwater in the subdrain is extracted and treated.

In Situ Soil Flushing

The corrective measure being applied to the core of the plume is in situ soil flushing. The configuration of the Building 52 lobe soil flushing system, including the location of the Building 46 Subdrain is shown on **Figure 2.3**. The in situ soil flushing system includes five injection wells. The injected water is captured by four extraction wells or further downgradient at the lobe margin by the Building 46 Subdrain.

Monitored Natural Attenuation and Enhanced Bioremediation

Observed ratios of parent compounds to degradation products within the Building 52 lobe indicate that natural degradation occurs during downgradient migration of the contaminated groundwater. Therefore, MNA and/or enhanced bioremediation may be implemented if either 1) soil flushing ceases to result in further significant declines in concentrations and MCSs have not been attained or 2) groundwater CVOC concentrations rebound to levels above MCLs after cessation of flushing.

Monitoring Requirements

The Water Board-approved groundwater monitoring schedule and locations of wells for monitoring of VOCs for the Building 52 Lobe are shown in **Appendix A: Table 2.4-5** and **Appendix A: Figure 2.4-5**, respectively.

2.1.3.6 Building 25A Lobe of the Old Town Groundwater Solvent Plume

Plume Characterization

The Building 25A Lobe lies near Buildings 25 and 25A (**Appendix A: Figure 2.4-6**), and encompasses two subplumes of groundwater contamination, containing different suites of COCs, which are likely derived from different sources. The primary western subplume contains TCE, 1,1-DCE and minor amounts of cis-1,2-DCE, and extends from the western portion of Building 25A westward to the eastern edge of Building 6. The secondary eastern subplume contains primarily PCE (approximately 20 µg/L maximum concentration), with lower concentrations of TCE and carbon tetrachloride. This subplume extends from east of Building 25A to south of Building 25.

The principal Building 25A lobe constituents are CVOCs that were used as cleaning solvents including TCE, PCE, and carbon tetrachloride and their degradation products (e.g., 1,1-DCE, cis-1,2-DCE, and chloroform). Based on the concentrations of COCs in the groundwater, the source area for the western subplume is located near the western end of Building 25A.

Maximum concentrations of groundwater COCs detected in the Building 25A lobe of the Old Town Groundwater Solvent Plume above MCLs during the fourth quarter of FY05 are shown in **Table 10** in comparison to MCLs (the required regulatory-based cleanup level) and the target risk-based MCSs. TCE, PCE, carbon tetrachloride, and 1-1-DCE exceeded the required MCS during the fourth quarter of FY05. Concentrations of all CVOCs were well below target risk-based values.

Table 10. Maximum Concentrations of COCs Exceeding MCLs during the Fourth Quarter of FY05 in the Building 25A Lobe of the Old Town Groundwater Solvent Plume

COC	Maximum Concentration Fourth Quarter FY05 (µg/L)	Regulatory-Based Groundwater MCS (MCL) (µg/L)	Target Risk-Based Groundwater MCS (µg/L)
TCE	**161**	5	1,594
PCE	**39**	5	343
Carbon tetrachloride	**1.5**	0.5	27
1,1-DCE	**19**	6	28,873

Note: Boldface type indicates that the concentration exceeds the required MCS.

Corrective Measures

In Situ Soil Flushing

The corrective measure being applied to the plume is in situ soil flushing. The configuration of the Building 25A lobe soil flushing system is shown on **Figure 2.3**. A groundwater collection trench located south of Building 44 controls the migration of contaminated groundwater from the Building 25A lobe source area on the west side of Building 25A. Contaminated groundwater is extracted from a well that was installed within the trench and from a groundwater monitoring well north of Building 25A. The extracted groundwater is treated and then injected into a shallow gravel-filled infiltration bed located upgradient of the trench to flush contaminants from the subsurface.

Monitored Natural Attenuation and Enhanced Bioremediation

Observed ratios of parent compounds to degradation products downgradient from the source area at Building 25A indicate that natural degradation occurs during downgradient migration of the contaminated groundwater. Therefore, MNA and/or enhanced bioremediation may be implemented if either 1) soil flushing ceases to result in further significant declines in concentrations and MCSs have not been attained or 2) groundwater CVOC concentrations rebound to levels above MCLs. The specific wells to be included in the program would be specified only after it was determined that MNA was required, so no MNA monitoring requirements are presented herein.

Extraction of Groundwater from Utility Manhole East of Building 6

Contaminated groundwater that is present in an electrical utility manhole east of Building 6 is pumped from the manhole to the Building 6 and 37 Treatment Systems. This measure prevents the migration of contaminated groundwater through electrical conduits to the Building 37 area.

Monitoring Requirements

The Water Board-approved groundwater monitoring schedule and locations of wells for monitoring of VOCs for the Building 25A Lobe are shown in **Appendix A: Table 2.4-6** and **Appendix A: Figure 2.4-6**, respectively.

2.1.3.7 Building 69A Area of Groundwater Contamination

The most likely source of the Building 69A Area of Groundwater Contamination was leakage from a pipeline in the Building 69A Hazardous Materials Storage and Delivery Area (AOC 3-1) that drains to the Building 69A Storage Area Sump (SWMU 3-5). A dislocation was observed in one of the sump drainpipes and repaired in 1987.

