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Interim Remedial Design for the Building 834 Operable Unit Treatment Facility at Lawrence Livermore National Laboratory Site 300

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February 2002

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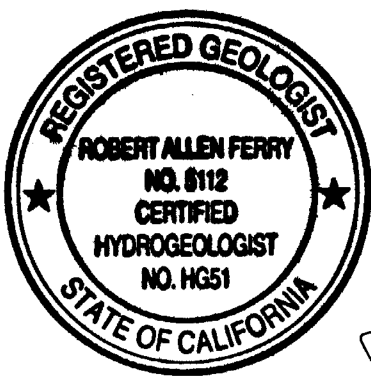
Certification

I certify that the work presented in this report was performed under my supervision. To the best of my knowledge, the data contained herein are true and accurate, and the work was performed in accordance with professional standards.



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Executive Summary

The U.S. Department of Energy (DOE) and Lawrence Livermore National Laboratory (LLNL) have prepared this Remedial Design (RD) report for the Building 834 Operable Unit (OU) at Site 300, in accordance with the Federal Facility Agreement. LLNL Site 300 is a DOE-owned experimental test facility operated by the University of California. An interim remedial action for the Building 834 OU was selected in the Interim Site-Wide Record of Decision (DOE, 2001). The selected remedy consists of continued and expanded ground water and soil vapor extraction and treatment, monitoring, and administrative controls (e.g., risk and hazard management). In addition, intrinsic *in situ* bioremediation will be used in the Core Area along with the conventional pump and treat methods.

This RD report summarizes the site history, site characterization work and removal actions performed to date, site geology and hydrogeology, treatability testing, existing remedial design, and describes the proposed remedial design for the Building 834 OU. In addition, it summarizes the performance of the existing remedial systems and presents a Remedial Action Work Plan for the selected remedy. All necessary administrative controls for the proposed remedial design are already in place and will be described in detail in the Risk and Hazard Management Program. The Risk and Hazard Management Program will be included in the Site-Wide Compliance Monitoring Plan due in 2002.

The Building 834 OU is divided into two geographic areas: (1) the Core Area, and (2) the Distal Area. The Core Area generally refers to the vicinity of the buildings and test cells in the center of the Building 834 Complex where the majority of contaminant releases occurred. The Distal Area, located to the south and southwest, refers to the dissolved contaminant plumes downgradient from the Core Area. Contaminants, mainly volatile organic compounds (VOCs), reside in unsaturated soil and perched ground water in the Core Area. Contaminants in the Distal Area reside mainly in perched ground water and the soil/bedrock in contact with this ground water.

Treatability testing of different remedial technologies, including soil vapor and ground water extraction, began in 1986. Continuous ground water extraction and treatment began in 1995. Continuous soil vapor and ground water extraction and treatment was added in 1998. With the exception of some treatability testing in the Distal Area, all soil and ground water remediation to date has taken place in the Core Area.

In addition to active remediation, passive microbial biodegradation (intrinsic biodegradation) of VOCs occurs in the Core Area. Intrinsic biodegradation at this site is facilitated by the presence of silicone oil co-contaminants, tetrakis (2-ethylbutyl) silane (TKEBS) and tetrabutyl ortho silicate (TBOS), whose fermentation yields hydrogen required for microbial dechlorination of VOCs. This process occurs under oxygen depleted conditions. Soil vapor extraction system operation, which introduces oxygen-rich vapors into the subsurface, inhibits intrinsic biodegradation. Microbial transformation of trichloroethylene (TCE) to cis-1,2-dichloroethylene (DCE) is well documented in the Core Area, however, further degradation beyond cis-1,2-DCE is still uncertain.

The remediation strategy for the Building 834 OU consists of: (1) continued soil vapor and ground water extraction and treatment in the Core Area, (2) expansion of the wellfield to extract soil vapor and ground water from the Distal Area, and (3) optimizing VOC mass removal by *in situ*

intrinsic bioremediation through cyclic operation of selected vapor extraction wells in the Core Area. Enhanced *in situ* bioremediation is currently being studied as a treatability test. Use of this technology may be necessary in the future to address VOCs in low conductivity subsurface sediments.

1. Introduction

This Remedial Design (RD) report describes the existing and proposed remedial designs for the Building 834 Operable Unit (OU) at Lawrence Livermore National Laboratory (LLNL), Site 300. Site 300 is a U.S. Department of Energy (DOE)-owned experimental test facility operated by the University of California (Figure 1). The site is located in the southeastern Altamont Hills of the Diablo Range, about 17 miles east-southeast of Livermore and 8.5 miles southwest of Tracy, California. The Building 834 OU is situated in the southeast portion of Site 300.

In 2001, an Interim Site-Wide Record of Decision (ROD) was signed by DOE and the regulatory agencies. In the Interim ROD, interim remedial actions were selected for a majority of the Site 300 OUs, including the Building 834 OU. The selected remedy for the Building 834 OU is ground water and soil vapor extraction and treatment along with compliance monitoring, and administrative controls. A Remedial Design Work Plan (Ferry et al., 2001) presents the strategic approach and schedule to implement the remedies selected in the Interim ROD.

DOE is the lead agency for cleanup at Site 300 with regulatory oversight by the U.S. Environmental Protection Agency (EPA), the California Department of Toxic Substances Control (DTSC), and the Regional Water Quality Control Board-Central Valley Region (RWQCB).

The scope and format of this document are consistent with EPA guidance documents (EPA, 1989; 1990). As suggested by EPA, this RD report contains engineering design specifications for the ground water extraction and soil vapor extraction systems, including Process and Instrumentation Diagrams (P&IDs), system descriptions, monitoring and construction schedules, and cost estimates. This RD report also includes Quality Assurance/Quality Control (QA/QC) Plans and Health and Safety Plans for both construction and operation and maintenance (O&M), and the requirements for onsite storage and offsite shipment of hazardous waste and project closeout.

Section 1 of this RD describes the location of the Building 834 OU, the history of the OU, previous investigations and removal actions, and regulatory history. Section 2 presents a summary of the geology and hydrogeology and contaminant distribution. Section 3 describes the treatability studies conducted in the OU. Section 4 presents the current remedial system design and the proposed long-term remedial design. Section 5 contains the Remedial Action Work Plan. The following appendices are also included:

Appendix A: Historical VOC Data in Building 834 Wells.

Appendix B: Monitoring and Reporting Requirement Documents:

1. Substantive Requirements, Building 834 Removal Action, Lawrence Livermore National Laboratory Site 300, San Joaquin County
2. Monitoring and Reporting Program Requirements for the Building 834 Removal Action, Lawrence Livermore National Laboratory Site 300
3. San Joaquin County San Joaquin Valley Unified Air Pollution Control District: Facilitywide Requirements

Appendix C: Construction Quality Assurance/Quality Control Plan.

Appendix D: Construction Health and Safety Plan.

Appendix E: Operations and Maintenance Quality Assurance/Quality Control Plan.

Appendix F: Operations and Maintenance Health and Safety Plan.

Appendix G: Soil vapor extraction system shutoff evaluation.

1.1. Location

The Building 834 OU is located in the southeast portion of Site 300 (Figure 2). A detailed map of the Building 834 OU with the existing ground water monitor wellfield is included as Figure 3. The Building 834 OU is bounded to the north by the Site 300 property line, to the east by the General Services Area OU, and to the south and west by the Building 832 Canyon OU.

Site 300 defense activities have always been focused in the Core Area which consists of four main buildings (A, B, C, and D) surrounded by a ring of eight peripheral buildings (E, F, G, H, J, K, L, and M). The functions of the various buildings are listed in Figure 4. The Core Area is located on an isolated hilltop at about 1,020 ft above sea level. Access to this area is restricted for security and safety reasons. The ground water and soil vapor treatment facility is located near Building D. A temporary trailer (T8340) is located near the treatment facility to house equipment and control systems.

1.2. Site History

Since the late 1950s, Building 834 facilities have been used for weapons testing activities. Trichloroethylene (TCE) was used as the primary heat transfer fluid in these experiments involving thermal cycling of weapon components. Occasionally TCE was mixed with silicone oils, tetrabutyl ortho silicate (TBOS) and tetrakis (2-ethylbutyl) silane (TKEBS), to prevent degradation of pump seals and gaskets. DOE/LLNL estimates that approximately 550 gallons of TCE were released mainly from leaking pipes, either directly to the ground surface and/or to a nearby septic system leach field through floor drains and pipes (Webster-Scholten, 1994). The thermal testing system was dismantled between September 1993 and May 1994 and TCE is no longer used in experiments at the facility.

High levels of nitrate also occur in the ground water in the Building 834 OU, but the source is uncertain. Effluent from the septic system leach field has possibly contributed to elevated nitrate concentrations in ground water. Additional natural and/or anthropogenic nitrate sources may exist. A separate nitrate source study is currently being conducted for the entire Site 300.

1.3. Site Characterization and Removal Actions

1.3.1. Site Characterization

Early site characterization activities in the Building 834 OU are described in the Site-Wide Remedial Investigation (SWRI) Report (Webster-Scholten, 1994). A summary of characterization activities performed in the Building 834 OU are listed in Table 1 of this report. The initial and most extensive phase of site characterization took place between 1983 and 1990. During this period, contaminant release areas were identified, wells were drilled to characterize the nature and extent of soil and ground water contamination, and some corrective actions were taken.

To date, 75 boreholes have been drilled in the Building 834 OU; 55 of these boreholes are completed as ground water monitor wells. Twenty-nine ground water monitor wells are located in the Core Area and 26 wells are located in the Distal Area (Figure 3). The geologic and chemical data from these wells and boreholes are used to characterize the site hydrogeology and monitor temporal and spatial changes in saturation and dissolved contaminants.

In 1988, 17 test pits were excavated along the hillslope southeast of the Core Area to monitor saturation along this seepage face and evaluate the potential for evapotranspiration of volatile organic compounds (VOCs). Shallow piezometers were installed in seven of these tests pit to monitor transient saturation in this area. Additional details regarding these test pits can be found in Chapter 10 and Appendix A of the SWRI Report (Webster-Scholten, 1994). Although ground water has not been detected in these piezometers during routine monthly monitoring, it is believed that short-term saturation occurs along this hillslope during heavy rainfall events. TCE detected in soil and soil vapor associated with these test pits is discussed in Sections 2.4.1 and 2.4.2, respectively.

From 1998 to 2000, a passive soil vapor survey using GORE-SORBERS® was conducted to more accurately define the current distribution of VOC contamination in soil and shallow ground water. The results of this survey are presented in Figure 5. Based on the GORE-SORBER® survey, 17 ground water monitor wells were installed (eight in the Core Area and nine in the Distal Area). These wells were installed to more accurately define and monitor temporal and spatial changes in saturation and dissolved contaminants. In addition, 10 wells were abandoned.

Also beginning in 1998, a detailed study was undertaken to verify and characterize intrinsic biodegradation at the site. This study included monthly monitoring (biomonitoring) of VOC concentrations, oxidation-reduction potential, dissolved oxygen, pH, nitrate, sulfide, and chloride, etc. The main objectives of the biomonitoring are to characterize biogeochemical processes and estimate natural attenuation of contaminants associated with intrinsic biodegradation. Microbial characterization (Halden et al., 2001), stable isotope analysis, and microcosm studies were also performed as part of this study (Halden et al., 1999; Vansheeswaran et al., 1999a; 1999b). The results of this study are summarized in Section 3.4 of this report.

1.3.2. Removal Actions

Cleanup began in October 1982 with the excavation of TCE-contaminated shallow soil from behind Building 834C. Additional excavations of TCE-contaminated soil were performed in 1983 at Buildings 834 B, C, D, G, and J (Ragaini, 1983). A reported volume of 110 yd^3 of contaminated soil were removed during these excavations (Lindeken et al., 1986); an estimated 96 kg of TCE was removed with the excavated soil. All excavations are documented in the Remedial Investigation and Feasibility Study for the Lawrence Livermore National Laboratory Site 300 Building 834 Complex (Bryn et al., 1990). A brief summary of excavated soil volumes and TCE mass removal is presented in Table 2.

Significant mass removal of TCE was attributed to early treatability testing of soil vapor and ground water extraction systems conducted from 1986 to 1989. Results from these tests were originally reported in the Building 834 Feasibility Study (Landgraf et al., 1994). These early treatability tests are briefly discussed further in Section 3 of this report because they are relevant to the existing and proposed remedial designs. It was reported that over 200 kg of TCE was removed during these tests (Bryn et al., 1990).

1n 1994, 17 Core Area ground water monitor wells were converted to ground water and soil vapor extraction wells. Continuous ground water extraction and treatment began in October 1995 following a series of Proof-of-System tests. Continuous ground water and soil vapor extraction began in 1998. Ground water and soil vapor mass removal is summarized in the Performance Summary, Section 4.3.

1.4. Regulatory History

Site 300 was placed on the EPA's National Priorities List in 1990. In June 1992, DOE, EPA, DTSC, and the RWQCB signed a Federal Facility Agreement (FFA) to facilitate compliance with the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA). As part of the CERCLA process, the LLNL Environmental Restoration Division (ERD) has prepared a series of documents for the Building 834 OU:

- The Site-Wide Remedial Investigation (SWRI) Chapter 10 (Webster-Scholten, 1994) characterized the site hydrogeology and contaminant distribution.
- An Interim Record of Decision for the Building 834 OU (DOE, 1995) emphasized the testing of innovative technologies at Building 834 to help select the most effective long-term remedy for the OU.
- The Site-Wide Feasibility Study (SWFS) (Ferry et al., 1999) screened and evaluated remedial alternatives for all OUs at Site 300.
- The Interim Site-Wide ROD (DOE, 2001) specifies ground water and soil vapor extraction, monitoring, and administrative controls (e.g., risk and hazard management) as components of the remedy for the Building 834 OU.
- The Remedial Design Work Plan (RDWP) (Ferry et al., 2001) describes the strategic approach and schedule to implement cleanup as established in the Interim Site-Wide ROD.

2. Geology and Hydrogeology

The geology and hydrogeology of the Building 834 OU are discussed in detail in Chapter 10 of the SWRI report and Section 2.5 of the Building 834 OU Interim ROD and briefly summarized below. This summary emphasizes those aspects of the conceptual hydrogeologic model that are relevant to the proposed remedial design.

2.1. Geology and Hydrogeology

The Building 834 OU is located on an isolated hilltop underlain by flat-lying, semi-consolidated sand, gravel, and clay (Tps). These deposits overlie Neroly Formation bedrock that dips gently to the southwest. As summarized in Table 3, six geologic units have been defined based on physical and hydraulic characteristics. Two water-bearing zones exist within these six geologic units:

1. A shallow (< 50 ft below ground surface [bgs]) variably saturated, perched water-bearing zone, and a
2. A deeper (~ 380 ft bgs) bedrock, water-supply aquifer.

The shallow perched water-bearing zone consists mainly of sands and gravels of the Tpsg interval. The Tpsg is underlain by a variable saturated perching horizon that is composed of a fine-grained clay (Tps clay) followed by an interbedded siltstone and claystone ($Tnsc_2$). Cleanup of contaminated soil and ground water in the Tpsg is the main focus of this RD report. Approximately 300 ft of unsaturated bedrock ($Tnbs_2$ and $Tnsc_1$) separate these shallow water-bearing zone from the deep water-supply aquifer ($Tnbs_1$).

2.2. Conceptual Hydrogeologic Model

A simplified conceptual hydrogeologic model is presented in Figure 6. Ground water enters the shallow perched water-bearing zone primarily through direct infiltration during heavy rainfall events. Some of this recharge water ultimately exits and/or evaporates on the hill slopes surrounding the Building 834 OU and some of it partitions into the underlying Tps clay and $Tnsc_2$ bedrock units, where it resides in long-term storage. Perched ground water beneath the Core Area is hydraulically separate from the southwestern Distal Area, except following heavy rainfall events (e.g., El Niño), when the areas may temporarily form a single continuous saturated zone. Most of the time these areas are hydraulically separated and ground water exists in isolated “static pools”.

The deeper $Tnbs_1$ regional aquifer contains ground water that is chemically distinct from shallow, perched ground water indicating that these two water-bearing zones are hydraulically separate. These two waters can be distinguished on the basis of inorganic chemistry and stable isotope (oxygen-18) signatures. For example, the shallow Tps water has a delta oxygen-18 signature of -3.7, while the deeper aquifer has a delta oxygen-18 signature of -6.2. Additionally, the deep aquifer beneath the Building 834 OU is devoid of anthropogenic chemicals and it is recharged by a different pathway than the shallow perched water-bearing zone. The $Tnbs_1$ aquifer is recharged in Elk Ravine, several hundred feet to the north and northwest of the Building 834 Core Area. The deep water table is about 270 ft below contaminated soil and shallow ground water beneath the Core Area.

2.3. Water Budget

A water budget analysis was conducted for the Building 834 Core Area to evaluate changes in saturation and storage resulting from recharge during a large-magnitude rainfall event. The analysis is based on monthly water level data collected in the Core Area during the El Niño rainfall events of January through June, 1998, when 15 inches of rainfall were recorded at Site 300. These rainfall events resulted in approximately 9×10^6 gallons (about three acre-feet) of water falling over the recharge area (950,000 ft^2). The observed change in storage in shallow ground water during this time period was approximately 1.3×10^6 gallons (15% of the total rainfall). Less than 5% of this recharge volume was extracted by the ground water remediation system during this same period.

2.4. Contaminant Distribution

Details of the nature and extent of contamination in the Building 834 OU are discussed in Chapter 10, Section 10-4 of the SWRI, summarized in Chapter 1 of the SWFS, and briefly discussed below. All confirmed contaminant release sites are presented in Figure 4. The approximate distribution of soil and ground water contamination is presented in Figures 7 and 8.

2.4.1. Soil/Bedrock

Most VOC contamination in soil and bedrock occurs beneath the Core Area in the vicinity of Buildings A, C, and D, although TCE releases have been confirmed at other building locations. The primary contaminants of concern in subsurface soil and bedrock are TCE, tetrachloroethylene (PCE), and toluene. Other contaminants of concern detected in soil or bedrock are TBOS/TKEBS and cis-1,2-dichloroethylene (DCE). TBOS/TKEBS were released as co-contaminants along with the TCE, while the cis-1,2-DCE is the result of microbial dechlorination of the TCE. Evidence of biodegradation of TCE to cis-1,2-DCE is discussed in Section 3.4.

TCE concentrations in surface and subsurface soils at the Building 834 Operable Unit are shown in Table 4. The extent of TCE soil contamination at concentrations greater than 0.1 milligram per kilogram (mg/kg) in the Core Area is presented in Figure 7. The highest TCE concentrations (10,000 to 12,000 mg/kg) in near surface soil (< 5 ft) were detected in samples collected near Building C. The highest VOC concentrations in deeper soil were detected in samples collected at the Tpsg/Tps clay interface in well W-834-D3 at a maximum concentration of 970 mg/kg. High VOC concentrations (257 mg/kg) were also encountered in soil samples collected from the unsaturated Tpsg in abandoned borehole B-834-D1 located in the D-Cell shed. Using EarthVision's volumetric analyses, the total VOC mass in the soil is estimated to be around 860 kg, or 155 gallons. However, the current extent and magnitude of VOC contamination beneath Building D is uncertain. This area is not easily accessible using a conventional drilling rig. Recent attempts to collect additional soil samples in the vicinity of the B-834–D1 borehole using a hand auger were unsuccessful due to a hard, cemented sand layer at a depth of about five feet. Ten soil samples were collected to a depth of five feet that contained low VOC concentrations (< 0.01 mg/kg). A limited access drilling rig will be needed to collect confirmatory soil samples below this cemented sand layer.

Although the bulk of VOC soil mass resides in shallow, unsaturated coarse-grained soils and at the Tpsg/Tps clay interface, significant VOC concentrations (> 10 mg/kg) have been detected in soil in the underlying Tps clay perching horizon during recent characterization activities. For example, wells W-834-A1, located west of Building A, and W-834–U1, located near a former diesel underground storage tank contained maximum VOC Tps clay soil concentrations of 13 and 8 mg/kg, respectively.

VOC concentrations in soil in the Distal Area are generally lower than the Core Area. The source of VOCs in the Distal Area was TCE spillage within the Core Area test cells that were connected to the septic leach field via floor drains. VOCs were also probably transported to the distal area via ground water transport during periods of high water elevations where the Core Area was hydraulically linked to the Distal Area. TCE soil concentrations up to 0.5 mg/kg have been detected in the Tpsg zone in the Distal Area, while higher concentrations (> 1 mg/kg) have been detected in the underlying Tps clay. Soil samples collected to a maximum depth of 13 ft bgs during excavation of the test pits on the hillslope southwest of the Core Area yielded relatively low TCE concentrations ranging from below analytical detection limits (< 0.0002 mg/kg) to 0.070 mg/kg.

2.4.2. Soil Vapor

Both active and passive **(**GORE-SORBER®**)** soil vapor surveys have been conducted at the Building 834 OU. In 1989, active soil vapor measurements were made in wells W-834-D3, -D4,

-D5 and seven nearby dedicated soil vapor monitoring points as part of initial soil vapor extraction treatability testing. TCE vapor concentrations ranging from less than 1 to 9,500 parts per million on a volume per volume basis ($ppm_{v/v}$) were detected during this test; the highest concentrations were detected in the vicinity of wells W-834-D3 and -D4. Vapor TCE concentrations decreased by one to three orders-of magnitude during this one month long test (Landgraf et al., 1994).

In the summer of 1999, an extensive passive soil vapor survey using GORE-SORBERS® was performed to define the distribution of VOC contamination in soil and shallow ground water throughout the Building 834 OU. As shown in Figure 5, GORE-SORBER® survey results are generally consistent with soil and ground water data with the exception of the ephemeral seepage face on the hillslope southwest of the Core Area. GORE-SORBERS® were placed in shallow test pit piezometers located on this hillslope. As displayed in Figure 5, VOC vapors were detected at these locations, suggesting the presence of VOC-contaminated soil moisture along this ephemeral seepage face. The high GORE-SORBER® survey results in this area probably result from the discharge of VOC-laden vapors along this hillslope, as a result of evaporation and evapotranspiration of residual VOCs in soil moisture. The relatively permeable, gravel-filled test pits may actually increase soil vapor flux along the slope. Additional GORE-SORBERS® were placed in two deep ground water monitor wells, W-834-D9A ($Tnbs_2$, 70 ft) and W-834-T1 ($Tnbs_1$, 320 ft). The objective of placing the GORE-SORBERS® in these wells was to determine whether VOC vapors could be detected in unsaturated Neroly bedrock. VOCs were detected in the W-834-D9A well; no VOCs were detected in the deeper W-834-T1 sample.

2.4.3. Ground Water

The distribution of contaminated ground water beneath the Building 834 OU is controlled primarily by temporal and spatial variations in saturation related to rainfall events and treatment facility operation. As shown in Figure 8, the current distribution of ground water contaminants is somewhat limited because the extent of saturation in the Core Area has been significantly reduced due to ground water cleanup efforts during the past five years.

The primary contaminants of concern in ground water in the Building 843 OU are VOCs. Total VOC concentrations in the Core Area generally range from 20,000 to 40,000 micrograms per liter (µg/L), although concentrations greater than 200,000 µg/L have been detected in recent samples collected from the Tps clay. Total VOC concentrations for individual Core Area wells generally show decreasing trends over the last 10 years of monitoring. The total mass of VOCs in the Core Area ground water in 1995 is estimated at 58.9 kg. Using the same assumptions, which are presented in Section 4.3 (Performance Summary), the mass of VOCs remaining in the Core Area ground water by the end of the third quarter of 2000 is 22.5 kg.

Most of the VOC mass exists as TCE, although significant concentrations of cis-1,2-DCE have also been detected. For example, the maximum total VOC concentration detected in a ground water sample collected from the Tpsg in 2000 was 130,000 µg/L. This sample, which was nearly all cis-1,2-DCE, was collected from well W-834-D4 following a 2.5-month period of soil vapor extraction system shut down. A long-term time series plot of TCE and cis-1,2-DCE for well W-834-D3 is presented in Figure 9. This plot shows that increases in cis-1,2-DCE concentrations are inversely correlated to TCE concentrations. These temporal changes in VOC concentrations are related to treatment facility operations and intrinsic biodegradation as discussed in Section 3.4.

The extent of VOC contamination in ground water in the $Tnsc_2$ bedrock unit beneath the Tps clay in the Core Area is unknown. Ground water in the $Tnsc_2$ unit is not currently being monitored in the Core Area although, as discussed below, this unit contains VOCs in the Distal Area.

VOC concentrations in ground water in the Distal Area range from 10,000 to over 30,000 µg/L. Lower VOC concentrations (1,000 to 3,000 µg/L) have been detected in the ground water samples from the deeper $Tnsc_2$ bedrock unit based on data from wells W-834-S8 and W-834-S9. Detections of cis-1,2-DCE in W-834–T2 cluster wells at concentrations of up to 2,400 µg/L, along with low dissolved oxygen and low oxidation/reduction potentials, suggest that intrinsic biodegradation is occurring in this area. TCE was detected in ground water samples from the former -T4 cluster wells (W-834-T4, -T4A, -T4B, and -T4C) at concentrations up to 30,000 µg/L. Sporadic detections (12 to 84 µg/L) of cis-1,2-DCE had also been reported in these wells. The total VOC mass in the Distal Area ground water is estimated to be 34.5 kg (± 30%).

Additional contaminants of concern at Building 834 OU include nitrate and TKEBS/TBOS. Nitrate concentrations in ground water during 2000 ranged from less than 10 milligrams per liter (mg/L) to 750 mg/L. This maximum concentration was detected in a recently installed monitor well, W-834-K1A, located near the former septic system leach field. Nitrate concentrations in the Core Area are generally an order-of-magnitude lower than nitrate concentrations in the Distal Area. The reduced nitrate concentrations in the Core Area is thought to result from microbial denitrification.

TKEBS and TBOS were detected at concentrations ranging up to 250,000 µg/L during 2000. Although these silicone oils have been detected almost exclusively in the Core Area, TBOS/TKEBS have been detected at 72 µg/L in well W-834-S13 located southwest of the Core Area, approximately 300 ft southwest of the former septic system leach field. It was also detected in recently installed monitor wells, W-834-C5 and W-834-U1, screened in the Tpsg and the underlying Tps clay, respectively.

Benzene, toluene, and ethylbenzene have been detected sporadically in a number of ground water samples collected in new wells in the Core Area, although only one well, W-834-U1, currently contains all three compounds at concentrations ranging from 8 to 33 µg/L.

3. Treatability Testing

A series of treatability tests were conducted to evaluate the effectiveness of both conventional and innovative technologies in remediating contaminants at the Building 834 OU. These tests are listed and briefly summarized in Table–4-5. For additional information regarding tests performed prior to 1995, see Appendices D and E of the Final Building 834 Feasibility Study (Landgraf et al., 1994).

3.1. Soil Vapor and Ground Water Extraction Testing

Treatability testing was conducted between 1986 and 1989 to evaluate ground water and soil vapor extraction systems performance. Soil vapor testing employed a water-filled Marathon pump with a maximum vacuum flow rate capacity of 100 standard cubic feet per minute (scfm). The testing determined that even at 40 scfm, vacuum influence could be detected at distances greater than 60 feet. This testing also determined that when a vacuum greater than 12 inches of mercury was applied, water was drawn upward in the well casing above the well screen. At higher vacuums, the water level rose to the ground surface. This demonstrated the necessity of conducting ground water extraction along with soil vapor extraction. TCE concentrations ranging from 350 to 9,500 ppm_v were measured in soil vapor in wells and soil vapor monitoring points. Soil vapor mass removal rates ranging from 8 to 30 kilograms per day (kg/day) were achieved during these initial treatability tests. The maximum mass removal rate was achieved by extracting from four wells (W-834-D3, -D4, -D5, and -D6) at a total flow rate of about 40 scfm. An estimated 201 kg of TCE was reported to have been removed from the vadose zone via soil vapor extraction. VOC concentrations of up to 510,000 µg/L in ground water were measured in samples collected from wells W-834-D3 and -D4 during the testing. It is estimated that approximately 6 kg of VOCs were removed via ground water extraction during these tests.

A long-term combined ground water and soil vapor extraction test was conducted from November 1988 to June 1989 in the Distal Area at the former W-834-T4 cluster. The results of this test further supported that soil vapor extraction is a superior mass removal mechanism to ground water extraction. During the -T4 test, former wells W-834-T4 and -T4C were pumped and wells W-834-T4A and -T4B were monitored for response. The initial ground water extraction rate was 0.44 gallons per minute (gpm), decreasing to a stabilized flow rate of 0.07 gpm (110 gallons per day). Significant water-level responses were observed in both wells W-834-T4A and -T4B, indicating hydraulic connectivity between wells more than 30 ft apart. Ground water TCE concentrations from the two extraction wells decreased from 19,000 µg/L to 440 µg/L during the test, while soil vapor concentrations increased from 0.04 ppm_v to 9.6 ppm_v.

3.2. Extraction Well Configuration Testing

From 2000 through March 2001, a number of tests were conducted to determine whether mass removal could be increased using different extraction wellfield configurations. Data indicated that greater VOC mass removal was achievable with a larger number of extraction wells. However, certain wells with low soil vapor concentrations and low ground water concentrations only dilute the extraction stream and do not provide much benefit. Therefore, well configuration testing, including zone of influence testing and individual soil vapor analyses, will continue as part of ongoing performance optimization activities.

3.3. Aqueous-Phase Granular Activated Carbon (GAC) Testing

Treatability testing is being conducted to evaluate whether air sparging could be eliminated from the ground water treatment system and replaced with aqueous-phase GAC. One 55-gallon GAC canister was placed upstream of the primary sparging unit. Aqueous samples of the GAC effluent are analyzed for VOCs and TKEBS/TBOS to evaluate the performance of the aqueous-phase GAC. Test results indicate that GAC effectively reduces VOC concentrations to below method detection limits. However, low levels of TBOS (1 to 11 µg/L) have been detected in the effluent from the aqueous-phase GAC on numerous occasions. This test is ongoing to evaluate longer-term effectiveness of aqueous-phase GAC.

3.4. Intrinsic Bioremediation Testing

An investigation to evaluate the role of intrinsic biodegradation in the Core Area was conducted from January 1998 through December 2000. This investigation involved the monthly sampling of biogeochemical indicators such as VOCs, pH, oxidation-reduction potential and dissolved oxygen, to determine whether microbial processes were degrading TCE. Laboratory experiments have shown that the breakdown of silicone oils (TBOS/TKEBS) result in the release of alcoholic compounds that, upon microbial fermentation, yield dissolved hydrogen (Vansheeswaran et al., 1999a). The latter then serves to drive the biotransformation of TCE to cis-1,2-DCE in the absence of oxygen. These experiments showed that biodegradation occurs in the form of anaerobic microbial dechlorination. The degradation pathway for TCE is as follows:

During the three year test, it was shown that intrinsic microbial degradation is inhibited during periods of active soil vapor extraction, because the soil vapor extraction system draws oxygen-rich vapors into the subsurface and the microbes become dormant. Microbial activity returns fairly quickly (within one week) when the soil vapor extraction system is shut off. Thus, the extraction system functions as an off/on switch for anaerobic microbial degradation of TCE and TBOS/TKEBS.

A more detailed field experiment was conducted to quantify the efficacy of intrinsic biodegradation of VOCs in the Core Area under monitored natural attenuation conditions. Two weeks after discontinuing ground water and soil vapor extraction, the ground water in the vicinity of two monitor wells turned anaerobic. Immediately thereafter, the onset of biologically-mediated reductive dehalogenation of TCE was indicated by increases in both cis-1,2-DCE and chloride concentrations and decreases in TCE concentrations in the two wells. Initial transformation of TCE to cis-1,2-DCE resulted in the net destruction of up to 1.7 ± 0.4 kg of VOC and transient accumulation of 4.7 ± 1.2 kg of cis-1,2-DCE as estimated from contaminant contour plots. Within a 10-day to two week period after recommencing both soil vapor and ground water extraction, the cis-1,2-DCE concentrations drop by 78% to 98%. Figure 9 shows the changing TCE and cis-1,2-DCE concentrations in extraction well W-834-D3 relative to facility operations. The ultimate fate of cis-1,2-DCE remains uncertain.

There is evidence that at least some of the cis-1,2-DCE is further degraded into compounds such as vinyl chloride and further to ethene and ethane. Historical TCE, cis-1,2-DCE, and vinyl chloride data are presented in Appendix A for those wells that have had any detections of cis-1,2-DCE. Vinyl chloride has been detected in two wells (W-834-B3 and W-834-U1) at low concentrations. There are likely significant concentrations of vinyl chloride in the other wells where biodegradation is measurable. Unfortunately, since the analytical laboratories have to dilute the highest concentration samples to force TCE and cis-1,2-DCE into calibration range, detection limits are very high for all constituents in these samples (including vinyl chloride). Detection limits for wells with high VOC concentrations where biodegradation is occurring, such as wells W-834-D3 and -D4, vary between 300 and 900 µg/L. Data in Table 6 demonstrates that, to some degree, the degradation proceeds to the production of ethene and ethane. As indicated by the concentrations, either a very small percentage of the DCE is degraded to that point, or there is a great deal of loss of these compounds during sample collection of light hydrocarbons.

Although there is evidence of some biodegradation, either a very small percentage of the cis-1,2-DCE is degraded further, or it is removed from the system by some other means. Likely removal mechanisms include:

- Complete reductive biodechlorination of cis-1,2-DCE to ethene and ethane, and/or
- Volatilization of cis-1,2-DCE followed by some other degradation process such as cooxidation in the aerobic, unsaturated soils, and/or
- Removal of cis-1,2-DCE via the ground water extraction system upon reinitiating of the extraction system.

As stated above, the fate of the DCE is uncertain. However, the biodegradation processes at Building 834 will continue to be studied and monitored.

The beneficial effect of silicone oils in the Core Area has sparked an interest to elicit similar biodegradative processes in the Distal Area and perhaps in the Tps clays in the Core Area. Field and laboratory studies are underway to determine whether the addition of microbial nutrients, other than silicone lubricants, to ground water also can effect rapid biological attenuation of TCE concentrations (enhanced *in situ* bioremediation). Evidence already suggests that a limited amount of microbial dechlorination is already occurring in an area monitored by well W-834-C5, in the T2 cluster area, and in the Tps clay formation in the vicinity of well W-834-U1. This was confirmed by periodic reducing conditions as well as the detection of cis-1,2-DCE.

Continued treatability testing of intrinsic bioremediation will take place during periods when selected wells are shut down to promote the anaerobic conditions and for a short period after restart. Detailed monitoring will be conducted for continued evidence of intrinsic biodegradation along with quantification of the TCE destruction. This biomonitoring will include field monitoring for dissolved oxygen, oxidation-reduction potentials, pH, and sulfides, and laboratory analyses of VOCs for TCE and cis-1,2-DCE comparisons, as well as analysis of other inorganic constituents such as chlorides, nitrates, etc. Recent data revealed that biodegradation may also be occurring in an area slightly to the north of the W-834-D3 and -D4 wells. This location, monitored by a new well, W-834-C5, does have low concentrations of TKEBS/TBOS that may be driving intrinsic biodegradation in this area. Therefore, biomonitoring of the wells to the north of the main extraction area will also be conducted to document intrinsic *in situ* biodegradation.

3.5. Other Treatability Tests

The Building 834 Core Area has also been used as a test bed for several innovative technology projects, including an EPA Superfund Innovative Technology Evaluation (SITE) test of a Perox-Pure™ ultraviolet soil vapor treatment system; an electrical soil-heating (Joule-Heating) pilot test; and a demonstration of an electron accelerator to treat soil vapor. A surfactant push-pull test was performed in 1998 to evaluate the use of surfactants to enhance dissolution of VOC source areas and increase ground water mass removal. These technologies and tests are described in the Site-Wide Feasibility Study (Ferry et al., 1999). They were not selected for use at Building 834 OU and therefore are not discussed further in this report.

4. Remedial Design

The existing ground water and soil vapor extraction and treatment systems have been in operation since 1995; first as a removal action and now as an interim remedial action under the Interim Site-Wide ROD. As a result, the concentration and volume of contaminants have been significantly reduced in the subsurface of the Building 834 Core Area. The remedial design of the Building 834 OU wellfield and treatment systems will focus on modifications to the existing treatment system and expansion of the extraction wellfield.

4.1. Wellfield Design

The ground water and soil vapor extraction wellfield design is based on hydrogeologic analyses, contaminant distribution data, and extraction well configuration testing. The existing extraction wellfield is discussed in Section 4.1.1. Modifications that will be made to the existing wellfield to maximize contaminant mass removal and prevent plume migration in the shallow, perched aquifer are discussed in Section 4.1.2.

4.1.1. Existing Extraction Wellfield

Currently, both soil vapor and ground water are extracted from 16 wells in the Core Area of the Building 834 OU (W-834-B2, -B3, -C2, -D3, -D4, -D5, -D6, -D7, -D10, -D11, -D12, -D13, -D14, -H2, -J1, -and -J2). However, several of these wells have not contributed significant volumes of water to the ground water treatment system in the past couple of years due to declining water elevations. The extraction systems were designed to remove VOCs from relatively high permeability soils and water-bearing zones to maximize contaminant mass removal from the Core Area source and prevent plume migration in the shallow, perched aquifer. Soil vapor extraction is the main mass removal mechanism, while ground water extraction exposes more soil/rock to the applied vacuum of soil vapor extraction, thereby significantly enhancing VOC mass removal. In addition, it is necessary to pump ground water in order to extract soil vapor from the wells due to up-coning of ground water which can cover the extraction well screen rendering it inaccessible to the soil vapor extraction system. Figure 10 presents the existing extraction wellfield in the Core Area.

Each extraction well contains an air pressure-actuated Solo pump (QED, Inc.). Solo pumps are equipped with float mechanisms that automatically trigger actuation of the pump upon recovery. Ground water yields in these wells range from 4 to 23 gallons per day, while the entire extraction wellfield produces approximately 800 to 1,200 gallons per week. Soil vapor is pumped from the extraction wells utilizing a 15-horsepower vacuum pump.

4.1.2. Extraction/Monitor Wellfield Expansion

The existing ground water and soil vapor extraction well field configuration in the Core Area will be slightly modified. Extraction wells W-834-B2, -D11, and -D12 have not yielded significant volumes of water in the past two years due to declining water levels. Although a small amount of water is available in some of these wells, there is insufficient volume to activate the dedicated extraction pumps, which require at least 4 ft of submergence. Obtaining a sample for contaminant or biodegradation monitoring purposes is not possible while the wells are equipped with dedicated ground water extraction pumps. Therefore, the extraction pumps will be removed from wells W-834-B2, -D11, and -D12 to enable ground water sample collection using a different device. Should conditions change, such as rising water elevations due to increased recharge, the wells can be easily converted back to extraction well status.

Well W-834-D10 is completed in the Tps clay, and due to the fine-grained nature of this formation, is not amenable to soil vapor or ground water extraction. It will be converted to a monitor well. Soil vapor extraction will continue on all remaining wells at this time. A full evaluation of individual extraction wells, including zone of influence testing, will be conducted as a baseline for the soil vapor extraction shutdown evaluation criteria. All data will be made available to the regulatory agencies and will be used to re-evaluate the status of all wells. The resulting extraction well configuration will consist of twelve wells for ground water extraction (W-834-B3, -C2, -D3, -D4, -D5, -D6, -D7, -D13, -D14, -H2, -J1, and -J2) and fifteen wells for soil vapor extraction (W-834-B2, -B3, -C2, -D3, -D4, -D5, -D6, -D7, -D11, -D12, -D13, -D14, -H2, -J1, and -J2). This will allow for optimum contaminant removal from both the Tpsg water-bearing zone and vadose zone within the Core Area.

The wellfield will also be expanded to include extraction from two Distal Area plumes, converting six existing monitor wells to extraction wells. All of these wells (W-834-S1, -S12A, -S13, -T2, -T2A, and -T2D) will be used for both ground water and soil vapor extraction from the Tpsg unit in the Distal Area. Additional extraction wells may be added to increase contaminant removal by converting existing monitor wells or drilling new wells. Locations for these wells, as well as the number necessary, will be determined after sufficient review of the facility performance in the new wellfield design has been completed.

Table 7 lists the extraction wells for the remediation of the Building 834 OU. The design specifications for the extraction wells are presented in Table 8. Figures 11 and 12 present the proposed extraction and monitor wellfield for the Core and Distal Areas, respectively. The proposed extraction well VOC concentrations, estimated yield, and flow weighted average for VOCs are shown in Table 9. These were used to calculate the estimated total influent concentration of 26,371 µg/L for the treatment system remedial design.

Additional monitor wells are proposed to: (1) further characterize the subsurface contaminant distribution, (2) help evaluate the extent of hydraulic capture and remediation effectiveness, and (3) identify areas of little or no ground water flow. To determine the extent of the VOC source remaining in the vadose zone beneath the D-Cell shed, one shallow borehole will be installed. Should high concentrations be encountered, the borehole may be converted into a soil vapor extraction well. At least six additional boreholes/wells will be completed to further characterize soil and ground water contamination in the Distal Area, and one additional borehole/well is planned in the Core Area. Approximate locations for these boreholes/wells are included in Figures 11 and 12. The exact location and number of wells will be determined after ground water extraction from the expanded extraction system begins and hydraulic testing is conducted to optimize well placement. Proposed monitoring well locations will be discussed with the regulatory agencies and approved prior to installation.

4.1.3. Ground Water Capture Zone Analysis

Estimated capture zones for the Core and Distal Areas are shown on Figures 13 and 14, respectively. The capture zones were calculated using an analytical-element flow model that conservatively assumed a constant recharge to the area and constant extraction rates from the wells. Due to the limited recharge in the Building 834 area, the actual capture zones may be larger than estimated. However, de-watering of the extraction wells may ultimately limit the extent of the capture zones. The size of the actual capture zones of the extraction wells will be verified using ground water elevation measurements.

4.2. Treatment System Design and Specifications

The Building 834 OU treatment systems are operated to treat contaminants in ground water and soil vapor extracted from the subsurface. The ground water treatment system is designed to remove VOCs and TBOS/TKEBs from extracted ground water to meet the Substantive Requirements for ground water discharge issued by the RWQCB. The soil vapor treatment system removes VOCs in extracted soil vapor to meet the permit requirements specified by the SJVUAPCD.

4.2.1. Existing Treatment System Design

The existing ground water extraction and treatment system consists of:

- A ground water extraction wellfield described in Section 4.1.
- Water distribution pipelines.
- An oil skimmer/phase separator.
- A pre-treatment storage tank.
- Air sparging units, a particulate filter, three vapor-phase GAC units, and an emissions stack.
- Post-treatment storage tanks.
- A post-treatment discharge pump.
- A final misting storage tank.
- A discharge line.
- A series of discharge misting nozzles.

The soil vapor extraction and treatment system consists of:

- A soil vapor wellfield described in Section 4.1.
- Vapor distribution pipelines.
- An air-intake valve.
- A water knock-out drum.
- A vacuum pump controlled by a variable speed motor controller.
- Four vapor-phase GAC units; the first two in parallel and final two in series.
- A stack to discharge the treated vapor stream to the atmosphere.

A Process and Instrumentation Diagram (P&ID) of the existing facility is included in Figures 15A–E. Extracted water and vapors are transferred through copper pipes to the treatment facility, located on a concrete slab/asphalt area next to trailer T8340. The extracted ground water passes through two 5-micron filters to remove particulates from ground water that could reduce the treatment system efficiency. An oil skimmer/phase separator is then used to remove TBOS/TKEBs in the light non-aqueous phase liquid (LNAPL) from extracted ground water. Extracted ground water and any entrained LNAPLs are pumped from the wells to a chamber containing a series of baffles and weirs that cause the LNAPLs to coalesce and separate from the ground water. LNAPLs float to the surface and gravity drain from a port near the top of the chamber. The gravity-drained LNAPLs are collected in drums.

The water stream then enters the air sparging units where VOCs are removed from the water by air injection. Two separate sparge tanks, aligned in series, subject the water to intense aeration, driving VOCs into the vapor phase. Contaminated vapor from the air sparging tanks passes through a heat exchanger that condenses and removes the water fraction. The air stream then passes through vapor-phase GAC canisters to sorb the VOCs.

Following air sparging, the treated water passes through two aqueous-phase GAC units as a final polishing step. Carbon dioxide is injected into the effluent to reduce the formation of precipitates in the discharge lines and/or to achieve a pH within the discharge limits, if necessary.

Effluent from the ground water treatment system is discharged into the air using misting towers. Nitrate is present in the treatment system effluent at varying concentrations (10 to 60 mg/L). The concentration of nitrate in the system effluent is affected by the amount of denitrification occurring in the subsurface. During periods when the extraction system is shut off on the key wells to promote the biodegradation of TCE, the nitrate levels will likely drop to below the Maximum Contaminant Level of 45 mg/L. The amount of nitrate released during misting operations is not significant enough to cause detectable increases in nitrate deposition rates downwind of the facility. Therefore, misting of nitrate-containing effluent is not expected to impact local ground water quality.

The soil vapor extraction system consists of a blower (Pego©) that is operated at a variable flow rate and electronically controlled to maintain a manifold vacuum of 8 in. Hg. The operating flow rate depends on the number of wells connected to the system, moisture conditions, pressure, etc. The maximum flow rate for this blower is around 300 scfm; the operating flow rate is about 100 scfm. Extracted soil vapor passes through a water knock-out drum to reduce the water content in the vapor. The VOCs are removed by passing the contaminated vapor stream through GAC units where the VOCs are adsorbed to the carbon. The treated vapor is then released to the atmosphere though a discharge stack under a permit from the SJVUAPCD. Additional details of the ground water and soil vapor extraction and treatment systems are contained in the Building 834 OU Feasibility Study (Landgraf et al., 1994).

Daily operation (i.e., 8 hr/day; 5 days/week) of both ground water and soil vapor extraction and treatment began in 1998 and continuous 24-hour operation began at the end of 1999. The treatment facility has been periodically shut down for periods of days to weeks for maintenance, modification, or to monitor intrinsic biodegradation.

4.2.2. Modified Treatment System Design

Two major design changes will be made to the current facility. First, as discussed in Section 4.1.2, the wellfield will be expanded to include ground water and soil vapor extraction in the

Distal Area. Second, the facility will be modified to use aqueous-phase GAC instead of air sparging to remove contaminants from ground water.

As discussed in Section 3.3, the use of aqueous-phase GAC has the potential for allowing the release of low levels (< 15 µg/L) of silicone oils (TBOS and TKEBS). During the aqueous-phase GAC testing, one 55-gallon GAC container was utilized. If the aqueous-phase GAC unit is approved to replace the air sparging unit as the primary treatment technology, DOE/LLNL anticipates installing two to three 1,000-gallon aqueous-phase GAC units. It is possible that TBOS or TKEBS will be totally adsorbed when using the larger capacity GAC units and no TBOS/TKEBS will be discharged. However, as requested by the RWQCB, DOE/LLNL evaluated the toxicity of TBOS/TKEBS potential breakdown products and possible esthetic effects if TBOS/TKEBS were discharged at low concentrations.

Potential breakdown products from TBOS and TKEBS under anaerobic conditions include 1-butanol and silicic acid, and 2-ethylbutanol and silicic acid, respectively. The alcohols, 1-butanol and 2-ethylbutanol, can also undergo additional breakdown to n-butyrate and 2-ethylbutyrate. The butanol and butyrate compounds have been detected in samples collected from several wells where anaerobic degradation of TCE occurs. However, these breakdown products have not been measured in the ground water treatment system effluent. There are no maximum contaminant levels or action levels published for either the original compounds or breakdown products. There are, however, preliminary remediation goals (PRGs) for 1-butanol listed in the EPA Region 9 PRG tables. The PRG concentration for tap water for 1-butanol is 3,600 µg/L. Since the maximum effluent concentration of TBOS/ TKEBS to be misted is not expected to exceed 15 µg/L, and the breakdown products would most likely be even lower in concentration, the amount of any breakdown products will be well below the PRGs. In addition, due to adsorption losses and low solubility, the quantity of oil or potential breakdown products that could impact ground water is very minimal.

Literature searches were conducted for toxicological data on TBOS/TKEBS and their breakdown products. Within the "Handbook of Toxic and Hazardous Chemicals and Carcinogens", information was available for 1-butanol that reported although EPA has not set any criteria on permissible concentrations in water, EPA has suggested ambient limits for n-butanol (1-butanol) at 2,070 µg/L, based on health effects. This is again well above the potential discharge concentrations. Data searches were also conducted within EPA's Integrated Risk Information System (IRIS). Data was available on human oral exposure to n-butanol. The oral Reference Dose (RfD) was listed at 1 mg/kg/day. It was reported in IRIS that based on a 10-year study, occupational exposure to 100 ppm butanol had no health impacts. Due to the location of the misting towers and the anticipated concentrations contained in the discharge, DOE/LLNL does not believe human oral exposure is an issue. The only other toxicological data found was included in the EPA Ecotoxicology Database, ECOTOX. This data only included toxicological effects of silicic acid, the other breakdown product of both TBOS and TKEBS, on aquatic life forms. Since the effluent from the Building 834 ground water treatment system is not being discharged to receiving waters, this data is not relevant.

DOE/LLNL also considered the esthetic affects of the discharge of TBOS/TKEBS from the ground water treatment system via the misting system and whether this discharge would lead to an oily buildup over time. Based on the low concentrations (< 15 µg/L), climatic conditions, and large surface area over which the discharge would be misted, DOE/LLNL does not believe that this would occur. However, DOE/LLNL will monitor the conditions of the ground surface and report on these conditions in each of the quarterly compliance monitoring reports. In summary, this evaluation suggests that there would be no negative impacts resulting from the misting of treated ground water containing detectable levels of TBOS/TKEBS.

The P&IDs for the proposed treatment facility are presented in Figures 16A–E. The Building 834 OU treatment system equipment specifications are included as Table 10. The remediation strategy is discussed in Section 5.3.

4.3. Performance Summary

The effectiveness and protectiveness of the remedy for the Building 834 OU was assessed primarily by reviewing contaminant concentration reduction and mass removal data. In the following sections, DOE has included estimates of the pre-remediation mass of contaminants in the subsurface, and compared these values to the mass of contaminants removed by ground water and soil vapor extraction. The estimates of the pre-remediation mass of contaminants in the subsurface have a degree of uncertainty and are given as a range of values, assuming an uncertainty of ±30% as calculated from sensitivity analyses. The comparison of pre-remediation mass to that removed through extraction should not be used as the basis for decision-making regarding the performance of the remedy.

4.3.1. Ground Water

The mass of VOCs estimated to have been present in the ground water in the Building 834 OU prior to the beginning of remediation was 93.4 kg. This includes an estimated 58.9 kg (41.2–76.6 kg) in the Core Area and 34.5 kg (24.2–44.8 kg) in the Distal Area. Since then, 34 kg of VOCs have been removed by ground water extraction, representing roughly 36% of the original mass. Over 174,000 gallons of contaminated ground water have been extracted and treated. The estimated amount of VOC mass remaining in the ground water in 2000 is 57 kg (39.9–74.1 kg), including both Core and Distal Areas. This represents roughly 61% of the VOCs mass remaining. Since ground water extraction can only account for a maximum of 36% of the removal, the difference may be related to measurement error and other factors such as diffusion, dilution, dispersion, and biodegradation. The cumulative mass of VOCs extracted from ground water over time is shown on Figure 17. Future mass removal rates are extremely difficult to predict because: (1) removal efficiency varies as a result of fluctuating ground water elevation and contaminant concentration, (2) changes in extraction well configuration affect removal rate, and (3) the mass removal rate will continue to decline as VOCs are removed from high-permeability sediments and diffuse slowly out of fine-grained materials.

DOE estimates that achieving MCLs for VOCs in ground water in the perched aquifer could require 140–220 years due to: (1) low well yields, (2) limited amount of ground water available for extraction, and (3) the difficulty in removing VOCs that have diffused into low-permeability sediments. To shorten cleanup time using only ground water extraction would require installing a large number of additional extraction wells (possibly more than 25), but the limited amount of recharge to the perched aquifer may not make this approach viable. However, since the perched aquifer at Building 834 is not used as a source of water, is isolated from the underlying regional water-supply, and is not significantly migrating, ground water extraction is a viable long-term strategy for reducing the mass of contaminants in the subsurface. An important aspect of DOE's cleanup strategy for the Building 834 OU is the application of other technologies (e.g., bioremediation) to supplement ground water extraction and reduce the time required to restore beneficial uses of ground water.

4.3.2. Vadose Zone

The original mass of VOCs estimated to have been present in the vadose zone was 602–1,118 kg. Since then, 275 kg of VOCs have been removed by soil vapor extraction, representing 25–46% of the original mass. Also, an estimated 96 kg was removed during early soil excavations. The cumulative mass of VOCs removed from the subsurface over time is shown on Figure 17. The rate of mass removal is extremely variable, possibly as a result of: (1) temporal permeability variations in the subsurface caused by changes in vadose zone moisture content, (2) seasonal changes in the thickness of the vadose zone from fluctuating ground water levels, and/or (3) changes in the VOC concentration in extracted soil vapor as the extraction and air injection well configuration is changed.

4.3.3. Removal Technology Effectiveness

As shown in Figure 17, soil vapor extraction is clearly a more effective mass removal technology for VOCs than ground water extraction. In fact, more mass was removed in six months (Fourth Quarter 1999–First Quarter 2000) using soil vapor extraction than was accomplished in the first five years using solely ground water extraction. The major controlling factor regarding ground water mass removal is the relatively small volume of ground water available and the low hydraulic conductivity of the subsurface. Ground water yields from individual wells are low; typically hundreds of gallons per month. Observations during hydraulic tests indicate that ground water capture zones are very limited, in some cases less than 10 ft in diameter. Ground water yield, however, is increased 2- to 3-fold when the ground water extraction system is operated concurrently with soil vapor extraction. The highest VOC mass removal rates (1 kg/month) in ground water to date were achieved during the months following the 1998 El Niño rains.

Intrinsic *in situ* biodegradation is an additional mass removal mechanism in the Core Area. Microbial dechlorination of TCE (molecular weight = 131.40 grams/mole) to cis-1,2-DCE (molecular weight = 96.95 grams/mole) results in mass reduction of 34.45 grams per mole. Intrinsic biodegradation is facilitated by the presence of the silicone oil, TKEBS/TBOS. Evidence of microbial dechlorination of TCE to cis-1,2-DCE has been detected in several wells in the Core Area, including (W-834-D3, -D4, -D5, -D13, and -B3) (Halden et al., 1999; Semprini et al., 2000). Within one week to ten days after shutting down the soil vapor extraction system, the oxygen levels in these wells decreased below 2 mg/L. Under anaerobic conditions, the TCE concentrations decreased by orders-of-magnitude and the cis-1,2-DCE concentrations increased by orders-of-magnitude. Biomonitoring data indicate that mass removal rates approaching 1 to 2 kg/month were potentially achievable via intrinsic biodegradation. Additional data will be necessary to confirm these mass removal rates. Treatability testing of intrinsic bioremediation is discussed in Section 3.4.

4.4. Performance Standards and Monitoring

Performance standards are set at the effluent discharge requirements for the ground water treatment system. To ensure these standards are met, periodic monitoring of influent and effluent concentrations is required as specified in the Substantive Requirements issued by the RWQCB (Appendix B). Performance standards for the soil vapor treatment system are specified by the SJVUAPCD Permit to Operate for the Building 834 Removal Actions (Appendix B). When the facility sparging units are replaced with aqueous-phase GAC, only one air permit will be needed for the soil vapor treatment system. Currently, two air permits are in place; one for the vapor stream generated by the air sparging unit and one for the soil vapor treatment unit vapor stream. Adjustments to in-flow rates or blower rates may be necessary. System performance will also be monitored to optimize mass removal. Sample port locations are identified in the P&IDs.

4.5. Controls and Safeguards

The Core Area ground water extraction and treatment system is designed so that the failure of any component or energy source (mechanical or electrical), or loss of control signal will cause the system to shut down safely. In addition, all pipelines will be visually monitored for leaks. The treatment facility is equipped with interlocks and an interlock control panel. If one of the components listed below malfunctions, the entire system will automatically shut down. The operator will need to determine and correct the problem before the system can be manually restarted.

A system shutdown involves de-energizing the following equipment:

- SVE Blower.
- Compressor.
- All transfer pumps.
- All pneumatic and electrical control valves.

A ground water extraction and treatment system shutdown would be initiated by the following interlocks:

- High water levels.
- Loss of power to controls and instrumentation.
- Thermal overload on electric pump.
- High pressure at the particulate filter influent due to blockage of the discharge line.

The high pressure interlock switch may be incorporated after regulatory approval of the RD design is received.

A soil vapor extraction and treatment system shutdown involves de-energizing the vacuum pump. A soil vapor extraction and treatment system shutdown would be initiated by the loss of power to controls and instrumentation. In addition, all above-ground pipelines will be visually monitored for signs of wear that may result in leakage.

4.6. Discharge of Treated Water and Vapor

Treated ground water will be discharged to misters located on the western side of the hilltop and will meet the discharge requirements specified in the Substantive Requirements for waste water discharge issued by the RWQCB (Appendix B).

The treated vapor stream from the soil vapor treatment systems will be discharged to the atmosphere in accordance with the air permits issued by the SJVUAPCD (Appendix B).

4.7. Construction, Startup, and Document Schedule

DOE/LLNL has completed the design, construction, and startup of the existing ground water and soil vapor treatment systems and a portion of the extraction wellfield. The schedule for extraction wellfield expansion and replacement of the ground water treatment system is shown in Table 11. Also included in Table 11, are the agreed upon submitted dates for the Draft, Draft Final, Building 834 Five-Year Review reports.

4.8. Costs Estimates

The cost for treatment system design, construction, and startup, and estimated costs for treatment system O&M are shown in Tables 12A–D.

5. Remedial Action Work Plan

The Remedial Action Work Plan for the Building 834 OU is the basis for DOE and LLNL's approach to the implementation of the designed Remedial Action. The Remediation Strategy, discussed in detail in Section 5.3, will consist of continued soil vapor and ground water extraction and treatment, build-out to include Distal Area soil vapor and ground water extraction, and *in situ* bioremediation. The Remedial Action Work Plan includes QA/QC Plans and Health and Safety Plans for construction and O&M that are attached in Appendices C, D, E, and F. The Remedial Action Work Plan also includes the monitoring and reporting requirements for the ground water and soil vapor treatment systems and for extraction wells and monitor wells (Appendix B). In addition, requirements for onsite storage and offsite shipment of hazardous waste, preliminary remediation completion criteria, and procedures for facility and well closure are discussed in this section.

5.1. Quality Assurance/Quality Control and Health and Safety Plans

The QA/QC and the Health and Safety Plans for construction are presented as Appendices C and D of this document. The QA/QC Plan for construction defines the quality objectives and areas of responsibility for the proposed modifications to the Building 834 OU remediation system. The Health and Safety Plan for these remediation system modifications defines areas of responsibility for health and safety during modification activities and references existing LLNL Health and Safety documents which address construction/modification health and safety issues.

The QA/QC Plan for O&M of the Building 834 OU treatment facilities is presented in Appendix E. This plan describes the organizational structure, responsibilities, and authority for O&M QA/QC and the objectives, quality goals, and QA elements for O&M of the Building 834 OU treatment facility. Appendix F contains the Health and Safety Plan for O&M of the Building 834 OU treatment facility. This plan presents: (1) organizational structure and responsibilities, (2) hazard analyses and control measures, (3) training requirements for the Building 834 OU treatment facility O&M, and (4) emergency safety procedures.

5.2. Monitoring and Reporting Programs

A Site-Wide Compliance Monitoring Plan for Site 300 is scheduled to be completed in 2002 that will include the monitoring and reporting program for the Building 834 OU. However, the monitoring and reporting requirements for facility operations and ground water extraction and monitor wells will be briefly discussed in this report. These monitoring activities are necessary to assess the ground water and vadose zone remediation progress.

5.2.1. Ground Water Treatment System Influent and Effluent

As stipulated by the RWQCB Substantive Requirements for the Building 834 Removal Action, the Monitoring and Reporting Program Requirements, and the monitoring reduction letter report (Appendix B), ground water treatment system influent and effluent sampling and/or monitoring will be used to evaluate facility performance and to meet discharge permit requirements. The current treatment system monitoring requirements are shown in Table 13, and are consistent with the requirements of the Substantive Requirements, the Monitoring and Reporting Program, and the monitoring reduction letter (Lamarre, 1998).

5.2.2. Ground Water Extraction and Monitor Wells

Ground water concentrations will be determined by analyzing samples collected from extraction and monitor wells to track changes in plume concentration and size that result from remediation and natural processes such as dispersion, degradation, adsorption, diffusion, advection, and biodegradation. Chemical analyses will be performed according to EPA Methods or analytical methods contained in the ERD Standard Operating Procedures (Dibley and Depue, 2000). Results will be evaluated according to QA/QC procedures contained in the Quality Assurance Project Plan (QAPP) (Dibley, 1999). Measured ground water concentrations will be used to prepare contaminant isoconcentration contour maps in order to assess the cleanup progress. These assessments enhance understanding of the response of contaminant concentrations to ground water extraction so that the extraction wellfield can be managed to achieve the most cost-effective and expeditious remediation.

Ground water concentrations at extraction and monitor wells will be measured at a sampling frequency specified by the Monitoring and Reporting Program or in the monitoring reduction letter. These frequencies are generally dependent on: (1) the rate of observed or expected changes in concentrations in each well and other nearby wells, (2) the location of the well, and (3) the purpose or current use of the well. Based on data from previous remediation, significant changes in ground water contaminant concentrations are expected to occur over time intervals of months to years.

The sampling schedule for Building 834 OU ground water extraction and monitor wells is shown in Table 14. DOE/LLNL will discuss any future proposed changes to the monitoring program with the regulatory agencies. Possible changes to the monitoring program may include, but not be limited to: (1) the addition of a monitoring schedule for new ground water extraction or monitor wells, and (2) changes in the sampling frequency or parameters of existing ground water extraction or monitor wells in order to better assess how the new extraction system is affecting ground water flow, contaminant migration, and ground water quality. DOE/LLNL will notify the regulatory agencies and solicit their input on sampling frequency and parameter changes when changes to the monitoring program are considered. The Site-Wide Compliance Monitoring Plan, scheduled to be finalized in September 2002, will supercede the RWQCB's Monitoring and Reporting Program and the sampling schedule contained in this document for the Building 834 OU.

5.2.3. Soil Vapor Treatment System Influent and Effluent

VOC concentrations in soil vapor measured before, during, and after treatment will be used to evaluate the performance of vadose zone remediation systems. Monitoring requirements are specified in the SJVUAPCD Permit to Operate for the Building 834 Removal Action (Appendix B). Based on treatability test data and experience at other sites, contaminant concentrations in soil vapor are anticipated to change over time intervals of weeks under stressed conditions (i.e., during soil vapor extraction), or months to years under natural conditions. Soil vapor sampling in the Building 834 area is not currently required under a specific permit. Periodically, individual soil vapor extraction wells will be monitored to assess the effectiveness of the soil vapor extraction system and extent of remaining VOC contamination in the vadose zone.

5.3. Remediation Strategy

The key to remediation performance at the Building 834 OU is understanding the three-dimensional distribution of VOCs and designing an appropriate, media-specific cleanup strategy. The bulk of VOC mass beneath the Core Area occurs in unsaturated soil, and extensive testing has shown that the most efficient mass removal technology for this site is soil vapor extraction. Soil vapor extraction mass removal rates are 5 to 6 times greater than ground water extraction mass removal rates, when both systems are operated concurrently.

The remedial strategy for the Building 834 OU consists of:

- Continued soil vapor and ground water extraction in the Core Area.
- Expansion of the wellfield to extract soil vapor and ground water from Distal Area wells.
- Optimizing VOC mass removal by intrinsic *in situ* bioremediation through cyclic operation of selected Core Area extraction wells.

Enhanced *in situ* bioremediation is currently being studied as a treatability test to evaluate the use of this technology to address dissolved and dense non-aqueous phase liquid (DNAPL) solvents in low hydraulic conductivity subsurface sediments as discussed in Section 5.3.4.

5.3.1. Continued Ground Water and Soil Vapor Extraction and Treatment in the Core Area

Ground water and soil vapor will be extracted simultaneously from eleven wells, while soil vapor only will be extracted from an additional four wells in the Core Area as described in Section 4.1.2. The treatment facility will be operated to maximize soil vapor extraction mass removal because this is a more efficient mass removal mechanism than ground water extraction. The ground water extraction system will be operated primarily to expose more soil and rock to the applied vacuum of the soil vapor extraction system, enhancing VOC mass removal. The extraction systems will also be operated cyclically on selected wells for mass removal by intrinsic *in situ* bioremediation as discussed in Section 5.3.3.

5.3.2. Wellfield Expansion in the Distal Area

The wellfield expansion will be performed to address the Distal Area contamination plumes. As discussed in Section 2.2, the perched water-bearing zones in the Core and Distal areas are for the most part hydraulically separated. Therefore, this expansion is necessary in order to remediate distal area perched water contamination, which cannot be remediated using the existing extraction wellfield in the Core Area. As discussed in Section 4.1.2, six additional Distal Area wells will be added to address the downgradient VOC contamination. As within the Core Area, extraction will include both soil vapor and ground water.

5.3.3. VOC Mass Removal Optimization through Intrinsic *In Situ* Bioremediation

Intrinsic biodegradation of TCE in the form of anaerobic dehalogenation is occurring in the Building 834 Core Area. Since the biodegradation of TCE is inhibited while the facility is in operation, both soil vapor and ground water extraction will be cycled on and off in selected wells, W-834-D3, -D4, -D5, and -D13, where significant TBOS is available and biodegradation is measurable. Bioremediation data suggests that a two-week period is sufficient to achieve anaerobic conditions and a nearly complete transformation of TCE to cis-1,2-DCE. Although it may not take the same period to reverse these conditions and remove, or cause the removal of, the DCE, DOE/LLNL proposes to use a two-week on and two-week off schedule. Samples will be collected at more frequent time intervals in order to fine-tune the cycling frequency. All other wells will remain on-line unless future monitoring data suggests a change to this configuration. In this way, DOE/LLNL can take advantage of the intrinsic biodegradation that occurs in the Core Area without discontinuing the conventional extraction and treatment in other parts of the Building 834 area. The facility will actually be used as an “on/off switch” to first promote the conversion of TCE to cis-1,2-DCE during shut-off, followed by complete degration or removal of the cis-1,2-DCE upon re-initiation of extraction in the selected wells. This will also help reduce the nitrate concentrations, by allowing regular denitrification. At some point in the future, when the majority of the contaminants have been removed from the higher permeability soils and water bearing zones, *in situ* bioremediation may be necessary to remove VOCs from low hydraulic conductivity sediments, as discussed below.

5.3.4. Treatability Studies of Enhanced *In Situ* Bioremediation

The presence of dissolved and dense non-aqueous phase liquid (DNAPL) solvents in low hydraulic conductivity subsurface materials may limit the performance of pump-and-treat operations, even in combination with soil vapor extraction. Pump-and-treat operations may at some point in the future become ineffective at the site due to: (1) subsurface heterogeneity and complex hydrogeology, (2) extremely limited ground water yield of less than 50 gallons per day per well, (3) seasonally fluctuating water levels and a limited extent of saturation, (4) the presumed presence of residual DNAPL sources, (5) limited ground water recharge and flushing of contaminants from the vadose zone, and (6) the constant diffusion of contaminants out of heavily contaminated fine-grained sediments (i.e., the Tps clay). Perched ground water at the site may not be remediated effectively unless contaminants diffusing out of the Tps clay are intercepted and destroyed.

Biogeochemical data collected in over three years of biomonitoring demonstrate that this site may be an appropriate candidate for deployment of enhanced *in situ* bioremediation. Characterization of the microbial community of the site indicates the presence of various indigenous dechlorinating microorganisms (Halden et al., 2001). Field data, stable-isotope analyses, and various microcosm studies have shown that significant mass removal is occurring in the Core Area through intrinsic *in situ* biodegradation (Halden et al., 1999; Vansheeswaran et al., 1999a; 1999b). Intrinsic biodegradation currently is limited to the Core Area where silicone-based lubricants serve as a strong driver of reductive dechlorination (Halden et al., 1999). In the T2 well cluster area and other locations of the site (W-834-U1 and -C5), biotransformation of contaminants, although occurring, is limited by a lack of nutrients.

Treatability testing will be conducted in the future to evaluate the use of enhanced *in situ* bioremediation for the cleanup of contamination in the Tps clay, and/or those areas of higher permeability such as the Tpsg where sufficient nutrients are not available. VOC contamination within low permeability materials, such as the Tps clay, are not readily accessible by conventional extraction methods. The treatability testing will involve several stages of work including characterization of the microbial community, testing of nutrient substrates, and evaluation of nutrient delivery methods. The nutrient delivery testing would possibly include the use of soil fracturing with concurrent nutrient injection and would be followed by implementation and monitoring. To obtain long-term protection of groundwater quality in permeable zones, enhanced *in situ* bioremediation may be able to intercept and biotransform pollutants that slowly diffuse out of heavily contaminated low-permeability zones by establishing a biodegradative permeable barrier (biofilm) at the interface between relatively clean high-permeability zones (sand and/or gravel units that are subject to ground water flushing) and highly contaminated low-permeability zones (silts and clays that potentially may function as long-term source areas). Growth of bacteria in strategic locations may be promoted by the use of hydraulic fracturing along the gravel/clay interface and concomitant injection of a slurry consisting of nutrients, proppant (e.g., diatomaceous earth) and, if necessary, TCE-transforming microorganisms.

Nutrient consumption by microorganisms is designed to trigger microbial growth and anaerobic conditions conducive to the *in situ* reductive dechlorination of contaminants. Fortuitous cooxidation reactions also may occur in locations where the biofilm is in contact with high-permeability material (Vancheeswaran et al., 1999). Once the injected nutrients are depleted, the decaying biofilm itself becomes a microbial food source that, over time, will slowly release organic compounds to sustain the long-term biotransformation of pollutants (McCarty, 2000). In situations where strong DNAPL sources exist, repeated injection of nutrients may be warranted to create thick bioreactive layers that effectively control rebound of contaminant concentrations in surrounding ground water. In this way, *in situ* bioremediation makes use of biofouling and biotransformation to confine and destroy contaminants *in situ.*

5.4. Hazardous Waste Handling

Aqueous-phase GAC containing sorbed VOCs are replaced on-site as needed to remain in compliance with RWQCB Substantive Requirements discharge limits. Vapor-phase GAC from the Building 834 OU soil vapor extraction and treatment system will be replaced as needed to remain in compliance with the SJVUAPCD air discharge limit. The spent aqueous-phase and vapor-phase GAC from the Building 834 OU treatment facility will be removed from the 1,000-lb capacity containers onsite by the vendor. The vendor will ship the spent GAC to a RCRA-permitted facility for regeneration or disposal. DOE/LLNL will comply with the Offsite Rule (40 CFR 300.440) for the offsite shipment of CERCLA waste.

5.5. Requirements for Closure

5.5.1. Ground Water Cleanup

Building 834 OU ground water cleanup will be complete when ground water samples demonstrate that cleanup standards, which will be selected and codified in the Final Site-Wide ROD, are achieved. When VOC concentrations in ground water have been reduced to agreed upon cleanup standards, the ground water extraction and treatment system will be shut off and placed on standby in concurrence with agreement from the regulatory agencies. VOC concentrations may rise in ground water after extraction ceases due to slow desorption from fine-grained sediments. Therefore, ground water post-closure monitoring will be performed for two years after pumping ceases. Should VOC concentrations in ground water rebound above cleanup standards, re-initiation of remediation efforts will be discussed with the regulatory agencies.

5.5.2. Soil Vapor Cleanup

The soil vapor extraction system will be operated until it is demonstrated that VOC removal from the vadose zone is no longer technically or economically feasible in meeting the aquifer cleanup standards sooner, more cost effectively, and more reliably. The decision on whether it is appropriate to shut off the soil vapor extraction system will be made based on the results of the "Soil Vapor Extraction System Shut-Off Evaluation" discussed in Appendix G in concurrence with the regulatory agencies. The evaluation presented in Appendix G was, by design, intended to be applicable to all OUs where soil vapor extraction will be conducted. In addition, site-specific considerations will need to be evaluated at the Building 834 OU and include the following:

1. At some point in the future, shut down of the soil vapor extraction system may be necessary to optimize VOC removal from low hydraulic conductivity sediments through *in situ* bioremediation as discussed in Section 5.3.4. In this eventuality, supportive data would be presented for the regulatory agencies to evaluate in order to make an informed decision.

2. A redesignation of ground water at the Building 834 OU through an amendment to the Basin Plan could affect ground water cleanup standards and alter the ground water and soil vapor remediation strategy.

When the decision is made by DOE and concurred by the regulatory agencies that the soil vapor extraction system will be shut down based on the results of the Soil Vapor Extraction System Shut-Off Evaluation, the monitoring of ground water and soil vapor will continue. Should site conditions change or monitoring indicate that soil vapor concentrations have rebounded and will cause the ground water to exceed ground water cleanup standards, re-initiation of remediation efforts will be discussed with the regulatory agencies.

Cleanup will be considered complete when contaminant concentrations in ground water remain below the cleanup standards for two years. Cleanup completion will be determined in conjunction with the regulatory agencies.

After concurrence with the regulatory agencies that cleanup is complete, the Building 834 OU extraction wells and monitor wells will be decommissioned. Wells will be closed by *in-situ* casing perforation and pressure grouting, or by well removal as appropriate, consistent with the approved LLNL Livermore Site and Site 300 Environmental Restoration Project Standard Operating Procedures (SOPs) (Dibley and Depue, 2000). Wellhead abandonment will include removal of any protective covers, instruments, concrete pads, etc., and the upper two to three ft will be filled with low-permeability soil to restore grade.

After remediation is complete, the Building 834 OU ground water and soil vapor treatment systems and their influent and discharge piping will be decontaminated, dismantled, and salvaged, or used at other locations. Any wash water containing hazardous materials will be collected, sampled, and disposed at one of several offsite RCRA-permitted facilities. GAC with sorbed VOCs will be disposed according to the specifications described in Section 5.4 “Hazardous Waste Handling.”

6. References for LLNL Facilities Standards, Specifications, and Guide Documents

6.1. General

Designs, construction drawings, and specifications will conform to and comply with the applicable requirements of the latest adopted edition of the references listed herein, which will be considered minimum requirements.

6.2. Regulations

<u>U.S. Department of Energy (DOE)</u>

DOE 5480.7A	Fire Protection Program
DOE 6430.1A	General Design Criteria

Code of Federal Regulations (CFR)

10 CFR 435	Energy Conservation Standards
29 CFR 1910	Occupational Safety and Health Standards (OSHA)
29 CFR 1910.7	Definitions and Requirements for a Nationally Recognized Testing Laboratory (NRTL)
47 CFR 15	Telecommunication (FCC Rules, Part 15)

State of California Department of Labor (DOL)

DOL Labor Code	Division 5—Safety in Employment Chapter 9—Miscellaneous Labor Provisions

California Code of Regulations (CCR)

CCR Title 8	Industrial Relations; Chapter 4, Subchapter 6
CCR Title 20	Public Utilities; Chapter 53—Energy Conservation in New Building Construction

University of California, Lawrence Livermore National Laboratory (UCRL)

UCRL 15910 Design and Evaluation Guidelines for Department of Energy Facilities Subjected to Natural Phenomena Hazards

UCRL 15714 Suspended Ceiling System Survey and Seismic Bracing Recommendations

6.3. Codes

American Concrete Institute (ACI)

ACI 318	Building Code Requirements for Reinforced Concrete

American Institute of Steel Construction (AISC)

AISC	Steel Construction Manual (Allowable Stress Design)

American National Standards Institute (ANSI)

ANSI A58.1	Building Code Requirements for Minimum Design Loads for Buildings and Other Structures

American Welding Society (AWS)

AWS D 1.1 Welding Code—Steel

International Conference of Building Officials (ICBO)

ICBO UBC Uniform Building Code

ICBO UMC Uniform Mechanical Code

ICBO UPC Uniform Plumbing Code

National Fire Protection Association (NFPA)

NFPA 70 National Electrical Code

NFPA 90A Installation of Air Conditioning and Ventilating Conditioning Systems

6.4. Standards

American Concrete Institute (ACI)

ACI 347 Recommended Practice for Concrete Form Work

American Society for Testing and Materials

American Water Works Association

Construction Specifications Institute

National Electric Manufacturers Association

Sheet Metal and Air Conditioning Contractors National Association, Inc.