Plume Characterization

The area of groundwater contamination is located to the southwest of Building 69 (**Appendix A: Figure 2.4-8**). The principal COCs in the area of groundwater contamination are

degradation products of CVOCs that were used as cleaning solvents (e.g., cis-1,2-DCE and vinyl chloride). Lower concentrations of trans-1,2-DCE, PCE, 1,1,1-TCA, and other VOCs, including aromatic hydrocarbons, have also been occasionally detected.

Maximum concentrations of groundwater COCs detected in the Building 69A Area of Groundwater Contamination above MCLs during the fourth quarter of FY05 are shown in **Table 11** in comparison to target risk-based MCSs (the required cleanup level). Vinyl chloride exceeded the required MCS during the fourth quarter of FY05.

Table 11. Maximum Concentrations of COCs Exceeding MCLs during the Fourth Quarter of FY05 in the Building 69A Area of Groundwater Contamination

COC	Maximum Concentration Fourth Quarter FY05 (µg/L)	Target Risk-Based Groundwater Media Cleanup Standard (µg/L)
cis-1,2-DCE	44	98,405
vinyl chloride	**52**	12

Note: Boldface type indicates that the concentration exceeds the required MCS.

Corrective Measures

Monitored Natural Attenuation and Enhanced Bioremediation

Available chemical and geochemical data indicate that biodegradation of groundwater contaminants by reductive dechlorination is occurring in the Building 69A Area of Groundwater Contamination. Therefore, MNA is the primary corrective measure. To expedite the cleanup process, MNA is being supplemented with enhanced bioremediation through injection of HRC into the source area.

Monitoring Requirements

The Water Board-approved groundwater monitoring schedule and locations of wells for monitoring of VOCs for the Building 69A Area of Groundwater Contamination are shown in **Appendix A: Table 2.4-8c** and **Appendix A: Figure 2.4-8**, respectively.

The requirements for monitoring parameters in support of MNA are listed in **Table 12**.

Table 12. Requirements for Monitored Natural Attenuation – Building 69A Area of Groundwater Contamination

Well Number	Location	Sampling Frequency	
		Geochemical Indicator Parameters[1]	VOCs (EPA Method 8260)
SB69A-00-1	Upgradient Plume Core	Annually (rainy season)	Annually (rainy season)
SB69A-99-1	Plume Core	Semiannually for one year and then annually	Semiannually
MW69-97-8	Downgradient Plume Core	Semiannually for one year and then annually	Semiannually
MW69A-92-22	Crossgradient	not required	Semiannually
SB77-02-1	Downgradient	not required	Semiannually

(1) The required parameters and analytical methods are provided in Berkeley Lab, 2005c.

2.1.3.8 Solvents in Groundwater South of Building 76 (AOC 4-5)

Building 76 is located in the western part of the Support Services Area of Berkeley Lab. The building is primarily used as a vehicle fueling and maintenance facility for the motor pool. The primary source of the groundwater contamination south of Building 76 is suspected to have been the result of motor pool operations, although the specific source has not been located.

Plume Characterization

The groundwater solvent plume extends approximately 100 feet southwards from the motor pool area on the south side of Building 76 (**Appendix A: Figure 2.4-8**). Groundwater containing CVOCs lies beneath the existing motor pool gasoline and diesel underground storage tanks and also extends northward beneath Building 76. Maximum concentrations of groundwater COCs detected in the Building 76 area above MCLs during the fourth quarter of FY05 are shown in **Table 13** in comparison to target risk-based MCSs (the required cleanup level). No COCs exceed the required target risk-based groundwater MCSs, so no corrective measures are required.

Table 13. Maximum Concentrations of COCs Exceeding MCLs during the Fourth Quarter of FY05 in the Building 76 Groundwater Solvent Plume

COC	Maximum Concentration Fourth Quarter FY05 (µg/L)	Maximum Contaminant Level (MCL) (µg/L)	Target Risk-Based Groundwater MCS (µg/L)
TCE	14.5	5	1,594

Monitoring Requirements

Groundwater monitoring is not required at this unit for compliance with CAP requirements, however, monitoring will be conducted to record the progress toward achieving the long-term site-wide goal of MCLs. The groundwater monitoring schedule and locations of wells for monitoring of VOCs for the Building 76 Groundwater Solvent Plume are shown in **Appendix A: Table 2.4-8a** and **Appendix A: Figure 2.4-8**, respectively.

2.1.3.9 Building 75/75A Area of Groundwater Contamination

Plume Characterization

A small area where CVOCs have been detected in the groundwater near Buildings 75 and 75A extends southward from the east side of Building 75A toward Building 75 (**Appendix A: Figure 2.4-8**). The contamination may be related to operations of the Building 75 Former Hazardous Waste Handling and Storage Facility; however, the source has not been confirmed since only relatively low concentrations of COCs have been detected in the soil in the area.

The principal Building 75A Area of Groundwater Contamination constituents are CVOCs that were used as cleaning solvents, including TCE and degradation products (e.g., 1,1-DCE, and cis-1,2-DCE). Maximum concentrations of groundwater COCs detected in the Building 75/75A Area of Groundwater Contamination above MCLs during the fourth quarter of FY05 are shown in **Table 14** in comparison to target risk-based MCSs (the required cleanup level). No COCs exceed the required target risk-based groundwater MCSs, so no corrective measures are required.

Table 14. Maximum Concentrations of COCs Exceeding MCLs during the Fourth Quarter of FY05 in the Building 75/75A Area of Groundwater Contamination

COC	Maximum Concentration Fourth Quarter FY05 (µg/L)	Maximum Contaminant Level (MCL) (µg/L)	Target Risk-Based Groundwater MCS (µg/L)
TCE	7.4	5	1,594
cis-1,2-DCE	43	6	98,405

Monitoring Requirements

Groundwater monitoring is not required at this unit for compliance with CAP requirements; however, monitoring will be conducted to record the progress toward achieving the long-term site-wide goal of MCLs. The groundwater monitoring schedule and locations of wells for monitoring of VOCs for the Building 75/75A Area of Groundwater Contamination are shown in **Appendix A: Table 2.4-8d** and **Appendix A: Figure 2.4-8**, respectively.

2.1.3.10 Building 77 Area of Groundwater Contamination

The location of the Building 77 Area of Groundwater Contamination is shown on **Appendix A: Figure 2.4-8**. The Building 77 Sanitary Sewer System (AOC 5-4) was considered the most likely source of the groundwater contamination, based on its location relative to the contamination. Soil and soil-gas sampling conducted along the sewer line, however, could not identify a source area.

Plume Characterization

The principal Building 77 Area of Groundwater Contamination constituents are degradation products of CVOCs that were used as cleaning solvents, including cis-1,2-DCE, trans-1,2-DCE, 1,1-DCE, and 1,1-DCA. No chemicals were detected in the groundwater at a concentration above the MCL in FY05; however, cis-1,2-DCE was detected at a concentration equal to the MCL (**Table 15**). No COCs exceed the required target risk-based groundwater MCSs, so no corrective measures are required.

Table 15. Maximum Concentrations of COCs Exceeding MCLs during the Fourth Quarter of FY05 in the Building 77 Area of Groundwater Contamination

COC	Maximum Concentration Fourth Quarter FY05 (µg/L)	Maximum Contaminant Level (MCL) (µg/L)	Target Risk-Based Groundwater MCS (µg/L)
none [(a)]			

(a) Cis-1,2-DCE was detected at the MCL (6.0 µg/L) in FY05. Cis-1,2-DCE (6.1 µg/L maximum) was detected at a concentration slightly above the MCL in FY04.

Monitoring Requirements

Groundwater monitoring is not required at this unit for compliance with CAP requirements; however, monitoring will be conducted to record the progress toward achieving the long-term site-wide goal of MCLs. The groundwater monitoring schedule and locations of wells for monitoring of VOCs for the Building 77 Area of Groundwater Contaminations are shown in **Appendix A: Table 2.4-8b** and **Appendix A: Figure 2.4-8**, respectively. If concentrations do not exceed MCLs for four consecutive quarters, groundwater monitoring will no longer be required for this unit.

2.1.3.11 Benzene Detected in Wells East of Building 75A

Benzene has been detected in two relatively deep monitoring wells (MW91-4 and MW75A-00-7) on the east side of Building 75A. The locations of the wells are shown on **Appendix A: Figure 2.4-8**. The wells are screened within the Orinda Formation from approximately 115 to 145 feet below ground surface. The source of the benzene is not known; however, since benzene has also been detected in other deep wells screened in the Orinda Formation at other locations at Berkeley Lab, it is possible that the benzene is naturally occurring.

Plume Characterization

Benzene has been detected in MW91-4 and MW75A-00-7 most quarters the wells have been sampled, and is generally the only VOC detected in either well. Benzene has not been detected in two shallower monitoring wells (MW75-99-7 and MW75-96-20), which are within approximately

14 feet of the deeper wells, but screened above a depth of 50 feet. The maximum concentration of benzene detected in each of the two deep wells in FY05 is listed in **Table 16**. Benzene has not been detected at a concentration above the target risk-based MCS, so no corrective measures are required.

Table 16. Maximum Concentrations of Benzene Detected in Groundwater during the Fourth Quarter of FY05 in the Building 75A Area

Well Number	Maximum Concentration Fourth Quarter FY05 (µg/L)	Maximum Contaminant Level (MCL) (µg/L)	Target Risk-Based Groundwater MCS (µg/L)
MW91-4	17.5	1	175
MW75A-00-7	69.5	1	175

Monitoring Requirements

Groundwater monitoring is not required at this unit for compliance with CAP requirements. Although the benzene may be naturally occurring, monitoring will continue, at least for the near term, as long as the benzene concentration is above the MCL. MW75A-00-7 will be monitored annually for VOC (**Appendix A: Table 2.4-8f).** The location of MW75A-00-7 is shown in **Appendix A: Figure 2.4-8**.