6.5. LLNL Manuals and Reports

M-010 LLNL Health and Safety Manual

LLNL Site Development and Facilities Utilization Plan

LLNL Landscape Master Plan and Design Guidelines

7. References

Bryn, S. M., R. K. Landgraf, and S. E. Booth (1990), *Draft Remedial Investigation and Feasibility Study for the Lawrence Livermore National Laboratory Site 300 Building 834 Complex*, Lawrence Livermore National Laboratory, Livermore, Calif. (UCRL-ID-103963).

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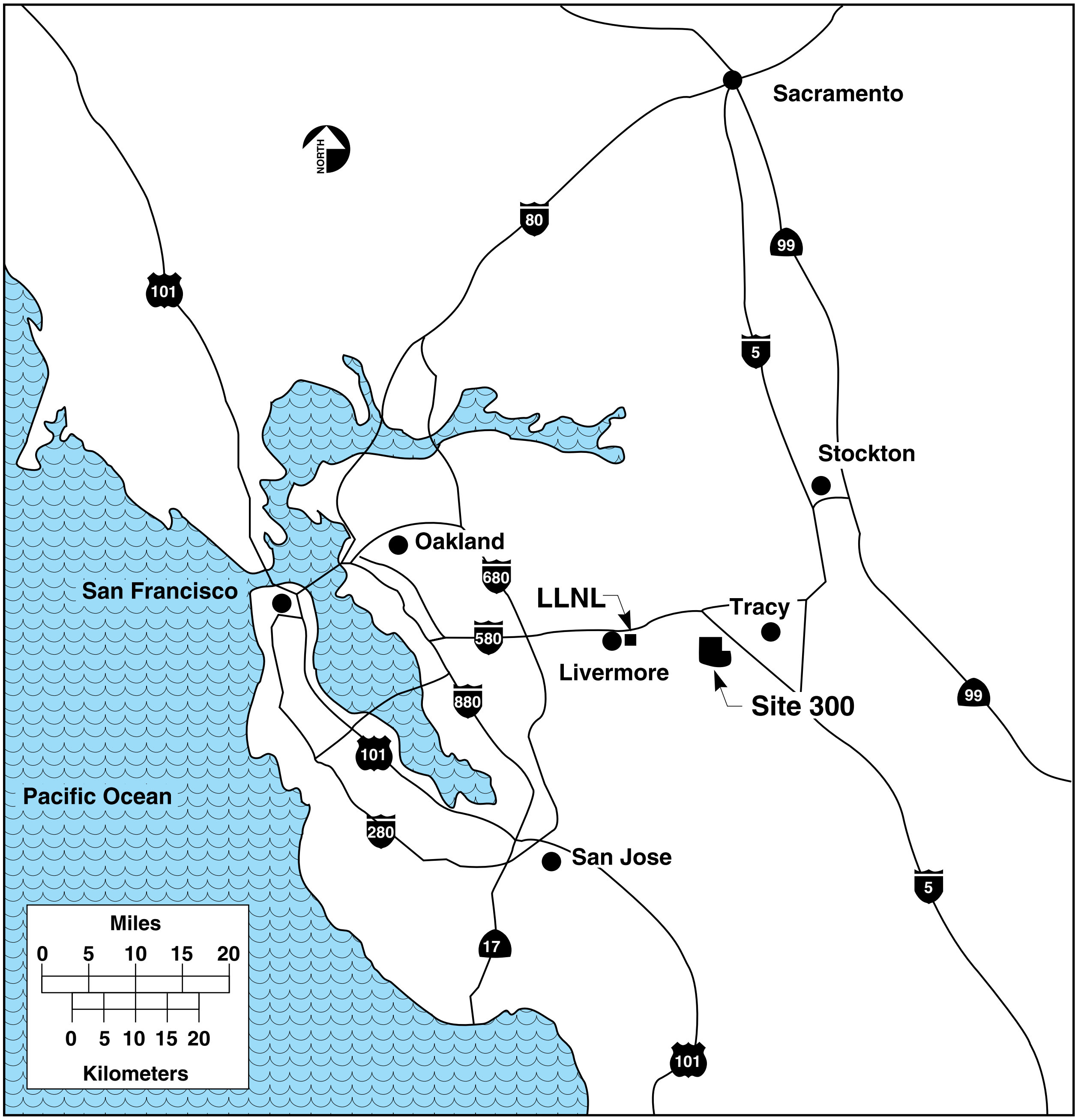
Figures



ERD-S3R-01-0097

Figure 1. Locations of LLNL Main Site and Site 300.

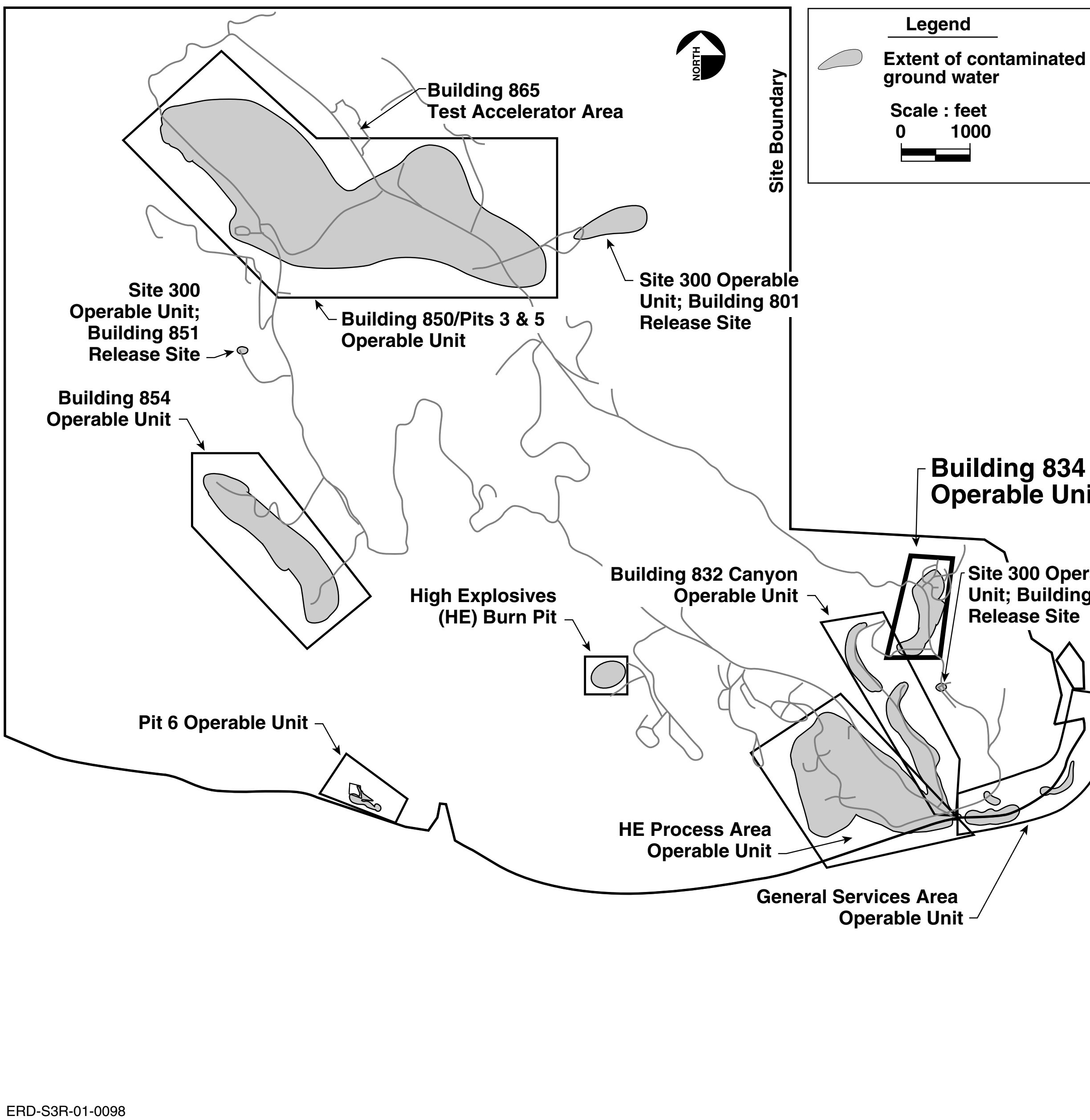


Figure 2. Locations of Building 834 and other operable units at LLNL Site 300.

Figure 3. Building 834 site map showing monitor well locations.

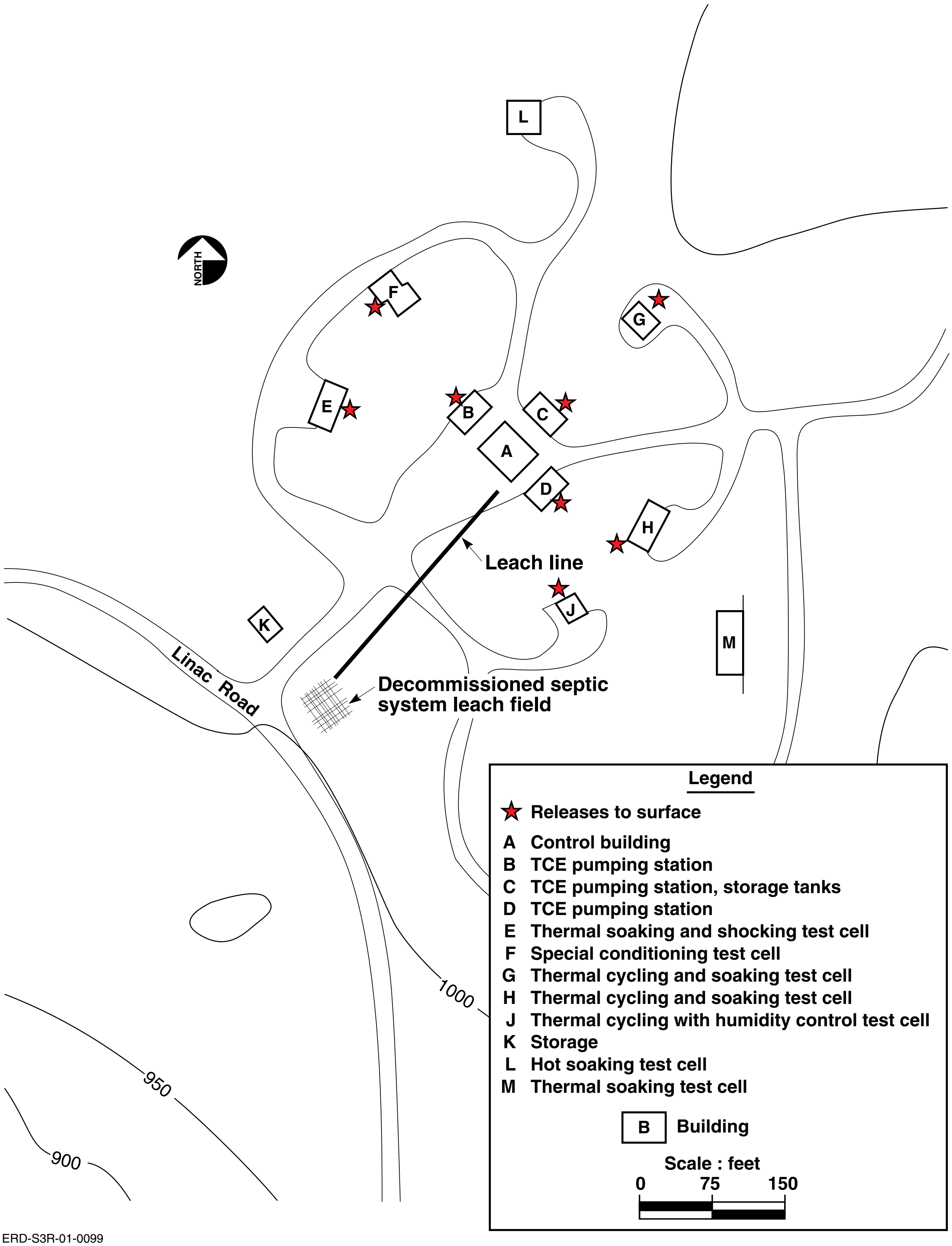


Figure 4. Functions of the buildings and confirmed release sites at the Building 834 Complex.

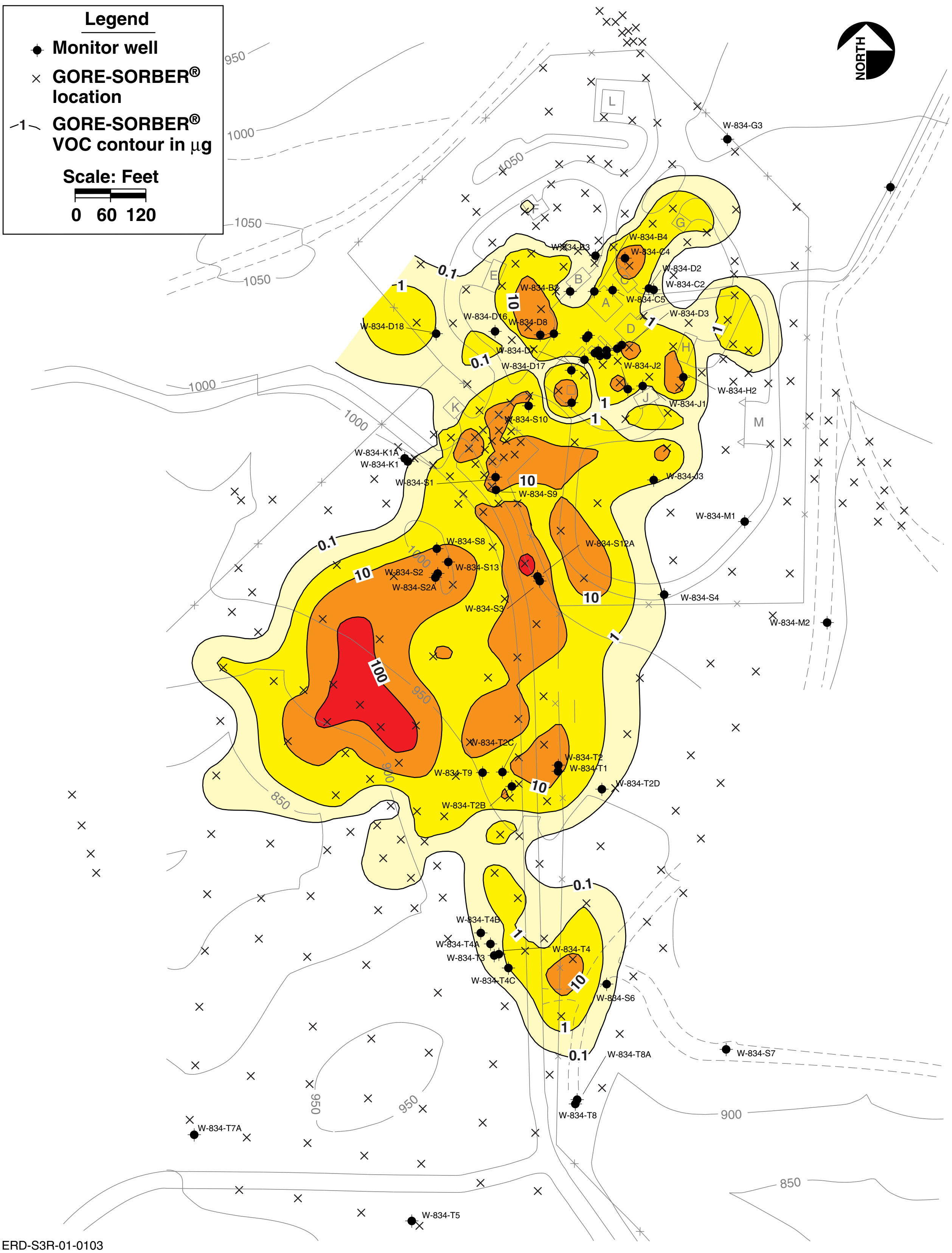


Figure 5. Building 834 site map showing contours of GORE-SORBER® results.

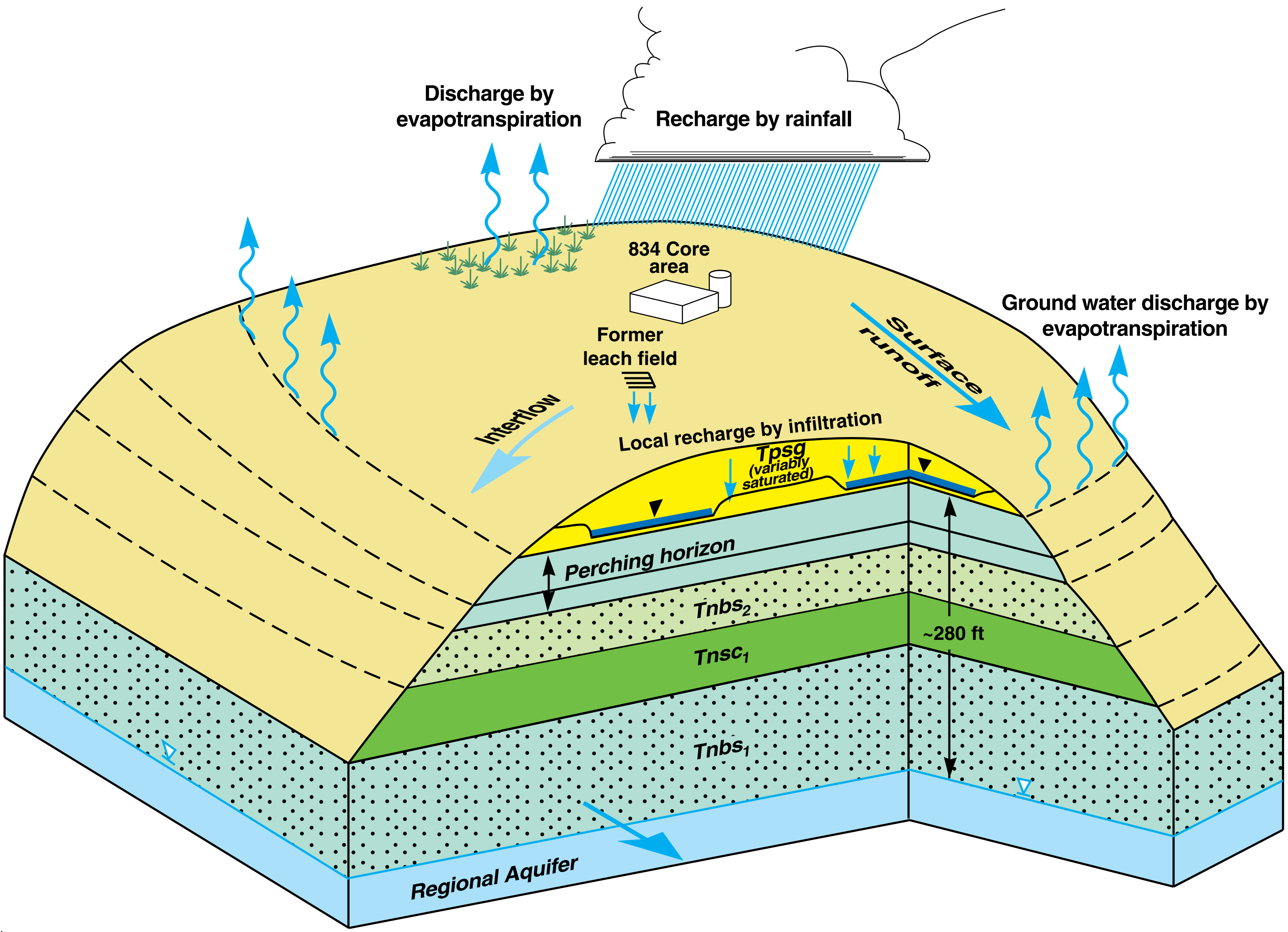


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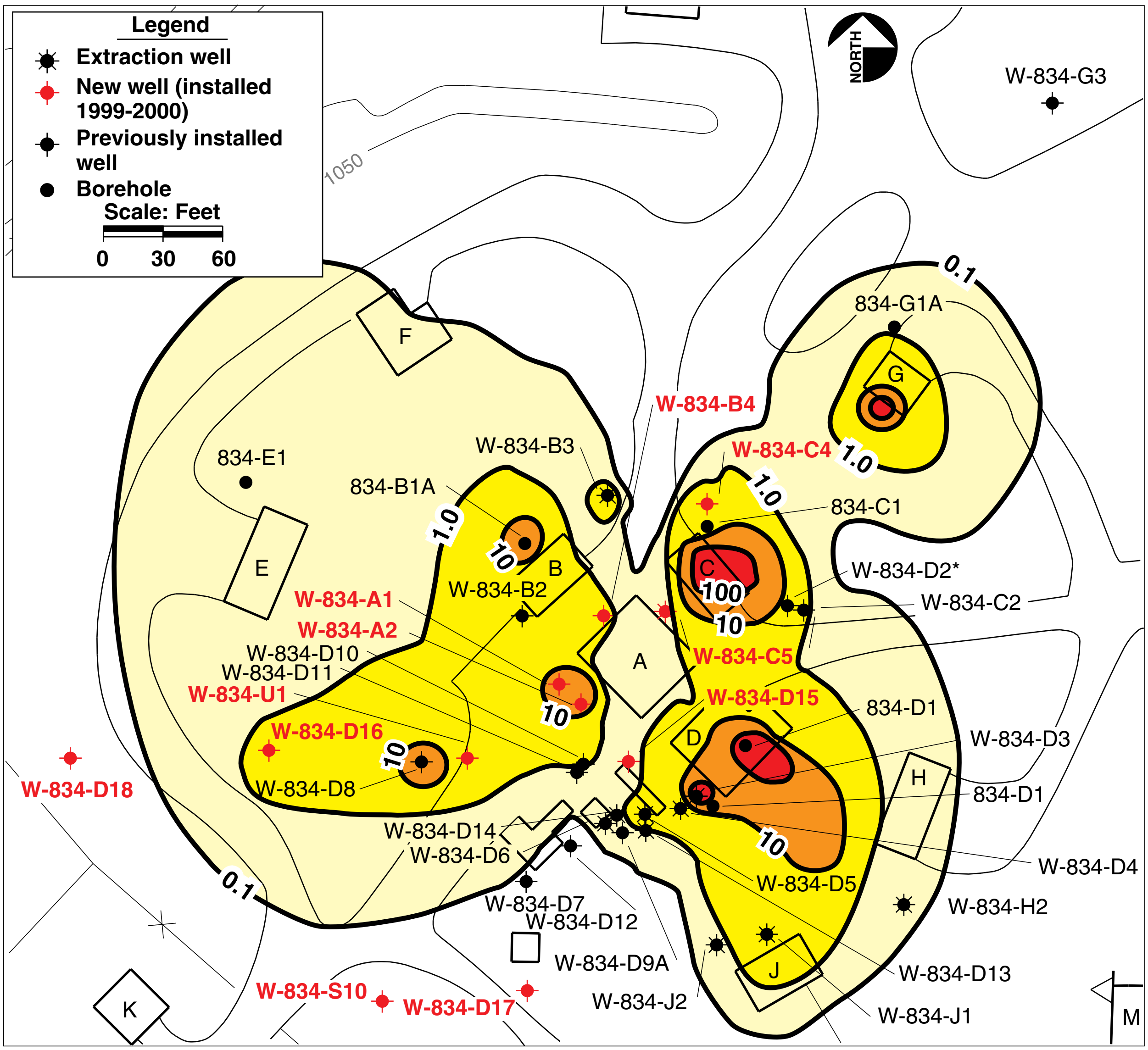
Figure 6. Conceptual hydrogeologic model of the Building 834 Operable Unit.



ERD-S3R-01-0091

Figure 7. Maximum aerial extent of TCE contamination in soil greater than 0.1 mg/kg at the Building 834 Complex (based on three dimensional spatial model).

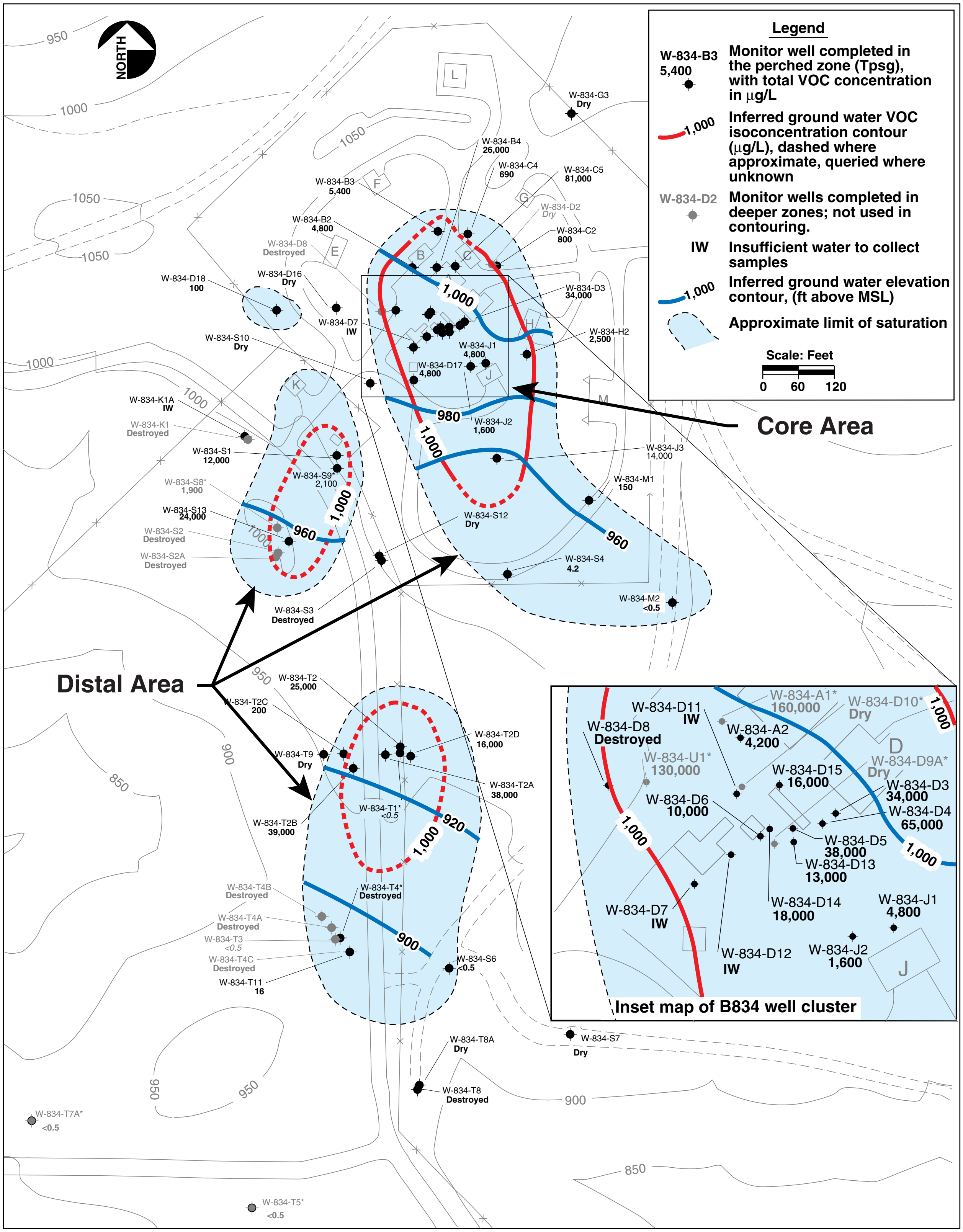


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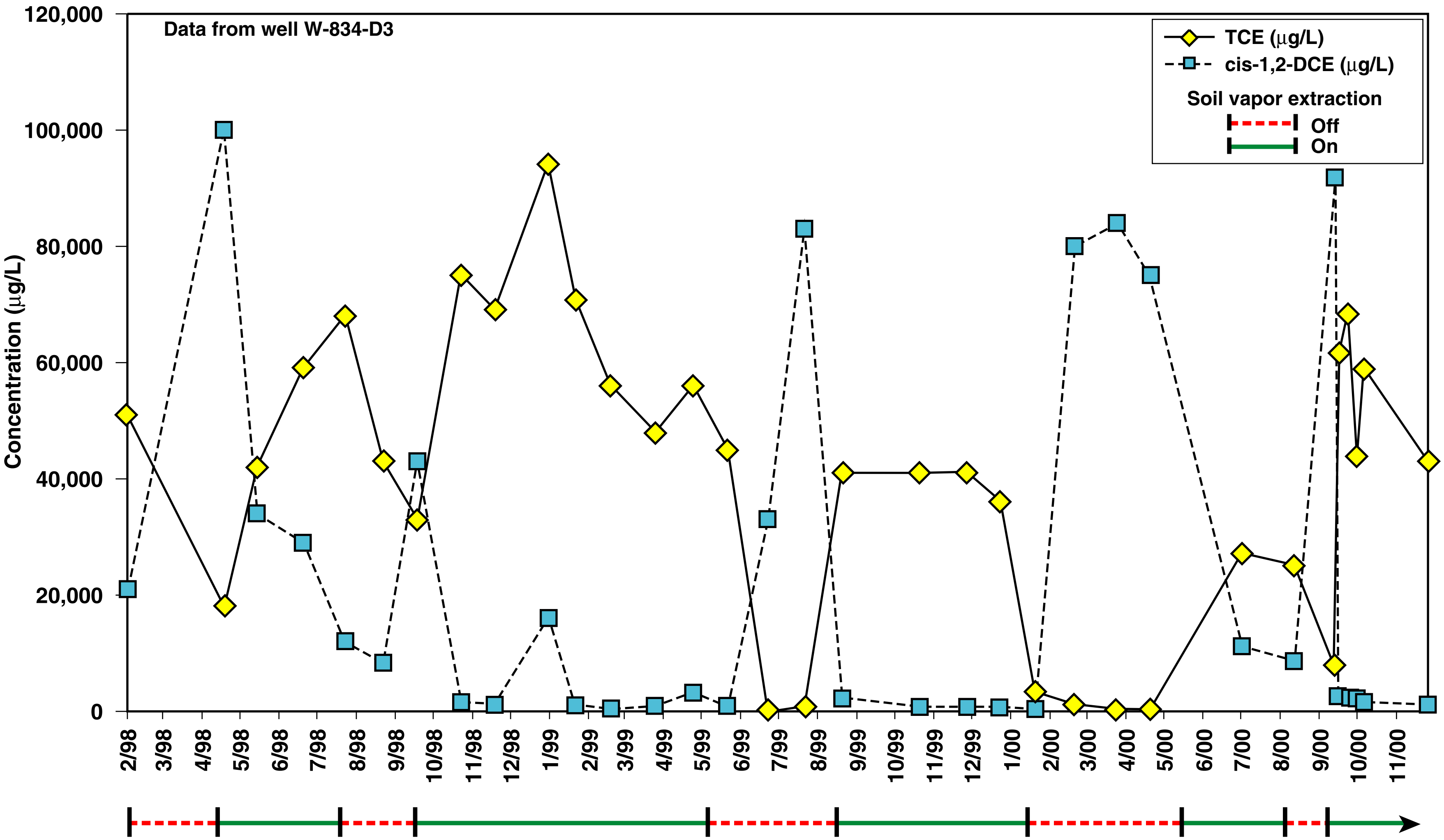
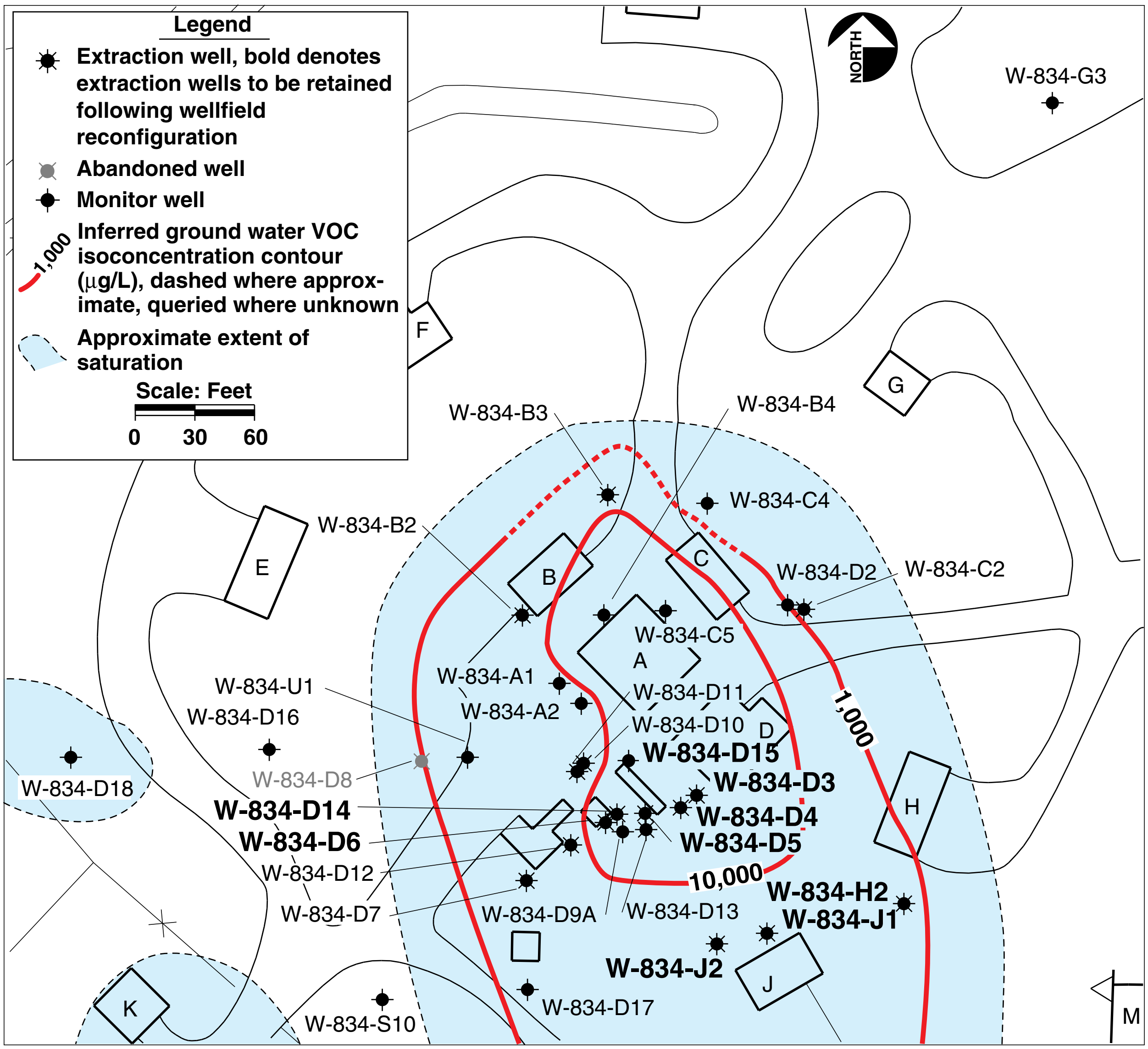
Figure 8. Extent of ground water contamination greater than 1,000 µg/L and potentiometric surface at the Building 834 Complex (based on 3rd Qtr 2000 monitoring data).



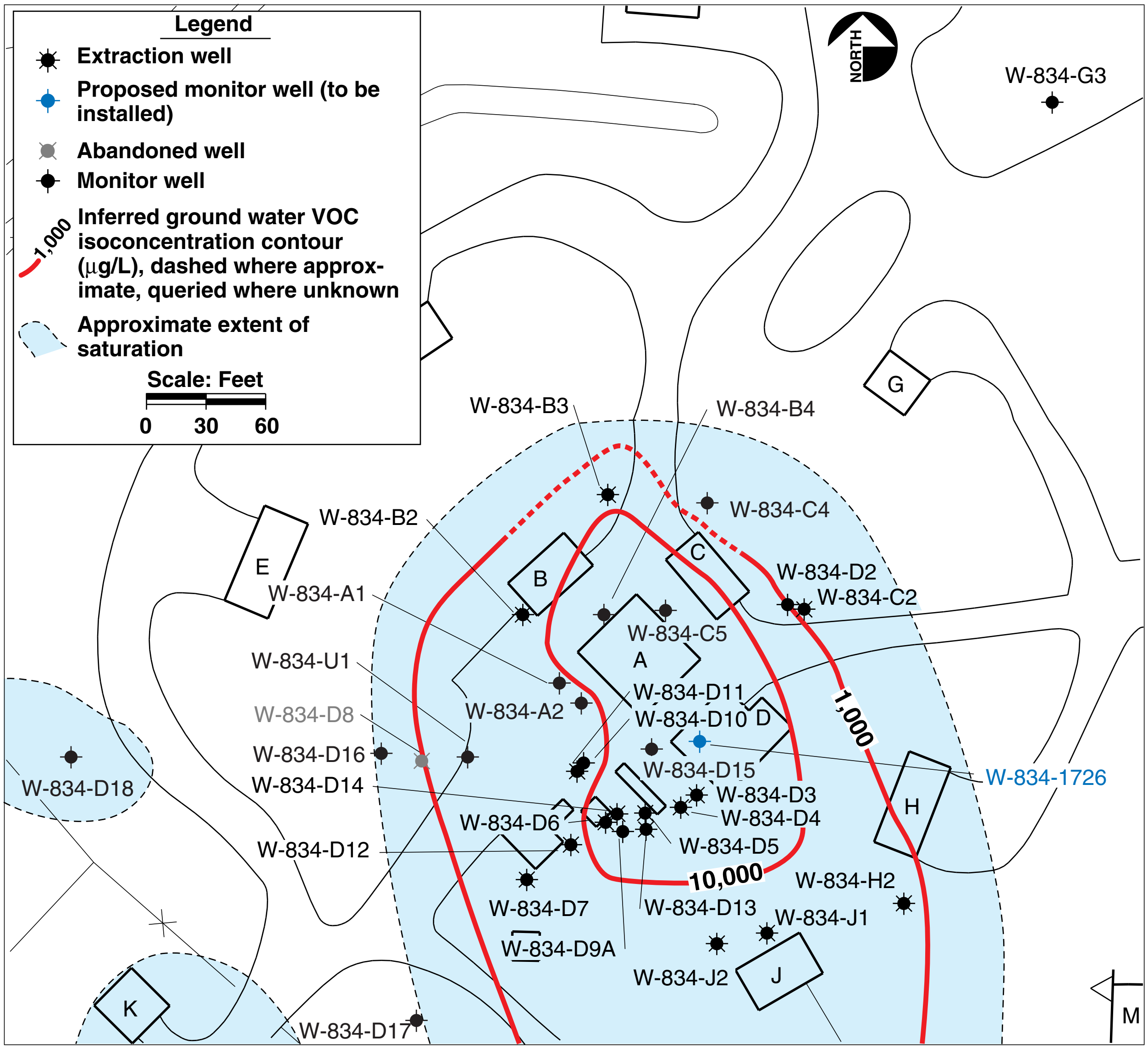
ERD-S3R-01-0104

Figure 9. Time-series plot of TCE and cis-1,2-DCE concentrations in W-834-D3 with corresponding facility operation status.



ERD-S3R-01-0093

Figure 10. Existing extraction and monitor wellfield in the Building 834 Core Area.



ERD-S3R-01-0090

Figure 11. Proposed extraction and monitor wellfield in the Building 834 Core Area.

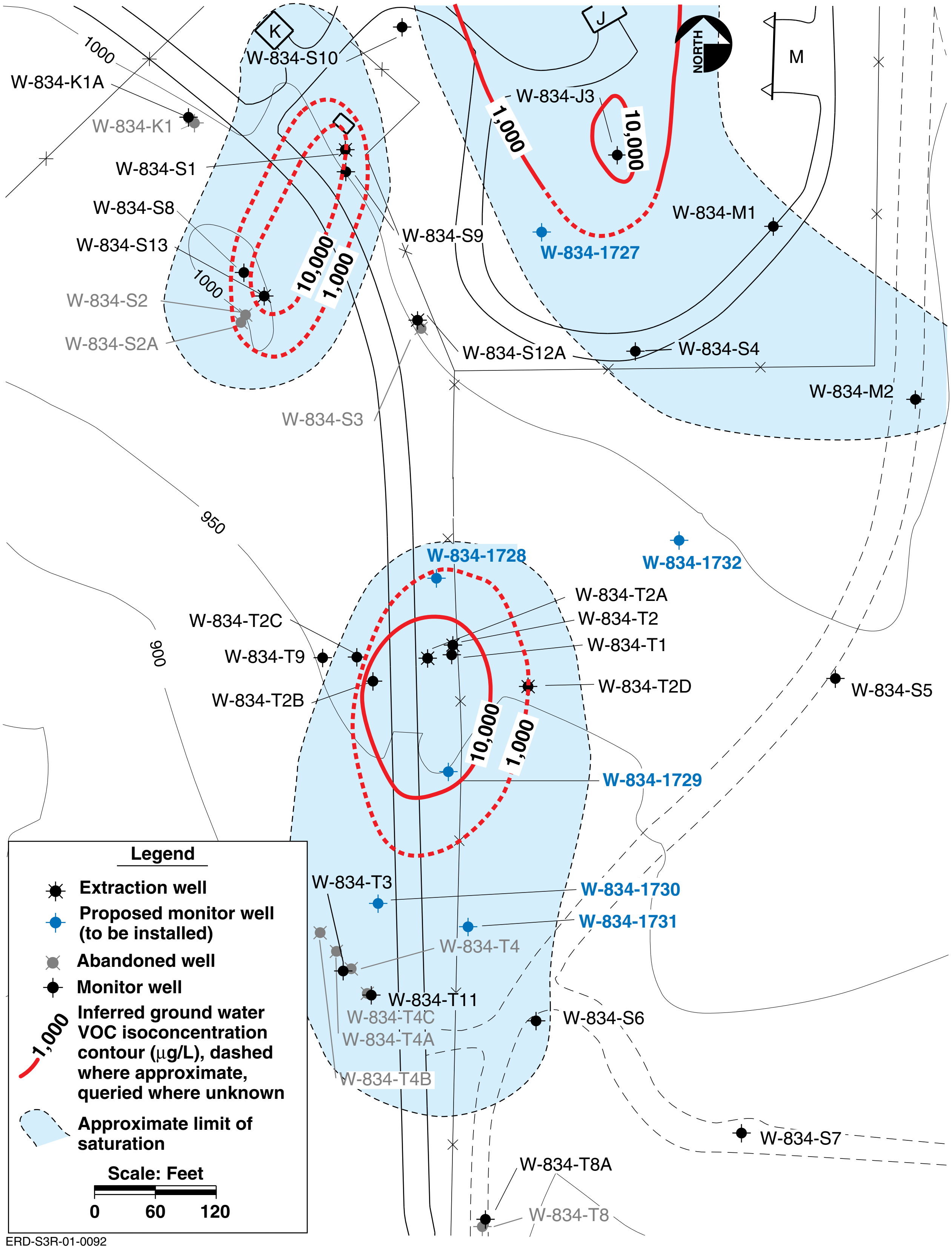
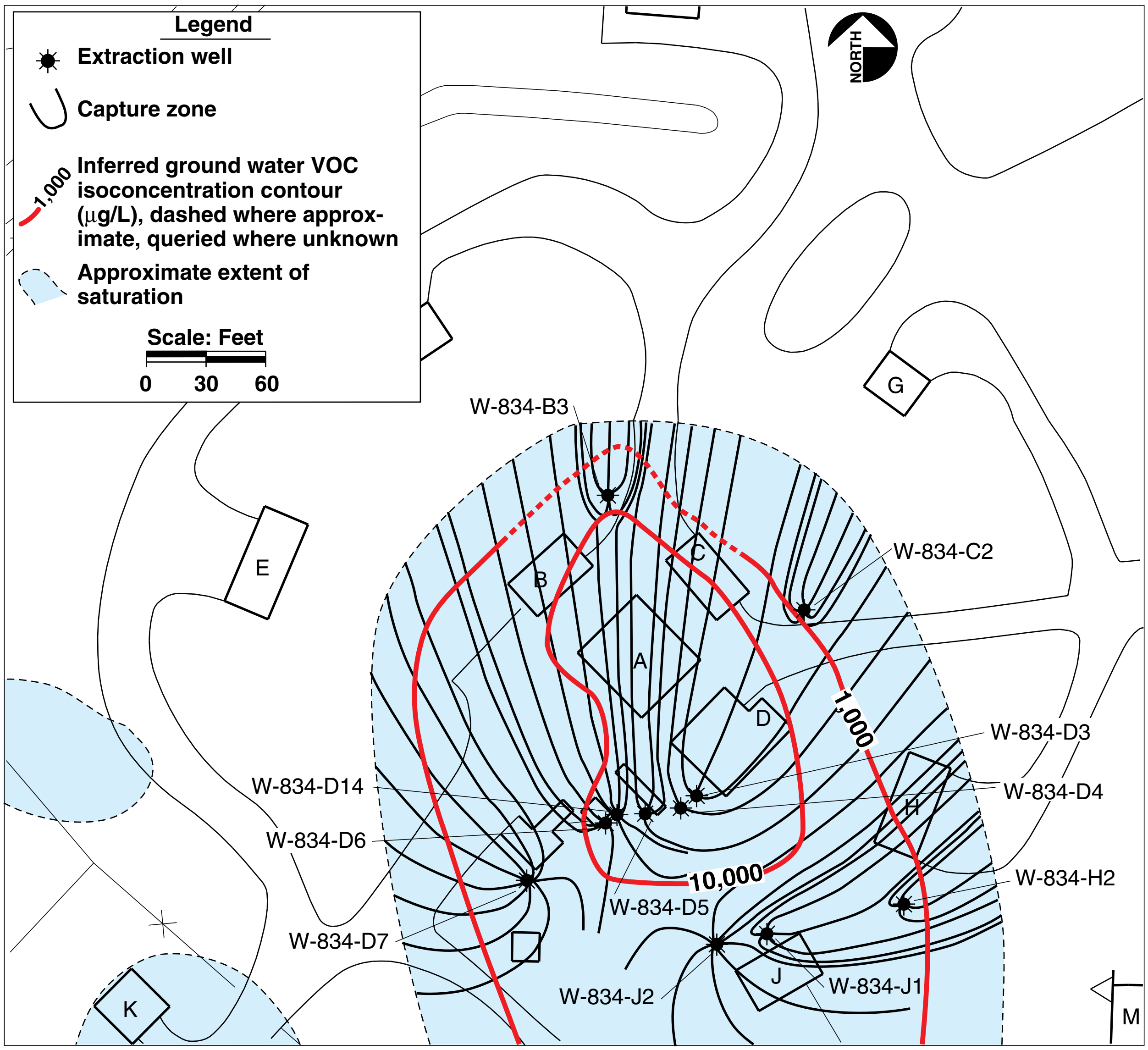


Figure 12. Proposed extraction and monitor wellfield in the Building 834 Distal Area.



ERD-S3R-01-0296

Figure 13. Ground water capture in the Building 834 Core Area.

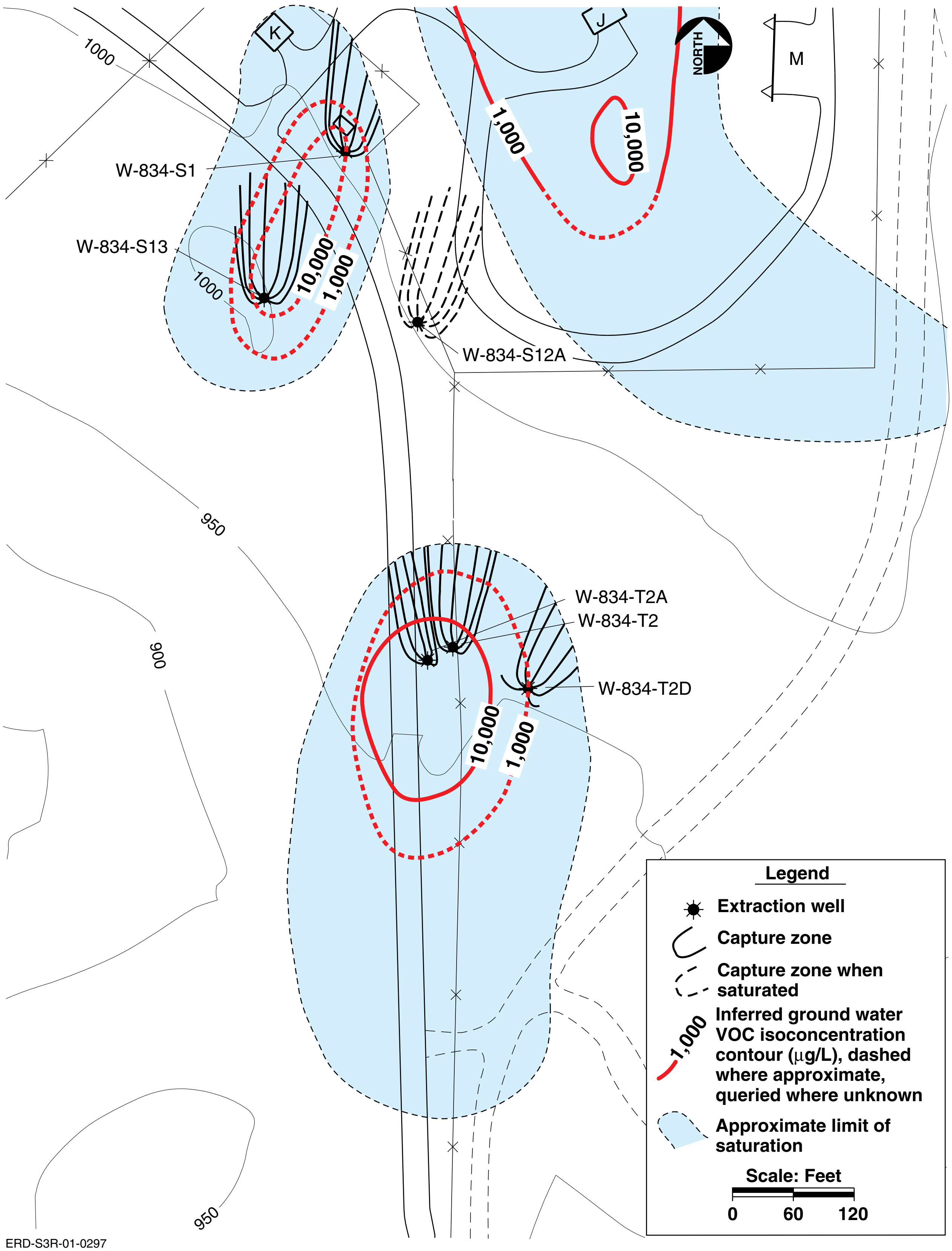
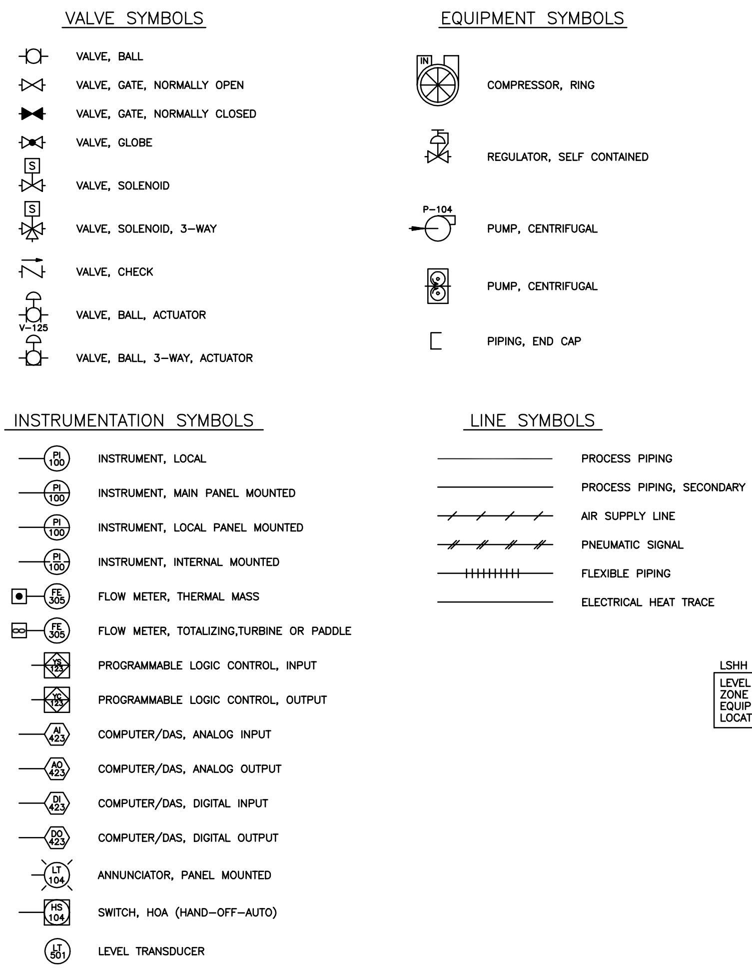
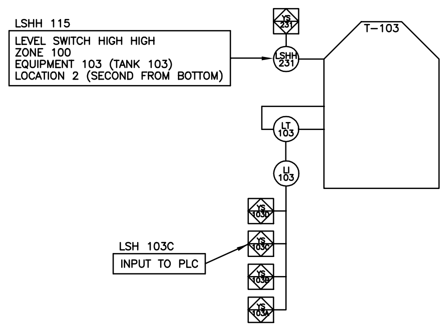


Figure 14. Ground water capture in the Building 834 Distal Area.



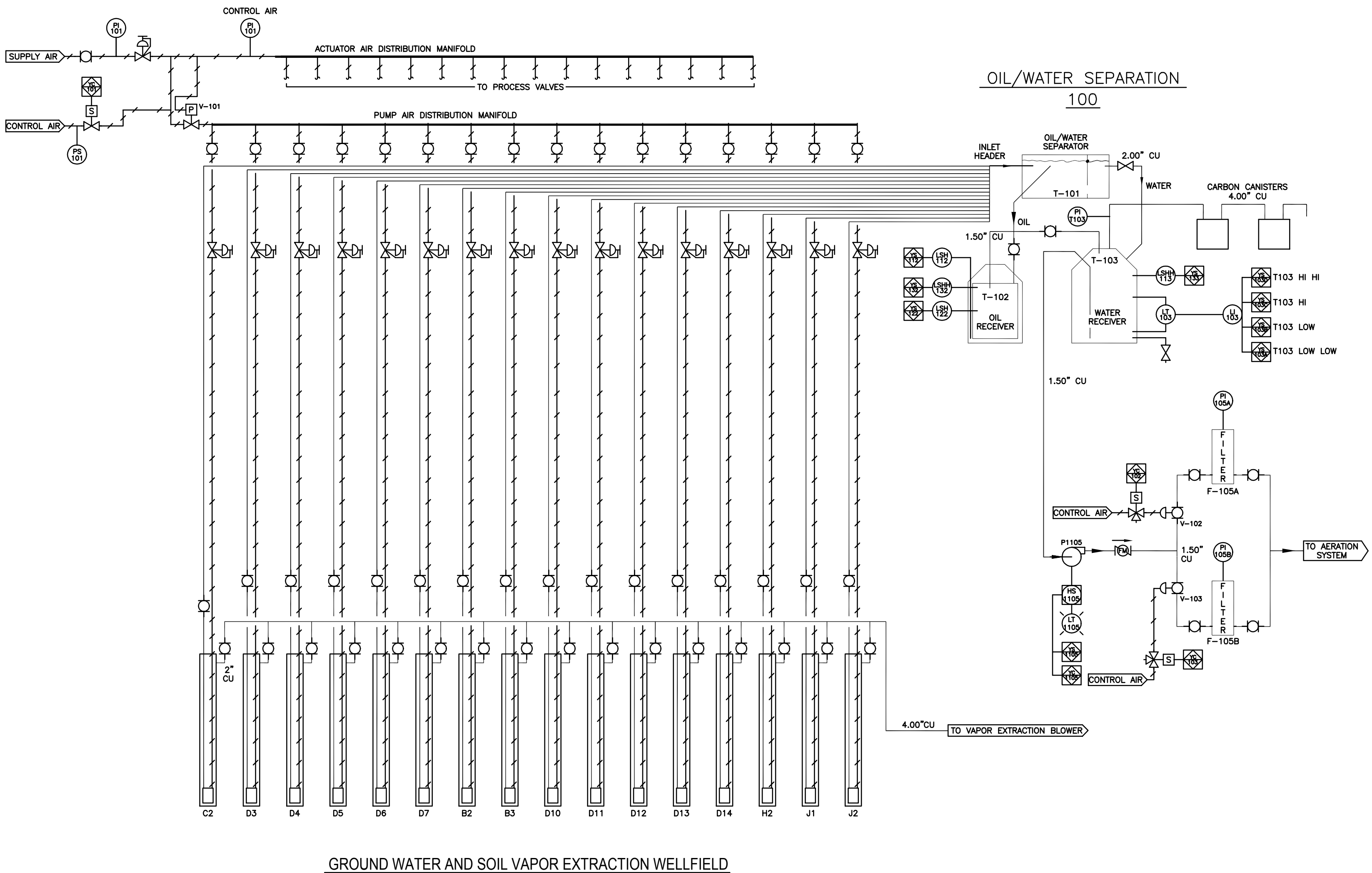


INSTRUMENTATION AND LOOP NUMBERS

INSTRUMENT LETTER IDENTIFICATION TABLE			
	FIRST LETTER MEASURED ON INTIATING VARIABLE	SECOND LETTER READOUT FOR OUTPUT FUNCTION	SUCCEEDING LETTERS (IF REQUIRED)
A	ANALYSIS	ALARM	ALARM
B	BURNER		
C	CONDUCTIVITY	CONTROL(LER)	CONTROL(LER)
D	DENSITY/DAMPER	DIFFERENTIAL	
E	VOLTAGE(ELECT)	PRIMARY ELEMENT	
F	FLOW	RATIO/BIAS	RATIO/BIAS
G	GAGING(DIMENSIONAL)	GLASS	
H	HAND(MANUAL)		HIGH
I	CURRENT(ELECT)	INDICATE	INDICATE
J	POWER	SCAN(NER)	
K	TIME	CONTROL STATION	
L	LEVEL	LIGHT	LOW
M	MOISTURE/MASS		MIDDLE/INTERMEDIATE
N			
O			
P	PRESSURE	POINT(TEST)	
Q	QUANTITY	TOTALIZE/QUANTITY	
R		RECORD	RECORD
S	SPEED/FREQUENCY	SAFETY/SWITCH	SWITCH
T	TEMPERATURE	TRANSMITTER	TRANSMITTER
U	MULTI-POINT/VARIABLE	MULTI-FUNCTION	MULTI-FUNCTION
V	VISCOSITY	VALVE	VALVE
W	WEIGHT	WELL	
X	SPECIAL	SPECIAL	SPECIAL
Y	INTERLOCK	RELAY/COMPUTE	RELAY/COMPUTE
Z	POSITION	DAMPER OR LOUVER DRIVE	

L	SH	211	A
FIRST LETTER	SUCCEEDING LETTERS	LOOP NUMBER	SUFFIX
FUNCTIONAL IDENTIFICATION		LOOP IDENTIFICATION	
INSTRUMENT IDENTIFICATION OR TAG NUMBER			

Figure 15A. Existing Process and Instrumentation Diagram for Building 834 Treatment Facility (symbol list).



ERD-S3R-01-0109

Figure 15B. Existing Process and Instrumentation Diagram for Building 834 Treatment Facility (extraction wellfield and oil/water separator).

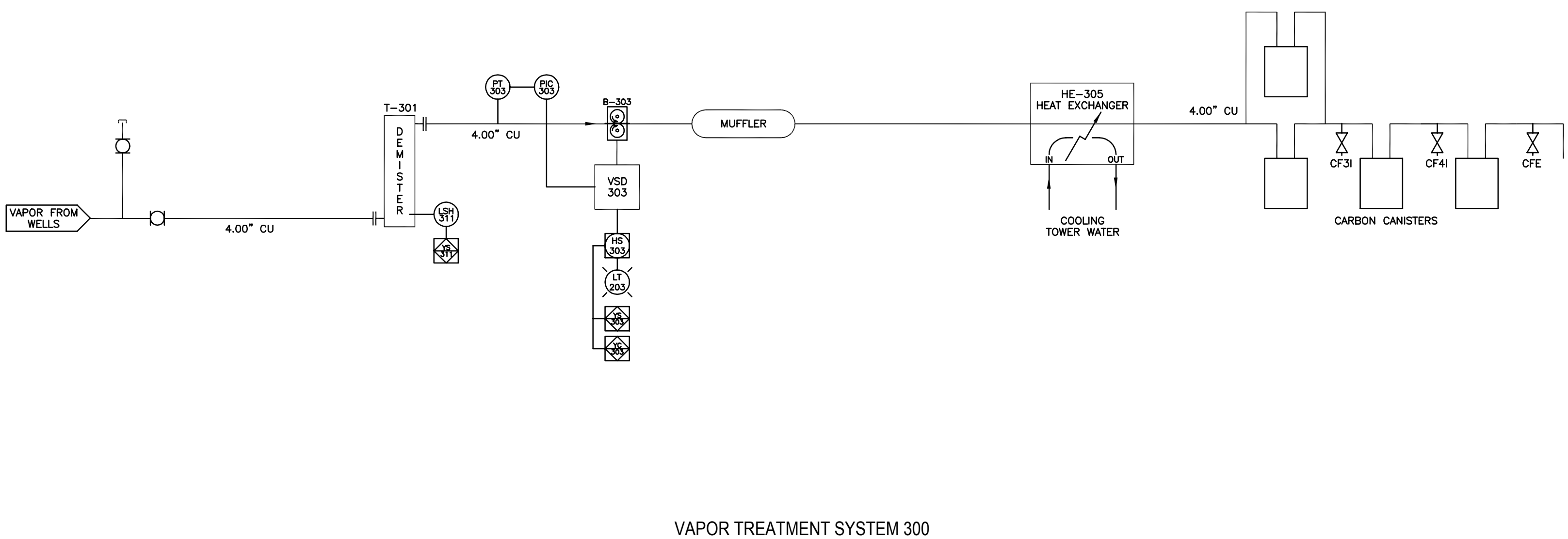
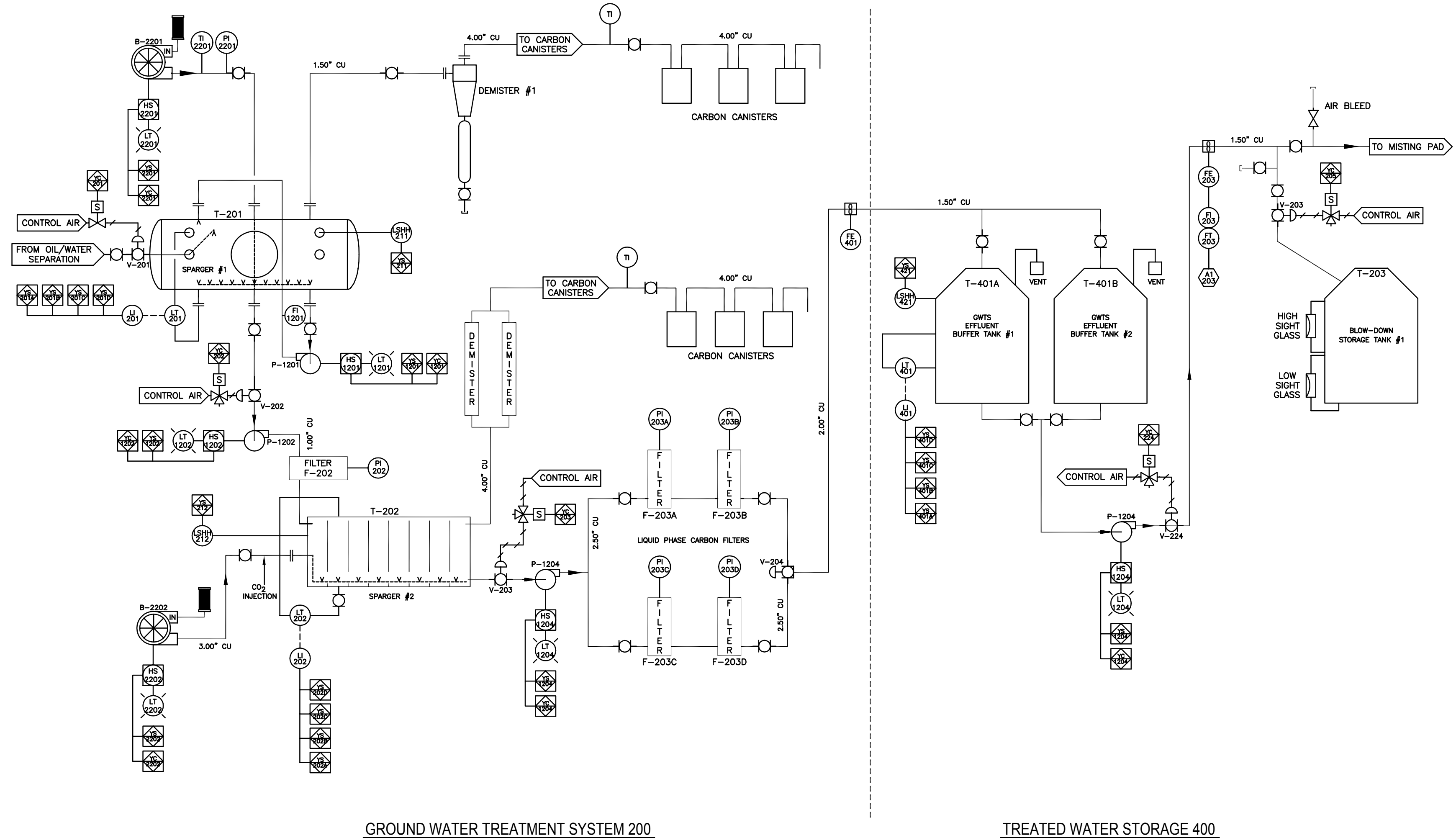
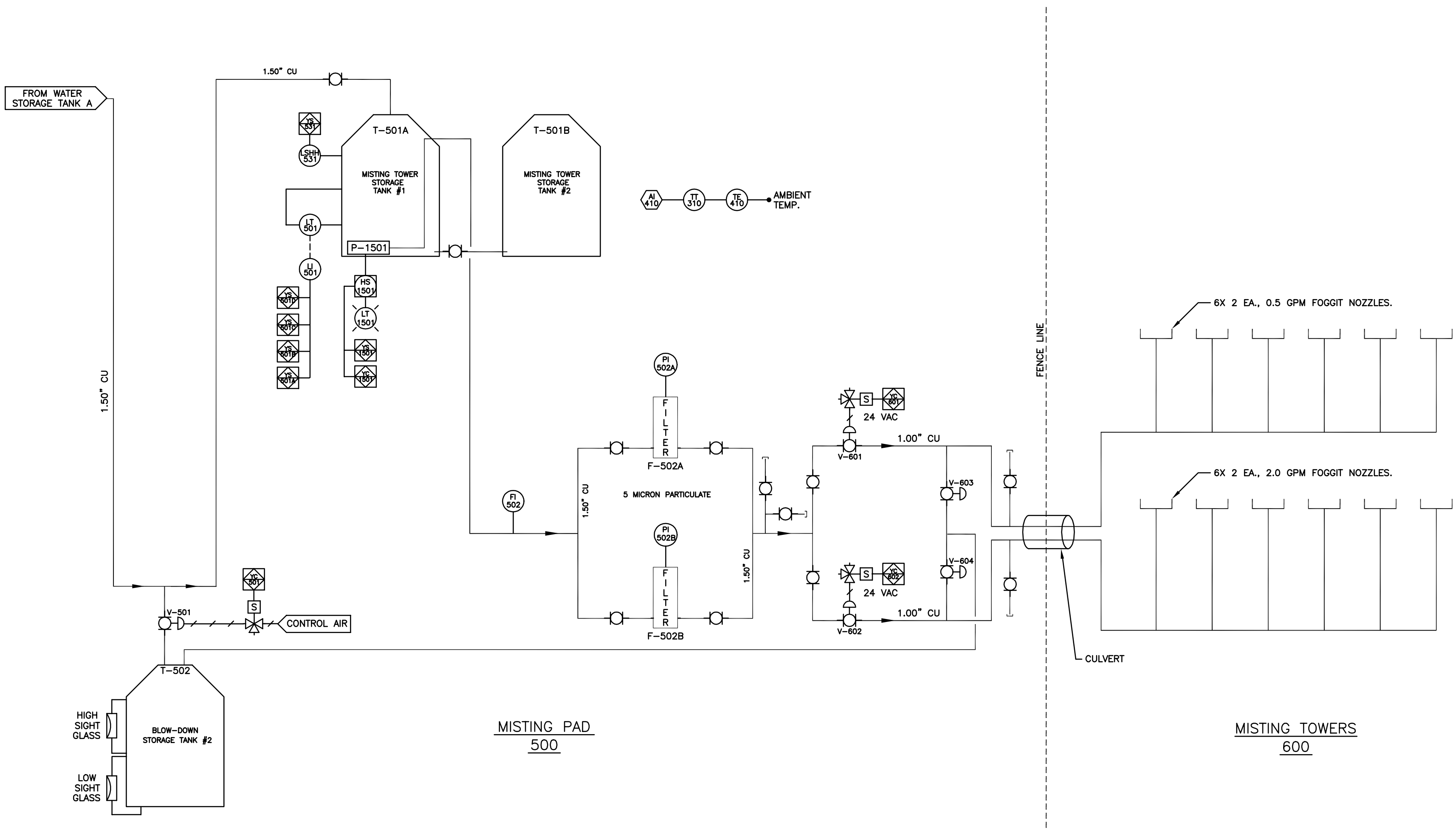


Figure 15C. Existing Process and Instrumentation Diagram for Building 834 Treatment Facility (vapor treatment system).



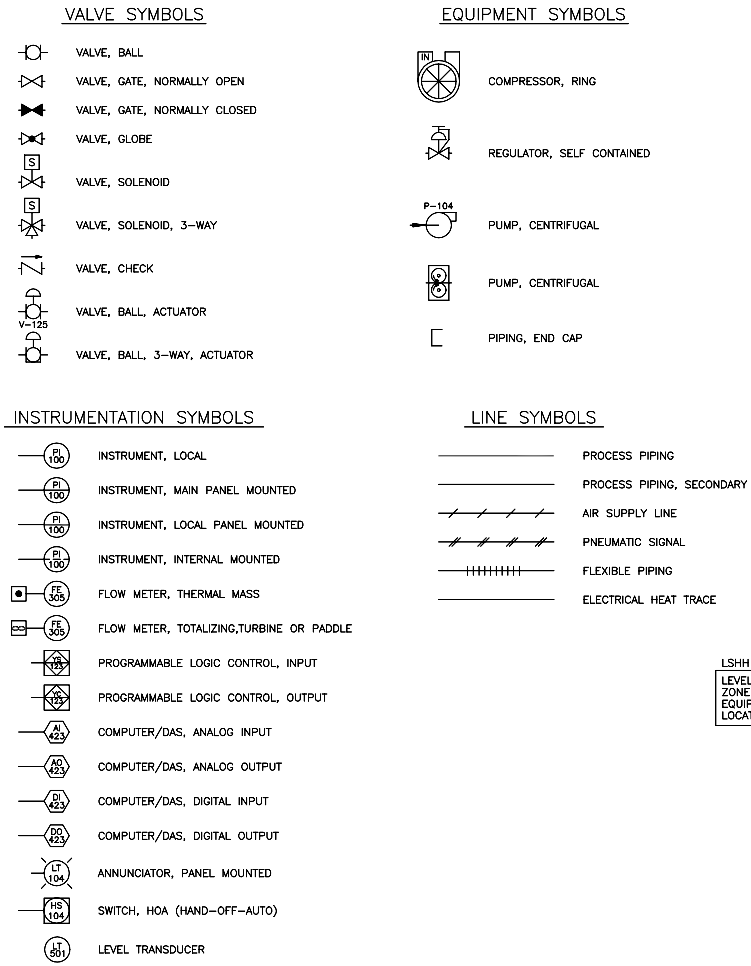
ERD-S3R-01-0111

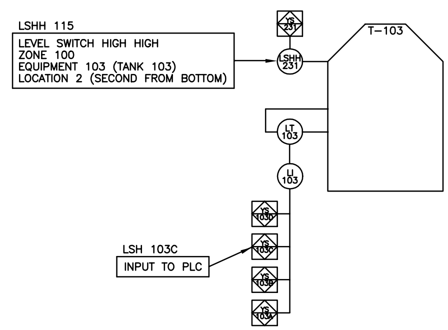
Figure 15D. Existing Process and Instrumentation Diagram for Building 834 Treatment Facility (ground water treatment system).



ERD-S3R-01-0159

Figure 15E. Existing Process and Instrumentation Diagram for Building 834 Treatment Facility (misting discharge system).