2.1.3.12 Building 75 Tritium Plume

Plume Characterization

The Building 75 Tritium Plume extends from the Corporation Yard (the area between Buildings 69 and 75) southwards towards Chicken Creek (**Appendix A, Figure 4-3**). The source of the plume was the former National Tritium Labeling Facility (NTLF), which operated inside Building 75 for almost 20 years until December 2001. Tritium concentrations in all monitoring wells have been less than the MCL (20,000 pCi/L), except for one well (MW75-97-5) which had a maximum tritium concentration of 21,301 pCi/L in FY05. Tritium concentrations in most wells have been declining since closure of the NTLF, with the concentration of tritium in MW75-97-5 declining to a level below the MCL during the third quarter of FY05.

Tritium has also been detected in a localized area near Building 71B (**Appendix A: Figure 4-1**), with concentrations substantially less than those detected in the Building 75 area. The tritium in the groundwater in this area was likely derived from surface runoff from the Lawrence Hall of Science area to the northeast of Building 71. The concentration of tritium in the groundwater near Building 71 has generally been below or only slightly above (610 pCi/L maximum) the 300 pCi/L reporting limit since closure of the NTLF.

Corrective Measures

Slope stability and observation wells within the Support Services Area were previously upgraded with bentonite and cement surface seals or were properly destroyed by overdrilling and backfilling with concrete to prevent infiltration of potentially contaminated surface water. In addition, a defect identified in the sanitary sewer line southeast of Building 75B was repaired in 1997. In addition, corrugated-metal stormdrains in this area were lined with PVC casings to prevent leakage of water from the stormdrains and eliminate the resultant artificial recharge of the groundwater, thereby reducing potential downgradient migration of tritium-contaminated groundwater.

Monitoring Requirements

The Water Board-approved groundwater monitoring schedule and locations of wells for monitoring of Building 75 Tritium Plume are shown in **Appendix A: Table 5-1** and **Appendix A: Figures 4-1** (Building 71B area) **and 4-6** (Building 75 area), respectively. Groundwater (and surface water) will continue to be monitored for tritium to ensure that current conditions are maintained or improved (i.e. tritium activities remain below levels of concern) by verification of the following:

1. Tritium activities remain below levels of concern (MCLs)
2. Tritium does not migrate offsite in the groundwater
3. The groundwater plume remains stable or the magnitude and/or extent of contamination decreases.

If the above conditions are maintained through 2008, Berkeley Lab will request that DOE approve that monitoring of groundwater be discontinued.

2.1.3.13 Metals Monitoring Program

Inorganic elements (metals) are not COCs at Berkeley Lab based on the findings of the HHRA (Berkeley Lab, 2003a). However, metals are present in a few locations at Berkeley Lab at concentrations that exceed both MCLs and Berkeley Lab background levels (Berkeley Lab, 2002a). Therefore, annual monitoring of metals is required for selected wells. Some of these metals may be present at naturally occurring levels but are detected at concentrations above estimated background levels because of the statistical method used to calculate background. The groundwater monitoring schedule for metals is shown in **Table 17**.

Table 17. Monitoring Wells Requiring Annual Sampling for Inorganic Elements (Metals) of Potential Concern

Monitoring Well	Inorganic Element of Potential Concern
MW7B-95-24	mercury
MW75-99-8	arsenic
MW51B-93-18A	
MW64-97-1	
MW37-92-18A	arsenic
MW64-97-2	selenium
MW77-92-10	molybdenum
MW77-94-5	
MW46-92-9	
MW51-92-2	
MW51-00-9	
MW51-00-10	

2.1.3.14 Perimeter and Offsite Monitoring Program

To ensure that COCs at Berkeley Lab do not migrate beyond the property boundary in the groundwater, a network of perimeter and offset wells has been defined. These wells are sampled for VOCs. The groundwater monitoring schedule and locations of wells for the perimeter and offsite monitoring program are shown in **Appendix A: Table 2.4-9** and **Appendix A: Figure 2.4-9**, respectively.

2.2 SURFACE WATER MONITORING

The Berkeley Lab surface water monitoring program is provided in **Table 18**. Surface water samples will be collected from all site creeks during the rainy season and from all flowing creeks during the dry season and analyzed for VOCs and metals. Surface water samples will also be collected at the same time for tritium analysis from Chicken Creek and North Fork Strawberry Creek. Since tritium concentrations in groundwater in these two watersheds have been declining, and the source of tritium (NTLF) ceased operations in 2001, Berkeley Lab will request that the DOE approve no further creek sampling for tritium associated with this Groundwater Monitoring and Management Plan at the end of 2008 if tritium is not detected above the reporting limit of 300 pCi/L. Any surface water sampling required by the Berkeley Lab Storm Water Monitoring Program will continue as required by that program

Table 18. Requirements for Surface Water Sampling

Sampling Location	VOC and Metals Sampling Schedule	Tritium Sampling Schedule
Chicken Creek Upstream and Downstream Locations	Semiannually – rainy and dry season	Semiannually through 2008 – rainy and dry season
North Fork Strawberry Creek Upstream and Downstream Locations	Semiannually – rainy and dry season	Semiannually through 2008 – rainy and dry season
Botanical Garden Creek	Semiannually – rainy and dry season	
Cafeteria Creek	Annually – rainy season	
No-Name Creek	Semiannually – rainy and dry season	
Ravine Creek	Annually – rainy season	
Ten-Inch Creek	Annually – rainy season	

2.3 GENERAL PROCEDURES AND REPORTING

Groundwater and surface water monitoring will be performed in accordance with requirements of the ERP Quality Assurance Program Plan (QAPP) (Berkeley Lab, 1994b), Berkeley Lab ERP Standard Operating Procedures (SOPs) (Berkeley Lab, 1994c), and the Berkeley Lab ERP Health and Safety Program Plan (HSPP) (Berkeley Lab, 2004a).