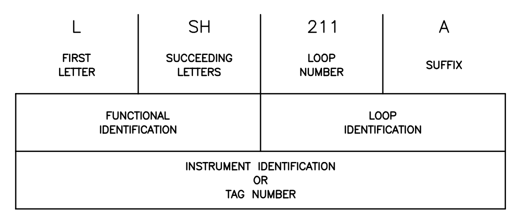




INSTRUMENTATION AND LOOP NUMBERS

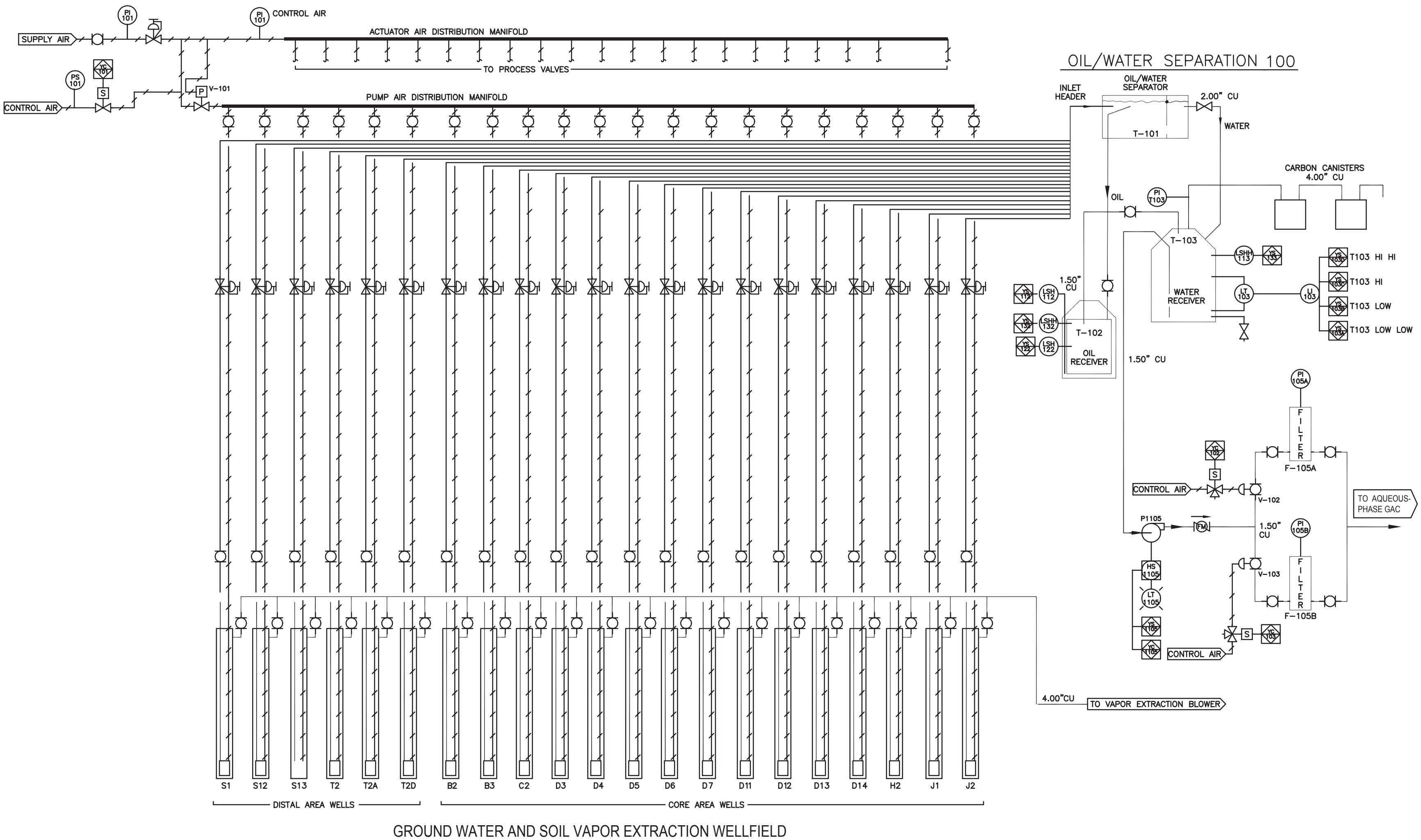
INSTRUMENT LETTER IDENTIFICATION TABLE

	FIRST LETTER MEASURED ON INTIATING VARIABLE	SECOND LETTER READOUT FOR OUTPUT FUNCTION	SUCCEEDING LETTERS (IF REQUIRED)
A	ANALYSIS	ALARM	ALARM
B	BURNER		
C	CONDUCTIVITY	CONTROL(LER)	CONTROL(LER)
D	DENSITY/DAMPER	DIFFERENTIAL	
E	VOLTAGE(ELECT)	PRIMARY ELEMENT	
F	FLOW	RATIO/BIAS	RATIO/BIAS
G	GAGING(DIMENSIONAL)	GLASS	
H	HAND(MANUAL)		HIGH
I	CURRENT(ELECT)	INDICATE	INDICATE
J	POWER	SCAN(NER)	
K	TIME	CONTROL STATION	
L	LEVEL	LIGHT	LOW
M	MOISTURE/MASS		MIDDLE/INTERMEDIATE
N			
O			
P	PRESSURE	POINT(TEST)	
Q	QUANTITY	TOTALIZE/QUANTITY	
R		RECORD	RECORD
S	SPEED/FREQUENCY	SAFETY/SWITCH	SWITCH
T	TEMPERATURE	TRANSMITTER	TRANSMITTER
U	MULTI-POINT/VARIABLE	MULTI-FUNCTION	MULTI-FUNCTION
V	VISCOSITY	VALVE	VALVE
W	WEIGHT	WELL	
X	SPECIAL	SPECIAL	SPECIAL
Y	INTERLOCK	RELAY/COMPUTE	RELAY/COMPUTE
Z	POSITION	DAMPER OR LOUVER DRIVE	



ERD-S3R-01-0108

Figure 16A. Proposed Process and Instrumentation Diagram for Building 834 Treatment Facility (symbol list).



ERD-S3R-01-0114

Figure 16B. Proposed Process and Instrumentation Diagram for Building 834 Treatment Facility (extraction wellfield and oil/water separator).

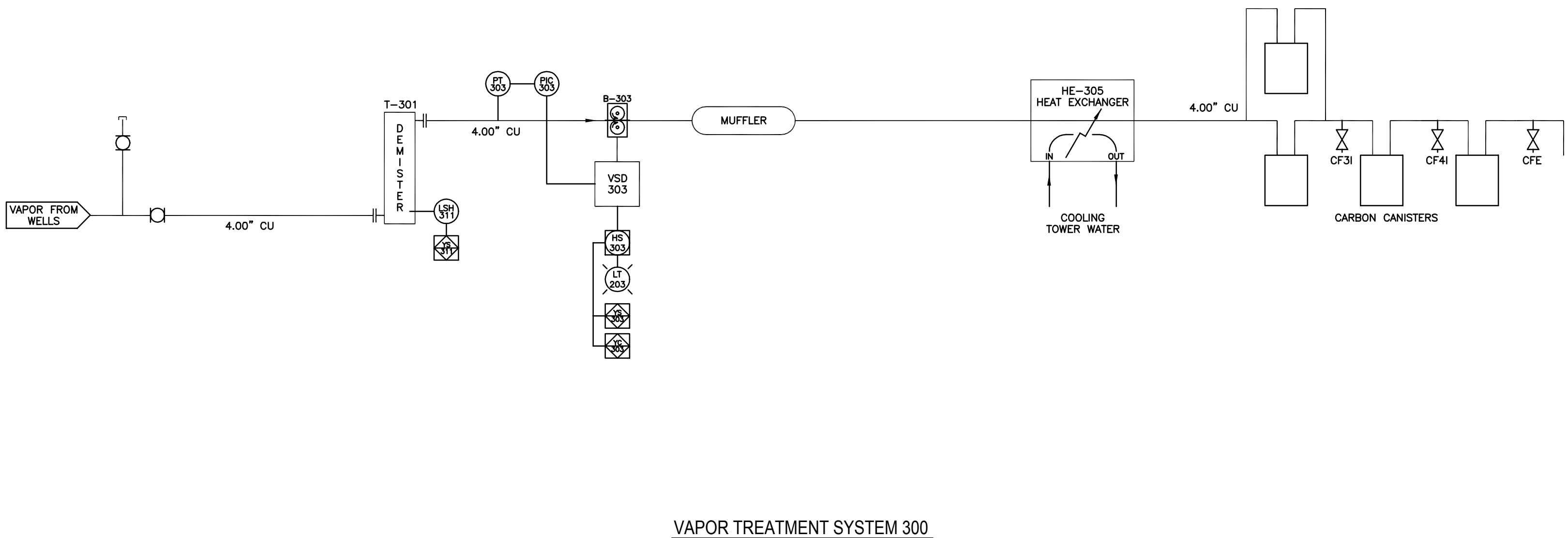
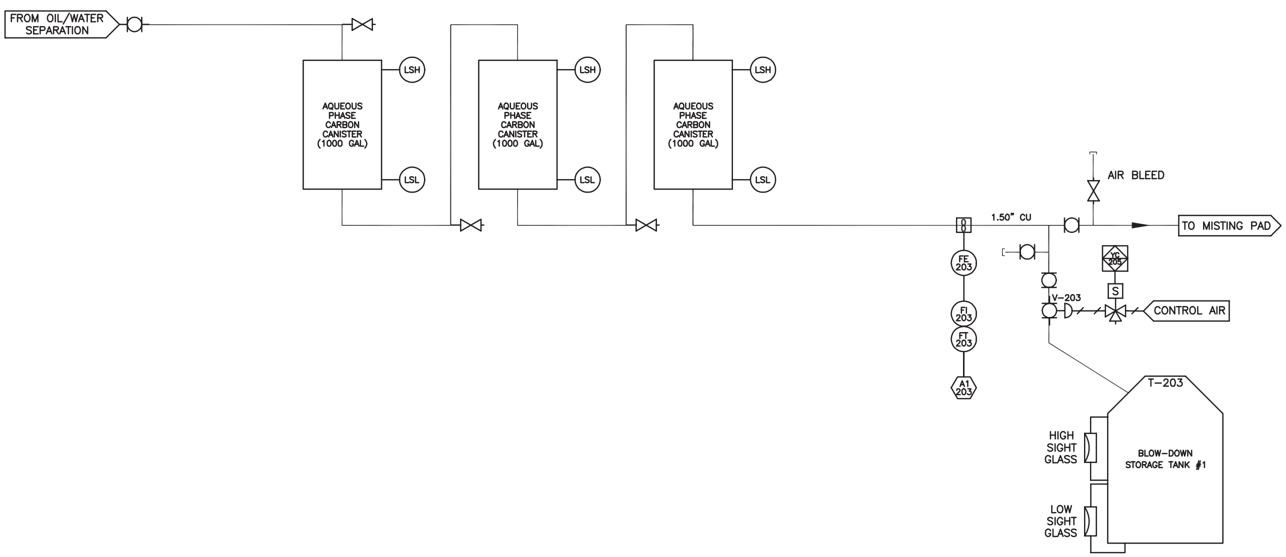


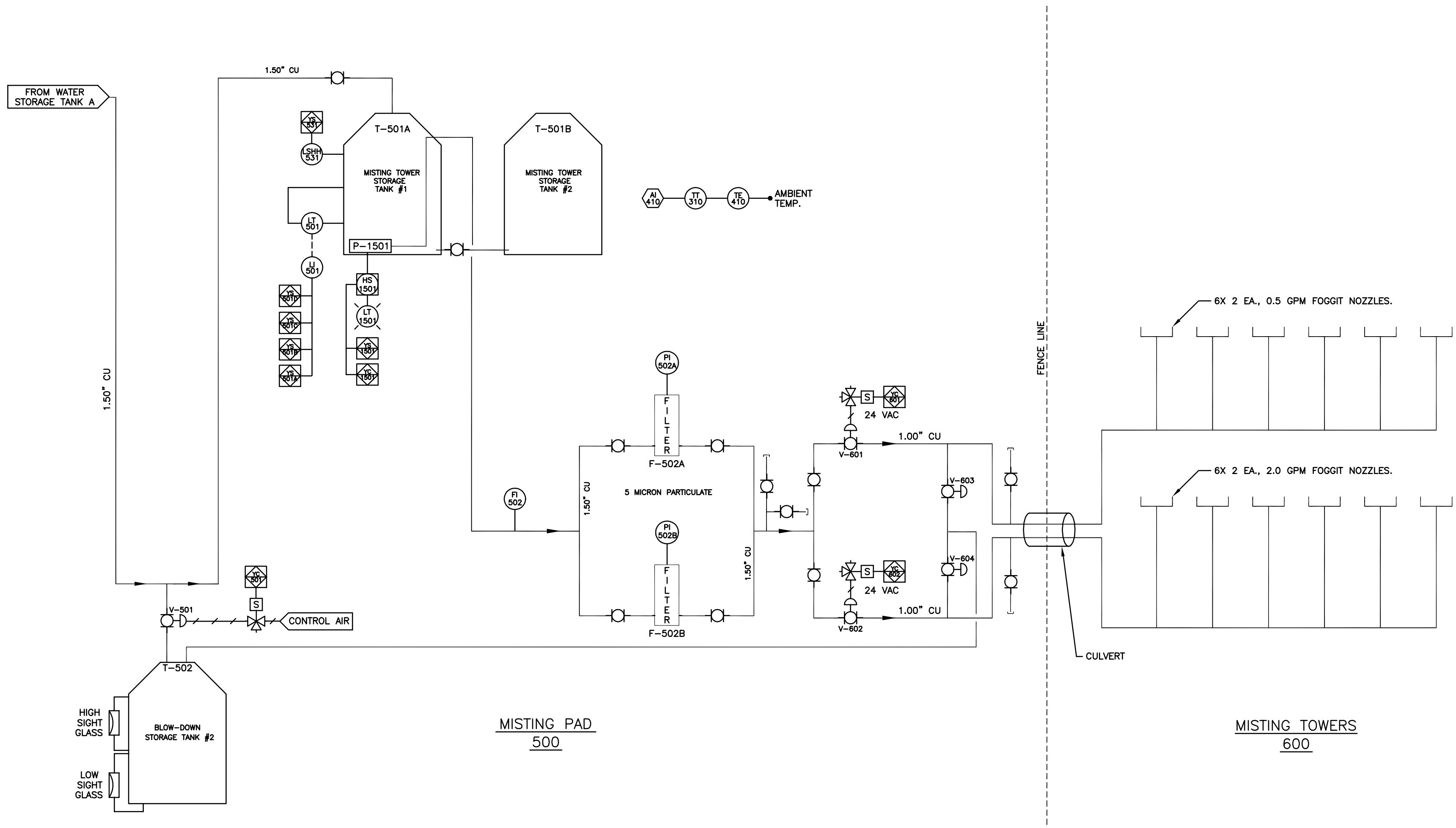
Figure 16C. Proposed Process and Instrumentation Diagram for Building 834 Treatment Facility (vapor treatment system).



GROUND WATER TREATMENT SYSTEM 200

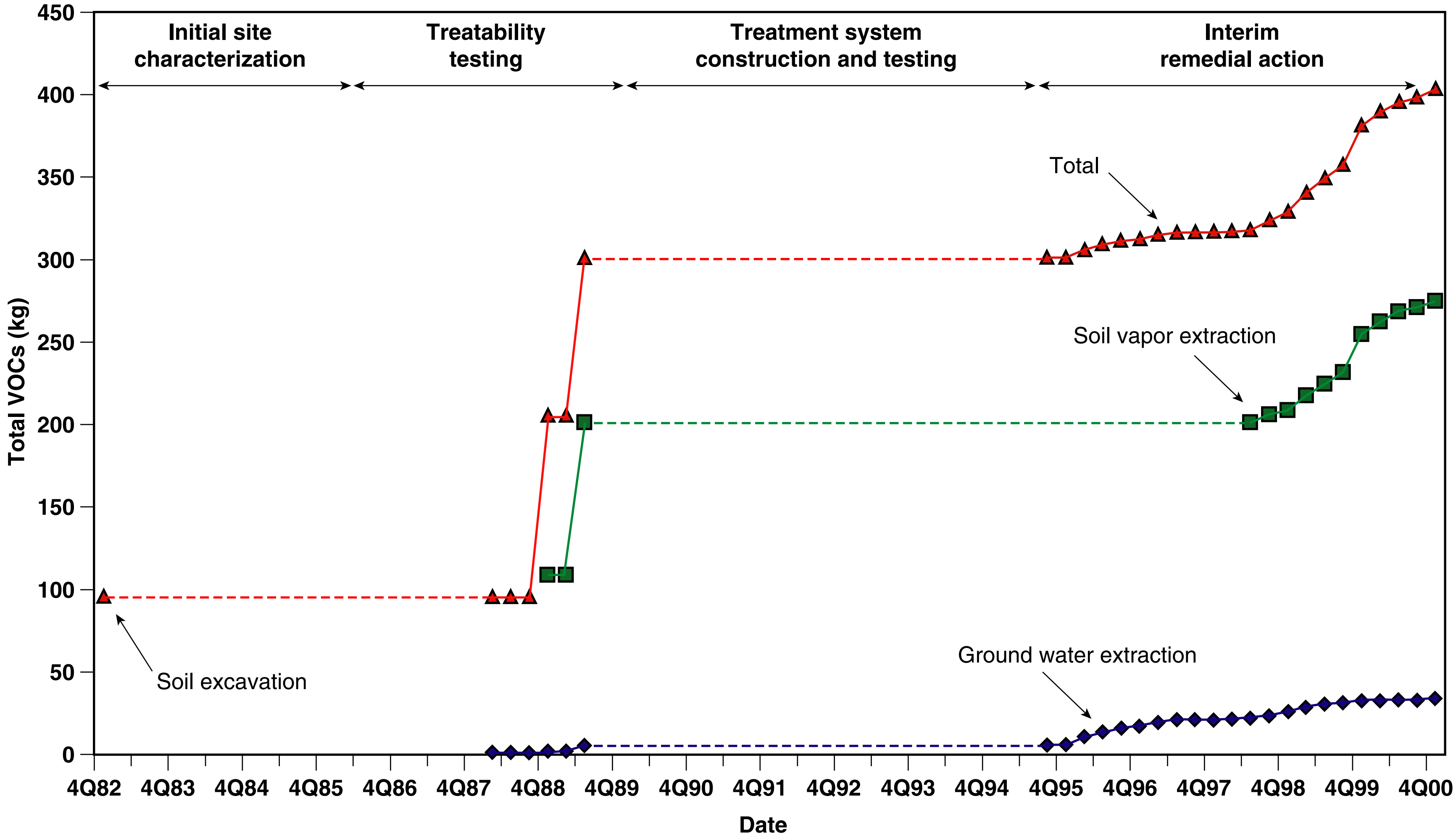
ERD-S3R-01-0113

Figure 16D. Proposed Process and Instrumentation Diagram for Building 834 Treatment Facility (ground water treatment system).



ERD-S3R-01-0112

Figure 16E. Proposed Process and Instrumentation Diagram for Building 834 Treatment Facility (misting discharge system).



ERD-S3R-01-0094

Figure 17. Time-series plot of cumulative mass of total VOCs removed from the Building 834 subsurface since 1982.

Tables

Table 1. Summary of characterization activities in the Building 834 Operable Unit.

	Events	Comments
1983–1985	Site inspection and surface soil sampling.	DNAPL discovered in soil near C-Cell.
1983	Excavation of DNAPL contaminated soils at Building 834 C-Cell.	Free phase DNAPL contaminated soil excavated and removed from the site.
1983–1989	Phase 1 of drilling/sampling of boreholes and installation of monitor wells.	Initial subsurface soil and ground water investigations. Seventeen core monitor wells converted to SVE/GWE wells.
1987	Rerouting of cooling tower blow down and septic system leach field.	Rerouted discharge line to leach field.
1986–1989	Pilot treatability testing of the GWE and SVE system. Soil vapor survey.	Initial testing of selected wells in the Core Area to determine ground water capture areas and SVE influence.
1988	Excavation of seepage face test pits and installation of test pit piezometers.	To locate contact between Tpsg and Tps, identify perched water discharge and lateral extent of VOCs.
1990–1994	Installation of the Core Area ground water and soil vapor treatment system.	
1994–1995	Proof-of-system Testing for GWE.	Testing required for startup of the GWE system.
1995–1998	Operation of GW treatment system only.	
1997	Surfactant push-pull tests.	
1998–1999	Continuous 8 hr/day, 5-day/wk operation of SVE and GWE.	
Summer 1999	GORE-SORBER® passive soil vapor survey.	GORE-SORBER® survey assisted in defining limits of soil contamination.
1999–2000	Ten existing wells destroyed and 17 new ground water monitor wells installed.	High soil and ground water concentrations in Tps clay-perching horizon discovered.
1999–present	Continuous 24-hr/day, 7-day/week operation of SVE and GWE.	
1998–2000	Biogeochemical monitoring of VOCs, redox, DO, pH, nitrate, etc. Tracking GWE/SVE system operations.	Monthly monitoring of biogeochemical indicators to evaluate intrinsic biodegradation in the Core Area.
1999–2000	Microbial characterization, stable isotope analyses, and microcosm studies.	Laboratory studies were conducted to indicate the potential for intrinsic and enhanced bioremediation.

Notes appear on following page.

Table 1. Summary of characterization activities in the Building 834 Operable Unit. (Cont. Page 2 of 2)

DNAPL =	**Dense, non-aqueous phase liquid.**
DO =	**Dissolved oxygen.**
GW =	**Ground water.**
GWE =	**Ground water extraction.**
hr =	**Hours.**
SVE =	**Soil vapor extraction.**
Tps =	**Pliocene nonmarine unit.**
Tpsg =	**Pliocene nonmarine unit (gravel facies).**
VOCs =	**Volatile organic compounds.**

Table 2. TCE soil mass removed during 1982–1983 soil excavations at Building 834 Core Area (assuming 1.75 g/cm³ soil density).

Excavation site	Soil excavated (yd^3)	Avgerage TCE concentration (mg/kg)	TCE (kg)
Building B	20	- 4.8	0.2
Building C	8	6, 300	88.2
Building D	40	110.5	7.7
Building G	20	0.2	0.007
Building J	20	2.6	0.09
		Total estimated TCE mass removed =	96.2

Notes:

g/cm^3 = Grams per cubic centimeter.

mg/kg = Milligrams per kilogram.

TCE = Trichloroethylene.

yd = Yard.

Table 3. Geologic units in the Building 834 Operable Unit.

Geologic units	Description	Depth (ft bgs)	Saturation	Comments
Tpsg	Sand and gravel	0–30	Multiple, variably saturated zones	May be hydraulically connected during high rainfall events
Tps	Clay	30–50	Saturated	Perching horizon for Tpsg
$Tnsc_2$	Siltstone/claystone	50–65	Saturated	
$Tnbs_2$	Sandstone	65–110	Unsaturated	
$Tnsc_1$	Siltstone/claystone	110–175	Unsaturated	
$Tnbs_1$	Sandstone	175–300	Unsaturated	
$Tnbs_1$	Sandstone	300→	Saturated	Regional water table

Notes:

ft bgs = Feet below ground surface.

$Tnbs_1$ = Miocene Neroly Formation – Lower Blue Sandstone Member.

$Tnbs_2$ = Miocene Neroly Formation – Upper Blue Sandstone Member.

$Tnsc_1$ = Miocene Neroly Formation – Middle Siltstone/Claystone Member.

$Tnsc_2$ = Miocene Neroly Formation – Upper Siltstone/Claystone Member.

Tps = Pliocene nonmarine unit.

Tpsg = Pliocene nonmarine unit (gravel facies).

Table 4. TCE concentrations in surface and subsurface soils at the Building 834 Operable Unit.

Sample location	Sample depth (ft)	TCE concentration (mg/kg)
W-834-A1	4.6	<0.0005
W-834-A1	7.1	<0.0005
W-834-A1	12.1	<0.0005
W-834-A1	14.6	0.73
W-834-A1	18.6	0.28
W-834-A1	22.6	0.16
W-834-A1	25.6	0.096
W-834-A1	28.1	13
W-834-A1	30.6	5
W-834-A2	0.3	0.037
W-834-A2	2.5	<0.0005
W-834-A2	5.0	<0.0005
W-834-A2	7.5	<0.0005
W-834-A2	10.0	<0.0005
W-834-A2	12.5	<0.0005
W-834-A2	15.0	0.026
W-834-A2	17.5	0.11
W-834-A2	20.0	0.021
W-834-A2	22.5	0.0077
W-834-A2	25.0	0.012
W-834-A2	27.5	0.96
W-834-A2	30.0	0.047
W-834-A2	32.5	6
W-834-A2	35.0	12
834-B1A	1.0	0.52
834-B1A	3.0	0.025
834-B1A	17.0	7.5
834-B1A	20.5	13.1
834-B1A	21.0	3.1
834-B1A	30.5	0.025
W-834-B2	6.1	0.0003
W-834-B2	8.0	0.0002
W-834-B2	10.6	0.015

Table 4. TCE concentrations in surface and subsurface soils at the Building 834 Operable Unit. (Cont. Page 2 of 10)

Sample location	Sample depth (ft)	TCE concentration (mg/kg)
W-834-B2	13.2	0.038
W-834-B2	15.8	4.3
W-834-B3	4.6	0.004
W-834-B3	6.5	0.002
W-834-B3	8.5	0.066
W-834-B3	10.4	1.8
W-834-B4	2.1	<0.0005
W-834-B4	4.3	<0.0005
W-834-B4	6.6	<0.0005
W-834-B4	9.1	<0.0005
W-834-B4	11.6	0.0053
W-834-B4	12.1	0.0052
W-834-B4	12.6	0.023
W-834-B4	14.0	0.37
W-834-B4	14.5	0.51
W-834-B4	16.6	3.3
W-834-B4	19.1	0.2
W-834-B4	21.6	0.14
W-834-B4	24.1	0.43
W-834-B4	26.6	0.099
W-834-B4	29.1	0.29
W-834-B4	31.6	0.35
W-834-B4	34.1	0.78
W-834-B4	36.6	0.22
834-C1	7.3	6.6
834-C1	7.8	9.8
834-C1	10.5	0.68
834-C1	16.0	0.18
834-C1	20.3	0.001
834-C1	40.0	0.05
834-C1	50.0	0.05
W-834-C2	4.7	0.0024

Table 4. TCE concentrations in surface and subsurface soils at the Building 834 Operable Unit. (Cont. Page 3 of 10)

Sample location	Sample depth (ft)	TCE concentration (mg/kg)
W-834-C2	8.6	0.006
W-834-C2	12.6	0.0026
W-834-C2	14.9	0.053
W-834-C2	17.3	0.17
W-834-C4	1.8	<0.0005
W-834-C4	6.8	<0.0005
W-834-C4	8.3	0.014
W-834-C4	10.8	0.007
W-834-C4	12.8	<0.0005
W-834-C4	15.3	<0.0005
W-834-C4	18.3	<0.0005
W-834-C4	20.8	<0.0005
W-834-C4	23.3	<0.0005
W-834-C4	25.8	<0.0005
W-834-C4	28.3	<0.0005
W-834-C4	31.3	<0.0005
W-834-C4	33.3	<0.0005
W-834-C5	5.0	<0.0005
W-834-C5	6.2	<0.0005
W-834-C5	8.7	<0.0005
W-834-C5	11.2	0.34
W-834-C5	12.4	0.35
W-834-C5	13.7	0.15
W-834-C5	16.2	0.18
W-834-C5	18.7	0.12
W-834-C5	21.2	0.025
W-834-C5	22.7	0.01
W-834-C5	26.2	<0.0005
W-834-C5	28.7	<0.0005
W-834-C5	31.2	<0.0005
W-834-C5	33.7	0.073
834-D1	1.8	55.08
834-D1	2.3	166

Table 4. TCE concentrations in surface and subsurface soils at the Building 834 Operable Unit. (Cont. Page 4 of 10)

Sample location	Sample depth (ft)	TCE concentration (mg/kg)
834-D1	4.0	68.75
834-D1	7.5	70.77
834-D1	8.0	257.5
834-D1	10.0	146.08
834-D1	15.5	4.46
834-D1	21.0	72
834-D1	25.8	2.71
834-D1	25.4	2.95
834-D1	30.2	1.84
834-D1	46.5	0.58
834-D1	48.5	0.05
834-D1	67.0	0.13
W-834-D3	10.3	0.7
W-834-D3	15.5	0.79
W-834-D3	20.5	0.079
W-834-D3	25.5	420
W-834-D3	29.5	970
W-834-D3	30.0	0.17
W-834-D4	5.7	0.4
W-834-D4	10.8	<0.2
W-834-D4	15.8	<0.2
W-834-D4	20.8	<0.2
W-834-D4	25.8	1
W-834-D4	30.8	<0.2
W-834-D4	35.8	<0.2
W-834-D4	40.8	<0.2
W-834-D5	5.8	<0.2
W-834-D5	10.8	<0.2
W-834-D5	15.8	<0.2
W-834-D5	20.8	0.5
W-834-D5	25.8	4
W-834-D5	30.7	<0.2
W-834-D5	36.1	<0.2

Table 4. TCE concentrations in surface and subsurface soils at the Building 834 Operable Unit. (Cont. Page 5 of 10)

Sample location	Sample depth (ft)	TCE concentration (mg/kg)
W-834-D5	40.8	<0.2
W-834-D6	5.8	<0.2
W-834-D6	10.7	<0.2
W-834-D6	15.8	<0.2
W-834-D6	20.8	<0.2
W-834-D6	27.1	0.8
W-834-D6	30.8	<0.2
W-834-D6	35.8	<0.2
W-834-D6	40.8	<0.2
W-834-D7	5.3	0.039
W-834-D7	10.3	0.0026
W-834-D7	20.3	0.0076
W-834-D7	25.3	0.031
W-834-D7	30.3	<0.2
W-834-D8	5.3	0.071
W-834-D8	10.3	0.001
W-834-D8	15.3	0.0002
W-834-D8	20.3	140
W-834-D8	25.3	0.19
W-834-D8	30.3	3.7
W-834-D8	35.3	0.071
834-D9	31.0	0.085
834-D9	34.0	0.0093
834-D9	37.8	<0.0005
W-834-D9A	37.0	0.0018
W-834-D9A	40.0	<0.2
W-834-D9A	43.5	0.038
W-834-D9A	48.0	0.0034
W-834-D9A	54.8	0.0014
W-834-D9A	59.8	0.0051
W-834-D9A	64.8	0.008

Table 4. TCE concentrations in surface and subsurface soils at the Building 834 Operable Unit. (Cont. Page 6 of 10)

Sample location	Sample depth (ft)	TCE concentration (mg/kg)
W-834-D9A	69.5	<0.0005
W-834-D9A	76.5	<0.0005
W-834-D9A	80.3	<0.0005
W-834-D9A	85.8	<0.0005
W-834-D9A	89.8	<0.0005
W-834-D9A	95.3	<0.0005
W-834-D9A	100.3	<0.0005
W-834-D9A	104.5	<0.0005
W-834-D9A	109.5	<0.0005
W-834-D9A	115.0	<0.0005
W-834-D9A	119.8	<0.0005
W-834-D9A	124.5	<0.0005
W-834-D9A	130.5	<0.0005
W-834-D9A	133.5	<0.0005
W-834-D10	6.3	0.17
W-834-D10	11.3	0.0083
W-834-D10	16.3	0.012
W-834-D10	21.3	0.14
W-834-D10	23.8	1.1
W-834-D10	29.3	0.013
W-834-D10	34.3	0.07
W-834-D11	6.3	0.046
W-834-D11	11.3	0.0014
W-834-D11	16.3	0.023
W-834-D11	21.3	0.012
W-834-D11	24.3	0.019
W-834-D12	6.3	0.05
W-834-D12	11.3	0.002
W-834-D12	16.3	0.0032
W-834-D12	20.6	0.002
W-834-D12	26.3	0.0096
W-834-D12	27.8	0.04

Table 4. TCE concentrations in surface and subsurface soils at the Building 834 Operable Unit. (Cont. Page 7 of 10)

Sample location	Sample depth (ft)	TCE concentration (mg/kg)
W-834-D13	6.3	0.004
W-834-D13	8.8	0.0007
W-834-D13	13.8	0.0036
W-834-D13	16.3	0.007
W-834-D13	21.3	0.036
W-834-D13	25.8	0.045
W-834-D13	29.3	1.1
W-834-D14	4.3	0.001
W-834-D14	8.8	0.0001
W-834-D14	10.8	0.0013
W-834-D14	15.3	0.0032
W-834-D14	19.3	0.0089
W-834-D14	23.5	0.009
W-834-D14	29.3	0.78
W-834-D15	8.5	<0.0005
W-834-D15	13.5	<0.0005
W-834-D15	18.5	0.0018
W-834-D15	22.5	0.33
W-834-D16	1.8	<0.0005
W-834-D16	4.3	<0.0005
W-834-D16	5.8	<0.0005
W-834-D16	6.8	<0.0005
W-834-D16	9.3	0.0053
W-834-D16	11.8	0.019
W-834-D16	14.3	0.071
W-834-D16	16.8	0.057
W-834-D16	19.3	0.071
W-834-D16	21.8	0.21
W-834-D16	24.3	0.24
W-834-D16	26.8	0.061
W-834-D16	29.3	1.6
W-834-D16	31.8	3
W-834-D16	34.3	8.6

Table 4. TCE concentrations in surface and subsurface soils at the Building 834 Operable Unit. (Cont. Page 8 of 10)

Sample location	Sample depth (ft)	TCE concentration (mg/kg)
W-834-D16	36.8	0.15
W-834-D16	39.3	0.16
W-834-D16	41.8	2
W-834-D16	44.3	0.19
W-834-D17	3.4	0.0025
W-834-D17	8.4	0.0044
W-834-D17	13.4	<0.0005
W-834-D17	18.4	<0.0005
W-834-D17	23.9	<0.0005
W-834-D17	27.4	0.0071
W-834-D17	28.4	0.038
834-E1	1.0	0.025
834-E1	15.0	0.025
834-E1	21.0	0.025
834-E1	25.5	0.025
834-E1	30.5	0.32
834-G1A	3.0	0.278
834-G1A	5.0	
834-G1A	10.5	0.05
834-G1A	20.5	0.006
834-G1A	26.0	0.05
834-G1A	36.0	0.05
834-G1A	46.0	0.05
834-G1A	62.0	0.05
834-G2	20.5	0.12
834-H1	4.0	0.12
W-834-H2	9.6	0.069
W-834-H2	13.6	0.39
W-834-H2	18.6	0.089
W-834-H2	23.4	0.056

Table 4. TCE concentrations in surface and subsurface soils at the Building 834 Operable Unit. (Cont. Page 9 of 10)

Sample location	Sample depth (ft)	TCE concentration (mg/kg)
W-834-H2	24.2	0.35
W-834-H2	28.1	0.14
W-834-H2	28.6	0.85
W-834-H2	30.6	0.016
W-834-H2	31.8	0.049
W-834-H2	32.4	0.19
W-834-H2	34.6	0.006
W-834-J1	8.1	0.001
W-834-J1	12.7	2.7
W-834-J1	18.2	2.5
W-834-J1	17.7	52
W-834-J1	22.7	2.6
W-834-J1	23.7	1.6
W-834-J1	28.2	1
W-834-J1	33.2	0.8
W-834-J1	37.7	0.1
W-834-J1	47.7	0.05
W-834-J2	9.9	0.059
W-834-J2	13.4	0.26
W-834-J2	17.9	0.2
W-834-J2	22.9	0.038
W-834-J2	27.9	0.032
W-834-J2	32.9	0.01
W-834-J2	37.9	0.015
W-834-U1	10.8	0.001
W-834-U1	13.3	0.001
W-834-U1	15.8	0.18
W-834-U1	18.3	8.1
W-834-U1	20.8	0.7
W-834-U1	23.3	0.24
W-834-U1	28.3	0.65
W-834-U1	30.3	2.5
W-834-U1	33.3	0.25

Table 4. TCE concentrations in surface and subsurface soils at the Building 834 Operable Unit. (Cont. Page 10 of 10)

Sample location	Sample depth (ft)	TCE concentration (mg/kg)
W-834-U1	35.8	1.4
W-834-U1	41.8	2.6
834C-HA1	0.5	9,500
834C-HA1	1.0	10,000
834C-HA1	2.0	23
834C-HA1	3.0	12,000
834C-HA2	0.5	132
834C-HA3	0.5	19
834C-HA3	1.0	0.16
834C-HA3	2.0	2.9
834C-HA3	2.3	0.15
834C-HA4	0.5	19
834C-HA4	3.3	10
834DBP	2.0	3.2
834DBH	2.0	3.6
834-G-4	1.0	0.1
834-G-6	1.0	4.5
834-G-8	1.0	1020

Table 5. Summary of treatability tests performed in the Building 834 Operable Unit.

	Events	Comments
August 1986	SVE pilot test using W-834-D3	Reported flow rates of 27 cfm with average VOC concentrations of 2,500 $ppm_{v/v}$.
October–December 1987	SVE pilot test using W-834-D4	Blower induced 20 and 28 in. Hg vacuums during two separate tests. Steady state reached within one hour.
February–April 1988	SVE and GWE pilot testing using W-834-D3, -D4, -D5, and -D6	Reported SVE flow rates of 42 scfm and average vapor concentration of 1,000 $ppm_{v/v}$. Reported 1.2 lbs of TCE per hour short-term mass removal rate. Also reported 1,000 gal of ground water removed during the test at an average concentration of 384 mg/L.
October–November 1988	SVE and GWE pilot testing using W-834-D4, and -D5	Reported SVE mass removal rates up to 30 lbs of TCE per day. One thousand gal of ground water removed during the test at an average concentrations of 200 mg/L.
1988–1989	Long-term SVE and GWE pilot testing using -T4 well cluster.	Stabilized flow rate of 0.07 gpm. Hydraulic connectivity between wells 30 feet apart. Ground water TCE decreased from 19 mg/L to 0.44 mg/L while soil vapor concentrations increased from 0.04 ppm_{vv} to 9.6 ppm_{vv}.
May–June 1989	SVE and GWE pilot testing using all D series wells	TCE removal rates of 2.5 kg/day and 0.1 kg/day via SVE and GWE, respectively.
1991	Electron beam experiment	Testing of electron accelerator radiolytic remediation of TCE vapors.
1992	Joule-heating experiment	*In-situ* electrical soil heating to enhance TCE removal via SVE.
1992	UV/oxidation test	*Ex-situ* oxidation of TCE using pulsed inert-gas lamps (flashlamps).
1998	Surfactant push-pull test	Testing the use of surfactants to enhance solubility and removal of VOCs.
1998–2000	Intrinsic bioremediation testing	Three years of monthly monitoring of biogeochemical indicators to evaluate intrinsic bioremediation.
2000–2001	Extraction well configuration testing	Evaluated various extraction well configurations to optimize remedial performance.
2000–2001	Aqueous-phase GAC testing	Tested to evaluate the replacement of sparging units with the aqueous-phase GAC for VOC removal.

Notes:

cfm = Cubic feet per minute.
gal = Gallons.
GAC = Granular activated carbon.
GWE = Ground water extraction.
Hg = Mercury.
kg = Kilograms.
mg/L = Milligrams per liter.
$ppm_{v/v}$ = Parts per million on a volume per volume basis.
scfm = Standard cubic feet per minute.
SVE = Soil vapor extraction.
TCE = Trichloroethylene.
UV = Ultra violet.
VOCs = Volatile organic compounds.

Table 6. Light hydrocarbon data for vapor and water samples at Building 834.

Sample ID	Date	Matrix	Ethene (ng/L)	Ethane (ng/L)	Methane (µg/L)	Hydrogen (nM)
W-834-B3	05/02/00	Vapor	85	<5.0	12.26	0.75
W-834-B3	05/02/00	Water	31	17	0.597	–
W-834-D3	07/07/99	Vapor	312	150	0.15	3.49
W-834-D3	05/09/00	Vapor	802	287	187.5	7.41
W-834-D3	05/09/00	Water	1,323	428	382	–
W-834-D4	07/07/99	Vapor	332	396	0.09	14.3
W-834-D4	07/14/99	Vapor	250	353	0.081	25
W-834-D4	05/09/00	Water	1,508	2,859	2.612	–
W-834-D5	07/07/99	Vapor	36	227	0.238	0.48
W-834-D5	05/03/00	Vapor	289	1,058	1.155	1.13
W-834-D5	05/03/00	Water	309	743	1.602	–
W-834-D6	07/07/99	Vapor	41	374	0.14	1.67
W-834-D6	05/02/00	Water	397	148	0.144	–
W-834-D7	07/07/99	Vapor	72	7	0.056	0.58
W-834-D12	07/07/99	Vapor	62	7	0.068	1.04
W-834-D13	07/07/99	Vapor	118	19	0.176	1.79
W-834-D13	05/09/00	Vapor	161	17	0.835	4.38
W-834-D13	05/09/00	Water	954	449	2.415	–
W-834-D15	05/02/00	Water	914	<5.0	0.202	–
W-834-D17	05/02/00	Water	1,172	35	0.301	–
W-834-J2	07/09/99	Vapor	66	6	0.079	1.57
W-834-J2	05/02/00	Vapor	8	<5.0	0.159	0.81
W-834-J2	05/02/00	Water	121	49	0.449	–
W-834-M1	07/14/99	Vapor	<5.0	<5.0	0.05	1.37
W-834-S4	07/14/99	Vapor	10	<5.0	0.059	1.36
W-834-S8	05/02/00	Water	476	57	0.331	–
W-834-S9	05/10/00	Vapor	806	2,087	0.353	2.42
W-834-S9	05/02/00	Water	727	2,520	0.768	–
W-834-T2	05/10/00	Water	218	150	0.147	–

Note:

– = No data to report

Table 7. Extraction wells for remediation of the Building 834 Operable Unit.

Well status	Building 834 Core Area Tpsg hydrogeologic unit	Building 834 Distal Area Tpsg hydrogeologic unit
Existing extraction well	W-834-B2, W-834-B3, W-834-C2, W-834-D3, W-834-D4, W-834-D5[a], W-834-D6 [a], W-834-D7, W-834-D11, W-834-D12, W-834-D13, W-834-D14, W-834-H2, W-834-J1, W-834-J2	None
Existing monitor well to be converted to an extraction well	None	W-834-S1, W-834-S12A, W-834-S13, W-834-T2, W-834-T2A, W-834-T2D

Notes:

Tpsg = Pliocene nonmarine unit (gravel facies).

$Tnsc_2$ = Miocene Neroly Formation – Upper Siltstone/Claystone Member.

[a] The bottom four feet of the screen zone is in the Tps-clay hydrogeologic unit.

Table 8. Design specifications for the Building 834 extraction wells.

Extraction well name	Date completed	Well type and status	Total depth (ft bgs)	Perforated interval (ft bgs)	Sand-pack interval (ft bgs)	Hydro-geologic unit	Estimated maximum long-term yield[a] (average gal per month)	Average TVOC concentration[b] (µg/L)	Average monthly VOC mass removed[c] (grams)	Pump type[d]	Pump intake depth (ft bgs)
Core Area											
W-834-B2	07/25/90	Active GWE and SVE : Proposed SVE only	14.5	7.0–14.5	6.5–14.5	Tpsg	<100	6,640	3.69	Solo	12.5
W-834-B3	08/09/90	Active GWE and SVE	10.5	5.5–10.5	5.0–10.5	Tpsg	134	11,640	5.87	Solo	8.5
W-834-C2	08/08/90	Active GWE and SVE : Proposed SVE only	15.8	6.0–15.8	5.5–15.8	Tpsg	<100	987	0.92	Solo	13.8
W-834-D3	07/08/88	Active GWE and SVE	28.0[e]	19.0–28.0	17.0–28.0	Tpsg	545	47,527	104.73	Solo	26.0
W-834-D4	11/11/86	Active GWE and SVE	28.0[e]	19.0–28.0	17.0–28.0	Tpsg	304	65,891	77.86	Solo	26.0
W-834-D5	11/11/86	Active GWE and SVE	30.0[e]	19.0–29.0	17.0–30.0	Tpsg/Tps clay	147	49,045	30.34	Solo	28.0
W-834-D6	11/11/86	Active GWE and SVE	25.5[e]	19.0–25.5	17.0–25.5	Tpsg/Tps clay	481	42,828	99.93	Solo	23.5

Table 8. Design specifications for the Building 834 extraction wells. (Cont. Page 2 of 4).

Extraction well name	Date completed	Well type and status	Total depth (ft bgs)	Perforated interval (ft bgs)	Sand-pack interval (ft bgs)	Hydro-geologic unit	Estimated maximum long-term yield[a] (average gal per month)	Average TVOC concentration[b] (μg/L)	Average monthly VOC mass removed[c] (grams)	Pump type[d]	Pump intake depth (ft bgs)
Core Area (Cont.)											
W-834-D7	04/12/88	Active GWE and SVE	31.0	16.0–26.0	11.0–29.0	Tpsg	790	13,500	40.37	Solo	30.0
W-834-D11	03/16/89	Active GWE and SVE : Proposed SVE only	22.0	12.0-22.0	7.0-23.0	Tpsg	<100	4,643	2.93	Solo	20.0
W-834-D12	03/21/89	Active GWE and SVE : Proposed SVE only	27.0	17.0-27	15.0-27.0	Tpsg	<100	7,350	20.01	Solo	25.0
W-834-D13	03/22/89	Active GWE and SVE	27.4	17.1–27.1	12.7–27.5	Tpsg	363	48,636	68.91	Solo	25.4
W-834-D14	11/27/91	Active GWE and SVE	27.6	17.3–27.3	10.9–27.6	Tpsg	278	17,045	48.35	Solo	25.6
W-834-H2	03/23/89	Active GWE and SVE	29.4	14.6–29.4	12.5–29.4	Tpsg	139	8,909	4.02	Solo	27.4
W-834-J1	07/12/83	Active GWE and SVE	30.0	25.0–30.0	21.0–34.0	Tpsg	223	9,136	6.74	Solo	28.0

Table 8. Design specifications for the Building 834 extraction wells. (Cont. Page 3 of 4).

Extraction well name	Date completed	Well type and status	Total depth (ft bgs)	Perforated interval (ft bgs)	Sand-pack interval (ft bgs)	Hydro-geologic unit	Estimated maximum long-term yield[a] (average gal per month)	Average TVOC concentration[b] (μg/L)	Average monthly VOC mass removed[c] (grams)	Pump type[d]	Pump intake depth (ft bgs)
Core Area (Cont.)											
W-834-J2	04/01/88	Active GWE and SVE	37.0	22.0–32.0	18.5–33.0	Tpsg	704	4,471	10.87	Solo	35.0
Distal Area											
W-834-S1	07/19/83	Active MW: Proposed GWE and SVE	32.5	27.5–32.5	18.0–34.0	Tpsg	354	12,492	TBD	Solo	30.5
W-834-S12A	04/12/00	Active MW: Proposed GWE and SVE	49.2	44–49	41–49.2	Tpsg	132	NA	TBD	Solo	47.2
W-834-S13	01/04/00	Active MW: Proposed GWE and SVE	44	38.5–43.5	34.5–44.5	Tpsg	132	16,800	TBD	Solo	42
W-834-T2	10/21/86	Active MW: Proposed GWE and SVE	40.7[e]	32.0–40.7	28.0–40.7	Tpsg	540	21,077	TBD	Solo	38.7
W-834-T2A	05/26/88	Active MW: Proposed GWE and SVE	38.0[e]	17.5–37.5	17.5–38.0	Tpsg	324	32,820	TBD	Solo	36.0

Table 8. Design specifications for the Building 834 extraction wells. (Cont. Page 4 of 4).

Extraction well name	Date completed	Well type and status	Total depth (ft bgs)	Perforated interval (ft bgs)	Sand-pack interval (ft bgs)	Hydro-geologic unit	Estimated maximum long-term yield[a] (average gal per month)	Average TVOC concentration[b] (μg/L)	Average monthly VOC mass removed[c] (grams)	Pump type[d]	Pump intake depth (ft bgs)
Distal Area (Cont.)											
W-834-T2D	06/21/88	Active MW: New GWE and SVE	33.8[e]	25.8–33.8	16.0–33.8	Tpsg	550	18,419	TBD	Solo	31.8

Notes:

ft bgs = Feet below ground surface.
gal = Gallons.
GWE = Ground water extraction.
μg/L = Micrograms per liter.
MW = Monitor well.
NA = Data not available.
SVE = Soil vapor extraction.
$Tnsc_2$ = Miocene Neroly Formation - Upper Siltstone/Claystone Member.
Tps = Pliocene nonmarine unit.
Tpsg = Pliocene nonmarine unit (gravel facies).
TVOC = Total volatile organic compound.
VOC = Volatile organic compound.
TBD = To be determined.

[a] Based on average of 1999 and Feb. & March 2001 pumping data for the Core Area wells; average of 1999 and 2000 data for the Distal Area wells.
[b] Based on average of 1999 and Feb. & March 2001 data for Core Area wells; average of 1999 and 2000 data for Distal Area wells.
[c] Based on average of 1999 and Feb. & March 2001 data.
[d] Indicates type of pump currently installed in existing extraction wells.
[e] Bottom of well plugged.

Table 9. B834 Area treatment system design ground water influent concentrations.

Extraction well	Estimated Extraction flow rate[a] (liters per month)	Recent average TVOC concentrations in ground water[b] (mg/L)	Percentage of total flow to treatment facility (%)	Flow weighted average TVOC concentration in ground water[c] (mg/L)
Core Area				
W-834-D3	2,062.8	47.5	7.53	3.58
W-834-D4	1,150.6	65.9	4.20	2.77
W-834-D5	556.4	49.0	2.03	0.99
W-834-D6	1,820.6	42.8	6.65	2.85
W-834-D7	2,990.2	13.5	10.92	1.47
W-834-D13	1,374.0	48.6	5.02	2.44
W-834-D14	1,052.2	17.0	3.84	0.65
W-834-H2	526.1	8.9	1.92	0.17
W-834-J1	844.1	9.1	3.08	0.28
W-834-J2	2,664.6	4.5	9.73	0.44
Distal Area				
W-834-S1	8,175.6	12.5	29.85	3.73
W-834-S8	1,226.3	1.6	4.48	0.07
W-834-S9	817.6	1.9	2.98	0.06
W-834-T2	817.6	21.1	2.98	0.63
W-834-T2A	492.1	32.8	1.80	0.59
W-834-T2D	817.6	18.4	2.98	0.55
Total Influent	27,388.4			TVOC = 21.3

Notes:

TVOC = Total Volatile Organic Carbon

[a] **Based on average of 1999 and Feb & March, 2001 pumping data for the Core Area wells and recovery rates for the Distal Area wells.**

[b] **Based on average of 1999 and Feb & March 2001 data for the Core Area wells; average of 1999 and 2000 data for the Distal Area wells.**

[c] **Weighted TVOC concentration calculated by multiplying the average TVOC concentration by the percentage of total water extracted.**

Table 10. Building 834 treatment system equipment specifications.

Equipment	Specifications[a]
Well Pumps	Sixteen pneumatic downhole pumps by QED; Short Body Solo II, SP2000L.
Compressed air flow counters	Cycle counter by QED; model 37000.
Air compressor	SULLAIR rotary screw, LS-10 Series.
Compressed air line	1/2" copper pipe.
Water conveyance piping	3/4" copper pipe.
Water conveyance piping	1" black steel or 1" PVC.
Oil water separator	Surface skimming type separator; built in-house; stainless-steel, 3.25 ft × 1.3 ft × 2 ft.
Oil receiver tank	Painted steel, rectangular, 2.1 ft × 2.3 ft × 3.25 ft.
Oil receiver tank level switches	Magnetic pendulum float.
Water receiver tank	Stainless Steel, rectangular, 200 gallon capacity, 3 ft × 3 ft × 3 ft
Water receiver tank level transducer	Vertical mounted multi float switch.
Water receiver tank level switch	Magnetic pendulum float.
Oil/water tank/vent carbon vessels	Two 55-gallon drums plumbed for vapor GAC.
Transfer pumps	TEEL, 2 hp, Model No. 39604; Bell and Gossett pump Series 15120-11/2 BC, 3-5 hp, 1,750 rpm, 208 V alternating current, 60 Hz, 3 ph, 5-45 gpm at 100 ft total dynamic head, or equivalent.
Particulate pre-filter canister	Cuno Model No. 12 DC3, stainless steel, 230 gpm, 150 psi.
Particulate pre-filter	Pleated cartridge, 5 micron.
Aqueous-phase granular activated carbon canisters	Three 1,000-lb GAC capacity, U.S. Filter Westates Carbon, Inc.
Aqueous-phase granular activated carbon	3,000 pounds total of virgin coal based carbon.
Water flow totalizers	Precision, mechanical.
Water flow meters	Signet Model No. P58640, digital, battery operated.
Blow-down storage tanks	Painted steel, 500-gallon capacity, 5 ft × 4 ft × 3.25 ft.
Misting storage tanks	Painted steel, 1,000-gallon capacity.
Misting tank level indicators	Magnetic pendulum float.
Misting tank pump	Grunfos, 1/2 to 1-1/2 hp, 220 V, 45 gpm or equivalent.
Particulate post-filter canister	Cuno Model No. 12 DC3, stainless steel, 230 gpm, 150 psi.
Particulate post-filter	Granular carbon cartridge.
Spray nozzles	24 - 0.5 gpm foggit nozzels.

Table 10. Building 834 treatment system equipment specifications (Cont. Page 2 of 2).

Equipment	Specifications[a]
Vapor de-mister	85-gallon drum with fabric and liquid effluent valve on lower side of drum.
Demister level switch	Float switch transmitter.
Vapor extraction blower	Pego©, variable speed drive, positive displacement blower with muffler.
Vapor heat exchanger	Built in-house, stainless steel, water-cooled with external cooling tower.
Vapor conveyance line	4" copper pipe.
Vapor-phase granular activated carbon canisters	Four 1,000-lb capacity. U.S. Filter Westates Carbon, Inc.
Vapor-phase granular activated carbon	4,000 pounds total of virgin coal based carbon.
Programmable logic controller	486 personal computer with Paragon control software and OPTO-22 I/O, or equivalent.
Pneumatic valves	Remote controlled solenoid with compressed gas actuation.
Ball valves	Cast iron, full port design ball valves.
Pressure gauges	Dwyer Series 61000 with safety blowout backing. Ranges vary.

Notes:

© = Copyright.
ft = Feet.
GAC = Granular activated carbon.
gpm = Gallons per minute.
hp = Horsepower.
Hz = Hertz.
lb = Pound.
ph = Phase.
psi = Pounds per square inch.
PVC = Polyvinyl chloride.
rpm = Revolutions per minute.
V = Volts.

[a] If a specific model is not available, an equivalent device that satisfies the intended function will be procured.

Table 11. Building 834 ground water and soil vapor extraction and treatment system design, construction, and startup completion dates.

Activity	Completion date
Design and testing	1987–1989
Construction	1990–1994
GWTS startup	1995
SVE and treatment startup	1998
Wellfield expansion and GWTS modification design	1999–2001
Expansion and modification construction	2003
System startup	2004
(First) Building 834 Five-Year Review[a]	
Final B834 Five-Year Review	February 11, 2002
(Second) Building 834 Five-Year Review[a]	
Draft B834 Five-Year Review	August 24, 2006
Draft Final B834 Five-Year Review	January 8, 2007
Final B834 Five-Year Review	February 7, 2007

Notes:

GWTS = Ground water treatment system.

SVE = Soil vapor extraction.

[a] Five-year reviews for the Building 834 OU are required by statute because the interim remedy will result in contaminants remaining at the site above concentrations that allow for unlimited use and unrestricted exposure (i.e., ground water cleanup standards have not yet been established). Cleanup was initiated at this OU as treatability studies, and the triggering action for the first review was the Interim Record of Decision (ROD) for the Building 834 OU in September 1995. The first review is scheduled to be completed in February 2002. The second review will be completed within five years of the signature date of the first review.

Table 12A. Cost summaries of ground water monitoring activities in the Building 834 Operable Unit.

Activity	Capital Costs ($)	Annual O&M ($)
Install Ground Water Monitor Wells [a]		
Drilling preparation	26,358	
Drilling	107,010	
Well design and construction	56,948	
Subtotal costs	**190,316**	**0**
Monitoring		
Water levels		5,784
Water quality sampling/analysis		86,214
Data analysis & representation		20,742
Pump maintenance or replacement		2,872
Subtotal costs	**0**	**115,612**
Total costs	**190,316**	**115,612**

Note:

O&M = Operations and maintenance.

[a] **Based on the installation of 7 wells at 50 ft depths.**

Table 12B. Cost summaries for the Building 834 ground water and soil vapor treatment system remedial design, modifications, and operations and maintenance.

Activity	Capital Costs ($)	Annual O&M ($)
Design and Construct Remediation System		
Remedial design report	68,110	
Design and Drafting Support	18,528	
Modification of Building 834 Extraction and Treatment System	127,200	
Subtotal costs	**145,728**	**0**
O&M - TF834		
Control/inst. calibration and maintenance		46,886
Mechanical O&M		188,292
Facility documentation and data collection		31,583
Remedial system permit report		24,829
Optimization		49,770
Subtotal costs	**0**	**341,360**
Total costs	**145,728**	**341,360**

Note:

O&M = Operations and maintenance.

Table 12C. Cost summaries for the Building 834 Operable Unit enhanced *in situ* bioremediation treatability study.

Activity	Capital Costs ($)	Annual O&M ($)
Install Ground Water Wellfield		
Drilling preparation	10,456	
Drilling	16,204	
Drilling footage	49,280	
Well design and construction	34,580	
Hydraulic testing	101,040	
Subtotal costs	**211,560**	**0**
Design and Construct Remediation System		
Perform microorganism experiments	18,400	
Remedial design report	31,070	
Data analysis & representation	18,400	
Modeling	18,400	
Permitting	9,158	
Subtotal costs	**95,428**	**0**
Operate In Situ Bioremediation Wellfield		
Operate injection wellfield		60,000
Data analysis & representation		18,400
Modeling		18,400
Water quality sampling/analysis		50,370
Subtotal costs	**0**	**147,170**
Total costs	**196,468**	**147,170**

Note:

O&M = Operations and maintenance.

Table 12D. Cost summaries for Building 834 Operable Unit risk and hazard management activities.

Activity	Capital Costs ($)	Annual O&M ($)
Institutional Controls		
Prepare Building Occupancy and Land Use Plan	3,663	
Review Building Occupancy and Land Use Plan		733
Install warning signs	535	
Subtotal costs	**4,198**	**733**
Occupational Safety Procedures		
Prepare Occupational Safety Procedures	2,381	
Subtotal costs	**2,381**	**0**
Total costs	**6,579**	**733**

Note:

O&M = Operations and maintenance.

Table 13. Current monitoring requirements for the Building 834 ground water treatment system (GWTS).

Monitoring requirements[a]	TF-834-I[b]	TF-834-E[c]	Sampling frequency
VOCs (EPA Method 601)	√	√	Monthly
TBOS/TKEBS (Modified EPA Method 8015)	√[d]	√	Monthly
Diesel[e] (Modified EPA Method 8015)		√	Monthly
Nitrate (EPA Method 300)	√	√	Monthly
pH (Field or EPA Method 9040)	√	√	Monthly
Total dissolved solids (TDS) (EPA Method 160)	√	√	Monthly
Electrical conductivity (Field or EPA Method 120)	√	√	Monthly

Note:

√ = Sample analytes required for this location.

[a] Monitoring requirements specified in the Substantive Requirements or agreed upon in the Monitoring and Reporting Program Requirements letter report (Lamarre, 1998). EPA Methods listed.

[b] Building 834 GWTS influent sampling port.

[c] Building 834 GWTS effluent sampling port.

[d] Influent samples for TBOS/TKEBS, which contribute the majority of the TBOS to the system, are collected from the two extraction wells (W-834-D3 and W-834–D4). No TBOS sample is collected form the influent sample port.

[e] Only effluent sample collected for diesel since the only major diesel contributor (W-834-D8) was destroyed due to poor completion.

Table 14. Proposed sampling schedule for Building 834 ground water monitor wells.[a]

Sample location	Analyses	Sampling frequency	Water level monitoring frequency
W-834-A1	EPA Method 601	Quarterly	Quarterly
	Metals: DDW List	Annual	
	General minerals, pH, SC, and TDS	Annual	
W-834-A2	Baseline[b]	Quarterly	Quarterly
W-834-B2	EPA Method 601	Quarterly	Quarterly
	Metals: Cu, Zn	Annual	
	General minerals, pH, SC, and TDS	Annual	
W-834-B3	EPA Method 601	Quarterly	Quarterly
	Metals: Cu, Zn	Annual	
	General minerals, pH, SC, and TDS	Annual	
W-834-B4	EPA Method 601	Quarterly	Quarterly
	EPA Method 8015 (TBOS)	Quarterly	
	Metals: DDW List	Quarterly	
W-834-C2	EPA Method 601	Quarterly	Quarterly
	Metals: Cu, Zn	Annual	
	General minerals, pH, SC, and TDS	Annual	
W-834-C4	EPA Method 601	Quarterly	Quarterly
	EPA Method 602	Semiannual	
	EPA Method 8015 (TBOS)	Semiannual	
	Metals: DDW List	Annual	
	General minerals, pH, SC, and TDS	Annual	
W-834-C5	EPA Method 601	Quarterly	Quarterly
	EPA Method 602	Semiannual	
	EPA Method 8015 (TBOS)	Semiannual	
	Metals: DDW List	Annual	
	General minerals, pH, SC, and TDS	Annual	
W-834-D3	EPA Method 601	Quarterly	Quarterly
	EPA Method 8015 (TBOS)	Quarterly	
	General minerals, pH, SC, and TDS	Annual	
W-834-D4	EPA Method 601	Quarterly	Quarterly
	EPA Method 8015 (TBOS)	Quarterly	
	Metals: Ba	Annual	
	General minerals, pH, SC, and TDS	Annual	
W-834-D5	EPA Method 601	Quarterly	Quarterly
	EPA Method 8015 (TBOS)	Semiannual	
	General minerals, pH, SC, and TDS	Annual	

Table 14. Proposed sampling schedule for Building 834 ground water monitor wells (Cont. 2 of 4).[a]

Sample location	Analyses	Sampling frequency	Water level monitoring frequency
W-834-D6	EPA Method 601 General minerals, pH, SC, and TDS	Quarterly Annual	Quarterly
W-834-D7	EPA Method 601 General minerals, pH, SC, and TDS	Quarterly Annual	Quarterly
W-834-D10	EPA Method 601 Metals: Ba, Cd, Cu, Pb, Hg, Mb, Ag, Zn General minerals, pH, SC, and TDS	Quarterly Annual Annual	Quarterly
W-834-D11	EPA Method 601 Metals: Ba General minerals, pH, SC, and TDS	Quarterly Annual Annual	Quarterly
W-834-D12	EPA Method 601 Metals: Ba General minerals, pH, SC, and TDS	Quarterly Annual Annual	Quarterly
W-834-D13	EPA Method 601 EPA Method 8015 (TBOS) General minerals, pH, SC, and TDS	Quarterly Semiannual Annual	Quarterly
W-834-D14	EPA Method 601 General minerals, pH, SC, and TDS	Quarterly Annual	Quarterly
W-834-D15	Baseline[b]	Quarterly	Quarterly
W-834-D16	Baseline[b]	Quarterly	Quarterly
W-834-D17	Baseline[b]	Quarterly	Quarterly
W-834-D18	Baseline[b]	Quarterly	Quarterly
W-834-G3	EPA Method 601 Metals: Ba, Cd, Cu, Pb, Hg, Mb, Ag, Zn General minerals, pH, SC, and TDS	Quarterly Annual Annual	Quarterly
W-834-H2	EPA Method 601 General minerals, pH, SC, and TDS	Quarterly Annual	Quarterly
W-834-J1	EPA Method 601 Metals: Cd General minerals, pH, SC, and TDS	Quarterly Annual Annual	Quarterly
W-834-J2	EPA Method 601 Metals: Zn General minerals, pH, SC, and TDS	Quarterly Annual Annual	Quarterly
W-834-J3	Baseline[b]	Quarterly	Quarterly
W-834-K1A	Baseline[b]	Quarterly	Quarterly

Table 14. Proposed sampling schedule for Building 834 ground water monitor wells (Cont. 3 of 4).[a]

Sample location	Analyses	Sampling frequency	Water level monitoring frequency
W-834-M1	EPA Method 601 Metals: Cd, Pb General minerals, pH, SC, and TDS	Quarterly Annual Annual	Quarterly
W-834-M2	EPA Method 601 Metals: Ba, Cd, Cu, Pb, Hg, Mb, Ag, Zn General minerals, pH, SC, and TDS	Semiannual Annual Annual	Quarterly
W-834-S1	EPA Method 601 Metals: Cd General minerals, pH, SC, and TDS	Quarterly Annual Annual	Quarterly
W-834-S4	EPA Method 601 Metals: Cd General minerals, pH, SC, and TDS	Semiannual Annual Annual	Quarterly
W-834-S5	EPA Method 601 Metals: Ba, Cd, Cu, Pb, Hg, Mb, Ag, Zn General minerals, pH, SC, and TDS	Annual Annual Annual	Quarterly
W-834-S6	EPA Method 601 General minerals, pH, SC, and TDS	Annual Annual	Quarterly
W-834-S7	EPA Method 601 Metals: Ba, Cd, Cu, Pb, Hg, Mb, Ag, Zn General minerals, pH, SC, and TDS	Annual Annual Annual	Quarterly
W-834-S8	EPA Method 601 Metals: Cd General minerals, pH, SC, and TDS	Quarterly Annual Annual	Quarterly
W-834-S9	EPA Method 601 Metals: Cd, Pb General minerals, pH, SC, and TDS	Quarterly Annual Annual	Quarterly
W-834-S10	Baseline[b]	Quarterly	Quarterly
W-834-S12A	Baseline[b]	Quarterly	Quarterly
W-834-S13	Baseline[b]	Quarterly	Quarterly
W-834-T1	EPA Method 601 General minerals, pH, SC, and TDS	Quarterly Annual	Quarterly
W-834-T2	EPA Method 601 Metals: Cd General minerals, pH, SC, and TDS	Quarterly Annual Annual	Quarterly
W-834-T2A	EPA Method 601 General minerals, pH, SC, and TDS	Quarterly Annual	Quarterly

Table 14. Proposed sampling schedule for Building 834 ground water monitor wells (Cont. 4 of 4).[a]

Sample location	Analyses	Sampling frequency	Water level monitoring frequency
W-834-T2B	EPA Method 601 Metals: Cd General minerals, pH, SC, and TDS	Quarterly Annual Annual	Quarterly
W-834-T2C	EPA Method 601 Metals: Cd General minerals, pH, SC, and TDS	Annual Annual Annual	Quarterly
W-834-T2D	EPA Method 601 General minerals, pH, SC, and TDS	Quarterly Annual	Quarterly
W-834-T3	EPA Method 601 General minerals, pH, SC, and TDS	Quarterly Annual	Quarterly
W-834-T5	EPA Method 601 Metals: Cd General minerals, pH, SC, and TDS	Semiannual Annual Annual	Quarterly
W-834-T7A	EPA Method 601 General minerals, pH, SC, and TDS	Semiannual Annual	Quarterly
W-834-T8A	Baseline[b]	Quarterly	Quarterly
W-834-T9	EPA Method 601 Metals: Ba, Cd, Cu, Pb, Hg, Mb, Ag, Zn General minerals, pH, SC, and TDS	Annual Annual Annual	Quarterly
W-834-T11	Baseline[b]	Quarterly	Quarterly
W-834-U1	EPA Method 601 EPA Method 602 EPA Method 8015 (TBOS)	Quarterly Semiannual Semiannual	Quarterly

Notes:

Ag = Silver.
Ba = Barium.
Cd = Cadmium.
Cu = Copper.
DDW = Dissolved drinking water.
Hg = Mercury.
Mb = Molybdenum.
Pb = Lead.
SC = Specific conductance.
TDS = Total dissolved solids.
Zn = Zinc.

[a] The Site-Wide Compliance Monitoring Plan, scheduled to be finalized in September 2002, will supercede this sampling schedule.

[b] Baseline sampling for new wells consists of EPA Method 624, TBOS, dissolved drinking water metals, general minerals, perchlorates, high-explosive compounds (HMX and RDX), and radiological monitoring, which include uranium isotopes, gross alpha and beta, and tritium. As these constituents are completed, a long-term set of monitoring constituents are chosen. This set of baseline analytes are self-imposed and are in the process of being modified to a Building 834 specific set of contaminants of concern.

Appendix A
Historical VOC Data in Building 834 Wells

Table A-1. Historical TCE, cis-1,2-DCE, and vinyl chloride in Building 834 wells.

Sample ID	Laboratory ID	Sample date	TCE µg/L	cis-1,2-DCE (µg/L)	Vinyl chloride (µg/L)
W-834-B2	BC9104301-1	04/11/91	14,000	<100	<100
W-834-B2	BC9202455-1	02/21/92	31,000	<200	<200
W-834-B2	BC9302154-3	02/05/93	19,000	<300	<300
W-834-B2	BC9306084-1	06/14/93	29,000	200	<0.5
W-834-B2	BC9306086-1	06/14/93	29,000	<300	<300
W-834-B2	BC9306116-2	06/25/93	28	<0.5	<0.5
W-834-B2	CSM43847A	03/22/94	920	<5	<5
W-834-B2	CSM80244A	03/03/95	21,000	65	<50
W-834-B2	CSN17744A	02/09/96	5,000	35	<13
W-834-B2	CSN34238A	06/26/96	6,000	42	<25
W-834-B2	CSN68011A	03/14/97	6,800	<25	<25
W-834-B2	CSP30162A	03/26/98	13,000	170	<25
W-834-B2	CSP48741A	06/16/98	15,000	710	<50
W-834-B2	CSP48742A	06/16/98	17,000	630	<50
W-834-B2	CSR03492A	02/26/99	1,500	41	<5
W-834-B2	BB9911409004	09/28/99	12,000	160	<30
W-834-B2	BB0003715002	03/24/00	3,800	49	<9
W-834-B2	BB0009536001	08/15/00	4,600	160	<10
W-834-B3	BC9104301-2	04/11/91	13,000	2,500	<100
W-834-B3	BC9109440-3	09/19/91	34,000	3,800	<200
W-834-B3	CL910917801A	09/19/91	23,000	2,100	<500
W-834-B3	BC9112587-4	12/27/91	2,800	1,500	<20
W-834-B3	BC9202455-2	02/21/92	17,000	5,200	<200
W-834-B3	BC9206633-10	06/26/92	22,000	14,000	<100
W-834-B3	BC9208429-3	08/20/92	40,000	41,000	<300
W-834-B3	BC9212460-2	12/18/92	2,900	7,300	<50
W-834-B3	BC9302154-4	02/05/93	2,300	21,000	<300
W-834-B3	BC9306086-2	06/14/93	1,700	9,600	<30
W-834-B3	CSM19942A	08/23/93	1,700	18,000	<500
W-834-B3	CSM32932A	12/15/93	1,700	13,000	<500
W-834-B3	CSM43846A	03/22/94	190	2,900	<25

Table A-1. Historical TCE, cis-1,2-DCE, and vinyl chloride in Building 834 wells.

Sample ID	Laboratory ID	Sample date	TCE μg/L	cis-1,2-DCE (μg/L)	Vinyl chloride (μg/L)
W-834-B2	BC9104301-1	04/11/91	14,000	<100	<100
W-834-B3	CSM52481A	06/09/94	1,700	31,000	<500
W-834-B3	CSM72417A	12/15/94	240	5,000	<50
W-834-B3	CSM80241A	03/03/95	220	4,100	<25
W-834-B3	GTC503005701	03/03/95	44	4,300	<1
W-834-B3	CSN13022A	12/20/95	370	48,000	<50
W-834-B3	CSN17742A	02/09/96	45	7,600	<10
W-834-B3	CSN30373A	05/30/96	170	25,000	<50
W-834-B3	CSN56262A	12/12/96	85	2,400	<5
W-834-B3	CSN67771A	03/13/97	280	17,000	<50
W-834-B3	CSN73046A	04/23/97	180	11,000	<50
W-834-B3	CSP10092A	12/16/97	130	4,000	<25
W-834-B3	CSP19221A	02/05/98	130	10,000	<50
W-834-B3	CSP30163A	03/26/98	410	11,000	<50
W-834-B3	CSP36171A	04/23/98	200	7,900	<50
W-834-B3	CSP41832A	05/18/98	490	19,000	<130
W-834-B3	CSP50381A	06/24/98	260	5,400	<50
W-834-B3	CSP58001A	07/28/98	170	3,000	<25
W-834-B3	CSP64774A	08/27/98	130	12,000	<50
W-834-B3	CSP70523B	09/23/98	200	17,000	<50
W-834-B3	CSP78101A	10/28/98	320	11,000	<50
W-834-B3	CSP83654A	11/23/98	200	11,000	<50
W-834-B3	CSP91611A	01/05/99	<50	5,000	<50
W-834-B3	CSP96281A	01/26/99	130	12,000	<5
W-834-B3	BB9902251001	02/23/99	66	8,800	14
W-834-B3	CSR02331A	02/23/99	94	9,300	<50
W-834-B3	BB9903780003	03/30/99	110	10,000	12
W-834-B3	BB9904949001	04/27/99	240	12,000	<30
W-834-B3	BB9906203001	05/26/99	170	12,000	<50
W-834-B3	BB9910098001	08/25/99	330	14,000	<200
W-834-B3	BB9911409006	09/28/99	1,000	11,000	<30

Table A-1. Historical TCE, cis-1,2-DCE, and vinyl chloride in Building 834 wells.

Sample ID	Laboratory ID	Sample date	TCE μg/L	cis-1,2-DCE (μg/L)	Vinyl chloride (μg/L)
W-834-B2	BC9104301-1	04/11/91	14,000	<100	<100
W-834-B3	BB9911409005	09/28/99	990	11,000	<30
W-834-B3	BB9912666002	10/26/99	1,300	8,700	4.0
W-834-B3	BB9914184002	12/01/99	1,400	11,000	<50
W-834-B3	BB0001053001	01/25/00	1,200	2,900	2.4
W-834-B3	BB0002493001	02/25/00	450	1,900	<3
W-834-B3	BB0003866001	03/29/00	280	1,100	<0.5
W-834-B3	BB0004977001	04/25/00	190	1,500	<3
W-834-B3	BB0005332004	05/03/00	410	1,900	<3
W-834-B3	MI505D-211	05/03/00	270	1,500	<5
W-834-B3	BB0007588001	06/29/00	180	3,100	<4
W-834-B3	BB0009536002	08/15/00	570	4,800	<30
W-834-B3	BB0013774001	11/30/00	100	55	<3
W-834-C2	BC9104301-3	04/11/91	14,000	<100	<100
W-834-C2	BC9202455-3	02/21/92	29,000	<200	<200
W-834-C2	BC9302149-1	02/05/93	14,000	130	<100
W-834-C2	BC9302154-1	02/05/93	20,000	<300	<300
W-834-C2	BC9306094-2	06/15/93	10,000	<300	<300
W-834-C2	CSM80243A	03/03/95	18,000	<50	<50
W-834-C2	CSN17743A	02/09/96	4,600	100	<10
W-834-C2	CSN34235A	06/26/96	2,200	21	<5
W-834-C2	CSN67782A	03/13/97	2,200	23	<5
W-834-C2	CSP18842A	02/04/98	560	6.9	<5
W-834-C2	CSP30171A	03/26/98	1,200	<5	<5
W-834-C2	CSP35872A	04/22/98	600	11	<5
W-834-C2	CSP41831A	05/18/98	660	<5	<5
W-834-C2	CSP50382A	06/24/98	510	<5	<5
W-834-C2	CSP57614A	07/27/98	530	<5	<5
W-834-C2	CSP65081A	08/28/98	450	<5	<5
W-834-C2	CSP70121A	09/22/98	540	<5	<5
W-834-C2	CSP78444A	10/29/98	770	<5	<5

Table A-1. Historical TCE, cis-1,2-DCE, and vinyl chloride in Building 834 wells.

Sample ID	Laboratory ID	Sample date	TCE μg/L	cis-1,2-DCE (μg/L)	Vinyl chloride (μg/L)
W-834-B2	BC9104301-1	04/11/91	14,000	<100	<100
W-834-C2	CSP83655A	11/23/98	820	10	<5
W-834-C2	CSP91825A	01/06/99	550	<5	<5
W-834-C2	CSP96693A	01/27/99	850	8.2	<5
W-834-C2	CSR02802A	02/24/99	1,600	8.1	<2.5
W-834-C2	CSR02801A	02/24/99	1,700	11	<5
W-834-C2	BB9905045001	04/29/99	500	3.4	<3
W-834-C2	BB9906244005	05/27/99	620	5.1	<2
W-834-C2	BB9912666001	10/26/99	560	31	<5
W-834-C2	BB9914184001	12/01/99	1,300	21	<7
W-834-C2	BB0001119001	01/26/00	1,400	16	<10
W-834-C2	BB0002493002	02/25/00	1,800	52	<1
W-834-C2	BB0003866005	03/29/00	1,500	36	<3
W-834-C2	BB0009536003	08/15/00	780	12	<0.5
W-834-D10	CSM32951A	12/15/93	1,100	<25	<25
W-834-D10	CSM44313A	03/23/94	2,500	<50	<50
W-834-D10	CSM44312A	03/23/94	2,700	<50	<50
W-834-D10	CSM52573A	06/09/94	440	<130	<130
W-834-D10	CSM80245A	03/03/95	7,100	<25	<25
W-834-D10	CSN13021A	12/20/95	1,400	<0.5	<0.5
W-834-D10	CSN20091A	02/28/96	27,000	68	<50
W-834-D10	CSN20096A	02/28/96	27,000	<50	<50
W-834-D10	CSN34239A	06/26/96	1,300	<50	<50
W-834-D10	CSN73362A	04/25/97	5,200	<50	<50
W-834-D10	CSP10093A	12/16/97	860	<2.5	<2.5
W-834-D10	CSP30176A	03/26/98	4,200	<5	<5
W-834-D10	CSP48743A	06/16/98	6,800	<50	<50
W-834-D10	CSP70111A	09/22/98	6,400	<50	<50
W-834-D10	CSP88543A	12/16/98	3,900	83	<50
W-834-D10	BB9911408004	09/28/99	7,900	270	<20
W-834-D11	BC9006443-5	06/20/90	44,000	<500	<500

Table A-1. Historical TCE, cis-1,2-DCE, and vinyl chloride in Building 834 wells.

Sample ID	Laboratory ID	Sample date	TCE µg/L	cis-1,2-DCE (µg/L)	Vinyl chloride (µg/L)
W-834-B2	BC9104301-1	04/11/91	14,000	<100	<100
W-834-D11	BC9105763-6	05/31/91	40,000	<200	<200
W-834-D11	BC9109443-5	09/19/91	7,200	<50	<50
W-834-D11	BC9202610-1	02/28/92	58,000	<200	<200
W-834-D11	BC9302153-1	02/05/93	43,000	<300	<300
W-834-D11	BC9306086-3	06/14/93	15,000	<300	<300
W-834-D11	CSM21043A	09/02/93	17,000	<25	<25
W-834-D11	CSM44315A	03/25/94	12,000	<500	<500
W-834-D11	CSM52574A	06/09/94	22,000	<500	<500
W-834-D11	CSN20092A	02/28/96	22,000	<50	<50
W-834-D11	CSN34234A	06/26/96	22,000	<50	<50
W-834-D11	CSN68001A	03/14/97	19,000	<50	<50
W-834-D11	BB9704367001	04/24/97	14,000	<600	<600
W-834-D11	CSN73191A	04/24/97	13,000	<50	<50
W-834-D11	CSP19222A	02/05/98	53,000	110	<50
W-834-D11	CSP30161A	03/26/98	16,000	<50	<50
W-834-D11	CSP30164A	03/26/98	13,000	97	<50
W-834-D11	CSP36172A	04/23/98	7,300	<50	<50
W-834-D11	CSP41833A	05/18/98	13,000	<50	<50
W-834-D11	CSP50831A	06/25/98	13,000	<50	<50
W-834-D11	CSP58002A	07/28/98	14,000	<50	<50
W-834-D11	CSP65082A	08/28/98	11,000	<50	<50
W-834-D11	CSP70123A	09/22/98	11,000	<50	<50
W-834-D11	CSP70122A	09/22/98	10,000	<50	<50
W-834-D11	CSP78445A	10/29/98	5,700	<50	<50
W-834-D11	CSP84224A	11/24/98	5,000	<50	<50
W-834-D11	CSP91824A	01/06/99	3,400	<25	<25
W-834-D11	CSP96691A	01/27/99	1,900	9.6	<5
W-834-D11	CSR02803A	02/24/99	430	2.9	<2.5
W-834-D11	BB9905045002	04/29/99	10,000	52	<0.5
W-834-D11	BB9906244001	05/27/99	7,800	<50	<50

Table A-1. Historical TCE, cis-1,2-DCE, and vinyl chloride in Building 834 wells.

Sample ID	Laboratory ID	Sample date	TCE µg/L	cis-1,2-DCE (µg/L)	Vinyl chloride (µg/L)
W-834-B2	BC9104301-1	04/11/91	14,000	<100	<100
W-834-D11	BB9910098004	08/25/99	7,900	220	<200
W-834-D11	BB9911408005	09/28/99	5,000	32	<20
W-834-D12	BC9002037-1	02/01/90	53,000	<200	<200
W-834-D12	BC9006443-4	06/20/90	57,000	<500	<500
W-834-D12	BC9105762-6	05/31/91	51,000	<200	<200
W-834-D12	BC9109443-6	09/19/91	55,000	<200	<200
W-834-D12	BC9202610-2	02/28/92	3,800	40	<20
W-834-D12	BC9212545-3	12/23/92	120,000	<500	<500
W-834-D12	BC9302154-2	02/05/93	63,000	<500	<500
W-834-D12	BC9306086-5	06/14/93	41,000	<500	<500
W-834-D12	CSM33743A	12/20/93	92,000	<2500	<2500
W-834-D12	CSM52487A	06/09/94	43,000	<1200	<1200
W-834-D12	CSM72418A	12/15/94	68,000	<1200	<1200
W-834-D12	CSM80248A	03/03/95	20,000	<130	<130
W-834-D12	CSN13024A	12/20/95	84,000	440	<250
W-834-D12	CSN20093A	02/28/96	25,000	<50	<50
W-834-D12	CSN34011A	06/25/96	15,000	<25	<25
W-834-D12	CSN56464A	12/13/96	71,000	<250	<250
W-834-D12	CSN68002A	03/14/97	21,000	55	<25
W-834-D12	CSN73192A	04/24/97	16,000	<50	<50
W-834-D12	CSP10094A	12/16/97	25,000	140	<50
W-834-D12	CSP30165A	03/26/98	21,000	<50	<50
W-834-D12	CSP48761A	06/16/98	43,000	<250	<250
W-834-D12	CSP70112A	09/22/98	9,800	<25	<25
W-834-D12	CSP88544A	12/16/98	29,000	190	<50
W-834-D12	CSR03493A	02/26/99	9,000	40	<25
W-834-D12	BB9907936001	07/07/99	20,000	150	<50
W-834-D12	BB9911409001	09/28/99	3,300	57	<0.5
W-834-D13	BC9002040-1	02/01/90	180,000	<1000	<1000
W-834-D13	BC9006439-7	06/20/90	130,000	<2000	<2000

Table A-1. Historical TCE, cis-1,2-DCE, and vinyl chloride in Building 834 wells.

Sample ID	Laboratory ID	Sample date	TCE µg/L	cis-1,2-DCE (µg/L)	Vinyl chloride (µg/L)
W-834-B2	BC9104301-1	04/11/91	14,000	<100	<100
W-834-D13	BC9105762-4	05/31/91	130,000	<500	<500
W-834-D13	BC9109443-7	09/19/91	140,000	<500	<500
W-834-D13	BC9302154-6	02/05/93	1,700	<30	<30
W-834-D13	BC9306094-4	06/15/93	4,100	<30	<30
W-834-D13	CSM33746A	12/20/93	61,000	<2500	<2500
W-834-D13	CSM52674A	06/13/94	97,000	<2500	<2500
W-834-D13	CSM72415A	12/15/94	33,000	210	<50
W-834-D13	CSN06392A	10/30/95	4,800	35	<5
W-834-D13	CSN13153A	12/21/95	71,000	330	<100
W-834-D13	CSN19632A	02/23/96	34,000	<250	<250
W-834-D13	CSN342311A	06/26/96	52,000	75	<50
W-834-D13	CSN46953A	09/25/96	53,000	<130	<130
W-834-D13	CSN56754A	12/16/96	94,000	300	<130
W-834-D13	CSN68003A	03/14/97	25,000	<130	<130
W-834-D13	CSN73045A	04/23/97	20,000	<130	<130
W-834-D13	CSP10412A	12/17/97	47,000	3,600	<130
W-834-D13	CSP10418A	12/17/97	51,000	3,700	<250
W-834-D13	CSP19223A	02/05/98	100,000	2,800	<130
W-834-D13	CSP30481A	03/27/98	41,000	1,200	<130
W-834-D13	CSP36173A	04/23/98	3,900	200	<13
W-834-D13	CSP41834A	05/18/98	14,000	<130	<130
W-834-D13	CSP50832A	06/25/98	5,800	44	<25
W-834-D13	CSP58003A	07/28/98	15,000	130	<130
W-834-D13	CSP65083A	08/28/98	15,000	<130	<130
W-834-D13	CSP70124A	09/22/98	45,000	440	<130
W-834-D13	CSP78446A	10/29/98	5,600	30	<25
W-834-D13	CSP84221A	11/24/98	26,000	230	<130
W-834-D13	CSP91823A	01/06/99	10,000	250	<130
W-834-D13	CSP96692A	01/27/99	4,200	<25	<25
W-834-D13	CSR02805A	02/24/99	13,000	<130	<130

Table A-1. Historical TCE, cis-1,2-DCE, and vinyl chloride in Building 834 wells.

Sample ID	Laboratory ID	Sample date	TCE μg/L	cis-1,2-DCE (μg/L)	Vinyl chloride (μg/L)
W-834-B2	BC9104301-1	04/11/91	14,000	<100	<100
W-834-D13	BB9903835002	03/31/99	47,000	580	<30
W-834-D13	BB9905045004	04/29/99	55,000	720	<200
W-834-D13	BB9906244002	05/27/99	72,000	620	<300
W-834-D13	BB9907575001	06/29/99	33,000	900	<100
W-834-D13	BB9908745001	07/26/99	36,000	580	<100
W-834-D13	BB9910098006	08/25/99	23,000	3,000	<500
W-834-D13	BB9911408001	09/28/99	51,000	1,100	<100
W-834-D13	BB9914247002	12/02/99	58,000	750	<100
W-834-D13	BB9915260001	12/28/99	63,000	790	<200
W-834-D13	BB0001119003	01/26/00	51,000	640	<200
W-834-D13	BB0003866007	03/29/00	55,000	15,000	<200
W-834-D13	BB0005091002	04/27/00	49,000	8,700	<100
W-834-D13	BB0005257003	05/02/00	27,000	2,600	<200
W-834-D13	MI505D-209	05/02/00	35,000	2,700	<5
W-834-D13	BB0007588006	06/29/00	20,000	4,600	<40
W-834-D13	BB0009536006	08/15/00	13,000	290	<30
W-834-D13	BB0011191003	09/26/00	36,000	350	<200
W-834-D13	BB0013774005	11/30/00	45,000	890	<700
W-834-D13	BB0014218002	12/11/00	53,000	<1000	<1000
W-834-D14	BC9002039-1	02/01/90	140,000	<1000	<1000
W-834-D14	BC9006439-8	06/20/90	78,000	<1000	<1000
W-834-D14	BC9105763-7	05/31/91	58,000	<500	<500
W-834-D14	BC9109443-8	09/19/91	98,000	<500	<500
W-834-D14	BC9202610-3	02/28/92	9,400	<50	<50
W-834-D14	BC9212516-13	12/22/92	150,000	<500	<500
W-834-D14	BC9212515-1	12/22/92	170,000	<1000	<1000
W-834-D14	BC9302227-3	02/09/93	10,000	<50	<50
W-834-D14	BC9306100-3	06/17/93	100,000	<50	<50
W-834-D14	CSM33131A	12/16/93	170,000	<2500	<2500
W-834-D14	CSM52683A	06/13/94	54,000	<1200	<1200

Table A-1. Historical TCE, cis-1,2-DCE, and vinyl chloride in Building 834 wells.

Sample ID	Laboratory ID	Sample date	TCE μg/L	cis-1,2-DCE (μg/L)	Vinyl chloride (μg/L)
W-834-B2	BC9104301-1	04/11/91	14,000	<100	<100
W-834-D14	CSM72414A	12/15/94	80,000	<500	<500
W-834-D14	CSN13152A	12/21/95	99,000	<500	<500
W-834-D14	CSN19633A	02/23/96	97,000	<250	<250
W-834-D14	CSN342310A	06/26/96	140,000	<250	<250
W-834-D14	CSN46954A	09/25/96	78,000	<250	<250
W-834-D14	BB9614472001	12/13/96	96,000	<5000	<5000
W-834-D14	CSN56466A	12/13/96	120,000	<250	<250
W-834-D14	CSN68012A	03/14/97	71,000	<250	<250
W-834-D14	CSN73048A	04/23/97	93,000	<250	<250
W-834-D14	CSN95372A	09/25/97	70,000	<250	<250
W-834-D14	CSP10413A	12/17/97	61,000	390	<250
W-834-D14	CSP19224A	02/05/98	120,000	<250	<250
W-834-D14	CSP30491A	03/27/98	47,000	<250	<250
W-834-D14	CSP36174A	04/23/98	9,000	26	<25
W-834-D14	CSP42261A	05/19/98	18,000	<130	<130
W-834-D14	CSP50833A	06/25/98	9,000	<50	<50
W-834-D14	CSP58004A	07/28/98	28,000	<250	<250
W-834-D14	CSP65084A	08/28/98	18,000	<130	<130
W-834-D14	CSP70125A	09/22/98	5,200	<25	<25
W-834-D14	CSP78447A	10/29/98	7,200	27	<25
W-834-D14	CSP84223A	11/24/98	41,000	<250	<250
W-834-D14	CSP91822A	01/06/99	18,000	<130	<130
W-834-D14	CSP96694A	01/27/99	2,000	7.4	<5
W-834-D14	CSR02804A	02/24/99	44,000	<250	<250
W-834-D14	BB9903835001	03/31/99	61,000	240	<20
W-834-D14	BB9905045003	04/29/99	66,000	320	<200
W-834-D14	BB9906244004	05/27/99	63,000	280	<200
W-834-D14	BB9907520001	06/28/99	53,000	280	<200
W-834-D14	BB9908745006	07/26/99	54,000	210	<100
W-834-D14	BB9910098005	08/25/99	79,000	<500	<500

Table A-1. Historical TCE, cis-1,2-DCE, and vinyl chloride in Building 834 wells.

Sample ID	Laboratory ID	Sample date	TCE µg/L	cis-1,2-DCE (µg/L)	Vinyl chloride (µg/L)
W-834-B2	BC9104301-1	04/11/91	14,000	<100	<100
W-834-D14	BB9911408006	09/28/99	31,000	260	<100
W-834-D14	BB9914184003	12/01/99	31,000	<200	<200
W-834-D14	BB9915260002	12/28/99	31,000	<200	<200
W-834-D14	BB0001119002	01/26/00	13,000	120	<70
W-834-D14	BB0003866006	03/29/00	74,000	<200	<200
W-834-D14	BB0005091001	04/27/00	51,000	120	<100
W-834-D14	BB0007588007	06/29/00	26,000	68	<40
W-834-D14	BB0009536008	08/15/00	18,000	70	<30
W-834-D3	BC9002041-1	02/01/90	230,000	<2000	<2000
W-834-D3	BC9006486-2	06/21/90	250,000	<2000	<2000
W-834-D3	BC9105763-3	05/31/91	340,000	<2000	<2000
W-834-D3	BC9109440-5	09/19/91	220,000	<2000	<2000
W-834-D3	BC9202610-4	02/28/92	140,000	<1000	<1000
W-834-D3	BC9302227-5	02/09/93	800,000	250,000	<5000
W-834-D3	BC9306100-4	06/17/93	150,000	88,000	<100
W-834-D3	CSM23331A	09/23/93	84,000	120,000	<1
W-834-D3	CSM34221A	12/21/93	60,000	43,000	<5000
W-834-D3	CSM34211A	12/21/93	44,000	36,000	<5000
W-834-D3	CH94003-0129	03/14/94	92,888	18,575	
W-834-D3	CSM42762A	03/14/94	110,000	22,000	<2500
W-834-D3	CSM52684A	06/13/94	71,000	52,000	<1200
W-834-D3	CSM72416A	12/15/94	110,000	7,400	<250
W-834-D3	CSM80467A	03/07/95	96,000	15,000	<250
W-834-D3	CSN06393A	10/30/95	13,000	150,000	<500
W-834-D3	CSN13156A	12/21/95	100,000	5,700	<1000
W-834-D3	CSN19634A	02/23/96	140,000	1,100	<500
W-834-D3	BB96033562	03/19/96	87,000	<5000	<5000
W-834-D3	CL960330402A	03/19/96	110,000	750	<0.5
W-834-D3	CSN22532A	03/19/96	170,000	670	<250
W-834-D3	CSN342314A	06/26/96	170,000	1,000	<250

Table A-1. Historical TCE, cis-1,2-DCE, and vinyl chloride in Building 834 wells.

Sample ID	Laboratory ID	Sample date	TCE μg/L	cis-1,2-DCE (μg/L)	Vinyl chloride (μg/L)
W-834-B2	BC9104301-1	04/11/91	14,000	<100	<100
W-834-D3	BB9611284001	09/25/96	71,000	620	<200
W-834-D3	CSN46959A	09/25/96	110,000	950	<500
W-834-D3	CSN56755A	12/16/96	73,000	420	<250
W-834-D3	CSN68013A	03/14/97	160,000	14,000	<250
W-834-D3	CSN730410A	04/23/97	130,000	84,000	<250
W-834-D3	CSN95375A	09/25/97	36,000	390,000	<2500
W-834-D3	CSP10414A	12/17/97	26,000	73,000	<130
W-834-D3	CSP19421A	02/06/98	51,000	21,000	<250
W-834-D3	CSP30492A	03/27/98	1,800	120,000	<250
W-834-D3	CSP36175A	04/23/98	18,000	100,000	<250
W-834-D3	CSP42263A	05/19/98	42,000	34,000	<250
W-834-D3	CSP50835A	06/25/98	59,000	29,000	<250
W-834-D3	CSP58007A	07/28/98	68,000	12,000	<250
W-834-D3	CSP64771A	08/27/98	43,000	8,300	<250
W-834-D3	CSP70525B	09/23/98	33,000	43,000	<250
W-834-D3	CSP78103A	10/28/98	75,000	1,500	<250
W-834-D3	CSP83651A	11/23/98	69,000	1,100	<250
W-834-D3	CSP91613A	01/05/99	94,000	16,000	<250
W-834-D3	CSP96283A	01/26/99	71,000	980	<250
W-834-D3	CSR02333A	02/23/99	56,000	440	<250
W-834-D3	BB9903780004	03/30/99	48,000	860	<30
W-834-D3	BB9904949003	04/27/99	56,000	3,200	<200
W-834-D3	BB9906203004	05/26/99	45,000	910	<200
W-834-D3	BB9907520002	06/28/99	<100	33,000	<100
W-834-D3	BB9908745004	07/26/99	870	83,000	<100
W-834-D3	BB9910098002	08/25/99	41,000	2,200	<100
W-834-D3	BB9911408003	09/28/99	40,000	810	<100
W-834-D3	BB9912666004	10/26/99	41,000	<2000	<3
W-834-D3	BB9914247004	12/02/99	41,000	700	<100
W-834-D3	BB9915207003	12/27/99	37,000	1,900	<100

Table A-1. Historical TCE, cis-1,2-DCE, and vinyl chloride in Building 834 wells.

Sample ID	Laboratory ID	Sample date	TCE µg/L	cis-1,2-DCE (µg/L)	Vinyl chloride (µg/L)
W-834-B2	BC9104301-1	04/11/91	14,000	<100	<100
W-834-D3	BB9915260005	12/28/99	<200	600	<200
W-834-D3	BB0001053003	01/25/00	3,200	360	<50
W-834-D3	BB0002493005	02/25/00	1,000	80,000	<100
W-834-D3	BB0003866003	03/29/00	<300	84,000	<300
W-834-D3	BB0004977004	04/25/00	190	75,000	<100
W-834-D3	MI512B-482	05/09/00	<2500	60,000	<2500
W-834-D3	BB0007588002	06/29/00	27,000	11,000	<100
W-834-D3	BB0009536005	08/15/00	25,000	8,600	<50
W-834-D3	BB0011191004	09/26/00	63,000	1,100	<300
W-834-D3	BB0013774002	11/30/00	43,000	<2000	<2000
W-834-D3	BB0014218003	12/11/00	46,000	2,500	<1000
W-834-D4	BC9002885-1	02/28/90	200,000	3,000	<1000
W-834-D4	BC9006439-4	06/20/90	93,000	540,000	<2000
W-834-D4	BC9106063-3	06/04/91	380,000	<2000	<2000
W-834-D4	BC9109443-1	09/19/91	350,000	210,000	<2000
W-834-D4	BC9302153-3	02/05/93	110,000	140,000	<1000
W-834-D4	BC9306111-2	06/23/93	40,000	190,000	<1000
W-834-D4	CSM23332A	09/23/93	27,000	230,000	<0.5
W-834-D4	CSM33133A	12/16/93	32,000	180,000	<2500
W-834-D4	CSM41481B	03/02/94	16,000	47,000	<1200
W-834-D4	CSM52682A	06/13/94	2,900	12,000	<250
W-834-D4	CSM724110A	12/15/94	4,600	53,000	<500
W-834-D4	CSM80862A	03/10/95	32,000	8,700	<130
W-834-D4	CSN06191A	10/27/95	2,200	160,000	<250
W-834-D4	CSN13154A	12/21/95	75,000	5,200	<250
W-834-D4	CSN20981A	03/06/96	82,000	660	<250
W-834-D4	CL960330401A	03/19/96	75,000	640	<0.5
W-834-D4	CSN22531A	03/19/96	82,000	750	<250
W-834-D4	CSN34233A	06/26/96	110,000	870	<500
W-834-D4	CSN342313A	06/26/96	97,000	1,200	<130

Table A-1. Historical TCE, cis-1,2-DCE, and vinyl chloride in Building 834 wells.

Sample ID	Laboratory ID	Sample date	TCE μg/L	cis-1,2-DCE (μg/L)	Vinyl chloride (μg/L)
W-834-B2	BC9104301-1	04/11/91	14,000	<100	<100
W-834-D4	CSN46957A	09/25/96	63,000	7,100	<250
W-834-D4	CSN56752A	12/16/96	170,000	18,000	<250
W-834-D4	CSN68004A	03/14/97	75,000	9,300	<250
W-834-D4	CSN73049A	04/23/97	95,000	40,000	<250
W-834-D4	CSN95373A	09/25/97	19,000	190,000	<1200
W-834-D4	CSN95377A	09/25/97	14,000	170,000	<250
W-834-D4	CSP10415A	12/17/97	12,000	150,000	<250
W-834-D4	CSP19225A	02/05/98	6,500	160,000	<250
W-834-D4	CSP30482A	03/27/98	2,000	98,000	<250
W-834-D4	CSP42262A	05/19/98	3,600	69,000	<250
W-834-D4	CSP50834A	06/25/98	50,000	13,000	<250
W-834-D4	CSP58006A	07/28/98	76,000	8,100	<250
W-834-D4	CSP64772A	08/27/98	40,000	4,500	<250
W-834-D4	CSP70524B	09/23/98	17,000	42,000	<250
W-834-D4	CSP78102A	10/28/98	60,000	4,600	<250
W-834-D4	CSP83652A	11/23/98	64,000	3,000	<250
W-834-D4	CSP91612A	01/05/99	81,000	29,000	<250
W-834-D4	CSP96282A	01/26/99	67,000	10,000	<250
W-834-D4	CSR02332A	02/23/99	50,000	1,900	<250
W-834-D4	BB9903780005	03/30/99	57,000	3,700	<30
W-834-D4	BB9904949002	04/27/99	60,000	2,900	<200
W-834-D4	BB9906203003	05/26/99	61,000	2,400	<200
W-834-D4	BB9907520003	06/28/99	51,000	6,300	<200
W-834-D4	BB9908745003	07/26/99	4,100	110,000	<100
W-834-D4	BB9910098003	08/25/99	35,000	22,000	<500
W-834-D4	BB9911408002	09/28/99	45,000	4,900	<100
W-834-D4	BB9912666003	10/26/99	54,000	3,200	<4
W-834-D4	BB9914247003	12/02/99	68,000	5,200	<100
W-834-D4	BB9915260004	12/28/99	57,000	4,800	<200
W-834-D4	BB0001053002	01/25/00	59,000	5,500	<10

Table A-1. Historical TCE, cis-1,2-DCE, and vinyl chloride in Building 834 wells.

Sample ID	Laboratory ID	Sample date	TCE µg/L	cis-1,2-DCE (µg/L)	Vinyl chloride (µg/L)
W-834-B2	BC9104301-1	04/11/91	14,000	<100	<100
W-834-D4	BB0002493004	02/25/00	2,600	48,000	<200
W-834-D4	BB0003866002	03/29/00	2,600	96,000	<500
W-834-D4	BB0004977003	04/25/00	<500	120,000	<500
W-834-D4	MI512B-483	05/09/00	2,900	110,000	<2500
W-834-D4	BB0007588003	06/29/00	350	110,000	<100
W-834-D4	BB0009536007	08/15/00	40,000	25,000	<50
W-834-D4	BB0011191002	09/26/00	38,000	10,000	<200
W-834-D4	BB0011191005	09/26/00	37,000	9,800	<200
W-834-D4	BB0013774003	11/30/00	48,000	15,000	<900
W-834-D4	BB0014218004	12/11/00	43,000	18,000	<1000
W-834-D5	BC9002886-1	02/28/90	100,000	400,000	<2000
W-834-D5	BC9006439-5	06/20/90	360,000	31,000	<5000
W-834-D5	BC9105763-4	05/31/91	37,000	46,000	<500
W-834-D5	BC9109443-2	09/19/91	34,000	44,000	<200
W-834-D5	BC9302153-2	02/05/93	560	2,300	<30
W-834-D5	BC9306111-3	06/23/93	3,400	1,800	<30
W-834-D5	CSM23333A	09/23/93	11,000	5,300	<0.5
W-834-D5	CSM33132A	12/16/93	460	1,000	<50
W-834-D5	CSM41482B	03/02/94	690	3,300	<130
W-834-D5	CSM72419A	12/15/94	<100	6,700	<100
W-834-D5	CSM80464A	03/07/95	410	1,400	<5
W-834-D5	CSN06391A	10/27/95	330	5,300	<25
W-834-D5	CSN13155A	12/21/95	4,000	840	<25
W-834-D5	CSN19635A	02/23/96	27,000	290	<130
W-834-D5	BB96033563	03/19/96	28,000	<2000	<2000
W-834-D5	CL960330403A	03/19/96	26,000	320	<0.5
W-834-D5	CSN22533A	03/19/96	23,000	340	<130
W-834-D5	CSN342312A	06/26/96	49,000	780	<130
W-834-D5	BB9611284002	09/25/96	32,000	1,200	<300
W-834-D5	CSN46958A	09/25/96	43,000	1,600	<130

Table A-1. Historical TCE, cis-1,2-DCE, and vinyl chloride in Building 834 wells.

Sample ID	Laboratory ID	Sample date	TCE µg/L	cis-1,2-DCE (µg/L)	Vinyl chloride (µg/L)
W-834-B2	BC9104301-1	04/11/91	14,000	<100	<100
W-834-D5	CSN56753A	12/16/96	52,000	4,500	<130
W-834-D5	CSN68014A	03/14/97	38,000	1,200	<130
W-834-D5	CSN73043A	04/23/97	31,000	1,500	<130
W-834-D5	CSP10416A	12/17/97	11,000	5,700	<130
W-834-D5	CSP30493A	03/27/98	28,000	4,100	<250
W-834-D5	CSP30494A	03/27/98	74,000	40,000	<130
W-834-D5	CSP48762A	06/16/98	26,000	800	<130
W-834-D5	CSP58005A	07/28/98	49,000	380	<130
W-834-D5	CSP65085A	08/28/98	18,000	160	<130
W-834-D5	CSP70521B	09/23/98	12,000	1,500	<130
W-834-D5	CSP78105A	10/28/98	71,000	550	<130
W-834-D5	CSP84222A	11/24/98	87,000	700	<250
W-834-D5	CSP91826A	01/06/99	62,000	2,100	<130
W-834-D5	CSP96695A	01/27/99	85,000	1,400	<130
W-834-D5	CSR02806A	02/24/99	57,000	460	<130
W-834-D5	BB9903780006	03/30/99	56,000	1,300	<30
W-834-D5	BB9904949004	04/27/99	49,000	1,400	<200
W-834-D5	BB9906244003	05/27/99	73,000	1,500	<200
W-834-D5	BB9907575003	06/29/99	46,000	2,000	<300
W-834-D5	CN9906779-01	06/29/99	47,000	1,600	<50
W-834-D5	BB9908745002	07/26/99	34,000	1,500	<100
W-834-D5	BB9910098007	08/25/99	51,000	4,100	<1000
W-834-D5	BB9911408009	09/28/99	35,000	2,400	<100
W-834-D5	BB9912721001	10/27/99	34,000	4,500	<200
W-834-D5	BB9914184004	12/01/99	38,000	2,400	<200
W-834-D5	BB9915260003	12/28/99	39,000	1,800	<200
W-834-D5	BB0001119004	01/26/00	35,000	900	<100
W-834-D5	BB0002493003	02/25/00	24,000	1,200	<200
W-834-D5	BB0003866010	03/29/00	41,000	2,800	<100
W-834-D5	BB0005091003	04/27/00	17,000	6,800	<2

Table A-1. Historical TCE, cis-1,2-DCE, and vinyl chloride in Building 834 wells.

Sample ID	Laboratory ID	Sample date	TCE µg/L	cis-1,2-DCE (µg/L)	Vinyl chloride (µg/L)
W-834-B2	BC9104301-1	04/11/91	14,000	<100	<100
W-834-D5	MI505D-212	05/03/00	23,000	6,400	<5
W-834-D5	BB0007588004	06/29/00	8,600	20,000	<40
W-834-D5	BB0009536004	08/15/00	35,000	3,000	<50
W-834-D5	BB0011191006	09/26/00	8,400	28,000	<200
W-834-D5	BB0013774004	11/30/00	<2000	32,000	<2000
W-834-D6	BC9002038-1	02/01/90	12,000	120	<50
W-834-D6	BC9006439-6	06/20/90	39,000	<1000	<1000
W-834-D6	CL900624701A	06/20/90	46,000	<1000	<1000
W-834-D6	BC9106063-4	06/04/91	37,000	<200	<200
W-834-D6	BC9109443-3	09/19/91	35,000	7,200	<200
W-834-D6	BC9302227-6	02/09/93	26,000	1,100	<300
W-834-D6	BC9306112-1	06/23/93	110,000	550	<0.5
W-834-D6	BC9306111-4	06/23/93	84,000	<300	<300
W-834-D6	CSM33745A	12/20/93	130,000	<2500	<2500
W-834-D6	CSM52676A	06/13/94	31,000	<1200	<1200
W-834-D6	CSM52675A	06/13/94	28,000	<1200	<1200
W-834-D6	CSM72413A	12/15/94	74,000	7,500	<500
W-834-D6	CSM80465A	03/07/95	22,000	2,300	<130
W-834-D6	CSN13151A	12/21/95	110,000	680	<500
W-834-D6	CSN19636A	02/23/96	39,000	<250	<250
W-834-D6	CSN34237A	06/26/96	73,000	<250	<250
W-834-D6	CSN46951A	09/25/96	73,000	<500	<500
W-834-D6	CSN56751A	12/16/96	55,000	460	<250
W-834-D6	CSN68005A	03/14/97	33,000	<250	<250
W-834-D6	CSN73047A	04/23/97	37,000	270	<250
W-834-D6	CSP10417A	12/17/97	47,000	1,300	<250
W-834-D6	CSP30484A	03/27/98	36,000	260	<250
W-834-D6	CSP48772B	06/17/98	29,000	<250	<250
W-834-D6	CSP70113A	09/22/98	19,000	<130	<130
W-834-D6	CSP88542A	12/16/98	69,000	<250	<250

Table A-1. Historical TCE, cis-1,2-DCE, and vinyl chloride in Building 834 wells.

Sample ID	Laboratory ID	Sample date	TCE µg/L	cis-1,2-DCE (µg/L)	Vinyl chloride (µg/L)
W-834-B2	BC9104301-1	04/11/91	14,000	<100	<100
W-834-D6	CSP88545A	12/16/98	89,000	<250	<250
W-834-D6	CSR03494A	02/26/99	93,000	530	<130
W-834-D6	BB9907568001	06/29/99	55,000	1,200	<200
W-834-D6	BB9911408008	09/28/99	20,000	310	<50
W-834-D6	BB0003715003	03/24/00	18,000	120	<80
W-834-D6	MI505D-208	05/02/00	12,000	150	<5
W-834-D6	BB0007588005	06/29/00	18,000	120	<40
W-834-D6	BB0009536012	08/15/00	10,000	170	<30
W-834-D7	BC9002036-1	02/01/90	54,000	<200	<200
W-834-D7	BC9006443-3	06/20/90	51,000	<500	<500
W-834-D7	BC9105763-5	05/31/91	49,000	<200	<200
W-834-D7	BC9109443-4	09/19/91	53,000	<200	<200
W-834-D7	BC9212516-14	12/22/92	56,000	<300	<300
W-834-D7	BC9302154-5	02/05/93	32,000	<300	<300
W-834-D7	BC9306086-4	06/14/93	13,000	<300	<300
W-834-D7	CSM44094A	03/24/94	37,000	<250	<250
W-834-D7	CSM44091A	03/24/94	32,000	<250	<250
W-834-D7	CSM80247A	03/03/95	17,000	<50	<50
W-834-D7	CSN13023A	12/20/95	67,000	<250	<250
W-834-D7	CSN20094A	02/28/96	26,000	58	<50
W-834-D7	CSN31641A	06/07/96	22,000	<100	<100
W-834-D7	CSN56465A	12/13/96	38,000	<250	<250
W-834-D7	CSN68015A	03/14/97	26,000	<50	<50
W-834-D7	CSN68016A	03/14/97	32,000	<130	<130
W-834-D7	CSN73042A	04/23/97	18,000	<50	<50
W-834-D7	BB9710360001	09/25/97	20,000	72	<0.5
W-834-D7	CSN95371A	09/25/97	18,000	91	<50
W-834-D7	CSP10095A	12/16/97	13,000	81	<50
W-834-D7	CSP30172A	03/26/98	5,400	<50	<50
W-834-D7	CSP30175A	03/26/98	6,900	<25	<25

Table A-1. Historical TCE, cis-1,2-DCE, and vinyl chloride in Building 834 wells.

Sample ID	Laboratory ID	Sample date	TCE µg/L	cis-1,2-DCE (µg/L)	Vinyl chloride (µg/L)
W-834-B2	BC9104301-1	04/11/91	14,000	<100	<100
W-834-D7	CSP48763A	06/16/98	19,000	74	<50
W-834-D7	CSP70114A	09/22/98	9,200	<50	<50
W-834-D7	CSP88546A	12/16/98	22,000	130	<50
W-834-D7	CSR03495A	02/26/99	14,000	74	<25
W-834-D7	BB9907568002	06/29/99	19,000	440	<200
W-834-D7	BB9907686001	07/01/99	14,000	160	<60
W-834-D7	BB9911409002	09/28/99	9,900	170	<30
W-834-D8	BC9001875-1	01/31/90	71,000	<500	<500
W-834-D8	BC9006486-1	06/21/90	45,000	<500	<500
W-834-D8	BC9008634-3	08/28/90	48,000	<500	<500
W-834-D8	BC9012473-1	12/19/90	59,000	<500	<500
W-834-D8	BC9103332-2	03/13/91	86,000	<500	<500
W-834-D8	BC9105762-3	05/31/91	82,000	<500	<500
W-834-D8	BC9109440-4	09/19/91	53,000	<500	<500
W-834-D8	BC9112587-3	12/27/91	50,000	<500	<500
W-834-D8	BC9203075-1	03/04/92	59,000	<500	<500
W-834-D8	BC9206633-8	06/26/92	71,000	<500	<500
W-834-D8	BC9208446-2	08/21/92	48,000	<500	<500
W-834-D8	BC9212516-12	12/22/92	4,100	<300	<300
W-834-D8	BC9302227-7	02/09/93	49,000	<300	<300
W-834-D8	BC9306085-1	06/14/93	34,000	<500	<500
W-834-D8	CSM44093A	03/24/94	36,000	760	<250
W-834-D8	CSM80462A	03/07/95	34,000	290	<250
W-834-D8	CSM80463A	03/07/95	29,000	500	<130
W-834-D8	CSN13157A	12/21/95	19,000	<250	<250
W-834-D8	CSN20982A	03/06/96	30,000	<250	<250
W-834-D8	BB9606584001	06/07/96	17,000	<700	<700
W-834-D8	CSN31644A	06/07/96	18,000	<100	<100
W-834-D8	CSN57123A	12/18/96	19,000	1,100	<130
W-834-D8	CSN57122A	12/18/96	18,000	1,200	<130

Table A-1. Historical TCE, cis-1,2-DCE, and vinyl chloride in Building 834 wells.

Sample ID	Laboratory ID	Sample date	TCE µg/L	cis-1,2-DCE (µg/L)	Vinyl chloride (µg/L)
W-834-B2	BC9104301-1	04/11/91	14,000	<100	<100
W-834-D8	CSN68006A	03/14/97	9,900	880	<50
W-834-D8	CSN73041A	04/23/97	60,000	600	<250
W-834-D8	CSN95376A	09/25/97	41,000	2,000	<250
W-834-D8	CSP10096A	12/16/97	43,000	1,500	<250
W-834-D8	CSP19422A	02/06/98	36,000	540	<250
W-834-D8	CSP30483A	03/27/98	31,000	1,800	<250
W-834-D8	CSP36451A	04/24/98	30,000	420	<250
W-834-D8	CSP42264A	05/19/98	25,000	1,200	<250
W-834-D8	CSP50836A	06/25/98	50,000	850	<250
W-834-D8	CSP58008A	07/28/98	51,000	1,100	<250
W-834-D8	CSP64773A	08/27/98	57,000	1,200	<250
W-834-D8	CSP70526B	09/23/98	51,000	1,900	<250
W-834-D8	CSP78104A	10/28/98	54,000	820	<250
W-834-D8	CSP83653A	11/23/98	30,000	950	<250
W-834-D8	CSP91614A	01/05/99	45,000	2,300	<250
W-834-D8	CSP96284A	01/26/99	88,000	1,500	<250
W-834-D8	CSR02334A	02/23/99	45,000	1,100	<250
W-834-D8	BB9906203002	05/26/99	42,000	1,800	<200
W-834-D8	BB9907637001	06/30/99	10,000	370	<50
W-834-D8	BB9908745005	07/26/99	9,200	280	<30
W-834-D8	BB9910188005	08/27/99	29,000	1,600	<100
W-834-D8	BB9911409003	09/28/99	16,000	1,300	<100
W-834-D8	BB9912666005	10/26/99	44,000	1,800	<400
W-834-D8	BB9914247005	12/02/99	80,000	1,100	<200
W-834-D8	BB9915260006	12/28/99	30,000	5,100	<50
W-834-D8	BB0001053004	01/25/00	26,000	26,000	<10
W-834-D8	BB0002493006	02/25/00	5,800	36,000	<50
W-834-D8	BB0003866004	03/29/00	8,700	18,000	<50
W-834-H2	BC9109209-1	09/10/91	84,000	<500	<500
W-834-H2	BC9203076-1	03/04/92	120,000	<1000	<1000

Table A-1. Historical TCE, cis-1,2-DCE, and vinyl chloride in Building 834 wells.

Sample ID	Laboratory ID	Sample date	TCE μg/L	cis-1,2-DCE (μg/L)	Vinyl chloride (μg/L)
W-834-B2	BC9104301-1	04/11/91	14,000	<100	<100
W-834-H2	BC9203075-2	03/04/92	130,000	<1000	<1000
W-834-H2	BC9208446-1	08/21/92	93,000	<500	<500
W-834-H2	BC9212516-11	12/22/92	59,000	<500	<500
W-834-H2	BC9302227-4	02/09/93	64,000	<1000	<1000
W-834-H2	BC9306094-1	06/15/93	50,000	<1000	<1000
W-834-H2	CSM21042A	09/02/93	18,000	<500	<500
W-834-H2	CSM34213A	12/21/93	14,000	<1200	<1200
W-834-H2	CSM44314A	03/24/94	25,000	<500	<500
W-834-H2	CSM52572A	06/10/94	36,000	<1200	<1200
W-834-H2	CSM80101A	03/02/95	60,000	<130	<130
W-834-H2	CSN12871A	12/19/95	30,000	<250	<250
W-834-H2	CSN20095A	02/28/96	33,000	<250	<250
W-834-H2	CSN30374A	05/30/96	53,000	<250	<250
W-834-H2	CSN56261A	12/12/96	13,000	<25	<25
W-834-H2	CSN67783A	03/13/97	14,000	<25	<25
W-834-H2	CSN73193A	04/24/97	9,500	<25	<25
W-834-H2	CSN95813A	09/26/97	4,800	<50	<50
W-834-H2	CSP30173A	03/26/98	15,000	<50	<50
W-834-H2	CSP48744A	06/16/98	36,000	<250	<250
W-834-H2	CSP70115A	09/22/98	32,000	<250	<250
W-834-H2	CSP88547A	12/16/98	36,000	<250	<250
W-834-H2	CSR03496A	02/26/99	14,000	<50	<50
W-834-H2	BB9911303002	09/24/99	810	<5	<5
W-834-H2	BB0009536009	08/15/00	2,500	<5	<5
W-834-J1	BC9001876-1	01/31/90	32,000	<200	<200
W-834-J1	BC9006331-1	06/14/90	40,000	<500	<500
W-834-J1	BC9008671-3	08/29/90	41,000	<200	<200
W-834-J1	BC9012171-5	12/07/90	23,000	<200	<200
W-834-J1	BC9103332-3	03/13/91	30,000	<200	<200
W-834-J1	BC9105762-2	05/31/91	60,000	<200	<200

Table A-1. Historical TCE, cis-1,2-DCE, and vinyl chloride in Building 834 wells.

Sample ID	Laboratory ID	Sample date	TCE μg/L	cis-1,2-DCE (μg/L)	Vinyl chloride (μg/L)
W-834-B2	BC9104301-1	04/11/91	14,000	<100	<100
W-834-J1	BC9109441-1	09/19/91	60,000	<500	<500
W-834-J1	BC9109440-1	09/19/91	62,000	<200	<200
W-834-J1	BC9112539-2	12/23/91	57,000	<500	<500
W-834-J1	BC9203075-3	03/04/92	71,000	<200	<200
W-834-J1	BC9206624-3	06/26/92	94,000	<500	<500
W-834-J1	BC9208446-3	08/21/92	91,000	<500	<500
W-834-J1	BC9212545-5	12/23/92	86,000	<500	<500
W-834-J1	BC9306094-5	06/15/93	57,000	<500	<500
W-834-J1	CSM44106A	03/23/94	32,000	<250	<250
W-834-J1	CSM52485A	06/09/94	29,000	<500	<500
W-834-J1	CSM80103A	03/02/95	24,000	<130	<130
W-834-J1	CSN12872A	12/19/95	21,000	<250	<250
W-834-J1	CSN17746A	02/09/96	26,000	<250	<250
W-834-J1	BB9606202001	05/29/96	17,000	<500	<500
W-834-J1	CSN30367A	05/29/96	30,000	<250	<250
W-834-J1	CSN56911A	12/17/96	40,000	<250	<250
W-834-J1	BB9702754001	03/13/97	19,000	2	<1
W-834-J1	CSN67772A	03/13/97	30,000	<50	<50
W-834-J1	BB9704367002	04/24/97	13,000	23	<20
W-834-J1	CSN73194A	04/24/97	14,000	<50	<50
W-834-J1	CSN95814A	09/26/97	16,000	<50	<50
W-834-J1	CSP10097A	12/16/97	14,000	<50	<50
W-834-J1	CSP30174A	03/26/98	16,000	<50	<50
W-834-J1	CSP48745A	06/16/98	15,000	<50	<50
W-834-J1	CSP70116A	09/22/98	11,000	<50	<50
W-834-J1	CSP88548A	12/16/98	15,000	<50	<50
W-834-J1	CSR03497A	02/26/99	15,000	<50	<50
W-834-J1	BB9907568003	06/29/99	11,000	<50	<50
W-834-J1	BB9911303003	09/24/99	8,600	<20	<20
W-834-J1	BB0006614001	06/06/00	5,500	0.92	<0.5

Table A-1. Historical TCE, cis-1,2-DCE, and vinyl chloride in Building 834 wells.

Sample ID	Laboratory ID	Sample date	TCE µg/L	cis-1,2-DCE (µg/L)	Vinyl chloride (µg/L)
W-834-B2	BC9104301-1	04/11/91	14,000	<100	<100
W-834-J1	BB0009536010	08/15/00	4,800	<10	<10
W-834-J2	BC9001879-1	01/31/90	52,000	<500	<500
W-834-J2	BC9006331-2	06/14/90	37,000	<500	<500
W-834-J2	BC9008671-2	08/29/90	26,000	<100	<100
W-834-J2	BC9012171-6	12/07/90	46,000	<200	<200
W-834-J2	BC9012519-2	12/21/90	42,000	<200	<200
W-834-J2	BC9103332-4	03/13/91	43,000	<200	<200
W-834-J2	BC9105763-1	05/31/91	45,000	<200	<200
W-834-J2	BC9109440-2	09/19/91	59,000	<200	<200
W-834-J2	BC9112539-1	12/23/91	64,000	<500	<500
W-834-J2	BC9206624-4	06/26/92	63,000	<500	<500
W-834-J2	BC9212545-4	12/23/92	59,000	<500	<500
W-834-J2	CL921232701A	12/23/92	39,000	<400	<500
W-834-J2	BC9306100-1	06/17/93	22,000	<500	<500
W-834-J2	CSM44107C	03/23/94	28,000	<250	<250
W-834-J2	CSM52483A	06/09/94	22,000	<500	<500
W-834-J2	GTC406021101	06/09/94	22,000	<50	<100
W-834-J2	CSM80102A	03/02/95	9,900	<50	<50
W-834-J2	CSN12873A	12/19/95	17,000	<100	<100
W-834-J2	CSN17745A	02/09/96	19,000	<130	<130
W-834-J2	CSN31175A	06/05/96	13,000	<50	<50
W-834-J2	CSN56912A	12/17/96	23,000	<50	<50
W-834-J2	CSN67784A	03/13/97	9,600	<50	<50
W-834-J2	CSN73044A	04/23/97	6,200	<50	<50
W-834-J2	CSN95815A	09/26/97	7,900	<25	<25
W-834-J2	CSP10098A	12/16/97	11,000	<25	<25
W-834-J2	CSP30166A	03/26/98	10,000	<50	<50
W-834-J2	CSP48746A	06/16/98	8,300	<50	<50
W-834-J2	CSP48747A	06/16/98	9,700	<50	<50
W-834-J2	CSP70117A	09/22/98	6,600	<25	<25

Table A-1. Historical TCE, cis-1,2-DCE, and vinyl chloride in Building 834 wells.

Sample ID	Laboratory ID	Sample date	TCE μg/L	cis-1,2-DCE (μg/L)	Vinyl chloride (μg/L)
W-834-B2	BC9104301-1	04/11/91	14,000	<100	<100
W-834-J2	CSP88549A	12/16/98	6,800	<25	<25
W-834-J2	CSR03498A	02/26/99	7,000	<25	<25
W-834-J2	BB9911303001	09/24/99	5,300	<20	<20
W-834-J2	BB9915207006	12/27/99	460	<1	<1
W-834-J2	BB0003715001	03/24/00	4,600	<9	<9
W-834-J2	MI505D-210	05/02/00	3,800	7.0	<5
W-834-J2	BB0007588008	06/29/00	1,400	<3	<3
W-834-J2	BB0009536011	08/15/00	1,600	<3	<3
W-834-J2	BB0011191007	09/26/00	3,000	<20	<20
W-834-J2	BB0014218001	12/11/00	5,700	<100	<100
W-834-K1	BC9001838-1	01/30/90	4,500	<20	<20
W-834-K1	BC9006331-3	06/14/90	4,700	<50	<50
W-834-K1	CL900612101A	06/14/90	2,700	<40	<50
W-834-K1	BC9008634-4	08/28/90	4,200	<20	<20
W-834-K1	CL900823301A	08/28/90	3,100	<40	<50
W-834-K1	BC9012171-4	12/07/90	4,400	<50	<50
W-834-K1	BC9103224-1	03/08/91	4,700	<50	<50
W-834-K1	BC9105615-2	05/23/91	5,000	<20	<20
W-834-K1	BC9109359-1	09/17/91	6,100	<20	<20
W-834-K1	BC9112507-3	12/20/91	6,400	<50	<50
W-834-K1	CL911220801A	12/20/91	3,500	<4	<5
W-834-K1	BC9206557-2	06/24/92	8,100	<50	<50
W-834-K1	BC9206558-1	06/24/92	9,400	<50	<50
W-834-K1	BC9212460-5	12/18/92	3,900	<50	<50
W-834-K1	BC9306100-2	06/17/93	3,500	<50	<50
W-834-K1	CSM43475A	03/16/94	2,400	<13	<13
W-834-K1	CSM79999A	03/01/95	2,800	<25	<25
W-834-K1	CSN12375A	12/14/95	2,700	9.9	<5
W-834-K1	CSN17602A	02/08/96	3,400	<13	<13
W-834-K1	CSN29537A	05/22/96	3,000	<13	<13

Table A-1. Historical TCE, cis-1,2-DCE, and vinyl chloride in Building 834 wells.

Sample ID	Laboratory ID	Sample date	TCE µg/L	cis-1,2-DCE (µg/L)	Vinyl chloride (µg/L)
W-834-B2	BC9104301-1	04/11/91	14,000	<100	<100
W-834-K1	CSN46956A	09/25/96	2,300	<10	<10
W-834-K1	CSN57711C	12/23/96	2,400	12	<10
W-834-K1	BB9702754002	03/13/97	3,000	<300	<300
W-834-K1	CSN67773A	03/13/97	3,000	17	<5
W-834-K1	CSN72636A	04/18/97	2,600	<13	<13
W-834-K1	CSN72631A	04/18/97	2,500	16	<5
W-834-K1	BB9710411001	09/26/97	2,300	26	<30
W-834-K1	CSN95816A	09/26/97	2,400	27	<5
W-834-K1	CSP08691A	12/08/97	3,200	17	<13
W-834-K1	CSP08692A	12/08/97	2,900	16	<13
W-834-K1	CSP27904A	03/17/98	2,100	22	<5
W-834-K1	BB9807015001	06/18/98	170	1.1	<0.5
W-834-K1	CSP49051A	06/18/98	230	<1	<0.5
W-834-K1	CSP69761A	09/21/98	94	<1	<0.5
W-834-K1	CSP885410A	12/16/98	170	<1	<0.5
W-834-K1	BB9907734001	07/02/99	1,800	49	<20
W-834-K1	BB9911517003	09/30/99	930	33	<5
W-834-K1	BB9915264001	12/28/99	1,900	68	<20
W-834-K1	BB0003862001	03/29/00	2,200	67	<0.5
W-834-S1	BC9001812-1	01/29/90	52,000	<500	<500
W-834-S1	BC9006439-1	06/20/90	45,000	<500	<500
W-834-S1	BC9008634-2	08/28/90	45,000	<500	<500
W-834-S1	BC9012138-3	12/06/90	48,000	<500	<500
W-834-S1	BC9103224-3	03/08/91	56,000	<500	<500
W-834-S1	BC9104258-1	04/10/91	51,000	<500	<500
W-834-S1	BC9109402-2	09/18/91	56,000	800	<200
W-834-S1	BC9112572-2	12/26/91	76,000	<500	<500
W-834-S1	BC9202376-1	02/19/92	62,000	<500	<500
W-834-S1	BC9208406-3	08/19/92	110,000	1,100	<500
W-834-S1	BC9212460-1	12/18/92	57,000	<500	<500

Table A-1. Historical TCE, cis-1,2-DCE, and vinyl chloride in Building 834 wells.

Sample ID	Laboratory ID	Sample date	TCE µg/L	cis-1,2-DCE (µg/L)	Vinyl chloride (µg/L)
W-834-B2	BC9104301-1	04/11/91	14,000	<100	<100
W-834-S1	BC9302227-1	02/09/93	89,000	990	<500
W-834-S1	BC9306103-3	06/18/93	94,000	<500	<500
W-834-S1	CL930624502A	06/18/93	76,000	460	<10
W-834-S1	CSM43443A	03/17/94	18,000	180	<100
W-834-S1	CSM52364A	06/08/94	14,000	<500	<500
W-834-S1	CSM79996A	03/01/95	24,000	<130	<130
W-834-S1	CSN12373A	12/14/95	20,000	<250	<250
W-834-S1	CSN34026A	06/25/96	15,000	<250	<250
W-834-S1	CSN56905A	12/17/96	21,000	<130	<130
W-834-S1	CSN72732A	04/21/97	13,000	<130	<130
W-834-S1	CSP08944A	12/09/97	15,000	180	<130
W-834-S1	CSP18841A	02/04/98	17,000	160	<130
W-834-S1	CSP27906A	03/17/98	16,000	330	<130
W-834-S1	CSP35871A	04/22/98	22,000	340	<130
W-834-S1	CSP42265A	05/19/98	17,000	310	<130
W-834-S1	CSP50383A	06/24/98	23,000	440	<130
W-834-S1	CSP57613A	07/27/98	22,000	540	<130
W-834-S1	CSP63363A	08/21/98	21,000	540	<130
W-834-S1	CSP70527B	09/23/98	18,000	490	<130
W-834-S1	CSP78443A	10/29/98	17,000	610	<130
W-834-S1	CSP84225A	11/24/98	21,000	560	<130
W-834-S1	CSP91821A	01/06/99	17,000	500	<130
W-834-S1	CSP96696A	01/27/99	14,000	680	<130
W-834-S1	CSR02807A	02/24/99	15,000	510	<130
W-834-S1	BB9903699001	03/29/99	13,000	480	<30
W-834-S1	BB9905045005	04/29/99	12,000	440	<50
W-834-S1	BB9906281001	05/28/99	12,000	410	<50
W-834-S1	BB9907460003	06/25/99	11,000	280	<50
W-834-S1	BB9908800005	07/27/99	10,000	240	<50
W-834-S1	BB9910137005	08/26/99	9,600	200	<100

Table A-1. Historical TCE, cis-1,2-DCE, and vinyl chloride in Building 834 wells.

Sample ID	Laboratory ID	Sample date	TCE µg/L	cis-1,2-DCE (µg/L)	Vinyl chloride (µg/L)
W-834-B2	BC9104301-1	04/11/91	14,000	<100	<100
W-834-S1	BB9912721003	10/27/99	12,000	170	<50
W-834-S1	BB9914306002	12/03/99	9,800	200	<50
W-834-S1	BB0007375003	06/23/00	11,000	320	<70
W-834-S1	BB0014279003	12/12/00	14,000	<500	<500
W-834-S1	BB0014417001	12/14/00	9,400	<300	<300
W-834-S2	BC9303580-1	03/19/93	65,000	<500	<500
W-834-S2	CSM33741A	12/20/93	62,000	<2500	<2500
W-834-S2	CSM52361A	06/08/94	68,000	<1000	<1000
W-834-S2	CSN12521A	12/15/95	45,000	<250	<250
W-834-S2	CSN34252A	06/26/96	51,000	<250	<250
W-834-S2	CSN72731A	04/21/97	45,000	<250	<250
W-834-S2	CSP49052A	06/18/98	28,000	<250	<250
W-834-S2	CSP885413A	12/16/98	36,000	<250	<250
W-834-S2	BB9907734002	07/02/99	26,000	230	<20
W-834-S2A	BC9001701-1	01/24/90	12,000	<100	<100
W-834-S2A	BC9006443-2	06/20/90	11,000	<100	<100
W-834-S2A	BC9008578-4	08/24/90	11,000	<100	<100
W-834-S2A	BC9012171-3	12/07/90	12,000	<100	<100
W-834-S2A	BC9103205-3	03/07/91	16,000	<100	<100
W-834-S2A	BC9105762-1	05/31/91	24,000	<100	<100
W-834-S2A	BC9105761-1	05/31/91	23,000	<100	<100
W-834-S2A	BC9109359-2	09/17/91	27,000	<100	<100
W-834-S2A	BC9112587-1	12/27/91	37,000	<200	<200
W-834-S2A	BC9208516-1	08/26/92	20,000	<100	<100
W-834-S2A	BC9212460-4	12/18/92	23,000	<300	<300
W-834-S2A	BC9302305-4	02/11/93	29,000	<300	<300
W-834-S2A	BC9306085-2	06/14/93	15,000	<300	<300
W-834-S2A	CSM43482A	03/17/94	14,000	<100	<100
W-834-S2A	CSM799911A	03/01/95	12,000	51	<50
W-834-S2A	CSN13012A	12/20/95	14,000	100	<50

Table A-1. Historical TCE, cis-1,2-DCE, and vinyl chloride in Building 834 wells.

Sample ID	Laboratory ID	Sample date	TCE µg/L	cis-1,2-DCE (µg/L)	Vinyl chloride (µg/L)
W-834-B2	BC9104301-1	04/11/91	14,000	<100	<100
W-834-S2A	CSN30621A	05/31/96	9,700	67	<25
W-834-S2A	BB9614765001	12/20/96	9,700	<500	<500
W-834-S2A	CSN57521A	12/20/96	11,000	26	<25
W-834-S2A	CSN72735A	04/21/97	14,000	38	<25
W-834-S2A	CSP09372A	12/11/97	16,000	57	<25
W-834-S2A	BB9806893001	06/16/98	14,000	97	<0.5
W-834-S2A	CSP48452A	06/16/98	22,000	87	<25
W-834-S2A	CSP885414A	12/16/98	8,700	<25	<25
W-834-S2A	BB9907734003	07/02/99	8,700	56	<20
W-834-S3	BC9001702-1	01/24/90	37,000	<200	<200
W-834-S3	BC9006443-1	06/20/90	22,000	<200	<200
W-834-S3	BC9008634-5	08/28/90	15,000	<200	<200
W-834-S3	BC9012171-2	12/07/90	13,000	<100	<100
W-834-S3	BC9103224-4	03/08/91	24,000	<200	<200
W-834-S3	BC9105763-2	05/31/91	20,000	<100	<100
W-834-S3	BC9109359-5	09/17/91	17,000	<100	<100
W-834-S3	BC9112510-2	12/20/91	28,000	<200	<200
W-834-S3	BC9206633-9	06/26/92	37,000	<200	<200
W-834-S3	BC9212516-7	12/22/92	84	<0.5	<0.5
W-834-S3	BC9306085-3	06/14/93	50,000	<300	<300
W-834-S3	CSM43441A	03/17/94	37,000	<250	<250
W-834-S3	CSM79995A	03/01/95	55,000	<130	<130
W-834-S3	CSN13141A	12/21/95	57,000	<250	<250
W-834-S3	CSN29891A	05/24/96	92,000	<250	<250
W-834-S3	CSN57412A	12/19/96	78,000	<250	<250
W-834-S3	CSN72874A	04/22/97	81,000	<250	<250
W-834-S3	CSN72872A	04/22/97	65,000	<130	<130
W-834-S3	CSP09373A	12/11/97	62,000	<130	<130
W-834-S3	CSP48751A	06/17/98	72,000	<130	<130
W-834-S3	CSP88961A	12/17/98	64,000	<250	<250

Table A-1. Historical TCE, cis-1,2-DCE, and vinyl chloride in Building 834 wells.

Sample ID	Laboratory ID	Sample date	TCE μg/L	cis-1,2-DCE (μg/L)	Vinyl chloride (μg/L)
W-834-B2	BC9104301-1	04/11/91	14,000	<100	<100
W-834-S3	CSP88962A	12/17/98	58,000	<130	<130
W-834-S3	BB9907734004	07/02/99	39,000	120	<20
W-834-S3	BB9910137003	08/26/99	12,000	<200	<200
W-834-S3	BB9910137004	08/26/99	31,000	<200	<200
W-834-S8	BC9001703-1	01/24/90	2,300	<20	<20
W-834-S8	BC9006330-1	06/14/90	2,900	<20	<20
W-834-S8	BC9006331-4	06/14/90	3,300	<20	<20
W-834-S8	BC9008578-5	08/24/90	3,500	<20	<20
W-834-S8	BC9012138-2	12/06/90	4,300	<20	<20
W-834-S8	BC9103205-2	03/07/91	4,200	50	<20
W-834-S8	BC9105582-4	05/22/91	9,000	130	<50
W-834-S8	BC9109358-1	09/17/91	4,500	<20	<20
W-834-S8	BC9109359-4	09/17/91	9,200	<50	<50
W-834-S8	BC9112510-3	12/20/91	8,900	<50	<50
W-834-S8	BC9206633-4	06/26/92	16,000	<50	<50
W-834-S8	BC9212460-3	12/18/92	2,000	32	<30
W-834-S8	BC9306112-2	06/23/93	8,600	<0.5	<0.5
W-834-S8	BC9306111-5	06/23/93	9,400	<50	<50
W-834-S8	CSM43481A	03/17/94	4,300	45	<25
W-834-S8	CSM799912A	03/01/95	2,900	44	<13
W-834-S8	CSN12374A	12/14/95	2,800	57	<5
W-834-S8	CSN29892A	05/24/96	4,200	62	<25
W-834-S8	CSN57413A	12/19/96	3,400	<25	<25
W-834-S8	BB9704192001	04/21/97	2,400	45	<2
W-834-S8	CSN72734A	04/21/97	2,500	<25	<25
W-834-S8	CSP09374A	12/11/97	2,500	40	<25
W-834-S8	CSP48454A	06/16/98	2,700	45	<5
W-834-S8	CSP885415A	12/16/98	6,800	<50	<50
W-834-S8	BB9907734005	07/02/99	1,900	50	<20
W-834-S8	BB9912721002	10/27/99	1,500	15	<5

Table A-1. Historical TCE, cis-1,2-DCE, and vinyl chloride in Building 834 wells.

Sample ID	Laboratory ID	Sample date	TCE µg/L	cis-1,2-DCE (µg/L)	Vinyl chloride (µg/L)
W-834-B2	BC9104301-1	04/11/91	14,000	<100	<100
W-834-S8	BB9914306003	12/03/99	110	4.0	<0.5
W-834-S8	BB0001193001	01/27/00	380	11	<1
W-834-S8	BB0002743002	03/02/00	1,900	35	<0.5
W-834-S8	BB0003920002	03/30/00	2,700	33	<3
W-834-S8	BB0005091006	04/27/00	2,500	33	<5
W-834-S8	MI505D-213	05/03/00	2,100	49	<5
W-834-S8	CNA060764-01	06/28/00	1,000	25	<10
W-834-S8	BB0007534002	06/28/00	1,800	41	<0.5
W-834-S8	BB0014279004	12/12/00	2,300	<70	<70
W-834-S9	BC9001839-1	01/30/90	1,600	<10	<10
W-834-S9	BC9006331-5	06/14/90	1,700	<10	<10
W-834-S9	BC9008635-1	08/28/90	1,200	<10	<10
W-834-S9	BC9008634-1	08/28/90	1,200	<10	<10
W-834-S9	BC9012138-4	12/06/90	1,100	<10	<10
W-834-S9	BC9103224-2	03/08/91	900	<5	<5
W-834-S9	BC9105615-4	05/23/91	610	<2	<2
W-834-S9	BC9109248-9	09/11/91	1,200	<5	<5
W-834-S9	BC9112272-1	12/11/91	1,100	<5	<5
W-834-S9	BC9202376-2	02/19/92	870	<5	<5
W-834-S9	BC9206633-6	06/26/92	1,200	<10	<10
W-834-S9	BC9208406-4	08/19/92	1,300	<5	<5
W-834-S9	BC9212460-6	12/18/92	800	<5	<5
W-834-S9	BC9302227-2	02/09/93	1,200	<5	<5
W-834-S9	BC9306103-2	06/18/93	1,600	<5	<5
W-834-S9	CSM43442A	03/17/94	960	<5	<5
W-834-S9	CSM79997A	03/01/95	900	<5	<5
W-834-S9	CSN12372A	12/14/95	1,600	<5	<5
W-834-S9	CSN29731A	05/23/96	1,000	<2.5	<2.5
W-834-S9	CSN57524A	12/20/96	2,300	<5	<5
W-834-S9	CSN72402A	04/17/97	1,800	<5	<5

Table A-1. Historical TCE, cis-1,2-DCE, and vinyl chloride in Building 834 wells.

Sample ID	Laboratory ID	Sample date	TCE µg/L	cis-1,2-DCE (µg/L)	Vinyl chloride (µg/L)
W-834-B2	BC9104301-1	04/11/91	14,000	<100	<100
W-834-S9	CSP09802A	12/15/97	1,900	<5	<5
W-834-S9	CSP49053A	06/18/98	1,900	<13	<13
W-834-S9	CSP885416A	12/16/98	1,700	<5	<5
W-834-S9	BB9907734006	07/02/99	2,200	<20	<20
W-834-S9	BB99077346A	07/02/99	2,200	<20	<20
W-834-S9	BB9910137001	08/26/99	1,100	<7	<7
W-834-S9	BB9910137002	08/26/99	1,700	<20	<20
W-834-S9	BB9915264002	12/28/99	1,800	<30	<30
W-834-S9	BB0005091005	04/27/00	2,300	<5	<5
W-834-S9	MI505D-214	05/03/00	1,800	5.0	<5
W-834-S9	BB0007474002	06/27/00	2,100	<20	<20
W-834-S9	BB0014279005	12/12/00	2,100	<70	<70
W-834-T2	BC9001628-1	01/23/90	35,000	<200	<200
W-834-T2	BC9006331-6	06/14/90	23,000	<200	<200
W-834-T2	BC9008578-2	08/24/90	27,000	<200	<200
W-834-T2	BC9012473-2	12/19/90	31,000	<200	<200
W-834-T2	BC9103205-1	03/07/91	32,000	<200	<200
W-834-T2	BC9105629-3	05/24/91	36,000	<200	<200
W-834-T2	BC9109402-1	09/18/91	43,000	<200	<200
W-834-T2	BC9112587-2	12/27/91	45,000	<200	<200
W-834-T2	BC9206633-5	06/26/92	66,000	<500	<500
W-834-T2	BC9212460-9	12/18/92	45,000	<300	<300
W-834-T2	CL921230201A	12/18/92	51,000	<10	<10
W-834-T2	BC9306115-6	06/24/93	61,000	<300	<300
W-834-T2	BC9306114-1	06/24/93	50,000	<100	<100
W-834-T2	CSM19782A	08/20/93	29,000	<500	<500
W-834-T2	CSM32751A	12/14/93	49,000	<2500	<2500
W-834-T2	CSM43474A	03/16/94	26,000	<130	<130
W-834-T2	GTC403034602	03/16/94	35,000	26	<1
W-834-T2	CSM52482A	06/09/94	34,000	<1200	<1200

Table A-1. Historical TCE, cis-1,2-DCE, and vinyl chloride in Building 834 wells.

Sample ID	Laboratory ID	Sample date	TCE µg/L	cis-1,2-DCE (µg/L)	Vinyl chloride (µg/L)
W-834-B2	BC9104301-1	04/11/91	14,000	<100	<100
W-834-T2	CSM72114A	12/13/94	30,000	<250	<250
W-834-T2	CSM72113A	12/13/94	28,000	<250	<250
W-834-T2	CSM79762A	02/28/95	27,000	<130	<130
W-834-T2	CSN13011A	12/20/95	37,000	<250	<250
W-834-T2	CSN29302A	05/21/96	48,000	<250	<250
W-834-T2	CSN72873A	04/22/97	39,000	<250	<250
W-834-T2	CSN72875A	04/22/97	78,000	<130	<130
W-834-T2	CSP48753A	06/17/98	33,000	<250	<250
W-834-T2	BB9903699002	03/29/99	23,000	<20	<20
W-834-T2	BB9904993002	04/28/99	24,000	<100	<100
W-834-T2	BB9906203005	05/26/99	24,000	<100	<100
W-834-T2	BB9907460004	06/25/99	22,000	<200	<200
W-834-T2	BB9908800006	07/27/99	24,000	<200	<200
W-834-T2	BB9910098008	08/25/99	4,100	<50	<50
W-834-T2	BB9912721005	10/27/99	23,000	<100	<100
W-834-T2	BB9914247006	12/02/99	24,000	<50	<50
W-834-T2	BB0001053005	01/25/00	19,000	<10	<10
W-834-T2	BB0002493007	02/25/00	14,000	<50	<50
W-834-T2	BB0003866011	03/29/00	24,000	<50	<50
W-834-T2	BB0004977005	04/25/00	26,000	<50	<50
W-834-T2	MI512B-484	05/10/00	22,000	<250	<250
W-834-T2	BB0007411002	06/26/00	25,000	16	<0.5
W-834-T2	CNA060683-01	06/26/00	20,000	12	<0.5
W-834-T2	BB0014412004	12/14/00	29,000	<500	<500
W-834-T2A	CSN34027A	06/25/96	35,000	<250	<250
W-834-T2A	CSN72733A	04/21/97	40,000	<250	<250
W-834-T2A	CSP49044A	06/18/98	49,000	<250	<250
W-834-T2A	BB9903699003	03/29/99	31,000	2,600	<30
W-834-T2A	BB9905045007	04/29/99	32,000	110	<100
W-834-T2A	BB9906281005	05/28/99	34,000	<200	<200

Table A-1. Historical TCE, cis-1,2-DCE, and vinyl chloride in Building 834 wells.

Sample ID	Laboratory ID	Sample date	TCE μg/L	cis-1,2-DCE (μg/L)	Vinyl chloride (μg/L)
W-834-B2	BC9104301-1	04/11/91	14,000	<100	<100
W-834-T2A	BB9907460005	06/25/99	31,000	<200	<200
W-834-T2A	BB9908800002	07/27/99	31,000	160	<100
W-834-T2A	BB9910188002	08/27/99	32,000	<700	<700
W-834-T2A	BB9912721004	10/27/99	33,000	<100	<100
W-834-T2A	BB9914247007	12/02/99	33,000	<50	<50
W-834-T2A	BB0001193002	01/27/00	31,000	<50	<50
W-834-T2A	BB0002743001	03/02/00	37,000	<50	<50
W-834-T2A	BB0003920001	03/30/00	33,000	<50	<50
W-834-T2A	BB0005091007	04/27/00	28,000	30	<20
W-834-T2A	BB0007411003	06/26/00	38,000	<100	<100
W-834-T2C	CSM32762A	12/14/93	2,400	<130	<130
W-834-T2C	CSM43473A	03/16/94	1,700	<10	<10
W-834-T2C	CSM52375A	06/08/94	2,100	<50	<50
W-834-T2C	CSM72116A	12/13/94	2,000	<25	<25
W-834-T2C	CSM79993A	03/01/95	3,800	<10	<10
W-834-T2C	CSM80001A	03/01/95	2,200	<10	<10
W-834-T2C	CSN34025A	06/25/96	1,700	<13	<13
W-834-T2C	CSN72403A	04/17/97	580	<2.5	<2.5
W-834-T2C	CSP49055A	06/18/98	3,900	<13	<13
W-834-T2C	BB9907636001	06/30/99	210	<0.5	<0.5
W-834-T2C	BB0007474003	06/27/00	200	<1	<1

Appendix B

Monitoring and Reporting Requirement Documents

Substantive Requirements, Building 834 Removal Action, Lawrence Livermore National Laboratory Site 300, San Joaquin County

Monitoring and Reporting Program Requirements for the Building 834 Removal Action, Lawrence Livermore National Laboratory Site 300, San Joaquin County

San Joaquin Valley Unified Air Pollution Control District: Facilitywide Requirements

STATE OF CALIFORNIA - Environmental Protection Agency PETE WILSON, Governor

CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD
CENTRAL VALLEY REGION
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3 January 1994

Mr. Richard Powell, Remedial Project Manager
U. S. Department of Energy Field Office, San Francisco
Lawrence Livermore National Laboratory
P.O. Box 808, L-574
Livermore, CA 94551

SUBSTANTIVE REQUIREMENTS, BUILDING 834 REMOVAL ACTION, LAWRENCE LIVERMORE NATIONAL LABORATORY SITE 300, SAN JOAQUIN COUNTY

We have reviewed your 16 December 1993 comments on the 17 November 1993 draft Substantive Requirements and Monitoring and Reporting Program for the Building 834 Removal Action. Enclosed are the final Substantive Requirements and Monitoring and Reporting Program, in which we have incorporated some of the changes in part or in whole as requested by the Department of Energy and Lawrence Livermore National Laboratory (hereafter referred to collectively as LLNL). The following is a discussion of the changes you requested which are not incorporated in the final document:

1. In Section A, Discharge Prohibitions, the wording is standard and the meaning clear without the words "ground water" being added. California Code of Regulations, Title 23, Division 3, Chapter 15 defines hazardous and designated waste, not waste ground water. Section A was not changed.

2. LLNL requested that "untreated water" be changed to "untreated ground water" and "from the ground water treatment system or from associated ground water extraction wells" be added to the spill notification. Provision 8 was changed to specify the spill of untreated ground water; however, "from the ground water treatment system or from associated ground water extraction wells" was not inserted because any spill of contaminated water to the ground must be reported.

3. At present, Provision 9 still requires monthly operation reports. The monthly report which coincides with the quarterly monitoring report can be issued with the quarterly report. No duplication of earlier monthly reports is required. The agencies and LLNL can discuss changing the reporting schedules for all the ongoing Removal Actions in the next RPM meeting. Meanwhile, the reporting requirements for the Central GSA, Eastern GSA, and the

Building 834 Removal Actions all require monthly operation reports and quarterly monitoring reports.

4. The "Standard Provisions and Reporting Requirements for Waste Discharge Requirements" are attached. These are standard provisions and will not be changed.

5. Monitoring of cations and anions, alkalinity and hardness will be required annually. If LLNL demonstrates that metals are not above background, then metals may be dropped from the analysis unless water levels rise significantly.

Also, since we agreed to your request to drain discharge lines onto ground during freeze conditions, provision D.2 was added.

As stated above, we are willing to discuss with LLNL and the other agencies revising reporting frequency and due dates at an upcoming meeting. If you have any questions, please contact me at (916) 255-3057.

Susan Timm

SUSAN TIMM
Remedial Project Manager

ST:ldj

Enclosure

cc: Richard Seraydarian, U.S. Environmental Protection Agency, San Francisco
Robert Feather, Department of Toxic Substances Control, Berkeley
Albert Lamarre, Lawrence Livermore National Laboratory, Livermore

CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD
CENTRAL VALLEY REGION

STANDARD PROVISIONS AND REPORTING REQUIREMENTS
FOR
WASTE DISCHARGE REQUIREMENTS

1 March 1991

A. General Provisions:

1. The requirements prescribed herein do not authorize the commission of any act causing injury to the property of another, or protect the discharger from liabilities under federal, state, or local laws. This Order does not convey any property rights or exclusive privileges.

2. The provisions of this Order are severable. If any provision of this Order is held invalid, the remainder of this Order shall not be affected.

3. After notice and opportunity for a hearing, this Order may be terminated or modified for cause, including, but not limited to:

    a. Violation of any term or condition contained in this Order;

    b. Obtaining this Order by misrepresentation, or failure to disclose fully all relevant facts;

    c. A change in any condition that results in either a temporary or permanent need to reduce or eliminate the authorized discharge;

    d. A material change in the character, location, or volume of discharge.

4. Before making a material change in the character, location, or volume of discharge, the discharger shall file a new Report of Waste Discharge with the Regional Board. A material change includes, but is not limited to, the following:

    a. An increase in area or depth to be used for solid waste disposal beyond that specified in waste discharge requirements

    b. A significant change in disposal method, location or volume, e.g., change from land disposal to land treatment.

    c. The addition of a major industrial, municipal or domestic waste discharge facility.

    d. The addition of a major industrial waste discharge to a discharge of essentially domestic sewage, or the addition of a new process or product by an industrial facility resulting in a change in the character of the waste.