The required analytical methods and reporting limits are listed in **Table 19**.

Table 19. Analytical Methods and Reporting Limits

Parameter	EPA Method	Reporting Limit
VOCs	8260	MCL
metals	6000 & 7000 series	MCL
PCBs	8082	MCL (0.5 µg/L)
Tritium	906	300 pCi/L

Groundwater and surface water sampling results will be documented in the Quarterly Progress Reports that are submitted to the DTSC in accordance with Berkeley Lab's RCRA Part B Permit requirements. The report for the fourth quarter of each fiscal year will provide tables and graphs of the historical groundwater data for VOCs and four quarters of groundwater data for metals, PCBs, and tritium; and will also discuss trends in the data and progress towards achieving MCSs.

In their approval of Berkeley Lab's 2005 *Proposal for Revised Groundwater Monitoring Schedule* (Water Board, 2005b), the Water Board made the approval contingent on two conditions. One of the conditions was that "Berkeley Lab shall incorporate all storm water, surface water (including hydraugers) analytical data into annual groundwater monitoring reports for a coordinated effort between the storm water, surface water and groundwater monitoring programs to insure contained groundwater is not migrating into surface water creeks." The Berkeley Lab Storm Water Monitoring Program analyzes surface water samples for selected metals (aluminum, iron, magnesium, and zinc), total petroleum hydrocarbons, ammonia, and nitrate, gross alpha and beta, and tritium. The only parameter required by both programs and associated with any known groundwater plumes is tritium. Storm water tritium results will therefore be included in the Quarterly Progress Report for the fourth quarter of each fiscal year.

SECTION 3

GROUNDWATER MANAGEMENT CONTROLS

Groundwater management controls are needed at Berkeley Lab to reduce or eliminate potential risks to human health from exposures associated with contaminated groundwater and the potential for releases of contaminated groundwater to the environment. To ensure compliance, these management controls will be incorporated into appropriate sections of the Berkeley Lab Health and Safety Manual (Pub-3000), which governs health and safety throughout the facility, and/or the Berkeley Lab Regulations and Procedures Manual (RPM), which summarizes policies and regulations governing operations at the facility.

Management controls for contaminated groundwater at Berkeley Lab include:

1. Restrictions on the permissible uses of contaminated groundwater.
2. Restrictions on future land use stemming from groundwater contamination.
3. Mitigation methods that must be employed during the construction of new site buildings in the vicinity of areas of groundwater contamination to protect the health of construction workers and/or future indoor workers in those buildings.
4. Written procedures for protecting workers and the environment if contaminated groundwater is encountered during excavation and construction.
5. A description of mitigation measures that must be employed for drain systems (i.e., hydraugers, building subdrains, stormdrains) that capture contaminated groundwater.

3.1 RESTRICTIONS ON GROUNDWATER EXTRACTION AND USE

The following restrictions apply to use of groundwater in all areas of Berkeley Lab where groundwater COC concentrations exceed detectable levels. The current locations subject to these restrictions are shown on **Figure 4.1.**

- Groundwater may not be used for drinking or other domestic purposes.
- Groundwater may not be used for industrial, irrigation, or other non-domestic purposes unless treated prior to use. These groundwater uses must follow discharge and reuse requirements (including permissible contaminant concentrations) specified in Water Board Order R2-2004-0055/NPDES NO. CAG912003 (**Appendix B**). These requirements include the filing of a Notice of Intent with the Water Board at least 60 days prior to any planned use of groundwater for these purposes.

3.2 RESTRICTIONS ON LAND USE

3.2.1 Chemical Contamination

3.2.1.1 Land Use and Cleanup Levels

Soil and groundwater cleanup requirements for chemicals at Berkeley Lab are based on an institutional/industrial land use scenario, which is consistent with the current and potential future land use at Berkeley Lab. Both the HHRA (Berkeley Lab, 2003a) and the CMS Report (Berkeley Lab, 2005a) were completed based on the assumption that an institutional land-use scenario consistent with operation of a research laboratory would continue at Berkeley Lab for the foreseeable future. That scenario was used for the primary risk evaluations in the HHRA and the determination of the required cleanup levels in the CMS Report. Areas of contamination that pose a potential risk to institutional workers are therefore being cleaned up to an institutional/industrial land-use level.