A. **General Provisions (continued)**

5. Except for material determined to be confidential in accordance with California law and regulations, all reports prepared in accordance with terms of this Order shall be available for public inspection at the offices of the Board. Data on waste discharges, water quality, geology, and hydrogeology shall not be considered confidential.

6. The discharger shall take all reasonable steps to minimize any adverse impact to the waters of the state resulting from noncompliance with this Order. Such steps shall include accelerated or additional monitoring as necessary to determine the nature and impact of the noncompliance.

7. The discharger shall maintain in good working order and operate as efficiently as possible any facility, control system, or monitoring device installed to achieve compliance with the waste discharge requirements.

8. The discharger shall permit representatives of the Regional Board (hereafter Board) and the State Water Resources Control Board, upon presentation of credentials, to:

    a. Enter premises where wastes are treated, stored, or disposed of and facilities in which any records are kept,

    b. Copy any records required to be kept under terms and conditions of this Order,

    c. Inspect at reasonable hours, monitoring equipment required by this Order, and

    d. Sample, photograph and video tape any discharge, waste, waste management unit or monitoring device.

9. For any electrically operated equipment at the site, the failure of which could cause loss of control or containment of waste materials, or violation of this Order, the discharger shall employ safeguards to prevent loss of control over wastes. Such safeguards may include alternate power sources, standby generators, retention capacity, operating procedures, or other means.

10. The fact that it would have been necessary to halt or reduce the permitted activity in Order to maintain compliance with this Order shall not be a defense for the discharger's violations of the Order.

11. Neither the treatment nor the discharge shall create a condition of nuisance or pollution as defined by the California Water Code, Section 13050.

A. General Provisions (continued)

12. The discharge shall remain within the designated disposal area at all times.

B. General Reporting Requirements

1. In the event the discharger does not comply or will be unable to comply with any prohibition or limitation of this Order for any reason, the discharger shall notify the Board by telephone at (916) 255-3000 as soon as it or its agents have knowledge of such noncompliance or potential for noncompliance, and shall confirm this notification in writing within two weeks. The written notification shall state the nature, time and cause of noncompliance, and shall describe the measures being taken to prevent recurrences and shall include a timetable for corrective actions.

2. The discharger shall have a plan for preventing and controlling accidental discharges, and for minimizing the effect of such events.

   This plan shall:

   a. Identify the possible sources of accidental loss or leakage of wastes from each waste management, treatment, or disposal facility.

   b. Evaluate the effectiveness of present waste management/treatment units and operational procedures, and identify needed changes or contingency plans.

   c. Predict the effectiveness of the proposed changes in waste management/treatment facilities and procedures and provide an implementation schedule containing interim and final dates when changes will be implemented.

   The Board, after review of the plan, may establish conditions that it deems necessary to control leakages and minimize their effects.

3. All reports shall be signed by persons identified below:

   a. For a corporation: by a principal executive officer of at least the level of senior vice-president.

   b. For a partnership or sole proprietorship: by a general partner or the proprietor.

   c. For a municipality, state, federal or other public agency: by either a principal executive officer or ranking elected or appointed official.

B. General Reporting Requirements (continued)

d. A duly authorized representative of a person designated in 3a, 3b or 3c of this requirement if;

(1) the authorization is made in writing by a person described in 3a, 3b, or 3c of this provision;

(2) the authorization specifies either an individual or a position having responsibility for the overall operation of the regulated facility or activity, such as the position of plant manager, operator of a waste management unit, superintendent, or position of equivalent responsibility. (A duly authorized representative may thus be either a named individual or any individual occupying a named position); and

(3) the written authorization is submitted to the Board

Any person signing a document under this Section shall make the following certification:

"I certify under penalty of law that I have personally examined and am familiar with the information submitted in this document and all attachments and that, based on my inquiry of those individuals immediately responsible for obtaining the information, I believe that the information is true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment."

4. Technical and monitoring reports specified in this Order are requested pursuant to Section 13267 of the Water Code. Failing to furnish the reports by the specified deadlines and falsifying information in the reports, are misdemeanors that may result in assessment of civil liabilities against the discharger.

5. The discharger shall mail a copy of each monitoring report and any other reports required by this Order to:

   California Regional Water Quality Control Board
   Central Valley Region
   3443 Routier Road, Suite A
   Sacramento, CA 95827-3098

   or the current address if the office relocates.

C. Provisions for Monitoring

1. All analyses shall be made in accordance with the latest edition of: (1) "Methods for Organic Chemical Analysis of Municipal and Industrial Wastewater" (EPA 600 Series) and (2) "Test Methods for Evaluating Solid Waste" (SW 846-latest edition). The test method may be modified subject to application and approval of alternate test procedures under the Code of Federal Regulations (40 CFR 136).

2. Chemical, bacteriological, and bioassay analyses shall be conducted at a laboratory certified for such analyses by the State Department of Health Services. In the event a certified laboratory is not available to the discharger, analyses performed by a noncertified laboratory will be accepted provided a Quality Assurance-Quality Control Program is instituted by the laboratory. A manual containing the steps followed in this program must be kept in the laboratory and shall be available for inspection by Board staff. The Quality Assurance-Quality Control Program must conform to EPA guidelines or to procedures approved by the Board.

   Unless otherwise specified, all metals shall be reported as Total Metals.

3. The discharger shall retain records of all monitoring information, including all calibration and maintenance records, all original strip chart recordings of continuous monitoring instrumentation, copies of all reports required by this Order, and records of all data used to complete the application for this Order. Records shall be maintained for a minimum of three years from the date of the sample, measurement, report, or application, This period may be extended during the course of any unresolved litigation regarding this discharge or when requested by the Regional Board Executive Officer.

   Record of monitoring information shall include:

   a. the date, exact place, and time of sampling or measurements,
   b. the individual(s) who performed the sampling of measurements,
   c. the date(s) analyses were performed,
   d. the individual(s) who performed the analyses,
   e. the laboratory which performed the analysis,
   f. the analytical techniques or methods used, and
   g. the results of such analyses.

4. All monitoring instruments and devices used by the discharger to fulfill the prescribed monitoring program shall be properly maintained and calibrated at least yearly to ensure their continued accuracy.

C. Provisions For Monitoring (continued)

5. The discharger shall maintain a written sampling program sufficient to assure compliance with the terms of this Order. Anyone performing sampling on behalf of the discharger shall be familiar with the sampling plan.

6. The discharger shall construct all monitoring wells to meet or exceed the standards stated in the State Department of Water Resources Bulletin 74-81 and subsequent revisions, and shall comply with the reporting provisions for wells required by Water Code Sections 13750 through 13755.22

D. Standard Conditions for Facilities Subject to California Code of Regulations, Title 23, Division 3, Chapter 15 (Chapter 15)

1. All classified waste management units shall be designed under the direct supervision of a California registered civil engineer or a California certified engineering geologist. Designs shall include a Construction Quality Assurance Plan, the purpose of which is to:

   a. demonstrate that the waste management unit has been constructed according to the specifications and plans as approved by the Board.

   b. provide quality control on the materials and construction practices used to construct the waste management unit and prevent the use of inferior products and/or materials which do not meet the approved design plans or specifications.

2. Prior to the discharge of waste to any classified waste management unit, a California registered civil engineer or a California certified engineering geologist must certify that the waste management unit meets the construction or prescriptive standards and performance goals in Chapter 15, unless an engineered alternative has been approved by the Board. In the case of an engineered alternative, the registered civil engineer or certified engineering geologist must certify that the waste management unit has been constructed in accordance with Board-approved plans and specifications.

3. Materials used to construct liners shall have appropriate physical and chemical properties to ensure containment of discharged wastes over the operating life, closure, and post-closure maintenance period of the waste management units.

4. Closure of each waste management unit shall be performed under the direct supervision of a California registered civil engineer or California certified engineering geologist.

E. Conditions Applicable to Discharge Facilities Exempted From Chapter 15 Under Section 2511

1. If the discharger's wastewater treatment plant is publicly owned or regulated by the Public Utilities Commission, it shall be supervised and operated by persons possessing certificates of appropriate grade according to California Code of Regulations, Title 23, Division 4, Chapter 14.

2. By-pass (the intentional diversion of waste streams from any portion of a treatment facility, except diversions designed to meet variable effluent limits) is prohibited. The Board may take enforcement action against the discharger for by-pass unless:

   a. (1) By-pass was unavoidable to prevent loss of life, personal injury, or severe property damage. (Severe property damage means substantial physical damage to property, damage to the treatment facilities that causes them to become inoperable, or substantial and permanent loss of natural resources that can reasonably be expected to occur in the absence of a by-pass. Severe property damage does not mean economic loss caused by delays in production); <u>and</u>

   (2) There were no feasible alternatives to by-pass, such as the use of auxiliary treatment facilities or retention of untreated waste. This condition is not satisfied if adequate back-up equipment should have been installed in the exercise of reasonable engineering judgment to prevent a by-pass that would otherwise occur during normal periods of equipment downtime or preventive maintenance; <u>or</u>

   b. (1) by-pass is required for essential maintenance to assure efficient operation; and

   (2) neither effluent nor receiving water limitations are exceeded; and

   (3) the discharger notifies the Board ten days in advance.

   The permittee shall submit notice of an unanticipated by-pass as required in paragraph B.1. above.

3. A discharger that wishes to establish the affirmative defense of an upset (see definition in E.6 below) in an action brought for noncompliance shall demonstrate, through properly signed, contemporaneous operating logs, or other evidence, that:

   a. an upset occurred and the cause(s) can be identified;

E. Dischargers Exempt from Chapter 15 (continued)

b. the permitted facility was being properly operated at the time of the upset;

c. the discharger submitted notice of the upset as required in paragraph B.1., above; and

d. the discharger complied with any remedial measures required by waste discharge requirements.

In any enforcement proceeding, the discharger seeking to establish the occurrence of an upset has the burden of proof.

4. A discharger whose waste flow has been increasing, or is projected to increase, shall estimate when flows will reach hydraulic and treatment capacities of its treatment, collection, and disposal facilities. The projections shall be made in January, based on the last three years' average dry weather flows, peak wet weather flows and total annual flows, as appropriate. When any projection shows that capacity of any part of the facilities may be exceeded in four years, the discharger shall notify the Board by **31 January.**

5. Effluent samples shall be taken downstream of the last addition of wastes to the treatment or discharge works where a representative sample may be obtained prior to disposal. Samples shall be collected at such a point and in such a manner to ensure a representative sample of the discharge.

6. Definitions

a. Upset means an exceptional incident in which there is unintentional and temporary noncompliance with effluent limitations because of factors beyond the reasonable control of the Discharger. An upset does not include noncompliance to the extent caused by operational error, improperly designed treatment facilities, inadequate treatment facilities, lack of preventive maintenance, or careless or improper action.

b. The monthly average discharge is the total discharge by volume during a calendar month divided by the number of days in the month that the facility was discharging. This number is to be reported in gallons per day or million gallons per day.

Where less than daily sampling is required by this Order, the monthly average shall be determined by the summation of all the measured discharges by the number of days during the month when the measurements were made.

E. **Dischargers Exempt from Chapter 15 (continued)**

c. The monthly average **concentration** is the arithmetic mean of measurements made during the month.

d. The "daily maximum" **discharge** is the total discharge by volume during any day.

e. The "daily maximum" **concentration** is the highest measurement made on any single discrete sample or composite sample.

f. A "grab" sample is any sample collected in less than 15 minutes.

g. Unless otherwise specified, a composite sample is a combination of individual samples collected over the specified sampling period;

(1) at equal time intervals, with a maximum interval of one hour

(2) at varying time intervals (average interval one hour or less) so that each sample represents an equal portion of the cumulative flow.

The duration of the sampling period shall be specified in the Monitoring and Reporting Program. The method of compositing shall be reported with the results.

7. Annual Pretreatment Report Requirements:

Applies to dischargers required to have a Pretreatment Program as stated in waste discharge requirements.)

The annual report shall be submitted **by 28 February** and include, but not be limited to, the following items:

a. A summary of analytical results from representative, flow-proportioned, 24-hour composite sampling of the influent and effluent for those pollutants EPA has identified under Section 307(a) of the Clean Water Act which are known or suspected to be discharged by industrial users.

The discharger is not required to sample and analyze for asbestos until EPA promulgates an applicable analytical technique under 40 CFR (Code of Federal Regulations) Part 136. Sludge shall be sampled during the same 24-hour period and analyzed for the same pollutants as the influent and effluent sampling and analysis. The sludge analyzed shall be a composite sample of a minimum of 12 discrete samples taken at equal time intervals over the 24-hour period. Wastewater and sludge sampling and analysis shall be

E. Dischargers Exempt from Chapter 15 (continued)

performed at least annually. The discharger shall also provide any influent, effluent or sludge monitoring data for nonpriority pollutants which may be causing or contributing to Interference, Pass Through or adversely impacting sludge quality. Sampling and analysis shall be performed in accordance with the techniques prescribed in 40 CFR Part 136 and amendments thereto.

b. A discussion of Upset, Interference, or Pass Through incidents, if any, at the treatment plant which the discharger knows or suspects were caused by industrial users of the system. The discussion shall include the reasons why the incidents occurred, the corrective actions taken and, if known, the name and address of the industrial user(s) responsible. The discussion shall also include a review of the applicable pollutant limitations to determine whether any additional limitations, or changes to existing requirements, may be necessary to prevent Pass Through, Interference, or noncompliance with sludge disposal requirements.

c. The cumulative number of industrial users that the discharger has notified regarding Baseline Monitoring Reports and the cumulative number of industrial user responses.

d. An updated list of the discharger's industrial users including their names and addresses, or a list of deletions and additions keyed to a previously submitted list. The discharger shall provide a brief explanation for each deletion. The list shall identify the industrial users subject to federal categorical standards by specifying which set(s) of standards are applicable. The list shall indicate which categorical industries, or specific pollutants from each industry, are subject to local limitations that are more stringent than the federal categorical standards. The discharger shall also list the noncategorical industrial users that are subject only to local discharge limitations. The discharger shall characterize the compliance status through the year of record of each industrial user by employing the following descriptions:

(1) Complied with baseline monitoring report requirements (where applicable);

(2) Consistently achieved compliance;

(3) Inconsistently achieved compliance;

(4) Significantly violated applicable pretreatment requirements as defined by 40 CFR 403.8(f)(2)(vii);

E. Dischargers Exempt from Chapter 15 (continued)

(5) Complied with schedule to achieve compliance (include the date final compliance is required);

(6) Did not achieve compliance and not on a compliance schedule;

(7) Compliance status unknown.

A report describing the compliance status of any industrial user characterized by the descriptions in items (d)(3) through (d)(7) above shall be **submitted quarterly from the annual report date** to EPA and the Board. The report shall identify the specific compliance status of each such industrial user. This quarterly reporting requirement shall commence upon issuance of this Order.

e. A summary of the inspection and sampling activities conducted by the discharger during the past year to gather information and data regarding the industrial users. The summary shall include but not be limited to, a tabulation of categories of dischargers that were inspected and sampled; how many and how often; and incidents of noncompliance detected.

f. A summary of the compliance and enforcement activities during the past year. The summary shall include the names and addresses of the industrial users affected by the following actions:

(1) Warning letters or notices of violation regarding the industrial user's apparent noncompliance with federal categorical standards or local discharge limitations. For each industrial user, identify whether the apparent violation concerned the federal categorical standards or local discharge limitations;

(2) Administrative Orders regarding the industrial user's noncompliance with federal categorical standards or local discharge limitations. For each industrial user, identify whether the violation concerned the federal categorical standards or local discharge limitations;

(3) Civil actions regarding the industrial user's noncompliance with federal categorical standards or local discharge limitations. For each industrial user, identify whether the violation concerned the federal categorical standards or local discharge limitations;

E. Dischargers Exempt from Chapter 15 (continued)

(4) Criminal actions regarding the industrial user's noncompliance with federal categorical standards or local discharge limitations. For each industrial user, identify whether the violation concerned the federal categorical standards or local discharge limitations.

(5) Assessment of monetary penalties. For each industrial user identify the amount of the penalties;

(6) Restriction of flow to the treatment plant; or

(7) Disconnection from discharge to the treatment plant.

g. A description of any significant changes in operating the pretreatment program which differ from the discharger's approved Pretreatment Program, including, but not limited to, changes concerning: the program's administrative structure; local industrial discharge limitations; monitoring program or monitoring frequencies; legal authority or enforcement policy; funding mechanisms; resource requirements; and staffing levels.

h. A summary of the annual pretreatment budget, including the cost of pretreatment program functions and equipment purchases.

i. A summary of public participation activities to involve and inform the public.

j. A description of any changes in sludge disposal methods and a discussion of any concerns not described elsewhere in the report.

Duplicate signed copies of these reports shall be submitted to the Board and:

Regional Administrator
U.S. Environmental Protection Agency W-5
75 Hawthorne Street
San Francisco, CA 94105

and

State Water Resources Control Board
Division of Water Quality
P.O. Box 944213
Sacramento, CA 94244-2130

Revised March 1993 to update phone number of Central Valley Regional Board.

SUBSTANTIVE REQUIREMENTS
FOR
UNIVERSITY OF CALIFORNIA
LAWRENCE LIVERMORE NATIONAL LABORATORY
AND U.S. DEPARTMENT OF ENERGY

SITE 300 BUILDING 834 REMOVAL ACTION

31 DECEMBER 1993

Findings:

1. The University of California, Lawrence Livermore National Laboratory Site 300 (LLNL) and the U.S. Department of Energy (DOE) (hereafter jointly referred to as Discharger), propose to start operating the Building 834 treatment system.

2. Shallow perched ground water, soil and soil vapor beneath the Building 834 Complex are contaminated with volatile organic compounds (VOCs), primarily TCE, and light, nonaqueous phase liquids (LNAPLs) which have been identified as diesel and tentatively as tetra 2-ethylbutylorthosilicate (T-BOS).

3. Because the chromatograph for the LNAPL closely resembles chromatographs of polychlorinated biphenyls (PCBs) and the Discharger has only made tentative identification of some components of the LNAPL, the Discharger will be required to determine if the LNAPL contains PCBs.

4. The treatment facility at Building 834 includes a soil vapor extraction and treatment system (SVE) and a ground water extraction and treatment system (GWTS).

5. Nine extraction wells, W-834-D3, W-834-D4, W-834-D5, W-834-D6, W-834-D7, W-834-D11, W-834-D12, W-834-D13, and W-834-D14, are currently connected to a vacuum manifold system (Figure 1).

6. The Discharger proposes adding up to six of the following existing monitor wells to the vacuum manifold system to enhance vadose zone extraction: W-834-B2, W-834-B3, W-834-D8, W-834-J1, W-834-J2, W-834-H2, and W-834-C2 (Figure 1).

7. The GWTS works as follows: 1) extracted ground water is pumped through an oil-water separator to remove LNAPLs, 2) the separator effluent is then aerated in a 500-gallon air sparging tank until effluent contaminant concentration levels have reached regulatory standards, 3) treated groundwater is pumped to two 500-gallon storage tanks on the misting discharge pad, and 4) from the misting discharge pad, the treated ground water is pumped to six 20-foot misting towers which are on-site, downwind of Building 834 (under prevailing conditions), and away from the main body of contaminated perched ground water (Figure 2). The Discharger proposes to vary the

misting rate to allow the mist to evaporate rather than reach the ground. During freeze conditions, the treatment system will be shut down. The Discharger proposes to drain any treated ground water remaining in the system discharge lines onto the ground surface to prevent freeze related damage to discharge lines. No more than 150 gallons of treated ground water is expected to drain onto the ground surface during a freeze event.

8. The Discharger anticipates that no more than 2,000 gallons/day can be extracted from the shallow water-bearing zone.

9. The Discharger conducted several tests to evaluate the performance of the soil vapor and ground water removal and treatment system between 1986 and 1992.

10. The Discharger will conduct proof-of-system testing prior to start-up of full scale operations.

11. The ground water and soil vapor extraction and treatment system start-up will involve several phases. First, total fluids, including dissolved and NAPL phase contaminants, will be extracted from extraction wells W-834-D3, W-834-D4, and W-834-D5 and the LNAPL phase skimmed off via an oil/water separator and treated. Second, after sufficient NAPLs have been removed, ground water will be extracted from the remaining ground water extraction wells and treated with air sparging. Finally, after the perched water table at the core of the complex has been sufficiently lowered to avoid pulling contaminated ground water into the SVE manifold, soil vapor extraction will begin at the soil vapor extraction wells listed in Finding 5.

The Discharger, in order to meet the provisions contained in Division 7 of the California Water Code and regulations adopted thereunder, shall comply with the following:

A. Discharge Prohibitions

1. Bypass or overflow of untreated or partially treated waste is prohibited.

2. Discharge of waste classified as 'hazardous' or 'designated', as defined in Sections 2521(a) and 2522(a) of Chapter 15, is prohibited.

3. Discharge in violation of State Board Resolution 68-16 is prohibited.

B. Effluent Limitations

1. The discharge of ground water effluent, in excess of the following limits is prohibited:

Compound	Maximum Daily Concentration(μg/l)[1]	Monthly Median Concentration(μg/l)
Tetrachloroethylene	5.0	0.5
Trichloroethylene	5.0	0.5
1,1-Dichloroethylene	5.0	0.5
1,2-Dichloroethylene	5.0	0.5
1,1,1-Trichloroethane	5.0	0.5
1,2-Dichloroethane	5.0	0.5
Carbon Tetrachloride	5.0	0.5
Chloroform	5.0	0.5
Benzene	5.0	0.5
Ethylbenzene	5.0	0.5
Toluene	5.0	0.5
Total Xylene Isomers	5.0	0.5
Freon 113	5.0	0.5
Trichlorofluoromethane	5.0	0.5
Total Volatile Organic Compounds[2]	5.0	0.5
Total Petroleum Hydrocarbons	100	50

[1] Using EPA Methods 601/602 (and Freon 113) with a detection limit of 0.5 μg/l or less, and Modified EPA Method 8015.

[2] Total VOCs will be the sum of all VOCs detected above 0.5 μg/l concentration.

2. The treated ground water shall not have a pH less than 6.5 nor greater than 8.5.

3. The 30-day average daily dry weather discharge of treated ground water shall not exceed 2,000 gallons. Upon approval of the Executive Officer this discharge limit may be increased should full scale operation indicate more treated ground water could be discharged without any adverse impacts to the environment.

4. The Discharger shall use the best practicable cost-effective control technique currently available to limit mineralization to no more than a reasonable increment.

C. Discharge Specifications

1. SYSTEM CHECK

Prior to operating the ground water treatment system with contaminated ground water, a system check shall be conducted to confirm the proper construction and operation of the treatment system. The following minimum requirements apply to this system check phase:

a. A conformance inspection shall be conducted to confirm that all equipment, piping, instrumentation, and control systems of the ground water treatment system and soil vapor extraction system have been installed according to the approved design. Any deficiencies in the ground water treatment system or soil vapor extraction system shall be corrected.

b. To confirm piping integrity, piping of the collection system and treatment system shall be pressure tested at 150 percent of the design pressure with potable water. Any leaks shall be repaired.

c. All instrumentation, control systems, and equipment shall be inspected for malfunctions. Instrumentation shall be calibrated and operational, prior to their use. All automatic controls, such as shutdown or alarm switches necessary for the operation of each treatment system phase, shall be certified operational prior to startup of that phase. Mechanical equipment, such as pumps, air blowers, and valves, required for the operation of the treatment phase, will be cycled or operated. Any functional deficiencies shall be corrected.

2. PROOF OF SYSTEM

a. The proof-of-system (POS) shall not begin until the system check has been completed and all deficiencies corrected.

b. The Discharger shall notify the Regional Water Quality Control Board (Board), the U.S. Environment Protection Agency (U.S. EPA), and the Department of Toxic Substances Control (DTSC) at least three working days prior to beginning the POS in case representatives of the agencies want to observe the system in operation.

c. The POS shall last long enough to demonstrate that contaminated ground water has been extracted from each extraction well and has been treated by the oil/water separator and the air sparging system.

d. Each of the extraction wells shall be pumped long enough to confirm that the ground water pumps and water level shutoff devices operate properly.

e. The Discharger shall analyze the ground water for LNAPLs and dissolved LNAPL constituents after passing it through the oil/water separator during the proof-of-system (POS) testing.

f. After treatment by the air sparging system, the treated ground water shall be sampled at the sparge system or discharged to a holding tank to be sampled and analyzed as required in the attached Monitoring and Reporting Program (MRP).

g. Water pumped from the extraction wells and water leaving the oil/water separator and the air sparging tank(s) shall be monitored in accordance with the POS monitoring plan in the MRP.

h. Upon approval of the Executive Officer, treated ground water shall be discharged via the misting system onto the ground if analyses show that it has been treated to regulatory standards.

i. If analyses show that ground water concentrations levels are above regulatory standards, the groundwater shall receive further treatment until the concentration levels reach regulatory standards.

j. All treatment, transport, and disposal components (including pumps, valves, liquid level controllers, pipelines, blowers, flow meters, pressure gauges, etc.) shall be inspected for leaks and/or malfunctions. In addition, the system's automatic controls, including the alarm/notification and shutdown systems, shall be inspected and certified operational. All mechanical equipment shall be operated under load to assure proper performance. Any deficiencies shall be corrected.

k. The POS will continue until the Discharger determines the residence time necessary in the oil/water separator and/or in the air sparging tanks to achieve concentration levels in the ground water which meet regulatory discharge standards identified in Section B (Effluent Standards).

l. The operation of the GWTS and SVE shall cease at the end of the POS testing period. The Discharger shall not resume operation of the system until the Board, the DTSC, and the U.S. EPA) have reviewed the POS report (Provision 4) and have authorized operation.

3. FULL SCALE OPERATION

a. All extracted ground water shall be treated by the treatment system and discharged to ground via misting.

b. The Discharger shall operate the treatment system to maximize removal of VOCs from the extracted ground water.

c. The system operations shall be monitored in accordance with the full scale operational phase monitoring plan in the attached MRP.

d. All treatment, transport, and disposal components (including pumping valves, liquid level controllers, pipelines, blowers, flow meters, pressure gauges, etc.) shall be inspected for leaks and/or malfunctions each business day that the system is operational during manual operation, and weekly during automated operation.

e. The system's automatic controls, including the alarm/notification and shutdown systems, shall be tested and certified operational on an annual basis.

4. DURING ALL PHASES OF OPERATIONS

a. Neither the treatment nor the discharge shall cause a nuisance or condition of pollution as defined by the California Water Code, Section 13050.

b. The discharge shall not cause degradation of any water supply.

c. Any collected screenings, sludge, and other solids removed from liquid wastes shall be disposed of in a manner consistent with Chapter 15, Division 3, Title 23, CCR.

d. The discharge of treated ground water from the GWTS shall not exceed the design capacity determined during the POS phase without prior approval from the Board, DTSC, and the U.S. EPA.

D. Provisions:

1. By 28 January 1994, the Discharger shall analyze the LNAPLs detected in ground water samples for PCBs using U.S. EPA Method 608 and report the results to the Board, DTSC, and the U.S. EPA.

2. By 28 January 1994, the Discharger shall inform the Board, DTSC, and the U.S. EPA of the method and location of discharge of the treated ground water to be drained from the discharge lines during freeze conditions.

3. The Discharger may be required to submit technical reports as directed by the Board, DTSC, and the U.S. EPA.

4. The Discharger shall comply with the attached MRP, which is part of these substantive requirements and any revisions thereto, i.e., monitoring frequency, locations, constituent changes, etc., as ordered by the Board, DTSC, and the U.S. EPA.

5. The Discharger shall submit a POS report to the Board, DTSC, and the U.S. EPA for approval at least two weeks prior to the proposed commencement of full scale operation of the GWTS. This report shall document compliance with Discharge Specifications C.1 and C.2. In addition, this report shall include a performance evaluation of the complete GWTS, based on the data collected during the POS in accordance with the attached MRP.

   The objectives of the performance evaluation are to determine the ability and reliability of the GWTS and SVE in meeting the effluent limitations established in B.1 and B.2 and to develop the operating parameters necessary during full-scale operations to maximize VOC removal from the vadose zone and extracted ground water.

6. The Discharger shall include in the first quarterly monitoring report, in addition to the information required by the MRP, a determination if the

influent to and/or effluent from the oil/water separator and air sparging tanks contains previously unidentified constituents of sufficient magnitude to affect the treatment effectiveness of the oil/water separator or air sparger. In the event that significant levels of previously unidentified pollutants are detected, the report shall show how the system will comply with the Anti-Degradation Policy and Article 5 of Chapter 15, including recommendations on possible GWTS modifications.

7. The Discharger shall notify the Board, DTSC, and the U.S. EPA within 24 hours of any unscheduled shutdown of the GWTS that potentially could result in noncompliance with the Substantive Requirements or of any other shutdown that lasts longer than 24 hours. This notification shall include the cause of the shutdown and the corrective action taken (or proposed to be taken) to restart the system. Required or scheduled shutdowns such as those during normal system check, proof of system testing, and manual full scale operation do not require notification to the Board, DTSC, and the U.S. EPA. Notification of unscheduled system shutdowns lasting less than 24 hours, such as for unscheduled system maintenance, will be provided in the monthly operation reports.

8. The Discharger shall notify the Board, DTSC, and the U.S. EPA immediately, during normal working hours via telephone, and at least within 24 hours of any spill of untreated ground water. This notification shall include the size and cause of the spill, any immediate damage to the environment, any corrective/cleanup actions taken and/or additional monitoring proposed.

9. The Discharger shall submit to the Board, DTSC, and the U.S. EPA monthly operation reports by the 15th day of the following month. These operational reports shall contain a summary of the operating parameters, operation and maintenance activities, and any shutdown or spill events that occurred during the month. The monthly report for the last month of each quarter (March, June, September and December) may be combined with the quarterly report (required in the Monitoring and Reporting Program attached to the Substantive Requirements and incorporated therein) and shall be submitted on the last day of the month following the quarter.

10. Prior to the end of the seventh month of full scale operation, the Discharger shall submit a system evaluation report to the Board, DTSC, and the U.S. EPA. The system evaluation report may be combined with the quarterly

monitoring report issued after the second quarter of full scale operation. The system evaluation report shall determine if the performance monitoring network provides sufficient hydrologic and water quality data and soil vapor pressure and quality data to accomplish the following objectives:

a. Monitor water levels and water quality within the permeable zone screened by the extraction wells.

b. Monitor soil vapor pressure and soil vapor quality within the vadose zone screened by the extraction wells.

c. Verify that the capture zones of individual extraction wells overlap and that migration of contaminants is being reduced in the vicinity of the extraction wells.

d. Verify that the radius of influence indicated by decrease in pressure in soil vapor monitor vents represents the effective soil vapor capture zone and that contaminant mass removal by soil vapor extraction is being optimized.

e. Determine hydrogeologic and water quality parameters of the ground water regime.

f. Operate the soil vapor and ground water extraction and discharge system in the most effective manner.

g. Provide sufficient information to determine whether monitoring frequency, location, and/or constituents should be increased or decreased.

11. The Discharger shall comply with the "Standard Provisions and Reporting Requirements for Waste Discharge Requirements", dated 1 March 1991, which are attached hereto and by reference a part of these Substantive Requirements. This attachment and its individual paragraphs are commonly referenced as "Standard Provisions".

12. The Discharger shall report promptly to the Board any material change or proposed change in the character location, or volume of the discharge.

13. In the event of any change in ownership of land or waste discharge facilities presently owned or controlled by the Discharger, and

associated with the ground water cleanup of the Building 834 area ground water, the Discharger shall notify at that time the succeeding owner or operator of the existence of these Substantive Requirements by letter. A copy of the notification shall be forwarded to this office.

14. A copy of these Substantive Requirements shall be kept at the discharge facility for reference by operating personnel. Key operating personnel shall be familiar with its contents.

15. The Board will review these Substantive Requirements periodically and may revise them. The Discharger shall be notified prior to the review of these Substantive Requirements by the Board, and have the opportunity to review and comment on the proposed changes.

MONITORING AND REPORTING PROGRAM
FOR
LAWRENCE LIVERMORE NATIONAL LABORATORY
AND U.S. DEPARTMENT OF ENERGY

SITE 300 BUILDING 834 REMOVAL ACTION

31 DECEMBER 1993

The following Monitoring and Reporting Program contains the minimum monitoring and reporting requirements necessary to determine compliance with the effluent limitations and other requirements of the Building 834 Removal Action Substantive Requirements. In addition, monitoring requirements are established to characterize the ground water and vadose zone during full-scale operation of the soil vapor extraction system (SVE) and the ground water treatment system (GWTS).

All monitoring samples will be 'grab' type samples, except for extraction and discharge rates and total volume which will be continuous, and water level and air pressure measurements which will be instantaneous at the time of measurement.

The Discharger may propose reductions in monitoring frequency, locations, and/or constituents one year after start of full-scale operations.

PROOF OF SYSTEM (POS) MONITORING

The objectives of the POS monitoring are to characterize the influent and effluent streams, determine the treatment efficiencies of the treatment system, and monitor the performance of the extraction wells and discharge system. Monitoring frequencies and constituents will be as follows:

A. During the SVE and GWTS POS monitoring, the following analyses shall be conducted at the start of the test and every six hours until the end of the test on:

1. The extraction wells during ground water extraction for

Constituents	Units
Total Volume of Water Extracted	gallons
Extraction Rate at Time of Sampling	gpm

2. Ground water leaving the air sparging tanks for:

Constituents	Units
Volatile Organic Compounds	μg/l
LNAPLs	μg/l

Electrical Conductivity	μmhos/cm
pH	pH units
Temperature	°C
Total Volume of Water Treated	gallons
Flow Rate at Time of Sampling	gpm

3. The effluent from the air sparging tanks for PCBs if PCBs have been detected in the influent LNAPLS or ground water. The results shall be reported in μg/l.

4. The extraction wells for air flow rate in cubic feet per minute (cfm).

B. The following analyses shall be conducted at start-up and end of POS on the ground water extraction wells during ground water extraction:

Constituents	Units
Volatile Organic Compounds	μg/l
Electrical Conductivity	μmhos/cm
pH	pH units
Temperature	°C

C. Water levels in the extraction wells shall be measured prior to start-up and at the end of the day during the POS test.

D. Water levels in the Building 834 monitor wells shall be monitored at initiation of start-up, hourly the first day of the test, then every two hours should the test continue beyond one day. All water level measurements shall be reported in feet, mean sea level (ft/msl). Table 1 identifies the ground water monitor wells to be measured for water levels during POS monitoring.

E. Vapor pressure shall be monitored in the soil vapor monitoring vents hourly during the POS. Table 2 identifies the soil vapor monitoring vents to be monitored during the POS.

F. Barometric pressure shall be recorded hourly during the POS.

FULL SCALE OPERATIONS

Treatment System Monitoring

The following analyses shall be conducted at the influent and effluent of the GWTS:

Constituents	Units	Sampling Frequency
Volatile Organic Compounds	μg/l	Monthly
Electrical Conductivity	μmhos/cm	Monthly
Total Dissolved Solids	mg/l	Monthly
pH	pH units	Monthly
Temperature	°C	Monthly
Total Volume of Water Treated	gallons	Continuous
Flow Rate at Time of Sampling	gpm	Continuous (if practicable)

Air flow rate shall be measured weekly in cfm on all individual vapor extraction wells.

Ground Water and Soil Vapor Monitoring

The monitoring and extraction wells for the GWTS shall include all wells listed on Table 3 and any extraction or monitoring wells which may be included in the future. All present and future monitoring and extraction wells included in the Removal Action shall be monitored as follows:

Constituents	Unit	Sampling Frequency
Volatile Organics	μg/l	See Table 3
Electrical Conductivity	μmhos/cm	See Table 3
Total Dissolved Solids	mg/l	See Table 3
pH	pH units	See Table 3
Temperature	°C	See Table 3
Water Surface Elevation	ft/msl	See Table 3
Chloride	mg/l	Annual
Sulfate	mg/l	Annual
Carbonate	mg/l	Annual
Bicarbonate	mg/l	Annual
Alkalinity	mg/l	Annual
Hardness (as $CaCO_3$)	mg/l	Annual
Nitrate (as N)	mg/l	Annual

Calcium	mg/l	Annual
Sodium	mg/l	Annual
Iron	mg/l	Annual[3]
Magnesium	mg/l	Annual[3]
Manganese[1]	mg/l	Annual[3]
Potassium	mg/l	Annual[3]
Cyanide	mg/l	Annual[3]
Barium[1]	mg/l	Annual[3]
Cadmium[1]	mg/l	Annual[3]
Copper[1]	mg/l	Annual[3]
Lead[1]	mg/l	Annual[3]
Mercury[2]	mg/l	Annual[3]
Molybdenum[1]	mg/l	Annual[3]
Silver[1]	mg/l	Annual[3]
Zinc[1]	mg/l	Annual[3]

[1] Inductively Coupled Argon Plasma Atomic Emission Spectroscopy (ICAP) may be used for analysis of these constituents (Method 6010)

[2] Manual Cold-Vapor Technique (Method 7470)

[3] If the Discharger can demonstrate with a year of quarterly monitoring that dissolved metals in the ground water in the extraction zone are at or below background, the Discharger will not be required to analyze for those metals, unless the ground water fluctuates higher than levels previously recorded during the regular monitoring of Building 834 wells.

The Discharger shall measure water levels to an accuracy of 0.01 feet MSL in all wells listed on Table 3. This information shall be used to determine the magnitude and direction of ground water flow and shall be displayed on a water table contour map.

The Discharger shall measure vapor pressure and air flow rate in the soil vapor monitor wells and at the sampling frequency listed on Table 4. Soil vapor pressure shall be measured to an accuracy of 0.1 inches water.

The volume of contaminant mass removed by the ground water and soil vapor extraction system shall be calculated and reported in the quarterly monitoring reports.

QUALITY CONTROL SAMPLES

For quality control purposes the Discharger shall collect and have analyzed on sampling blank and one duplicate for every ten samples collected and analyzed. Each of these quality control samples shall be analyzed for the same parameters as the other samples collected.

REPORTING

In reporting the monitoring data, the Discharger shall arrange the data in tabular form so that the sampling location, date, constituent/parameters, and concentrations/measurements are readily discernible. The data shall be summarized in such a manner to illustrate clearly the compliance with the Substantive Requirements.

Quarterly monitoring reports shall be submitted to the Board, DTSC, and the U.S. EPA by the last day of the month following the quarter in which the samples were taken or observations made. The fourth quarterly report shall contain an annual summary of the data from the previous year which shall be presented in tabular and graphical form. The report shall discuss the compliance record and the corrective actions taken or planned which may be needed to bring the discharge into full compliance with the Substantive Requirements.

The results of any monitoring done more frequently or in addition to that required at the locations specified in the Monitoring and Reporting Program shall be reported to the Board, DTSC, and the U.S. EPA.

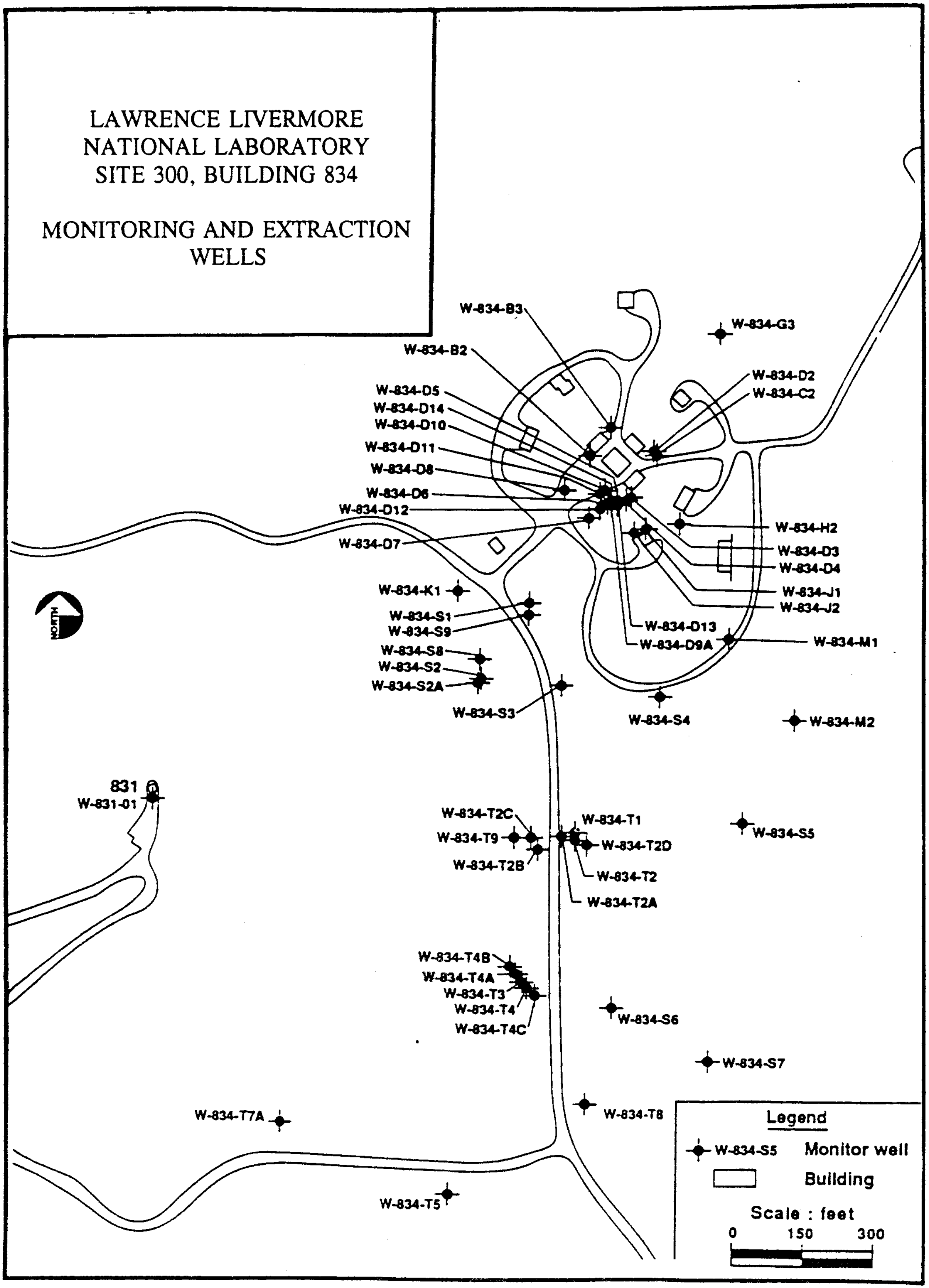
LAWRENCE LIVERMORE
NATIONAL LABORATORY
SITE 300, BUILDING 834
MONITORING AND EXTRACTION
WELLS
W-834-B3
W-834-G3
W-834-B2
W-834-D2
W-834-C2
W-834-D5
W-834-D14
W-834-D10
W-834-D11
W-834-D8
W-834-D6
W-834-D12
W-834-H2
W-834-D7
W-834-D3
W-834-D4
NORTH
W-834-K1
W-834-J1
W-834-J2
W-834-S1
W-834-S9
W-834-D13
W-834-D9A
W-834-M1
W-834-S8
W-834-S2
W-834-S2A
W-834-S3
W-834-S4
W-834-M2
831
W-831-01
W-834-T2C
W-834-T1
W-834-S5
W-834-T9
W-834-T2D
W-834-T2B
W-834-T2
W-834-T2A
W-834-T4B
W-834-T4A
W-834-T3
W-834-T4
W-834-T4C
W-834-S6
W-834-S7
W-834-T7A
W-834-T8
W-834-T5
Legend
W-834-S5 Monitor well
Building
Scale : feet
0 150 300

FIGURE 1

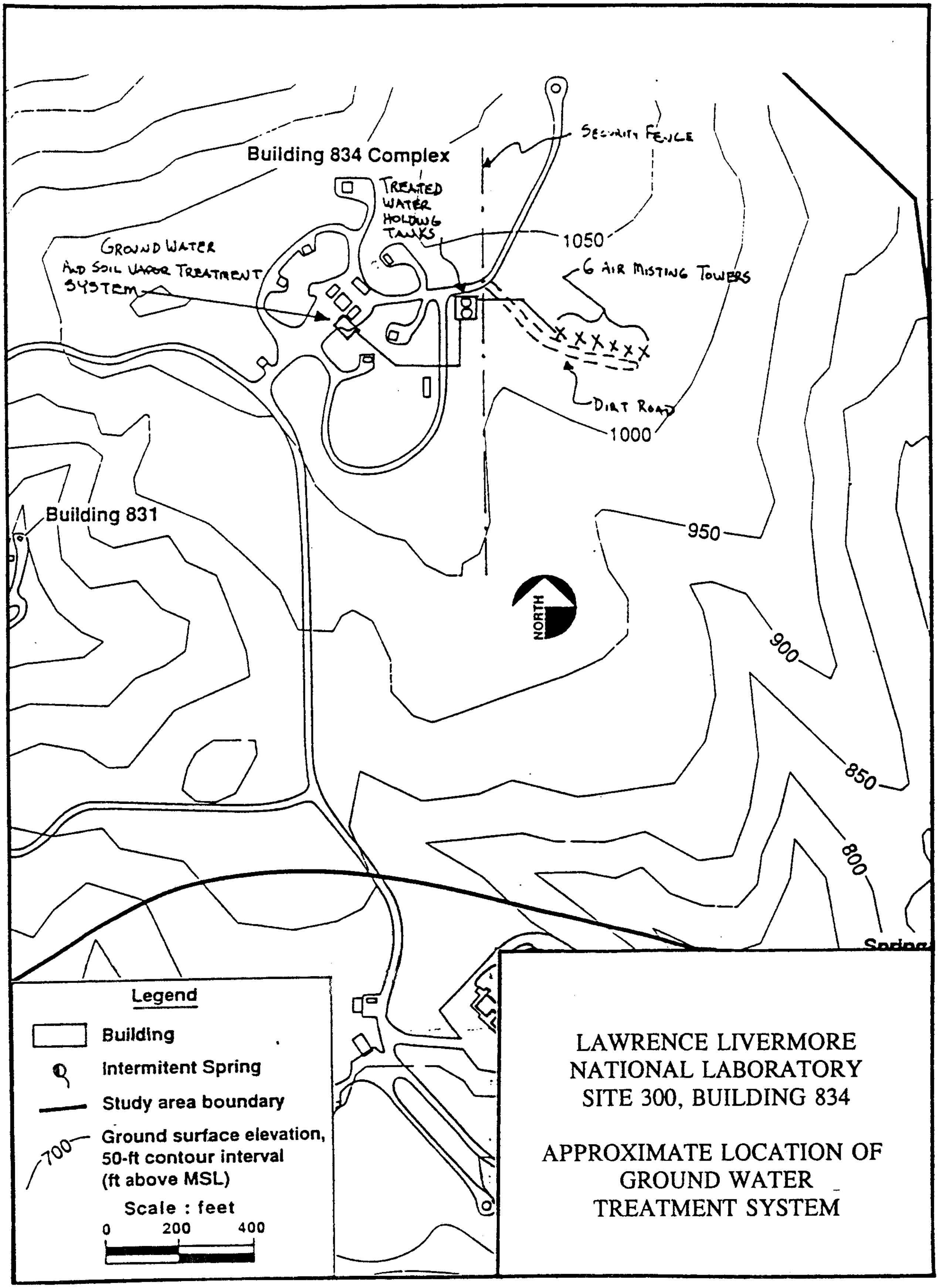
Building 834 Complex
Security Fence
Treated Water Holding Tanks
1050
Ground Water And Soil Vapor Treatment System
6 Air Misting Towers
Dirt Road
1000
Building 831
950
NORTH
900
850
800
Legend
Building
Intermitent Spring
Study area boundary
700
Ground surface elevation, 50-ft contour interval (ft above MSL)
Scale : feet
0 200 400
LAWRENCE LIVERMORE
NATIONAL LABORATORY
SITE 300, BUILDING 834
APPROXIMATE LOCATION OF
GROUND WATER
TREATMENT SYSTEM

FIGURE 2

Table 1. Proposed Building 834 POS Water Level Monitoring Wells.

Monitor Well ID	Location/Criteria[1]	Hydrologic unit of completion	Water Level Monitoring Frequency[2]
W-834-B2	Core area	Qt-Tpsg	Hourly
W-834-B3	Core area	Qt-Tpsg	Hourly
W-834-C2	Core area	Qt-Tpsg	Hourly
W-834-D3	Ex well	Qt-Tpsg/Tps-Tnsc2	Initially/shutdown**
W-834-D4	Ex well	Qt-Tpsg/Tps-Tnsc2	Initially/shutdown**
W-834-D5	Ex well	Qt-Tpsg/Tps-Tnsc2	Initially/shutdown**
W-834-D6	Core area*	Qt-Tpsg/Tps-Tnsc2	Hourly
W-834-D7	Core area*	Qt-Tpsg/Tps-Tnsc2	Hourly
W-834-D8	Core area*	Qt-Tpsg/Tps-Tnsc2	Hourly
W-834-D10	Core area	Tps-Tnsc2	Hourly
W-834-D11	Core area*	Qt-Tpsg	Hourly
W-834-D12	Core area*	Qt-Tpsg	Hourly
W-834-D13	Core area*	Qt-Tpsg	Hourly
W-834-D14	Core area*	Qt-Tpsg	Hourly
W-834-H2	Outside core area	Qt-Tpsg	Hourly
W-834-J1	Outside core area	Qt-Tpsg/Tps-Tnsc2	Hourly
W-834-J2	Outside core area	Qt-Tpsg/Tps-Tnsc2	Hourly

[1] Ex Well - Ground water extraction well

[2] Water elevations measured hourly for first 24 hours of POS testing, then every two hours thereafter

* - Possible future ground water extraction well

** - Pneumatic extraction pumps will produce erroneous water level data in pumping well.

Table 2. Proposed Building 834 POS Soil Vapor Monitor Wells and Sampling Frequency.

Vapor Monitor Well ID	Location/ Criteria[1]	Hydrologic unit completion	Sampling Frequency - Air flow rate (cfm)	Sampling Frequency—Vapor Pressure (in. H_2O)
W-834-B2	Core area	Qt-Tpsg	6 Hours	Hourly
W-834-B3	Core area	Qt-Tpsg	6 Hours	Hourly
W-834-C2	Core area	Qt-Tpsg	6 Hours	Hourly
W-834-D3	Ex Well	Qt-Tpsg/Tps-$Tnsc_2$	6 Hours	N/A
W-834-D4	Ex Well	Qt-Tpsg/Tps-$Tnsc_2$	6 Hours	N/A
W-834-D5	Ex Well	Qt-Tpsg/Tps-$Tnsc_2$	6 Hours	N/A
W-834-D6	Ex Well	Qt-Tpsg/Tps-$Tnsc_2$	6 Hours	N/A
W-834-D7	Ex Well	Qt-Tpsg/Tps-$Tnsc_2$	6 Hours	N/A
W-834-D8	Core area	Qt-Tpsg/Tps-$Tnsc_2$		Hourly
W-834-D10	Core area	Tps-$Tnsc_2$		Hourly
W-834-D11	Ex Well	Qt-Tpsg	6 Hours	N/A
W-834-D12	Ex Well	Qt-Tpsg	6 Hours	N/A
W-834-D13	Ex Well	Qt-Tpsg	6 Hours	N/A
W-834-D14	Ex Well	Qt-Tpsg	6 Hours	N/A
W-834-H2	Complex area	Qt-Tpsg		Hourly
W-834-J1	Complex area	Qt-Tpsg/Tps-$Tnsc_2$		Hourly
W-834-J2	Complex area	Qt-Tpsg/Tps-$Tnsc_2$		Hourly
W-834-G3	Complex area	Qt-Tpsg/Tps-$Tnsc_2$		Hourly
W-834-K1	Complex area	Qt-Tpsg/Tps-$Tnsc_2$		Hourly

[1] Ex Well - Ground water extraction well

N/A - Not applicable, soil vapor extraction well

Note: Future modifications to the SVE system may include the capability of measuring soil vapor pressure at the soil vapor extraction wells.

Table 3. Proposed Building 834 GWTS Monitor Well Ground Water Sampling Frequency and Analytes for Full Scale Operation.

Monitor Well ID	Location/ Criteria[1]	Hydrologic unit well completion	Analytes (EPA Method)[2]	Water Level Monitoring Frequency
W-834-B2	Core area	Qt-Tpsg	VOCs	Quarterly
W-834-B3	Core area	Qt-Tpsg	VOCs	Quarterly
W-834-C2	Core area	Qt-Tpsg	VOCs	Quarterly
W-834-D3	Ex Well	Qt-Tpsg/Tps-$Tnsc_2$	VOCs	Quarterly
W-834-D4	Ex Well	Qt-Tpsg/Tps-$Tnsc_2$	VOCs	Quarterly
W-834-D5	Ex Well	Qt-Tpsg/Tps-$Tnsc_2$	VOCs	Quarterly
W-834-D6	Core area*	Qt-Tpsg/Tps-$Tnsc_2$	VOCs	Quarterly
W-834-D7	Core area*	Qt-Tpsg/Tps-$Tnsc_2$	VOCs	Quarterly
W-834-D8	Core area*	Qt-Tpsg/Tps-$Tnsc_2$	VOCs	Quarterly
W-834-D10	Core area	Tps-$Tnsc_2$	VOCs	Quarterly
W-834-D11	Core area*	Qt-Tpsg	VOCs	Quarterly
W-834-D12	Core area*	Qt-Tpsg	VOCs	Quarterly
W-834-D13	Core area*	Qt-Tpsg	VOCs	Quarterly
W-834-D14	Core area*	Qt-Tpsg	VOCs	Quarterly
W-834-H2	Complex area	Qt-Tpsg	VOCs	Quarterly
W-834-J1	Complex area	Qt-Tpsg/Tps-$Tnsc_2$	VOCs	Quarterly
W-834-J2	Complex area	Qt-Tpsg/Tps-$Tnsc_2$	VOCs	Quarterly
W-834-G3	Complex area	Qt-Tpsg/Tps-$Tnsc_2$	VOCs	Quarterly
W-834-K1	Complex area	Qt-Tpsg/Tps-$Tnsc_2$	601	Quarterly
W-834-M1	Complex area	Qt-Tpsg/Tps-$Tnsc_2$	601	Quarterly
W-834-M2	East well	Qt-Tpsg/Tps-$Tnsc_2$	601	Biannual
W-834-S1	Septic tank area	Qt-Tpsg	601	Biannual
W-834-S2	Septic tank area	Qt-Tpsg/Tps-$Tnsc_2$	601	Biannual
W-834-S2A	Septic tank area	Tps-$Tnsc_2$	601	Biannual
W-834-S3	Septic tank area	Qt-Tpsg/Tps-$Tnsc_2$	601	Biannual
W-834-S4	Septic tank area	Qt-Tpsg/Tps-$Tnsc_2$	601	Biannual
W-834-S5	Plume well	Qt-Tpsg/Tps-$Tnsc_2$	601	Annual
W-834-S6	Plume well	Qt-Tpsg/Tps-$Tnsc_2$	601	Annual
W-834-S7	Plume well	Qt-Tpsg/Tps-$Tnsc_2$	601	Annual
W-834-S8	Septic tank area	Tps-$Tnsc_2$	601	Biannual

Table 3 (Cont'd).

Monitor Well ID	Location/ Criteria[1]	Hydrologic unit well completion	Analytes (EPA Method)[2]	Water Level Monitoring Frequency
W-834-S9	Septic tank area	Tps-Tnsc2	601	Biannual
W-834-T1	Regional Aquifer	Tnbs1	601	Quarterly
W-834-T2	Plume well	Qt-Tpsg/Tps-Tnsc2	601	Annual
W-834-T2A	Plume well	Qt-Tpsg/Tps-Tnsc2	601	Annual
W-834-T2B	Plume well	Qt-Tpsg	601	Annual
W-834-T2C	Plume well	Qt-Tpsg/Tps-Tnsc2	601	Annual
W-834-T2D	Plume well	Qt-Tpsg/Tps-Tnsc2	601	Biannual
W-834-T3	Regional Aquifer	Tnbs1	601	Quarterly
W-834-T4	Plume well	Qt-Tpsg/Tps-Tnsc2	601	Annual
W-834-T4A	Plume well	Qt-Tpsg/Tps-Tnsc2	601	Annual
W-834-T4B	Plume well	Tps-Tnsc2	601	Annual
W-834-T4C	Plume well	Qt-Tpsg/Tps-Tnsc2	601	Annual
W-834-T5	Downgradient well	Qt-Tpsg/Tps-Tnsc2	601	Biannual
W-834-T7A	Downgradient well	Qt-Tpsg/Tps-Tnsc2	601	Biannual
W-834-T8	Plume well	Qt-Tpsg/Tps-Tnsc2	601	Annual
W-834-T9	Plume well	Qt-Tpsg/Tps-Tnsc2	601	Annual

[1] Ex Well - Ground water extraction well

* - Possible future ground water extraction well

[2] All sampling includes electrical conductivity, TDS, pH, temperature, and water surface elevation (ft above mean sea level).

VOCs - indicates EPA Methods 601 and 602, freon 113 analysis, and Modified EPA Method 8015 (M8015); EPA 608 analyses will be performed should PCBs be detected in the LNAPLs.

Table 4. Proposed Building 834 Soil Vapor Monitor Wells and Sampling Frequency for Full Scale Operation.

Vapor Monitor Well ID	Location/ Criteria	Hydrologic unit completion	Sampling Frequency— Air flow rate (cfm)	Sampling Frequency— Vapor Pressure (in. H_2O)
W-834-B2	Core area	Qt-Tpsg	Quarterly**	Monthly**
W-834-B3	Core area	Qt-Tpsg	Quarterly**	Monthly**
W-834-C2	Core area	Qt-Tpsg	Quarterly**	Monthly**
W-834-D3	Ex Well	$Tnbs_1$	Quarterly*	N/A
W-834-D4	Ex Well	Qt-Tpsg/Tps-$Tnsc_2$	Quarterly*	N/A
W-834-D5	Ex Well	Qt-Tpsg/Tps-$Tnsc_2$	Quarterly*	N/A
W-834-D6	Ex Well	Qt-Tpsg/Tps-$Tnsc_2$	Quarterly*	N/A
W-834-D7	Ex Well	Qt-Tpsg/Tps-$Tnsc_2$	Quarterly*	N/A
W-834-D8	Core area	Qt-Tpsg/Tps-$Tnsc_2$	Quarterly**	Monthly**
W-834-D10	Core area	Tps-$Tnsc_2$		Monthly
W-834-D11	Ex Well	Qt-Tpsg	Quarterly*	N/A
W-834-D12	Ex Well	Qt-Tpsg	Quarterly*	N/A
W-834-D13	Ex Well	Qt-Tpsg	Quarterly*	N/A
W-834-D14	Ex Well	Qt-Tpsg	Quarterly*	N/A
W-834-H2	Complex area	Qt-Tpsg	Quarterly**	Monthly**
W-834-J1	Complex area	Qt-Tpsg/Tps-$Tnsc_2$	Quarterly**	Monthly**
W-834-J2	Complex area	Qt-Tpsg/Tps-$Tnsc_2$	Quarterly**	Monthly**
W-834-G3	Complex area	Qt-Tpsg/Tps-$Tnsc_2$		Monthly
W-834-K1	Complex area	Qt-Tpsg/Tps-$Tnsc_2$		Monthly

[1] Ex Well - Ground water extraction well

N/A - Not applicable, soil vapor extraction well

* Proposed future ground water extraction well

** Proposed future soil vapor extraction well

Note: Future modifications to the SVE system may include the capability of measuring soil vapor pressure at the soil vapor extraction wells.

ENVIRONMENTAL RESTORATION DIVISION

June 30, 1998

Susan Timm
California Regional Water Quality Control Board
3443 Routier Road
Sacramento, CA 95827-3098

Re: Monitoring and Reporting Program Requirements for the Building 834 Removal Action, Lawrence Livermore National Laboratory Site 300, San Joaquin County

Dear Ms. Timm:

The Lawrence Livermore National Laboratory (LLNL) has recently completed a review of historical analytical data from the Building 834 Treatment Facility (B834 TF) and ground water monitor wells in the Building 834 Operable Unit (B834 OU). Available data were primarily obtained to comply with monitoring programs outlined in the Substantive Requirements for the Building 834 Removal Action issued by the Regional Water Quality Control Board (RWQCB). In addition, some information was available due to sampling events and chemical analyses carried out voluntarily.

The above data review was extremely helpful in understanding the behavior and fate of some of the pollutants present at the site. Specifically, we have determined that the contour of the trichloroethylene (TCE) plume has been fairly stable over the past eight years and that maximum concentrations have dropped markedly in the area of contaminant release (core area). Further, obtained profiles of *cis*-1,2-dichloroethylene (*cis*-DCE) and chloride concentrations indicate that, in addition to our active treatment efforts, passive bioremediation processes appear to play an important role in contaminant attenuation in the B834 OU.

During analysis of available data we also identified a need for reviewing the sampling plan for the B834 OU. On the one hand, the plan in its current form yields a lot of data derived from sampling and monitoring for pollutants that do not present a problem or for which the resulting data is not meaningful. On the other hand, the sampling frequency and list of target analytes is too restricted to verify a conceptual model of mass removal processes put forward in a joint effort by LLNL and research staff of the Oregon State University.

In order to meet additional sampling needs without increasing the current budget, LLNL proposes to modify the monitoring requirements for the B834 Removal Action. The proposal, described and presented herein for your review and consideration, consists of eliminating analyses from the B834 TF and the B834 monitor wells which do not provide meaningful and useful results. Cost savings resulting from the proposed sampling reduction will make possible additional sampling and monitoring activities required to fill current data gaps. We believe that the proposed modifications will not impact the integrity of our monitoring programs and will result in significant cost savings as well as a better understanding of the mass removal processes occurring at the B834 OU.

6-98/ERD–B834 Requirements:rtd

1. Proposed Reduction in Analytical Sampling for the B834 TF and B834 Monitor Wells

The items on the following list of analyses currently included under the existing Substantive Requirements for the Building 834 Removal Action are proposed for modification or elimination. Justification for each is included subsequently.

- EPA Method 602 (aromatic VOCs).
- Modified EPA Method 8015 for alkyl silicate synthetic oils such as tetra-butyl orthosilicate (TBOS).
- Metals.
- Cyanide.
- pH.
- Specific conductance (SC).
- Total dissolved solids (TDS).

1.1. EPA Method 602 Analyses

We propose to discontinue sampling for aromatic hydrocarbons (BTEX) by EPA Method 602 at the B834 TF and all monitor wells in the B834 OU. No aromatic hydrocarbons have been detected in any of the B834 TF influent or effluent samples as presented in Table 1. Only two out of a total of 21 wells (W-834-D8 and W-834-J1) have had any detections of BTEX compounds. No detections were observed in the last year. In all cases, reported concentrations were low (less than 50 ppb; see Table 2) and close to the reported detection limit raising concerns about the quality of the data. Detection limits are historically quite high due to elevated chlorinated hydrocarbon concentrations that necessitate substantial dilution of samples prior to analysis. As a result of the raised detection limits, it is very unlikely that we will see any reliable detection of BTEX compounds in the future. Thus, we propose to discontinue sampling for BTEX by EPA Method 602. The modification should be reevaluated if concentrations of chlorinated hydrocarbons decline in the future thereby allowing reliable analysis of BTEX in the low ppb-range. As a measure of safety, samples from well W-834-D8 will be analyzed biannually for total petroleum hydrocarbons (TPH) originating from diesel fuel; BTEX compounds are commonly associated with petroleum contamination and will contribute to reported TPH concentrations. Therefore, the proposed elimination of sampling events will not compromise the integrity of the monitoring program.

1.2. Modified EPA Method 8015 (TBOS) Analyses

We propose to restrict monitoring for TBOS by the modified EPA Method 8015 to those monitor wells that historically have shown detectable concentrations of this analyte plus one additional monitor well immediately downgradient of the known TBOS plume. TBOS and related silicone oils such as tetra-kis-2-ethylbutyl orthosilicate (TKEBS) are extremely hydrophobic compounds that are not water soluble (solubility much less than 1 mg/L) and that are readily immobilized in soil due to sorption to soil organic matter and inorganic, hydrophobic surfaces. As a result, these chemicals migrate not at all or only very slowly from their release area even over extended periods of time (e.g., decades) no matter whether they are in the dissolved phase or present as light nonaqueous phase liquid (LNAPL). As summarized in Table 3, groundwater samples of only four wells have historically contained TBOS (W-834-D3, W-834-D4, W-834-D5, W-834-D8). We propose to limit future sampling for TBOS to these four wells and a fifth well, W-834-D13, suitable for confirming the limited spacial extent of TBOS contamination. In addition, we propose to reduce the sampling frequency from quarterly to biannually since the existing data set is adequate to represent seasonal fluctuations in TBOS concentrations.

1.3. Metals and Cyanide Analyses

Under the Substantive Requirements, LLNL is required to annually monitor the B834 monitor wells for the following: barium, cadmium, copper, cyanide, lead, mercury, molybdenum, silver, and zinc. All historical data for metals and cyanide from the B834 monitor wells are listed in Table 4. We propose to reduce sampling events and analyses for metals to only those wells and analytes that previously were found to be above the range of background concentrations encountered at comparable locations not affected by anthropogenic point source releases. Table 5 lists the proposed metal analyses for the B834 monitor wells. We also propose to discontinue cyanide analyses since this contaminant has not been detected during more than two years of monitoring (Table 4).

1.4. Analysis for pH, SC, and TDS

According to the Substantive Requirements, 23 of the B834 monitor wells are to be sampled and analyzed for pH, SC, and TDS on a quarterly basis. Eleven wells are on a biannual schedule. These constituents, along with general minerals, are typically used in environmental applications to characterize inorganic water chemistry of aquifers and water-bearing zones. Differences in water chemistry are then used, along with other data, to determine hydraulic communication between aquifers, integrity of confining layers, well completion zones, and fracture permeability flow paths. Since sufficient data for characterization of the B834 OU has been obtained, we propose to reduce the frequency of sampling and analysis of these 34 wells to an annual schedule. Historical SC and pH data are included with the general mineral results presented in Table 6. Historical TDS values are listed in Table 7. Samples will be collected and analyzed for pH, SC, TDS as well as general minerals on an annual schedule. Field measurements of the pH and SC are collected during each monitor well sampling event as part of LLNL's Standard Operation Procedures (SOPs). These values can be used for additional interpretation needs.

1.5. Summary of Proposed Monitoring Program Reductions for the Building 834 Removal Actions

We are confident that the proposed changes in sampling frequency and types of analyses will not compromise the integrity of the B834 Removal Action monitoring program. We will continue to monitor all wells with concentrations of VOCs, TBOS, and metals above background levels. General minerals including pH, SC, and TDS will be monitored on an annual basis. The proposed changes will not impact our ability to generate VOC isoconcentration contour maps and track VOC plume migration.

Tenets of the proposed Building 834 sampling plan are listed below.

- All the B834 monitor wells will be sampled and analyzed for halogenated VOCs using EPA Method 601 as per the schedules set in the Substantive Requirements.
- Analysis for BTEX compounds using EPA Method 602 will be discontinued in all wells.
- One well, W-834-D8, will be sampled biannually for TPH Diesel using a modified version of EPA Method 8015.
- In the future, only wells previously found to be contaminated plus one analyte-free downgradient well will be sampled and monitored for TBOS by the modified EPA

Method 8015 (currently, this definition includes the TBOS-containing wells W-834-D3, W-834-D4, W-834-D5, and W-834-D8, as well as the "clean" downgradient well W-834-D13); sampling will occur at a reduced frequency, in biannual rather than quarterly intervals.

- Metal analyses will be reduced to only those wells and analytes (listed in Table 5) that historically have been detected above background concentrations.
- Sample analyses for cyanide will be discontinued in all wells.
- Samples for pH, SC, and TDS will only be collected and analyzed annually along with the general minerals analyses.
- Resulting budget savings will (in part) be used to perform additional analyses suitable for characterizing the role of physical, chemical, and biological processes for pollutant removal. These new analyses may include soil vapor and soil flux measurements, redox conditions as well as levels of various electron acceptors and metabolites in ground water. Any analyses carried out in addition to those specified in the Substantive Requirements will be documented in forthcoming quarterly reports along with the collected data.

Table 8 lists the proposed sampling schedule pertaining to the Substantive Requirements. If you have any questions, please contact Rolf Halden at (925) 422-0655.

Sincerely,

Albert L Lamarre

Albert L. Lamarre
Division Leader
Environmental Restoration Division
UC/LLNL

ALL:RH:rtd

Attachments

cc: K. Angleberger, DOE/HQ
L. Cleland (w/o attach)
H. Galles (w/o attach)
J. Ziagos (w/o attach)

Table 1. Building 834 TF historical results of EPA 602 analyses.

Sample location	Sample date	Benzene (μg/L)	Chloro-benzene (μg/L)	1,2-Dichloro-benzene (μg/L)	1,3-Dichloro-benzene (μg/L)	1,4-Dichloro-benzene (μg/L)	Ethyl-benzene (μg/L)	Toluene (μg/L)	Xylenes (μg/L)
TF-834-I	11/08/95	<300	<300	<300	<300	<300	<300	<300	<600
TF-834-I	1/03/96	<150	<150	<150	<150	<150	<150	<150	<300
TF-834-I	1/16/96	<150	<150	<150	<150	<150	<150	<150	<300
TF-834-I	1/22/96	<150	<150	<150	<150	<150	<150	<150	<300
TF-834-I	1/29/96	<150	<150	<150	<150	<150	<150	<150	<300
TF-834-I	2/01/96	<150	<150	<150	<150	<150	<150	<150	<300
TF-834-I	2/06/96	<150	<150	<150	<150	<150	<150	<150	<300
TF-834-I	2/08/96	<150	<150	<150	<150	<150	<150	<150	<300
TF-834-I	2/13/96	<150	<150	<150	<150	<150	<150	<150	<300
TF-834-I	2/16/96	<150	<150	<150	<150	<150	<150	<150	<300
TF-834-I	2/21/96	<150	<150	<150	<150	<150	<150	<150	<300
TF-834-I	2/26/96	<150	<150	<150	<150	<150	<150	<150	<300
TF-834-I	2/28/96	<150	<150	<150	<150	<150	<150	<150	<300
TF-834-I	3/03/96	<150	<150	<150	<150	<150	<150	<150	<300
TF-834-I	3/05/96	<150	<150	<150	<150	<150	<150	<150	<300
TF-834-I	3/11/96	<150	<150	<150	<150	<150	<150	<150	<300
TF-834-I	3/15/96	<150	<150	<150	<150	<150	<150	<150	<300
TF-834-I	3/18/96	<150	<150	<150	<150	<150	<150	<150	<250
TF-834-I	3/21/96	<150	<150	<150	<150	<150	<150	<150	<250
TF-834-I	3/29/96	<150	<150	<150	<150	<150	<150	<150	<250
TF-834-I	4/22/96	<150	<150	<150	<150	<150	<150	<150	<250
TF-834-I	4/25/96	<150	<150	<150	<150	<150	<150	<150	<250
TF-834-I	4/30/96	<150	<150	<150	<150	<150	<150	<150	<250
TF-834-I	5/07/96	<150	<150	<150	<150	<150	<150	<150	<250
TF-834-I	5/10/96	<150	<150	<150	<150	<150	<150	<150	<250
TF-834-I	5/16/96	<150	<150	<150	<150	<150	<150	<150	<250
TF-834-I	5/21/96	<150	<150	<150	<150	<150	<150	<150	<250
TF-834-I	5/30/96	<150	<150	<150	<150	<150	<150	<150	<250
TF-834-I	6/10/96	<150	<150	<150	<150	<150	<150	<150	<250
TF-834-I	6/15/96	<150	<150	<150	<150	<150	<150	<150	<250
TF-834-I	6/24/96	<150	<150	<150	<150	<150	<150	<150	<250
TF-834-I	6/27/96	<150	<150	<150	<150	<150	<150	<150	<250
TF-834-I	7/05/96	<150	<150	<150	<150	<150	<150	<150	<250

Table 1. Building 834 TF historical results of EPA 602 analyses.

Sample location	Sample date	Benzene (µg/L)	Chloro-benzene (µg/L)	1,2-Dichloro-benzene (µg/L)	1,3-Dichloro-benzene (µg/L)	1,4-Dichloro-benzene (µg/L)	Ethyl-benzene (µg/L)	Toluene (µg/L)	Xylenes (µg/L)
TF-834-I	7/15/96	<150	<150	<150	<150	<150	<150	<150	<250
TF-834-I	7/23/96	<150	<150	<150	<150	<150	<150	<150	<250
TF-834-I	7/30/96	<150	<150	<150	<150	<150	<150	<150	<250
TF-834-I	8/13/96	<150	<150	<150	<150	<150	<150	<150	<250
TF-834-I	9/04/96	<150	<150	<150	<150	<150	<150	<150	<250
TF-834-I	9/20/96	<150	<150	<150	<150	<150	<150	<150	<250
TF-834-I	10/07/96	<150	<150	<150	<150	<150	<150	<150	<250
TF-834-I	11/19/96	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.5
TF-834-I	11/26/96	<150	<150	<150	<150	<150	<150	<150	<250
TF-834-I	12/19/96	<150	<150	<150	<150	<150	<150	<150	<250
TF-834-I	12/26/96	<150	<150	<150	<150	<150	<150	<150	<250
TF-834-I	1/08/97	<150	<150	<150	<150	<150	<150	<150	<250
TF-834-I	1/13/97	<150	<150	<150	<150	<150	<150	<150	<250
TF-834-I	2/11/97	<150	<150	<150	<150	<150	<150	<150	<250
TF-834-I	2/19/97	<150	<150	<150	<150	<150	<150	<150	<250
TF-834-I	2/25/97	<150	<150	<150	<150	<150	<150	<150	<250
TF-834-I	2/27/97	<150	<150	<150	<150	<150	<150	<150	<250
TF-834-I	3/04/97	<150	<150	<150	<150	<150	<150	<150	<250
TF-834-I	3/12/97	<150	<150	<150	<150	<150	<150	<150	<250
TF-834-I	3/18/97	<150	<150	<150	<150	<150	<150	<150	<250
TF-834-I	3/21/97	<150	<150	<150	<150	<150	<150	<150	<250
TF-834-I	3/28/97	<150	<150	<150	<150	<150	<150	<150	<250
TF-834-I	4/04/97	<150	<150	<150	<150	<150	<150	<150	<250
TF-834-I	5/02/97	<150	<150	<150	<150	<150	<150	<150	<250
TF-834-I	5/09/97	<150	<150	<150	<150	<150	<150	<150	<250
TF-834-I	5/19/97	<150	<150	<150	<150	<150	<150	<150	<250
TF-834-I	5/22/97	<150	<150	<150	<150	<150	<150	<150	<250
TF-834-I	5/23/97	<150	<150	<150	<150	<150	<150	<150	<250
TF-834-I	5/29/97	<150	<150	<150	<150	<150	<150	<150	<250
TF-834-I	6/19/97	<150	<150	<150	<150	<150	<150	<150	<250
TF-834-I	7/29/97	<15	<15	<15	<15	<15	<15	<15	<25
TF-834-I	12/15/97	<30	<30	<30	<30	<30	<30	<30	<50
TF-834-E	11/08/95	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.6

Table 1. Building 834 TF historical results of EPA 602 analyses.