The HHRA provided risk estimates for institutional receptors by calculating theoretical incremental lifetime cancer risks (ILCRs) and non-cancer hazard indices (HIs), assuming an industrial/institutional land use scenario. These calculated measures of risk were compared to established threshold values. The theoretical ILCRs were compared to the USEPA target cancer risk range of 10^{-4} to 10^{-6}, which is considered by the agency to be safe and protective of public health [Federal Register 56(20): 3535, Wednesday, January 30, 1991]. Exposure to chemicals with an HI below 1.0 is considered unlikely to result in adverse non-cancer health effects over a lifetime of exposure. Although the USEPA considers an ILCR anywhere within the target range for risk managers (also referred to as the risk management range) of 10^{-4} to 10^{-6} to be safe and protective of public health, the lowest reasonably achievable level within the risk management range (10^{-6}), or an HI of 1.0 was selected for determining target cleanup level. The upper limit of the risk management range (10^{-4}) or an HI of 1.0 is the basis for determining whether institutional land use restrictions should apply.

The HHRA also provided supplemental risk estimates for a hypothetical future restricted residential land use scenario (i.e., assessing risks to residents but assuming that domestic use of site groundwater would not occur). The primary HHRA risk driver for all wells was cancer risk

for the adult resident. Cancer risks for the child resident and HI thresholds for adult and child residents did not drive risks at any wells. Results of this supplemental estimate are used as the basis for restrictions proposed on residential land use in this plan. Residential land use restrictions are proposed where the theoretical ILCR is greater than 10^{-6} or the HI is greater than 1.0 for a hypothetical future adult resident.

3.2.1.2 Residential Land Use Restrictions

To determine the needed extent of residential land use restrictions, the results of the HHRA residential-risk evaluation of site groundwater were updated using the maximum groundwater contaminant concentrations detected at each well during calendar year 2005. In addition, risks for 1,1-dichloroethene (1,1-DCE) were not included because that analyte was reclassified as a non-carcinogen subsequent to completion of the original HHRA calculations. The relationship between theoretical ILCR and chemical concentrations as calculated in the HHRA is linear for each well. Therefore, updated ILCRs were recalculated based on this linear relationship for wells in all areas of groundwater contamination at Berkeley Lab. The results of this analysis are provided in **Appendix C** and are illustrated on **Figure 4.2**. These results indicate that chemical concentrations in groundwater pose potential risks to hypothetical future residential receptors in six areas, based on the risk evaluation method provided in the HHRA, as updated with calendar year 2005 data. At this time, these areas are therefore considered unsuitable for residential land use, so should be restricted to institutional land use unless measures are implemented to mitigate the risk or additional data are collected to show that the risk is within acceptable levels. (Note that 1,1-DCE was reclassified by DTSC as a non-carcinogen as the HHRA was being published. Since a small area southeast of Building 75B was calculated in the HHRA to have unacceptable potential risks solely due to 1,1-DCE concentrations, **Figure 4.2** has been modified to exclude this area.)

Risk mitigation measures might include:

- Remediating contaminated groundwater to levels that are protective of unrestricted land use.

- Collecting soil gas samples at the units to provide the data to estimate risks more directly and accurately than the groundwater sampling data from which the potential risks were previously estimated. Soil gas sampling data should be collected using guidelines outlined in the DTSC *Interim Final Guidance for the Evaluation and Mitigation of Subsurface Vapor Intrusion to Indoor Air* (DTSC, 2004). The soil gas data should be compared to values acceptable to DTSC, which may include Office of Environmental Health Hazard Assessment (OEHHA, 2005) soil gas screening numbers or Water Board soil gas screening numbers if OEHHA chemical specific values are not available (Water Board, 2003); alternatively, a more detailed site-specific risk evaluation might be completed using the soil gas data.

3.2.1.3 Institutional Use Restrictions on Construction of New Site Buildings or Improvements

As shown on **Figure 4.3**, only two areas of groundwater contamination are currently considered unsuitable for unrestricted institutional use because groundwater concentrations exceed upper-limit MCSs. Upper-limit MCSs are presented in the CMS Report, and represent the COC concentrations that would result in a Theoretical Incremental Lifetime Cancer Risk (ILCR) of 10^{-4} or a Hazard Index (HI) equal to 1.0 for institutional land use. Although cleanup of these areas to concentrations below target MCSs (ILCR of 10^{-6} or a Hazard Index (HI) equal to 1.0 for institutional land use) is planned for the CMI, new buildings or other improvements intended for human occupancy may not be constructed at these locations until one or more of the following conditions are met and approved by DTSC:

- COC concentrations are lower than upper-limit MCSs,
- mitigation methods are implemented to ensure that risks to future building occupants are within acceptable levels, or
- additional groundwater or soil gas data are collected to document that risks to human health would be within acceptable levels.

Mitigation methods may include engineering controls used to eliminate contaminant migration pathways. Typically, such controls include installation of contaminant-resistant subslab organic-vapor barriers, lateral routing of utilities to avoid vapor barrier penetration, sealing of utility penetrations, and/or subslab ventilation systems (DTSC, 2004). Any mitigation measures implemented would require the approval of the DTSC. In addition, post-construction

soil-gas and/or indoor air monitoring should be considered, or may be required by the DTSC, to document that risks to indoor workers are within acceptable levels.