Sample location	Sample date	Benzene (μg/L)	Chloro-benzene (μg/L)	1,2-Dichloro-benzene (μg/L)	1,3-Dichloro-benzene (μg/L)	1,4-Dichloro-benzene (μg/L)	Ethyl-benzene (μg/L)	Toluene (μg/L)	Xylenes (μg/L)
TF-834-E	1/03/96	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.6
TF-834-E	1/16/96	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.6
TF-834-E	1/22/96	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.6
TF-834-E	1/29/96	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.6
TF-834-E	2/01/96	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.6
TF-834-E	2/06/96	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.6
TF-834-E	2/08/96	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.6
TF-834-E	2/13/96	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.6
TF-834-E	2/16/96	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.6
TF-834-E	2/21/96	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.6
TF-834-E	2/26/96	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.6
TF-834-E	2/28/96	<150	<150	<150	<150	<150	<150	<150	<300
TF-834-E	3/03/96	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.6
TF-834-E	3/05/96	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.6
TF-834-E	3/11/96	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.6
TF-834-E	3/15/96	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.6
TF-834-E	3/18/96	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.5
TF-834-E	3/21/96	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.5
TF-834-E	3/21/96	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.5
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TF-834-E	4/22/96	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.5
TF-834-E	4/25/96	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.5
TF-834-E	4/30/96	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.5
TF-834-E	5/07/96	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.5
TF-834-E	5/10/96	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.5
TF-834-E	5/16/96	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.5
TF-834-E	5/21/96	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.5
TF-834-E	5/30/96	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.5
TF-834-E	6/10/96	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.5
TF-834-E	6/15/96	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.5
TF-834-E	6/24/96	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.5
TF-834-E	6/27/96	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.5
TF-834-E	7/05/96	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.5

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TF-834-E	7/23/96	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.5
TF-834-E	7/30/96	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.5
TF-834-E	8/13/96	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.5
TF-834-E	9/04/96	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.5
TF-834-E	9/20/96	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.5
TF-834-E	10/07/96	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.5
TF-834-E	11/19/96	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.5
TF-834-E	11/26/96	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.5
TF-834-E	12/19/96	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.5
TF-834-E	12/26/96	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.5
TF-834-E	1/08/97	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.5
TF-834-E	1/13/97	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.5
TF-834-E	2/11/97	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.5
TF-834-E	2/19/97	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.5
TF-834-E	2/25/97	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.5
TF-834-E	2/27/97	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.5
TF-834-E	3/04/97	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.5
TF-834-E	3/12/97	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.5
TF-834-E	3/18/97	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.5
TF-834-E	3/21/97	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.5
TF-834-E	3/28/97	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.5
TF-834-E	4/04/97	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.5
TF-834-E	5/02/97	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.5
TF-834-E	5/09/97	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.5
TF-834-E	5/19/97	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.5
TF-834-E	5/22/97	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.5
TF-834-E	5/23/97	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.5
TF-834-E	5/29/97	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.5
TF-834-E	6/19/97	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.5
TF-834-E	7/29/97	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.5
TF-834-E	12/15/97	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.5

Table 2. Building 834 monitor well historical results of EPA 602 analyses.

Sample location	Sample date	Benzene (µg/L)	Chloro-benzene (µg/L)	1,2-Dichloro-benzene (µg/L)	1,3-Dichloro-benzene (µg/L)	1,4-Dichloro-benzene (µg/L)	Ethyl-benzene (µg/L)	Toluene (µg/L)	Xylenes (µg/L)
W-834-B3	3/03/95	<0.5	NR	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-834-B3	12/20/95	<30	<30	<30	<30	<30	<30	<30	<60
W-834-B3	2/09/96	<6	<6	<6	<6	<6	<6	<6	<12
W-834-B3	5/30/96	<30	<30	<30	<30	<30	<30	<30	<50
W-834-B3	12/12/96	<3	<3	<3	<3	<3	<3	<3	<5
W-834-B3	3/13/97	<30	<30	<30	<30	<30	<30	<30	<50
W-834-B3	4/23/97	<30	<30	<30	<30	<30	<30	<30	<50
W-834-B3	12/16/97	<15	<15	<15	<15	<15	<15	<15	<25
W-834-C2	3/03/95	<30	<30	<30	<30	<30	<30	<30	<60
W-834-C2	2/09/96	<6	<6	<6	<6	<6	<6	<6	<12
W-834-C2	6/26/96	<3	<3	<3	<3	<3	<3	<3	<5
W-834-C2	3/13/97	<3	<3	<3	<3	<3	<3	<3	<5
W-834-D3	9/09/93	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.6
W-834-D3	12/21/93	<3000	<3000	<3000	<3000	<3000	<3000	<3000	<6000
W-834-D3	12/21/93	<3000	<3000	<3000	<3000	<3000	<3000	<3000	<6000
W-834-D3	3/14/94	<1500	<1500	<1500	<1500	<1500	<1500	<1500	<3000
W-834-D3	3/14/94	<80	NR	NR	NR	NR	<80	<80	<160
W-834-D3	3/22/94	<300	<300	<300	<300	<300	<300	<300	<600
W-834-D3	6/13/94	<750	<750	<750	<750	<750	<750	<750	<1500
W-834-D3	12/15/94	<150	<150	<150	<150	<150	<150	<150	<300
W-834-D3	3/07/95	<150	<150	<150	<150	<150	<150	<150	<300
W-834-D3	12/21/95	<600	<600	<600	<600	<600	<600	<600	<1200
W-834-D3	2/23/96	<300	<300	<300	<300	<300	<300	<300	<600
W-834-D3	6/26/96	<150	<150	<150	<150	<150	<150	<150	<250
W-834-D3	9/25/96	<200	<200	<200	<200	<200	<200	<200	<400
W-834-D3	9/25/96	<300	<300	<300	<300	<300	<300	<300	<500
W-834-D3	12/16/96	<150	<150	<150	<150	<150	<150	<150	<250
W-834-D3	3/14/97	<150	<150	<150	<150	<150	<150	<150	<250
W-834-D3	4/23/97	<150	<150	<150	<150	<150	<150	<150	<250
W-834-D3	9/25/97	<1500	<1500	<1500	<1500	<1500	<1500	<1500	<2500
W-834-D3	12/17/97	<75	<75	<75	<75	<75	<75	<75	<130
W-834-D4	9/09/93	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.6
W-834-D4	12/16/93	<1500	<1500	<1500	<1500	<1500	<1500	<1500	<3000

Table 2. Building 834 monitor well historical results of EPA 602 analyses.

Sample location	Sample date	Benzene (μg/L)	Chloro-benzene (μg/L)	1,2-Dichloro-benzene (μg/L)	1,3-Dichloro-benzene (μg/L)	1,4-Dichloro-benzene (μg/L)	Ethyl-benzene (μg/L)	Toluene (μg/L)	Xylenes (μg/L)
W-834-D4	3/02/94	<750	<750	<750	<750	<750	<750	<750	<1500
W-834-D4	3/22/94	<7.5	<7.5	<7.5	<7.5	<7.5	<7.5	<7.5	<15
W-834-D4	6/13/94	<150	<150	<150	<150	<150	<150	<150	<300
W-834-D4	12/15/94	<300	<300	<300	<300	<300	<300	<300	<600
W-834-D4	3/10/95	<75	<75	<75	<75	<75	<75	<75	<150
W-834-D4	12/21/95	<150	<150	<150	<150	<150	<150	<150	<300
W-834-D4	3/06/96	<150	<150	<150	<150	<150	<150	<150	<300
W-834-D4	6/26/96	<75	<75	<75	<75	<75	<75	<75	<130
W-834-D4	6/26/96	<300	<300	<300	<300	<300	<300	<300	<500
W-834-D4	9/25/96	<150	<150	<150	<150	<150	<150	<150	<250
W-834-D4	12/16/96	<150	<150	<150	<150	<150	<150	<150	<250
W-834-D4	3/14/97	<150	<150	<150	<150	<150	<150	<150	<250
W-834-D4	4/23/97	<150	<150	<150	<150	<150	<150	<150	<250
W-834-D4	9/25/97	<750	<750	<750	<750	<750	<750	<750	<1200
W-834-D4	9/25/97	<150	<150	<150	<150	<150	<150	<150	<250
W-834-D4	12/17/97	<150	<150	<150	<150	<150	<150	<150	<250
W-834-D5	9/09/93	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.6
W-834-D5	12/16/93	<30	<30	<30	<30	<30	<30	<30	<60
W-834-D5	3/02/94	<75	<75	<75	<75	<75	<75	<75	<150
W-834-D5	3/22/94	<75	<75	<75	<75	<75	<75	<75	<150
W-834-D5	12/15/94	<60	<60	<60	<60	<60	<60	<60	<120
W-834-D5	3/07/95	<3	<3	<3	<3	<3	<3	<3	<6
W-834-D5	12/21/95	<15	<15	<15	<15	<15	<15	<15	<30
W-834-D5	2/23/96	<75	<75	<75	<75	<75	<75	<75	<150
W-834-D5	6/26/96	<75	<75	<75	<75	<75	<75	<75	<130
W-834-D5	9/25/96	<300	<300	<300	<300	<300	<300	<300	<600
W-834-D5	9/25/96	<75	<75	<75	<75	<75	<75	<75	<130
W-834-D5	12/16/96	<75	<75	<75	<75	<75	<75	<75	<130
W-834-D5	3/14/97	<75	<75	<75	<75	<75	<75	<75	<130
W-834-D5	4/23/97	<75	<75	<75	<75	<75	<75	<75	<130
W-834-D5	12/17/97	<75	<75	<75	<75	<75	<75	<75	<130
W-834-D6	9/24/93	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.6
W-834-D6	12/20/93	<1500	<1500	<1500	<1500	<1500	<1500	<1500	<3000

Table 2. Building 834 monitor well historical results of EPA 602 analyses.

Sample location	Sample date	Benzene (μg/L)	Chloro-benzene (μg/L)	1,2-Dichloro-benzene (μg/L)	1,3-Dichloro-benzene (μg/L)	1,4-Dichloro-benzene (μg/L)	Ethyl-benzene (μg/L)	Toluene (μg/L)	Xylenes (μg/L)
W-834-D6	3/17/94	<600	<600	<600	<600	<600	<600	<600	<1200
W-834-D6	3/17/94	<750	<750	<750	<750	<750	<750	<750	<1500
W-834-D6	3/17/94	<80	NR	NR	NR	NR	<80	<80	<160
W-834-D6	3/17/94	<80	NR	NR	NR	NR	<80	<80	<160
W-834-D6	3/23/94	<150	<150	<150	<150	<150	<150	<150	<300
W-834-D6	6/13/94	<750	<750	<750	<750	<750	<750	<750	<1500
W-834-D6	6/13/94	<750	<750	<750	<750	<750	<750	<750	<1500
W-834-D6	12/15/94	<300	<300	<300	<300	<300	<300	<300	<600
W-834-D6	3/07/95	<75	<75	<75	<75	<75	<75	<75	<150
W-834-D6	12/21/95	<300	<300	<300	<300	<300	<300	<300	<600
W-834-D6	2/23/96	<150	<150	<150	<150	<150	<150	<150	<300
W-834-D6	6/26/96	<150	<150	<150	<150	<150	<150	<150	<250
W-834-D6	9/25/96	<300	<300	<300	<300	<300	<300	<300	<500
W-834-D6	12/16/96	<150	<150	<150	<150	<150	<150	<150	<250
W-834-D6	3/14/97	<150	<150	<150	<150	<150	<150	<150	<250
W-834-D6	4/23/97	<150	<150	<150	<150	<150	<150	<150	<250
W-834-D6	12/17/97	<150	<150	<150	<150	<150	<150	<150	<250
W-834-D7	9/14/93	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.6
W-834-D7	12/20/93	<1500	<1500	<1500	<1500	<1500	<1500	<1500	<3000
W-834-D7	3/24/94	<150	<150	<150	<150	<150	<150	<150	<300
W-834-D7	3/24/94	<150	<150	<150	<150	<150	<150	<150	<300
W-834-D7	6/09/94	<300	<300	<300	<300	<300	<300	<300	<600
W-834-D7	12/15/94	<300	<300	<300	<300	<300	<300	<300	<600
W-834-D7	3/03/95	<30	<30	<30	<30	<30	<30	<30	<60
W-834-D7	12/20/95	<150	<150	<150	<150	<150	<150	<150	<300
W-834-D7	2/28/96	<30	<30	<30	<30	<30	<30	<30	<60
W-834-D7	6/07/96	<60	<60	<60	<60	<60	<60	<60	<100
W-834-D7	12/13/96	<150	<150	<150	<150	<150	<150	<150	<250
W-834-D7	3/14/97	<30	<30	<30	<30	<30	<30	<30	<50
W-834-D7	3/14/97	<75	<75	<75	<75	<75	<75	<75	<130
W-834-D7	4/23/97	<30	<30	<30	<30	<30	<30	<30	<50
W-834-D7	9/25/97	<0.5	NR	NR	NR	NR	<0.5	<0.5	<1
W-834-D7	9/25/97	<30	<30	<30	<30	<30	<30	<30	<50

Table 2. Building 834 monitor well historical results of EPA 602 analyses.

Sample location	Sample date	Benzene (µg/L)	Chloro-benzene (µg/L)	1,2-Dichloro-benzene (µg/L)	1,3-Dichloro-benzene (µg/L)	1,4-Dichloro-benzene (µg/L)	Ethyl-benzene (µg/L)	Toluene (µg/L)	Xylenes (µg/L)
W-834-D7	12/16/97	<30	<30	<30	<30	<30	<30	<30	<50
W-834-D8*	9/24/93	<0.3	<0.3	6.7	<0.3	25	<0.3	<0.3	<0.6
W-834-D8	12/15/93	<1500	<1500	<1500	<1500	<1500	<1500	<1500	<3000
W-834-D8	12/15/93	<50	<50	<50	<50	<50	<50	<50	<50
W-834-D8	3/24/94	<150	<150	<150	<150	<150	<150	<150	<300
W-834-D8	6/10/94	<300	<300	<300	<300	<300	<300	<300	<600
W-834-D8	12/15/94	<750	<750	<750	<750	<750	<750	<750	<1500
W-834-D8	3/07/95	<150	<150	<150	<150	<150	<150	<150	<300
W-834-D8	3/07/95	<75	<75	<75	<75	<75	<75	<75	<150
W-834-D8	12/21/95	<150	<150	<150	<150	<150	<150	<150	<300
W-834-D8	3/06/96	<150	<150	<150	<150	<150	<150	<150	<300
W-834-D8*	3/06/96	1.4	<0.3	<0.3	<0.3	<0.3	<0.3	0.9	20
W-834-D8	6/07/96	<700	<700	<700	<700	<700	<700	<700	<1000
W-834-D8	6/07/96	<60	<60	<60	<60	<60	<60	<60	<100
W-834-D8	12/18/96	<75	<75	<75	<75	<75	<75	<75	<130
W-834-D8	12/18/96	<75	<75	<75	<75	<75	<75	<75	<130
W-834-D8	3/14/97	<30	<30	<30	<30	<30	<30	<30	<50
W-834-D8	4/23/97	<150	<150	<150	<150	<150	<150	<150	<250
W-834-D8	9/25/97	<150	<150	<150	<150	<150	<150	<150	<250
W-834-D8	12/16/97	<150	<150	<150	<150	<150	<150	<150	<250
W-834-D10	9/14/93	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.6
W-834-D10	12/15/93	<15	<15	<15	<15	<15	<15	<15	<30
W-834-D10	3/23/94	<30	<30	<30	<30	<30	<30	<30	<60
W-834-D10	3/23/94	<30	<30	<30	<30	<30	<30	<30	<60
W-834-D10	6/09/94	<75	<75	<75	<75	<75	<75	<75	<150
W-834-D10	3/03/95	<15	<15	<15	<15	<15	<15	<15	<30
W-834-D10	12/20/95	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.6
W-834-D10	2/28/96	<30	<30	<30	<30	<30	<30	<30	<60
W-834-D10	2/28/96	<30	<30	<30	<30	<30	<30	<30	<60
W-834-D10	6/26/96	<30	<30	<30	<30	<30	<30	<30	<50
W-834-D10	4/25/97	<30	<30	<30	<30	<30	<30	<30	<50
W-834-D10	12/16/97	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<2.5
W-834-D11	9/02/93	<25	<25	<25	<25	<25	<25	<25	<50

Table 2. Building 834 monitor well historical results of EPA 602 analyses.

Sample location	Sample date	Benzene (µg/L)	Chloro-benzene (µg/L)	1,2-Dichloro-benzene (µg/L)	1,3-Dichloro-benzene (µg/L)	1,4-Dichloro-benzene (µg/L)	Ethyl-benzene (µg/L)	Toluene (µg/L)	Xylenes (µg/L)
W-834-D11	3/25/94	<300	<300	<300	<300	<300	<300	<300	<600
W-834-D11	6/09/94	<300	<300	<300	<300	<300	<300	<300	<600
W-834-D11	2/28/96	<30	<30	<30	<30	<30	<30	<30	<60
W-834-D11	6/26/96	<30	<30	<30	<30	<30	<30	<30	<50
W-834-D11	3/14/97	<30	<30	<30	<30	<30	<30	<30	<50
W-834-D11	4/24/97	<300	<300	<300	<300	<300	<300	<300	<500
W-834-D11	4/24/97	<30	<30	<30	<30	<30	<30	<30	<50
W-834-D12	9/14/93	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.6
W-834-D12	12/20/93	<1500	<1500	<1500	<1500	<1500	<1500	<1500	<3000
W-834-D12	3/23/94	<150	<150	<150	<150	<150	<150	<150	<300
W-834-D12	6/09/94	<750	<750	<750	<750	<750	<750	<750	<1500
W-834-D12	12/15/94	<750	<750	<750	<750	<750	<750	<750	<1500
W-834-D12	3/03/95	<75	<75	<75	<75	<75	<75	<75	<150
W-834-D12	12/20/95	<150	<150	<150	<150	<150	<150	<150	<300
W-834-D12	2/28/96	<30	<30	<30	<30	<30	<30	<30	<60
W-834-D12	6/25/96	<15	<15	<15	<15	<15	<15	<15	<25
W-834-D12	12/13/96	<150	<150	<150	<150	<150	<150	<150	<250
W-834-D12	3/14/97	<15	<15	<15	<15	<15	<15	<15	<25
W-834-D12	4/24/97	<30	<30	<30	<30	<30	<30	<30	<50
W-834-D12	12/16/97	<30	<30	<30	<30	<30	<30	<30	<50
W-834-D13	9/14/93	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.6
W-834-D13	12/20/93	<1500	<1500	<1500	<1500	<1500	<1500	<1500	<3000
W-834-D13	3/10/94	<3	<3	<3	<3	<3	<3	<3	<6
W-834-D13	3/10/94	<0.5	NR	NR	NR	NR	<0.5	<0.5	<0.5
W-834-D13	3/10/94	<2	NR	NR	NR	NR	<2	<2	<4
W-834-D13	3/23/94	<150	<150	<150	<150	<150	<150	<150	<300
W-834-D13	6/13/94	<1500	<1500	<1500	<1500	<1500	<1500	<1500	<3000
W-834-D13	12/15/94	<30	<30	<30	<30	<30	<30	<30	<60
W-834-D13	3/10/95	<3	<3	<3	<3	<3	<3	<3	<6
W-834-D13	12/21/95	<60	<60	<60	<60	<60	<60	<60	<120
W-834-D13	2/23/96	<150	<150	<150	<150	<150	<150	<150	<300
W-834-D13	6/26/96	<30	<30	<30	<30	<30	<30	<30	<50
W-834-D13	9/25/96	<75	<75	<75	<75	<75	<75	<75	<130

Table 2. Building 834 monitor well historical results of EPA 602 analyses.

Sample location	Sample date	Benzene (µg/L)	Chloro-benzene (µg/L)	1,2-Dichloro-benzene (µg/L)	1,3-Dichloro-benzene (µg/L)	1,4-Dichloro-benzene (µg/L)	Ethyl-benzene (µg/L)	Toluene (µg/L)	Xylenes (µg/L)
W-834-D13	12/16/96	<75	<75	<75	<75	<75	<75	<75	<130
W-834-D13	3/14/97	<75	<75	<75	<75	<75	<75	<75	<130
W-834-D13	4/23/97	<75	<75	<75	<75	<75	<75	<75	<130
W-834-D13	12/17/97	<75	<75	<75	<75	<75	<75	<75	<130
W-834-D13	12/17/97	<150	<150	<150	<150	<150	<150	<150	<250
W-834-D14	9/14/93	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.6
W-834-D14	12/16/93	<1500	<1500	<1500	<1500	<1500	<1500	<1500	<3000
W-834-D14	3/15/94	<600	<600	<600	<600	<600	<600	<600	<1200
W-834-D14	3/15/94	<80	NR	NR	NR	NR	<80	<80	<160
W-834-D14	3/23/94	<150	<150	<150	<150	<150	<150	<150	<300
W-834-D14	3/23/94	<60	<60	<60	<60	<60	<60	<60	<120
W-834-D14	6/13/94	<750	<750	<750	<750	<750	<750	<750	<1500
W-834-D14	12/15/94	<300	<300	<300	<300	<300	<300	<300	<600
W-834-D14	3/07/95	<15	<15	<15	<15	<15	<15	<15	<30
W-834-D14	12/21/95	<300	<300	<300	<300	<300	<300	<300	<600
W-834-D14	2/23/96	<150	<150	<150	<150	<150	<150	<150	<300
W-834-D14	6/26/96	<150	<150	<150	<150	<150	<150	<150	<250
W-834-D14	9/25/96	<150	<150	<150	<150	<150	<150	<150	<250
W-834-D14	12/13/96	<5000	<5000	<5000	<5000	<5000	<5000	<5000	<10000
W-834-D14	12/13/96	<150	<150	<150	<150	<150	<150	<150	<250
W-834-D14	3/14/97	<150	<150	<150	<150	<150	<150	<150	<250
W-834-D14	4/23/97	<150	<150	<150	<150	<150	<150	<150	<250
W-834-D14	9/25/97	<150	<150	<150	<150	<150	<150	<150	<250
W-834-D14	12/17/97	<150	<150	<150	<150	<150	<150	<150	<250
W-834-H2	9/02/93	<25	<25	<25	<25	<25	<25	<25	<50
W-834-H2	12/21/93	<750	<750	<750	<750	<750	<750	<750	<1500
W-834-H2	3/24/94	<300	<300	<300	<300	<300	<300	<300	<600
W-834-H2	6/10/94	<750	<750	<750	<750	<750	<750	<750	<1500
W-834-H2	3/02/95	<75	<75	<75	<75	<75	<75	<75	<150
W-834-H2	12/19/95	<150	<150	<150	<150	<150	<150	<150	<300
W-834-H2	2/28/96	<150	<150	<150	<150	<150	<150	<150	<300
W-834-H2	5/30/96	<150	<150	<150	<150	<150	<150	<150	<250
W-834-H2	12/12/96	<15	<15	<15	<15	<15	<15	<15	<25

Table 2. Building 834 monitor well historical results of EPA 602 analyses.

Sample location	Sample date	Benzene (µg/L)	Chloro-benzene (µg/L)	1,2-Dichloro-benzene (µg/L)	1,3-Dichloro-benzene (µg/L)	1,4-Dichloro-benzene (µg/L)	Ethyl-benzene (µg/L)	Toluene (µg/L)	Xylenes (µg/L)
W-834-H2	3/13/97	<15	<15	<15	<15	<15	<15	<15	<25
W-834-H2	4/24/97	<15	<15	<15	<15	<15	<15	<15	<25
W-834-H2	9/26/97	<30	<30	<30	<30	<30	<30	<30	<50
W-834-J1	6/22/88	<250	<250	<250	<250	<250	<250	<250	<250
W-834-J1*	9/24/93	<0.3	<0.3	34	<0.3	<0.3	<0.3	<0.3	<0.6
W-834-J1	6/09/94	<300	<300	<300	<300	<300	<300	<300	<600
W-834-J1	12/13/94	<150	<150	<150	<150	<150	<150	<150	<300
W-834-J1	3/02/95	<75	<75	<75	<75	<75	<75	<75	<150
W-834-J1	12/19/95	<150	<150	<150	<150	<150	<150	<150	<300
W-834-J1	2/09/96	<150	<150	<150	<150	<150	<150	<150	<300
W-834-J1	5/29/96	<150	<150	<150	<150	<150	<150	<150	<250
W-834-J1	12/17/96	<150	<150	<150	<150	<150	<150	<150	<250
W-834-J1	3/13/97	<1	<1	<1	<1	<1	<1	<1	<2
W-834-J1	3/13/97	<30	<30	<30	<30	<30	<30	<30	<50
W-834-J1	4/24/97	<300	<300	<300	<300	<300	<300	<300	<500
W-834-J1	4/24/97	<30	<30	<30	<30	<30	<30	<30	<50
W-834-J1	9/26/97	<30	<30	<30	<30	<30	<30	<30	<50
W-834-J1	12/16/97	<30	<30	<30	<30	<30	<30	<30	<50
W-834-J2	6/22/88	<250	<250	<250	<250	<250	<250	<250	<250
W-834-J2	9/24/93	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.6
W-834-J2	12/15/93	<1500	<1500	<1500	<1500	<1500	<1500	<1500	<3000
W-834-J2	3/23/94	<150	<150	<150	<150	<150	<150	<150	<300
W-834-J2	6/09/94	<300	<300	<300	<300	<300	<300	<300	<600
W-834-J2	6/09/94	<50	NR	NR	NR	NR	<50	<50	<50
W-834-J2	12/13/94	<150	<150	<150	<150	<150	<150	<150	<300
W-834-J2	3/02/95	<30	<30	<30	<30	<30	<30	<30	<60
W-834-J2	12/19/95	<60	<60	<60	<60	<60	<60	<60	<120
W-834-J2	2/09/96	<75	<75	<75	<75	<75	<75	<75	<150
W-834-J2	6/05/96	<30	<30	<30	<30	<30	<30	<30	<50
W-834-J2	12/17/96	<30	<30	<30	<30	<30	<30	<30	<50
W-834-J2	3/13/97	<30	<30	<30	<30	<30	<30	<30	<50
W-834-J2	4/23/97	<30	<30	<30	<30	<30	<30	<30	<50
W-834-J2	9/26/97	<15	<15	<15	<15	<15	<15	<15	<25

Table 2. Building 834 monitor well historical results of EPA 602 analyses.

Sample location	Sample date	Benzene (μg/L)	Chloro-benzene (μg/L)	1,2-Dichloro-benzene (μg/L)	1,3-Dichloro-benzene (μg/L)	1,4-Dichloro-benzene (μg/L)	Ethyl-benzene (μg/L)	Toluene (μg/L)	Xylenes (μg/L)
W-834-J2	12/16/97	<15	<15	<15	<15	<15	<15	<15	<25
W-834-S1	9/24/93	<0.3	<0.3	<0.3	<0.3	15	<0.3	<0.3	<0.6
W-834-S1	12/20/93	<1500	<1500	<1500	<1500	<1500	<1500	<1500	<3000
W-834-S1	3/17/94	<60	<60	<60	<60	<60	<60	<60	<120
W-834-S1	6/08/94	<300	<300	<300	<300	<300	<300	<300	<600
W-834-S1	12/13/94	<150	<150	<150	<150	<150	<150	<150	<300
W-834-S1	3/01/95	<75	<75	<75	<75	<75	<75	<75	<150
W-834-S3	9/24/93	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.6
W-834-S3	12/21/93	<750	<750	<750	<750	<750	<750	<750	<1500
W-834-S3	3/17/94	<150	<150	<150	<150	<150	<150	<150	<300
W-834-S3	6/08/94	<600	<600	<600	<600	<600	<600	<600	<1200
W-834-S3	3/01/95	<75	<75	<75	<75	<75	<75	<75	<150
W-834-S9	9/24/93	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.6
W-834-S9	12/17/93	<60	<60	<60	<60	<60	<60	<60	<120
W-834-S9	3/17/94	<3	<3	<3	<3	<3	<3	<3	<6
W-834-S9	6/08/94	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.6
W-834-S9	12/13/94	<6	<6	<6	<6	<6	<6	<6	<12
W-834-S9	3/01/95	<3	<3	<3	<3	<3	<3	<3	<6
W-834-T2D	6/21/88	<250	<250	<250	<250	<250	<250	<250	<250
W-834-T7	1/13/88	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5

Notes:

NR = No results obtained from analytical laboratory.

***Only detections of BTEX compounds.**

Table 3. Building 834 monitor well historical tetra-butyl orthosilicate (TBOS) results.

Sample location	Laboratory ID	Sample date	TBOS (μg/L)
W-834-B2	M80244C	3/03/95	<100
W-834-B2	N17744F	2/09/96	<100
W-834-B2	N68011E	3/14/97	<100
W-834-B3	M80241C	3/03/95	<100
W-834-B3	N13022D	12/20/95	<100
W-834-B3	N17742F	2/09/96	<100
W-834-B3	N30373E	5/30/96	<100
W-834-B3	N56262D	12/12/96	<100
W-834-B3	N67771E	3/13/97	<100
W-834-B3	N73046D	4/23/97	<100
W-834-B3	P10092B	12/16/97	<100
W-834-C2	M80243C	3/03/95	<100
W-834-C2	N17743F	2/09/96	<100
W-834-C2	N34235C	6/26/96	<100
W-834-C2	N67782E	3/13/97	<100
W-834-D3	M42762B	3/14/94	730
W-834-D3	M80467C	3/07/95	44000
W-834-D3	N06393C	10/30/95	260000
W-834-D3	N13156C	12/21/95	7300000
W-834-D3	N19634F	2/23/96	4400
W-834-D3	96033562	3/19/96	<1
W-834-D3	960330402E	3/19/96	4900
W-834-D3	N22532D	3/19/96	4900
W-834-D3	N342314C	6/26/96	26000
W-834-D3	N46959E	9/25/96	12000
W-834-D3	N56755D	12/16/96	43000
W-834-D3	N68013E	3/14/97	20000
W-834-D3	N730410E	4/23/97	9100
W-834-D3	N95375E	9/25/97	12000
W-834-D3	P10414C	12/17/97	100000
W-834-D4	M41481A	3/02/94	830000
W-834-D4	M80862D	3/10/95	13000
W-834-D4	N06191B	10/27/95	82000
W-834-D4	N13154C	12/21/95	970
W-834-D4	N20981D	3/06/96	740
W-834-D4	96033561	3/19/96	<1
W-834-D4	960330401E	3/19/96	1400
W-834-D4	N22531D	3/19/96	890
W-834-D4	N342313C	6/26/96	210
W-834-D4	N34233C	6/26/96	780
W-834-D4	N46957E	9/25/96	1700
W-834-D4	N56752D	12/16/96	4500
W-834-D4	N68004E	3/14/97	780
W-834-D4	N73049D	4/23/97	1300
W-834-D4	N95811A	9/26/97	12000
W-834-D4	N95812A	9/26/97	7000
W-834-D4	P10415C	12/17/97	21000
W-834-D5	M41482A	3/02/94	120
W-834-D5	M80464C	3/07/95	360
W-834-D5	N06391C	10/27/95	2900
W-834-D5	N13155C	12/21/95	<100
W-834-D5	N19635F	2/23/96	230
W-834-D5	96033563	3/19/96	<1
W-834-D5	960330403E	3/19/96	<100
W-834-D5	N22533D	3/19/96	150
W-834-D5	N342312C	6/26/96	120
W-834-D5	N46958D	9/25/96	<100

Table 3. Building 834 monitor well historical tetra-butyl orthosilicate (TBOS) results.

Sample location	Laboratory ID	Sample date	TBOS (μg/L)
W-834-D5	N56753D	12/16/96	210
W-834-D5	N68014D	3/14/97	<100
W-834-D5	N73043D	4/23/97	<100
W-834-D5	P10416C	12/17/97	100
W-834-D6	M43225B	3/17/94	<500
W-834-D6	M80465C	3/07/95	<100
W-834-D6	N06394C	10/30/95	<100
W-834-D7	M80247C	3/03/95	<100
W-834-D7	N13023D	12/20/95	<100
W-834-D7	N20094F	2/28/96	<100
W-834-D7	N31641E	6/07/96	<100
W-834-D7	N56465D	12/13/96	<100
W-834-D7	N68015E	3/14/97	<100
W-834-D7	N68016E	3/14/97	<100
W-834-D7	N73042E	4/23/97	<100
W-834-D7	9710360001	9/25/97	<1
W-834-D7	N95371E	9/25/97	<100
W-834-D7	P10095B	12/16/97	<100
W-834-D8	M80463C	3/07/95	<5000
W-834-D8	N13157C	12/21/95	<100
W-834-D8	N20982D	3/06/96	<1000
W-834-D8	9606584001	6/07/96	<20
W-834-D8	N31644E	6/07/96	<100
W-834-D8	N57122E	12/18/96	1600
W-834-D8	N57123E	12/18/96	1200
W-834-D8	N68006E	3/14/97	<100
W-834-D8	N73041E	4/23/97	<100
W-834-D8	N95376E	9/25/97	<100
W-834-D10	N20091F	2/28/96	<100
W-834-D10	N34239B	6/26/96	<100
W-834-D11	N20092F	2/28/96	<100
W-834-D11	N34234C	6/26/96	<100
W-834-D11	N68001E	3/14/97	<100
W-834-D11	9704367001	4/24/97	<1
W-834-D11	N73191C	4/24/97	<100
W-834-D12	M80248C	3/03/95	<100
W-834-D12	N13024D	12/20/95	<100
W-834-D12	N20093F	2/28/96	<100
W-834-D12	N34011E	6/25/96	<100
W-834-D12	N56464D	12/13/96	<100
W-834-D12	N68002E	3/14/97	<100
W-834-D12	N73192C	4/24/97	<100
W-834-D12	P10094B	12/16/97	<100
W-834-D13	N06392C	10/30/95	<100
W-834-D13	N13153C	12/21/95	<100
W-834-D13	N19632F	2/23/96	<100
W-834-D13	N342311C	6/26/96	<100
W-834-D13	N46953E	9/25/96	<100
W-834-D13	N56754D	12/16/96	<100
W-834-D13	N68003E	3/14/97	<100
W-834-D13	N73045E	4/23/97	<100
W-834-D13	P10412C	12/17/97	<100
W-834-D13	P10418C	12/17/97	<100
W-834-D14	N06395C	10/30/95	<100
W-834-D14	N13152C	12/21/95	<100
W-834-D14	N19633F	2/23/96	<100
W-834-D14	N342310C	6/26/96	<100

Table 3. Building 834 monitor well historical tetra-butyl orthosilicate (TBOS) results.

Sample location	Laboratory ID	Sample date	TBOS (μg/L)
W-834-D14	N46954E	9/25/96	<100
W-834-D14	N56466D	12/13/96	<100
W-834-D14	N68012E	3/14/97	<100
W-834-D14	N73048E	4/23/97	<100
W-834-D14	N95372E	9/25/97	<100
W-834-D14	P10413C	12/17/97	<100
W-834-H2	N12871B	12/19/95	<100
W-834-H2	N20095D	2/28/96	<100
W-834-H2	N30374E	5/30/96	<100
W-834-H2	N56261D	12/12/96	<100
W-834-H2	N67783E	3/13/97	<100
W-834-H2	N73193C	4/24/97	<100
W-834-H2	N95813C	9/26/97	<100
W-834-J1	M80103C	3/02/95	<100
W-834-J1	N12872B	12/19/95	<100
W-834-J1	N17746F	2/09/96	<100
W-834-J1	9606202001	5/29/96	<200
W-834-J1	N30367E	5/29/96	<100
W-834-J1	N56911B	12/17/96	<100
W-834-J1	9702754001	3/13/97	<1
W-834-J1	N67772E	3/13/97	<100
W-834-J1	9704367002	4/24/97	<1
W-834-J1	N73194C	4/24/97	<100
W-834-J1	N95814E	9/26/97	<100
W-834-J1	P10097B	12/16/97	<100
W-834-J2	M80102C	3/02/95	<100
W-834-J2	N12873B	12/19/95	<100
W-834-J2	N17745F	2/09/96	<100
W-834-J2	N31175B	6/05/96	<100
W-834-J2	N56912B	12/17/96	<100
W-834-J2	N67784E	3/13/97	<100
W-834-J2	N73044E	4/23/97	<100
W-834-J2	N95815E	9/26/97	<100
W-834-J2	P10098B	12/16/97	<100
W-834-K1	M79999B	3/01/95	<100

Table 4. Building 834 monitor well historical results of metals and cyanide analyses.

Sample location	Sample date	Barium (mg/L)	Cadmium (mg/L)	Copper (mg/L)	Cyanide (mg/L)	Lead (mg/L)	Mercury (mg/L)	Molybdenum (mg/L)	Silver (mg/L)	Zinc (mg/L)
W-834-B2	2/9/1996	<0.025	<0.0005	<0.01	<0.02	<0.002	<0.0002	<0.025	<0.01	<0.02
W-834-B2	3/14/1997	<0.025	0.00058	0.74	<0.02	<0.002	<0.0002	<0.05	<0.001	0.93
W-834-B3	12/20/1995	<0.02	<0.0005	<0.002	<0.02	<0.002	<0.0002	<0.05	<0.0005	<0.02
W-834-B3	2/9/1996	<0.025	<0.0005	<0.01	<0.02	<0.002	<0.0002	<0.025	<0.01	<0.02
W-834-B3	5/30/1996	<0.025	<0.0005	<0.01	<0.02	<0.002	<0.0002	<0.05	<0.001	<0.02
W-834-B3	12/12/1996	<0.025	<0.0005	<0.01	<0.01	0.0029	<0.0002	<0.05	<0.001	0.58
W-834-B3	3/13/1997	<0.025	<0.0005	0.064	<0.02	<0.002	0.00021	<0.05	<0.001	<0.02
W-834-B3	4/23/1997	<0.025	<0.0005	0.32	<0.02	<0.002	<0.0002	<0.05	<0.001	0.041
W-834-B3	12/16/1997	<0.025	<0.0005	0.150	<0.02	<0.005	<0.0002	<0.050	<0.001	0.100
W-834-C2	2/9/1996	<0.025	<0.0005	<0.01	<0.02	0.0031	<0.0002	<0.025	<0.01	<0.02
W-834-C2	6/26/1996	<0.025	<0.0005	<0.01	–	<0.002	<0.0002	<0.05	<0.001	<0.02
W-834-C2	3/13/1997	<0.025	<0.0005	<0.01	<0.02	<0.002	<0.0002	<0.05	<0.001	<0.02
W-834-D3	12/21/1995	0.05	<0.0005	<0.002	<0.02	<0.005	<0.0002	<0.05	<0.0005	0.04
W-834-D3	2/23/1996	0.052	<0.005	<0.01	<0.02	0.013	<0.0002	<0.025	<0.01	<0.02
W-834-D3	6/26/1996	0.048	<0.0005	<0.01	<0.02	<0.002	<0.0002	<0.05	<0.001	0.024
W-834-D3	9/25/1996	0.043	0.00091	0.125[a]	<0.02	<0.005	<0.0002	<0.05	<0.001	0.028
W-834-D3	9/25/1996	0.026	<0.0005	<0.01	<0.02	<0.002	<0.0002	<0.05	<0.001	<0.02
W-834-D3	12/16/1996	0.037	<0.0005	<0.01	<0.01	<0.002	<0.0002	<0.05	<0.001	<0.02
W-834-D3	12/16/1996	0.037	<0.0005	<0.01	<0.01	<0.002	<0.0002	<0.05	<0.001	<0.02
W-834-D3	3/14/1997	0.056	<0.0005	<0.01	<0.02	<0.002	<0.0002	<0.05	<0.001	<0.02
W-834-D3	4/23/1997	0.082	<0.0005	<0.01	<0.02	<0.002	<0.0002	<0.05	<0.001	0.02
W-834-D3	9/25/1997	0.092	<0.0005	<0.01	<0.02	<0.002	<0.0002	<0.05	<0.001	0.021
W-834-D3	12/17/1997	0.048	<0.0005	<0.010	<0.02	<0.005	<0.0002	<0.050	<0.002	0.020
W-834-D4	12/21/1995	0.07	<0.0005	0.003	<0.02	<0.002	<0.0002	<0.05	<0.0005	<0.02
W-834-D4	3/6/1996	0.079	<0.0005	<0.01	<0.02	<0.002	<0.0002	<0.05	<0.01	0.024
W-834-D4	6/26/1996	0.073	<0.0005	0.011	<0.02	<0.002	<0.0002	<0.05	<0.001	0.058
W-834-D4	6/26/1996	<0.025	<0.0005	<0.01	<0.02	<0.002	<0.0002	<0.05	<0.001	<0.02
W-834-D4	9/25/1996	0.061	<0.0005	<0.01	<0.02	<0.002	<0.0002	<0.05	<0.001	<0.02
W-834-D4	12/16/1996	0.078	<0.0005	<0.01	<0.01	<0.002	<0.0002	<0.05	<0.001	<0.02
W-834-D4	12/16/1996	0.078	<0.0005	<0.01	<0.01	<0.002	<0.0002	<0.05	<0.001	<0.02
W-834-D4	3/14/1997	0.081	<0.0005	0.017	<0.02	<0.002	<0.0002	<0.05	<0.001	0.032
W-834-D4	4/23/1997	0.13	<0.0005	<0.01	<0.02	<0.002	<0.0002	<0.05	<0.001	<0.02
W-834-D4	9/26/1997	0.19	<0.0005	<0.01	<0.02	<0.002	<0.0002	<0.05	<0.001	0.025
W-834-D4	9/26/1997	0.2	<0.0005	<0.01	<0.02	<0.002	<0.0002	<0.05	<0.001	0.046
W-834-D4	12/17/1997	0.110	<0.0005	<0.010	<0.02	<0.005	<0.0002	<0.050	<0.002	0.021
W-834-D5	12/21/1995	0.04	<0.0005	0.024	<0.02	<0.002	<0.0002	<0.05	<0.0005	0.11
W-834-D5	2/23/1996	0.037	<0.005	<0.01	<0.02	<0.002	<0.0002	<0.025	<0.01	0.065

Table 4. Building 834 monitor well historical results of metals and cyanide analyses.

Sample location	Sample date	Barium (mg/L)	Cadmium (mg/L)	Copper (mg/L)	Cyanide (mg/L)	Lead (mg/L)	Mercury (mg/L)	Molybdenum (mg/L)	Silver (mg/L)	Zinc (mg/L)
W-834-D5	6/26/1996	0.048	<0.0005	0.028	<0.02	<0.002	<0.0002	<0.05	<0.001	1.2
W-834-D5	9/25/1996	0.055	<0.0005	0.019	<0.02	<0.005	<0.0002	<0.05	<0.001	0.095
W-834-D5	9/25/1996	0.036	<0.0005	<0.01	<0.02	<0.002	<0.0002	<0.05	0.014[a]	0.28
W-834-D5	12/16/1996	0.043	<0.0005	<0.01	<0.01	<0.002	<0.0002	<0.05	<0.001	0.1
W-834-D5	12/16/1996	0.043	<0.0005	<0.01	<0.01	<0.002	<0.0002	<0.05	<0.001	0.1
W-834-D5	3/14/1997	0.043	<0.0005	0.029	<0.02	<0.002	<0.0002	<0.05	<0.001	0.059
W-834-D5	4/23/1997	0.047	<0.0005	0.032	<0.02	<0.002	<0.0002	<0.05	<0.001	0.054
W-834-D5	12/17/1997	0.056	<0.0005	0.093	<0.02	<0.005	<0.0002	<0.050	<0.002	0.210
W-834-D6	12/21/1995	0.04	<0.0005	<0.002	–	<0.002	<0.0002	<0.05	<0.0005	<0.02
W-834-D6	2/23/1996	0.041	<0.005	<0.01	–	<0.002	<0.0002	<0.025	<0.01	<0.02
W-834-D6	6/26/1996	0.043	<0.0005	<0.01	–	<0.002	<0.0002	<0.05	<0.001	0.081
W-834-D6	9/25/1996	<0.025	<0.0005	<0.01	–	<0.002	<0.0002	<0.05	<0.001	0.079
W-834-D6	12/16/1996	0.037	<0.0005	0.032	–	<0.002	<0.0002	<0.05	<0.001	0.027
W-834-D6	12/16/1996	0.037	<0.0005	0.032	–	<0.002	<0.0002	<0.05	<0.001	0.027
W-834-D6	3/14/1997	0.041	<0.0005	<0.01	–	<0.002	<0.0002	<0.05	<0.001	<0.02
W-834-D6	4/23/1997	0.042	<0.0005	0.029	–	<0.002	<0.0002	<0.05	<0.001	0.042
W-834-D6	12/17/1997	0.042	<0.0005	0.030	–	<0.005	<0.0002	<0.050	<0.002	0.150
W-834-D7	12/20/1995	0.04	<0.0005	<0.002	<0.02	<0.002	<0.0002	<0.05	<0.0005	<0.02
W-834-D7	2/28/1996	0.047	<0.0005	<0.01	<0.02	<0.002	<0.0002	<0.025	<0.01	<0.02
W-834-D7	6/7/1996	0.046	<0.0005	<0.01	<0.02	0.0022	<0.0002	<0.05	<0.001	<0.02
W-834-D7	12/13/1996	0.045	<0.0005	<0.01	<0.01	<0.002	<0.0002	<0.05	<0.001	<0.02
W-834-D7	12/13/1996	0.045	<0.0005	<0.01	<0.01	<0.002	<0.0002	<0.05	<0.001	<0.02
W-834-D7	3/14/1997	0.066	<0.0005	<0.01	<0.02	<0.002	<0.0002	<0.05	<0.001	0.033
W-834-D7	3/14/1997	0.059	<0.0005	<0.01	<0.02	<0.002	<0.0002	<0.05	<0.001	0.029
W-834-D7	4/23/1997	0.059	<0.0005	0.036	<0.02	<0.002	<0.0002	<0.05	<0.001	0.031
W-834-D7	9/25/1997	0.058	<0.005	<0.05	<0.02	<0.005	<0.0002	<0.05	<0.001	0.034
W-834-D6	9/25/1997	0.055	<0.0005	<0.01	<0.02	<0.002	<0.0002	<0.05	<0.001	<0.02
W-834-D6	12/16/1997	0.060	<0.0005	0.018	<0.02	<0.005	<0.0002	<0.050	<0.001	0.130
W-834-D8	12/21/1995	0.5	<0.0005	0.002	<0.02	<0.002	<0.0002	<0.05	<0.0005	<0.02
W-834-D8	3/6/1996	0.094	<0.0005	<0.01	<0.02	<0.002	<0.0002	<0.05	<0.01	<0.02
W-834-D8	6/7/1996	0.062	<0.0005	<0.05	<0.02	<0.005	<0.002	<0.05	<0.001	<0.05
W-834-D8	6/7/1996	0.059	<0.0005	<0.01	<0.02	<0.002	<0.0002	<0.05	<0.001	<0.02
W-834-D8	12/18/1996	0.086	<0.0005	<0.01	<0.01	0.0051	<0.0002	<0.05	<0.001	<0.02
W-834-D8	12/18/1996	0.088	<0.0005	<0.01	<0.01	0.0072	<0.0002	<0.05	<0.001	<0.02
W-834-D8	12/18/1996	0.086	<0.0005	<0.01	<0.01	0.0051	<0.0002	<0.05	<0.001	<0.02
W-834-D8	12/18/1996	0.088	<0.0005	<0.01	<0.01	0.0072	<0.0002	<0.05	<0.001	<0.02
W-834-D8	3/14/1997	0.092	<0.0005	<0.01	<0.02	0.005	<0.0002	<0.05	<0.001	0.17

Table 4. Building 834 monitor well historical results of metals and cyanide analyses.

Sample location	Sample date	Barium (mg/L)	Cadmium (mg/L)	Copper (mg/L)	Cyanide (mg/L)	Lead (mg/L)	Mercury (mg/L)	Molybdenum (mg/L)	Silver (mg/L)	Zinc (mg/L)
W-834-D8	4/23/1997	0.067	<0.0005	0.36	<0.02	<0.002	<0.0002	<0.05	<0.001	0.022
W-834-D8	9/25/1997	0.063	<0.0005	0.022	<0.02	<0.002	<0.0002	<0.05	<0.001	<0.02
W-834-D8	12/16/1997	0.160	<0.0005	<0.010	<0.02	<0.005	<0.0002	<0.050	<0.001	0.013
W-834-D11	2/28/1996	0.25	<0.0005	<0.01	<0.02	<0.002	<0.0002	<0.025	<0.01	0.034
W-834-D11	6/26/1996	<0.025	<0.0005	<0.01	<0.02	<0.002	<0.0002	<0.05	<0.001	<0.02
W-834-D11	3/14/1997	0.036	<0.0005	0.063	<0.02	<0.002	<0.0002	<0.05	<0.001	0.038
W-834-D11	4/25/1997	0.043	<0.0005	0.052	<0.02	<0.002	<0.0002	<0.05	<0.001	0.021
W-834-D11	4/25/1997	0.045	<0.0005	0.062	<0.02	<0.005	<0.0002	<0.05	<0.001	0.02
W-834-D12	12/20/1995	0.02	<0.0005	<0.002	<0.02	<0.002	<0.0002	0.07	<0.0005	<0.02
W-834-D12	2/28/1996	0.064	<0.0005	<0.01	<0.02	<0.002	<0.0002	<0.025	<0.01	<0.02
W-834-D12	6/25/1996	0.075	<0.0005	<0.01	<0.02	<0.002	<0.0002	<0.05	<0.001	<0.02
W-834-D12	12/13/1996	0.045	<0.0005	<0.01	<0.01	<0.002	<0.0002	<0.05	<0.001	<0.02
W-834-D12	12/13/1996	0.045	<0.0005	<0.01	<0.01	<0.002	<0.0002	<0.05	<0.001	<0.02
W-834-D12	3/14/1997	0.12	<0.0005	0.078	<0.02	<0.002	<0.0002	<0.05	<0.001	0.12
W-834-D12	4/24/1997	0.11	<0.0005	0.021	<0.02	<0.002	<0.0002	<0.05	<0.001	0.034
W-834-D12	12/18/1997	0.048	<0.0005	0.029	<0.02	<0.005	<0.0002	<0.050	<0.002	0.051
W-834-D13	12/21/1995	0.04	<0.0005	0.003	<0.02	<0.002	<0.0002	<0.05	<0.0005	<0.02
W-834-D13	2/23/1996	0.035	<0.005	<0.01	<0.02	<0.002	<0.0002	<0.025	<0.01	<0.02
W-834-D13	6/26/1996	0.054	<0.0005	<0.01	<0.02	<0.002	<0.0002	<0.05	<0.001	<0.02
W-834-D13	9/25/1996	0.039	<0.0005	<0.01	<0.02	<0.002	<0.0002	<0.05	<0.001	0.035
W-834-D13	12/16/1996	0.055	<0.0005	<0.01	<0.01	<0.002	<0.0002	<0.05	<0.001	<0.02
W-834-D13	12/16/1996	0.055	<0.0005	<0.01	<0.01	<0.002	<0.0002	<0.05	<0.001	<0.02
W-834-D13	3/14/1997	0.031	<0.0005	<0.01	<0.02	<0.002	<0.0002	<0.05	<0.001	0.11
W-834-D13	4/23/1997	0.042	<0.0005	0.017	<0.02	<0.002	<0.0002	<0.05	<0.001	0.042
W-834-D13	12/17/1997	0.045	<0.0005	0.016	<0.02	<0.005	<0.0002	<0.050	<0.002	0.099
W-834-D14	12/21/1995	0.04	<0.0005	<0.002	<0.02	<0.002	<0.0002	<0.05	<0.0005	<0.02
W-834-D14	2/23/1996	0.031	<0.005	<0.01	<0.02	<0.002	<0.0002	<0.025	<0.01	<0.02
W-834-D14	6/26/1996	0.039	<0.0005	<0.01	<0.02	<0.002	<0.0002	<0.05	<0.001	0.032
W-834-D14	9/25/1996	0.033	<0.0005	<0.01	<0.02	<0.002	<0.0002	<0.05	<0.001	0.12
W-834-D14	12/13/1996	0.042	<0.0005	<0.01	<0.02	<0.005	<0.0002	<0.05	<0.001	<0.01
W-834-D14	12/13/1996	0.04	<0.0005	<0.01	<0.01	<0.002	<0.0002	<0.05	<0.001	0.036
W-834-D14	12/13/1996	0.042	<0.0005	<0.01	<0.02	<0.005	<0.0002	<0.05	<0.001	<0.01
W-834-D14	12/13/1996	0.04	<0.0005	<0.01	<0.01	<0.002	<0.0002	<0.05	<0.001	0.036
W-834-D14	3/14/1997	0.037	<0.0005	<0.01	<0.02	<0.002	<0.0002	<0.05	<0.001	0.034
W-834-D14	4/23/1997	0.04	<0.0005	0.017	<0.02	<0.002	<0.0002	<0.05	<0.001	0.032
W-834-D14	9/25/1997	0.05	<0.0005	<0.01	<0.02	<0.002	<0.0002	<0.05	<0.001	0.047
W-834-D14	12/17/1997	0.053	<0.0005	<0.010	<0.02	<0.005	<0.0002	<0.050	<0.002	0.076

Table 4. Building 834 monitor well historical results of metals and cyanide analyses.

Sample location	Sample date	Barium (mg/L)	Cadmium (mg/L)	Copper (mg/L)	Cyanide (mg/L)	Lead (mg/L)	Mercury (mg/L)	Molybdenum (mg/L)	Silver (mg/L)	Zinc (mg/L)
W-834-H2	12/19/1995	0.04	<0.0005	<0.005	–	<0.002	<0.0002	<0.05	<0.0005	<0.05
W-834-H2	2/28/1996	0.028	<0.0005	<0.01	–	<0.002	<0.0002	<0.025	<0.01	<0.02
W-834-H2	5/30/1996	<0.025	<0.0005	<0.01	<0.02	0.0022	<0.0002	<0.05	<0.001	0.038
W-834-H2	12/12/1996	<0.025	<0.0005	<0.01	<0.01	<0.002	<0.0002	<0.05	<0.001	0.073
W-834-H2	12/12/1996	<0.025	<0.0005	<0.01	<0.01	<0.002	<0.0002	<0.05	<0.001	0.073
W-834-H2	3/13/1997	<0.025	<0.0005	<0.01	<0.02	<0.002	<0.0002	<0.05	<0.001	<0.02
W-834-H2	4/24/1997	<0.025	<0.0005	<0.01	<0.02	<0.002	0.00022	<0.05	<0.001	0.042
W-834-H2	9/26/1997	<0.025	<0.0005	0.033	–	<0.002	<0.0002	<0.05	<0.001	0.29
W-834-J1	12/19/1995	0.05	<0.0005	<0.005	<0.02	<0.002	<0.0002	<0.05	<0.0005	<0.02
W-834-J1	2/9/1996	0.038	<0.0005	<0.01	<0.02	<0.002	<0.0002	<0.025	<0.01	<0.02
W-834-J1	5/29/1996	0.034	<0.0005	<0.05	<0.02	<0.005	<0.0002	<0.05	<0.001	<0.05
W-834-J1	5/29/1996	0.047	0.0011[a]	<0.01	<0.02	0.0032	<0.0002	<0.05	<0.001	0.024
W-834-J1	12/17/1996	0.027	<0.0005	<0.01	<0.01	<0.002	0.00026	<0.05	<0.001	0.056
W-834-J1	12/17/1996	0.027	<0.0005	<0.01	<0.01	<0.002	0.00026	<0.05	<0.001	0.056
W-834-J1	3/13/1997	0.031	<0.0005	<0.01	<0.02	<0.002	0.00024	<0.05	<0.001	<0.02
W-834-J1	3/13/1997	0.036	<0.0005	<0.01	<0.02	<0.005	<0.0002	<0.05	<0.001	0.01
W-834-J1	4/24/1997	0.034	<0.0005	<0.01	<0.02	<0.002	0.00051	<0.05	<0.001	0.07
W-834-J1	4/24/1997	0.034	<0.0005	<0.01	<0.02	<0.005	<0.0002	<0.05	<0.001	0.012
W-834-J1	9/26/1997	0.025	<0.0005	<0.01	<0.02	<0.002	<0.0002	<0.05	<0.001	0.027
W-834-J1	12/16/1997	0.037	<0.0005	0.020	<0.02	<0.005	<0.0002	<0.050	<0.001	0.540
W-834-J2	12/19/1995	0.05	<0.0005	<0.005	<0.02	<0.002	<0.0002	<0.05	<0.0005	<0.02
W-834-J2	2/9/1996	0.025	<0.0005	<0.01	<0.02	<0.002	<0.0002	<0.025	<0.01	<0.02
W-834-J2	6/5/1996	0.034	0.0005	<0.01	<0.02	0.0048	<0.0002	<0.05	<0.001	0.32
W-834-J2	12/17/1996	0.031	<0.0005	<0.01	<0.01	<0.002	<0.0002	<0.05	<0.001	<0.02
W-834-J2	12/17/1996	0.031	<0.0005	<0.01	<0.01	<0.002	<0.0002	<0.05	<0.001	<0.02
W-834-J2	3/13/1997	0.035	<0.0005	<0.01	<0.02	<0.002	<0.0002	<0.05	<0.001	<0.02
W-834-J2	4/23/1997	0.03	<0.0005	0.012	<0.02	<0.002	<0.0002	<0.05	<0.001	<0.02
W-834-J2	9/26/1997	0.04	<0.0005	0.038	<0.02	<0.002	<0.0002	<0.05	<0.001	0.034
W-834-J2	12/16/1997	0.046	<0.0005	0.051	<0.02	<0.005	<0.0002	<0.050	<0.001	0.180
W-834-K1	12/14/1995	0.03	<0.0005	0.002	<0.02	<0.002	<0.0002	<0.05	<0.0005	<0.02
W-834-K1	2/8/1996	0.045	<0.0005	0.061	<0.02	<0.002	<0.0002	0.079	0.025	0.063
W-834-K1	5/22/1996	0.025	0.0051	<0.01	<0.02	0.008	<0.0002	<0.05	<0.001	<0.02
W-834-K1	9/25/1996	<0.025	0.0017	<0.01	<0.02	<0.002	<0.0002	0.052	<0.001	<0.02
W-834-K1	12/23/1996	0.026	<0.0005	<0.01	<0.01	<0.002	0.0003	<0.05	<0.001	<0.02
W-834-K1	12/23/1996	0.026	<0.0005	<0.01	<0.01	<0.002	0.0003	<0.05	<0.001	<0.02
W-834-K1	3/13/1997	0.026	<0.0005	<0.01	<0.02	<0.002	<0.0002	<0.05	<0.001	<0.02
W-834-K1	3/13/1997	0.028	<0.0005	<0.01	<0.02	<0.005	<0.0002	<0.05	<0.001	0.017

Table 4. Building 834 monitor well historical results of metals and cyanide analyses.

Sample location	Sample date	Barium (mg/L)	Cadmium (mg/L)	Copper (mg/L)	Cyanide (mg/L)	Lead (mg/L)	Mercury (mg/L)	Molybdenum (mg/L)	Silver (mg/L)	Zinc (mg/L)
W-834-K1	4/18/1997	0.03	<0.0005	<0.01	<0.02	<0.002	<0.0002	<0.05	<0.001	<0.02
W-834-K1	4/18/1997	0.028	<0.0005	<0.01	<0.02	<0.002	<0.0002	<0.05	<0.001	<0.02
W-834-K1	9/26/1997	0.028	<0.0005	<0.05	<0.02	<0.005	<0.0002	<0.05	<0.001	<0.02
W-834-K1	9/26/1997	0.027	<0.0005	<0.01	<0.02	<0.002	<0.0002	<0.05	<0.001	<0.02
W-834-K1	12/8/1997	0.035	<0.0005	0.016	<0.02	<0.002	<0.0002	<0.050	<0.001	<0.020
W-834-K1	12/8/1997	0.029	<0.0005	0.016	<0.02	<0.002	<0.0002	<0.050	<0.001	<0.020
W-834-M1	12/7/1995	0.04	<0.001	<0.05	<0.02	<0.01	<0.0002	<0.05	<0.01	<0.05
W-834-M1	2/6/1996	0.056	<0.0005	<0.01	<0.02	<0.002	<0.0002	–	0.018	<0.02
W-834-M1	6/6/1996	0.032	0.013	<0.01	<0.02	0.015	<0.0002	<0.05	<0.001	<0.02
W-834-M1	9/26/1996	<0.025	0.0063	<0.01	<0.02	<0.002	<0.0002	<0.05	<0.001	<0.02
W-834-M1	12/17/1996	0.026	<0.0005	0.021	<0.01	<0.002	<0.0002	<0.05	<0.001	<0.02
W-834-M1	12/17/1996	0.026	<0.0005	0.021	<0.01	<0.002	<0.0002	<0.05	<0.001	<0.02
W-834-M1	2/27/1997	0.038	<0.0005	<0.01	<0.02	<0.002	<0.0002	<0.05	<0.001	<0.02
W-834-M1	4/16/1997	0.032	<0.0005	<0.01	<0.02	<0.002	0.00026	<0.05	<0.001	<0.02
W-834-M1	9/26/1997	0.03	<0.0005	<0.01	<0.02	<0.002	<0.0002	<0.05	<0.001	<0.02
W-834-M1	11/24/1997	0.037	<0.0005	0.026	<0.02	<0.002	<0.0002	<0.050	<0.001	<0.020
W-834-M2	11/24/1997	<0.025	<0.0005	0.010	<0.02	<0.002	<0.0002	<0.050	<0.001	<0.020
W-834-S1	12/14/1995	0.07	0.0011	0.007	<0.02	<0.002	<0.0002	<0.05	<0.0005	0.02
W-834-S1	6/25/1996	0.076	0.0009	<0.01	<0.02	<0.002	<0.0002	<0.05	<0.001	<0.02
W-834-S1	12/17/1996	0.063	<0.0005	<0.01	<0.01	<0.002	<0.0002	<0.05	<0.001	<0.02
W-834-S1	12/17/1996	0.063	<0.0005	<0.01	<0.01	<0.002	<0.0002	<0.05	<0.001	<0.02
W-834-S1	4/21/1997	0.074	0.0011	<0.01	<0.02	<0.002	<0.0002	<0.05	<0.001	<0.02
W-834-S1	12/9/1997	0.067	0.0008	<0.010	<0.02	<0.005	<0.0002	<0.050	<0.001	<0.010
W-834-S2	12/15/1995	0.08	<0.0005	0.003	–	<0.002	<0.0002	<0.05	<0.0005	<0.02
W-834-S2	6/26/1996	0.09	<0.0005	<0.01	<0.02	<0.002	<0.0002	<0.05	<0.001	<0.02
W-834-S2	4/21/1997	0.077	<0.0005	<0.01	<0.02	<0.002	<0.0002	<0.05	<0.001	<0.02
W-834-S2A	12/20/1995	0.08	<0.0005	<0.01	<0.02	<0.002	<0.0002	<0.025	<0.01	<0.02
W-834-S2A	5/31/1996	0.085	0.0032	<0.01	<0.02	0.01	<0.0002	<0.05	<0.001	<0.02
W-834-S2A	12/20/1996	0.1	<0.0005	<0.01	<0.02	<0.005	<0.0002	<0.05	<0.001	<0.01
W-834-S2A	12/20/1996	0.088	<0.0005	<0.01	<0.01	<0.002	<0.0002	<0.05	<0.001	<0.02
W-834-S2A	12/20/1996	0.1	<0.0005	<0.01	<0.02	<0.005	<0.0002	<0.05	<0.001	<0.01
W-834-S2A	12/20/1996	0.088	<0.0005	<0.01	<0.01	<0.002	<0.0002	<0.05	<0.001	<0.02
W-834-S2A	4/21/1997	0.069	<0.0005	<0.01	<0.02	<0.002	<0.0002	<0.05	<0.001	<0.02
W-834-S2A	12/11/1997	0.099	<0.0005	<0.010	<0.02	<0.005	<0.0002	<0.050	<0.001	<0.010
W-834-S3	12/21/1995	<0.025	<0.0005	<0.01	<0.02	<0.002	<0.0002	<0.025	<0.01	<0.02
W-834-S3	5/24/1996	<0.025	<0.0005	<0.01	<0.02	<0.002	<0.0002	<0.05	<0.001	<0.02
W-834-S3	12/19/1996	<0.025	<0.0005	<0.01	<0.01	<0.002	<0.0002	<0.05	<0.001	<0.02

Table 4. Building 834 monitor well historical results of metals and cyanide analyses.

Sample location	Sample date	Barium (mg/L)	Cadmium (mg/L)	Copper (mg/L)	Cyanide (mg/L)	Lead (mg/L)	Mercury (mg/L)	Molybdenum (mg/L)	Silver (mg/L)	Zinc (mg/L)
W-834-S3	12/19/1996	<0.025	<0.0005	<0.01	<0.01	<0.002	<0.0002	<0.05	<0.001	<0.02
W-834-S3	4/22/1997	<0.025	<0.0005	<0.01	<0.02	<0.002	<0.0002	<0.05	<0.001	<0.02
W-834-S3	4/22/1997	<0.025	<0.0005	0.012	<0.02	<0.002	<0.0002	<0.05	<0.001	<0.02
W-834-S3	12/11/1997	<0.025	<0.0005	<0.010	<0.02	<0.005	<0.0002	<0.050	<0.001	<0.010
W-834-S4	12/8/1995	<0.02	<0.001	<0.05	<0.02	<0.01	<0.0002	<0.05	<0.01	<0.05
W-834-S4	6/24/1996	<0.025	0.0005	<0.01	<0.02	<0.002	<0.0002	<0.05	<0.001	<0.02
W-834-S4	12/17/1996	<0.025	<0.0005	<0.01	<0.01	0.0026	<0.0002	<0.05	<0.001	<0.02
W-834-S4	12/17/1996	<0.025	<0.0005	<0.01	<0.01	0.0026	<0.0002	<0.05	<0.001	<0.02
W-834-S4	4/15/1997	<0.025	<0.0005	<0.01	<0.02	<0.002	0.00025	<0.05	<0.001	<0.02
W-834-S4	12/15/1997	<0.100	<0.001	<0.010	<0.02	<0.005	<0.0002	<0.050	<0.002	<0.010
W-834-S6	6/25/1996	0.047	<0.0005	<0.01	<0.02	<0.002	<0.0002	<0.05	<0.001	<0.02
W-834-S6	4/16/1997	0.03	<0.0005	<0.01	<0.02	<0.002	<0.0002	<0.05	<0.001	<0.02
W-834-S8	12/14/1995	0.07	<0.0005	0.004	<0.02	<0.002	<0.0002	<0.05	<0.0005	<0.02
W-834-S8	5/24/1996	0.088	0.0025	<0.01	<0.02	<0.002	<0.0002	<0.05	<0.001	0.031
W-834-S8	12/19/1996	<0.025	<0.0005	<0.01	<0.01	<0.002	<0.0002	<0.05	<0.001	<0.02
W-834-S8	12/19/1996	<0.025	<0.0005	<0.01	<0.01	<0.002	<0.0002	<0.05	<0.001	<0.02
W-834-S8	4/21/1997	0.079	<0.0005	<0.01	<0.02	<0.002	<0.0002	<0.05	<0.001	<0.02
W-834-S8	4/21/1997	0.078	<0.0005	<0.01	<0.02	<0.005	<0.0002	<0.05	<0.001	<0.01
W-834-S8	12/11/1997	0.084	<0.0005	<0.010	<0.02	<0.005	<0.0002	<0.050	<0.001	<0.010
W-834-S9	12/14/1995	<0.02	<0.0005	0.002	<0.02	<0.002	<0.0002	<0.05	<0.0005	<0.02
W-834-S9	5/23/1996	0.069	0.0049	<0.01	<0.02	0.0056	<0.0002	<0.05	<0.001	<0.02
W-834-S9	12/20/1996	<0.025	<0.0005	<0.01	<0.01	<0.002	<0.0002	<0.05	<0.001	<0.02
W-834-S9	12/20/1996	<0.025	<0.0005	<0.01	<0.01	<0.002	<0.0002	<0.05	<0.001	<0.02
W-834-S9	4/17/1997	<0.025	<0.0005	<0.01	<0.02	<0.002	<0.0002	<0.05	<0.001	<0.02
W-834-S9	12/15/1997	<0.100	<0.001	<0.010	<0.02	0.019	<0.0002	<0.050	<0.002	<0.010
W-834-T1	12/8/1995	0.02	<0.001	<0.05	<0.02	<0.01	<0.0002	<0.05	<0.01	<0.05
W-834-T1	2/6/1996	<0.025	<0.0005	<0.01	<0.02	<0.002	<0.0002	–	<0.01	<0.02
W-834-T1	6/19/1996	<0.025	<0.0005	<0.01	<0.02	<0.002	<0.0002	<0.05	<0.001	<0.02
W-834-T1	9/26/1996	<0.025	<0.0005	<0.01	<0.02	<0.002	<0.0002	<0.05	<0.001	<0.02
W-834-T1	12/20/1996	0.026	<0.0005	<0.01	<0.01	<0.002	<0.0002	<0.05	<0.001	<0.02
W-834-T1	12/20/1996	0.026	<0.0005	<0.01	<0.01	<0.002	<0.0002	<0.05	<0.001	<0.02
W-834-T1	2/27/1997	0.026	<0.0005	<0.01	<0.02	<0.002	<0.0002	<0.05	<0.001	<0.02
W-834-T1	4/16/1997	0.026	<0.0005	<0.01	<0.02	<0.002	<0.0002	<0.05	<0.001	<0.02
W-834-T1	8/27/1997	0.027	<0.0005	<0.01	<0.02	<0.002	<0.0002	<0.05	<0.001	<0.02
W-834-T1	11/24/1997	0.029	<0.0005	<0.010	<0.02	<0.002	<0.0002	<0.050	<0.001	<0.020
W-834-T2	5/21/1996	0.058	0.0009	<0.01	<0.02	0.0039	<0.0002	<0.05	<0.001	<0.02
W-834-T2	4/22/1997	0.056	<0.0005	<0.01	<0.02	<0.002	<0.0002	<0.05	<0.001	<0.02

Table 4. Building 834 monitor well historical results of metals and cyanide analyses.

Sample location	Sample date	Barium (mg/L)	Cadmium (mg/L)	Copper (mg/L)	Cyanide (mg/L)	Lead (mg/L)	Mercury (mg/L)	Molybdenum (mg/L)	Silver (mg/L)	Zinc (mg/L)
W-834-T2	4/22/1997	0.057	<0.0005	<0.01	<0.02	<0.002	<0.0002	<0.05	<0.001	<0.02
W-834-T2A	6/25/1996	0.041	<0.0005	<0.01	<0.02	<0.002	<0.0002	<0.05	<0.001	<0.02
W-834-T2A	4/21/1997	0.036	<0.0005	<0.01	<0.02	<0.002	<0.0002	<0.05	<0.001	<0.02
W-834-T2B	6/25/1996	0.11	0.0023	<0.01	<0.02	<0.002	<0.0002	<0.05	<0.001	<0.02
W-834-T2B	4/18/1997	0.1	<0.0005	<0.01	<0.02	<0.002	<0.0002	<0.05	<0.001	<0.02
W-834-T2C	6/25/1996	0.089	0.0031	<0.01	<0.02	<0.002	<0.0002	<0.05	<0.001	<0.02
W-834-T2C	4/17/1997	0.079	0.00074	<0.01	<0.02	<0.002	0.00041	<0.05	<0.001	<0.02
W-834-T2D	12/20/1995	0.03	<0.0005	<0.002	<0.02	<0.002	<0.0002	<0.05	<0.0005	<0.02
W-834-T2D	6/6/1996	0.037	0.00059	<0.01	<0.02	0.0046	<0.0002	<0.05	<0.001	<0.02
W-834-T2D	12/19/1996	<0.025	<0.0005	<0.01	<0.01	<0.002	<0.0002	<0.05	<0.001	<0.02
W-834-T2D	12/19/1996	<0.025	<0.0005	<0.01	<0.01	<0.002	<0.0002	<0.05	<0.001	<0.02
W-834-T2D	4/22/1997	0.037	<0.0005	<0.01	<0.02	<0.002	<0.0002	<0.05	<0.001	0.079
W-834-T2D	12/11/1997	0.038	<0.0005	<0.010	<0.02	<0.005	<0.0002	<0.050	<0.001	<0.010
W-834-T3	12/7/1995	0.02	<0.001	<0.05	<0.02	<0.01	<0.0002	<0.05	<0.01	<0.05
W-834-T3	2/7/1996	0.027	<0.0005	<0.01	<0.02	<0.002	<0.0002	<0.025	<0.01	<0.02
W-834-T3	6/19/1996	0.03	<0.0005	<0.01	<0.02	<0.002	<0.0002	<0.05	<0.001	<0.02
W-834-T3	9/24/1996	<0.025	<0.0005	<0.01	<0.02	<0.002	<0.0002	<0.05	<0.001	<0.02
W-834-T3	12/20/1996	0.032	<0.0005	<0.01	<0.01	<0.002	<0.0002	<0.05	<0.001	<0.02
W-834-T3	12/20/1996	0.032	<0.0005	<0.01	<0.01	<0.002	<0.0002	<0.05	<0.001	<0.02
W-834-T3	2/27/1997	0.046	<0.0005	0.014	<0.02	<0.002	<0.0002	<0.05	<0.001	0.027
W-834-T3	4/16/1997	0.025	<0.0005	0.014	<0.02	<0.002	<0.0002	<0.05	<0.001	0.02
W-834-T3	8/27/1997	<0.025	<0.0005	0.14	<0.02	<0.002	<0.0002	<0.05	<0.001	0.057
W-834-T3	11/24/1997	0.026	<0.0005	0.200	<0.02	<0.002	<0.0002	<0.050	<0.001	0.046
W-834-T4	5/21/1996	0.21	0.0085	<0.01	<0.02	0.012	<0.0002	<0.05	<0.001	<0.02
W-834-T4	4/18/1997	0.24	<0.0005	<0.01	<0.02	<0.002	<0.0002	<0.05	<0.001	<0.02
W-834-T4A	5/22/1996	0.25	0.011	<0.01	<0.02	0.013	<0.0002	<0.05	<0.001	<0.02
W-834-T4A	4/17/1997	0.31	0.00056	<0.01	<0.02	<0.002	0.00027	<0.05	<0.001	<0.02
W-834-T4B	5/22/1996	<0.025	0.00081	<0.01	<0.02	0.004	<0.0002	<0.05	<0.001	<0.02
W-834-T4B	4/17/1997	0.077	<0.0005	<0.01	<0.02	<0.002	<0.0002	<0.05	<0.001	<0.02
W-834-T4C	5/20/1996	0.16	0.004	<0.01	<0.02	0.0087	<0.0002	<0.05	<0.001	<0.02
W-834-T4C	4/18/1997	0.16	<0.0005	0.013	<0.02	<0.002	<0.0002	<0.05	<0.001	<0.02
W-834-T5	12/7/1995	0.04	<0.001	<0.05	<0.02	<0.01	<0.0002	<0.05	<0.01	<0.05
W-834-T5	6/25/1996	0.06	0.0065	<0.01	<0.02	<0.002	<0.0002	<0.05	<0.001	<0.02
W-834-T5	12/17/1996	0.055	<0.0005	<0.01	<0.01	<0.002	<0.0002	<0.05	<0.001	<0.02
W-834-T5	12/17/1996	0.055	<0.0005	<0.01	<0.01	<0.002	<0.0002	<0.05	<0.001	<0.02
W-834-T5	4/15/1997	0.053	<0.0005	<0.01	<0.02	<0.002	0.0003	<0.05	<0.001	<0.02
W-834-T5	11/24/1997	0.055	<0.0005	<0.010	<0.02	<0.002	<0.0002	<0.050	<0.001	<0.020

Table 4. Building 834 monitor well historical results of metals and cyanide analyses.

Sample location	Sample date	Barium (mg/L)	Cadmium (mg/L)	Copper (mg/L)	Cyanide (mg/L)	Lead (mg/L)	Mercury (mg/L)	Molybdenum (mg/L)	Silver (mg/L)	Zinc (mg/L)
W-834-T7A	12/13/1996	0.038	<0.0005	<0.01	<0.01	0.0025	<0.0002	<0.05	<0.001	<0.02
W-834-T7A	12/13/1996	0.038	<0.0005	<0.01	<0.01	0.0025	<0.0002	<0.05	<0.001	<0.02
W-834-T7A	4/15/1997	0.038	<0.0005	<0.01	<0.02	<0.002	0.00025	<0.05	<0.001	<0.02
W-834-T7A	11/24/1997	0.043	<0.0005	<0.010	<0.02	<0.002	<0.0002	<0.050	<0.001	<0.020
	Average Value:	0.061	0.0032	0.058	<0.015	0.0065	0.0003	0.0670	0.0215	0.0997
	Standard Dev.:	0.052	0.0034	0.116	0.000	0.0045	0.0001	0.0137	0.0049	0.1812
	Max. Value:	0.500	0.013	0.740	0.000	0.015	0.0005	0.079	0.025	1.2
	Background Conc. or Range:	0.004-0.1	<0.0001-0.0001	NA	NA	<0.001-0.002	<0.0001-<0.001	0.049	0.004	<0.005-0.12
	CA MCL (mg/L)	1.0	0.005	1.0	0.2	0.05	0.002	NA	0.1	5.0

Notes:

Averages do not take in consideration the non-detect values.

Shaded concentration values indicates wells have concentrations over Site 300 background levels.

Shaded Well ID indicates wells which have concentrations at or exceeding MCLs for certain compounds.

[a] Value is suspect due to a non-detect duplicate result.

NA = Not available.

Dev. = Deviation.

Max. = Maximum.

Conc. = Concentration.

Table 5. Recommended metals sampling list for the B834 monitor wells.

Sample ID	Barium	Cadmium	Copper	Lead	Mercury	Molybdenum	Silver	Zinc
W-834-B2			X					X
W-834-B3			X					X
W-834-C2								
W-834-D3								
W-834-D4	X							
W-834-D5								X
W-834-D6								
W-834-D7								
W-834-D8	X		X					
W-834-D10[a]	X	X	X	X	X	X	X	X
W-834-D11	X							
W-834-D12	X							
W-834-D13								
W-834-D14								
W-834-G3[a]	X	X	X	X	X	X	X	X
W-834-H2								
W-834-J1		X						X
W-834-J2								X
W-834-K1		X						
W-834-M1		X		X			X	
W-834-M2[a]	X	X	X	X	X	X	X	X
W-834-S1		X						
W-834-S2								
W-834-S2A		X		X				
W-834-S3								
W-834-S4		X						
W-834-S5[a]	X	X	X	X	X	X	X	X
W-834-S6								
W-834-S7[a]	X	X	X	X	X	X	X	X
W-834-S8		X						
W-834-S9		X		X				
W-834-T1								
W-834-T2		X						
W-834-T2A								
W-834-T2B		X						
W-834-T2C		X						
W-834-T2D								
W-834-T3								
W-834-T4	X	X		X				
W-834-T4A	X	X		X				
W-834-T4B		X		X				
W-834-T4C	X	X		X				
W-834-T5		X						
W-834-T7A								
W-834-T8[a]	X	X	X	X	X	X	X	X
W-834-T9[a]	X	X	X	X	X	X	X	X

Notes:

X = Analysis recommended.

Table 5. Recommended metals sampling list for the B834 monitor wells.

Sample ID	Barium	Cadmium	Copper	Lead	Mercury	Molybdenum	Silver	Zinc

[a] Monitor well usually dry or low producer; insufficient metals data to eliminate analyses.

Table 6. Building 834 monitor well historical results of general minerals, pH, and specific conductivity.

Sample location	Sample date	Total Alk. (mg/L)	Bicarbonate Alk. (mg/L)	Calcium (mg/L)	Carbonate Alk. (mg/L)	Chloride (mg/L)	Total Hardness (mg/L)	Iron (mg/L)	Magnesium (mg/L)	Manganese (mg/L)	Nitrate (mg/L)	pH (Units)	Potassium (mg/L)	Sodium (mg/L)	Specific Cond. (μmhos/cm)
W-834-B2	3/14/1997	240	240	20	<1	8.5	110	<0.1	15	<0.03	41	7.2	5.2	100	620
W-834-B2	2/9/1996	240	240	17	<1.0	5.4	96	<0.1	13	<0.03	49	8.2	5.4	100	540
W-834-B3	12/20/1995	440	540	34	<1	22	110	<0.05	7	<0.03	37	7.6	<1	200	830
W-834-B3	2/9/1996	280	280	27	<1.0	10	150	<0.1	20	<0.03	46	7.8	4.9	93	550
W-834-B3	5/30/1996	310	310	30	<1	12	120	<0.1	21	<0.03	46	7.9	5.3	95	620
W-834-B3	12/13/1996	350	350	34	<1	13	220	<0.1	<0.5	27	33	7.3	6	110	760
W-834-B3	3/13/1997	380	380	39	<1	15	210	<0.1	28	0.55	24	8	5.7	120	790
W-834-B3	4/24/1997	380	380	35	<1	11	190	<0.1	25	0.28	26	7.8	5.6	110	770
W-834-C2	2/9/1996	210	210	22	<1.0	17	120	<0.1	16	<0.03	44	8	4.3	87	510
W-834-C2	3/13/1997	190	190	22	<1	15	120	<0.1	16	<0.03	51	8.2	3.7	82	560
W-834-D3	12/21/1995	380	460	32	<1	16	190	<0.05	26	0.04	29	7.8	9	110	740
W-834-D3	2/23/1996	420	420	39	<1.0	19	230	<0.1	32	0.045	13	7.5	9.1	130	740
W-834-D3	9/25/1996	347	347	27	<1	8.3	162	<0.05	23	0.125	18.6	7.87	7.3	96	728
W-834-D3	9/25/1996	310	310	31	<1	10	170	<0.1	24	0.12	19	7.3	7.8	95	650
W-834-D3	12/16/1996	330	330	27	<1	12	180	<0.1	23	0.67	20	7.3	7.3	93	730
W-834-D3	3/14/1997	420	420	40	<1	23	230	<0.1	32	0.68	<0.5	7.6	9.2	120	850
W-834-D3	4/23/1997	410	410	55	<1	68	300	0.86	39	2.3	<5	7.4	10	120	1000
W-834-D4	12/21/1995	480	580	40	<1	19	230	<0.05	32	0.47	8.2	7.8	11	130	890
W-834-D4	3/6/1996	390	390	42	<1.0	38	250	<0.1	35	0.29	36	7.3	11	140	950
W-834-D4	6/26/1996	270	270	35	<1	23	240	<0.1	37	0.22	11	7.2	9.6	140	900
W-834-D4	9/25/1996	500	500	45	<1	<50	260	0.16	35	0.63	2.6	7	9.7	130	850
W-834-D4	12/16/1996	470	470	40	<1	19	270	<0.1	33	0.79	<0.5	7.1	9.3	120	910
W-834-D4	3/14/1997	490	490	44	<1	19	250	<0.1	35	0.42	8.7	7.5	10	140	970
W-834-D4	4/23/1997	500	500	59	<1	130	350	2.4	48	2.8	<5	7.7	11	150	1200
W-834-D5	12/21/1995	180	210	22	<1	16	110	<0.05	12	0.05	0.6	7.6	<1	65	440
W-834-D5	2/23/1996	280	280	32	<1.0	16	160	<0.1	19	<0.03	20	7.4	7.4	99	610
W-834-D7	12/20/1995	340	410	35	<1	100	190	<0.05	25	<0.03	80	7.8	11	210	1300
W-834-D7	2/28/1996	430	430	30	<1.0	82	160	0.15	20	<0.03	52	7.6	9.2	210	1100
W-834-D7	6/7/1996	440	440	35	<1	80	170	<0.1	20	<0.03	65	7.5	9.6	200	1100
W-834-D7	12/13/1996	340	340	25	<1	57	140	<0.1	17	<0.03	62	7.6	8.8	180	1000
W-834-D7	3/14/1997	410	410	38	<1	65	200	<0.1	26	<0.03	110	7.7	11	240	1300
W-834-D7	3/14/1997	430	430	38	<1	65	200	<0.1	26	<0.03	110	7.8	11	240	1300
W-834-D7	4/23/1997	400	400	31	<1	72	170	<0.1	22	<0.03	74	8	10	210	1200
W-834-D8	12/21/1995	400	490	19	<1	12	120	<0.05	18	0.03	<0.4	7.6	<1	140	730
W-834-D8	3/6/1996	380	380	20	<1.0	18	140	<0.1	18	<0.03	43	7.5	6.9	140	790
W-834-D8	3/6/1996	410	NR	20	NR	15	140	<0.03	22	<0.03	36	7.6	7	150	850
W-834-D8	6/7/1996	356	339	16.5	17	7.5	102	<0.1	14.8	0.041	9.3	8.8	6.2	134	732
W-834-D8	6/7/1996	350	350	19	<1	15	110	<0.1	15	<0.03	7.9	7.5	6.1	130	670
W-834-D8	12/18/1996	420	420	25	<1	9	190	<0.1	24	<0.03	18	7.1	6	140	850
W-834-D8	12/18/1996	420	420	25	<1	9	200	<0.1	24	<0.03	17	7.1	6.1	140	860
W-834-D8	3/14/1997	360	360	27	<1	8.5	170	<0.1	25	<0.03	1.7	7.6	6.5	150	750
W-834-D8	4/23/1997	350	350	18	<1	14	110	<0.1	16	<0.03	14	7.9	5.9	140	750
W-834-D11	2/28/1996	330	330	20	<1.0	54	110	<0.1	14	<0.03	31	7.7	8.4	160	770
W-834-D11	3/14/1997	300	300	23	<1	87	130	<0.1	17	<0.03	51	8	8.9	180	1000
W-834-D11	4/25/1997	310	310	26	<1	100	140	<0.1	19	<0.03	53	7.9	9.4	180	1000
W-834-D11	4/25/1997	307	307	26	<1	101	145	<0.05	19.4	<0.01	57.6	7.59	10.2	186	1100
W-834-D12	12/20/1995	320	390	26	<1	39	150	<0.05	20	<0.03	76	8.1	12	160	930
W-834-D12	2/28/1996	310	310	39	<1.0	160	200	0.18	26	<0.03	87	7.6	11	220	1200

Table 6. Building 834 monitor well historical results of general minerals, pH, and specific conductivity.

Sample location	Sample date	Total Alk. (mg/L)	Bicarbonate Alk. (mg/L)	Calcium (mg/L)	Carbonate Alk. (mg/L)	Chloride (mg/L)	Total Hardness (mg/L)	Iron (mg/L)	Magnesium (mg/L)	Manganese (mg/L)	Nitrate (mg/L)	pH (Units)	Potassium (mg/L)	Sodium (mg/L)	Specific Cond. (μmhos/cm)
W-834-D12	6/25/1996	330	330	47	<1	230	240	<0.1	29	<0.03	100	7.6	11	280	1500
W-834-D12	12/13/1996	300	300	27	<1	21	160	<0.1	19	<0.03	53	7.5	9.2	150	1100
W-834-D12	3/14/1997	280	280	70	<1	440	370	<0.1	47	<0.03	110	7.4	13	320	2800
W-834-D12	4/24/1997	310	310	64	<1	350	340	<0.1	44	<0.03	81	7.8	13	300	2000
W-834-D13	12/21/1995	350	430	37	<1	40	220	<0.05	30	<0.03	50	7.9	11	150	930
W-834-D13	2/23/1996	340	340	26	<1.0	13	150	<0.1	20	<0.03	27	7.9	8.1	120	730
W-834-D13	6/26/1996	320	320	38	<1	37	210	<0.1	27	<0.03	57	7.6	8.8	130	820
W-834-D13	9/25/1996	400	400	38	<1	21	210	<0.1	28	<0.03	28	7.4	9.2	120	800
W-834-D13	12/16/1996	380	380	33	<1	22	220	<0.1	26	<0.03	35	7.5	8.7	120	910
W-834-D13	3/14/1997	300	300	26	<1	23	150	<0.1	21	<0.03	45	7.7	8	120	910
W-834-D13	4/23/1997	290	290	29	<1	34	170	<0.1	24	<0.03	50	8.4	8.5	130	840
W-834-D14	12/21/1995	320	390	27	<1	32	150	<0.05	21	<0.03	73	8	10	150	870
W-834-D14	2/23/1996	290	290	25	<1.0	37	140	<0.1	18	<0.03	48	7.8	9.1	140	800
W-834-D14	6/26/1996	260	260	31	<1	39	160	<0.1	21	<0.03	120	7.6	9.4	150	810
W-834-D14	9/25/1996	260	260	33	<1	41	180	<0.1	23	<0.03	120	7.5	9.9	130	860
W-834-D14	12/13/1996	309	271	26	38.4	26	146	<0.05	19.8	<0.01	75.3	8.36	9.3	140	873
W-834-D14	12/13/1996	270	270	28	<1	30	170	<0.1	21	<0.03	<25	7.6	9.5	130	890
W-834-D14	3/14/1997	270	270	28	<1	30	150	<0.1	20	<0.03	77	7.8	9.6	140	870
W-834-D14	4/23/1997	290	290	25	<1	24	140	<0.1	19	<0.03	63	8.2	9.2	140	840
W-834-H2	5/30/1996	220	220	11	<1	26	100	<0.1	9.8	<0.03	49	8.2	5	120	580
W-834-H2	12/13/1996	220	220	14	<1	20	99	0.17	12	<0.03	49	7.8	5.3	130	680
W-834-H2	3/13/1997	210	210	11	<1	20	73	<0.1	11	<0.03	53	8.3	5.1	130	650
W-834-H2	4/24/1997	210	210	11	<1	18	69	<0.1	10	<0.03	50	8.3	4.9	120	610
W-834-J1	12/19/1995	260	320	19	<1	43	140	1.5	22	0.04	58	7.8	7	120	750
W-834-J1	2/9/1996	250	250	20	<1.0	45	130	<0.1	21	<0.03	53	7.9	6.2	130	730
W-834-J1	5/29/1996	250	250	18.8	<1	40	133	<0.1	21	<0.03	50.5	8.1	5.7	116	786
W-834-J1	5/29/1996	260	260	20	<1	63	140	<0.1	21	<0.03	53	8.1	6	120	690
W-834-J1	12/17/1996	240	240	16	<1	37	150	<0.1	18	<0.03	44	7.7	4.8	100	730
W-834-J1	3/13/1997	246	246	17	<1	24.8	120	<0.05	18.9	<0.01	47.4	8.19	5.6	108	708
W-834-J1	3/13/1997	240	240	18	<1	30	130	<0.1	20	<0.03	46	8.2	5.4	120	720
W-834-J1	4/24/1997	253	226	16.3	27	27	119	<0.05	18.9	<0.01	48.3	8.33	5.3	115	727
W-834-J1	4/24/1997	250	250	18	<1	29	130	<0.1	20	<0.03	43	8.2	5.3	120	700
W-834-J2	12/19/1995	270	330	21	<1	42	140	0.15	22	<0.03	64	8.2	<1	120	790
W-834-J2	2/9/1996	250	250	21	<1.0	32	130	<0.1	20	<0.03	53	7.9	6.6	120	710
W-834-J2	6/5/1996	220	220	22	<1	67	130	<0.1	19	<0.03	62	7.7	5.9	110	690
W-834-J2	12/17/1996	250	250	19	<1	37	160	<0.1	20	<0.03	49	7.9	5.7	110	750
W-834-J2	3/13/1997	210	210	20	<1	45	<1	<0.1	20	<0.03	62	8.3	6	120	740
W-834-J2	4/23/1997	220	210	18	11	38	120	<0.1	19	<0.03	57	8.6	5.7	110	680
W-834-K1	12/14/1995	310	380	33	<1	720	200	1.2	28	0.05	200	8	10	580	3100
W-834-K1	2/8/1996	320	320	31	<1.0	690	180	<0.1	26	<0.03	180	7.8	10	610	2900
W-834-K1	5/22/1996	300	300	33	<1	700	200	<0.1	28	<0.03	240	7.6	10	620	3000
W-834-K1	9/25/1996	310	310	35	<1	540	200	<0.1	28	<0.03	180	7.7	9.3	580	2700
W-834-K1	12/23/1996	310	310	28	<1	470	200	<0.1	24	<0.03	170	7.9	8.6	530	3000
W-834-K1	3/13/1997	320	320	32	<2.6	540	191	<0.05	27	<0.01	159	8.15	9.2	564	3000
W-834-K1	3/13/1997	300	300	30	<1	590	180	<0.1	26	<0.03	200	8.2	9.4	600	3000
W-834-K1	4/18/1997	300	300	33	<1	610	190	<0.1	27	<0.03	190	7.6	9.5	590	3000
W-834-K1	4/18/1997	290	290	32	<1	550	190	<0.1	27	<0.03	190	7.9	9.5	580	3100
W-834-M1	12/7/1995	76	76	270	<1	2300	1600	<0.1	240	<0.03	260	7.6	22	900	6300

Table 6. Building 834 monitor well historical results of general minerals, pH, and specific conductivity.

Sample location	Sample date	Total Alk. (mg/L)	Bicarbonate Alk. (mg/L)	Calcium (mg/L)	Carbonate Alk. (mg/L)	Chloride (mg/L)	Total Hardness (mg/L)	Iron (mg/L)	Magnesium (mg/L)	Manganese (mg/L)	Nitrate (mg/L)	pH (Units)	Potassium (mg/L)	Sodium (mg/L)	Specific Cond. (μmhos/cm)
W-834-M1	2/6/1996	130	130	250	<1.0	2100	1600	<0.1	230	<0.03	240	7.6	23	900	6300
W-834-M1	6/6/1996	73	73	340	<1	2200	1900	<0.1	250	<0.03	290	7.5	23	930	6200
W-834-M1	9/26/1996	76	76	380	<1	1800	2200	<0.1	300	<0.03	290	7.5	23	990	6500
W-834-M1	12/17/1996	74	74	290	<1	1900	2300	<0.1	270	<0.03	280	7.5	22	980	7800
W-834-M1	2/27/1997	80	80	340	<1	2200	2000	<1	290	<0.3	300	8	22	1000	7600
W-834-M1	4/16/1997	72	72	310	<1	2000	1900	<0.1	280	<0.03	310	7.8	22	620	8400
W-834-S1	12/14/1995	610	740	41	<1	77	260	<0.05	38	<0.03	150	7.7	12	270	1600
W-834-S1	6/25/1996	240	240	16	<1	110	200	<0.1	40	<0.03	140	7.6	13	310	1300
W-834-S1	12/17/1996	570	570	35	<1	53	270	<0.1	33	<0.03	80	7.5	11	240	1400
W-834-S1	4/21/1997	600	600	38	<1	52	240	<0.1	35	<0.03	90	7.7	12	270	1500
W-834-S2	4/22/1997	390	390	36	<1	170	230	<0.1	35	<0.03	90	8.2	13	260	1500
W-834-S2A	12/20/1995	290	290	43	<1	590	250	<0.1	35	<0.03	130	7.6	14	430	2300
W-834-S2A	5/31/1996	280	280	48	<1	490	260	<0.1	35	<0.03	130	7.7	13	420	2000
W-834-S2A	12/20/1996	270	270	36	<1	370	210	<0.1	30	<0.03	120	7.6	11	360	2200
W-834-S2A	4/21/1997	280	280	40	<1	410	240	<0.1	34	<0.03	120	8	13	420	2400
W-834-S3	12/21/1995	310	310	8.9	<1	110	47	<0.1	6.1	<0.03	55	8	6.3	200	790
W-834-S3	5/24/1996	260	260	9.3	<1	120	48	<0.1	6.1	<0.03	59	7.9	6.6	200	850
W-834-S3	12/19/1996	270	270	9.4	<1	73	50	<0.1	6.3	<0.03	100	7.9	6.2	180	960
W-834-S3	4/22/1997	270	270	8.9	<1	80	48	<0.1	6.3	<0.03	45	8.3	6.3	200	870
W-834-S3	4/22/1997	260	260	8.9	<1	80	48	<0.1	6.3	<0.03	47	8.3	6.3	200	860
W-834-S4	12/8/1995	140	140	28	<1	280	150	<0.1	20	<0.03	150	7.7	9.3	170	930
W-834-S4	6/24/1996	270	270	30	<1	220	160	<0.1	20	<0.03	_	7.9	8.4	170	1100
W-834-S4	12/17/1996	120	120	28	<1	180	170	<0.1	21	<0.03	140	7.9	7.9	160	1100
W-834-S4	4/15/1997	130	130	29	<1	190	160	<0.1	21	<0.03	130	8	9.1	180	1200
W-834-S6	6/25/1996	180	180	62	<1	190	300	<0.1	36	<0.03	120	7.6	8.5	78	840
W-834-S6	4/17/1997	110	110	61	<1	180	310	<0.1	39	<0.03	480	8	9.3	81	1100
W-834-S8	12/14/1995	310	370	31	<1	350	180	<0.05	25	<0.03	120	8.2	10	390	2200
W-834-S8	5/24/1996	350	350	40	<1	370	220	<0.1	30	<0.03	130	7.7	11	470	2300
W-834-S8	12/19/1996	290	290	30	<1	300	170	<0.1	23	<0.03	120	7.8	9.8	360	2100
W-834-S8	4/21/1997	316	296	36	20	316	205	<0.05	28	<0.01	115	8.18	10.5	432	2280
W-834-S8	4/21/1997	290	290	33	<1	260	190	<0.1	27	<0.03	110	8.1	11	410	2200
W-834-S9	12/14/1995	91	<1	15	24	180	64	1.5	6	0.2	84	9.1	10	170	940
W-834-S9	5/23/1996	94	94	8.9	<1	180	41	<0.1	4.6	<0.03	98	8.5	9.8	200	910
W-834-S9	12/20/1996	59	39	6.7	19	170	28	<0.1	2.9	<0.03	80	9	9.1	170	990
W-834-S9	4/17/1997	79	79	6.5	<1	180	25	0.12	2.2	<0.03	81	9.2	10	190	1000
W-834-T1	12/8/1995	150	150	39	<1	82	160	<0.1	16	0.13	<5	7	6	77	510
W-834-T1	2/6/1996	140	140	43	<1.0	46	180	0.16	18	0.15	<0.50	7.2	6.5	80	580
W-834-T1	6/19/1996	140	140	39	<1	78	160	0.11	15	0.14	<0.5	7.1	5.4	69	540
W-834-T1	9/26/1996	140	140	41	<1	48	170	0.11	16	0.14	<0.5	7.2	5.8	72	530
W-834-T1	12/20/1996	130	130	35	<1	47	150	<0.1	15	0.14	<0.5	7	5.6	71	640
W-834-T1	2/27/1997	140	140	38	<1	47	160	<0.1	15	0.15	<0.5	8.1	5.9	75	650
W-834-T1	4/16/1997	130	130	39	<1	51	160	0.16	16	0.12	<0.5	7.8	6	80	670
W-834-T2	5/21/1996	240	240	25	<1	240	120	<0.1	21	<0.03	73	8	9	250	1200
W-834-T2	4/22/1997	180	180	18	<1	250	120	<0.1	17	<0.03	83	8.5	8.7	250	1300
W-834-T2	4/22/1997	180	180	19	5.2	240	120	<0.1	18	<0.03	85	8.5	8.9	250	1400
W-834-T2A	6/25/1996	300	300	17	<1	160	100	<0.1	14	<0.03	62	8	7.9	260	1100
W-834-T2A	4/21/1997	290	290	14	<1	130	89	<0.1	13	<0.03	59	8.2	7.8	240	1200
W-834-T2B	6/25/1996	160	160	70	<1	820	420	<0.1	59	<0.03	160	7.8	9.3	530	2500

Table 6. Building 834 monitor well historical results of general minerals, pH, and specific conductivity.

Sample location	Sample date	Total Alk. (mg/L)	Bicarbonate Alk. (mg/L)	Calcium (mg/L)	Carbonate Alk. (mg/L)	Chloride (mg/L)	Total Hardness (mg/L)	Iron (mg/L)	Magnesium (mg/L)	Manganese (mg/L)	Nitrate (mg/L)	pH (Units)	Potassium (mg/L)	Sodium (mg/L)	Specific Cond. (μmhos/cm)
W-834-T2B	4/18/1997	170	170	53	<1	690	330	<0.1	49	<0.03	120	7.7	8.8	440	2800
W-834-T2C	6/25/1996	160	160	59	<1	740	340	<0.1	45	<0.03	150	8	11	500	2300
W-834-T2C	4/17/1997	140	140	46	<1	710	280	<0.1	40	<0.03	120	8.3	9.5	440	2900
W-834-T2D	12/20/1995	210	260	22	<1	170	130	<0.05	19	<0.03	110	8.3	9	210	1200
W-834-T2D	6/6/1996	190	190	24	<1	180	130	<0.1	17	<0.03	110	7.9	7.7	190	1000
W-834-T2D	12/19/1996	190	190	20	<1	140	110	<0.1	16	<0.03	93	7.8	7.1	180	1100
W-834-T2D	4/22/1997	190	190	19	<1	150	110	0.12	16	<0.03	95	8.2	8.2	190	1000
W-834-T3	12/7/1995	160	160	44	<1	86	190	<0.1	20	0.059	<5	7.5	7.9	84	630
W-834-T3	2/7/1996	170	170	45	<1.0	48	200	<0.1	21	0.066	<0.50	7.4	7.9	85	710
W-834-T3	6/19/1996	160	160	46	<1	78	190	<0.1	19	0.058	<0.5	7.4	7.9	74	600
W-834-T3	9/24/1996	160	160	46	<1	46	200	<0.1	21	0.062	<0.5	7.3	6.2	72	610
W-834-T3	12/20/1996	150	150	46	<1	50	210	<0.1	22	<0.03	<0.5	7.3	6.4	74	990
W-834-T3	2/27/1997	130	130	110	<1	50	480	<0.1	46	0.35	<0.5	7.9	8.2	82	1200
W-834-T3	4/16/1997	99	99	87	<1	51	360	<0.1	35	0.29	<0.5	7.4	6.6	77	1000
W-834-T4	5/21/1996	190	190	100	<1	960	450	<0.1	76	<0.03	140	7.6	13	460	2700
W-834-T4	4/18/1997	170	170	98	<1	940	600	<0.1	86	<0.03	140	7.7	15	470	3400
W-834-T4A	5/22/1996	120	120	100	<1	1100	690	<0.1	110	<0.03	200	7.2	18	460	3000
W-834-T4A	4/17/1997	120	120	130	<1	1300	860	<0.1	130	<0.03	190	8	19	500	4500
W-834-T4B	5/23/1996	200	200	29	<1	260	190	<0.1	29	<0.03	180	7.6	15	250	1400
W-834-T4B	4/17/1997	190	190	29	<1	260	200	<0.1	30	<0.03	150	8.1	13	240	1500
W-834-T4C	5/20/1996	230	230	52	<1	540	300	<0.1	40	<0.03	85	7.7	11	330	2200
W-834-T4C	4/18/1997	210	210	62	<1	480	370	<0.1	52	<0.03	95	7.8	11	360	2500
W-834-T5	12/7/1995	150	150	23	<1	360	120	<0.1	15	<0.03	130	7.8	8.8	250	1300
W-834-T5	6/25/1996	150	150	26	<1	310	130	<0.1	16	<0.03	170	7.9	8.2	260	1200
W-834-T5	12/17/1996	150	150	22	<1	230	120	<0.1	15	<0.03	130	7.8	7.7	220	1400
W-834-T5	4/15/1997	160	160	22	<1	250	120	<0.1	15	<0.03	130	8.1	8.6	250	1400
W-834-T7A	12/13/1996	270	270	9.1	<1	110	41	<0.1	5	<0.03	71	8.2	6.2	210	1100
W-834-T7A	4/15/1997	270	250	9.4	16	120	46	<0.1	5.4	<0.03	72	8.5	6.4	240	1100
	Average Value:	267.18	273.22	44.19	20.20	251.05	258.05	0.57	34.86	1.10	93.11	7.81	9.23	237.08	1465.75
	Standard Dev.:	110.02	118.09	59.05	10.09	445.57	366.35	0.71	50.70	4.48	73.22	0.39	3.75	195.57	1379.07
	Background Conc. or range:	NA	100.0-310.0	3.0-133.0	<0.6-120.0	34.0-230.0	NA	<0.01-3.8	0.26-102.0	<0.01-0.20	<0.4-91.0	NA	2.7-67.0	34.0-480.0	NA

Notes:

Shaded values indicate wells have concentrations over Site 300 background levels.

Alk. = Alkalinity.

Cond. = Conductivity.

NR = No results obtained from analytical laboratory.

Dev. = Deviation.

Conc. = Concentration.

NA = Not available.

Table 7. Building 834 monitor well historical total dissolved solids (TDS) results.

Sample location	Laboratory ID	Sample date	TDS (mg/L)
W-834-B2	N17744C	2/09/96	370
W-834-B2	N68011D	3/14/97	410
W-834-B3	9104301-2	4/11/91	600
W-834-B3	N13022B	12/20/95	460
W-834-B3	53616001	12/20/95	480
W-834-B3	N17742C	2/09/96	390
W-834-B3	N30373B	5/30/96	430
W-834-B3	N56462A	12/13/96	480
W-834-B3	N67771D	3/13/97	470
W-834-B3	N73196A	4/24/97	510
W-834-C2	N17743C	2/09/96	370
W-834-C2	N67782D	3/13/97	370
W-834-D3	8901593-1	1/27/89	490
W-834-D3	N13156B	12/21/95	470
W-834-D3	53616106	12/21/95	480
W-834-D3	N19634D	2/23/96	530
W-834-D3	96033562	3/19/96	588
W-834-D3	960330402D	3/19/96	560
W-834-D3	N22532B	3/19/96	580
W-834-D3	96033582	3/20/96	602
W-834-D3	960330502A	3/20/96	570
W-834-D3	N22722A	3/20/96	580
W-834-D3	9611284001	9/25/96	475
W-834-D3	N46959D	9/25/96	490
W-834-D3	N56755E	12/16/96	450
W-834-D3	N68013D	3/14/97	560
W-834-D3	N730410D	4/23/97	700
W-834-D3	N95375C	9/25/97	770
W-834-D4	8911207-1	11/07/89	690
W-834-D4	N13154B	12/21/95	570
W-834-D4	53616104	12/21/95	600
W-834-D4	N20981C	3/06/96	630
W-834-D4	96033561	3/19/96	802
W-834-D4	960330401D	3/19/96	610
W-834-D4	N22531B	3/19/96	620
W-834-D4	96033583	3/20/96	624
W-834-D4	960330503A	3/20/96	620
W-834-D4	N22723A	3/20/96	620
W-834-D4	N34233E	6/26/96	640
W-834-D4	N46957D	9/25/96	650
W-834-D4	N56752E	12/16/96	570
W-834-D4	N68004D	3/14/97	610
W-834-D4	N73049E	4/23/97	810
W-834-D4	N95811C	9/26/97	1200
W-834-D4	N95812C	9/26/97	1600
W-834-D5	8911208-1	11/07/89	990
W-834-D5	N13155B	12/21/95	280
W-834-D5	53616105	12/21/95	270
W-834-D5	N19635D	2/23/96	400
W-834-D5	96033563	3/19/96	524
W-834-D5	960330403D	3/19/96	500
W-834-D5	N22533B	3/19/96	500
W-834-D5	96033581	3/20/96	542
W-834-D5	960330501A	3/20/96	500
W-834-D5	N22721A	3/20/96	500

Table 7. Building 834 monitor well historical total dissolved solids (TDS) results.

Sample location	Laboratory ID	Sample date	TDS (mg/L)
W-834-D6	8911246-1	11/08/89	380
W-834-D7	8810259-1	10/13/88	700
W-834-D7	N13023B	12/20/95	840
W-834-D7	53616002	12/20/95	830
W-834-D7	N20094D	2/28/96	700
W-834-D7	N31641C	6/07/96	720
W-834-D7	N56465C	12/13/96	650
W-834-D7	N68015D	3/14/97	850
W-834-D7	N68016D	3/14/97	850
W-834-D7	N73042D	4/23/97	740
W-834-D7	97103601G	9/25/97	745
W-834-D7	N95371C	9/25/97	720
W-834-D8	8810259-2	10/13/88	680
W-834-D8	N13157B	12/21/95	490
W-834-D8	53616107	12/21/95	490
W-834-D8	N20982C	3/06/96	560
W-834-D8	63121101	3/06/96	590
W-834-D8	9606584001	6/07/96	480
W-834-D8	N31644C	6/07/96	480
W-834-D8	N57122C	12/18/96	560
W-834-D8	N57123C	12/18/96	550
W-834-D8	N68006D	3/14/97	560
W-834-D8	N73041D	4/23/97	490
W-834-D8	N95376C	9/25/97	500
W-834-D10	N13021B	12/20/95	590
W-834-D10	N20091D	2/28/96	680
W-834-D11	N20092D	2/28/96	530
W-834-D11	N68001D	3/14/97	620
W-834-D11	97044151G	4/25/97	665
W-834-D11	N73363A	4/25/97	650
W-834-D12	8911245-1	11/08/89	1000
W-834-D12	9105762-6	5/31/91	1500
W-834-D12	N13024B	12/20/95	610
W-834-D12	53616003	12/20/95	640
W-834-D12	N20093D	2/28/96	830
W-834-D12	N34011B	6/25/96	1000
W-834-D12	N56464C	12/13/96	660
W-834-D12	N68002D	3/14/97	590
W-834-D12	N73192E	4/24/97	1100
W-834-D13	8911247-1	11/08/89	760
W-834-D13	N13153B	12/21/95	610
W-834-D13	53616103	12/21/95	630
W-834-D13	N19632D	2/23/96	460
W-834-D13	N342311E	6/26/96	570
W-834-D13	N46953D	9/25/96	630
W-834-D13	N56754E	12/16/96	550
W-834-D13	N68003D	3/14/97	490
W-834-D13	N73045D	4/23/97	540
W-834-D14	8911248-1	11/08/89	580
W-834-D14	N13152B	12/21/95	570
W-834-D14	53616102	12/21/95	600
W-834-D14	N19633D	2/23/96	510
W-834-D14	N342310E	6/26/96	600
W-834-D14	N46954D	9/25/96	670
W-834-D14	9614472001	12/13/96	600

Table 7. Building 834 monitor well historical total dissolved solids (TDS) results.

Sample location	Laboratory ID	Sample date	TDS (mg/L)
W-834-D14	N56466C	12/13/96	660
W-834-D14	N68012D	3/14/97	570
W-834-D14	N73048D	4/23/97	530
W-834-D14	N95372C	9/25/97	660
W-834-H2	9109209-1	9/10/91	560
W-834-H2	N20095C	2/28/96	390
W-834-H2	N30374B	5/30/96	390
W-834-H2	N56463A	12/13/96	440
W-834-H2	N67783D	3/13/97	400
W-834-H2	N73193E	4/24/97	400
W-834-J1	N12872D	12/19/95	510
W-834-J1	53602102	12/19/95	500
W-834-J1	N17746C	2/09/96	480
W-834-J1	9606202001	5/29/96	505
W-834-J1	N30367B	5/29/96	480
W-834-J1	N56911C	12/17/96	560
W-834-J1	9702754001	3/13/97	455
W-834-J1	N67772D	3/13/97	420
W-834-J1	97043672G	4/24/97	440
W-834-J1	N73194E	4/24/97	450
W-834-J1	N95814C	9/26/97	400
W-834-J2	8810297-1	10/14/88	440
W-834-J2	9105763-1	5/31/91	360
W-834-J2	N12873D	12/19/95	480
W-834-J2	53602103	12/19/95	520
W-834-J2	N17745C	2/09/96	460
W-834-J2	N31175C	6/05/96	460
W-834-J2	N56912C	12/17/96	460
W-834-J2	N67784D	3/13/97	410
W-834-J2	N73044D	4/23/97	430
W-834-J2	N95815C	9/26/97	500
W-834-K1	8810165-5	10/10/88	1600
W-834-K1	N12375B	12/14/95	1900
W-834-K1	53596704	12/14/95	1900
W-834-K1	N17602C	2/08/96	1800
W-834-K1	N29537B	5/22/96	1900
W-834-K1	N46956D	9/25/96	1800
W-834-K1	N57711E	12/23/96	1800
W-834-K1	9702754002	3/13/97	1800
W-834-K1	N67773D	3/13/97	1700
W-834-K1	N72631D	4/18/97	1900
W-834-K1	N72636D	4/18/97	1800
W-834-K1	97104111G	9/26/97	1820
W-834-K1	N95816C	9/26/97	1800
W-834-M1	8810297-2	10/14/88	1800
W-834-M1	N11463D	12/07/95	4900
W-834-M1	N17212C	2/06/96	4800
W-834-M1	N31401B	6/06/96	5000
W-834-M1	N47081D	9/26/96	5500
W-834-M1	N56903D	12/17/96	5000
W-834-M1	N65634D	2/27/97	5800
W-834-M1	N72291D	4/16/97	5800
W-834-M1	N95817C	9/26/97	5500
W-834-M2	8810342-3	10/17/88	490
W-834-S1	9104258-1	4/10/91	910

Table 7. Building 834 monitor well historical total dissolved solids (TDS) results.

Sample location	Laboratory ID	Sample date	TDS (mg/L)
W-834-S1	9109402-2	9/18/91	520
W-834-S1	N12373B	12/14/95	1000
W-834-S1	53596702	12/14/95	1100
W-834-S1	N34026B	6/25/96	1100
W-834-S1	N56905D	12/17/96	910
W-834-S1	N72732D	4/21/97	960
W-834-S2	N12521B	12/15/95	900
W-834-S2	N72877A	4/22/97	980
W-834-S2A	8810188-1	10/11/88	1300
W-834-S2A	N13012E	12/20/95	860
W-834-S2A	N30621C	5/31/96	1500
W-834-S2A	N57521C	12/20/96	1300
W-834-S2A	N72735D	4/21/97	1400
W-834-S3	8810297-6	10/14/88	570
W-834-S3	N13141E	12/21/95	1900
W-834-S3	N29891D	5/24/96	560
W-834-S3	N57412C	12/19/96	580
W-834-S3	N72872D	4/22/97	570
W-834-S3	N72874D	4/22/97	570
W-834-S4	8810260-3	10/13/88	530
W-834-S4	N11661D	12/08/95	690
W-834-S4	N33861B	6/24/96	670
W-834-S4	N56904D	12/17/96	640
W-834-S4	N72003D	4/15/97	670
W-834-S6	8810342-4	10/17/88	490
W-834-S6	N34022B	6/25/96	610
W-834-S6	N72405A	4/17/97	750
W-834-S8	8902077-1	2/02/89	1400
W-834-S8	9112510-3	12/20/91	1600
W-834-S8	N12374B	12/14/95	1200
W-834-S8	53596703	12/14/95	1300
W-834-S8	N29892D	5/24/96	1600
W-834-S8	N57413C	12/19/96	1300
W-834-S8	97041921G	4/21/97	1420
W-834-S8	N72734D	4/21/97	1300
W-834-S9	8902078-1	2/02/89	710
W-834-S9	9105615-4	5/23/91	590
W-834-S9	N12372B	12/14/95	520
W-834-S9	53596701	12/14/95	560
W-834-S9	N29731D	5/23/96	580
W-834-S9	N57524C	12/20/96	550
W-834-S9	N72402D	4/17/97	570
W-834-T1	8707022#9	7/01/87	440
W-834-T1	8810297-3	10/14/88	460
W-834-T1	N11662D	12/08/95	430
W-834-T1	N17213C	2/06/96	430
W-834-T1	N331210B	6/19/96	610
W-834-T1	N47082D	9/26/96	1900
W-834-T1	N57522C	12/20/96	420
W-834-T1	N65635D	2/27/97	430
W-834-T1	N72293D	4/16/97	450
W-834-T1	N90412D	8/27/97	460
W-834-T2	8810297-4	10/14/88	860
W-834-T2	9105629-3	5/24/91	840
W-834-T2	N29302C	5/21/96	830

Table 7. Building 834 monitor well historical total dissolved solids (TDS) results.

Sample location	Laboratory ID	Sample date	TDS (mg/L)
W-834-T2	N72873D	4/22/97	810
W-834-T2	N72875D	4/22/97	790
W-834-T2A	N34027B	6/25/96	750
W-834-T2A	N72733D	4/21/97	720
W-834-T2B	N34024B	6/25/96	1800
W-834-T2B	N72632D	4/18/97	1600
W-834-T2C	N34025B	6/25/96	1700
W-834-T2C	N72403D	4/17/97	1500
W-834-T2D	N13025B	12/20/95	680
W-834-T2D	53616004	12/20/95	700
W-834-T2D	N31404B	6/06/96	660
W-834-T2D	N57414C	12/19/96	680
W-834-T2D	N72871D	4/22/97	650
W-834-T3	8707022#10	7/01/87	460
W-834-T3	8810297-5	10/14/88	470
W-834-T3	N11462D	12/07/95	460
W-834-T3	N17402C	2/07/96	500
W-834-T3	N33129B	6/19/96	700
W-834-T3	N46758B	9/24/96	510
W-834-T3	N57523C	12/20/96	520
W-834-T3	N65636D	2/27/97	870
W-834-T3	N72294D	4/16/97	720
W-834-T3	N90413D	8/27/97	700
W-834-T4	N29301C	5/21/96	2000
W-834-T4	N72633D	4/18/97	2100
W-834-T4A	8911034-1	11/01/89	1500
W-834-T4A	N29531B	5/22/96	2400
W-834-T4A	N72404D	4/17/97	2900
W-834-T4B	8911035-1	11/01/89	860
W-834-T4B	N29736A	5/23/96	890
W-834-T4B	N72401D	4/17/97	860
W-834-T4C	8911250-1	11/08/89	1200
W-834-T4C	N29065C	5/20/96	1400
W-834-T4C	N72634D	4/18/97	1500
W-834-T5	8707022#11	7/01/87	730
W-834-T5	8902079-1	2/02/89	960
W-834-T5	N11461D	12/07/95	820
W-834-T5	N34023B	6/25/96	850
W-834-T5	N56902D	12/17/96	820
W-834-T5	N72001D	4/15/97	810
W-834-T7A	8810296-1	10/14/88	610
W-834-T7A	N56461C	12/13/96	660
W-834-T7A	N72002D	4/15/97	640

Table 8. Proposed sampling schedule for Building 834 ground water monitor wells.

Sample location	Analyses	Sampling frequency	Water level monitoring frequency
W-834-B2	EPA Method 601	Quarterly	Quarterly
	Metals: Cu, Zn	Annual	
	General minerals, pH, SC, and TDS	Annual	
W-834-B3	EPA Method 601	Quarterly	Quarterly
	Metals: Cu, Zn	Annual	
	General minerals, pH, SC, and TDS	Annual	
W-834-C2	EPA Method 601	Quarterly	Quarterly
	General minerals, pH, SC, and TDS	Annual	
W-834-D3	EPA Method 601	Quarterly	Quarterly
	EPA Method 8015 (TBOS)	Biannual	
	General minerals, pH, SC, and TDS	Annual	
W-834-D4	EPA Method 601	Quarterly	Quarterly
	EPA Method 8015 (TBOS)	Biannual	
	Metals: Ba	Annual	
	General minerals, pH, SC, and TDS	Annual	
W-834-D5	EPA Method 601	Quarterly	Quarterly
	EPA Method 8015 (TBOS)	Biannual	
	General minerals, pH, SC, and TDS	Annual	
W-834-D6	EPA Method 601	Quarterly	Quarterly
	General minerals, pH, SC, and TDS	Annual	
W-834-D7	EPA Method 601	Quarterly	Quarterly
	General minerals, pH, SC, and TDS	Annual	
W-834-D8	EPA Method 601	Quarterly	Quarterly
	EPA Method 602	Biannual	
	EPA Method 8015 (TBOS and TPH Diesel)	Biannual	
	Metals: Ba, Cu	Annual	
	General minerals, pH, SC, and TDS	Annual	
W-834-D10	EPA Method 601	Quarterly	Quarterly
	Metals: Ba, Cd, Cu, Pb, Hg, Mb, Ag, Zn	Annual	
	General minerals, pH, SC, and TDS	Annual	
W-834-D11	EPA Method 601	Quarterly	Quarterly
	Metals: Ba	Annual	
	General minerals, pH, SC, and TDS	Annual	
W-834-D12	EPA Method 601	Quarterly	Quarterly
	Metals: Ba	Annual	
	General minerals, pH, SC, and TDS	Annual	

Table 8. (Continued)

Sample location	Analyses	Sampling frequency	Water level monitoring frequency
W-834-D13	EPA Method 601	Quarterly	Quarterly
	General minerals, pH, SC, and TDS	Annual	
W-834-D14	EPA Method 601	Quarterly	Quarterly
	General minerals, pH, SC, and TDS	Annual	
W-834-G3	EPA Method 601	Quarterly	Quarterly
	Metals: Ba, Cd, Cu, Pb, Hg, Mb, Ag, Zn	Annual	
	General minerals, pH, SC, and TDS	Annual	
W-834-H2	EPA Method 601	Quarterly	Quarterly
	General minerals, pH, SC, and TDS	Annual	
W-834-J1	EPA Method 601	Quarterly	Quarterly
	Metals: Cd	Annual	
	General minerals, pH, SC, and TDS	Annual	
W-834-J2	EPA Method 601	Quarterly	Quarterly
	Metals: Zn	Annual	
	General minerals, pH, SC, and TDS	Annual	
W-834-K1	EPA Method 601	Quarterly	Quarterly
	Metals: Cd, Ag	Annual	
	General minerals, pH, SC, and TDS	Annual	
W-834-M1	EPA Method 601	Quarterly	Quarterly
	Metals: Cd, Pb	Annual	
	General minerals, pH, SC, and TDS	Annual	
W-834-M2	EPA Method 601	Biannual	Biannual
	Metals: Ba, Cd, Cu, Pb, Hg, Mb, Ag, Zn	Annual	
	General minerals, pH, SC, and TDS	Annual	
W-834-S1	EPA Method 601	Biannual	Biannual
	Metals: Cd	Annual	
	General minerals, pH, SC, and TDS	Annual	
W-834-S2	EPA Method 601	Biannual	Biannual
	General minerals, pH, SC, and TDS	Annual	
W-834-S2A	EPA Method 601	Biannual	Biannual
	Metals: Cd	Annual	
	General minerals, pH, SC, and TDS	Annual	
W-834-S3	EPA Method 601	Biannual	Biannual
	General minerals, pH, SC, and TDS	Annual	
W-834-S4	EPA Method 601	Biannual	Biannual
	Metals: Cd	Annual	
	General minerals, pH, SC, and TDS	Annual	

Table 8. (Continued)

Sample location	Analyses	Sampling frequency	Water level monitoring frequency
W-834-S5	EPA Method 601	Annual	Annual
	Metals: Ba, Cd, Cu, Pb, Hg, Mb, Ag, Zn	Annual	
	General minerals, pH, SC, and TDS	Annual	
W-834-S6	EPA Method 601	Annual	Annual
	General minerals, pH, SC, and TDS	Annual	
W-834-S7	EPA Method 601	Annual	Annual
	Metals: Ba, Cd, Cu, Pb, Hg, Mb, Ag, Zn	Annual	
	General minerals, pH, SC, and TDS	Annual	
W-834-S8	EPA Method 601	Biannual	Biannual
	Metals: Cd	Annual	
	General minerals, pH, SC, and TDS	Annual	
W-834-S9	EPA Method 601	Biannual	Biannual
	Metals: Cd, Pb	Annual	
	General minerals, pH, SC, and TDS	Annual	
W-834-T1	EPA Method 601	Quarterly	Quarterly
	General minerals, pH, SC, and TDS	Annual	
W-834-T2	EPA Method 601	Annual	Annual
	Metals: Cd	Annual	
	General minerals, pH, SC, and TDS	Annual	
W-834-T2A	EPA Method 601	Annual	Annual
	General minerals, pH, SC, and TDS	Annual	
W-834-T2B	EPA Method 601	Annual	Annual
	Metals: Cd	Annual	
	General minerals, pH, SC, and TDS	Annual	
W-834-T2C	EPA Method 601	Annual	Annual
	Metals: Cd	Annual	
	General minerals, pH, SC, and TDS	Annual	
W-834-T2D	EPA Method 601	Biannual	Biannual
	General minerals, pH, SC, and TDS	Annual	
W-834-T3	EPA Method 601	Quarterly	Quarterly
	General minerals, pH, SC, and TDS	Annual	
W-834-T4	EPA Method 601	Annual	Annual
	Metals: Ba, Cd, Pb	Annual	
	General minerals, pH, SC, and TDS	Annual	

Table 8. (Continued)

Sample location	Analyses	Sampling frequency	Water level monitoring frequency
W-834-T4A	EPA Method 601	Annual	Annual
	Metals: Ba, Cd, Pb	Annual	
	General minerals, pH, SC, and TDS	Annual	
W-834-T4B	EPA Method 601	Annual	Annual
	Metals: Cd	Annual	
	General minerals, pH, SC, and TDS	Annual	
W-834-T4C	EPA Method 601	Annual	Annual
	Metals: Ba, Cd, Pb	Annual	
	General minerals, pH, SC, and TDS	Annual	
W-834-T5	EPA Method 601	Biannual	Biannual
	Metals: Cd	Annual	
	General minerals, pH, SC, and TDS	Annual	
W-834-T7A	EPA Method 601	Biannual	Biannual
	General minerals, pH, SC, and TDS	Annual	
W-834-T8	EPA Method 601	Annual	Annual
	Metals: Ba, Cd, Cu, Pb, Hg, Mb, Ag, Zn	Annual	
	General minerals, pH, SC, and TDS	Annual	
W-834-T9	EPA Method 601	Annual	Annual
	Metals: Ba, Cd, Cu, Pb, Hg, Mb, Ag, Zn	Annual	
	General minerals, pH, SC, and TDS	Annual	

Notes:

Ba = Barium.

Cd = Cadmium.

Cu = Copper.

Pb = Lead.

Hg = Mercury.

Mb = Molybdenum.

Ag = Silver.

Zn = Zinc.

TDS = Total dissolved solids.

SC = Specific conductivity.

TBOS = Tetra-butyl orthosilicate.

San Joaquin Valley Unified
Air Pollution Control District

Facilitywide Requirements

PERMIT NO: N-472-0-0 **EXPIRATION DATE:** 01/31/2003

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1. No air contaminant shall be released into the atmosphere which causes a public nuisance. [District Rule 4102]

2. No air contaminant shall be discharged into the atmosphere for a period or periods aggregating more than three minutes in any one hour which is as dark as, or darker than, Ringelmann 1 or 20% opacity. [District Rule 4101]

These terms and conditions are part of the Facilitywide Permit to Operate. Any amendments to these Facility Wide Requirements that affect specific Permit Units may constitute a modification of those Permit Units.

San Joaquin Valley Unified Air Pollution Control District

PERMIT UNIT: N-472-12-3 (B834) **EXPIRATION DATE:** 01/31/2003

EQUIPMENT DESCRIPTION:

SINGLE BAFFLED POLYETHYLENE BUBBLER TANK SYSTEM (#3) FOR GROUNDWATER REMEDIATION SERVED BY A CARBON ADSORPTION SYSTEM OR CATALYTIC OXIDIZER.

Permit Unit Requirements

1. A minimum of two carbon canisters connected in series shall be utilized. [District Rule 2201]

2. Sampling ports adequate for extraction of grab samples, measurement of gas flow rate, and use of an FID, PID, or other District-approved VOC detection device shall be provided for the effluent gas stream. [District Rule 1081]

3. Ongoing compliance with the VOC emission rate requirement shall be demonstrated by sampling the effluent gas stream with an FID, PID, or other District-approved VOC detection device. [District Rule 1081]

4. Sampling to demonstrate ongoing compliance shall be performed at least once per week. [District Rule 1081]

5. The remediation system shall be maintained in proper operating condition at all times. [District Rule 2201]

6. The carbon canisters removed from the system shall be sealed vapor tight. [District Rule 2201]

7. The effluent gas flow rate shall not exceed 705 scfm. [District Rule 2201]

8. The VOC concentration of the effluent gas from the remediation system shall not exceed 6.0 ppmv. [District Rule 2201]

9. Records of the cumulative running time and the measured effluent VOC concentrations shall be maintained. [District Rule 2201]

10. All records shall be retained for a minimum of 2 years, and shall be made available for District inspection upon request. [District Rule 2201]

11. Operation of the remediation system shall not occur past February 1, 2023, without prior District approval. [District Rule 2201]

These terms and conditions are part of the facilitywide Permit to Operate.

San Joaquin Valley Unified Air Pollution Control District

PERMIT UNIT: N-472-54-2 (B834) **EXPIRATION DATE:** 01/31/2003

EQUIPMENT DESCRIPTION:

TCE VAPOR EXTRACTION SYSTEM #2 SERVED BY TWO CARBON CANISTERS IN SERIES OR BY A CATALYTIC OXIDIZER.

Permit Unit Requirements

1. A minimum of two carbon canisters which are connected in series shall be utilized. [District Rule 2201]

2. Sampling ports adequate for extraction of grab samples, measurement of gas flow rate, and use of an FID, PID, or other District-approved VOC detection device shall be provided for the effluent gas stream. [District Rule 1081]

3. Ongoing compliance with the VOC emission rate shall be demonstrated by sampling the effluent gas stream with an FID, PID, or other District-approved VOC detection device. [District Rule 1081]

4. Sampling to demonstrate ongoing compliance shall be performed at least once per week when utilizing either carbon canisters or a catalytic oxidizer. [District Rule 1081]

5. The soil remediation system shall be maintained in proper operating condition at all times. [District Rule 2201]

6. The carbon canisters removed from the system shall be sealed vapor tight. [District Rule 2201]

7. Neither the soil ventilation rate or the effluent gas flow rate shall exceed 400 scfm. [District Rule 2201]

8. The VOC concentration of the effluent gas from the soil remediation system shall not exceed 6 ppmv. [District Rule 2201]

9. Records of the cumulative running time and the measured effluent VOC concentrations shall be maintained. [District Rule 2201]

10. All records shall be retained for a minimum of 2 years, and shall be made available for District inspection upon request. [District Rule 2201]

11. Operation of the remediation system shall not occur past November 15, 2023, without prior District approval. [District Rule 2201]

12. The District shall be notified in writing at least 30 days prior to a change from one type of control equipment to another. Only the control equipment specifically identified in this permit shall be used. [District Rule 2201]

These terms and conditions are part of the facilitywide Permit to Operate.

Appendix C

Construction Quality Assurance/ Quality Control Plan

Appendix C

Construction Quality Assurance/ Quality Control Plan

C-1. Introduction

This Quality Assurance/Quality Control (QA/QC) plan has been developed in support of the construction and buildout of the Building 834 OU ground water and soil vapor extraction and treatment systems and extraction wellfield. Because these facilities have already been constructed as part of the Building 834 OU interim remedial actions, this plan will apply only to wellfield expansion, ground water treatment facility replacement, and any future construction activities.

The purpose of this plan is to define quality objectives and areas of responsibility in accordance with the requirements for the construction and buildout of LLNL extraction and treatment facilities. This plan has been developed to comply with LLNL QA policy and to address the applicable elements of DOE Order 414.1A.

The QA/QC objectives are to:

- Assure excellence in construction design and implementation, and
- Provide the QA/QC requirements to meet all programmatic and institutional needs.

The QA/QC Plan provides confidence that these objectives will be achieved and that achievement will include due consideration for health, safety, property, and the environment.

C-2. QA/QC Processes and Procedures

Detailed QA/QC processes and procedures for construction activities are addressed in one or more of the following documents, which are incorporated by reference into this plan:

- U.S. Department of Energy (DOE) Order 414.1A, Quality Assurance Program (DOE, 1999).
- Lawrence Livermore National Laboratory (LLNL) Environmental Protection Department (EPD) Quality Assurance Management Plan (QAMP) (LLNL, 2001).
- LLNL Site 300 Environmental Restoration Project Quality Assurance Project Plan (QAPP) (Dibley, 1999).
- LLNL Livermore Site and Site 300 Environmental Restoration Project Standard Operating Procedures (SOPs) (Dibley and Depue, 2000).
- LLNL Construction Manager Manual - Subcontracted Construction Projects, Plant Engineering Department (LLNL, 1989).

- LLNL Construction Inspectors Policy and Procedure Manual, Plant Engineering Department (LLNL, 1990).

Table C-1 shows the 10 elements of the EPD QAMP, which implements DOE Order 414.1A, and their applicability to any future construction related activities for the Building 834 OU ground water and soil vapor extraction and treatment systems. The construction QA/QC plan follows the Environmental Restoration Project QAPP approved by the U.S. EPA.

C-3. Organization

This section documents the organizational structure, functional responsibilities, and lines of communication for those aspects of construction related activities for the Building 834 OU ground water and soil vapor extraction and treatment systems that affect quality.

Figure C-1 shows the organizational structure for construction QA/QC activities. The descriptions below generally describe the QA/QC responsibilities of those involved in carrying out the QA/QC program for the construction of the Building 834 ground water and soil vapor treatment systems. Project personnel as shown in Figure C-1 have the following responsibilities:

- The U.S. DOE is the Principal Responsible Party for the LLNL Site 300 for CERCLA related activities. Environmental restoration activities at Site 300 are conducted by LLNL Environmental Restoration Division (ERD) by University of California staff, hereafter referred to as LLNL, under the direction of the DOE Site 300 Remedial Project Manager (RPM). The DOE RPM coordinates these activities through the U.S. Environmental Protection Agency, and California Department of Toxic Substances Control and the Regional Water Quality Control Board RPMs.
- The LLNL Environmental Protection Department (EPD) Quality Assurance Manager provides oversight and monitors QA related activities of divisions within the EPD, including ERD. The Quality Assurance Manager reports the results of quality verification to the EPD Department Head who, in turn, relays this information to DOE.
- The LLNL ERD Division Leader is responsible for implementing the EPD and ERD QA programs as it relates to activities in the division and ensuring that nonconforming conditions are promptly addressed and documented. The ERD Division Leader reports to both the EPD Department Head and to DOE.
- The LLNL ERD Site 300 Project Leader is responsible for ensuring that approved procedures related to QA are used during activities in the project and division and ensuring that nonconforming conditions are promptly addressed and documented. The Site 300 Project Leader issues the QA/QC plan and periodically reviews its implementation. The Site 300 Project Leader reports to the ERD Division Leader on QA conformance and other QA-related issues.
- The LLNL ERD Quality Assurance Implementation Coordinator is responsible for the development and implementation for the QA/QC plan, establishment and control of the applicable QA/QC requirements, coordination with appropriate project personnel to assure compliance within groups over which the quality organization has no administrative control, and development of tracking and reporting systems to provide management visibility of implementation activities and results. The Quality Assurance

Implementation Coordinator maintains direct communication and liaison with the EPD Quality Assurance Manager and has line authority through the ERD Division Leader for the implementation of the QA Program within the division.

- The LLNL Quality Assurance Engineer is responsible for providing direction to the Subproject Leader, Remediation Engineer, and Technician Supervisor in the selection and installation of the equipment and remediation systems to meet QA objectives and ensuring that construction meets design criteria specified in the design documents. The Quality Assurance Engineer reports directly to the Quality Assurance Implementation Coordinator on construction QA/QC related activities.

  The Quality Assurance Implementation Coordinator and Quality Assurance Engineer constitute the independent quality assurance reviewers as defined in the EPD Quality Assurance Management Plan. The Quality Assurance Management Plan requires that design/technical reviews are conducted by competent, independent reviewers other than those involved in the original design activity although they may be from the same organization. Additional QA audits of ERD activities are regularly conducted by DOE. The ERD Division Leader may assign an outside (non-LLNL), independent QA team as appropriate (i.e., when the necessary technical expertise to conduct design review is not available within the LLNL organization).

- The LLNL Subproject Leader is responsible for coordinating facility construction. The Subproject Leader reports directly to the Site 300 Project Leader.

- The LLNL Remediation Engineer is responsible for writing design criteria for equipment and flow rates to treat water and vapors, as well as providing oversight for construction activities. The Remediation Engineer is the equivalent to the Remedial Design Engineer. The Remediation Engineer reports to the Subproject Leader regarding facility design and construction.

- The LLNL Plant Engineering Project Manager (PEPM) is responsible for coordinating Plant Engineering activities, if any. The PEPM reports functionally during any assigned construction activities to the ERD Site 300 Project Leader and the Subproject Leader. The PEPM is Plant Engineering's primary contact with ERD for the assigned project. He/she is responsible for coordinating and executing the project assigned to him/her.

- The LLNL ERD Technician Supervisor is responsible for the supervision and oversight of day-to-day construction activities. The Technician Supervisor is the equivalent to the Remedial Action Constructor. The Technician Supervisor reports to the Subproject Leader regarding construction-related activities.

C-4. Training and Qualifications

Personnel supporting Environmental Restoration Projects are trained to ensure that they have the skills and knowledge necessary to perform their work assignments in a safe, competent, uniform, and environmentally sound manner. Technicians performing construction activities comply with the EPD's Training Management Plan, the Safety and Security Directorate Training Implementation Plan, and the LLNL Training Program Manual. In addition to the regulatory driven training such as hazardous waste operations and emergency response certification, Superfund Amendments and Reauthorization Act/Occupational Safety and Health Administration (SARA/OSHA), and the Environment, Safety, and Health courses provided by LLNL, technicians also receive on-the-job training for their specific work tasks. All training is tracked and recorded by the EPD Training Section.

C-5. Quality Improvement

ERD technicians integrate quality improvement into all construction activities by communicating to management, per the requirements of SOP 4.12, Quality Improvement Forms, any unsafe practice or nonconforming item or process (e.g., faulty material, malfunctioning equipment, process defects, data irregularities, and deviations from standard operating procedures) that could potentially compromise worker safety or the activity's deliverable. The technicians also identify and communicate methods to improve quality or achieve greater efficiency of the treatment facilities or associated extraction system under construction.

C-6. Construction

C-6.1. Identification and Control of Items

Material delivered to the job site is inspected to verify compliance with the approved submittal to assure that only correct and accepted items are used or installed.

The Technician Supervisor will request identification and inspection of items arriving at the construction site, when required. Acceptance of items or materials not in conformance with the design requirements shall be approved by the Project Manager and QA Engineer.

C-6.2. Inspection, Test, and Operating Status

The Technician Supervisor and Remediation Engineer shall maintain cognizance of incoming and stored materials and items, and inspect or test them for conformance to requirements, as necessary. They shall tag rejected items to ensure that they are not inadvertently used.

Lockout tags shall be tied on electrical equipment, lifts and hoists, valves, etc. where such items (1) are unsafe to use, (2) are uncertified, or (3) may pose a risk to personnel working on the system.

C-6.3. Design Changes

If during the course of construction, design changes are necessary, these changes must be controlled in accordance with the following requirements:

- Changes to final designs, field changes, and nonconforming items dispositioned "use as is" or "repair" must be justified and must be subject to design control measures commensurate with those applied to the original design.
- Design control measures for changes must include provisions to ensure that the design analyses for the item are still valid.

- Changes must be approved by the same groups or organizations that reviewed and approved the original design documents.
- If a significant design change becomes necessary because of an incorrect original design, the design process and design verification methods and implementing procedures must be reviewed and modified as appropriate. These design deficiencies must be documented according to the requirements provided using the organization's nonconformance reporting process.
- Field changes must be incorporated into the applicable design documents.
- Design changes that affect related implementing procedures or training programs must be communicated to the appropriate organizations.

C-6.4. Inspection

All construction work is subjected to inspection. The QA Engineer shall notify the Subproject Leader and Remediation Engineer if the work does not meet design criteria or quality requirements. After construction, the QA Engineer shall verify the accuracy of the as-built drawings to the final constructed facility.

C-7. Activation

C-7.1. System Check

Prior to operating the modified ground water treatment facility with contaminated ground water, a system check will be conducted to confirm the proper construction and operation of the treatment system. The following minimum requirements apply to this system check phase:

- A conformance inspection will be conducted to confirm that all equipment, piping, instrumentation, and control systems of the ground water treatment system have been installed according to the approved design. Any deficiencies in the ground water treatment system will be corrected.
- To confirm piping integrity, piping of the collection system and treatment system will be tested. Any leaks will be repaired.
- All instrumentation, control systems, and equipment will be inspected for malfunctions. All automatic controls, such as shutdown or alarm switches necessary for the operation of each treatment system phase, will be inspected for operational readiness prior to startup of that phase. Mechanical equipment, such as pumps, air blowers, and valves, required for the operation of the treatment phases, will be cycled or operated. Any functional deficiencies will be corrected.

C-7.2. Proof-of-System Check

After the system check has been conducted and any deficiencies corrected, a proof-of-system check will be conducted to ensure that the extraction wellfield and replacement treatment system will remove and treat contaminated ground water to meet regulatory effluent discharge limits. The proof-of-system check will consist of the following elements:

- The proof-of-system check will last long enough to demonstrate that contaminated ground water has been extracted from each extraction well and has been treated by the treatment system to meet effluent discharge limitations.
- Each of the new extraction wells will be pumped long enough to confirm that the ground water pumps and water level shutoff devices operate properly.
- The treated ground water will be analyzed for volatile organic compounds, TBOS/TKEBS, and nitrate after passing through the treatment system.
- If analysis show that ground water concentrations are above the effluent discharge limitations, the ground water will receive further treatment until the concentrations reach regulatory standards.
- All treatment, transport, and disposal components (including pumps, valves, liquid level controllers, pipelines, blowers, flow meters, pressure gauges, etc.) will be inspected for leaks and/or malfunctions. In addition, the system's automatic controls will be inspected for operational readiness. All mechanical equipment will be operated under load to assure proper performance. Any deficiencies will be corrected.

C-7.3. Proof-of-System Monitoring

Proof-of-system monitoring will be conducted to characterize changes to the treatment system influent and effluent stream as a result of connecting new extraction wells, to determine the treatment efficiencies of the modified ground water treatment facility, and to monitor the performance of the new extraction wells.

During the proof-of-system monitoring, the following analyses or measurements will be conducted:

- Total volume of water extracted from each new extraction well.
- Water levels in the new extraction wells.
- Total volume of water treated.
- Analysis of treatment system effluent samples for volatile organic compounds, TBOS/TKEBs nitrate, electrical conductivity, pH, temperature.

The quality of the data generated as part of the proof-of-system testing will be assessed following the data quality assessment procedures outlined in Section 3.1.3 and Section 4 (Data Validation and Usability) of the ERD QAPP (Dibley, 1999).

C-7.4. Measuring and Testing Equipment Calibration and Verification

All Measuring and Test Equipment used in acceptance testing of electronic, monitoring, and interlock systems and items will be calibrated in accordance with the applicable LLNL or manufacturer's calibration manual. The individual conducting the test will be responsible for assuring that all test equipment is calibrated and within its certification period.

C-8. References

Dibley, V. (March 1999), *Environmental Restoration Division, Quality Assurance Project Plan, Livermore Site and Site 300 Environmental Restoration Projects*, Lawrence Livermore National Laboratory, Livermore, Calif. (UCRL-AR-103160 Rev. 2).

Dibley V., and R. Depue (Eds.) (2000), *LLNL Livermore Site and Site 300 Environmental Restoration Project Standard Operating Procedures (SOPs),* Lawrence Livermore National Laboratory, Livermore Calif. (UCRL-MA-109115 Rev. 8).

LLNL (July 2001), *Environmental Protection Department (EPD) Quality Assurance Management Plan (QAMP), Rev. 5*., Lawrence Livermore National Laboratory, Livermore, Calif.

LLNL (1989), Construction Manager Manual - Subcontracted Construction Projects, Plant Engineering Department.

LLNL (1990), Construction Inspector's Policy and Procedure Manual, Plant Engineering Department.

U.S. DOE (1999), DOE Order 414.1A, Quality Assurance Program, Office of Nuclear Safety Policy and Standards.

Table C-1. Applicability of the EPD QAMP elements to the construction/replacement of the Building 834 OU ground water and soil vapor treatment system and wellfield buildout.

EPD QAMP requirement	Title	Applicable ?
Element 1	EPD Quality Assurance Program Description	Yes
Element 2	Training and Qualification	Yes
Element 3	Quality Improvement	Yes
Element 4	Document and Records	Yes
Element 5	Work Processes	Yes
Element 6	Design Control	Yes
Element 7	Procurement	Yes
Element 8	Inspection and Acceptance Testing	Yes
Element 9	Management Assessment	Yes
Element 10	Independent Assessment	Yes

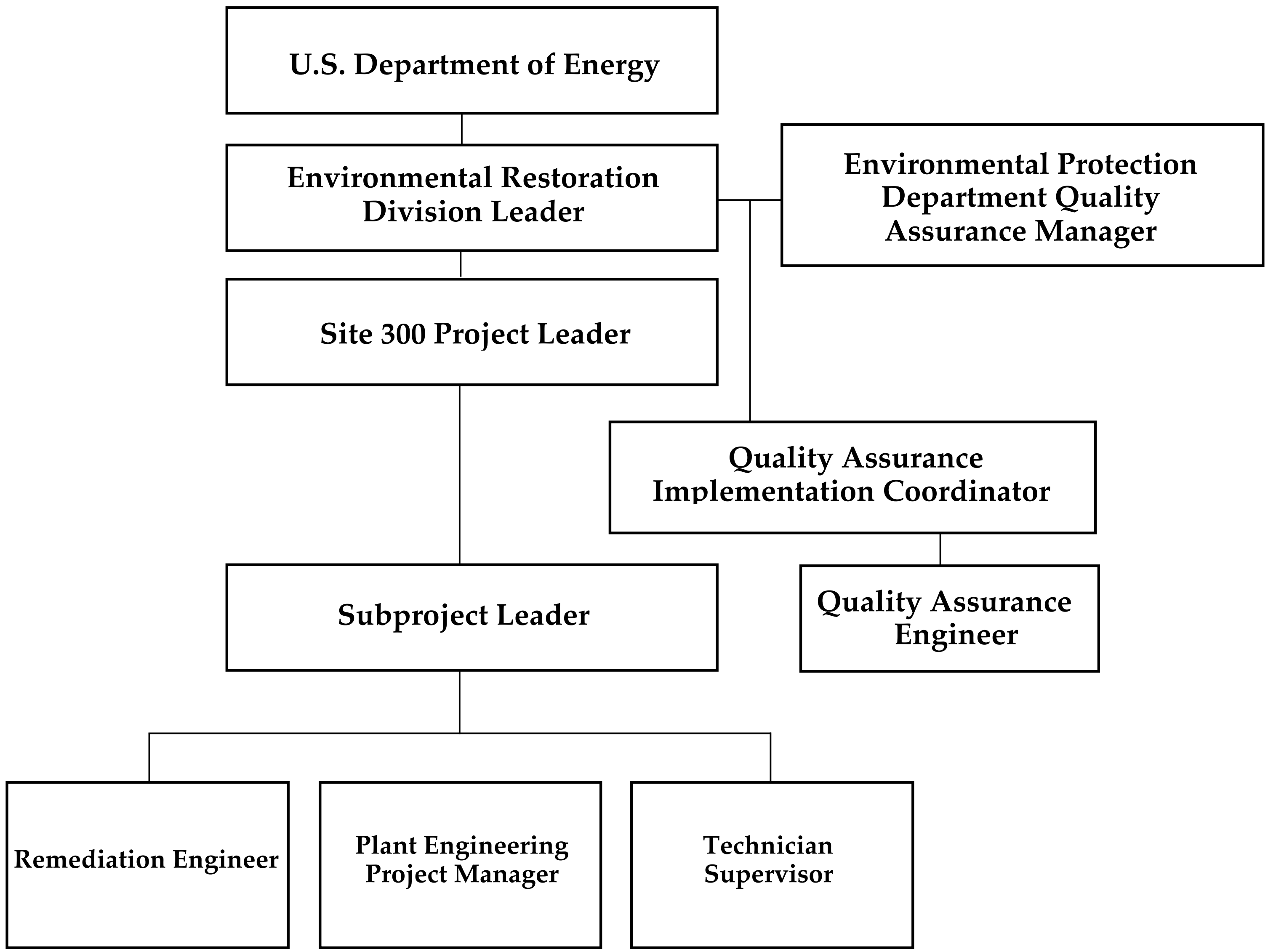

Figure C-1. Organizational structure for construction QA activities.

Appendix D

Construction Health and Safety Plan

Appendix D

Construction Health and Safety Plan

This Appendix contains the Construction Health and Safety Plan (HASP) for the Building 834 Operable Unit Remedial Action.

D-1. Reason for Issue

Safety procedures are required to construct the Building 834 OU remedial action. This Health and Safety Plan also serves as an administrative tool to summarize many of the requirements that are pertinent to the Building 834 OU treatment facility (TF) construction. Because this facility has already been constructed as part of the Building 834 OU interim remedial action, this HASP will apply only to any future construction activities, such extraction wellfield expansion and replacement of the existing ground water treatment facility. Any potential health and safety hazards and the control of such hazards during construction are addressed in one or more of the following documents:

- Lawrence Livermore National Laboratory (LLNL) Environment, Safety, and Health Manual (LLNL, 2000).
- LLNL Environment, Safety, and Health Manual, Supplement 1.11 - Construction Subcontractor Safety Program (LLNL, 2000).
- LLNL Environmental Restoration Division (ERD) Site Safety Plan for Lawrence Livermore National Laboratory CERCLA Investigations at Site 300 (LLNL, 2000).

The requirements of the LLNL ES&H Manual are based on DOE's Integrated Safety Management System Principles and Work Smart Standards.

D-2. Work to be Done and Location of Activity

D-2.1. Location of Treatment Facilities

The Building 834 OU is located in the southeast part of LLNL Site 300. The ground water TF is located approximately 30 ft south of Building 834D. The soil vapor TF is located approximately 100 ft southwest of Building 834D.

D-2.2. Existing Treatment Facilities

Contaminated ground water is pumped from 16 extraction wells. Volatile organic compounds (VOCs) are currently treated using an air sparging unit. The contaminated vapor stream created in the sparging process is treated using vapor-phase granular activated carbon units (GAC). A phase-separator removes silicon-based oils (tetra-butyl-orthosilicate or TBOS and tetra-kis-2-ethylbutyl-orthosilicate or TKEBS) from extracted ground water. Vapor-phase

GAC units are also used to treat VOCs in soil vapor extracted from 16 dual ground water-soil vapor extraction wells in the Building 834 Core Area. Health and safety hazards and controls for the operation of this facility are discussed in Appendix F (Operations and Maintenance Health and Safety Plan).

D-2.3. Replacement of Air Sparging Unit with Aqueous-Phase GAC

The Remedial Design for Building 834 OU includes plans to replace the air sparging tanks with aqueous-phase GAC units to remove VOCs from extracted ground water. This system change will eliminate the need for vapor-phase GAC treatment of the contaminated vapors that were generated by the air sparging process. Once the sparge tank has been replaced with the aqueous-phase GAC units, an air permit will no longer be needed for the discharge of treated vapor from the ground water treatment system.

The air sparge tank will be disconnected from the influent lines and placed on standby. Three 1,000-lb. aqueous-phase GAC units will be placed in series on the treatment pad and connected to the influent line from the extraction wells. Two existing water-holding tanks will be removed to accommodate the GAC units.

D-2.4. Extraction Wellfield Expansion

Extraction of ground water and soil vapor will continue from twelve wells in the Building 834 Core Area. Ground water extraction will be discontinued in three existing wells that will be used only to extract soil vapor. One existing ground water and soil vapor extraction well in the Core Area will be converted to a monitor well. Six existing ground water monitor wells in the distal plume areas will be converted to ground water and soil vapor extraction wells. Four of these wells will be used to for remediation of the Tpsg unit, while two wells will be used for cleanup of contaminants in the deeper $Tnsc_2$ unit.