Since the primary risk driver at the areas shown on **Figure 4.3** results from the potential for infiltration of vapor volatilized from soil migrating into indoor air, soil gas samples could be collected to provide a more accurate estimate of risk than was derived based on the groundwater sampling results. Any soil-gas sampling should be conducted in accordance with guidelines specified in the DTSC Interim Final Guidance for the Evaluation and Mitigation of Subsurface Vapor Intrusion to Indoor Air (DTSC, 2004). The soil gas data should be compared to the most recent SB32 soil gas screening numbers (OEHHA, 2005) (or other applicable and appropriate screening numbers available) to assess whether risks exceed the screening levels. In plume areas that are subject to ongoing remediation at the time that such soil-gas sampling took place, the documentation that risks are sustainably below threshold levels must include an assessment of the potential for rebound in concentration levels upon termination of remediation measures.

Although only two relatively small areas are currently considered unsuitable for unrestricted institutional use, groundwater concentrations exceed target MCSs (ILCRs that exceed 10^{-6}) in five areas (**Figure 4.3**). Although land use restrictions are not proposed for institutional use of those areas, risk management measures should be incorporated into future site development plans for those areas.

Designs for new buildings or other improvements must include accommodations to ensure that groundwater remediation systems can continue operation, or can be replaced with systems that can meet the cleanup objectives. In addition, groundwater monitoring wells used for compliance in these areas must either remain in place and accessible, or must be replaced with wells that meet the objectives listed in Section 2. Construction planning documents must provide for proper destruction procedures for groundwater monitoring wells that are no longer needed, in accordance with California Department of Water Resources (DWR) (DWR, 1991) Guidelines for destroying wells. In addition, a permit application for well destruction must be submitted to the City of Berkeley.

3.2.2 Restrictions at Radiological Units

The United States Department of Energy (DOE) has specified restrictions on the use of the eight identified radiological units at Berkeley Lab. DOE stipulated that release of the units to the general public was not authorized. One of these units, the former National Tritium Labeling Facility, was the source of both the Building 75 groundwater tritium plume, and a relatively small area of tritium-contaminated groundwater in the vicinity of Building 71B. Therefore, the areas overlying these zones of tritium-contaminated groundwater are restricted from residential use until DOE approves the release of these areas for unrestricted use. The locations of these areas are shown on **Figure 4.4**.

3.3 EXCAVATION AND CONSTRUCTION ACTIVITIES

Preconstruction Evaluation of Groundwater

Prior to beginning any penetration action of ground or existing surfaces at Berkeley Lab, including locations where groundwater may be encountered, a Permit to Penetrate Ground or Existing Surfaces of LBNL Property must be obtained in accordance with requirements of Administrative Procedure (ADMN-053). Section 4.0 of the Procedure is a Ground or Existing Surfaces Penetration Job Safety Analysis (JSA) Checklist, which includes an Existing Contamination Evaluation as Item 48. The Administrative Procedure (ADMN-053) is included as **Appendix D** to this Groundwater Monitoring and Management Plan.

After it is determined that soil or groundwater is to be disturbed at a project site, the responsible individual/project manager or sponsoring-group representative will notify the Environmental Services Group (ESG) to initiate a preconstruction site evaluation. The ESG will then evaluate the proposed project location to determine:

- The nature and extent of any contamination known or likely to be present in the soil or groundwater
- Whether any preconstruction soil or groundwater sampling is required

The initial evaluation will consist of a review of **Figures 2.1 to 2.3**, which show the locations of subsurface groundwater remediation systems; **Figures 4.1 through 4.4**, which show

the locations of groundwater contaminant plumes and associated use restrictions; and the figures presented in **Appendix A**, which show the locations of Berkeley Lab monitoring wells used for compliance monitoring. Detailed information on the nature and extent of groundwater contamination can be obtained from additional reference sources, including the various RFI reports (Berkeley Lab, 1994a, 1995, and 2000), the *Human Health Risk Assessment* (Berkeley Lab, 2003a), the CMS Report (Berkeley Lab, 2005a), and the *Proposal for Revised Monitoring Schedule for the Lawrence Berkeley National Laboratory Environmental Restoration Program* (Berkeley Lab, 2005b).

Written procedures will be provided for protection of workers and the environment for excavation and construction projects that may encounter groundwater in the vicinity of groundwater plumes. For all Berkeley Lab plume areas shown in **Figure 4.1**, project-specific construction risk management plans will be prepared to document procedures for site monitoring, spill contingency, and treatment and discharge requirements. If groundwater must be extracted from construction excavations, or could be released to surface water courses or drain systems in the vicinity of the plumes identified in **Figure 4.1**, it should be captured and treated. Capture would generally involve installation of extraction wells, sumps, or trenches, and construction of piping to an appropriate and permitted discharge point. Discharges to the sanitary sewer must comply with the provisions of the EBMUD wastewater discharge permit.

For groundwater plume areas where risk-based MCSs are exceeded, project-specific construction risk management plans will be prepared to document construction worker protection and training requirements to mitigate potential health risks to construction workers due to contact with or ingestion of groundwater (**Figure 4.3**). Generally, such workers would need to maintain OSHA HAZWOPER training certification at a minimum.