Much of the pipeline has already been installed to connect downgradient wells to the treatment facility. The pipeline will need to be attached to both the extraction wellhead and the treatment facility. Some soldering may be necessary.

D-3. Responsibilities

Ed Folsom, phone number (925) 422-0389, LLNL pager number 02892, and home phone number (925) 455-2715, is responsible for the safety of this operation and for assuring that all work is performed in conformance with this HASP. In the absence of the responsible individual, P.J. Lyra, phone number (925) 422-1830, LLNL pager number 05157, or Greg Santucci, phone number (925) 422-3089, LLNL pager number 06502, shall assume these responsibilities.

Any changes in construction activities that improve or do not significantly affect safety and environmental controls may be approved by the responsible individual(s) listed above, and the LLNL Environmental Safety & Health (ES&H) team leader. The responsible individual will ensure that this action is documented in a memorandum. Any changes in the operation that increase the hazard level, introduce additional hazards, or decrease safety shall not be made until a revision to this HASP has been reviewed and approved, consistent with the LLNL Environmental Restoration Division review and approval process.

Before starting construction activities, the responsible individual shall verify and document that the operating personnel have read and understand the HASP, relevant Integration Work Sheets (IWSs), and associated LLNL ES&H Manual sections referenced in Section D-5.2.

D-4. Hazard Analysis

D-4.1. Noise Hazard

Irreversible hearing loss can occur due to long-term exposure to noise from operating fans and blowers, and heavy equipment. Noise can also aggravate pre-existing hypertension. The American Conference of Industrial Hygienists has established a standard of 85 dBA over an 8-hour day. Exposure to noise louder than 85 dBA is permitted, as long as the average exposure for the entire day is less than 85 dBA.

D-4.2. Electrical Hazard

A 480, 208/230, and 110 VAC electrical power supply is used to operate the Building 834 OU ground water and vapor extraction and treatment systems. Electrical shock and injury may occur if personnel come into contact with exposed energized parts during servicing and maintenance activities.

D-4.3. Pressure Hazard

Compressed gas cylinders are used as part of the Building 834 OU treatment process. These pressurized gas cylinders can pose a hazard to personnel, equipment, and facilities if improperly operated and/or handled including blast effects, shrapnel, equipment damage, and personnel injury.

D-4.4. Chemical Hazard

Volatile organic compounds including trichloroethylene, tetrachloroethylene, trichloroethane, and dichloroethylene are contained in the extracted ground water treated in the Building 834 OU treatment system at concentrations up to 50,000 ppb total VOCs. These chemical hazards are listed as potential carcinogens and liver toxins that may enter the body through inhalation, skin absorption, and/or ingestion. They are irritating to the eyes, nose, and throat and may affect the central nervous system.

D-4.5. Confined Space Hazard

A confined space is defined as an enclosed area that is large enough for an employee to enter and perform assigned work, has limited or restricted means of entry or exit, and is not designed for continuous human occupancy. If an ignition source is present in or introduced into an enclosed space that contains flammable gases, solvents, or dust, the atmosphere may burn or explode. Serious injury or death may result when the atmosphere contains even low concentrations of toxic gases.

D-4.6. Hand and Portable Power Tool Hazard

The Laboratory provides hand and portable tools that meet accepted national safety standards. However, these tools can still cause injury and must be properly used and maintained.

D-4.7. Working Alone Hazard

Working alone means performing any activity out of sight or communication for more than a few minutes at a time. For work on exposed energized electrical equipment, an individual is considered to be working alone if not within sight of someone else. The major danger in working alone is sustaining an illness or injury that precludes self-rescue.

D-4.8. Physical and Biological Hazards

Physical hazards associated with working at Site 300 include extreme temperatures with temperatures often exceeding 100º F in the summer. High air temperatures coupled with use of semi-permeable or impermeable protective clothing and/or strenuous physical activities have a high potential for inducing heat stress in workers. In addition, hazardous conditions may exist during lightning storms at Site 300. Biological hazards include rattlesnakes and insects (i.e., tarantulas, black widow spiders, scorpions, etc.).

D-4.9. Slip/Trip/Fall Hazards

The surfaces that operators stand or work on can be hazardous if not properly designed or maintained. Injuries can result from slips, trips, or falls on work surfaces. Work at heights or at elevated locations can also pose a fall hazard.

D-4.10. Material Handling Hazards

The hazards associated with improper material handling include being struck by a load, losing control of a load, physical overexertion, and exceeding equipment capacities. Such accidents can lead to injuries.

D-4.11. Mechanical Motion Hazards

A wide variety of mechanical motions and actions may present hazards to personnel. These can include the movement of rotating members, reciprocating arms, moving belts, meshing gears, cutting teeth, and any part that may cause impact or shear. These different types of hazardous mechanical motions and actions are basic in varying combinations to nearly all machines.

D-4.12. Hazards to Eyes

During construction activities, flying particles or objects can present a hazard to worker's eyes. The use of soldering or welding equipment also poses an eye hazard.

D-4.13. Fire Hazards

Soldering or welding of pipe connections may be necessary to connect pipeline to extraction wells or to the treatment facility. These hot-work activities present a fire hazard, particularly when performed in the more remote, grassy areas of the OU during the summer months when the grass is dry and highly ignitable.

In addition, vehicle travel off-road into grassy areas may be necessary during pipeline construction or hook-up. Hot engine and vehicle exhaust components may present a fire hazard when contacting high, dry grass or vegetation.

D-5. Hazard Control

Controls for the hazards identified in Section D-4 are based on selected sections of LLNL Environment, Safety, and Health (ES&H) Manual, the Site Safety Plan for LLNL CERCLA Investigations at Site 300 (2000), and ERD Integration Work Sheet #239.

D-5.1. Noise Hazard Control

Based on previous experience, it is not anticipated that the noise level will be of concern during construction activities. However, sound levels will be monitored during any operation that may generate hazardous noise levels. Construction personnel will be required to wear noise protection when working within the noise hazard area, if required by LLNL Industrial Hygiene personnel. Engineered and/or administrative controls should also be implemented, as necessary, to limit noise and protect worker's hearing. The work supervisor shall provide workers affected by noise with earplugs or earmuffs as needed.

The facility operator is required to follow noise safety precautions outlined in the LLNL ES&H Manual, Section 10.08 "Hearing Conservation" and Supplement to 10.08.

D-5.2. Electrical Hazard Control

D-5.2.1. Access Control

Inadvertent contact with energized equipment is prevented by limiting access to the breaker switches. All breaker switches are contained in cabinets with keyed locks.

D-5.2.2. Electrical System Maintenance Safety Procedures

Only qualified electricians or electrical technicians perform activities on the electrical systems for the treatment facilities during construction work. These personnel will follow safety precautions as outlined in the LLNL ES&H Manual, Chapter 23, "Electrical Safety," and the Electronics Engineering Department–Electrical Safety Policy, LED-61-00-01-A1A. These personnel will also follow the LLNL Lockout and Tag program as defined in Chapter 26.13 of the LLNL ES&H Manual and IWS Safety Procedure #239 whenever any work is to be done that would expose them to energized equipment.

D-5.3. Pressurized Gas Hazard Control

All compressed gas cylinders in service or storage shall be secured to prevent them from falling. The hazard classification or name of gas being stored shall be prominently marked in container storage area, and "No Smoking" signs posted where appropriate. Cylinders should be stored away from sources of intense heat and cylinders stored in the sun should be shaded during the summer, whenever possible. Store containers with protective valve caps in place when the cylinder is not connected to a regulator or manifold. Always assume a cylinder is pressured; handling it carefully and avoid bumping or dropping. Two people are required to lift a standard cylinder or any cylinder weighing more than 50 pounds. Technicians should be familiar with and follow these and the other requirements for handling, operation and storing of compressed gas cylinders in the LLNL ES&H Manual, Section 32.3.8.

D-5.4. Chemical Hazard Control

Concentrations of VOCs in the treatment facility influent are generally several orders of magnitude lower than the recommended permissible exposure limits (PELs) or threshold limit values (TLVs) for these chemicals. Therefore, it is not anticipated that exposure levels in excess of PELs or TLVs will be encountered. However, precautions, such as use of personal protective equipment or clothing (i.e., gloves, safety glasses) should be taken to prevent exposure when potential contact with contaminated, untreated ground water is possible. In addition, to prevent the ingestion of hazardous materials, workers should wash their hands prior to eating, drinking, smoking, or using restroom facilities. The Material Safety Data Sheets for the chemical encountered in Building 834 OU ground water are maintained at the technician's office at Site 300 and in the Site Safety Plan for LLNL CERCLA Investigations at Site 300 (2000).

D-5.5. Confined Space Hazard Control

Confined space entries are not anticipated as part of construction activities in the Building 834 area at this time. However, construction personnel and technicians should be familiar with and perform all work in confined spaces in accordance with the LLNL ES&H Manual, Section 3, "Controls for Working in Confined Spaces". Technicians and construction personnel should contact Hazards Control Team #1 prior to entry in any confined space. A Confined Space permit is required for hazardous confined space work. Only qualified personnel with recent confined space training are permitted to work in confined spaces and are required to comply with the two-man rule.

D-5.6. Hand and Portable Tool Hazard Control

Facility technicians and construction personnel are responsible for selecting and using the proper tools for the job assigned and for wearing the appropriate personal protective equipment (i.e., safety glasses, etc.) when working with hand and portable tools. All hand and portable tools should be inspected prior to use to make sure they are not damaged and are in good-working condition. Any tool that is damaged or unfit for use should be immediately removed from service. Personnel are responsible for following the work safety standards outlined in LLNL ES&H Manual, Section 26.5.

D-5.7. Working Alone Hazard Control

When working alone on a non-hazardous activity, facility technicians and construction personnel will advise a co-worker or supervisor that they will being working alone and when they expect to return. For potentially hazardous activities, technicians will: (1) exercise prudent judgement whether or not to perform the activity alone, and (2) obtain prior authorization from work supervisor before beginning planned hazardous-work-alone operations to ensure that all hazards have been thoroughly evaluated from the perspective of working alone. Work supervisors are responsible for ensuring an IWS is prepared for activities classified as hazardous for working alone. Personnel are responsible for following the work safety standards outlined in LLNL ES&H Manual, Section 26.12 and the Environmental Restoration Division Working Alone Guidelines (in ERD O&M Manual, Appendix L) for all work-alone activities.

D-5.8. Physical and Biological Hazard Control

During late spring and summer months, technicians and construction personnel should ingest fluids and evaluate their physical conditions regularly and break when necessary to avoid overheating. Work should be conducted in accordance with the LLNL ES&H Manual, Section 26.16. All personnel should follow procedures outlined in the Site 300 Lightning Procedures (S300 MGM-T-7) during a lightning alert at Site 300.

Technicians and construction personnel should inspect work areas for snakes and other biological hazards before commencing work. The use of high top work boots is recommended. Avoid biological hazards when possible; do not harass wildlife. Anyone who is bitten should be moved to a safe area and kept calm. Notify the Emergency Dispatch (911) immediately.

D-5.9. Slip/Trip/Fall Hazard Control

Work surfaces around the treatment facilities should be properly maintained at all times to prevent slips, trips, and falls. Maintenance includes assuring all spills and foreign materials (i.e., tools, excess equipment, etc.) are promptly removed, installing rubber or slip resistant mats at locations that may accumulate water, and ensuring that floor openings are equipped with adequate covers when worker exposure is possible. Any access to elevated locations or work at heights requires guardrails, an administrative control system, or fall protection devices. Personnel are responsible for following the work safety standards outlined in LLNL ES&H Manual, Sections 26.17 and 10.09.

D-5.10. Material Handling Hazard Control

When lifting or handling materials manually, operators should use methods that ensure personal safety and safety of the material being handled. Objects that are too heavy or bulky to handle safely should be moved using more than one person or mechanical lifting device. All material lifting or handling should be performed in accordance with the safety standards and procedures for lifting contained in the LLNL ES&H Manual, Section 29.3.

D-5.11. Mechanical Motion Hazard Control

Any machine part, function, or process which may cause injury shall either be guarded (physical barriers which prevent access to danger areas) or safeguarded (provided with devices which inhibit machine operation, to mitigate or eliminate danger areas).

Machine operators shall be trained in the proper use of equipment and associated guards/safeguards to protect themselves and others from machine-related hazards. Machine operators shall wear protective clothing or personal protective equipment as necessary whenever engineering controls are not available or are not fully capable of protecting personnel. At a minimum, safety shoes and safety glasses shall be worn by all personnel operating or working within close proximity of heavy machinery or equipment. When there is a potential for head injury, hard hats shall be worn.

D-5.12. Eye Hazard Control

Eye protection shall be provided and worn by technicians where flying particles or objects present a hazard. The minimum type of eye protection is a pair of safety glasses. Increased protection against flying particles is provided when safety glasses have side shields; side shields should be used in most cases. Special eye protection is required when operations such as welding or metal cutting with a torch or arc are performed.

Generally, the technician supervisor will select the eye protection that is appropriate for the type of work being conducted by the technician. Additional details for eye protection are contained in the LLNL ES&H Manual, Section 10.3.6.

D-5.13. Fire Hazard Control

As part of the LLNL program to control fire hazards, permits are required for welding, soldering, and other hot-work operations with a high fire potential. The permits are obtained from the LLNL Fire Department at Site 300. Construction areas shall be maintained in a fire-safe condition, including ensuring that the construction site is accessible to the Fire Department. Technicians will obtain fire permits for all soldering or welding work with a high fire potential. This work will be also be conducted in accordance with the requirements of the LLNL ES&H Manual, Section 25, LLNL Fire Protection Program Manual, and National Fire Protection Association (NFPA) 51 (Standard for Fire Prevention During Welding, Cutting, or Other Hot Work).

In addition, technicians must obtain approval to access any construction work site that requires off-pavement travel as defined by the LLNL “Restricted Off-Pavement Travel at Site 300” policy manual. Technicians planning to travel off-pavement must receive prior permission from the Site 300 Manager, the Functional Area Supervisor, and the CAS Operator and carry a trunked radio for communications. In addition, appropriate training is required for all personnel engaging in off-road travel at Site 300. Personnel should not park or drive through dry, tall grass. Technicians performing off-road travel during construction activities shall be familiar with and must be listed as ‘qualified personnel’ on IWS #1960 “Site 300 Restricted Travel to Perform ERD Activities.”

In case of fire, contact the LLNL Fire Department by dialing 911 or 925-447-6880 from a cellular phone.

D-6. Stop Work Procedures

LLNL’s stop-work procedure applies to all work done at the Laboratory. Activities that are imminently dangerous to workers, the public, or the environment shall be stopped immediately by any Laboratory employee, supplemental labor employee, or contractor. Each worker is empowered to stop work if there is a perceived unsafe or unapproved condition. “Stopping work” includes stabilizing an imminent danger situation to the extent that it can be left unattended for a prolonged period of time until the issue is resolved. The person requesting the work stoppage shall notify manager responsible for the work. The manager shall notify the area ES&H Team and the Directorate ES&H Assurance Manager as soon as possible of this action. Informal stop work interventions to correct minor conditions (e.g., to remind workers to put on their hard hats, safety glasses etc.) do not require formal notification. Details of the Stop Work Process are included in the LLNL ES&H Manual, Section 1.7.

D-7. Emergency Response Procedures

In the event of an emergency, facility operations personnel will first dial "911" to report to the Emergency Dispatcher, then administer first aid, if necessary and if trained appropriately, to injured personnel. The Emergency Dispatcher uses reserved telephone lines to promptly relay the emergency call to the following members of the LLNL Emergency Response Team:

- Fire Department.
- Security Department.
- Hazards Control Safety Teams.
- Plant Engineering.
- Health Services.

The Emergency Response Team will go to the scene of the emergency immediately. The phone numbers of individuals to be notified in the event of an emergency during off-shift hours are posted at the Building 834 OU TFs. The LLNL ES&H Manual describes the emergency response procedures.

D-8. Applicable Documents

The following documents and/or sections thereof apply to safely performing construction activities at the Building 834 OU and are incorporated into this HASP by reference.

D-8.1 Integration Work Sheet Safety Procedures #239 (Lockout and Tag Program for Institutional and PE Maintained Programmatic Equipment)

D-8.2. LLNL Environment, Safety, and Health Manual Sections

Section 1.	LLNL ES&H Policies, General Worker Responsibilities, and Integrated Safety Management
Section 1.7.	Stop Work Procedures
Section 2.	Integrating ES&H into Laboratory Activities
Section 10.08	Hearing Protection
Section 21.	Chemicals
Section 21.3.5	Facilities and Equipment
Section 21.3.7	Handling Solid and Liquid Chemicals
Section 23.	Electrical Safety

Section 23.1	Introduction
Section 23.2	Hazards
Section 23.3	Controls for Electrical Work and Electrical Equipment
Section 23.4	Responsibilities
Section 23.5	Work Standards
Section 23.6	Resources for More Information
Appendix 23-B	Effects of Electrical Energy on Humans

D-8.3. LLNL Environment, Safety, and Health Manual, Supplement 1.11 - Construction Subcontractor Safety Program (LLNL, 2000).

D-8.4. LLNL Electronics Engineering Department—Electrical Safety Policy, LED-61-00-01-A1A

D-8.5. Site Safety Plan for LLNL CERCLA Investigations at Site 300, November 2000

D-8.6. LLNL Environment, Safety, and Health Manual Supplements

Section 10.08	Hearing Conservation
Section 11.07	Personnel Safety Interlocks
Section 26.13	LLNL Lockout and Tag Program

D-9. References

LLNL (2000), LLNL Environment, Safety, and Health Manual.

LLNL (2000), LLNL Environment, Safety, and Health Manual, Supplement 1.11—Construction Subcontractor Safety Program.

LLNL (2000), *Site Safety Plan for Lawrence Livermore National Laboratory CERCLA Investigations at Site 300*, Lawrence Livermore National Laboratory, Livermore, Calif. (UCRL-21172 Rev. 3).

LLNL (latest edition), *Fire Protection Program Manual*, Lawrence Livermore National Laboratory, Livermore, Calif. (UCRL-MA-116646).

Appendix E

Operations and Maintenance Quality Assurance/Quality Control Plan

Appendix E

Operations and Maintenance Quality Assurance/Quality Control Plan

E-1. Introduction

This Quality Assurance/Quality Control (QA/QC) plan has been developed in support of the Operations and Maintenance (O&M) for the Building 834 OU ground water and soil vapor extraction and treatment systems. The purpose of the plan is to define the quality objectives and areas of responsibility to operate and maintain these facilities. This plan meets the QA requirements of the U.S. Department of Energy (DOE) Order 414.1A, the Environmental Protection Department (EPD) Quality Assurance Management Plan (QAMP), (2001), and the Quality Assurance Project Plan (QAPP) for the Livermore Site and Site 300 Environmental Restoration Projects (1999).

E-2. Organization

This section documents the organizational structure, functional responsibilities, levels of authority, and lines of communications for those aspects of the O&M of the Building 834 OU ground water and soil vapor treatment systems that affect quality.

Figure E-1 shows the organizational structure for QA/QC activities. The descriptions below generally describe the QA/QC responsibilities of those mainly involved in carrying out the QA/QC program for the O&M of the Building 834 OU ground water and soil vapor treatment systems. The LLNL Environmental Restoration Division (ERD) Site 300 Project Leader, the Quality Assurance Engineer, the Subproject Leader, and other individuals shown in Figure E-1 have the following responsibilities:

- The Site 300 Project Leader issues this QA/QC plan and periodically reviews its implementation. The Site 300 Project Leader may request an independent review or formal audit of the QA/QC program.
- The Quality Assurance Implementation Coordinator is responsible for the development and implementation of the QA/QC plan, establishment and control of the QA document files, coordination with appropriate project personnel to assure compliance within groups over which the quality organization has no administrative control, and development of tracking and reporting systems to provide management visibility of implementation activities and results.
- The Quality Assurance Engineer is responsible for providing direction in the O&M of remediation systems to meet QA/QC objectives.

- The Subproject Leader is responsible for overseeing facility startup and monitoring its performance and operations.
- The Remediation Engineer is responsible for providing technical direction in the O&M of treatment systems, reviewing and tracking failure of equipment and systems and determining the root cause of failures. The Remediation Engineer is also responsible for implementing the changes to the preventative maintenance schedule to reduce facility maintenance cost and downtime.
- The LLNL Plant Engineering Project Manager reports functionally during any assigned maintenance activities to the ERD Site 300 Project Leader and the Subproject Leader. The Plant Engineering Project Manager is Plant Engineering's primary contact with ERD for the assigned project. He/she coordinates and executes the project assigned to him/her. He/she is responsible for approving minor technical field design changes related to treatment facility modifications and/or O&M activities.
- The Technician Supervisor is responsible for the day-to-day supervision of the facility technicians who operate and maintain the treatment facilities. This includes scheduling required maintenance and ensuring completion in a timely fashion.
- The Treatment Facility Operator/Technician is responsible for the day-to-day operation and maintenance of the treatment facilities. This includes operating equipment, sampling, and performing maintenance to approved procedures, ensuring the measuring and testing equipment is properly calibrated and is of the proper type, range, and accuracy, reporting nonconformances or improvements, and reviewing facility data.
- State Certified Analytical Laboratories using EPA methods are responsible for providing independent chemical analytical results on water samples. For the Building 834 OU ground water treatment system, these samples are submitted as part of the monitoring program required by LLNL's discharge permits, in addition to operational testing samples collected prior to the official operation of a facility and routine samples taken to evaluate facility performance.

E-3. Quality Assurance Program

This section covers the objectives, quality goals, and the QA/QC elements. The procedures for implementation of QA/QC requirements are included in this plan, in the ERD Standard Operating Procedures (SOPs) (2000), the ERD O&M Manual for Site 300 Treatment Facilities, Volume I (2000), or in the Building 834 OU ground water and soil vapor treatment system O&M manual (under development).

The objectives of the project supported by this QA/QC plan are to:

- Assure excellence in maintenance services and operations to achieve quality, and
- Provide the QA/QC requirements to meet all programmatic and institutional needs.

This QA/QC plan defines the process for providing confidence that these QA/QC objectives will be achieved and that achievement will include due consideration for health, safety, property, and the environment.

Table E-1 shows the 10 elements of the EPD QAMP, which implements DOE Order 414.1A, and their applicability to the operation and maintenance of Building 834 OU ground water and soil vapor treatment systems.

The SOPs (2000), the ERD O&M Manual for Site 300 Treatment Facilities, Volume I (2000), and the Building 834 OU ground water and soil vapor treatment systems O&M manual (under development) provide the procedures to implement the applicable elements of the EPD QAMP. In addition, they include lists of the QA auditable records, including the responsible personnel, that are required to document compliance with the requirements of the EPD QAMP.

E-4. Training and Qualifications

ERD facility technicians may only perform work for which they are trained and qualified including the operation and maintenance of the Building 834 OU treatment facilities. Untrained personnel may temporarily work under the supervision of a trained person until the required training is completed. The EPD Training Management Plan, the Safety and Security Directorate Training Implementation Plan, the LLNL Training Program Manual, and training questionnaires completed by supervisors dictate the training requirements for treatment facility personnel including course work and on-the-job training.

E-5. Quality Improvement

ERD facility technicians integrate quality improvement into all treatment facility O&M activities by communicating to management per the requirements of SOP 4.12, Quality Improvement Forms, any unsafe practice or nonconforming item or process (e.g., faulty material, malfunctioning equipment, process defects, data irregularities, and deviations from standard operating procedures) that could potentially compromise worker safety, the activity's deliverable, or the compliance status of the facility. The technicians also identify and communicate methods to improve quality or achieve greater efficiency of the treatment facilities. These personnel also participate in facility assessments and operations meetings to address quality improvement issues.

E-6. Operations and Maintenance

E-6.1. Scope

The Building 834 OU ground water and soil vapor treatment systems will be operated to treat ground water and vapor containing volatile organic compounds (VOCs) and silicon-based oils [tetra-butyl-orthosilicate (TBOS) and tetra-kis-2-ethylbutyl-orthosilicate (TKEBS)]. The water will be treated to meet the requirements specified by the Regional Water Quality Control Board (RWQCB), and the vapor will be treated to meet the requirements specified by the San Joaquin Valley Unified Air Pollution Control District (SJVUAPCD). Therefore, O&M activities at this facility shall be controlled by quality procedures designed to meet these requirements.

E-6.2. Operations

E-6.2.1. General Operating Procedures

The Site 300 Project Leader is responsible for ensuring the quality of operations at these facilities. The Technician Supervisor is responsible for ensuring that all field operations, including maintenance and operations, are performed with the appropriate quality procedures and are completed in a timely fashion.

Each treatment facility, per its respective permits, has a required monitoring program as described in Appendix B. This involves monitoring the performance of the soil vapor treatment system to meet the SJVUAPCD vapor discharge requirements. Water samples are collected to monitor the performance of the ground water treatment systems in meeting Substantive Requirements for waste water discharge issued by the RWQCB. The Technician Supervisor is responsible for ensuring that the facility technicians are properly trained to collect these samples according to documented standard operating procedures. Samples generated as part of the treatment facility monitoring are assigned unique identifiers and documented traceability of these identifiers are maintained throughout the handling of the samples (the Chain-of-Custody process) and the data generated from measurements of the samples.

The Building 834 OU ground water and soil vapor treatment systems have their own set of operating procedures. These procedures, which are being developed as part of the O&M manual, cover the different modes of operation including startup, shutdown, normal operation, safety considerations, and maintenance procedures.

Waste products (i.e., TBOS/TKEBS) that are generated as part of the treatment facility operation process are assigned unique identifiers and documented traceability of these identifiers is maintained throughout the handling of the samples (the Chain-of-Custody process). These waste products are turned over to LLNL's Hazardous Waste Management Division for shipment to an offsite permitted recycling facility. The spent aqueous-phase and vapor-phase granular activated carbon (GAC) from the Building 834 OU treatment facility will be removed from the 1,000-lb capacity containers onsite by the vendor. The vendor will ship the spent GAC to a RCRA-permitted facility for regeneration or disposal.

E-6.2.2 Equipment Calibration and Verification

All measuring and test equipment used at the treatment facilities should be calibrated, maintained, and controlled per ERD Standard Operating Procedure 4.8 "Calibration/Verification and Maintenance of Measuring and Test Equipment" and the EPD QAMP, Section 5.5.5, to assure conformance with standards of known accuracy and traceability. Facility technicians are responsible for ensuring the calibration status of all data collection and monitoring equipment is current prior to use. The calibration status of this equipment will be identified and tracked in a Calibration/Maintenance Log.

E-6.2.3. Record Keeping

An operational logbook is kept at each facility. The logbook entries include the operating parameters of each system (i.e., temperature, pressure, etc.), the number and type of samples taken, maintenance performed on the system, and all adjustments made by the operators to the system.

In addition, the following QA records are generated by treatment facility activities:

- Chain-of Custodies.
- Analytical data.
- Instrument calibration and maintenance logbooks.
- Assessment reports and checklists.
- Course and On-the-Job Training completion records.
- Completed Quality Improvement Forms.
- Standard traceability certificates.

E-6.3. Maintenance

Two types of maintenance are performed at the Building 834 OU ground water and soil vapor treatment systems:

- Preventive.
- Corrective.

E-6.3.1. Preventive Maintenance

Preventive maintenance is performed on those treatment facility components that need routine servicing and are part of systems related to quality. The preventive maintenance schedule is kept at the facility with the operations procedures. The Technician Supervisor is responsible for ensuring that preventive maintenance is scheduled and completed on schedule to minimize downtime. Maintenance will be performed by LLNL Plant Engineering and/or ERD personnel, and will follow the requirements set in the O&M manual to ensure the maintenance functions are performed as planned.

Table E-2 is a tentative schedule of the preventive maintenance for the Building 834 OU ground water and soil vapor treatment systems.

E-6.3.2. Corrective Maintenance

Corrective maintenance is performed when a system component fails or is beginning to fail and the quality of facility operations could be compromised if operation continues. Using the graded approach, root cause analysis is performed when a component fails before the corrective maintenance action commences. This is to ensure that the nature of the problem is understood and can be prevented. This root cause analysis is also used to modify the preventive maintenance plan where appropriate. The results of the root cause analyses are documented in the daily facility operations logbook. Quality Improvement Forms are used to document component failures, root cause analysis, and preventive maintenance per SOP 4.12. As with preventive maintenance, corrective maintenance is performed by Plant Engineering personnel or ERD personnel in accordance with this QA/QC plan.

All corrective maintenance actions and their times of completion are recorded in the facility daily operations logs. Once complete, the specific component or system is started up and operated. This ensures that the maintenance was correctly performed and that system quality is maintained. An entry in the facility log is made, indicating that an operational check was made following preventive or corrective maintenance and the performance of the new component is noted. If successful, the system is allowed to resume normal operations. Startup sampling will be performed upon system restart, if necessary, in accordance with the requirements of the RWQCB Substantive Requirements for the Building 834 OU ground water treatment system.

When the O&M manual for the Building 834 OU ground water and soil vapor treatment systems is developed, it will indicate the required spare parts for system components that have relatively high risk of failure or a long lead time for procurement. These components are to be maintained onsite to prevent extended shutdown of the treatment system.

E-6.3.3. Maintenance Support

Maintenance support activities including the identification and control of O&M materials, inspection and testing of treatment facilities, monitoring of operating status, control of processes, and control of measuring and test equipment, will be implemented as outlined in the Building 834 OU ground water and soil vapor treatment systems O&M manual (under development).

E-7. Assessment Tools

ERD performs QA/Management self-assessments of the treatment facilities triennially. These assessments review treatment facility activities to QA and ES&H requirements and procedures. A member of the ERD management team participates on the assessment team to identify, correct, and prevent management problems that hinder the achievement of ERD's objectives. ERD uses the results of the assessments performed by internal and external organizations to assess the performance of treatment facility activities. Additional information on assessment tools can be found in the ERD Quality Assurance Project Plan (1999) and the EPD QAMP (2001).

E-8. References

Dibley, V. (March 1999), *Environmental Restoration Division, Quality Assurance Project Plan, Livermore Site and Site 300 Environmental Restoration Projects*, Lawrence Livermore National Laboratory, Livermore, Calif. (UCRL-AR-103160 Rev. 2).

Dibley, V., and R. Depue (Eds.) (2000), *LLNL Livermore Site and Site 300 Environmental Restoration Project Standard Operating Procedures (SOPs)*, Lawrence Livermore National Laboratory Livermore, Calif. (UCRLMA-109115 Rev. 8).

LLNL, Environmental Restoration Division, Operations and Maintenance Manual for the Building 834 ground water and soil vapor treatment systems (under development).

LLNL (July 2001), Environmental Protection Department (EPD) *Quality Assurance Management Plan (QAMP), Rev. 5*, Lawrence Livermore National Laboratory, Livermore, Calif.

LLNL (March 2000), *Environmental Restoration Division, Operations and Maintenance Manual, Volume 1: Treatment Facility Quality Assurance and Documentation, Rev. 1*, Lawrence Livermore National Laboratory, Livermore, Calif.

U.S. DOE (1999), DOE Order 414.1A, Quality Assurance Program, Office of Nuclear Safety Policy and Standards.

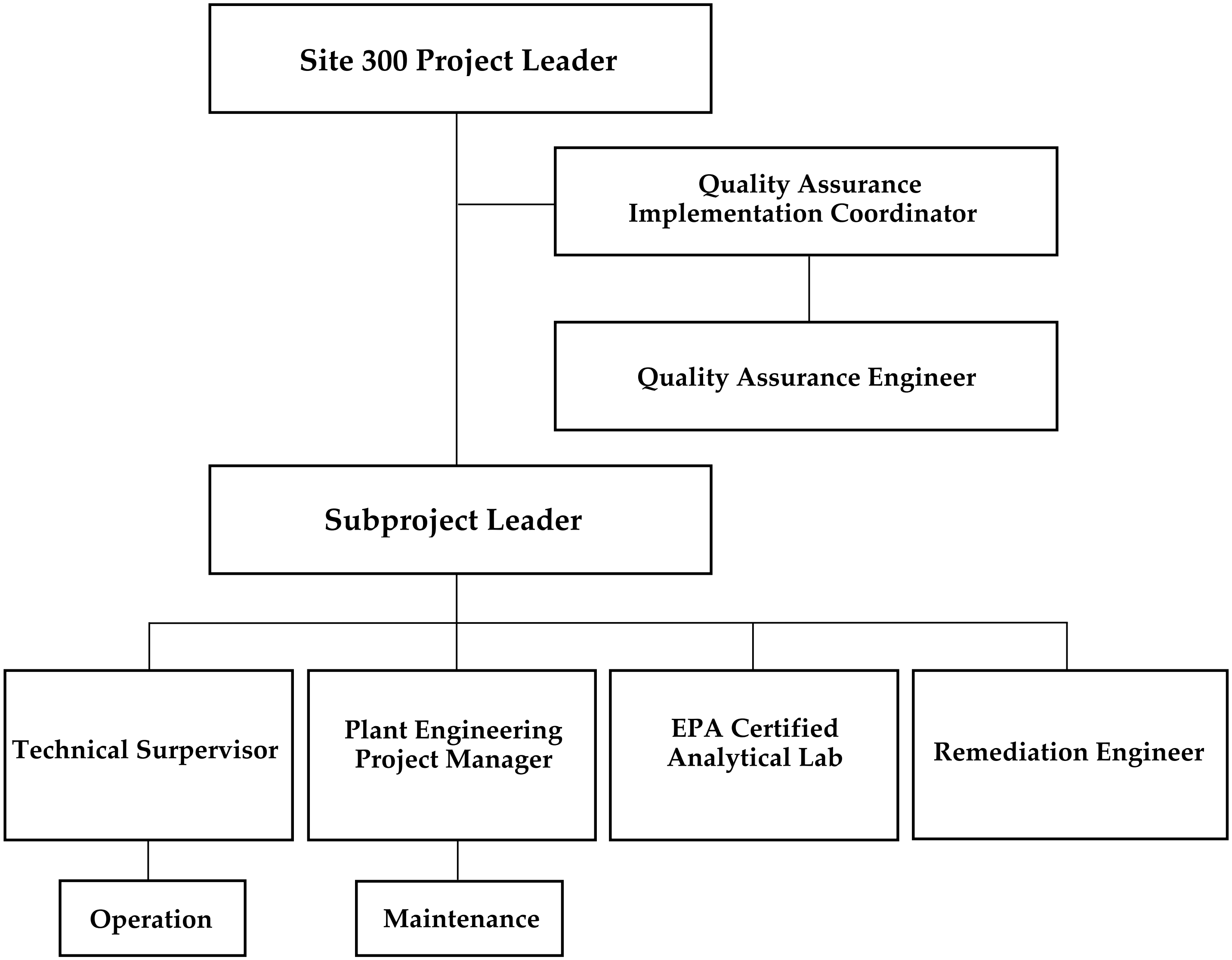

Figure E-1. Organizational chart for O&M QA/QC for the Building 834 treatment facilities.

Table E-1. Applicability of the EPD QAMP elements to the operation and maintenance of the Building 834 OU ground water and soil vapor extraction and treatment systems.

EPD QAMP requirement	Title	Applicable ?
Element 1	EPD Quality Assurance Program Description	Yes
Element 2	Training and Qualification	Yes
Element 3	Quality Improvement	Yes
Element 4	Document and Records	Yes
Element 5	Work Processes	Yes
Element 6	Design Control	Yes
Element 7	Procurement	Yes
Element 8	Inspection and Acceptance Testing	Yes
Element 9	Management Assessment	Yes
Element 10	Independent Assessment	Yes

Table E-2. Preventive maintenance for the Building 834 OU ground water and soil vapor extraction and treatment systems.

Action	Frequency/comments
Inspect variable speed submersible pump	**Annually**
Perform preventive maintenance for air sparger and associated piping	**Annually** (Discontinued when the air sparger is replaced with aqueous-phase GAC)
Check aqueous-phase granular activated carbon (GAC) units and associated piping	**Weekly** (Once the air sparger is replaced with aqueous-phase GAC)
Check discharge lines	**Weekly**
Monitor pump controller	**Weekly**
Monitor level sensors	**Weekly**
Monitor pressure indicator	**Weekly**
Monitor pH meter	**Weekly**
Monitor flow indicator	**Weekly**
Inspect miscellaneous hoses, seals, fittings, etc.	**Weekly**
Perform preventive maintenance for wellhead demister	**Annually**
Perform preventive maintenance for well pumps	**Quarterly**
Perform preventive maintenance for vacuum and pressure gauges	**Annually**
Perform preventive maintenance for temperature sensors	**Annually**
Perform preventive maintenance for temperature indicators	**Annually**
Perform preventive maintenance for air flow sensor	**Annually**
Perform preventive maintenance for process air heater	**Annually**
Check vapor-phase GAC	**Weekly**
Check electrical breakers and disconnects[a]	**Annually**
Perform preventive maintenance for soil vapor extraction blower	**Annually**
Perform preventive maintenance for programmable logic controller (PLC)	**Annually**
Inspect sampling ports	**Before use**
Clean organic debris from area surrounding the building	**As needed**

[a] **All electrical system maintenance to be performed by a qualified electrician or electrical technician.**

Appendix F

Operations and Maintenance Health and Safety Plan

Appendix F

Operations and Maintenance Health and Safety Plan

This Appendix contains the Operations and Maintenance (O&M) Health and Safety Plan (HASP) for the Building 834 OU ground water and soil vapor extraction and treatment facilities (TFs).

F-1. Reason for Issue

Safety procedures are required to operate and maintain the phase separator, air-sparging system, water filtering system, and soil vapor extraction and treatment system for the Building 834 OU TF. This HASP also serves as an administrative tool to summarize many of the requirements of the Lawrence Livermore National Laboratory (LLNL) Environment, Safety, and Health (ES&H) Manual (LLNL, 2000), Site Safety Plan for LLNL Site 300 (LLNL, 2000), Building 834 OU Integration Work Sheets (IWSs) for Safety Procedures, and the Building 834 Operating Safety Procedures that are pertinent to the Building 834 OU TF O&M. The requirements of the LLNL ES&H Manual are based on DOE's Integrated Safety Management System Principles and Work Smart Standards.

F-2. Work to be Done and Location of Activity

F-2.1. Location of Treatment Facilities

The Building 834 OU is located in the southeast part of LLNL Site 300. The ground water TF is located approximately 30 ft south of Building 834D. The soil vapor TF is located approximately 100 ft southwest of Building 834D.

F-2.2. Treatment Objectives and Methods

The Building 834 OU TF is used to remove volatile organic compounds (VOCs), silicon-based oils (tetra-butyl-orthosilicate or TBOS and tretra-kis-2-ethylbutyl-orthosilicate or TKEBS), and nitrate from ground water and soil vapor to meet permit discharge requirements. Ground water containing VOCs will be pumped from 12 extraction wells utilizing submersible pumps generating around 200 gallons per day (gpd) output. An air sparging unit is currently used to treat VOCs from 16 core area wells although it is planned to replace the sparging unit with aqueous-phase granular activated carbon (GAC). A phase-separator will remove TBOS/TKEBs from extracted ground water. Nitrate is present in the TF effluent and is discharged via misting towers at concentrations of about 30–40 mg/L. The amount of nitrate released during misting operations is not significant enough to cause detectable increases in nitrate deposition rates downwind of the facility. Therefore, misting of nitrate-containing treatment facility effluent is not expected to impact local ground water quality.

Vapor-phase GAC units will continue to be used to treat VOCs in soil vapor extracted from 12 dual ground water-soil vapor extraction wells and three soil vapor extraction wells in the Building 834 area. Soil vapor will be extracted from these extraction wells utilizing a 15-horsepower vacuum pump.

F-2.3. Particulate Filtration

Extracted ground water from Building 834 OU wellfield passes through two 5-micron filters that have differential pressure gauges across them in the range of 0 to 25 pounds per square inch (psi). This filtration process is designed to remove particulates from ground water that could reduce treatment system efficiency.

F-2.4. Scale and pH Control

In the ground water TF, polyphosphate, carbon dioxide, or other approved additives may be injected into the TF influent flow as needed to reduce the formation of precipitates in the treatment system. Carbon dioxide is currently injected into the effluent to reduce the formation of precipitates in the discharge lines and/or to achieve a pH within the discharge limits, if necessary. However, once the sparge unit is replaced by aqueous-phase GAC, it will no longer be necessary to make this pH adjustment by injecting carbon dioxide.

F-2.5. Ground Water Treatment Process

TBOS in the light non-aqueous phase liquid (LNAPL) form is collected by aboveground phase separation. Extracted ground water and any entrained LNAPLs are pumped from the wells to a chamber containing a series of baffles and weirs that cause NAPLs to coalesce and separate from the ground water. LNAPLs float to the surface and gravity drain from a port near the top of the chamber. The gravity-drained LNAPLs are collected in drums. All collected NAPLs are removed from the site by a licensed hauler and transported to a permitted facility for either incineration or recycling.

After passing through the phase separator, water is currently forced to pass through two air-sparging tank to treat VOCs. VOCs are removed from the water by injecting air into the air sparge tank and subjecting the water to intense aeration, driving VOCs into the vapor phase. The VOC-laden vapor is then treated as discussed in Section F-2.7. The air sparge tanks will eventually be replaced by aqueous-phase GAC units. As part of this treatment process, contaminated vapor will no longer be generated by the treatment of ground water.

F-2.6. Discharge of Treated Ground Water

Treated ground water from the Building 834 OU TF is discharged through misting towers located approximately 400 ft northeast of the TF. Treatment facility effluent sprayed from the misting towers typically will form a cloud of water vapor that quickly evaporates.

F-2.7. Vapor Treatment Process

Vapor from the air sparging tank passes through a heat exchanger that condenses and removes the water droplet fraction. The air stream then passes through vapor-phase GAC canisters that trap the VOCs. Once the aqueous-phase GAC units are installed to treat ground water, vapor treatment will no longer be necessary as part of the ground water treatment process. In the soil vapor TF, extracted soil vapor passes through a water knock-out drum to reduce water content in the vapor. The VOCs are then removed by passing the contaminated vapor stream through carbon beds where the VOCs are adsorbed to the carbon.

F-3. Responsibilities

Ed Folsom, phone number (925) 422-0389, LLNL pager number 02892, and home phone number (925) 455-2715, is responsible for the safety of this operation and for assuring that all work is performed in conformance with this HASP and applicable sections of the LLNL ES&H Manual, Environmental Protection Handbook, and the Site Safety Plan for CERCLA Investigations at LLNL Site 300. In the absence of the responsible individual, P.J. Lyra, phone number (925) 422-1830, LLNL pager number 05157, or Greg Santucci, phone number (925) 422-3089, LLNL pager number 06502, shall assume these responsibilities.

Any changes in operations that improve or do not significantly affect safety and environmental controls may be approved by the responsible individual(s) listed above, and the LLNL Environmental Safety & Health (ES&H) team leader. The responsible individual will ensure that this action is documented in a memorandum. Any changes in the operation that increase the hazard level, introduce additional hazards, or decrease safety shall not be made until a revision to this HASP has been reviewed and approved, consistent with the LLNL Environmental Restoration Division review and approval process.

Before starting operation, the responsible individual shall verify and document that the operating personnel have read and understand the HASP, relevant Integration Work Sheets, and associated LLNL ES&H Manual sections referenced in Section F-5 below.

F-4. Hazard Analysis

A Preliminary Hazard Analysis of the Building OU treatment facilities was conducted by LLNL Hazards Control. The Hazards Control team classified the ERD treatment facilities as “excluded” facilities. An excluded facility is a facility that is not designated by DOE as a nuclear facility or by LLNL as a high-, moderate, or low-hazard non-nuclear facility. Excluded facilities do not require Facility Safety Procedures. However, a number of hazards are associated with work at the Building 834 OU as described below.

F-4.1. Noise Hazard

Irreversible hearing loss can occur due to long-term exposure to noise from operating fans and blowers, and heavy equipment. Noise can also aggravate pre-existing hypertension. The American Conference of Industrial Hygienists has established a standard of 85 dBA over an 8-

hour day. Exposure to noise louder than 85 dBA is permitted, as long as the average exposure for the entire day is less than 85 dBA.

F-4.2. Electrical Hazard

A 480, 208/230, and 110 VAC electrical power supply is used to operate the Building 834 OU ground water and soil vapor extraction and treatment systems. Electrical shock and injury may occur if personnel come into contact with exposed energized parts during servicing and maintenance activities.

F-4.3. Seismic Hazard

Personnel may be injured during an earthquake due to falling equipment or missile hazards (equipment or materials moving energetically due to seismic forces).

F-4.4. Pressure Hazard

Compressed gas cylinders are used as part of the Building 834 OU treatment process. These pressurized gas cylinders can pose a hazard to personnel, equipment, and facilities if improperly operated and/or handled including blast effects, shrapnel, equipment damage, and personnel injury.

F-4.5. Chemical Hazard

Volatile organic compounds including trichloroethylene, tetrachloroethylene, trichloroethane, and dichloroethylene are contained the extracted ground water treated in the Building 834 OU treatment system at concentrations up to 50,000 ppb total VOCs. These chemical hazards are listed as potential carcinogens and liver toxins that may enter the body through inhalation, skin absorption, and/or ingestion. They are irritating to the eyes, nose, and throat and may affect the central nervous system.

F-4.6. Confined Space Hazard

A confined space is defined as an enclosed area that is large enough for an employee to enter and perform assigned work, has limited or restricted means of entry or exit, and is not designed for continuous human occupancy. If an ignition source is present in or introduced into an enclosed space that contains flammable gases, solvents, or dust, the atmosphere may burn or explode. Serious injury or death may result when the atmosphere contains even low concentrations of toxic gases.

F-4.7. Hand and Portable Power Tool Hazard

The Laboratory provides hand and portable tools that meet accepted national safety standards. However, these tools can still cause injury and must be properly used and maintained.

F-4.8. Working Alone Hazard

Working alone means performing any activity out of sight or communication for more than a few minutes at a time. For work on exposed energized electrical equipment, an individual is considered to be working alone if not within sight of someone else. The major danger in working alone is sustaining an illness or injury that precludes self-rescue.

F-4.9. Physical and Biological Hazards

Physical hazards associated with working at Site 300 include extreme temperatures with temperatures often exceeding 100º F in the summer. High air temperatures coupled with use of semi-permeable or impermeable protective clothing and/or strenuous physical activities have a high potential for inducing heat stress in workers. In addition, hazardous conditions may exist during lightning storms at Site 300. Biological hazards include rattlesnakes and insects (i.e., tarantulas, black widow spiders, scorpions, etc.).

F-4.10. Slip/Trip/Fall Hazards

The surfaces that operators stand or work on can be hazardous if not properly designed or maintained. Injuries can result from slips, trips, or falls on work surfaces. Work at heights or at elevated locations can also pose a fall hazard.

F-4.11. Material Handling Hazards

The hazards associated with improper material handling include being struck by a load, losing control of a load, physical overexertion, and exceeding equipment capacities. Such accidents can lead to injuries.

F-4.12. Mechanical Motion Hazards

A wide variety of mechanical motions and actions may present hazards to personnel. These can include the movement of rotating members, reciprocating arms, moving belts, meshing gears, cutting teeth, and any part that may cause impact or shear. These different types of hazardous mechanical motions and actions are basic in varying combinations to nearly all machines.

F-5. Hazard Control

Controls for the hazards identified in Section F-4 are based on selected sections of LLNL Environment, Safety, and Health (ES&H) Manual, the Site Safety Plan for LLNL CERCLA Investigations at Site 300 (2000), the Vapor Extraction and Water Treatment for the Building 834 Trichloroethene Remediation Action Operational Safety Procedure, and ERD Integration Work Sheets #239 and #552.

F-5.1. Noise Hazard Control

F.5.1.1. Noise Protection

Noise exposure is primarily associated with fans, blowers, and air compressors at Building 834 OU TF. Based on previous experience, it is not anticipated that the noise level in this area will be of concern. However, sound levels will be monitored during any operation that may generate hazardous noise levels. The facility operator will be required to wear noise protection when working within the noise hazard area, if required by LLNL Industrial Hygiene personnel. Engineered and/or administrative controls should also be implemented, as necessary, to limit noise and protect worker's hearing. The work supervisor shall provide workers affect by noise with earplugs or earmuffs as needed.

The facility operator is required to follow noise safety precautions outlined in the LLNL ES&H Manual, Section 10.08 "Hearing Conservation" and Supplement to 10.08.

F-5.2. Electrical Hazard Control

F-5.2.1. Access Control

Inadvertent contact with energized equipment is prevented by limiting access to the breaker switches. All breaker switches are contained in cabinets with keyed locks.

F-5.2.2. Electrical System Maintenance Safety Procedures

Only qualified electricians or electrical technicians perform maintenance activities on the electrical systems for the treatment facilities. These personnel will follow safety precautions as outlined in the LLNL ES&H Manual, Chapter 23, "Electrical Safety," and the Electronics Engineering Department–Electrical Safety Policy, LED-61-00-01-A1A. These personnel will also follow the LLNL Lockout and Tag program as defined in Chapter 26.13 of the LLNL ES&H Manual and IWS Safety Procedure #239 whenever any work is to be done that would expose them to energized equipment.

F-5.3. Seismic Hazard Control

Equipment will remain securely bolted to concrete pads to avoid damage and injury during an earthquake. To preclude injury from missile hazards (equipment or materials moving energetically due to seismic forces), any equipment or materials stored at a height of 5 ft or more shall be seismically restrained.

E-5.4. Pressurized Gas Hazard Control

All compressed gas cylinders in service or storage shall be secured to prevent them from falling. The hazard classification or name of gas being stored shall be prominently marked in container storage area, and "No Smoking" signs posted where appropriate. Cylinders should be stored away from sources of intense heat and cylinders stored in the sun should be shaded during the summer, whenever possible. Store containers with protective valve caps in place when the cylinder is not connected to a regulator or manifold. Always assume a cylinder is pressured; handling it carefully and avoid bumping or dropping. Two people are required to lift a standard cylinder or any cylinder weighing more than 50 pounds. Technicians should be familiar with and follow these and the other requirements for handling, operation and storing of compressed gas cylinders in the LLNL ES&H Manual, Section 32.3.8.

F-5.5. Chemical Hazard Control

Concentrations of VOCs in the treatment facility influent are generally several orders of magnitude lower than the recommended permissible exposure limits (PELs) or threshold limit values for these chemicals. Therefore, it is not anticipated that exposure levels in excess of PELs or TLVs will be encountered. However, precautions, such as use of personal protective equipment or clothing (i.e., gloves, safety glasses) should be taken to prevent exposure when potential contact with contaminated, untreated ground water is possible. In addition, to prevent the ingestion of hazardous materials, workers should wash their hands prior to eating, drinking, smoking, or using restroom facilities. The Material Safety Data Sheets for the chemical encountered in Building 834 OU ground water are maintained at the technician's office at Site 300 and in the Site Safety Plan for LLNL CERCLA Investigations at Site 300 (2000).

F-5.6. Confined Space Hazard Control

Occasional confined space entries are performed in the Building 834 area at this time. These entries primarily consist of operators inserting their arms into GAC units during carbon change-outs and into the sparge tanks during routine maintenance. Facility operators and technicians should be familiar with and perform all work in confined spaces in accordance with the LLNL ES&H Manual, Section 3, "Controls for Working in Confined Spaces." Technicians should contact Hazards Control Team #1 prior to entry in any confined space. A Confined Space permit is required for hazardous confined space work. Only qualified personnel with recent confined space training are permitted to work in confined spaces and are required to comply with the two-man rule.

F-5.7. Hand and Portable Tool Hazard Control

Facility technicians are responsible for selecting and using the proper tools for the job assigned and for wearing the appropriate personal protective equipment (i.e., safety glasses, etc.) when working with hand and portable tools. All hand and portable tools should be inspected prior to use to make sure they are not damaged and are in good-working condition. Any tool that is damaged or unfit for use should be immediately removed from service. Personnel are responsible for following the work safety standards outlined in LLNL ES&H Manual, Section 26.5.

F-5.8. Working Alone Hazard Control

When working alone on a non-hazardous activity, facility technicians will advise a co-worker or supervisor that they will being working alone and when they expect to return. For potentially hazardous activities, technicians will: (1) exercise prudent judgement whether or not to perform the activity alone, and (2) obtain prior authorization from work supervisor before beginning planned hazardous-work-alone operations to ensure that all hazards have been thoroughly evaluated from the perspective of working alone. Work supervisors are responsible for ensuring an IWS is prepared for activities classified as hazardous for working alone. Personnel are responsible for following the work safety standards outlined in LLNL ES&H Manual, Section 26.12 and the Environmental Restoration Division Working Alone Guidelines (in ERD O&M Manual, Appendix L) for all work-alone activities.

F-5.9. Physical and Biological Hazard Control

During late spring and summer months, technicians should ingest fluids and evaluate their physical conditions regularly and break when necessary to avoid overheating. Work should be conducted in accordance with the LLNL ES&H Manual, Section 26.16. All personnel should follow procedures outlined in the Site 300 Lightning Procedures (S300 MGM-T-7) during a lightning alert at Site 300.

Technicians should inspect work areas for snakes and other biological hazards before commencing work. The use of high top work boots is recommended. Avoid biological hazards when possible; do not harass wildlife. Anyone who is bitten should be moved to a safe area and kept calm. Notify the Emergency Dispatch (911) immediately.

F-5.10. Slip/Trip/Fall Hazard Control

Work surfaces around the treatment facilities should be properly maintained at all times to prevent slips, trips, and falls. Maintenance includes assuring all spills and foreign materials (i.e., tools, excess equipment, etc.) are promptly removed, installing rubber or slip resistant mats at locations that may accumulate water, and ensuring that floor openings are equipped with adequate covers when worker exposure is possible. Any access to elevated locations or work at heights requires guardrails, an administrative control system, or fall protection devices. Personnel are responsible for following the work safety standards outlined in LLNL ES&H Manual, Sections 26.17 and 10.09.

F-5.11. Material Handling Hazard Control

When lifting or handling materials manually, operators should use methods that ensure personal safety and safety of the material being handled. Objects that are too heavy or bulky to handle safely should be moved using more than one person or mechanical lifting device. All material lifting or handling should be performed in accordance with the safety standards and procedures for lifting contained in the LLNL ES&H Manual, Section 29.3.

F-5.12. Mechanical Motion Hazard Control

Any machine part, function, or process which may cause injury shall either be guarded (physical barriers which prevent access to danger areas) or safeguarded (provided with devices which inhibit machine operation, to mitigate or eliminate danger areas).

Machine operators shall be trained in the proper use of equipment and associated guards/safeguards to protect themselves and others from machine-related hazards. Machine operators shall wear protective clothing or personal protective equipment as necessary whenever engineering controls are not available or are not fully capable of protecting personnel. At a minimum, safety shoes and safety glasses shall be worn by all personnel operating or working within close proximity of heavy machinery or equipment. When there is a potential for head injury, hard hats shall be worn.

F-6. Environmental Concerns and Controls

F-6.1. Ground Water Extraction and Treatment Systems

Concern: Discharge of untreated ground water.

Controls:

- Interlocks shut off the system and the flow of air and water if physical damage to the treatment system occurs.
- Scheduled sampling per waste discharge permit monitors treated ground water discharge.
- Facility operator inspects the system periodically.

F-6.2. Soil Vapor Extraction and Treatment System

Concern: Atmospheric discharge of untreated vapor.

Controls:

- Scheduled monitoring of treated vapor discharge per air permit.
- Facility operator inspects the system periodically.

F-7. Training

F-7.1. Basic Facility Operator Courses

The following courses are required for all Building 834 OU TF operators:

- HS-0039—SARA/OSHA Training (40-hour course with yearly refreshers).
- HS-0001—New Employee Safety Orientation.
- HS-1620—Standard First Aid (First Aid Certification valid for 2 years).
- HS-5300—Back Care Workshop.
- HS-4360—Noise Safety
- HS-0095— Site 300 Safety
- HS-2080—Site 300 Explosives Safety Training for Crafts, Protective Services, and Fire Personnel

F-7.2. Selective Training Courses

The following courses may be required when they apply to the tasks assigned to the facility operator:

- HS-0006—Hazardous Waste Handling Practices (refresher training required annually).
- HS-4150—Confined Space Entry.
- HS-4240—Chemical Safety.
- HS-5030—Pressure Orientation (required every 5 years).
- HS-5220—Electrical Safety (required every 5 years).
- HS-5245—Lockout and Tag Procedure (refresher training required every 5 years).

F-7.3. Training Responsibilities and Documentation

Training courses identified in this section do not qualify a person to operate the treatment equipment and treatment systems located in Building 834 OU. Only the responsible individual(s) identified in Section F-3 of this HASP will determine if and when a person is qualified to operate the treatment facilities. Once qualified, each technician's personnel file is updated to reflect their status as a treatment facility operator.

The responsible individual, or designee, shall ensure that all required training (including on-the-job training if applicable) is completed and documented in the LLNL Repository of Completed Courses. Untrained personnel may work under the supervision of a trained person until the required training is completed.

F-8. Maintenance

Items requiring periodic maintenance do not impact the safety of the operation. Interlocks shall be tested annually.

F-9. Quality Assurance

O&M activities at the Building 834 OU TFs shall be controlled by quality procedures designed to meet ground water and soil vapor treatment and discharge requirements specified in the waste discharge permits for ground water and air discharge permits. Controls to prevent the discharge of untreated ground water or vapor and meet quality objectives include:

- Annual interlock function checks shall be performed by the Facility Electronics Staff or Plant Engineering Electronic Engineering Staff. Test documentation shall be maintained by the Facility Electronics Supervisor, or designee.
- Scheduled weekly, monthly, quarterly, and annual sampling of water and vapor shall be performed at various points in the ground water and soil vapor extraction and treatment systems to ensure compliance and quality.

- TF-related analytical data will be reviewed by the Quality Assurance Coordinator or designee to ensure the data meets quality objectives.

F-10. Emergency Response Procedures

In the event of an emergency, facility operations personnel will first dial "911" to report to the Emergency Dispatcher, then administer first aid, if necessary, to injured personnel. The Emergency Dispatcher uses reserved telephone lines to promptly relay the emergency call to the following members of the LLNL Emergency Response Team:

- Fire Department.
- Security Department.
- Hazards Control Safety Teams.
- Plant Engineering.
- Health Services.

The Emergency Response Team will go to the scene of the emergency immediately. The phone numbers of individuals to be notified in the event of an emergency during off-shift hours are posted at the Building 834 OU TFs. The LLNL ES&H Manual describes the emergency response procedures.

F-11. Applicable Documents

The following documents and/or sections thereof apply to the safe operation of the Building 834 OU TFs and are incorporated into this HASP by reference.

F-11.1. Treatment Facility Operating Manual for the Air Sparger (in process)

F-11.2. Integration Work Sheet Safety Procedures #552 (Ground Water and Soil Vapor Extraction at Building 834) and #239 (Lockout and Tag Program for Institutional and PE Maintained Programmatic Equipment)

F-11.3. LLNL Environment, Safety, and Health Manual Sections

Section 1.	LLNL ES&H Policies, General Worker Responsibilities, and Integrated Safety Management
Section 2.	Integrating ES&H into Laboratory Activities
Section 10.08	Hearing Protection
Section 21.	Chemicals
Section 21.3.5	Facilities and Equipment

Section 21.3.7	Handling Solid and Liquid Chemicals
Section 23.	Electrical Safety
Section 23.1	Introduction
Section 23.2	Hazards
Section 23.3	Controls for Electrical Work and Electrical Equipment
Section 23.4	Responsibilities
Section 23.5	Work Standards
Section 23.6	Resources for More Information
Appendix 23-B	Effects of Electrical Energy on Humans

F-11.4. LLNL Electronics Engineering Department—Electrical Safety Policy, LED-61-00-01-A1A

F-11.5. Site Safety Plan for LLNL CERCLA Investigations at Site 300, November 2000

F-11.6. Vapor Extraction and Water Treatment for the Building 834 Trichloroethene Remediation Action Operational Safety Procedure (OSP 834.01)

F-11.7. LLNL Environment, Safety, and Health Manual Supplements

Section 10.08	Hearing Conservation
Section 11.07	Personnel Safety Interlocks
Section 26.13	LLNL Lockout and Tag Program

F-12. References

LLNL (2000), LLNL Environment, Safety, and Health Manual.

LLNL (2000), *Site Safety Plan for Lawrence Livermore National Laboratory CERCLA Investigations at Site 300*, Lawrence Livermore National Laboratory, Livermore, Calif. (UCRL-21172 Rev. 3).

Appendix G

Soil Vapor Extraction System Shut-off Evaluation

Appendix G

Soil Vapor Extraction System Shut-off Evaluation

G-1. Introduction

This Appendix presents a methodology for evaluating whether a soil vapor extraction (SVE) system can be shut off. This decision requires a comprehensive evaluation of site characterization issues, trend analysis of soil vapor concentrations and mass removal rates, human health risk, and SVE system performance. This methodology is potentially applicable to any SVE system at Site 300. It is based on similar evaluations presented in the General Services Area (GSA) Record of Decision (ROD) U.S. Department of Energy (DOE) (1997), U.S. Army Corps of Engineers (1995), and an unpublished report on SVE shut-off criteria for Castle Air Force Base (1999).

As presented in the SVE System Shut-off flow chart (Figure G-1), this evaluation is subdivided into three parts:

- Prerequisites to begin an SVE System Shut-off Evaluation
- SVE System Shut-off Evaluation.
- Resolution of the SVE Shut-off Evaluation.

DOE/LLNL will make the decision to shut off the SVE system permanently only after receiving concurrence from the regulatory agencies for this action. The evaluation methodology presented here is intended to provide a framework to facilitate this decision. Other factors may be considered upon agreement with the regulatory agencies.

G-2. Prerequisites to begin an SVE System Shut-off Evaluation

An evaluation may begin after all parties agree that existing data are adequate to address the following characterization, human health risk, and SVE system performance issues:

1. There is no immediate or unacceptable human health risk.
2. The site has been adequately characterized.
    - Unsaturated (vadose) and saturated zone contamination is delineated.
    - SVE wells and soil vapor monitoring points are located appropriately both in the horizontal and vertical planes.
    - Subsurface parameters influencing soil vapor migration are quantified (i.e., moisture content, air permeability, porosity, retardation, partitioning coefficients, carbon content, etc.).
    - Geologic features that influence soil moisture and soil vapor migration are identified (i.e., low permeability zones, preferential vapor and moisture pathways, etc.).

- Ground water flow direction, elevation changes, and other sources of ground water contamination are determined.

3. The site conceptual model is supported by subsurface and treatment facility operational data.
   - Borings, wells, and soil vapor monitoring points installed over time yield expected geologic, pressure, and chemistry data.
   - Initial and current estimates of subsurface contaminant mass agree with cumulative mass removed at the treatment facility.
4. Trend analysis of soil vapor concentration data indicate that:
   - Soil vapor and ground water concentrations in wells show decreasing trends immediately down gradient from the vadose zone sources without active ground water remediation.
   - Soil vapor concentrations show decreasing trends in all wells.
   - No significant soil vapor concentration gradients exist toward potential receptors.
   - Soil vapor concentrations have reached asymptotic levels in all wells.
   - Soil vapor concentrations in wells do not significantly increase after temporary events of SVE system shut off and subsequent restart.
5. The SVE system is designed appropriately and optimized as best as possible.
   - Vacuum influence tests show that soil vapor is extracted from contaminated areas, unsaturated zone contamination is fully captured, and maximum flushing rates are obtained in the high concentration zones.
   - SVE well field management has been optimized over time to maximize mass removal (flow rates, alternating SVE well use, etc.).
   - Mass removal rate at the treatment facility has reached asymptotic levels with no significant increase after temporary events of SVE system shutdown.
   - SVE system zone of influence reaches all contaminated areas, including potential stagnation zones in the subsurface.

G-3. SVE System Shut-off Evaluation

This evaluation can be grouped into the following three general topics:

- Quantitative analysis.
- Relationship to ground water cleanup.
- Cost/benefit analysis.

These topics represent different approaches to SVE System Shut-off Evaluation. They are not listed in order of priority and they do not all need to be satisfied to shut off an SVE system. A series of questions are presented under each topic to facilitate the evaluation. The answers to these questions will provide a basis for negotiations between DOE/LLNL and the regulatory agencies regarding whether to continue or discontinue SVE system operation.

1. Quantitative analysis for evaluating potential impact to ground water (and/or other potential receptors) from residual vadose zone contamination, using predictive tools.
   - What is the estimated residual mass in vadose zone in each media (soil vapor, soil moisture, separate phase)?
   - How is the residual contamination distributed in the subsurface?
   - What is the site-specific infiltration and percolation rates from rainfall recharge?
   - What are the estimated values of soil vapor and soil moisture migration parameters such as, relative permeability, porosity, moisture content, carbon content, intrinsic biodegradation rates, etc.?
   - What is the lowest observed depth to water at the site, and how much does it fluctuate?
   - Based on the above information, does the predicted concentration of leachate in the vadose zone (using an appropriate vadose zone partitioning model) exceed ground water cleanup standard?
   - Based on the leachate concentration, do the predicted ground water concentrations (using an appropriate vadose zone and ground water transport model) exceed ground water cleanup standard?
2. Assessment of SVE system operation relative to the state of ground water remediation, to determine if continued operation of the SVE system further assists reaching the overall cleanup standards.
   - What are the location and capture zones of ground water extraction wells relative to the vadose zone contamination?
   - What is the predicted time to cleanup for ground water (using a ground water transport model) with and with out operation of the SVE system?
   - Does the operation of the SVE system enhance or impede ground water remediation system performance?
   - Does the operation of the SVE system enhance or impede intrinsic degradation processes in ground water and/or vadose zone?
3. Preparation of a detailed, comparative cost-benefit analysis to assess the feasibility of long-term costs under continued operation versus shut-off scenarios.
   - What is the cost per unit contaminant mass removed from the subsurface by the SVE and ground water extraction (GWE) systems?
   - What is the predicted time to cleanup and cost (using appropriate vadose zone and ground water transport models) for the vadose zone and ground water contamination when both SVE and GWE systems are operational?
   - What is the predicted time to cleanup and cost (using appropriate vadose zone ground water transport models) for the vadose zone and ground water contamination when only the GWE system is operational and there is additional impact from residual contamination from the vadose zone?

- Based on the above information, does the operation of the SVE system significantly reduce the time and cost to reach ground water cleanup standards?
- What are the predicted effectiveness and cost of further enhancements to the SVE system (e.g., additional SVE wells, air injection, air-sparging, bioventing) beyond optimization of the existing system?
- How does the mass removed by operating the SVE system under asymptotic concentrations compare to the resulting environmental impact of operating the SVE system?

G-4. Resolution of the SVE Shut-off Evaluation

There are five general outcomes from an SVE Shut-off Evaluation. They are:

1. The vadose zone remediation is determined to be complete and the SVE system can be permanently shut off.
2. The residual mass of contaminants in the vadose zone will not impact ground water at concentrations exceeding cleanup standards. Therefore continued soil vapor and ground water monitoring without SVE system operation is appropriate.
3. The residual mass of contaminants in the vadose zone will impact ground water at concentrations exceeding cleanup standards, however, continued SVE system operation will not significantly reduce the time to reach ground water cleanup standards. Therefore continued ground water extraction without SVE system operation is appropriate.
4. The residual vadose zone contamination will impact ground water at concentrations exceeding cleanup standards, therefore continued SVE system operation is appropriate.
5. The residual vadose zone contamination will impact ground water at concentrations exceeding cleanup standards and continued SVE system operation is not adequate to remediate the residual contamination. Therefore the deployment of an SVE enhancement technology (air-sparging, bioventing, permeability enhancement methods, thermal or chemical enhancement methods, etc.) and/or another remedial solution (excavation, vitrification, barometric pumping, horizontal wells, etc.) is appropriate.

Ground water and soil vapor monitoring will be conducted throughout the life of the Building 834 OU remediation project. Monitoring data will be used to continually optimize treatment system operation and provide input for this evaluation.

G-5. References

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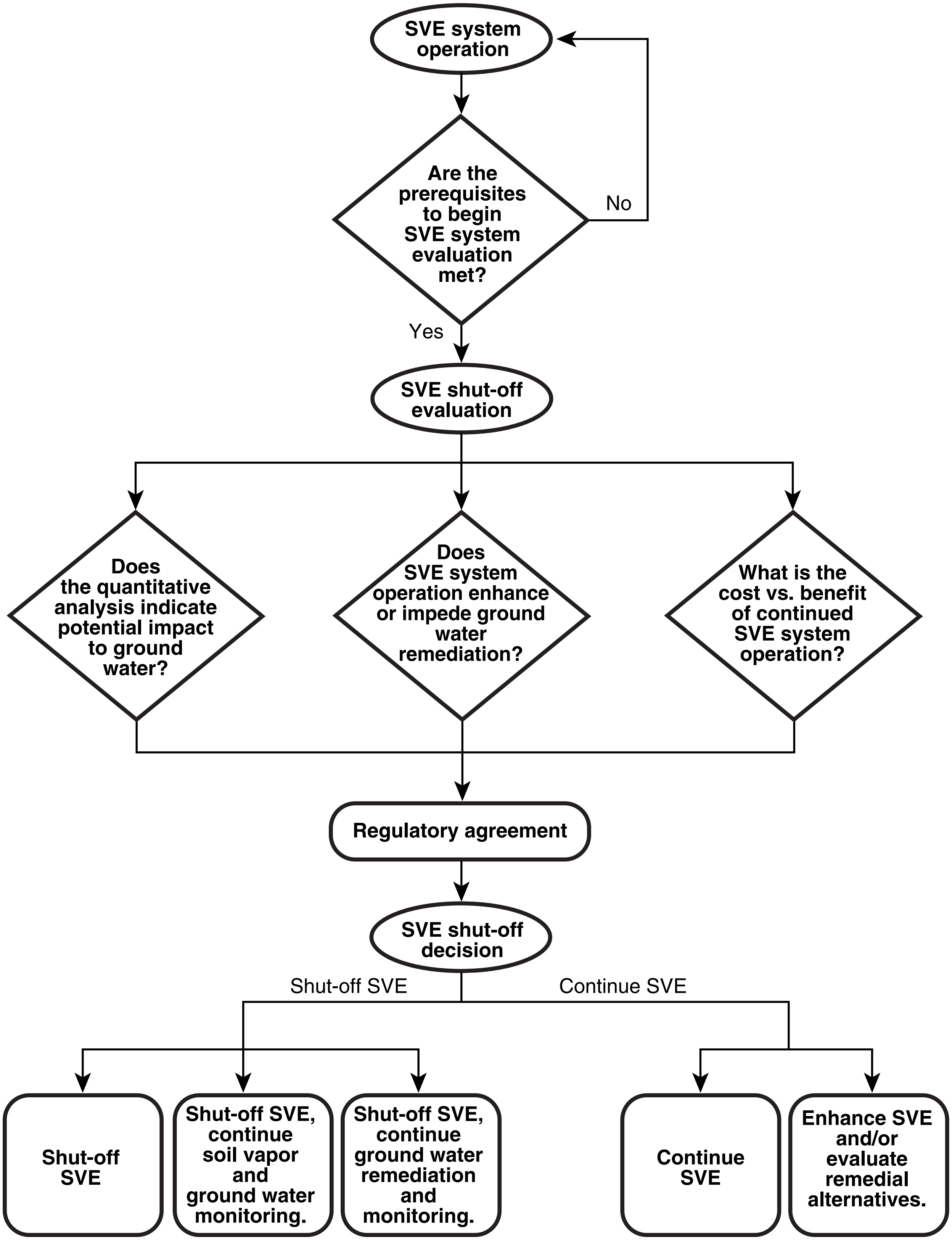

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Figure G-1. Soil vapor extraction (SVE) system shut-off evaluation flow chart.

Acronyms and Abbreviations

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1,2-DCE	1,2-dichloroethylene
2-D	*two-dimensional*
3-D	*three-dimensional*
ACI	American Concrete Institute
AISC	American Institute of Steel Construction
Ag	silver
ANSI	American National Standards Institute
AWS	American Welding Society
Ba	barium
bgs	below ground surface
©	Copyright
CCR	California Code of Regulations
Cd	cadmium
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
Cu	copper
DDW	dissolved drinking water
DNAPL	Dense Non-Aqueous Phase Liquids
DO	dissolved oxygen
DOE	U.S. Department of Energy
DOL	Department of Labor
DTSC	California Department of Toxic Substances Control
EPA	U.S. Environmental Protection Agency
EPD	Environmental Protection Department
ERD	Environmental Restoration Division
ES&H	Environmental Safety & Health
FFA	Federal Facility Agreement
ft	feet, foot
ft/yr	feet per year
GAC	granular activated carbon
gal	gallon(s)
gpm	gallons per minute
g/ccm	grams per cubic centimeter
GWE	ground water extraction
HASP	Health and Safety Plan
Hg	mercury
hp	horsepower
hr	hour(s)
Hz	hertz
ICBO	International Conference of Building Officials (ICBO)
in.	inch(es)
in. Hg	inches of mercury
IRIS	Integrate Risk Information System

IWS	Integration Work Sheet
kg	kilograms
kg/day	kilograms per day
lb	pound(s)
LLNL	Lawrence Livermore National Laboratory
LNAPL	Light Non-Aqueous Phase Liquid
Mb	molybdenum
MCL	Maximum Contaminant Level
μg/L	micrograms per liter
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
NFPA	National Fire Protection Association
NRTL	Nationally Recognized Testing Laboratory
O&M	operations and maintenance
OSHA	Occupational Safety and Health Administration
OU	operable unit
Pb	lead
PEPM	Plant Engineering Project Manager
PEL	Permissible Exposure Limit
PH	phase
P&ID	piping and instrumentation diagram
PLC	Programmable logic controller
$ppm_{v/v}$	parts per million on a volume per volume basis
PRGs	preliminary remediation goals
psi	pounds per square inch
PVC	polyvinyl chloride
QA	quality assurance
QAIC	Quality Assurance Implementation Coordinator
Qal	Quaternary Alluvium
QAMP	Quality Assurance Management Plan
QAPP	Quality Assurance Project Plan
QA/QC	quality assurance/quality control
QC	quality control
®	Registered
RCRA	Resource Conservation and Recovery Act
RD	Remedial Design
RDWP	Remedial Design Work Plan
RfD	Reference Dose
RI/FS	Remedial Investigation/Feasibility Study
ROD	Record of Decision
RPM	Remedial Project Manager
RWQCB	California Regional Water Quality Control Board
SARA	Superfund Amendments and Reauthorization Act
SC	specific conductance
scfm	standard cubic feet per minute

SJVUAPCD	San Joaquin Valley Unified Air Pollution Control District
SOP	Standard Operating Procedure
SVE	Soil vapor extraction
SWFS	Site-Wide Feasibility Study
SWRI	Site-Wide Remedial Investigation
TBOS	tertrabutyl ortho silicate
TCE	trichloroethylene
TDS	total dissolved solids
TKEBS	tetrakis (2-ethylbutoxy) silane
$Tnbs_1$	Miocene Neroly Formation - Lower Blue Sandstone Member
$Tnbs_2$	Miocene Neroly Formation - Middle Blue Sandstone Member
$Tnsc_1$	Miocene Neroly Formation - Middle Siltstone/Claystone Member
$Tnsc_2$	Miocene Neroly Formation - Upper Siltstone/Claystone Member
Tps	Pliocene nonmarine unit
Tpsg	Pliocene nonmarine unit (gravel facies)
TVOC	total volatile organic compounds
UCRL	University of California Radiation Laboratory
V	Volts
yd	yard(s)
VOC	volatile organic compound
Zn	zinc