3.4 MITIGATION CRITERIA FOR DRAIN SYSTEMS

Groundwater entering existing and planned drain systems (i.e., hydraugers, building subdrains, stormdrains) that capture contaminated groundwater from groundwater plumes (**Figure 4.1**) falls under the same restrictions for reuse of treated groundwater detailed in Section 3.1 above.

SECTION 4
REFERENCES

Berkeley Lab, 1992. *RCRA Facility Assessment at the Lawrence Berkeley Laboratory*, Environmental Restoration Program. September 30, 1992.

Berkeley Lab, 1994a. RCRA Facility Investigation Phase I Progress Report, Environmental Restoration Program, Lawrence Berkeley Laboratory, Berkeley, California, November 1994.

Berkeley Lab (1994b). Lawrence Berkeley National Laboratory Quality Assurance Program Plan for the Environmental Restoration Program. Lawrence Berkeley National Laboratory, Berkeley, California. July 1994.

Berkeley Lab (1994c). Standard Operating Procedure for Lawrence Berkeley National Laboratory Environmental Restoration Program. Lawrence Berkeley National Laboratory, Berkeley, California.

Berkeley Lab, 1995. RCRA Facility investigation Phase II Progress Report, Environmental Restoration Program, Lawrence Berkeley National Laboratory, Berkeley, California, September 1995.

Berkeley Lab, 2000. Draft Final RCRA Facility Investigation Report for the Lawrence Berkeley Laboratory, Environmental Restoration Program, September 2000.

Berkeley Lab, 2001. *Proposal for Revised Groundwater Monitoring Schedule*, Environmental Restoration Program, Lawrence Berkeley National Laboratory, Berkeley, California, October 2001.

Berkeley Lab, 2002a. *Analysis of Background Distributions of Inorganic Elements in Groundwater at Lawrence Berkeley National Laboratory*, Environmental Restoration Program, Lawrence Berkeley National Laboratory, Berkeley, California, July 2002.

Berkeley Lab, 2002b. *Ecological Risk Assessment for Radionuclides for the Lawrence Berkeley National Laboratory*, Environmental Restoration Program, January 2002.

Berkeley Lab, 2003a. *Human Health Risk Assessment for the Lawrence Berkeley National Laboratory*, Environmental Restoration Program, Lawrence Berkeley National Laboratory, Berkeley, California, My 2003.

Berkeley Lab, 2003b *Summary of Radionuclide Investigations for the Lawrence Berkeley National Laboratory*, Environmental Restoration Program, September, 2003.

Berkeley Lab, 2004a. Health and Safety Program Plan for the Environmental Restoration Program, Revision 4, Lawrence Berkeley Laboratory, Berkeley, California, January, 2004.

Berkeley Lab, 2005a. *Corrective Measures Study Report*, Environmental Restoration Program, Lawrence Berkeley National Laboratory, Berkeley, California, July 2004.

Berkeley Lab, 2005b, *Proposal for Revised Groundwater Monitoring Schedule for the Lawrence Berkeley National Laboratory Environmental Restoration Program*, Environmental Restoration Program, Lawrence Berkeley National Laboratory, Berkeley, California, May 2005.

Berkeley Lab, 2005c, *Monitoring Protocols for Monitored Natural Attenuation and Enhanced Bioremediation for the Lawrence Berkeley National Laboratory Environmental Restoration Program*, Environmental Restoration Program, Lawrence Berkeley National Laboratory, Berkeley, California, November, 2005.

DTSC, 2004. DTSC Interim Final Guidance for the Evaluation and Mitigation of Subsurface Vapor Intrusion to Indoor Air, December 15, 2004 (revised February 7, 2005).

DWR, 1991. California Well Standards, Bulletin 74-90. California Department of Water Resources, June 1991.

Office of Environmental Health Hazard Assessment (OEHHA), 2005. Human-Exposure-Based Screening Numbers Developed to Aid Estimation of Cleanup Costs for Contaminated Soil, November 2004 (January 2005 Revision).

Water Board, 1995. *Proposed Changes in Monitoring Well Sampling Schedule.* Letter from Steven Ritchie (Water Board) to Iraj Javandel (Berkeley Lab), File No. 2199.9026A(JHG). April 13, 1995.

Water Board, 1997. *Proposed Changes in Monitoring Well Schedule.* Letter from Loretta K. Barsamian (Water Board) to Iraj Javandel (Berkeley Lab), File No. 2199.9026A(JHG). June 19, 1997.

Water Board, 1999, *Proposal for Revised Groundwater Monitoring Schedule dated June 1999*, Letter from Michael Rochette (Water Board) to Iraj Javandel (Berkeley Lab), July 27, 1999.

Water Board, 2003, Screening for Environmental Concerns at Sites with Contaminated Soil and Groundwater, California Regional Water Quality Control Board San Francisco Bay Region, Interim Final-July 2003 (updated 9/4/03).

Water Board, 2005, Water Board Approval of the Proposal for Revised Groundwater Monitoring Schedule for Lawrence Berkeley National Laboratory, May 2005, File No. 2199.9026 (MBR), Letter from Michael Rochette (Water Board) to Iraj Javandel (Berkeley Lab), August 1, 2005.